

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

Abstract

The study investigated the impact of various treatment combinations on the nutrient uptake of rice grains and straw. Nitrogen content in grains ranged from 1.12% to 1.33%, with treatment T₇ (T₃ + foliar application of Bio-dynamic compost wash) recording the highest value. Protein content in grains varied from 7.00% to 8.31%, with T₇ again demonstrating the highest protein content. Phosphorus content in grains showed a range from 0.30% to 0.36%, and potassium content ranged from 1.15% to 1.28%. Similar trends were observed in straw for nitrogen, phosphorus, and potassium content. Nitrogen uptake in rice grains ranged from 44.32 kg ha⁻¹ to 77.03 kg ha⁻¹, with T₇ exhibiting the highest uptake. Phosphorus uptake in grains varied from 11.90 kg ha⁻¹ to 20.85 kg ha⁻¹, and potassium uptake ranged from 22.16 kg ha⁻¹ to 45.17 kg ha⁻¹. In straw, phosphorus uptake varied from 8.17 kg/ha to 15.62 kg ha⁻¹, and potassium uptake ranged from 66.67 kg ha⁻¹ to 100.55 kg ha⁻¹. The application of organic manures significantly influenced nutrient uptake, attributed to enhanced photosynthesis, increased biomass, and improved nutrient availability. The integration of various organic manures resulted in higher NPK uptake, potentially due to increased microbial activity and the release of organic acids. The findings align with previous research, emphasizing the positive impact of organic manure on nutrient uptake in rice crops. These study contribute valuable insights into optimizing agricultural practices for enhanced nutrient management and sustainable crop production.

Keywords: Nutrient uptake, Bio dynamic compost, Organic Manures, Bio mass

Introduction: Agriculture is confronted with the dual challenge of meeting increasing global food demands while minimizing environmental impact. Traditional farming practices often rely on synthetic fertilizers, contributing to soil degradation and environmental pollution. Bio-dynamic compost emerges as a promising alternative,

leveraging a holistic approach to soil fertility and plant nutrition. Rice straw is most suited for this purpose (**Ponnamperuma et al. 1984**) because, on average, it contains about 0.9%N, 0.2%P, 0.2%S, 2.5%K, 0.6% Ca, 7.0% Si and 40% C. Other factors that favor the use of rice straw as an organic supplement are its on-the-spot availability in amount varying from 2 to 5 dry matter ha⁻¹ person and elimination of straw disposal problem. Depending upon the soil-plant-environment, locations vary greatly in how straw is managed. Burning of crop residue CO₂ increased 70%, Carbon monoxide rises by 7%, Nitrogen dioxide shoots up 2.1% Nitrogen 6-7 kg (80%), phosphorus 1-1.7 kg (25%), Potassium 14-25 kg (21%), Sulphur 1.2-1.5 kg (4-60%). Department of PAU Ludhiana, reported the following Nutrient losses with the burning of ton straw during 2010, Nitrogen 6-7 kg (80%), phosphorus 1-1.7 kg (25%), potassium 14-25 kg (21%) and Sulphur 1.2-1.5 kg (4-60%).

The utilization of organo- mineral fertilizer is recognized as a low-input technology that can effectively enhance the nutrient-deficient condition of tropical soils, thereby promoting sustainable crop production. This type of fertilizer combines the beneficial characteristics of both organic and inorganic sources, working synergistically to improve yield. Currently, there is a growing trend worldwide to move away from solely relying on either organic or inorganic fertilizers, and instead, there is increasing emphasis on the combined use of these fertilizers for optimal results. Now that Nigeria is facing the greatest challenges of food insecurity resulting from the recent flooding that devastated some parts of the country coupled with the fast declining productivity of our soils. It becomes imperative that the combined use of organic and inorganic fertilizers (organo-mineral fertilizer) should be encouraged and introduced to our numerous farmers in order to achieve their yield expectancy and maximum benefit from their introduction. Current research on organo-mineral fertilizer has shown better yield performances than the single ones. (**Olowokere, 2004, and Ojeniyet et al., 2009**).

Bio-decomposed compost wash is produced by repeatedly spraying water on compost, allowing it to seep through and collecting the washed water. This process is repeated until only a minimal amount of washed water remains, which is then utilized as compost wash. This method, known as biodynamic composting, is an expedited approach to compost production conducted on the surface rather than in traditional

pits. The compost heap is energized using specific preparations to enhance nutrient content and accelerate decomposition. Built on a flat site, away from tree shade and waterlogging, the compost heap takes the form of a rectangle, typically 2m wide and 4m long, depending on biomass availability. A wind tunnel of logs is placed lengthwise in the middle of the rectangle.

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 affecting root growth, humic acid enhances the soil's physical, chemical, and biological qualities and has an impact on plant growth. By adding humic and fulvic acids to the soil, it is possible to see the beginning of root augmentation and improved root development (**Pettit, 2004**). Macro nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), are present in organic 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 macro nutrients in organic 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, Kar et al., 2012 and Ramalakshmi et al., 2013**).

Fulvic acid plays an important role in influencing fertility and productivity of soil. Reactivity of humic acid and fulvic acid is influenced by their molecular weights, the amount, quality, and proportion of aliphatic and aromatic rings in the molecules (**Debnath et al., 2013**) Prior research has shown that fertilisers can significantly increase rice yield and quality with cautious and effective use. Continuous use of chemical fertilisers accelerates the loss of organic matter in the soil, degrades its

physical and chemical composition, and results in deficits in micronutrients. The application of urban compost is one of the source of plant nutrients and also enhances physical, chemical and biological properties of soil. This can able to replenish the nutrients from the soil to the crop.

Bio-dynamic compost 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. Rice, a staple crop feeding billions, serves as an ideal candidate for studying the impact of bio-dynamic compost due to its global significance and sensitivity to soil conditions. The microbial diversity within bio-dynamic compost introduces a dynamic element to soil ecosystems, promoting symbiotic relationships between microorganisms and plant roots. This symbiosis stimulates nutrient cycling, facilitating the absorption of essential elements by rice plants. Consequently, the nutrient-rich environment is anticipated to manifest in superior grain quality, addressing both quantity and nutritional value in the pursuit of sustainable agriculture.

This research aims to investigate the impact of diverse treatment combinations on nutrient uptake in rice crops. Given the essential role of agriculture in global food security, optimizing nutrient management, particularly through organic manure application, is critical for sustainable crop productivity. 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 present research was conducted.

Materials and Methods:

For the analysis of nutrient uptake, plant shoot samples endured diacid 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 (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 (1962)**, expressed as a percentage on dry weight basis.

Available nitrogen in soil was determined using the alkaline potassium permanganate method by **Subbaiah and Asija (1956)**. The procedure involved distilling 20g of soil with 0.32% KMnO_4 and 2.5% NaOH , absorbing ammonia gas in 4% boric acid (pH 4.5), and back titrating with 0.02 N H_2SO_4 . Results were converted to kg ha^{-1} . Available phosphorus was assessed following **Olsen and Watanabe's (1954)** method. In a 150 ml flask, 2.5g of air-dry soil was mixed with P-free activated charcoal, Olsen's reagent (NaHCO_3 , pH 8.5), and shaken. Color development was measured at 660 nm using a spectrophotometer, with values converted to kg ha^{-1} . For available potassium determination, soil extraction utilized neutral ammonium acetate (pH 7.0) following **Jackson's method (1973)**. Potassium levels in the extract were measured using a flame photometer, and results were converted to kg ha^{-1} .

Results and Discussion:

Nitrogen content in grain (%):

The analysis of nitrogen content in grains, as presented in Table-1, revealed variations influenced by different treatment combinations. The highest recorded nitrogen content in grains (1.33%) occurred with treatment T_7 (T_3 + foliar application of 10 ml lit^{-1} Bio-dynamic compost wash), significantly surpassing T_1 (control) and statistically comparable to T_5 (T_3 + Root dipping with 10 ml lit^{-1} Bio-dynamic wash) and T_6 (Bio-decomposed compost 2 q ha^{-1} + 50% RDF). Conversely, the lowest nitrogen content (1.12%) in grains was observed in treatment T_1 (Control). These findings align with those reported by **Bisht *et al.* (2013)**.

Nitrogen content in straw (%):

The perusal of data concerning nitrogen content in straw, as depicted in Table 1, reveals that various treatment combinations influenced the results. The highest nitrogen content in straw (0.47%) was observed in treatment T_7 (T_3 + foliar application of 10 ml lit^{-1} Bio-dynamic compost wash), significantly outperforming T_1 (control) and statistically equivalent to T_5 (T_3 + Root dipping with bio-decomposed wash 10 ml lit^{-1} of water) and T_6 (Bio-dynamic compost 2 q ha^{-1} + 50% RDF). Conversely, the lowest nitrogen content in straw (0.37%) was noted in treatment

T₁(Control). These findings are consistent with the research of **Satish *et al.* (2011)** and **Ramalakshmi *et al.* (2012)**.

Protein content in grain (%):

The examination of data concerning protein content in grains, as presented in Table 4, indicates that various treatment combinations influenced the outcomes. The highest recorded protein content in grains (8.31%) was associated with treatment T₇ (T₃ + foliar application of 10 ml lit⁻¹ Bio-dynamic compost wash), significantly surpassing T₁ (control) and statistically comparable to T₅ (T₃ + Root dipping with Bio-dynamic wash 10 ml lit⁻¹ of water) and T₆ (Bio-decomposed compost 2 q ha⁻¹ + 50% RDF). In contrast, the lowest protein content (7.00%) was noted in treatment T₁ (Control).

Additionally, **Balasubramaniam *et al.* (1989)** reported a significant increase in protein content in groundnut with the application of humic acid (HA). The stimulatory effects of humic acid on RNA synthesis and phosphate uptake were suggested as potential causes for the observed rise in protein content (**Vaughan and MacDonald, 1970**).

Phosphorus content in grain (%):

The data presented in Table 4 concerning phosphorus content in grains indicates the influence of various treatment combinations. The maximum phosphorus content in grains (0.36%) was observed with treatment T₇ (T₃ + foliar application of 10 ml lit⁻¹ Bio-dynamic compost wash), significantly exceeding T₁ (control) and statistically comparable to T₅ (T₃ + Root dipping with Bio-dynamic wash 10 ml lit⁻¹ of water) and T₆ (Bio-dynamic compost 2 q ha⁻¹ + 50% RDF). In contrast, the minimum phosphorus content (0.30%) in grains was noted in treatment T₁ (Control). These results are consistent with the findings of **Mondal *et al.* (2016)**.

Table-1: Details of treatment

TreatmentNo.	Treatmentdetails
T₁	AbsoluteControl
T₂	BioDynamicCompost 1q/ha+50%RDF
T₃	BioDynamic compost1.5q/ha+50%RDF
T₄	T ₂ +RootdippingwithBioDynamic compostwash10ml/litofwater
T₅	T ₃ +Rootdippingwith BioDynamic compost wash10ml/litofwater
T₆	T ₂ +foliarapplicationofBioDynamic compost washof10ml/litofwater
T₇	T ₃ +foliarapplicationofBioDynamic compostwashof10ml/litofwater
T₈	100%RDF

Table-2: Effect of BioDynamic Compost and BioDynamic Compost on nitrogen content in grain (%), straw and protein content in grain of rice.

S.No.	Treatment combination	N content in grain (%)	N content in straw (%)	Protein Content in grain (%)
T ₁	Control	1.12	0.37	7.0
T ₂	BioDynamic compost 1 q ha ⁻¹ + 50 % RDF	1.19	0.38	7.4
T ₃	BioDynamic compost 1.5 q ha ⁻¹ + 50 % RDF	1.24	0.39	7.7
T ₄	T ₂ + Root dipping with BioDynamic compost wash 10 ml lit ⁻¹ of water	1.28	0.42	8.0
T ₅	T ₃ + Root dipping with BioDynamic wash 10 ml lit ⁻¹ of water	1.32	0.46	8.2
T ₆	T ₂ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	1.28	0.43	8.0
T ₇	T ₃ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	1.33	0.47	8.3
T ₈	100% RDF	1.25	0.4	7.81

SEm±	0.017	0.006	0.109
C.Dat 5%	0.051	0.017	0.332

Table-3: Effect of Bio Dynamic Compost and Bio Dynamic Compost Wash on phosphorus content in grain (%), straw in rice.

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S.No.	Treatment combination	P content in grain (%)	P content in straw (%)
T ₁	Control	0.30	0.15
T ₂	Biodynamic compost 1 q ha ⁻¹ + 50% RDF	0.31	0.14
T ₃	Biodynamic compost 1.5 q ha ⁻¹ + 50% RDF	0.31	0.16
T ₄	T ₂ + Root dipping with Bio dynamic compost wash 10 ml lit ⁻¹ of water	0.33	0.17
T ₅	T ₃ + Root dipping with Bio dynamic wash 10 ml lit ⁻¹ of water	0.35	0.19
T ₆	T ₂ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	0.33	0.17
T ₇	T ₃ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	0.36	0.19
T ₈	100% RDF	0.32	0.16
SEm±		0.005	0.002
C.Dat 5%		0.016	0.006

Potassium content in grain (%)

The analysis of data pertaining to potassium content in grains, as presented in Table 4, highlights the influence of various treatment combinations. The maximum potassium

content in grains (1.28%) was observed with treatment T₇ (T₃ + foliar application of 10 ml lit⁻¹ Bio-dynamic compost wash), significantly surpassing T₁ (control) and statistically comparable to T₅ (T₃ + Root dipping with Bio-dynamic wash 10 ml lit⁻¹ of water) and T₆ (Bio-dynamic compost 2 q ha⁻¹ + 50% RDF). Conversely, the minimum potassium content in grains (1.15%) was noted in treatment T₁ (Control). These findings are not in accordance with the results reported by **Mohapatra *et al.* (2008)**.

Potassium content in straw(%):

The analysis of data regarding potassium content in straw, as presented in Table 4, reveals the impact of various treatment combinations varied in different treatments. The maximum potassium content in straw (0.19%) was observed with treatment T₇ (T₃ + foliar application of 10 ml lit⁻¹ Bio-dynamic compost wash), significantly surpassing T₁ (control) and T₅ (T₃ + Root dipping with Bio-dynamic wash 10 ml lit⁻¹ of water), and statistically comparable to T₆ (Bio-dynamic compost 2 q ha⁻¹ + 50% RDF). In contrast, the minimum potassium content in straw (0.15%) was noted in treatment T₁ (Control). These findings are inconsistent with the results reported by **Kumari *et al.* (2013)**.

Table-4: Effect of Bio Dynamic Compost and Bio Dynamic Compost wash on uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) in grain and straw of rice.

S.No.	Treatment combination	K content in grain (%)	K content in straw (%)
T ₁	Control	0.61	1.15
T ₂	Bio dynamic compost 1 qha ⁻¹ + 50% RDF	0.63	1.18
T ₃	Bio dynamic compost 1.5 qha ⁻¹ + 50% RDF	0.64	1.18
T ₄	T ₂ + Root dipping with Bio dynamic compost wash 10 ml lit ⁻¹ of water	0.68	1.21
T ₅	T ₃ + Root dipping with Bio dynamic wash 10 ml lit ⁻¹ of water	0.79	1.27
T ₆	T ₂ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	0.71	1.23
T ₇	T ₃ + foliar application of Bio dynamic compost wash of 10 ml lit ⁻¹ of water	0.78	1.28
T ₈	100% RDF	0.66	1.20
SEm\pm		0.009	0.016
C.Dat 5%		0.029	0.049

Effect of Bio Dynamic Compost and Bio Dynamic Compost wash on available nitrogen uptake (kg/ha):

The nitrogen uptake in rice grains exhibited a range from 44.32 kg/ha to 77.03 kg/ha, as indicated in Table 4. The highest nitrogen uptake in rice grains was observed in treatment "T₇" (77.03 kg/ha), statistically comparable to T₅ (74.41 kg/ha). Conversely, the lowest nitrogen uptake in rice grains was recorded in the control plot "T₁" (44.32 kg/ha). In the case of rice straw, nitrogen uptake ranged from 20.16 kg/ha to 36 kg/ha. The highest nitrogen uptake in rice straw occurred in T₇ (35.36 kg/ha), statistically at

par with T₅ (37.6 kg/ha), while the lowest nitrogen uptake was observed in the control plot "T₁" (20.16 kg/ha).

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)**.

Moreover, the integration of various organic manures not only improved nutrient content but also facilitated early nutrient availability, enhancing microbial activity. This microbial activity led to the release of organic acids, promoting the solubilization of native soil nutrients, making them available for plant uptake.

Evaluation of Bio Dynamic Compost and Bio Dynamic wash on available phosphorus on phosphorus uptake (kg ha⁻¹):

The phosphorus uptake in rice grains displayed a range from 11.90 kg/ha to 20.85 kg/ha, as presented in the table. The highest phosphorus uptake in rice grains was observed in treatment T₇ (20.85 kg/ha), statistically comparable to T₅ (20.60 kg/ha), while the lowest phosphorus uptake occurred in the control plot T₁ (11.90 kg/ha). In the case of rice straw, phosphorus uptake varied from 8.17 kg/ha to 15.62 kg/ha. The highest phosphorus uptake in rice straw was recorded in T₇ (15.77 kg/ha), statistically at par with T₅ (15.53 kg/ha), and the lowest phosphorus uptake was found in the control plot T₁ (8.17 kg/ha).

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. These results align with the findings of **Mohapatra *et al.* (2008)**. Additionally, the application of bio-fertilizers further facilitates the increased availability of nitrogen and phosphorus in the soil, enhancing their uptake by plants.

Effect of Bio Dynamic Compost and Bio Dynamic Compost wash on available potassium on potassium uptake(kg/ha):

The organic potassium uptake in rice grains exhibited a range from 22.16 kg ha⁻¹ to 45.17 kg ha⁻¹, as outlined in Table 4. The highest potassium uptake in rice grains was observed in treatment T₇ (45.17 kg/ha), statistically comparable to T₅ (44.41 kg/ha), while the lowest potassium uptake occurred in the control plot T₁ (22.16 kg/ha). In the case of rice straw, potassium uptake ranged from 66.67 kg/ha to 100.55 kg/ha. The highest potassium uptake in rice straw was found in T₇ (100.55 kg/ha), statistically at par with T₅, and the lowest potassium uptake was recorded in the control plot T₁ (66.67 kg/ha).

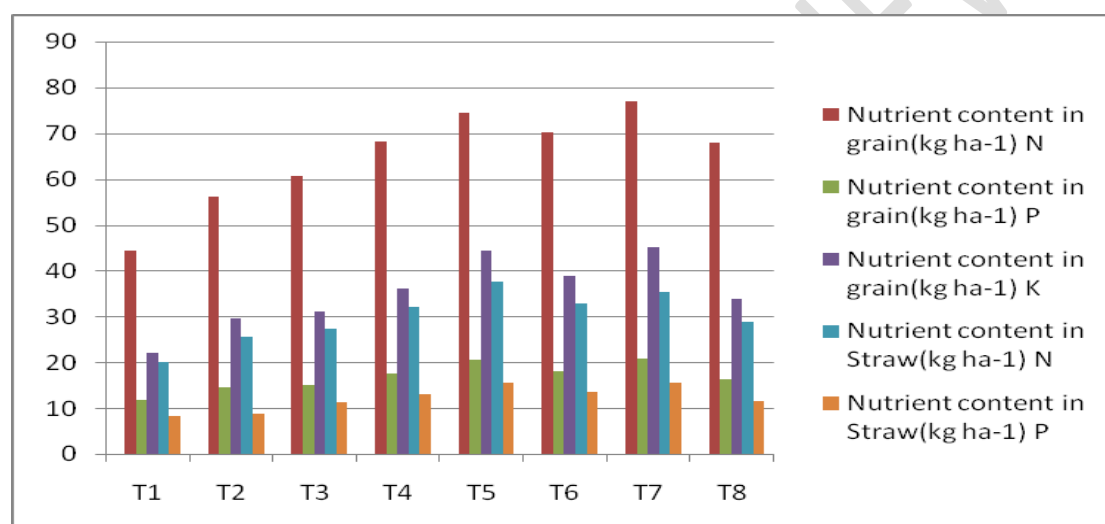


Fig: 1 Effect of Bio Dynamic Compost and Bio Dynamic Compost wash on uptake of nitrogen, phosphorus and potassium (kg ha⁻¹) in grain and straw of rice.

The increased uptake of potassium in both grain and straw may be attributed to the application of organic nitrogen sources, which released more NH₄⁺ and NO₃⁻ in the soil. This, in turn, occupied the selective exchange sites in the 2:1 layer clay minerals, replacing the K⁺ 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. In comparison, 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.

Conclusion: In conclusion, the study underscores the significant positive impact of organic manure application, particularly in treatment T₇, 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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