**Impact of various Integrated Nutrient Modules on Rice (*Oryza sativa* L) varieties: Crop Productivity, Nutrient Uptake and Profitability under SRI method**

**ABSTRACT**

In order to assess the rice (*Oryza sativa* L) varieties for crop productivity, nutrient uptake, and profitability at various integrated nutrient modules in the SRI method, the current study was conducted during the 2017 (Kharif) season at the Agronomy Research Farm of Narendra Deva University of Agriculture & Technology, Ayodhya (Uttar Pradesh). The treatment combinations consist of three prominent rice varieties (M1- NDR-97, M2- Sarjoo-52, and M3- Mahsuri) as primary treatments, alongside three distinct nutrient levels (N1- 100% RDF, N2- 75% RDF + 25% FYM, and N3- 75% RDF + 25% Vermicompost) as subplot treatments. These were arranged in a Split Plot design and replicated four times. The findings demonstrated that grain and straw yield (t ha-1) and nutrient content and uptake (NPK) in both grain and straw were highest in the Mahsuri variety, which outperformed the Sarjoo-52 and NDR-92 types. The application of N1-100% RDF resulted in significantly higher crop yields, including grain and straw yield, as well as nutrient content and uptake (NPK) in both grain and straw, compared to the treatments of N2-75% RDF+25% FYM and N3-75% RDF+25% Vermicompost, respectively. The findings also revealed that the highest gross and net returns were observed with Mahsuri using the full recommended dosage of fertilizers. The highest benefit-cost ratio (1.13) was observed in Mahsuri with 100% RDF, followed by Sarjoo-52 with 100% RDF, which demonstrated greater profitability than the other treatment combinations evaluated during the study. Consequently, it can be inferred that the use of 100% RDF in conjunction with the Mahsuri variety is the most effective treatment combination for enhancing crop production, nutrient absorption, and profitability of rice cultivation.

**Key words:** Rice,Crop Productivity, Nutrient Uptake and Profitability.

**INTRODUCTION**

Rice (paddy) is a fundamental food crop that sustains over half of the global population and contributes around 19% of the world's nutritional energy (Singh *et al*., 2023; Singh *et al.,* 2024). Food output must augment by approximately 60% to satisfy world food demand by 2050, as per projections (Tyagi et al., 2020). India generates roughly 152.6 million tonnes from 42.5 million hectares, yielding an average productivity of 3.57 tons per hectare, while China produces 204.3 million tonnes from 30.3 million hectares, achieving an average productivity of 6.73 tons per hectare (Apon et al., 2018: Singh *et al*., 2024). To provide food security in rice-consuming nations globally, rice output must be augmented by 50% in these countries by 2025. The supplementary rice must be cultivated on less area with diminished water, labor, and pesticides to meet the anticipated objective of 771 million tonnes (Mt) by 2030 (Weijabhandara et al., 2011; Shahi *et al*., 2024; Singh *et al*., 2024). To address these issues, rice productivity must be enhanced through the implementation of suitable technologies that can minimize irrigation water usage in conventional rice cultivation, specifically by decreasing water losses at the field level and optimizing the utilization of available water (Chandra *et al*., 2020; Singh O. 2023; Ghazaryan *et al*., 2024). The System of Rice Intensification (SRI) is an innovative approach to enhance the productivity of irrigated rice through the modification of plant, soil, water, and nutrient management, leading to improved soil and plant health, increased root development, and greater abundance and diversity of soil microorganisms (Kumar and Shivay 2004; Weijabhandara *et al*., 2011).

 The paramount challenge confronting Indian farmers is to enhance agricultural output while maintaining soil fertility to achieve greater crop yields, thereby meeting the anticipated food demands of the nation in the coming decades in an economically viable and environmentally sustainable manner. Organic matter in soil significantly influences its qualities, such as water retention and fertility (Murphy, 2015; Singh *et al*., 2024). The principal cause of the deteriorating soil health and sustainability in India's intensive rice-based farming systems is the depletion of soil organic matter (Timsina and Connor, 2001). Soil functions as a nutrient recycling mechanism capable of degrading dangerous pollutants, necessitating the continual incorporation of organic matter to maintain its health. To satisfy the worldwide need of the expanding population, rice output must be significantly enhanced through the prioritization of Integrated Nutrient Management (INM) (Kumar et al., 2021; Singh O. 2023). Integrated nutrient management employs both inorganic fertilizers and organic sources to enhance the availability of nutrients for plants and to improve the physical, chemical, and biological aspects of soil, thereby directly influencing soil fertility (Sannathimmappa *et al*., 2015; Saikanth *et al*., 2023). Over the long term, the integration of chemical fertilizers and organic sources can enhance soil quality and elevate crop output (Kumar *et al*., 2021). The application of chemical fertilizers and organic manures has demonstrated efficacy in reversing the decline in soil health and productivity by rectifying marginal deficiencies in primary and secondary nutrients, fauna, and microflora, along with their advantageous effects on the physical, chemical, and biological properties of soil. An integrated nutrient management system can establish equilibrium between degenerative and regenerative processes within the soil ecosystem (Upadhyay *et al*., 2011). The combined application of manure and inorganic fertilizer facilitated the maintenance of soil fertility, aggregation, moisture retention, and nutrient balance (Tadesse et al., 2013). This combination also promotes the rectification of secondary and micronutrient deficiencies, along with the long-term enhancement of soil quality (Ghosh et al., 2022; Dutta *et al*., 2024). Numerous studies have demonstrated enhanced crop yield and improved rice nutrient absorption when organic manure is combined with inorganic fertilizer.

 The environmental consequences of extensive output, excessive pesticide application, and inundated cultivation conditions include significant water consumption and contamination, a pronounced reliance on electricity, and considerable greenhouse gas emissions (Subash *et al*., 2023). The System of Rice Intensification (SRI) has been extensively advocated for its capacity to provide significant yield enhancements, decrease water use and greenhouse gas emissions, and augment profitability (Gathorne-Hardy *et al*., 2016). The objective of this study was to examine the response of rice (Oryza sativa L.) regarding crop productivity, nutrient uptake, and economic returns across several integrated nutrition modules utilizing the SRI method in Uttar Pradesh.

 2. **MATERIALS AND METHODS**

**2.1 *Location***

The field study was carried out at the Narendra Deva University of Agriculture & Technology's Agronomy Research Farm in Ayodhya, Uttar Pradesh, India, during the 2017 kharif season. The terrain was adequately leveled with favorable soil conditions. Ayodhya (Kumarganj) is located in a subtropical climate at a latitude of 26.470° North and a longitude of 82.120° East, with an elevation of 113 meters above sea level.

**2.2 *Treatments and design***

The experiment implemented a split plot design, featuring three rice varieties as main plots and three nutritional levels as subplots, reproduced four times. The treatment combinations consist of three prevalent rice types (M1- NDR-97, M2- Sarjoo-52, and M3- Mahsuri) as primary treatments and three distinct nutritional levels (N1- 100% RDF, N2- 75% RDF + 25% FYM, and N3- 75% RDF + 25% Vermicompost) as subplot treatments, respectively. The dimensions of the experimental plot were 5.0 m by 3.0 m. The seedlings of several rice types, aged 21 days, were transplanted using a spacing of 25 cm × 25 cm. The experimental field was equipped with enough irrigation channels, and the individual plots were delineated by bunds.

**2.3 *Soil properties* and *Fertilizer application***

The experimental soil exhibited a silty loam texture, an alkaline response, non-saline characteristics, low organic carbon content, low available nitrogen (N - 161.43 kg ha-1), and medium levels of accessible phosphorus (P2O5 - 14.71 kg ha-1) and potassium (K2O - 240.33 kg ha-1) during the kharif season of 2017. Nutrient application was conducted according to the treatment protocol. The advised application rate of fertilizer, specifically N, P2O5, K2O, and ZnSO4 at 150, 60, 60, and 25 kg ha-1, respectively, was utilized. In the primary plots, fifty percent of the total nitrogen supply, together with the complete dosage of phosphorus and potassium, was applied just prior to transplanting on a puddled surface and physically integrated into the top 15 cm of soil using a spade. Zinc sulfate was applied at a rate of 25 kilogram per hectare. The residual half quantity of nitrogen was applied using urea fertilizer in two equal installments during the active tillering stage and 5-7 days prior to panicle commencement. Farmyard manure and vermicompost were manually integrated into the plots at the time of sowing according to the treatment specifications.

**2.4 *Calculations and statistical analysis***

All data obtained from the experiment, conducted under randomized block design were statistically analyzed using the F-test as per the procedure given by Gomez and Gomez (1984). Critical differences (CD) values at P = 0.05 were used to determine the significance of difference between treatment means. Treatment differences that were non-significant were denoted by NS. The crop growth, yield and yield attributes data were recorded, analyzed using the software OPSTAT and tabulated after statistical test.

**3. RESULT AND DISCUSSION:**

**3.1. Crop Yield**

**3.1.1 Grain Yield (t ha-1):** The grain yield of the long-duration variety Mahsuri was maximal at 5.17 t ha-1, greatly surpassing the output of variety NDR-97, which was 3.86 t ha-1. The variety Sarjoo-52 achieved a grain yield of 4.97 t ha-1. The data clearly indicate that grain yield was substantially influenced by various combinations of inorganic and organic nutrition sources (Fig.1). The highest grain production of 4.76 t ha-1 was seen in the treatment with 100% RDF, which was considerably superior to the treatments N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost). The treatment with 100% RDF (N1) exhibited a percentage improvement in grain output of 13.44% over 75% RDF + 25% FYM (N2) and 7.98% over 75% RDF + 25% vermicompost (N3).



**Fig 1: Yield and harvest index of rice as affected by various treatments**

**3.1.2. Straw Yield (t ha-1):**

The highest straw yield of 6.62 t ha-1 was recorded for the variety Mahsuri, while the variety Sarjoo-52 yielded 6.02 t ha-1 (Fig.1). The variety NDR-97 yielded a straw production of 4.41 t ha-1, which was the lowest among the three types evaluated in the study. The diverse fertilizer sources significantly influenced straw yield. The treatment utilizing 100% RDF yielded the highest straw production of 5.91 t ha-1, greatly surpassing the N3 (75% RDF + 25% vermicompost) and N2 (75% RDF + 25% FYM) treatments throughout the study.
The yields of grain and straw in rice were greatly impacted by the crop type. The Mahsuri variety produced markedly greater grain and straw yields, followed by Sarjoo-52 and NDR-97, respectively. Yield is a function of the intricate interrelationship between growth during the vegetative period and yield qualities. Mahsuri exhibited superior crop growth and development due to its genetic characteristics, leading to enhanced yield qualities that directly influenced grain and straw production. Enhanced vegetative development, along with superior yield characteristics, led to increased grain and straw yield. The greater number of panicles per unit area, larger panicle size, and higher percentage of filled grains in Mahsuri compared to other types may account for the superiority of this treatment. The genetic composition may have resulted in considerable heterogeneity in grain and straw yield among different types (Singh *et al*., 2012; Das and Chandra, 2013). The yield obtained with 100% RDF was markedly superior than those of the other treatments. This may result from sufficient nutrient availability, which facilitated increased dry matter accumulation. The productivity of a crop is collectively influenced by the vigor of vegetative growth, development, and yield qualities, which arise from enhanced transfer of photosynthates from the leaves and stem to the grains. Seventy-five percent RDF combined with twenty-five percent vermicompost yielded superior grain and straw compared to seventy-five percent RDF with twenty-five percent FYM, likely due to its narrower C:N ratio and consequently enhanced nutrient availability, which may have facilitated increased yield. The findings align with those of Singh *et al*., (2013) and Tomar *et al*., (2018).

**3.3.3. Harvest Index:**

The harvest index denotes the correlation between economic yield and biological yield (Fig.1). The highest harvest index of 45.21% was seen in Mahsuri, followed by the Sarjoo-52 variety, which recorded a harvest value of 43.85%. The cultivar NDR-97 exhibited a minimum harvest index of 43.59%. The statistics clearly indicate that the harvest index was substantially influenced by the different nutrient combinations. The highest harvest index was recorded with 100% RDF, followed by N3 (75% RDF + 25% Vermicompost), while the lowest was reported with (75% RDF + 25% FYM) throughout the experiment.

 The harvest index is the ratio of grain yield to total biological yield (grain plus straw). The harvest index indicates the efficiency of converting dry matter into the grain component. The various types and nutritional levels significantly influenced the grain yield of rice per unit of biological yield. The harvest index was dramatically affected by varying sources and nutrient levels. The elevated harvest index was seen with 100% RDF (44.74%), attributable to the increased grain production of rice per unit of biological yield, resulting in a higher harvest index. Treatment N3 (75% RDF + 25% vermicompost) outperformed treatment N2 (75% RDF + 25% FYM) in terms of grain yield relative to biological yield. Comparable findings were reported by Singh *et al*., (2012) and Singh A.K. (2017).

**3.2 Nutrient content:**

**3.2.1. Nitrogen content in grain and straw (%):**

Nitrogen concentration in grain and straw affected by various cultivars and nutrient levels (Table 1). The varieties exhibited no substantial impact on the nitrogen levels in the grain. The analysis of the data indicated that the nitrogen concentration in the cultivars Mahsuri, Sarjoo-52, and NDR-97 was 1.41%, 1.38%, and 1.35%, respectively. Of the three types, Mahsuri exhibited the highest nitrogen concentration, comparable to that of Sarjoo-52 and NDR-97, respectively. The application of the full recommended amount of fertilizer (RDF: 150, 60, 60 kg NPK ha-1) resulted in the highest nitrogen concentration in grain, comparable to the treatment with 75% RDF plus 25% vermicompost (1.39%). The nitrogen concentration in the grain was markedly higher in the treatment with 75% RDF plus 25% vermicompost (1.39%) compared to the treatment with 75% RDF plus 25% FYM (1.33%). The various types markedly affected the nitrogen content in the straw. The highest nitrogen concentration (0.52%) was observed in the Mahsuri variety (V3), while the lowest (0.49%) was found in the NDR-97 variety (V1). The nitrogen concentration in straw was markedly affected by diverse food combinations. The highest nitrogen concentration in straw was observed with (N1) 100% RDF (0.52%), which was comparable to (N3) 75% RDF + 25% vermicompost, both of which were significantly superior to (N2) 75% RDF + 25% FYM (0.49%).
The highest nitrogen content was observed in the Mahsuri variety, followed by Sarjoo-52 and NDR-97, respectively. The Mahsuri cultivar exhibited superior growth characteristics due to genetic factors, enabling it to effectively absorb larger nutrients from the soil under SRI conditions. Diverse nutritional sources were identified as affecting the nitrogen level of both grain and straw. The treatment receiving 100% RDF exhibited the highest nitrogen uptake in both grain and straw, likely attributable to the immediate availability of nutrients and the absorption of these mineral elements from the soil. The nitrogen concentration in grain and straw was greater in the treatment with 75% RDF plus 25% vermicompost compared to the treatment with 75% RDF plus 25% FYM. This may be attributed to the narrow carbon-to-nitrogen ratio of vermicompost, which, along with the enhanced activity of nitrogen-fixing bacteria during the composting process, likely contributed to the elevated nitrogen content in both grain and straw during vermicomposting (Daniel and Anderson, 1992). This outcome closely aligns with those reported by Singh *et al*., (2013) and Wolie and Admassu (2016).

**3.2.2. Phosphorus content in grain and straw (%):**

The phosphorus content in grain and straw, affected by varying irrigation and fertility levels, is reported in Table 1. It demonstrates that several cultivars significantly influenced the phosphorus content in the grain. Mahsuri outperformed the NDR-97 variety, exhibiting a phosphorus concentration of 0.31% in its grain. The phosphorus concentration in the grain of Sarjoo-52 was 0.30%, comparable to that of Mahsuri. The highest phosphorus level in grain was recorded at 0.32% with N1 (100% RDF), followed by N3 (75% RDF + 25% vermicompost). Minimum (0.29%) observed under N2 (75% RDF + 25% FYM) during the experimentation period. It is evident that differing types do not considerably affect the phosphorus concentration in straw. The highest phosphorus level (0.12%) was observed in Mahsuri (V3), while the lowest (0.10%) was recorded in NDR-97 (V1). The phosphorus concentration in the straw of Sarjoo–52 was 0.11%. The phosphorus concentration in straw was dramatically affected by diverse nutrient combinations. Moreover, the maximum phosphorus concentration in straw was observed with (N1) 100% RDF (0.121%), which was considerably greater than (N3) 75% RDF + 25% vermicompost and (N2) 75% RDF + 25% FYM (0.10%), respectively. The variety Mahsuri exhibited the highest phosphorus concentration, followed by Sarjoo-52 and NDR-97. The elevated phosphorus level in Mahsuri was mostly attributable to enhanced growth and development resulting from its superior genetic traits. Diverse nutritional sources were identified as affecting the nitrogen level of both grain and straw. The treatment receiving 100% RDF exhibited the highest phosphorus uptake in both grain and straw. This may result from effective root establishment, enhanced availability and absorption of mineral nutrients from the soil, increased nutrient transfer to grains, and robust plant growth. The phosphorus concentration in grain was higher in the treatment with 75% RDF and 25% vermicompost compared to the treatment with 75% RDF and 25% FYM. The augmentation of phosphorus content in the crop may be attributed to the capacity of organic anions to enhance phosphorus availability to plants. Singh, A.K. (2017) and Wolie and Admassu (2016) obtained similar results.

**3.2.3. Potassium content in grain and straw (%):**

The potassium concentration in grain and straw, affected by various types and nutritional levels, is presented in Table 1. It indicates that several cultivars did not significantly affect the potassium concentration in the grain. The variety Mahsuri exhibited a higher potassium level of 0.49%, followed closely by the variety Sarjoo-52 at 0.48%. The lowest potassium level in grain was seen in the cultivar NDR-97 (0.47%). Diverse nutrition sources and their quantities significantly influenced the potassium content of the grain. The maximum potassium concentration in grain was seen with 100% RDF, surpassing the N3 treatment (75% RDF + 25% vermicompost) and N1 treatment (75% RDF + 25% FYM). The various cultivars did not markedly affect the potassium content in straw. The variety Mahsuri (V1) exhibited a higher potassium concentration of 0.12%, followed by the variety Sarjoo-52. The cultivar NDR-97 exhibited the lowest potassium concentration in straw during the test. The potassium concentration in straw was dramatically affected by different nutrition levels. The maximum potassium concentration in straw was observed in (N1) 100% RDF (1.51%), which was comparable to (N3) 75% RDF + 25% vermicompost, both of which were significantly higher than (N2) 75% + 25% FYM (1.45%) throughout the study.

 The highest potassium concentration was observed in the Mahsuri cultivar. The elevated potassium concentration was primarily attributable to enhanced growth and development. This may be attributed to the more extensive and prolific root system established by young seedlings cultivated using the SRI method, which provided optimal conditions for nutrient absorption, ultimately resulting in elevated potassium levels in both grain and straw. The Mahsuri variety exhibited superior growth characteristics due to genetic factors, enabling it to effectively absorb larger nutrients from the soil. Of the two other kinds, Sarjoo-52 had superior potassium content compared to NDR-97, attributable to differences in growth characteristics. The highest concentration of accessible soil potassium was recorded in N1 (100% RDF), followed by N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost), attributed to the immediate availability of nutrients during the crop growing period. The minimal value of accessible soil potassium was observed with treatment N2 (75% RDF + 25% FYM), possibly due to the majority of potassium in FYM being retained in organic form. This result is in close proximity to those obtained by Singh *et al*., (2013) and Bejbaruah *et al.*,(2013).

**Table 1: Nitrogen, phosphorus and potassium content and uptake affected by different treatments**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Nitrogen content****(%)** | **Phosphorus content (%)** | **Potassium content****(%)** | **Nitrogen****uptake****(kg ha-1)** | **Phosphorus uptake****(kg ha-1)** | **Potassium uptake****(kg ha-1)** |
| **Grain** | **Straw** | **Grain** | **Straw** | **Grain** | **Straw** |
| **Varieties** |
| **V1:**NDR-97 | 1.35 | 0.49 | 0.29 | 0.10 | 0.47 | 1.46 | 62.3 | 13.22 | 73.46 |
| **V2:**Sarjoo-52 | 1.38 | 0.51 | 0.30 | 0.11 | 0.48 | 1.48 | 99.11 | 21.70 | 112.92 |
| **V3:**Mahsuri | 1.41 | 0.52 | 0.31 | 0.12 | 0.49 | 1.49 | 107.39 | 24.16 | 124.45 |
| S.Em+ | 0.02 | 0.01 | 0.00 | 0.00 | 0.01 | 0.02 | 2.73 | 0.58 | 4.70 |
| C.D.(p=0.05) | 0.07 | 0.01 | 0.02 | 0.01 | 0.03 | 0.08 | 8.49 | 1.81 | 14.06 |
| **Nutrient levels** |
| **N1:**100% RDF | 1.42 | 0.52 | 0.32 | 0.12 | 0.50 | 1.51 | 31.01 | 22.46 | 113.30 |
| **N2:**75%RDF + 25% FYM | 1.33 | 0.49 | 0.29 | 0.10 | 0.47 | 1.45 | 25.46 | 17.24 | 95.05 |
| **N3:**75%RDF+ Vermicompost | 1.39 | 0.51 | 0.30 | 0.11 | 0.48 | 1.47 | 28.35 | 19.39 | 102.48 |
| S.Em+ | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.15 | 0.66 | 0.32 | 1.40 |
| C.D.(p=0.05) | 0.04 | 0.02 | 0.01 | 0.00 | 0.02 | 0.05 | 2.25 | 1.09 | 4.75 |

**3.3 Nutrient Uptake by the crop:**

**3.3.1: Nitrogen Uptake (kg ha-1):**

The crop's nitrogen uptake was markedly influenced by various types and nutrient levels (Table 1). The total nitrogen intake was highest in variety Mahsuri (V3) at 107.33 kg ha-1, comparable to variety Sarjoo-52 (V2), but much more than NDR-97 (V1). The lowest nitrogen uptake, measured at 62.3 kg ha-1, was observed in the cultivar NDR-97. The total nitrogen intake in grain and straw was highest under N1 (100% RDF) at 31.01 kg ha-1, greatly surpassing N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost). The total nitrogen intake by crops in N1 (100% RDF) increased by 8.57% compared to N3 and by 17.89% compared to N2.

**3.3.2. Phosphorus uptake (kg ha-1):**

Phosphorus uptake by the crop was significantly affected by the different varieties (Table 1). It clearly indicated that total phosphorus uptake (24.16 kg ha-1) was maximum for variety Mahsuri (V1) which was statistically superior to Sarjoo-52 (V2) and was also significantly superior over variety NDR-97, respectively. Total phosphorus uptake was maximum with N1 (100% RDF) which was significantly superior over N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost). The percentage increase in total phosphorus uptake with 100% RDF were 23.24% and 15.83% over N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost), respectively.

**3.3.3 Potassium uptake (kg ha-1):**

Total potassium uptake as influenced by different varieties and nutrient levels (Table 1). The highest potassium uptake (124.45 kg ha-1) was recorded in variety Mahsuri (V3) which was significantly superior over NDR-97 (V1) but, statistically at par with Sarjoo-52. Minimum total potassium uptake (73.46 kg ha-1) was recorded in variety NDR-97 (V1), during the course of experimentation. Scanning of data pertaining to potassium uptake clearly reveals that nutrient levels and sources significantly influenced total potassium uptake. The maximum total potassium uptake (113.30 kg ha-1) was recorded in N1 (100% RDF) which was significantly superior over N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost). The percentage increase in total potassium uptake with N1 were 9.54% and 16.10% over N2 (75% RDF + 25% FYM) and N3 (75% RDF + 25% vermicompost), respectively.

Significant variations among the nutrient uptake were observed mainly due to the variation in the grain and straw yield of the crop. The uptake of nitrogen, phosphorus and potassium was significantly more in long duration variety Mahsuri and was followed by varieties Sarjoo-52 and NDR-97. Integrated nutrientmodules significantly influenced the uptake of nitrogen, phosphorus and potassium. The maximum uptake of NPK by the crop was noted in N1(100% RDF) followed by N3 (75% RDF + 25% vermicompost) and N2 (75% RDF + 25% FYM). This might be due to adequate availability of nitrogen, phosphorus and potassium which stimulates the metabolism and helped more rapidly in their uptake. Similar findings were reported by Sekhar *et al*., (2014); Wolie and Admassu(2016) Chandra *et al*., 2021 and Kumar *et al.,* 2022.

**3.4. Profitability:**

**3.4.1 Cost of cultivation (Rs. ha-1):**

Fig.2 presents the cultivation costs of rice across various treatments. The expense of farming was unaffected by the varieties. The lowest cultivation cost (Rs. 38035.2 ha-1) occurred with the application of 100% RDF across all kinds, with costs rising in accordance with the varied mixes of organic sources. The cultivation cost was greatest (Rs. 41203.7 ha-1) in the treatment utilizing 75% RDF and 25% farmyard waste across all evaluated types during the trial.

**3.4.2 Gross return (Rs. ha-1):**

The data about the gross return of various treatments unequivocally demonstrate that the incorporation of the Mahsuri variety significantly enhanced the gross income of rice (Fig.2). The highest gross return of Rs. 81,100 per hectare was observed with the combination of Mahsuri and 100% RDF (V3N1). The minimal gross return of Rs. 54,500 ha-1 was achieved with the combination of NDR-97, 75% RDF, and 25% FYM (V1N2).

**3.4.3 Net return (Rs. ha-1):**

Net return also varied with different treatment combinations of varieties and nutrient sources, as well (Fig.2). Minimum net return of Rs. 13296.3 ha-1 was recorded when NDR-97 was clubbed with 75% RDF + 25% FYM. On the other hand, the maximum net return of Rs. 43065 ha-1 was received under treatment combination of V3N1 (100 % RDF in conjunction with rice variety Mahsuri), respectively.

**3.4.4 Benefit- cost ratio:**

The maximum benefit-cost ratio of 1.13 was seen with the combination of 100% RDF and Mahsuri, followed by Sarjoo-52 with 100% RDF (Fig.2). The lowest benefit-to-cost ratio of 0.3222 was documented in NDR-97, associated with the application of 75% RDF and 25% FYM per hectare.

 The expense of cultivation is unaffected by varietal changes and is solely influenced by the sources and quantity of nutrients utilized. The lowest cultivation cost (Rs. 38035.20 ha-1) was seen with the NDR-97 variety combined with 100% RDF (N1), which escalated with the augmentation of organic nutrient sources. The highest cultivation cost (Rs. 41,203.7 per hectare) was seen with 75% RDF and 25% FYM, attributed to increased expenditure on FYM. Tomar *et al*., (2018) documented analogous findings. The gross monetary return is closely correlated with the market value of the produce. The lowest gross monetary return of Rs. 54,500 ha-1 was observed in treatment V1N2, which involved the combination of Mahsuri with 75% RDF and 25% FYM. The highest net return of Rs. 43,065.8 per hectare was observed with the Mahsuri variety in conjunction with 100% RDF (V3N1). Regarding net income and B-C ratio, the Mahsuri variety combined with 100% RDF exhibited the greatest values (Rs. 43065.8 ha-1 and 1.13). The similar results were also reported by Ranjitha *et al.*, (2013) and Singh *et al.*,(2018).

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**Fig 2: Economics of various treatment combination of different varieties of rice and nutrient levels**

**4. Conclusion**

The findings indicated that the Mahsuri variety had the highest grain and straw production (t ha-1) as well as superior nutritional content and absorption (NPK) in both grain and straw, surpassing the Sarjoo-52 and NDR-92 types. The application of (N1) 100 percent RDF led to markedly superior crop yields, including grain and straw yields, along with enhanced nutrient content and uptake (NPK) in both grain and straw, in comparison to the treatments of (N2) 75 percent RDF + 25 percent FYM and (N3) 75 percent RDF + 25 percent Vermicompost, respectively. The highest gross and net return, with a benefit-cost ratio of 1.13, was observed for Mahsuri at 100 percent RDF, followed by Sarjoo-52 at 100 percent RDF, both demonstrating greater profitability than the other treatment combinations evaluated in the study. Consequently, it can be concluded that employing 100 percent RDF alongside the Mahsuri variety is the optimal treatment combination for maximizing rice crop yield while maintaining soil health and profitability in Eastern Uttar Pradesh.

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**REFERENCES**

Apon M, Gohain T, Apon R, Banik M and Mandal AK. 2018. Effect of integrated nutrient management on growth and yield of local rice (*Oryza sativa* L.) under rainfed upland condition of Nagaland. *The Pharma Innovation Journal*; 7(7): 426-429.

Bejbaruah R, Sharma RC, Banik P. 2013. Split application of vermicompost to rice (Oryza sativa L.): its effect on productivity, yield component, and N dynamics. *Organic Agriculture*. 3:123-128.

Chandra M.S., Naresh R. K., Vivek, Singh S.P., Purushottam,Vivak Kumar, Jat P.C. and Himanshu Tiwari. 2021. Effect of Planting Techniques and NutrientManagement Options on Crop Productivityand Soil Health of Wet Rice (Oryza sativa L)in Typic Ustochrept Soils. *International Journal of Plant & Soil Science.* 33(22): 39-54,

Chandra MS, Kumar KA. 2020. Evaluation of rice (*Oryza sativa* L.) varieties for yield, yield attributes and quality parameters under alternate wetting and drying method in puddled soil. Multilogic in Science, 10(23): 689-694.

Daniel O, Anderson J.M. 1992. Microbial biomass and activity in contrasting soil material after passage through the gut of earthworm Lumbricus rubellus Hoffmeister. *Soil Biol Biochem*, 24: 465-470.

Dass, A and Chandra, S. 2012. Effect of different components of SRI on yield, quality, nutrient accumulation and economics of rice (*Oryza sativa*) in *tarai* belt of Northern India. *Indian Journal of Agronomy.* 57 (3): 250-254.

Dutta, D., Meena, A. L., Bhanu, C., Ghasal, P. C., Choudhary, J., Kumar, S., Mishra, R. P., Ansari, M. A., Raghavendra, K. J., Prusty, A. K., Jat, P. C., Kashyap, P., Punia, P., Dixit, M., Singh, O., Rai, A. K., Meena, A. K., Rathi, S., & Yadav, P. (2024). Sustainable soil management for climate resilience: Long- dynamics in a semi-arid tropical Inceptisol of India. Journal of Soil Science and Plant Nutrition. https://doi.org/10.1007/s42729-024-01844-4

Gathorne-Hardy A., Narasimha Reddy D., Venkatanarayana M., Harriss-White B. 2016. System of Rice Intensification provides environmental and economic gains but at the expense of social sustainability — A multidisciplinary analysis in India. *Agricultural Systems* 143: 159–168.

Ghazaryan, K., Pandey, D., Singh, S., Varagyan, V., Alexiou, A., Petropoulos, D., Kriemadis, A., Rajput, V., Minkina, T., Singh, R., Sousa, J., Kumar, S., El-Ramady, H., Singh, O., & Singh, A. (2024). Enhancing Crop Production: Unveiling the Role of Nanofertilizers in Sustainable Agriculture and Precision Nutrient Management. Egyptian Journal of Soil Science, 64(3), 981 – 1007. doi: 10.21608/ejss.2024.282778.1748

Ghosh D, Brahmachari K, Skalický M, Roy D, Das A, Sarkar S, et al. 2022. The combination of organic and inorganic fertilizers influence the weed growth, productivity and soil fertility of monsoon rice. PLoS ONE 17(1): e0262586. <https://doi.org/10.1371/journal.pone.0262586>.

Gomez, K.A. and Gomez, A. (1984) Statistical Procedure for Agricultural Research—Hand Book. John Wiley & Sons, New York.

Kumar KY, Singh V, Singh SK, George SG. (2022). Assessment of Rice (Oryza sativa L.) Hybrids on Growth and Yield under Agro-climatic Conditions of Prayagraj, U. P. *Int. J. Plant Soil Sci.* 34(18):45-9. https://journalijpss.com/index.php/IJPSS/article/view/1848

Kumar S.S., Sultan A., Adiba Ejaz and Radha Krishna, J. 2021. Integrated Nutrient Management in Rice- A Critical Review. *Global Scientific Journals* 9(12): 1385-1400.

Kumar, D. and Shivay, Y.S. 2004. System of rice intensification. *Indian Farming*, November, pp.18-21.

Murphy B. 2015. Key soil functional properties affected by soil organic matter—evidence from published literature. In IOP Conf. Series: *Earth Env. Sci*, 2015. 25: p. 1–6.

Ranjitha P.S. and Reddy. K.I. 2013. Effect of different nutrient management options on rice under SRI method of cultivation- a review. *International Journal of Plant Animal and Environment Sciences*. 3(4).

Saikanth, D. R. K., Singh, B. V., Rai, A. K., Kumar, U. S., Surender, Yadav B., & Singh, O. (2023). Biochar implementation in rice paddies for addressing greenhouse gas emissions and nutrient loss: a review. *International Journal of Plant & Soil Science*, *35*(18), 610–623. https://doi.org/10.9734/ijpss/2023/v35i183326.

Sekhar D., Pradeep Kumar P.B., and Tejeswara Rao K. 2014. Effect of Coffee Husk Compost on Growth and Yield of Paddy. Journal of Academia and Industrial Research. 3(4): 195-197.

Senthilvalavan, P. and Ravichandran, M. 2016. Growth and physiological characters of rice (Oryza sativa) as influenced by integrated nutrient management under SRI in Cauvery Deltaic Zone of Tamil Nadu. *Annals of Plant and Soil Research* 21(3): 210-216.

Shahi, U. P., Singh, O., Singh, V. K., Shivangi, P. K., Singh, R., Singh, V. K., Anand Singh, Rajput, V. D., Rajput, V. D., Singh, A., Ghazaryan, K. A., & Al Tawaha, A. R. M. (2024). Nanotechnology in rice farming: Optimizing nutrient management with nanofertilizers. In: Sustainable Agriculture: Nanotechnology and Biotechnology for Crop Production and Protection. Walter de Gruyter GmbH. DOI: 10.1515/9783111234694-003

Singh A. K., Manibhushan, Meena, M. K., and Upadhyaya, A. 2012. Effect of sulphur and zinc on rice performance and nutrient dynamics in plants and soil of indo gangetic plains. *Journal of Agricultural Science*, 4(11):162-170.

Singh, A., Rawat, S., Rajput, V. D., Minkina, T., Mandzhieva, S., Eloyan, A. S., Singh, R. K., Singh, O., El-Ramady, H., & Ghazaryan, K. (2024). Nanotechnology products in agriculture and environmental protection: Advances and challenges. Egyptian Journal of Soil Science, 64(4), 1355-1378.

Singh, A.K. 2017. Effect of balanced use of nutrient on productivity and economics of wheat. Annals of Plant and Soil Research, 19(1): 105- 109.

Singh, D.K., Pandey, P.C., Nanda, G. and Gupta, S. 2018. Long-term effects of inorganic fertilizer and farmyard manure application on productivity, sustainability and profitability of rice-wheat system in Mollisols. *Archives of Agronomy and Soil Science.* 65, 139–151.

Singh, O, Shahi, U. P., Shivangi, Singh, V. K., Singh, P. K., Singh, R. and Singh, A. (2024). Enhancing crop nutrition with zinc nanoparticles: A novel approach to cereal crop micronutrient management. In:Sustainable Agriculture: Nanotechnology and Biotechnology for Crop Production and Protection. Walter de Gruyter GmbH. DOI: 10.1515/9783111234694-006

Singh, O. (2023). Nanotechnology for sustainability and food security in agriculture: A nanopriming long story in short. In A. Singh, V. Rajput, K. Ghazaryan, S. Gupta, & T. Minkina (Eds.), *Nanopriming Approach to Sustainable Agriculture (pp. 315-339). IGI Global. https://doi.org/10.4018/978-1-6684-7232-3.ch014.*

Singh, O., Shahi, U.P., Dhyani, B.P., Kumar, S., Vivek, S., Sengar, R.S., Shivangi, and Singh, A. (2023). Effect of zinc oxide nanoparticles application on growth and yield of basmati rice (*Oryza sativa*) in alkaline soil. *Indian Journal of Agronomy,* 68(3), 1-6.

Singh, S., Singh, O., Shahi, U. P., Singh, P. K., Singh, A., Rajput, V. D., Minkina, T., El-Ramady, H., & Ghazaryan, K. (2024). Carbon sequestration through organic amendments, clay mineralogy and agronomic practices: A review. *Egyptian Journal of Soil Science*, 64(2), 581-598.

Singh, V.P., Pal, B. Sharma, Y.K. 2013. Response of rice to nitrogen and zinc application irrigated with saline water. Environment and Ecology; 31(1A): 344-349.

Srinivasarao C., et al. 2013. Sustainable management of soils of dryland ecosystems of India for enhancing agronomic productivity and sequestering carbon. *Adv. Agron*. 121:253–329.

Subash, N., Dutta, D., Ghasal, P., Ravisankar, N., Chaudhary, V. P., Kumar, S., Meena, L. R., Singh, O., Brahmdutt, Singh, S., & Sunita, K. (2023). A Composite Index to Assess the Climate-Carbon-Yield-Sustainability of Cereal Based Cropping System. *International Journal of Plant Production,* 17, 729–755 (2023). https://doi.org/10.1007/s42106-023-00268-x.

Tadesse T. 2013. Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. *Am. J. Plant Sci,* 2013. 4: p. 309– 316.

Timsina J., and Connor D.J. 2001. Productivity and management of rice–wheat cropping systems: issues and challenges. *Field Crop. Res*., 69(2):p.93–132.

Tomar, R., Singh, N. B., Singh, V. and Kumar, D. 2018. Effect of planting and integrated nutrient management on growth parameters, yield and economics of rice. *Journal of Pharmacognosy and Phytochemistry*, 7(2): 520-527.

Tyagi, S.; Naresh, R.K.; Bhatt, R.; Chandra, M.S.; Alrajhi, A.A.; Dewidar, A.Z.; Mattar, M.A. Tillage, Water and Nitrogen Management Strategies Influence the Water Footprint, Nutrient Use Efficiency, Productivity and Profitability of Rice in Typic Ustochrept Soil. Agronomy 2022, 12, 1186. <https://doi.org/10.3390/agronomy12051186>.

Upadhyay, V.B., Jain. V., Vishwakarma, S.K. and Kumhar, A.K. 2011. Production potential, soil health, water productivity and economics of rice (Oryza sativa)–based cropping systems under different nutrient sources. Indian Journal of Agronomy. 56(4): 311–16.

 Weijabhandara D.M.D.I., Dasog G.S., Patil P.L. and Manjunath Hebbar. 2011. Effect of Nutrient Levels on Rice (*Oryza sativa* L.) under System of Rice Intensification (SRI) and Traditional Methods of Cultivation. *Journal of the Indian Society of Soil Science*, 59(1): 67-73.

Wolie AW, Admassu MA. 2016. Effects of Integrated Nutrient Management on Rice (Oryza sativa L) Yield and Yield Attributes, Nutrient Uptake and Some Physico-Chemical Properties of Soil: A Review. *Journal of Biology, Agriculture and Healthcare*. 6:20-26.