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Impact of Different Nutrient Sources on Yield, Nutrient Content and Uptake of Rice (*Oryza sativa* L.) in Organic Agriculture

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ABSTRACT

A field experiment was conducted to study aimed to investigate the impact of different organic nutrient sources on rice var. GNR-7 at the Organic Farm, ASPEE College of Horticulture, Navsari Agricultural University, Navsari, Gujarat, during the Kharif season of 2021. The experiment was laid out in Randomized Block Design with a Factorial concept, consisting of two levels viz., soil application and foliar application. Total of 12 treatments i.e. S_1, 100% RDN through NADEP compost, S_2, 80% RDN through NADEP compost along with Azospirillium and PSB @ 2 l/ha each, S_3, 60% RDN through NADEP compost along with Azospirillium and PSB @ 2 l/ha each and S_4, Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha, and that of foliar application was, F_0, control, F_1, Novel Organic liquid nutrient @ 1% and F_2, Moringa leaf extract @ 3%. The application of foliar spray was done thrice at 15, 30 and 45 days after sowing was replicated thrice. The result revealed that the mean data of nutrient content in rice grain and straw did not significantly change due to soil and foliar application of different organic nutrient sources. The total NPK uptake was recorded as significantly the highest with the S_1 treatment, and was statistically similar to the treatment S_2. The foliar application of treatment F_2 recorded significantly the highest total NPK uptake by crop, but was statistically similar to treatment F_1.

So, it can be concluded that providing 100 percent RDN through NADEP compost in the soil and along with the application of 3 percent Moringa leaf extract or 1 percent Novel organic liquid nutrients on days 15, 30, and 45 post-planting on leaves, resulted in significantly higher grain yield, and total nutrient uptake of N, P, and K compared to treatments involving Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha on soil, and the control.

Keywords: *Biofertilizer; NADEP compost; Ghan-jivamrut; jivamrut; novel organic liquid nutrient; moringa leaf extract; rice; organic agriculture.*

INTRODUCTION

In recent years, organic farming has been increasingly recognized for its inherent advantages in sustaining crop production, maintaining dynamic soil nutrient status, and ensuring a safe environment. Rice (*Oryza sativa* L.) is the primary food source for about half of the world's population and one of Asia's most significant food crops. Rice is consumed by more than half of the world's population. It has a significant impact on diet, economy, employment, culture, and history. Rice is a staple food for almost 65 percent of India's population. Rice demand is likely to outpace output in most nations. Global rice demand is expected to be 700 million tonnes in 2025, but the present production is only 545 million tonnes [1]. Asia is known as the world's "rice bowl," producing and consuming more than 90% of the world's rice. It is the world's most important food crop. After China, India is the world's second-largest producer of rice. India's current rice acreage is 46 million hectares, with an output of 135.52 million tonnes and average productivity of 3021.14 kg/ha in 2022-2023 [2].

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The adoption of green revolution technology to meet escalating food grain demands has resulted in excessive reliance on chemical fertilizers, causing degradation of soil quality. Organic farming emerges as a solution to this issue, emphasizing greater utilization of on-farm inputs while eschewing the use of chemical fertilizers, insecticides, pesticides, and similar synthetic substances. Composting stands out as a highly effective and beneficial component of organic farming, serving as a form of biological recycling where waste is transformed into valuable organic manure. The NADEP composting method produces high-quality black or brown compost, abundant in essential plant nutrients, and with the added benefit of retaining soil moisture efficiently [3]. Additionally, organic manures derived from cow-based products such as jivamrut, bijamrut, and panchgavya offer excellent alternatives to chemical fertilizers, further promoting sustainable agricultural practices [4]. Biofertilizers, comprising efficient strains of beneficial microorganisms, play a vital role in accelerating microbial processes to enhance nutrient availability in forms readily assimilable by plants [5]. Researchers are increasingly focusing on utilizing *Moringa leaf extract* as a bio-stimulant for foliar spray, despite its current lack of popularity, due to its easy availability and simple preparation methods for farmers [6]. *Moringa oleifera*, also known as the drumstick tree, offers leaves rich in fiber, protein, carbohydrates, essential amino acids, minerals, and vitamins, making it nutritionally and medicinally valuable.

Notably, fresh Moringa oleifera leaves contain zeatin, a cytokinin-related hormone, which has been demonstrated to enhance crop growth and yield, highlighting its potential as a beneficial agricultural input [7]. Enriched banana pseudo-stem sap is derived from the liquid obtained during the extraction of fibers from the banana pseudo-stem. This sap is rich in macro-elements, containing approximately 1% to 1.12% nitrogen (N), 0.50% to 0.71% phosphorus (P), and 2.39% to 20.2% potassium (K), as well as various essential micronutrients such as iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu), ranging from 259 to 323.2 mg/kg Fe, 47.3 to 241.3 mg/kg Mn, 10.1 to 107.4 mg/kg Zn, and 13.4 to 83.6 mg/kg Cu [8]. The foliar application of this sap is known to stimulate crop growth, provide protection against harmful pests, and enhance overall crop yield [9]. Recognizing its potential, a patented product called "NOVEL-Liquid Organic Nutrient" has been developed by the Banana Pseudo-stem Processing Unit at Navsari Agricultural University, Navsari, Gujarat.

MATERIALS AND METHODS

The field experiment carried out at the Organic Farm of ASPEE College of Horticulture, Navsari Agricultural University, Navsari during the *kharif* season of 2021 on rice var. GNR-7.

The experiment was laid out in a Randomized Block Design with a Factorial concept (FRBD), with two factors *viz*., soil application and foliar application, and replicated thrice. The fourth levels of soil application included: S_1: 100% RDN through NADEP compost, S_2: 80% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each S_3: 60% RDN through NADEP compost along with *Azospirillium* and PSB @ 2 l/ha each and S_4: Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha and that of foliar application was, F_0: Control, F_1: Novel organic liquid nutrient @ 1% and F_2: *Moringa leaf extract* @ 3%. Foliar spraying was carried out thrice at 15, 30, and 45 days after sowing. Twenty-one days old seedlings were transplanted at the spacing of 20 cm row -to- row and 15 cm plant-to-plant distance. Two to three seedlings per hill were transplanted. The experimental field's soil had a clayey texture (57.20%) with high organic carbon content (0.77%) and medium levels of available K_2O (495.52 kg/ha), available N (266.8 kg/ha), and available P_2O_5 (60.52 kg/ha). Favorable weather conditions prevailed throughout the cropping period, facilitating optimal crop growth and development. The nutrient content of various organic sources utilized during the experiment is presented below in Table 1.

Table 1. The chemical composition of different organic sources

Sr. No.	Parameters	Liquid/ Solid organic sources				
		NADEP compost (%)	Ghan-jivamrut (%)	Jivamrut (%)	Novel organic liquid nutrient (%)	*Moringa leaf extract* (%)
1.	N	1.17	0.95	0.09	0.062	0.95
2.	P	0.95	0.40	0.02	0.018	0.29
3.	K	1.32	1.11	0.12	0.180	0.90

Table 2. Different methods adopted for the analysis of plant samples

Sr. No.	Parameters	Methods of analysis	Reference
1.	Nitrogen (N)	Kjeldahl's Methods	[10]
2.	Phosphorus	Spectrophotometric Method	[10]
3.	Potassium (K)	Flame Photometric Method	[10]

2.1 Chemical Analysis of Plant Sample

The plant samples were collected after harvest of the crop and oven dried at 60º C for 24 hrs. separately for grains and straw. After oven drying, these were ground with the help of a mechanical grinder with a stainless blade and were sieved using a 2 mm sieve. Later, these samples were employed for analyzing the content of nitrogen (N), phosphorus (P), and potassium (K) utilizing the standard methods shown in Table 2. While the nutrient uptake was calculated using the formula.

2.1.1 Nutrient content (%)

The nutrient content analysis of both grain and straw was conducted using the collected samples, employing various standard methods shown in Table 2. Plant samples underwent digestion using concentrated H_2SO_4 for nitrogen analysis, and diacid was utilized for analyzing phosphorus and potassium content.

2.1.1 Nutrient uptake (kg/ha)

The uptake of nitrogen (N), phosphorus (P), and potassium (K) nutrients by both grain and straw was determined by calculating the individual nutrient concentration in conjunction with the dry matter yield of grain and straw.

The nutrient uptake (N, P, and K) by plants was calculated using the following formula;

Nutrient Uptake (kg/ha) = (Nutrient content (%) × Dry matter yield of grain/straw (kg/ha) / 100

3. RESULTS AND DISCUSSION

3.1 Effect of Different Treatments on Yield and Harvest Index of Rice

3.1.1 Grain yield

The grain yield was determined based on the yield obtained from the net plot (kg/plot) and subsequently subjected to statistical analysis. The resulting findings have been presented in Table 3. Upon examining the analyzed data, a significant result emerged regarding the grain yield, indicating a positive impact from the soil application of organic nutrient sources. The S_1 (100% RDN through NADEP compost) treatment recorded a significantly higher grain yield of 3749 kg/ha and it remained at par with the S_2 (80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each) treatment which recorded 3538 kg/ha grain yield. The result revealed that the foliar application of *Moringa leaf extract* @ 3 per cent *viz*., F_2 treatment recorded a significantly higher grain yield of 3312 kg/ha but was statistically similar with F_1 treatment where, Novel organic liquid nutrient @ 1 per cent was sprayed and it recorded 3257 kg/ha grain yield. The F_0 treatment, which served as the control with no spray applied, recorded the lowest grain yield at 2959 kg/ha. The reason for the higher grain yield attributed to *Moringa leaf extract* may be attributed to its ability to enhance the loading and unloading of assimilates across membrane boundaries within vascular tissues, thereby increasing yield. Additionally, the cytokinin'-s present in MLE promote carbohydrate metabolism and establish new source-sink relationships, consequently resulting in an increased crop yield. The statistical analysis revealed that the interaction effect of soil and foliar application on grain yield was not significant, indicating no variation in grain yield due to the interaction effect. This finding was noted in previous experiments conducted by Sahara and Mahanpatra [11] on rice, Ghube *et al*. [12] on organic rice, Jhilik *et al*. [13] on wheat, and Biswas *et al*. [14] on maize which closely correspond with the results of the present research.

3.1.2 Straw yield

The straw yield from the net plot was recorded at the time of harvest and subsequently converted to obtain the straw yield on a hectare basis. The specifics regarding the straw yield of rice have been presented in Table 3. Based on the results obtained, it was concluded that the straw yield was significantly influenced by the soil application of organic nutrient sources. The S_2 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each significantly recorded the highest straw yield *i.e*. 5442 kg/ha. While the S_4 treatment where Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha was applied recorded the lowest straw yield of 4329 kg/ha. The foliar spray of 3 per cent *Moringa leaf extract* (F_2 treatment) resulted in significantly higher straw yield (5265 kg/ha) and was statistically similar to the foliar spray of 1 per cent Novel organic liquid nutrient (F_1 treatment) which recorded 5117 kg/ha straw yield. While the F_0 treatment as control where no foliar application was given recorded the lowest grain yield *i.e*. 4605 kg/ha (Table 2). The statistically non-significant result was obtained for the straw yield due to the interaction effect between the soil and foliar application of various nutrient organic sources. The findings of the present research work were closely related to previous experiment results observed by Parmar *et al*. [15] on maize, Abusuwar and Abohassan [16] on cereals forages, and Safiullah *et al*. [17] in sweet corn.

3.1.3 Harvest index

The harvest index was calculated based on the grain yield and biological yield, and subsequently subjected to statistical analysis depicted in Table 3. The results revealed that the application of S_1 100% RDN through NADEP compost significantly recorded the highest harvest index at 40.9%, followed by S_2 and S_3 treatments at 39.4% and 37.9%, respectively. The foliar application of different treatments did not show a significant difference in the resulting harvest index. The F_0 treatment (Control) showed the highest numerical harvest index of 39.1%, compared to the F_1 treatment and F_2 treatment, which recorded harvest indices of 38.7% and 38.5%, respectively. The analysis revealed that the harvest index was not significantly affected by the interaction between soil and foliar application of various organic nutrient sources, with the obtained result being statistically non-significant.

3.2 Effect of Different Treatments on Nutrient Content in Grain and Straw of rice

3.2.1 Nutrient Content in Grain

The analysis of nutrient content, nitrogen (N), phosphorus (P), and potassium (K) percentages in rice grains was conducted using various methods. The results obtained from this analysis have been presented in Table 4. The soil application and foliar application of different organic nutrient sources sprayed thrice at 15, 30 and 45 DAS failed to affect, the NPK content of rice grain, and the resultant data were statistically non- significant.

The nitrogen content in grain was numerically recorded the highest for the S_1 treatment (100% RDN through NADEP compost) followed by S_2 (80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each) and S_3 (60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each) containing 1.261, 1.232 and 1.224 percent nitrogen content in grain respectively. The mean data collected for phosphorus content in grains revealed no significant variation, as indicated by the statistically non-significant results. Numerically, the highest phosphorus content in grains, at 0.535 percent, was observed in the S_2 treatment, while the lowest, at 0.514 percent, was recorded for the S_1 treatment. The application of organic soil sources did not result in significant differences in the potassium content observed in the grains. The result concluded that numerically, the highest potassium content in grains, at 0.259 percent, was observed in the S_2 treatment, while the lowest, at 0.248 percent, was recorded for the S_4 treatment.

On statistical analysis, the nitrogen content in rice grains had a non-significant result. Numerically, the highest nitrogen content value, 1.264 percent, was observed for the F_1 treatment, while the lowest value, 1.199 percent, was recorded for the F_0 treatment. Regarding the phosphorus content in grains, the obtained result was statistically non-significant. It can be inferred that numerically, the F_0 treatment, has the highest phosphorus content at 0.530 percent, followed by the F_1 treatment (Novel organic liquid nutrient 1%) with 0.520 percent phosphorus content. The estimated potassium content indicated no variation resulting from the foliar application of various organic nutrient sources. Numerically, the highest potassium content, at 0.256 percent, was recorded for the F_2 treatment, while the F_0 treatment exhibited the lowest potassium content in rice grains, at 0.254 percent. Upon analyzing data, it was revealed that the interaction effect between soil and foliar application of various organic nutrient sources resulted in a non-significant effect on the major nutrients *viz* nitrogen, phosphorus, and potassium content in rice grains.

3.2.2 Nutrient Content in Straw

The data regarding the estimated nutrient content in the straw of rice, presented in Table 4, indicated that soil application of organic nutrient sources did not influence the major nutrient content, as no variation was observed among them. Numerically the obtained mean data for the nitrogen content in straw, concluded that the application of 100 per cent RDN through NADEP compost (S_1 treatment) recorded the highest 0.656 per cent N content in straw. The application of Ghan- jivamrut @ 500 kg/ha + jivamrut @ 500 l/ha (S_4 treatment) resulted in the lowest 0.646 per cent nitrogen content in the straw of rice however, the combined application of Ghan-jivamrut @ 500 kg/ha + Jivamrut 500 l/ha (S4) recorded better results, 0.639 per cent nitrogen content in comparison to S_2 treatment. Numerically, the highest phosphorus content in the straw of rice was obtained in the S_2 treatment, followed by the S_3 and S_1 treatments, with values of 0.251%, 0.249%, and 0.240%, respectively. The potassium content in the straw showed no variation due to soil application of nutrient sources. Numerically, the highest potassium content of 1.229 percent was observed in the S_2 treatment, while the S_1 treatment exhibited the lowest potassium content of 1.200 percent in the straw of rice. The foliar spray of nutrient sources applied at 15, 30, and 45 days after sowing (DAS) did not significantly influence the NPK content in the straw of rice.

Numerically, the highest nitrogen content value in the straw, 0.650%, 0.650%, was obtained in the F_2 treatment where 3 percent *Moringa leaf extract* was applied and F_0 control. The data evaluated for phosphorus content in the straw did not exhibit significant variation and was statistically non-significant. However, numerically, the F_1, and F_2 treatments noted the highest phosphorus content at 0.245%, 0.245% while the F_0 treatment recorded the lowest phosphorus content at 0.243% in the straw of rice. Upon reviewing the data concerning potassium content in the straw of rice, it was observed that foliar spray did not influence the potassium content. Numerically, the potassium content was higher for the F_1 treatment at 1.237 percent, followed by the F_0 treatment with 1.206 percent K, and lastly, the F_2 treatment with 1.205 percent potassium content in the straw of rice. Upon statistical assessment of the data regarding the major nutrient content in straw, it was observed that the interaction effect of soil and foliar application of organic sources did not result in significant differences in the NPK content in the straw of rice, as the obtained results were statistically non-significant.

3.3 Effect of Different Treatments on Grain, Straw, and Total Nutrient Uptake by Rice Plant

3.3.1 Nutrient uptake by grain

The details regarding the N uptake, P uptake and K uptake have been presented in Table 5. A
significant difference was noticed due to the effect of soil application of different treatments on the nitrogen, phosphorus and potassium uptake by the grains. The data about nitrogen uptake by the grains was found to be statistically significant. The S_1 treatment, where 100 percent RDN was applied through NADEP compost, recorded a significantly higher nitrogen uptake of 41.4 kg/ha. This was comparable to the S_2 treatment, where 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each resulted in a nitrogen uptake of 37.1 kg/ha. In contrast, the S_4 treatment, where Ghan-jivamrut at 500 kg/ha + jivamrut at 500 l/ha was used, exhibited the lowest nitrogen uptake by grains at 25.4 kg/ha. The data about phosphorus uptake by the grain was found to be statistically significant due to soil application of different organic sources. The results obtained for the S_1 treatment, recorded a significantly higher phosphorus uptake of 16.9 kg/ha followed by the S_2 treatment of 16.1 kg/ha. While S_4 treatment, obtained the lowest phosphorus uptake of 11.2 kg/ha. The results obtained for the potassium uptake by grains revealed that found to be statistically significant due to soil application of different organic sources. The S_1 treatment, recorded a significantly higher potassium uptake of 8.5 kg/ha followed by the S_2 treatment of 7.8 kg/ha. While S_4 treatment, obtained the lowest potassium uptake of 5.3 kg/ha. On the assessment of NPK uptake by grains it was noticed that the foliar spray of liquid organic nutrient given at 15, 30, and 45 DAS significantly influenced the nutrient uptake. The results for nitrogen uptake by grains indicated that the F_2 treatment (*Moringa* leaf extract@ 3%) exhibited a significantly higher uptake of 34.9 kg/ha N, which was statistically similar to the F_1 treatment (Novel Organic liquid nutrient @ 1%) with a recorded uptake of 34.3 kg/ha N by grains of rice. Conversely, the F_0 treatment displayed the lowest uptake of nitrogen by grains at 30.4 kg/ha. The mean data for phosphorus uptake by grains revealed a significantly higher uptake of 14.8 kg/ha P in the F_2 treatment (*Moringa leaf extract* @ 3%), which was statistically similar to the F_1 treatment (Novel organic liquid nutrient @ 1%), recording a phosphorus uptake of 14.1 kg/ha by the grains. While, the control treatment exhibited the lowest phosphorus uptake by grains at 13.3 kg/ha. The current data on the influence of foliar spray on potassium uptake by grains concluded that the F_2 treatment exhibited a significantly higher K uptake of 7.3 kg/ha, which was statistically comparable to the K uptake of 6.9 kg/ha recorded in the F_1 treatment. The lowest uptake of potassium, at 6.4 kg/ha, was observed in the F_0 treatment, where no spray was applied. The higher nutrient uptake observed in plants treated with 3% *Moringa leaf extract* is attributed to its function as a plant bio-stimulant, containing essential macronutrients and micronutrients. Additionally, *Moringa leaf extract* is rich in phytohormones such as Indole-3-Acetic Acid (IAA), gibberellins (GAs), and zeatin, which act as cytokinins, further enhancing plant growth and nutrient absorption. The interaction between the soil and foliar application of organic sources did not show a significant difference in the N uptake by the grains of rice. The interaction between the soil and foliar application was found significant difference in phosphorus, and potassium uptake by grains of rice. The combined application of S_1F_2 i.e., 100% RDN through NADEP compost + *Moringa leaf extract* 3% significantly higher P uptake of 19.3 kg/ha and K uptake of 10.0 kg/ha by grains of rice. The findings of the present research work were found to be closely related to the results reported by Jondhale *et al.* [18[on rice and Somasundaram *et al*. (19) on maize.

3.3.2 Nutrient uptake by straw

The current data regarding the major nutrient uptake by the straw of rice is presented in Table 5. Significant variations were observed in the major nutrient uptake due to the influence of soil application of organic manure, and upon statistical analysis, the results were found to be statistically significant. The mean data concerning nitrogen uptake by the straw revealed that the S_1 treatment (100 % RDN through NADEP compost) recorded a significantly higher nitrogen uptake of 25.5 kg/ha, which was statistically similar to the S_2 treatment (80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each) with a recorded nitrogen uptake of 23.2 kg/ha. In contrast, the S_4 treatment (Ghan-jivamrut @ 500 kg/ha + jivamrut 500 l/ha) exhibited the lowest nitrogen uptake by the straw, at 19.7 kg/ha. The analyzed data on phosphorus uptake by straw showed that the application of 100% RDN through NADEP compost (S_1 treatment) resulted in a significantly higher phosphorus uptake of 9.3 kg/ha. This was statistically comparable to the phosphorus uptake of 9.1 kg/ha recorded in the S_2 treatment. Conversely, the S_4 treatment exhibited the lowest phosphorus uptake by straw, at 7.3 kg/ha. The application of various organic nutrient sources to the soil significantly affected the potassium uptake by the straw. It was observed that the S_1 treatment recorded a significantly higher potassium uptake of 46.8 kg/ha, which was statistically comparable to the potassium uptake of 44.5 kg/ha noted in the S_2 treatment. Looking at the analyzed results, the nutrient uptake by straw was significantly influenced by the foliar spray of different liquid organic sources applied at 15, 30 and 45 days after sowing. An evaluation of nitrogen uptake data revealed that the highest uptake of nitrogen, at 24.1 kg/ha, was significantly observed in the F_2 treatment, where 3% *Moringa leaf extract* was sprayed. In contrast, the F_0 treatment (control) exhibited the lowest nitrogen uptake, at 21.1 kg/ha. The F_1 treatment, involving the application of Novel organic liquid nutrient at 1%, demonstrated a better nitrogen uptake of 22.4 kg/ha by the straw. The F_2 treatment exhibited the highest phosphorus uptake by straw, significantly recording 9.1 kg/ha.

In comparison, the F_1 treatment showed a phosphorus uptake of 8.6 kg/ha. While, the lowest phosphorus uptake of 7.9 kg/ha was observed in the F_0 treatment. Upon assessing the potassium uptake by the straw, it was observed that the F_2 treatment (*Moringa leaf extract* @ 3%) significantly exhibited the highest potassium uptake, recording 44.5 kg/ha. The F_1 treatment (Novel organic liquid nutrient @ 1%) showed a potassium uptake of 43.4 kg/ha, which was superior to that of the control. The interaction between soil and foliar application of the various nutrient organic sources did not significantly influence the major nutrient uptake by straw. The utilization of bio-stimulants such as *Moringa leaf extract* through foliar feeding represents a complementary technique capable of augmenting crop growth, enhancing yield, and mitigating the adverse impacts of abiotic stress throughout crop development. Foliar feeding entails the application of liquid fertilizer directly onto the leaves, in contrast to soil application methods. Their epidermis and stomata efficiently absorb the potassium, phosphorus, and nitrogen nutrients from liquid fertilizer to support plant growth [16]. Similar results were reported by Davari *et al*. [20] on wheat and Yadav *et al*. [21] on rice, aligning with the findings of the present research.

3.3.3 Total NPK uptake by plants of rice

The total nutrient uptake, calculated from the combined nutrient uptake by grains and straw, is presented in Table 5. A significant influence of soil application of organic nutrient sources on the total nutrient uptake was observed, resulting in considerable variation among the treatments. The mean data for total nitrogen uptake indicated that the S_1 treatment significantly recorded the highest total nitrogen uptake at 67.0 kg/ha. While, the lowest total nitrogen uptake of 45.2 kg/ha was observed in the S_4 treatment. The S_1 treatment, where 100% RDN was applied through NADEP compost, significantly recorded the highest total phosphorus uptake at 26.2 kg/ha. Conversely, the lowest total phosphorus uptake (18.5 kg/ha) was observed in the S_4 treatment. Upon perusing the data for total potassium uptake, a significantly higher total K uptake of 55.2 kg/ha was observed for the S_1 treatment. This finding was statistically similar to the total K uptake of 52.3 kg/ha noted in the S_2 treatment. Conversely, the S_4 treatment exhibited the lowest total K uptake of 42.6 kg/ha by rice. The prevailing data of total nutrient uptake by rice was significantly influenced by the foliar spray of different liquid nutrient sources applied thrice *i.e*. at 15 DAS, 30 DAS and 45 DAS. The F_2 treatment, involving *Moringa leaf extract* at 3%, significantly recorded the highest total nutrient uptake for rice, with total N uptake, total P uptake, and total K uptake of 58.9 kg/ha, 23.9 kg/ha, and 51.8 kg/ha, respectively. In contrast, the lowest total nutrient uptake by rice, including total N uptake (51.5 kg/ha), total P uptake (21.2 kg/ha), and total K uptake (45.7 kg/ha), was observed for the F_0 treatment (control), where no spray was given. The F_1 treatment where 1 per cent Novel organic liquid nutrient was sprayed recorded better results in comparison to the control *i.e*. total N uptake (56.7 kg/ha), total P uptake (22.7 kg/ha), and total K uptake (50.3 kg/ha). The statistically non-significant results were obtained for the total nitrogen, and potassium uptake by rice as it was not influenced by the interaction effect of the soil and foliar application of different organic nutrient sources. The statistically significant result was obtained for the interaction effect of soil and foliar application (S_1F_2 *i.e*., 100% RDN through NADEP compost + *Moringa leaf extract* 3%) on total phosphorus uptake by rice at 30.1 kg/ha. The significant results observed for the NPK uptake by grains and straw may be attributed to the calculation of these parameters based on their respective yield and nutrient content. These findings align with previous experiments reported by Shwetha [22] on soybean-wheat cropping systems.

From the conducted experiment, it can be inferred that providing 100% RDN through NADEP compost in the soil, along with foliar application of 3% *Moringa leaf extract* or 1% Novel organic liquid nutrients on days 15, 30, and 45 after planting, resulted in significantly higher grain yield, straw yield, and total uptake of N, P, and K compared to treatments involving Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha, and control.

Table 3: Effect of different treatments on grain yield, straw yield and harvest index of Rice

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Factor I: Soil application (S)			
S_1 - 100% RDN through NADEP compost	3749	5437	40.9
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	3538	5442	39.4
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	2908	4774	37.9
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	2511	4329	36.8
SEm±	96	149	0.9
CD at 5%	281	437	2.8
Factor II: Foliar application (F)			
F_0 – Control	2959	4605	39.1
F_1 - Novel Organic liquid nutrient @ 1%	3257	5117	38.7
F_2 - *Moringa* leaf extract@ 3%	3312	5265	38.5
SEm±	83	129	0.8
CD at 5%	243	378	NS
Interaction			
S×F	NS	NS	NS
CV (%)	9.0	8.9	7.1

Table 4: Effect of different treatments on N, P and K content in grain and straw of rice

Treatments	NPK content in grain (%)			NPK content in straw (%)		
Factor I: Soil application (S)	**N**	**P**	**K**	**N**	**P**	**K**
S_1 - 100% RDN through NADEP compost	1.261	0.514	0.258	0.656	0.240	1.200
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	1.232	0.535	0.259	0.639	0.251	1.229
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	1.224	0.517	0.255	0.642	0.249	1.212
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	1.189	0.527	0.248	0.646	0.238	1.222
SEm±	0.023	0.007	0.005	0.007	0.005	0.019
CD at 5%	NS	NS	NS	NS	NS	NS
Factor II: Foliar application (F)						
F_0 – Control	1.199	0.530	0.254	0.650	0.243	1.206
F_1 - Novel Organic liquid nutrient @ 1%	1.264	0.520	0.255	0.637	0.245	1.237
F_2 - *Moringa* leaf extract @ 3%	1.217	0.519	0.256	0.650	0.245	1.205
SEm±	0.020	0.006	0.004	0.006	0.004	0.016
CD at 5%	NS	NS	NS	NS	NS	NS
Interaction						
S×F	NS	NS	NS	NS	NS	NS
CV (%)	5.59	3.98	5.48	3.29	6.08	4.60

Table 5. Effect of different treatments on N, P and K uptake by grain, straw and total uptake by rice

Treatments	NPK uptake by grain (kg/ha)			NPK uptake by straw (kg/ha)			Total NPK uptake (kg/ha)		
	N	P	K	N	P	K	N	P	K
Factor I: Soil application (S)									
S_1 - 100% RDN through NADEP Compost	41.4	16.9	8.5	25.5	9.3	46.8	67.0	26.2	55.2
S_2 - 80% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	37.1	16.1	7.8	23.2	9.1	44.5	60.3	25.1	52.3
S_3 - 60% RDN through NADEP compost along with *Azospirillum* and PSB @ 2 l/ha each	28.8	12.2	6.0	21.6	8.4	40.9	50.5	20.5	47.0
S_4 - Ghan-jivamrut @ 500 kg/ha + Jivamrut @ 500 l/ha	25.4	11.2	5.3	19.7	7.3	37.3	45.2	18.5	42.6
SEm±	1.3	0.4	0.3	0.8	0.3	1.4	1.5	0.6	1.4
CD at 5%	3.9	1.2	0.8	2.1	0.9	4.0	4.5	1.7	4.2
Factor II: Foliar application (F)									
F_0 – Control	30.4	13.3	6.4	21.1	7.9	39.3	51.5	21.2	45.7
F_1 - Novel Organic liquid nutrient @ 1%	34.3	14.1	6.9	22.4	8.6	43.4	56.7	22.7	50.3
F_2 - *Moringa* leaf extract @ 3%	34.9	14.8	7.3	24.1	9.1	44.5	58.9	23.9	51.8
SEm±	1.1	0.3	0.2	0.6	0.2	1.2	1.3	0.5	1.2
CD at 5%	3.4	1.1	0.7	1.8	0.8	3.5	3.9	1.4	3.6
Interaction									
S×F	NS	Sig.	Sig.	NS	NS	NS	NS	Sig.	NS
CV (%)	12.1	8.9	11.7	9.5	10.5	9.7	8.2	7.5	8.7

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