NANGARHAR UNIVERSITY
INTERNATIONAL JOURNAL OF BIOSCIENCES
ORIGINAL ARTICLE
e-ISSN: 2957-9988
NUIJB Vol 4, Issue 4 | 2025

Received: 30 Sep 2025 Accepted after revision: 24 Dec 2025 Published Online: 30 Dec 2025

Effect of Integrated Nutrient Management with Nitrogen, FYM, and Foliar Panchagavya on Rice Growth and Yield in the Semi-Arid Region of Afghanistan

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ABSTRACT

A field experiment was conducted at the Sheshambagh Agricultural Station Nangarhar, Afghanistan, to evaluate the effect of integrated application of inorganic nitrogen and organic nutrient sources on the growth and yield of rice (*Oryza sativa* L. cv. Jalalabad-014). The experiment was laid out in a randomized complete block design (RCBD) with nine treatments and three replications involving different combinations of recommended nitrogen doses, farmyard manure (FYM), and foliar application of Panchagavya. The result showed that, the combined application of 100 kg nitrogen per hectare, with six foliar sprays of 3 percent panchagavya, significantly enhanced growth parameters, including plant height, tiller number, and leaf area index (LAI), compared with the control. This treatment also produced the highest yield attributes, such as effective tillers per hill, grains per panicle, and 1000-grain weight, resulting in maximum grain yield (10.83 t ha^{-1}) and straw yield (12.72 t ha^{-1}). However, these responses were statistically comparable with treatments receiving either 100 kg N ha^{-1} alone or reduced nitrogen doses supplemented with Panchagavya and/or FYM. Overall, the results indicate that integrated use of inorganic nitrogen with organic nutrient sources, particularly Panchagavya, enhances rice productivity and may improve nitrogen-use efficiency under semi-arid agro-ecological conditions.

Keywords: Nitrogen, Inorganic, Organic, Panchagavya and FYM

INTRODUCTION

Rice (*Oryza sativa* L.) is a self-fertilizing cereal species in the Poaceae family and serves as a major staple crop in tropical and subtropical climates (Habib *et al*., 2012). Worldwide, rice cultivation spans roughly 165 million hectares, producing an estimated 744.4 million tonnes of paddy, of which 496.4 million tonnes are milled (FAO, 2014). The Asian continent represents the core region for both rice production and dietary dependence. (Plodpai *et al*., 2013; Mohapatra *et al*., 2022). In Afghanistan, rice is the second most important staple food after wheat and plays a critical role in national food security. Yet, poor grain quality and low crop yields have severely hindered farmers, intensifying the country's widespread malnutrition crisis. (kakar *et al* 2019). (Amanullah., 2016). Efficient nitrogen management is essential for optimizing rice yield, and its metabolic functions (Ghoneim & Ebid, 2015). However, excessive or imbalanced nitrogen use reduces nitrogen-use efficiency, degrades soil health, and increases environmental risks (Shaiful islam *et al*., 2009), using the right amount of nitrogen not only reduces expenses but also guarantees environmental safety. However, excessive use of nitrogen fertilizers can lead to long-term negative effects on both soil health and the surrounding ecosystem, as noted by Salem. (2006), rice grains weight and protein content rose dramatically when nitrogen treatment were maximized. No single source of plant nutrients, such as organic manures or fertilizers, can fully satisfy the nutrient demands for maintainable crop yield. While the application of chemical fertilizer has been rising to meet these needs, their high cost remains a significant challenge. Additionally, the application of chemical fertilizers is often imbalanced, failing to support soil health, which is crucial for long-term crop productivity (Eltan *et al*., 2002). FYM improves soil structure, microbial activity, and water retention; however, it alone cannot meet nutrient demands. Integrated nutrient management (INM) strategies, which combine organic and inorganic sources, have gained importance. While combining organic and inorganic sources have gained importance. Panchagavya, a traditional fermented organic formulation, has been reported to enhance plant growth through bioactive compounds, plant hormones, beneficial microbes, and improved nutrient uptake efficiency. Several studies have shown that integrating Panchagavya with nitrogen fertilizers can enhance tillering, leaf area development, photosynthetic activity, and grain formation. This strategy provides a balanced nutrient supply, supporting long-term soil fertility and sustained agricultural output. (Bodruzzaman et al., 2010). . Despite these promising findings, limited research has evaluated the combined effects of inorganic nitrogen, FYM, and Panchagavya on the growth and yield of rice under the semi-arid agro-ecological conditions of eastern Afghanistan. Additionally, evidence is lacking on the potential of such integrated approaches to improve nitrogen-use efficiency and economic returns in local rice production systems.

Therefore, the present study was undertaken to assess the influence of different combinations of inorganic nitrogen, farmyard manure, and foliar application of Panchagavya on the growth, yield attributes, and productivity of rice (cv. Jalalabad-014) under the agro-climatic conditions of Sheshambagh, Nangarhar. The findings aim to provide a scientific basis for promoting integrated nutrient management practices for sustainable rice production in Afghanistan.

MATERIALS AND METHODS

Study Area

The experiment was conducted during the 2024 growing season at the Sheshambagh Agricultural Research Station of the Nangarhar Agriculture, Irrigation and Livestock Directorate, Jalalabad, Afghanistan. The site is characterized by a semi-arid to arid climate, receiving 250–400 mm of annual rainfall, with summer temperatures rising to 48–49 °C. Geographically, the experimental site is located ar 34º 26’3’’N latitude and 70º 26’52’’ E longitude, with 580 meters above sea level. The total experimental field covered an area of 371 m^2.

Experimental Design and Treatments

The experiment was laid out in a randomized complete block design (RCBD) with nine treatments and three replications. Plots of each unit ware 7.2 square meter (4 x 1.8). the distances between blocks and unit plot were 1 and 0.5 meters, respectively. plots ware assigned treatment at random. Nine treatments were established using different combinations of recommended nitrogen doses (RDN), farmyard manure (FYM), and Panchagavya:

- T_1: Control (no fertilizer)
- T_2: FYM @ 10 t ha^{-1}
- T_3: Panchagavya 3% (six foliar sprays)
- T_4: 100% RDN (100 kg N ha^{-1})
- T_5: FYM @ 10 t ha^{-1} + Panchagavya 3% (six sprays)
- T_6: FYM @ 10 t ha^{-1} + 50% RDN (50 kg N ha^{-1})
- T_7: Panchagavya 3% (six sprays) + 50% RDN
- T_8: Panchagavya 3% (six sprays) + 100% RDN
- T_9: FYM @ 10 t ha^{-1} + Panchagavya 3% (six sprays) + 50% RDN

FYM was incorporated into the soil 10 days before the transplanting. Nitrogen was applied in three split 50% at the time of transplanting, 25% at the tillering stage and 25% at the panicle ignition stage. Panchagavya (3%) was applied as a foliar spray at every 15 days, for a total of six applications.

Crop Establishment and Management

The rice variety Jalalabad-014 was used as the test crop. Seedlings were transplanted on 10 July 2024"].

Three seedlings per hill were transplanted at a spacing of 15 × 30 cm. The crop was raised following standard recommended practices. Flood irrigation was carried out according to the crops critical growth stage, insuring water depth of up to 10 cm in each plot. The experimental plots received water through designated irrigation channels. A single weeding was performed during the crops growth period 30 days after transplanting push weeder and hand weeding effectively minimize weed competition and helping maintain ideal condition field conditions. For the Preventive control of yellow rice stem borer (Scripopaga incertulas) purdain was used during the tillering stage at the rate of 17 kg ha^{-1}, Chloropyrifos 48% at dosage of 1.5 lit ha^{-1} was applied to successfully control the yellow rice stem. Infection, which happened during the panicle initiating stage.

Soil Characteristics

Table 1 presents the physicochemical properties of the topsoil (0–15 cm) at the experimental site.

Physicochemical property	Value
Sand (%)	57.2
Silt (%)	22.8
Clay (%)	20
Texture class	Sandy clay loam
Electrical Conductivity (dSm^{-1})	0.188
pH of Soil (1:2:5 Soil: Water ratio)	8.2
Organic carbon (kg/ha)	21,645
Available N (kg/ha)	318
Available P_2O_5 (kg/ha)	72.8
Available K_2O (kg/ha)	72.8

Data Collection

Growth parameters, such as plant height, tiller number per hill, and leaf area index (LAI), were recorded at 30 days after transplanting (DAT), 60 DAT, and at harvest, using standard methods.

- Plant height was measured from the soil surface to the tip of the tallest leaf/panicle.
- Tiller number was recorded from five randomly selected hills per plot.
- To calculate the leaf area index, the number of leaves on each plant was counted, their length and average breadth were measured, and the result was multiplied by 0.75 (Kluen and wolf, 1986).

$$\text{Laf area index} = \frac{\text{Surface area x correction factor}}{\text{Ground area}}$$

Yield attributes such as effective tillers per hill, panicle length, grains per panicle, 1000-grain weight, grain yield, and straw yield were measured at maturity following standard agronomic procedures.

Statistical Analysis

Data were analysed using one-way analysis of variance (ANOVA) in SPSS (version 25). Treatment means were compared using Tukey's Honest Significant Difference (HSD) test at $p < 0.05$. **[Specify whether assumptions (normality, homogeneity of variance) were checked before ANOVA]**.

RESULTS

Growth Parameters

Plant Height

Significant differences in plant height were observed among treatments at all three growth stages (30 DAT, 60 DAT, and at harvest) (Table 2). Treatment T_8 (100% RDN + Panchagavya 3% sprays) produced the tallest plants at each stage, recording 61.87 cm at 30 DAT, 101.00 cm at 60

DAT, and 115.87 cm at harvest. In contrast, the control treatment (T_1) consistently showed the shortest plant height, with values of 35.93 cm, 75.20 cm, and 83.60 cm at the respective stages.

Number of Tillers per Hill

The number of tillers per hill also varied significantly across treatments (Table 2). T8 recorded the maximum tiller numbers at 30 DAT (34.20), 60 DAT (39.40), and harvest (32.13). Treatments T6 and T7 produced comparatively higher numbers, while the lowest tiller counts were observed in the control (T1), with 17.40 tillers at 30 DAT, 18.33 at 60 DAT, and 14.13 at harvest.

Leaf Area Index

Leaf area index (LAI) exhibited significant variation among treatments (Table 2). The highest LAI was obtained in T8 (2.88), followed by T9 (2.84) and T4 (2.83). The lowest LAI was recorded in T1 (1.79), indicating limited canopy development under unfertilized conditions.

Table 2: Impact of Nitrogen Levels and Organic Manures on Rice Growth.

Treatment	*Plant height(cm)*			*Number of tiller per hills*			*Leaf area index*
	30 DAT	**60 DAT**	**At Harvest**	**30 DAT**	**60 DAT**	**At Harvest**	
T_1	35.93^{e}	75.20^{h}	83.60^{k}	17.40^{c}	18.33^{d}	14.13^{f}	1.79^{d}
T_2	37.13^{d}	79.00^{g}	87.47^{h}	19.13^{c}	22.80^{c}	18.53^{e}	1.88^{d}
T_3	44.07^{d}	80.60^{f}	89.40^{g}	19.47^{c}	25.00^{c}	20.87^{d}	2.01^{c}
T_4	53.33^{a,b}	97.73^{b}	112.60^{b}	33.80^{a}	34.93^{b}	29.80 ^{b}	2.83^{a}
T_5	49.20^{c}	84.20^{e}	93.93^{f}	21.40^{c}	25.80^{c}	23.33^{c}	2.06^{c}
T_6	51.87^{a,b}	94.93^{c,d}	107.33^{e}	27.93^{b}	34.80^{b}	30.40 ^{b}	2.60^{b}
T_7	56.67^{a,b}	94.13^{d}	108.93^{d}	29.80^{a,b}	35.47^{b}	29.40 ^{b}	2.64^{b}
T_8	61.87^{a}	101.00^{a}	115.87^{a}	34.20^{a}	39.40^{a}	32.13^{a}	2.88^{a}
T_9	52.07^{a,b}	95.93^{c}	110.27^{c}	33.27^{a}	36.80^{a,b}	30.07^{b}	2.84^{a}
CD (P=0.05)	**14.14**	**1.51**	**1.23**	**3.77**	**3.00**	**1.28**	**0.08**
CV%	**16.78**	**0.99**	**0.71**	**8.37**	**5.76**	**2.94**	**2.06**
SEm±	**4.76**	**0.51**	**0.41**	**1.27**	**1.01**	**0.43**	**0.03**

Values within the same column sharing the same letter are not significantly different, while those with different letters indicate a significant difference at the 0.05 probability level.

Yield Attributes

Effective Tillers

The number of effective tillers per hill differed significantly among treatments (Table 3). T8 recorded the highest number of effective tillers (24.53), whereas the control (T1) produced the fewest (8.87).

Grains per Panicle

Significant differences were observed in the number of grains per panicle (Table 3). T8 produced the maximum number of grains (132.13), statistically comparable with T9 (130.33) and T4 (129.93). The lowest grain number was recorded in the control treatment (T1), with 102.93 grains per panicle.1000-Grain Weight

The 1000-grain weight showed considerable variation among treatments (Table 3). The highest grain weight (27.03 g) was obtained in Grain and Straw Yield

Grain Yield

Grain yield was significantly influenced by the treatments (Table 3). T8 produced the highest grain yield (10.83 t ha⁻¹), followed closely by T9 (10.36 t ha⁻¹) and T7 (10.04 t ha⁻¹). The lowest yield was observed in the control (T1), with 5.31 t ha⁻¹.

Straw Yield

Straw yield followed a trend similar to grain yield. T8 recorded the highest straw yield (12.72 t ha⁻¹), while T1 produced the minimum (7.40 t ha⁻¹). Treatments T7, T4, and T9 also exhibited relatively high straw yields.

Table 3: Impact of Organic manure and Inorganic nitrogen on yield of rice.

Treatment	Fertile tiller per hills	Panicle length (cm)	Number of grain per panicle	1000 Grain Weight (gr)	Grain yield ($t\ h^{-1}$)	Straw yield($t\ h^{-1}$)
T_1	8.87	19.60^{e}	102.93^{f}	19.1^{f}	5.31^{f}	7.40^{e}
T_2	11.40	21.67^{d}	108.93^{f}	20.8^{e}	7.57^{e}	9.84^{d}
T_3	12.60	22.67^{d}	112.13^{e}	21.77^{e}	7.64^{e}	9.90^{d}
T_4	22.53	29.43^{a}	$129.93^{a,b}$	$26.00^{a,b}$	9.97^{c}	$12.02^{a,b}$
T_5	14.87	23.93^{c}	116.13^{d}	23.33^{d}	7.99^{e}	10.69^{c}
T_6	19.20	26.40^{b}	124.27^{c}	24.77^{c}	9.76^{d}	11.52^{b}
T_7	20.73	27.27^{b}	127.73^{b}	24.83^{c}	$10.04^{b,c}$	12.37^{a}
T_8	24.53	30.03^{a}	132.13^{a}	27.03^{a}	10.83^{a}	12.72^{a}
T_9	22.53	29.37^{a}	130.33^{a}	25.90^{b}	10.36^{a}	$12.17^{a,b}$
CD (P=0.05)	1.14	1.04	1.97	1.04	0.41	0.94
CV	3.79	2.37	0.95	2.56	2.62	5.02
SEm±	0.38	0.35	0.66	0.35	0.14	0.32

Values within the same column that share the same letter are not significantly different, while those marked with different letters indicate a significant difference at the 0.05 probability level.

Economic Analysis

Economic analysis revealed clear differences in profitability among treatments (Table 4). The highest benefit–cost (B:C) ratio was achieved in T7 (4.15), followed closely by T8 (4.11). The lowest B:C ratio was recorded in the control (T1) at 2.02. These results indicate that integrated nutrient management strategies, particularly those involving Panchagavya in combination with inorganic nitrogen, enhanced economic returns compared to unfertilized or singly fertilized treatments.

Table 4: Economical analysis of inorganic nitrogen and organic manure.

TREATMANT	straw yield/ ha (Af)	yield per ha (Af)	Gross returan	Fixed cost/ha	Variable Cost	Total cost/ha	Net returen	B C
T_1	18870	116820	135690	45000	0	45000	90690	2.02
T_2	25092	166540	191632	45000	8000	53000	138632	2.62
T_3	25245	168080	193325	45000	1500	46500	146825	3.16
T_4	30651	219340	249991	45000	6510	51510	198481	3.85
T_5	27259.5	175780	203039.5	45000	9500	54500	148539.5	2.73
T_6	29376	214720	244096	45000	11255	56255	187841	3.34
T_7	31543.5	220880	252423.5	45000	4005	49005	203418.5	4.15
T_8	32436	238260	270696	45000	8010	53010	217686	4.11
T_9	31033.5	227920	258953.5	45000	8755	53755	205198.5	3.82

Rice yield price= kg per 22 AFN

Straw yield price= kg per 2.55 AFN

Discussion

The present study demonstrated that integrated application of inorganic nitrogen with organic nutrient sources (FYM and Panchagavya) significantly improved growth parameters, yield attributes, and overall productivity of rice compared to sole applications or control. These results support the general concept of integrated nutrient management (INM), which aims to enhance nutrient availability and uptake while sustaining or improving soil fertility (Selim, 2025). Organic matter from FYM improves soil physical and biological properties, and inorganic nitrogen provides readily available nutrients for crop uptake, resulting in synergistic effects on plant growth (Udhaya et al., 2024).

The significant increase in plant height, tiller number, and leaf area index in treatments combining 100% recommended dose of nitrogen (RDN) with Panchagavya (T8) and/or FYM is consistent with previous findings showing that balanced use of organic and inorganic inputs enhances vegetative growth and canopy development (Manjappa, 2023). In INM systems, organic manures such as FYM release nutrients slowly through microbial mineralization, while inorganic fertilizers supply nutrients immediately after application, ensuring nutrient availability throughout key growth stages (Udhaya et al., 2024).

Panchagavya contains a mixture of cow dung, cow urine, milk, curd, and ghee, which are reported to contain plant growth-regulatory substances such as indole-3-acetic acid (IAA) and gibberellins, along with beneficial microbes that enhance nutrient uptake and plant growth (Krishnareddy et al., 2022). Such bio-formulations have been shown to improve soil fertility, microbial activity, and nutrient availability, contributing to improved vegetative growth and yield (Bajaj et al., 2022). The positive effects of Panchagavya observed in this study align with other research demonstrating enhanced crop growth and yield in Panchagavya-treated plots compared with control (Kumar & Singh, 2020).

The highest number of effective tillers, grains per panicle, and 1000-grain weight in integrated treatments corroborate earlier studies suggesting that combined nutrient sources can optimize yield components through balanced nutrient supply (Manjappa, 2023). Such improvements in yield components likely contributed to the superior grain and straw yields observed in treatments involving both inorganic nitrogen and organic amendments. INM has been shown to stabilize yield by compensating for micro- and secondary nutrient deficiencies and enhancing overall soil nutrient status (Selim, 2025).

The economic analysis in this study revealed that integrated treatments not only improved agronomic performance but also enhanced economic returns, with higher benefit–cost (B:C) ratios. This is consistent with other reports indicating that INM practices can increase profitability by optimizing fertilizer use efficiency and reducing unnecessary input costs (Manjappa, 2023).

Although treatments with full RDN combined with organic sources produced high yields, some treatments with reduced nitrogen doses supplemented with FYM and/or Panchagavya had statistically comparable yields to full RDN

alone, suggesting that INM can help reduce chemical nitrogen input without sacrificing productivity. This aligns with sustainable agriculture goals of maintaining high yields while minimizing environmental impact and preserving soil health (Selim, 2025).

CONCLUSION

The present study demonstrated that integrating inorganic nitrogen fertilizers with organic nutrient sources, particularly Panchagavya and farmyard manure, substantially enhanced the growth, yield attributes, and productivity of rice under the semi-arid conditions of Nangarhar, Afghanistan. Among the treatments, the combined application of 100% recommended nitrogen dose (100 kg N ha^{-1}) with six foliar sprays of 3% Panchagavya (T8) consistently produced the highest plant height, tiller number, leaf area index, effective tillers, grains per panicle, 1000-grain weight, and ultimately the greatest grain and straw yields. Although T8 was the most productive treatment, several integrated treatments with reduced nitrogen (e.g., T7 and T9) produced yields statistically comparable to the full nitrogen dose alone, indicating that supplementing lower N levels with organic inputs can partially replace chemical fertilizers without compromising yield. This highlights the potential of integrated nutrient management (INM) to improve nitrogen-use efficiency, reduce reliance on chemical fertilizers, and promote more sustainable rice production systems. Economic analysis further revealed that integrated treatments, particularly T7 and T8, provided the highest benefit–cost ratios, confirming the economic viability of combining organic and inorganic nutrient sources. Overall, the findings support the adoption of integrated nutrient management strategies as an effective approach to enhance rice productivity, improve soil health, and increase profitability for farmers in semi-arid rice-growing regions.

ACKNOWLEDGMENT:

The author express his sincere gratitude to Dr. Asmatullah Durani for his invaluable guidance and supervision throughout this study. Appreciation is also extended to Associate Professor Noor Ali Noor and Associate Professor Dr. Sajidullah Safi for their continuous support and constructive insights. The author further acknowledge Dr. Azizullah Khalili for his assistance, and thank their families for their encouragement during the course of this work.

Conflict of Interest: The authors declare no conflicts of interest.

Funding: This study did not receive any external funding.

Authors' Contributions: A. Durani conceptualized the study, designed the methodology, and supervised the research. N. A. Noor and S. Safi provided technical guidance and contributed to refining the manuscript. A. Niazi conducted the field experiment, collected and analyzed the data, prepared the figures, and drafted the manuscript. All authors reviewed and approved the final version.

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