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Effect of *in-situ* green manuring and integrated nutrient management on growth and yield of transplanted rice

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ABSTRACT

A field experiment was conducted on clay soils during the *kharif* season of 2024-2025 at the Agricultural Research Station, Ghantasala, Andhra Pradesh, to assess the effects of *in-situ* green manuring and integrated nutrient management (INM) on growth and yield of transplanted rice (*Oryza sativa* L.). The study utilized a split-plot design with four main green manure treatments, M_1: Control (Fallow), M_2: Dhaincha (*Sesbania bispinosa* L.), M_3: Sunnhemp (*Crotalaria juncea* L.), M_4: Greengram (*Vigna radiata* L.) and four subplot INM treatments, S_1: 100% Recommended Dose of Nitrogen [RDN], S_2: 75% RDN, S_3: 75% RDN + Biofertilizer (*Azospirillum*), S_4: 50% RDN + Bio-fertilizer (*Azospirillum*). In-situ incorporation of Dhaincha (M_2) significantly enhanced plant height at maturity (59.3 cm), drymatter accumulation (700 kg ha^{-1}), productive tillers (319 m^{-2}) and grain yield (6166 kg ha^{-1}) compared to the control (M1: 47.2 cm, 404 kg ha^{-1}, 261 m^{-2}, 4695 kg ha^{-1}) and it was on par with in-situ incorporation of sunnhemp. Among INM treatments, 100% RDN (S_1) recorded the highest values (59.4 cm, 689 kg ha^{-1}, 316 m^{-2}, 6033 kg ha^{-1}), closely followed by 75% RDN + Biofertilizer (*Azospirillum*) (S_3). These findings suggest that integrating Dhaincha green manuring with 75% RDN + Biofertilizer (*Azospirillum*) optimizes rice growth and yield.

Keywords: *Growth,, In-situ green manuring, INM, Productive tillersm and Rice yield*

Rice (*Oryza sativa* L.) is a critical staple crop, supporting nearly half the global population, particularly in Asia, where it accounts for 90% of global consumption (Ministry of Agriculture & Farmers Welfare, 2023). In India, rice is cultivated over 47.82 million hectares, with an average yield of 2,882 kg ha^{-1}. The indiscriminate and excessive use of chemical fertilizers adversely affects beneficial soil microbial communities, accelerating mineralization of soil organic carbon and results in the depletion of soil organic carbon Singh B., 2018 and it leads to declining in soil fertility and low nitrogen use efficiency (30–50 %) challenging sustainable production. In view of sustenance of productivity & soil health, adoption of a holistic approach of Integrated Nutrient Management (INM) *i.e.,* supplementing the nutrition requirement of the crop through the application of bio-fertilizers, green manures along with synthetic fertilizers, should be the prime concern in the present day agriculture.

Significant nitrogen needs of the rice crop can be met by growing wide range of leguminous green manure crops, *viz*., *Dhaincha*, S*unhemp*, G*reengram* as they contain 3.50%, 2.30% and 1.67% nitrogen content on dry weight basis respectively and have the nitrogen fixing ability Ramanjaneyulu *et al*., 2021. *Azospirillum* promotes the plant growth through the production of hormones such as indole-3-acetic acid (IAA), cytokinins, gibberellins, and abscisic acid which will increase the plant bio mass led to enhanced crop yield Anamalagundam *et al*. 2022. Application of biofertilizer when combined with moderate levels of chemical fertilizer enhanced the crop growth and yield of rice Rodrigues *et al*., 2009.

This study evaluates the impact of in-situ green manuring and INM on these key parameters in transplanted rice during the kharif season of 2024-2025 in Andhra Pradesh.

MATERIAL AND METHODS

The experiment was conducted at the Agricultural Research Station, Ghantasala, Krishna District, Andhra Pradesh during the *kharif* season of 2024-2025. The soil was clayey, neutral in pH, with medium organic carbon, low nitrogen, medium

phosphorus and potassium. A split-plot design with three replications was employed, with four main plot green manure treatments (M_1: Control (Fallow), M_2: Dhaincha *Sesbania bispinosa* L., M_3: Sunnhemp *(Crotalaria juncea* L.), M_4: Greengram (*Vigna radiata* L.) and four subplot INM treatments, S_1: 100% Recommended Dose of Nitrogen [RDN], S_2: 75% RDN, S_3: 75% RDN + Biofertilizer (*Azospirillum*), S_4: 50% RDN + Bio-fertilizer (*Azospirillum*). Green manure crops were sown at 45 kg ha^{-1} in June 2024 and incorporated at 45 days after sowing using a power tiller. The rice variety MTU 1061 (Indra) was transplanted (20 cm × 15 cm spacing, 2–3 seedlings per hill) after nursery raising. Nitrogen (urea) was applied in three splits (basal, active tillering, panicle initiation), phosphorus (single super phosphate) basally, and potassium (muriate of potash) split between basal and flowering stages. Azospirillum (1.25 L ha^{-1}) with FYM was applied one week after transplanting.

Plant Height was measured at maturity from ground level to the panicle tip on five tagged plants per plot, expressed in cm Table 1. Drymatter Accumulation recorded from five plants per plot at maturity were oven-dried at 60°C to constant weight, expressed in kg ha^{-1} Table 1. Productive Tillers: Counted using a quadrant at harvest, expressed as m^{-2} Table 2. Grain Yield: Net plots were harvested, sun-dried, threshed, and weighed, expressed in kg ha^{-1} Table 2. Data were analysed using ANOVA Panse and Sukhatme, 1978 with significance tested at $P < 0.05$.

RESULTS AND DISCUSSIONS

Plant height

In-situ incorporation dhaincha (M_2) recorded the highest plant height at maturity (128 cm), statistically comparable to Sunnhemp (M_3: 124 cm) but significantly superior to Greengram (M_4) and control (M_1: 101 cm) Table 1. This might be due to

Table 1. Plant height (cm) and dry matter accumulation (kg ha^{-1}) of rice at different growth stages as influenced by green manure *in-situ* and INM

Treatments		Plant height (cm)	Dry matter accumulation (kg ha-1)
Main plot: Green manure crops			
M_1	Control (Fallow)	101	11920
M_2	Dhaincha (*Sesbania bispinosa* L.)	128	14371
M_3	Sunhemp (*Crotalaria juncea* L.	124	14103
M_4	Greengram (*Vigna radiata* L.)	112	13015
SEm±		2.8	313
CD (P=0.05)		9.5	1085
CV (%)		8.2	8.1
Sub plot: Integrated Nutrient Management			
S_1	100% RDN	124	14185
S_2	75% RDN	105	12822
S_3	75% RDN + Bio-fertilizer (Soil application of *Azospirillum* along with FYM)	123	13872
S_4	50% RDN + Bio-fertilizer (Soil application of *Azospirillum* along with FYM)	114	11929
SEm±		2.5	292.7
CD (P=0.05)		7.3	855
CV (%)		7.4	7.7
Interaction			
SEm+		5	585.55
CD (P=0.05)		NS	

dhainchas high nitrogen fixation (113.8 kg ha^{-1}) and organic matter addition, improving soil fertility and nutrient availability Ramanjaneyulu *et al.,* 2021. These results are similar with Sree *et al*., 2016 and Premalatha *et al*., 2017. Among INM treatments, 100% RDN (S_1) achieved the highest plant height (124 cm), followed by 75% RDN + Azospirillum (S3: 123 cm) both significantly outperforming 75% RDN (S_2) and 50% RDN + Azospirillum (S_4). It might be due to adequate supply of nitrogen through 100% RDN Which enhances the plant height. These results are in accordance with Chhabra *et al*., 2022 and Vineela *et al*., 2023.

Drymatter Accumulation

Dhaincha (M2) recorded significantly highest drymatter accumulation (14371 kg ha^{-1}), comparable to Sunnhemp (M3) but significantly higher than control (M1: 11920 kg ha^{-1}) at maturity Table 1. Among INM treatments, 100% RDN (S1) achieved 689 kg ha^{-1}, statistically similar to 75% RDN + Azospirillum (S3: 647 kg ha^{-1}), both outperforming 75% RDN (S2: 408 kg ha^{-1}). This might be due to increased availability as well as assimilation of nitrogen by the crop plants throughout the grand growth period led to the greater dry matter production by roots, stem, leaves and grains, which enhanced the overall dry weight production. The research findings are in comparable with other scientists like Vineela *et al*., 2023

Productive tillers

In-situ incorporation of dhaincha (M_2) produced the highest number of productive tillers (319 m^{-2}), comparable to Sunnhemp (M_3) but significantly higher than control (M_1: 261 m^{-2}) Table 2. Increase in productive tillers per square meter of rice might be due to more residual effect of biological N-fixed in the root nodules of previous green manuring crop. These results are in accordance with the findings of Pooniya and Shivay 2011. Among INM treatments, 100% RDN (S_1) recorded 316 m^{-2}, statistically similar to 75% RDN + Azospirillum (S_3: 310 m^{-2}), both

Table 2. Productive tillers (m^{-2}), grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of rice as influenced by green manure *in-situ* and INM

Treatments		Productive tillers (m-2)	Grain yield (kg ha-1)	Straw yield (kg ha-1)
Main plot: Green manure crops				
M_1	Control (Fallow)	261	5795	44.7
M_2	Dhaincha (*Sesbania bispinosa* L.)	319	7266	45.9
M_3	Sunhemp (*Crotalaria juncea* L.	314	7111	45.8
M_4	Greengram (*Vigna radiata* L.)	287	6603	45.1
SEm±		2.9	147.1	217
CD (P=0.05)		26	509	509
CV (%)		8.8	9.2	7.6
Sub plot: Integrated Nutrient Management				
S_1	100% RDN	316	6033	7156
S_2	75% RDN	266	4973	6096
S_3	75% RDN + Bio-fertilizer (Soil application of *Azospirillum* along with FYM)	310	5862	6984
S_4	50% RDN + Bio-fertilizer (Soil application of *Azospirillum* along with FYM)	289	5416	6539
SEm±		2.8	149.8	160
CD (P=0.05)		21	437	437
CV (%)		8.6	9.3	7.8
Interaction				
SEm+		5.7	299.6	321
CD (P=0.05)		NS		

superior to 75% RDN (S_2: 266 m^{-2}). This could be attributed to adequate nitrogen supporting cellular processes during panicle initiation and development, led to a higher number of panicle bearing tillers per square meter Bokado *et al*., 2020.

Grain yield

Dhaincha incorporation (M_2) yielded the highest grain yield (6166 kg ha^{-1}), statistically comparable to Sunnhemp (M_3: 5981 kg ha^{-1}) but significantly superior to control (M1: 4695 kg ha^{-1}) Table 2. As the plant's vegetative portion acts as a source and the productive tillers bearing fertile spikelet's as a sink, the total dry matter accumulation might have profound influence on economic yield Dhiman *et al*., 2000. These results are in confirmation with the findings of These results are in confirmation with the findings of Lakshmi *et al*., 2021, Song *et al*., 2022 and Kamboj *et al*., 2024.

Among INM treatments, 100% RDN (S_1) recorded 6033 kg ha^{-1}, comparable to 75% RDN + Azospirillum (S_3: 5862 kg ha^{-1}), both outperforming 75% RDN (S_2: 4973 kg ha^{-1}). This can be attributed due to higher growth and yield attributing characters viz. number of tillers (m^2). These recordings were in accordance with the findings of Singh *et al*., 2022 and Chhabra *et al*., 2023.

Straw yield

Dhaincha incorporation (M_2) yielded the highest straw (7266 kg ha^{-1}) yield, significantly superior to control (M1: 5795 kg ha^{-1}) Table 2. Increased growth and drymatter accumulation by incorporation of green manure might have resulted in the more straw yield. Similar findings were also registered by Song *et al*., 2022 and Kamboj *et al*., 2024. Among INM treatments, 100% RDN (S1) achieved 6033 kg ha^{-1} grain and 7156 kg ha^{-1} straw, comparable to S3 (5862 kg ha^{-1} grain, 6984 kg ha^{-1} straw). A rise in plant height, number of tillers per hill, and dry matter accumulation is evident with the balanced and optimal use of fertilizers, ultimately leading to increased straw yield. These findings are comparable with the findings of other research scientists like Chhabra *et al*., 2023 and Vineela *et al*., 2023.

CONCLUSION

In-situ incorporation of Dhaincha, followed by Sunnhemp, significantly improved plant height, dry matter accumulation, productive tillers and grain yield of rice. Among INM treatments, 100% RDN and 75% RDN + Azospirillum were most effective. Combining Dhaincha with 75% RDN + Azospirillum is recommended for optimizing rice productivity and sustainability in the Krishna Eastern Delta region.

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