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Influence of Nitrogen Levels and Microbial Inoculation on Growth, Yield and Straw of Direct Seeded Basmati Rice (*Oryza sativa* L.)

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ABSTRACT

Background: Rice, a staple cereal, serves as the primary food for almost 50% of the world's population. Nitrogen is the predominant mineral element found in crops and serves as the primary constraint on rice production. Direct-seeded rice cultivation has emerged as a potential alternative to traditional transplanting method. The goal is to provide insights that may be used to build sustainable agricultural methods that are specifically designed for basmati rice production.

Methods: This study aim to evaluate the effect of different N application levels (M_1: 0 kg ha^{-1}, M_2: 40 kg ha^{-1} and M_3: 60 kg ha^{-1}) options as first factor with four microbial inoculation treatments (S_1-Control, S_2-Azosprillum (618 g/ha) + Streptomyces's (618g/ha), S_3- Consortium (1235 g/ha) and S_4- AMF (1235 g/ha). The experiment was conducted using a split-plot design (SPD) with three replications.

Result: The study revealed that the maximum yield and yield attributes *viz*. plant height (116.47 cm), effective tillers (354.13 m^2), leaf area index (2.64), no. of grains per panicle (84.17), length of panicle (24.66 cm), no. of filled grains per panicle (125.0), grain yield (54.30 q ha^{-1}), straw yield (80.42 q ha^{-1}), biological yield (134.72 q ha^{-1}) and 1000-grain weight (24.64 g), maximum protein content (%) in grains (8.73%), straw (5.78%) was recorded in M_3S_2 *i.e.* 60 kg N ha^{-1} with azosprillum (618 g/ha) + streptomyces's (618 g/ha) significantly highest compared to other nitrogen levels and microbial inoculation treatments. Hence, the application of N @ 60 kg ha^{-1} along with azosprillum (618 g/ha)+Streptomyces's (618 g/ha) can be suggested to achieve higher rice grain yield, yield attributes and nitrogen content in grain and straw in DSR.

Key words: Basmati, Direct-seeded rice, Microbial inoculation, N content, Nitrogen levels.

INTRODUCTION

Rice (*Oryza sativa* L.) is a widely consumed grain that serves as a fundamental food source for over 3.5 billion people worldwide. The present worldwide paddy production is estimated to be over 755 million tons, with a global cultivated area of rice ranging about 167 million hectares. The demand for rice is projected to consistently increase as a result of the continuing growth of the global population (FAO, 2021). Rice cultivation has occupied a land area of 45.7 million hectares in India, yielding a total of 124 million tones at a productivity of 2717 kg ha^{-1} (India stat, 2021-22). India is the major producer of basmati rice in the world, constituting more than 70 per cent of the total world basmati rice production (Sidhu *et al.,* 2014). The unique fragrance and flavor of basmati is due to the presence of a chemical compound called 2-acetyl-1-pyrroline, which makes it unmatched by any other aromatic rice in the world (Routray *et al.,* 2018).

Nevertheless, during the last 20 years, there has been a lack of progress in improving rice production and cultivated areas. This may be attributed to the scarcity of water available for irrigation, rising expenses associated with agriculture (Hussain *et al.,* 2020).

Microorganisms play a crucial role in maintaining and promoting soil health in both natural and managed agricultural systems. They are involved in important processes such as forming soil structure, breaking down organic matter, removing toxins, preventing plant diseases and facilitating the cycling of carbon, nitrogen, phosphorous and sulfur (Olanrewaju *et al*., 2017). Azosprillum sp. is known to produce Indole-3-acetic acid (IAA), a plant hormone that promotes the growth of root hairs and increases the size of plant roots (Rodrigues *et al.,* 2015). Streptomyces's are used as biocontrol agents to enhance rice growth and development (Ngalimat *et al.,* 2021). The consortium can integrate plenty of modes of actions, which is expected to result in more effective management of pests and diseases (Sharma *et al.,* 2015). AMF enhances the ability of plants to absorb nutrients and withstand different types of stress. They have the capacity to shield the host plant against a wide range of pests and diseases (Rivero *et al.,* 2021).

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Direct seeding of rice (DSR) is a cost-effective way of establishing the crop by placing seeds directly in the field, as opposed to transplanting. Rice may be immediately planted, hence reducing the need for nursery preparation, seedling cultivation, uprooting and transferring (Singh *et al.,* 2018). Direct seeding (DS) is a cultivation technique that can save up to 12-35% of irrigation water and up to 60% of labor compared to the traditional transplanting (TP) method. Direct seeded rice (DSR) is gaining popularity because of its cost-effectiveness, lower water consumption and reduced labor requirements compared to traditional crop establishment methods (Kumar *et al.,* 2019).

Nitrogen is the most crucial nutrient for the growth and productivity of rice crops which is needed in larger quantities in comparison to other nutrients (Djaman *et al.,* 2018). Proper application of N fertilizer also enhances insect resistance, promotes dry matter buildup and facilitates improved nutrient absorption in rice plants. This knowledge is particularly important due to the significant influence of nitrogen fertilization on grain yield in rice plants (Chaturvedi, 2006). Hence, the objective of this study was to evaluate the effect of microbial inoculants and different doses of nitrogen fertilizer on the growth and yield of DS- Basmati rice.

MATERIALS AND METHODS

A field study was conducted in *kharif* season of 2023 at a Research Farm, Department of Agronomy, School of Agriculture, Lovely Professional University (LPU), Punjab, located at latitude of 31°24′N and a longitude of 75°69′W. It is situated at an altitude of 245 m above sea mean level. The experiment was laid out in a split-plot design (SPD) with three replications. The size of each plot was 20 m^2 (5 m in width and 4 m in length) and at spacing of 20 cm × 15 cm. The study included main plot consisting of three nitrogen levels such as M_1: 0 kg ha^{-1}, M_2: 40 kg ha^{-1} M_3: 60 kg ha^{-1}, in sub-plots microbial inoculation treatments: S_1-Control, S_2-Azosprillum (618 g/ha)+Streptomyces's (618 g/ha), S_3-Consortium (1235 g/ha) and S_4-AMF (1235 g/ha). Based on the soil analysis, all plots received phosphorus and potassium @ 30 and 30 kg/ha^{-1} while nitrogen was applied as per treatments. Fertilizers N, P and K were applied through urea (46% N), single super phosphate (16% P_2O_5) and muriate of phosphate (60% K_2O) respectively. A half Dose of nitrogen, full dose of phosphorus and potassium were given as a basal, with the remaining half dose applied twice equal splits at active tillering and panicle initiation stages as per treatment to their respective plots. Application of microbial inoculant is done as a seed treatment technique. The rice variety 'Pusa basmati 1509' was used in the study. The crop was planted on the date, on June 20th and harvested on October 20th in 2023. The meteorological data of weather parameters, *viz*. rainfall and temperature were recorded during the experiment. The highest amount of rainfall (411.3 mm) by the southwest monsoon was recorded in June and the maximum temperature was 45.9°C in June while the minimum temperature 20.5°C in October. Soil samples (0-20 cm depth) were collected from the research experiment site before sowing and after harvesting, analyzed for mechanical and physicochemical properties. The soil texture was sandy clay loam (USDA), neutral in pH 7.4, low organic carbon 0.38%, low in available nitrogen 197.8 kg ha^{-1}, medium in phosphorous (P_2O_5) 21.56 kg ha^{-1} and potassium (K_2O) 205.5 kg ha^{-1}.

Statistical analysis

The data performed using analysis of variance (ANOVA). The parameters were separated using the least significant difference (LSD) test at a significance level of (p<0.05) was generated using Origin Pro (ver. 10.1.0.178).

RESULTS AND DISCUSSION

Growth attributes

Effect of nitrogen

A research study evaluated the effect of varying nitrogen levels (0, 40 and 60 N kg ha^{-1}) and different microbial inoculations on plant height, number of tillers per square meter and leaf area index (LAI). Significant differences were observed across treatments (Table 1). Higher nitrogen levels resulted in increased plant height, with the treatment M_3 *i.e.* 60 N kg ha^{-1} (106.77 cm) followed by the M_2 *i.e.*

Table 1: Growth parameters of rice as influenced by nitrogen levels and microbial inoculants (at harvest).

Treatments	Plant height (cm)	No. of tillers/m^2	Leaf area index
Nitrogen application levels			
M_1: N-0 kg ha^{-1}	83.12^c	271.24^c	1.64^c
M_2: N-40 kg ha^{-1}	96.95^b	313.77^b	2.07^b
M_3: N-60 kg ha^{-1}	106.77^a	337.34^a	2.36^a
Microbial inoculation			
S_1: Control	85.10^d	286.08^d	1.78^d
S_2: Azosprullum (618 g/ha)+Streptomyces′s (618 g/ha)	102.97^a	322.14^a	2.20^a
S_3: Consortium (1235 g/ha)	99.22^b	314.45^b	2.1^b
S_4: AMF (1235 g/ha)	95.16^c	307.45^c	2.01^c
SD	12.47	31.95	0.35
S.Em(±)	2.07	5.32	0.05

40 N kg ha^{-1} (96.95 cm) and M_1 *i.e.* 0 N kg ha^{-1} (83.12 cm). The number of tillers per square meter was also highest in the M_3 (337.34 tillers/m^2), followed by M_2 (313.77 tillers/m^2) and M_1 (271.24 tillers/m^2). Similarly, LAI was highest in M_3 (2.36), followed by M_2 (2.07) and M_1 (1.64). Malik *et al.* (2014) also reported that application of N fertilizers increased plant height, no. of tiller/m^2, LAI.

Effect of microorganism

For microbial inoculations, the highest plant height was observed in the S_2 *i.e.* Azospirullum (618 g/ha)+ Streptomyces's (618 g/ha) (102.97 cm), followed by S_3 *i.e.* Consortium (1235 g/ha) (99.22 cm), S_4 *i.e.* AMF (1235 g/ha) (95.16 cm) and S_1 *i.e.* control (85.10 cm). The S_2 also had the highest number of tillers (322.14 tillers/m^2) and LAI (2.20). Boa *et al.* (2013) found that inoculating rice seedling with Azospirillum sp. B510 resulted in a substantial increase in plant height, tillers number and shoot length throughout growth in a rice field.

Interaction effect of nitrogen and microorganism

Results revealed that plant height (cm), number of effective tillers per m^2, leaf area index (LAI) was significantly influenced by combination of nitrogen levels and microbial inoculation treatments (Table 2). Treatment M_3S_2 *i.e.* N-60 kg/ha^{-1} along with Azosprillum (618 g/ha)+ Streptomyces (618 g/ha) recorded a significantly higher plant height (116.74 cm) followed by N-60 kg/ha^{-1} along with Consortium (1235 g/ha) (111.86 cm). Nitrogen is related to an enhancement in protoplasm, cell division and cell enlargement, which leads to taller plants (Chamely *et al.,* 2015). The number of effective tillers per m^2 had a similar trend to that of plant height. Treatment M_3S_2 *i.e.* N-60 kg /ha^{-1} along with Azosprillum (618 g/ha) + Streptomyces (618 g/ha) recorded a significantly higher number of effective tillers (354.13) followed by N-60 kg/ha^{-1} along with Consortium (1235 g/ha) (349.6). The tiller number showed a corresponding increase in response to higher nitrogen levels, shown by (Haque *et al.,* 2004). M_3S_2 produced maximum leaf area index (2.64) and the minimum leaf area index (1.58) was produced by M_1S_1. (Squire *et al.,* 1987) found that the primary impact of N fertilizer is to enhance the rate of leaf growth, resulting in more interception of daily solar radiation by the canopy.

Yield attributes

Effect of nitrogen

The study evaluated the effect of different nitrogen application levels (0, 40 and 60 N kg ha^{-1}) and microbial inoculation on various rice yield attributes. Significant differences were observed among the treatments (Table 3 and Table 5). Increasing nitrogen levels resulted in a higher number of grains per panicle, with the treatment M_3 *i.e.* 60 N kg ha^{-1} having the highest grains/panicle (80.64 grains/ panicle), followed by M_2 *i.e.* 40 N kg ha^{-1} (78.36 grains/ panicle) and M_1 *i.e.* 0 N kg ha^{-1} (70.85 grains/panicle). Panicle length also increased with nitrogen levels, with M_3 *i.e.* 60 N kg ha^{-1}, having the longest length of panicle (23.76 cm). The number of filled grains per panicle was highest in the treatment M_3 (110.81 filled grains/panicle), while the number of unfilled grains decreased with higher nitrogen levels, with M_1 (control) having the most unfilled grains/ panicle (24.85 grains/panicle). Treatment M_3 *i.e.* 60 N kg ha^{-1} had the highest test weight (22.30 g), grain yield (52.42 q ha^{-1}), straw yield (77.22 q ha^{-1}) and biological yield (129.65 q ha^{-1}), followed by the 40 N kg ha^{-1} (M_2) and 0 N kg ha^{-1} (M_1). Increases in panicle per hill, grains per panicle, filled grains per panicle and seed size were observed with an application of 60 kg N/ha, according to Haque *et al.* (2016). Additionally, the study found that dry matter translocation from vegetative to reproductive organ increased with increased nitrogen levels up to 60 kg N/ha.

Table 2: Interaction effect of nitrogen levels and microbial inoculants on growth parameters of rice (at harvest).

M_1	S_1	70.88^{h}	263.73^{g}	1.58^{i}
	S_2	89.48^{fg}	283.91^{f}	1.72^{h}
	S_3	87.9^{fg}	272.68^{g}	1.65^{hi}
	S_4	84.23^{g}	264.64^{g}	1.63^{hi}
M_2	S_1	90.99^{ef}	291.34^{f}	1.83^{g}
	S_2	102.68^{bc}	328.28^{c}	2.26^{d}
	S_3	97.9^{cd}	321.07^{cd}	2.18^{d}
	S_4	96.22^{de}	314.28^{d}	2.04^{e}
M_3	S_1	93.45^{def}	303.17^{e}	1.94^{f}
	S_2	116.74^{a}	354.13^{a}	2.64^{a}
	S_3	111.86^{a}	349.6^{ab}	2.50^{b}
	S_4	105.04^{b}	342.46^{b}	2.37^{c}
LSD (p=0.05)		3.97	6.69	0.06
Factor (A)		<0.0001	<0.0001	<0.0001
Factor (B)		<0.0001	<0.0001	<0.0001
Interaction		0.06	<0.0001	<0.0001

Signification codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05< .< 0.1 < ° < 1.

Effect of microorganism

Microbial inoculation showed significant impact on all treatments. The treatment S_2 *i.e.* Azospirullum (618 g/ha) + Streptomyces's (618 g/ha) (102.97 cm) had the highest number of grains per panicle (79.47 grains/panicle), the longest panicle length (22.51 cm) and the highest filled grains per panicle (104.48 grains/panicle). The control (S_1) had the highest number of unfilled grains (104.48 unfilled grains/panicle). The treatment S_2 had the highest test weight (21.64 g), grain yield (51.15 q ha^{-1}), straw yield (73.80 q ha^{-1}) and biological yield (124.96 q ha^{-1}). Azospirillum inoculation of rice seedling improved reproductive performance, increased tillering, grain yield. Both the grain yield and the weight of grain per plant during harvest have been found to be substantially increased Watanabe *et al.* (1984).

Interaction effect of nitrogen and microorganism

Data presented in (Table 4) revealed significant differences between nitrogen levels and microbial inoculation. The highest number of grains per panicle (84.17) was recorded at M_3S_2 (60 N ha^{-1} with azosprillum (618 g/ha)+ streptomyces (618 g/ha) and the lowest mean number of grains per panicle (67.97) was observed in M_1S_1 at the level (0 N kg ha^{-1}). However, 60 N ha^{-1}+ Consortium (1235 g/ha) and 60 N ha^{-1} + AMF (1235 g/ha) statistically at par for the number of grains per panicle. Haryanto *et al.* (2008) observed that, apart from tiller count, the length of the panicle and the weight of 1000 grains a higher total number of grains per panicle would also lead to an increase in rice yield. Among the different treatments, the longest panicle length was recorded at the level 60 kg N ha^{-1} with azosprillum (618 g/ha +streptomyces's (618 g/ha). Similarly results found that maximum panicle length by applying the maximum amount of nitrogen (Ghoneim *et al.,* 2018). Maximum filled grain per panicle was recorded at M_3S_2 *i.e.* (60 kg N ha^{-1} with azosprillum (618 g/ha)+streptomyces's (618 g/ha), were statistically at par with M_3S_3 (117.70) and the minimum filled grain (71.78) was observed in control without application of N kg ha^{-1}. These results agree with the observations

Table 3: Yield attributes of rice as influenced by nitrogen levels and microbial inoculants.

Treatments	No. of grains/panicle	Length of panicle (cm)	No. filled grains/panicle	No. unfilled grains/panicle
Nitrogen application levels				
M_1: N-0 kg ha^{-1}	70.85^b	18.90^c	77.29^c	24.85^a
M_2: N-40 kg ha^{-1}	78.36^a	22.48^b	96.11^b	20.10^b
M_3: N-60 kg ha^{-1}	80.64^a	23.76^a	110.81^a	17.11^c
Microbial inoculation				
S_1: Control	72.06^b	20.77^b	82.02^b	24.04^a
S_2: Azosprullum (618 g/ha)+Streptomyces's (618 g/ha)	79.47^a	22.51^a	104.48^a	18.28^c
S_3: Consortium (1235 g/ha)	78.03^a	21.86^a	98.63^a	19.58^{bc}
S_4: AMF (1235 g/ha)	76.93^a	21.72^{ab}	93.82^a	20.86^b
SD	5.85	2.34	19.44	4.32
S.Em(±)	0.97	0.39	3.24	0.72

Table 4: Interaction effect of nitrogen levels and microbial inoculants on yield attributes of rice.

M_1	S_1	67.97^e	18.6^d	18.6^d	18.6^d
	S_2	72.73^{cde}	19.4^d	19.4^d	19.4^d
	S_3	71.63^{de}	18.86^d	18.86^d	18.86^d
	S_4	71.09^{de}	18.76^d	18.76^d	18.76^d
M_2	S_1	73.80^{cd}	21.26^c	21.26^c	21.26^c
	S_2	81.51^{ab}	23.46^{ab}	23.46^{ab}	23.46^{ab}
	S_3	80.40^{ab}	22.66^{bc}	22.66^{bc}	22.66^{bc}
	S_4	77.76^{bc}	22.53^{bc}	22.53^{bc}	22.53^{bc}
M_3	S_1	74.40^{cd}	22.46^{bc}	22.46^{bc}	22.46^{bc}
	S_2	84.17^a	24.66^a	24.66^a	24.66^a
	S_3	82.06^{ab}	24.06^{ab}	24.06^{ab}	24.06^{ab}
	S_4	81.93^{ab}	23.86^{ab}	23.86^{ab}	23.86^{ab}
LSD (p=0.05)		3.76	1.14	1.14	1.14
Factor (A)		<0.0001	<0.0001	<0.0001	<0.0001
Factor (B)		<0.0001	0.01	0.01	0.01
Interaction		0.83	0.85	0.85	0.85

Signification codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05< .< 0.1 < ° < 1.

made by (Bokado *et al.,* 2020). Under the nitrogen levels, increasing nitrogen at the levels (60 N kg ha^{-1}) led to a decrease in the number of unfilled grains per panicle (13.99) and decreasing nitrogen at the levels (0 N kg ha^{-1}) led to a increases in the number of unfilled grain per panicle (26.20). These results are similar to the findings of Metwally *et al.,* (2010).

The grain yield of rice was significantly influenced by different nitrogen levels and microbial inoculants combinations (Table 6). The maximum grain yield (54.30 q ha^{-1}) recorded at M_3S_2 under the treatment 60 N kg ha^{-1} with azosprillum (618 g/ha) + streptomyces (618 g/ha) followed by M_3S_3 (54.02 q ha^{-1}) 40 N kg ha^{-1} + consortium (1235 g/ha). The increases in grain yield may be attributed to the application of nitrogen, which enhances the production of dry matter and improves the growth rate of rice, enhancing the elongation of internodes and stimulating the action of growth hormones like as gibberellins. The results are corroborated by the findings of Singh *et al.,* (2000). The abundant growth of advantageous microorganisms, such as unusual acidobacteria and actinobacteria, significantly improved the rice yields Prior research has shown the beneficial function of these substances in safeguarding plant development and enhancing nutrient absorption (Kumari *et al.,* 2019). However, the maximum straw yield was recorded in M_3S_2 (80.42 q ha^{-1}) at a level (60 N kg ha^{-1}) as followed by M_3S_3 (78.85 q ha^{-1}) at a level (40 N kg ha^{-1}. The results confirmed by the findings of (Murthy *et al.,* 2012), which indicated that higher nitrogen levels had a significant beneficial influence on all aspects of rice production, including yield characteristic, grain yield and straw yield. Maximum 1000-grain weight (24.64 g) was observed in M_3S_2 (60 kg N ha^{-1} with azosprillum (618 g/ha)+ streptomyces's (618 g/ha) and the minimum 1000-grain weight (17.87 g) was recorded in M_1S_1 at the level (0 N kg ha^{-1}).

Protein content (%) in grains and straw

The results showed that protein content in grains and straw was significantly influenced by nitrogen levels and microbial inoculation among the different treatments. The protein

Table 5: Effect of nitrogen application levels and microbial inoculation on rice yield and biomass parameters.

Treatments	Test weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})
Nitrogen application levels				
M_1: (N-0 kg ha^{-1})	18.51^c	45.43^c	62.83^c	108.26^c
M_2: (N-40 kg ha^{-1})	20.24^b	49.89^b	73.66^b	123.55^b
M_3: (N-60 kg ha^{-1})	22.30^a	52.42^a	77.22^a	129.65^a
Microbial inoculation				
S_1: (Control)	18.83^c	46.58^c	67.40^c	113.98^c
S_2: (Azosprullum (618 g/ha)+Streptomyces's (618 g/ha)	21.64^a	51.15^a	73.80^a	124.96^a
S_3: (Consortium (1235 g/ha)	20.81^{ab}	50.06^{ab}	72.35^b	122.41^b
S_4: (AMF (1235 g/ha)	20.12^b	49.1^b	71.40^b	120.59^b
SD	2.18	3.71	6.74	10.23
S.Em(±)	0.36	0.61	1.12	1.70

Table 6: Interaction effect of nitrogen levels and microbial inoculants on rice yield and biomass parameters.

M_1	S_1	17.87^g	43.61^g	59.26^h	102.88^j
	S_2	18.87^{efg}	46.82^{def}	65.44^f	112.27^h
	S_3	18.73^{efg}	45.97^{efg}	63.77^{fg}	109.74^{hi}
	S_4	18.58^{fg}	45.31^{fg}	62.86^g	108.17^i
M_2	S_1	19.23^{efg}	47.84^{cdef}	70.90^e	118.75^g
	S_2	21.41^{bcd}	52.34^{ab}	75.54	127.88^{cd}
	S_3	20.51^{cde}	50.21^{bc}	74.43^c	124.64^{de}
	S_4	19.79^{def}	49.15^{cd}	73.77^{cd}	122.93^{ef}
M_3	S_1	19.4^{efg}	48.27^{cde}	72.04^{de}	120.32^{fg}
	S_2	24.64^a	54.30^a	80.42^a	134.72^a
	S_3	23.17^{ab}	54.02^a	78.85^{ab}	132.87^{ab}
	S_4	22.00^{bc}	53.11^a	77.58^c	130.69^{bc}
LSD (p=0.05)		1.21	1.82	1.20	2.42
Factor (A)		<0.0001	<0.0001	<0.0001	<0.0001
Factor (B)		<0.0001	<0.0001	<0.0001	<0.0001
Interaction		0.06	0.36	0.11	0.13

Signification codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05< .< 0.1 < °< 1.

content in grains varied from 7.71 to 8.73%, while in straw varied from 3.68 to 5.83%. The maximum protein content (8.73%) was obtained in M_3S_2 at the level [60 kg N ha^{-1}with azosprillum (618 g/ha) + streptomyces's (618 g/ha] followed by M_3S_3(8.55%) at the level (60 kg N ha^{-1}with consortium (1235 g/ha). The minimum protein content (7.71%) was found in control (without N application). Similarly, the maximum protein content in straw (5.78%) was obtained in M_3S_2 at the level [60 kg N ha^{-1} with azosprillum (618 g/ha) + streptomyces's (618 g/ha)) followed by M_3S_3 (5.67%) at the level (60 kg N ha^{-1} with consortium (1235 g/ha]. The minimum protein content (3.68%) was recorded in M_1S_1 at the level (0 N kg ha^{-1}). These results are similar to the findings of Perez *et al.* (1996).

CONCLUSION

The concluded that application of 60 N kg ha^{-1} along with Azospirullum (250 g/acre)+Streptomyces's (618 g/ha) significantly enhanced the grain yield and yield attributes. Applying the appropriate dose of nitrogen fertilizer along with microbial treatments has favored crucial aspect in enhancing rice grain production, while a recommendation for the most effective utilization quantity is made, more analysis is needed.

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Conflict of interest

The authors declare no conflict of interest.

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