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Growth dynamics of direct-seeded rice (*Oryza sativa* L.) under brown manuring timing and nitrogen levels

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Abstract

The present field study was conducted at the Agricultural College Farm, Bapatla, Andhra Pradesh during the kharif seasons of 2024 and 2025 using a randomized block design which was replicated three. There were total of seven treatments and the details were as follows: M₁ - 100% RDN, M₂ - 75% RDN + Brown manuring with sunnhemp at 30 DAS, M₃ - 100% RDN + Brown manuring with sunnhemp at 30 DAS, M₄-125% RDN + Brown manuring with sunnhemp at 30 DAS, M₅ - 75% RDN + Brown manuring with sunnhemp at 45 DAS, M₆ - 100% RDN + Brown manuring with sunnhemp at 45 DAS and M₇-125% RDN + Brown manuring with sunnhemp at 45 DAS. Rice crop was grown under semi-dry conditions during both the years. The treatment employed under study has significantly influenced the growth attributes of rice. From pooled analysis, significantly the highest plant height (115.5 cm), tiller numbers per m² (435) and drymatter accumulation (13544 kg ha⁻¹) was recorded in M₄ (125% RDN + Brown manuring with sunnhemp at 30 DAS) which was not comparable with any of the treatments studied. The next best performance was reported with M₃ and M₇ which showed similarity with each other in case of both plant height (101.5, 100.6 cm) tiller number per m²(386 and 383) and drymatter accumulation (11849, 11812 kg ha⁻¹). The lowest performance (plant height of 68.6 cm, 270 tillers per m² and drymatter of 7797 kg ha⁻¹) was observed with 75% RDN + Brown manuring with sunnhemp at 45 DAS.

Keywords: Brown manuring, rdn, sunnhemp, rice, semi-dry, plant height, tiller number, drymatter accumulation, pooled analysis

Introduction

Rice is the dominant cereal crop which is the major food source for nearly half of the global population and is the principal source of calories for people across Asia. In India, it is grown approximately in 46.38 million ha, with an annual production of 130.29 million tonnes and an average productivity of 2.81tha⁻¹. Rice cultivation in Andhra Pradesh covers about 2.25 million ha, producing 7.79 million tonnes with a mean productivity of 3.47tha⁻¹ (Ministry of Agriculture & Farmers Welfare, Directorate of Economics & Statistics, 2024) ^[1].

In the Krishna agro-climatic zone, cultivation of rice is frequently constrained by the erratic onset of the southwest monsoon and delayed canal water supply. These conditions often postpone transplanting operations, forcing farmers to use over-aged seedlings resulting in poor establishment and ultimately reduced grain yield. Moreover, the conventional puddled transplanted rice system requires large quantities of water and labor, degrades soil structure, restricts the growth of succeeding upland crops and contributes to greenhouse gas emissions, particularly methane (Denman *et al.*, 2007) ^[2]. These challenges have intensified the need for production technologies that improve resource-use efficiency while sustaining crop productivity. The substantial gains in agricultural production achieved during the green revolution were largely supported by increased fertilizer consumption, especially nitrogen fertilizers. However, continuous reliance on high fertilizer inputs without adequate organic amendments has resulted in nutrient imbalances, declining soil quality and reduced fertilizer-use efficiency. Therefore, integrating organic nutrient sources with inorganic fertilizers has become an important strategy for maintaining soil fertility and ensuring long-term agricultural sustainability. Among the available crop establishment options, direct-seeded rice (DSR) has attracted considerable attention because it requires less water and labor than conventional transplanting.

When combined with brown manuring, DSR promotes efficient nutrient recycling, suppresses weeds, enhances soil biological activity and improves the sustainability of rice-based production systems.

In this context the present investigation was carried out to find the suitable nutrient management options for direct sown rice in combination with brown manuring with particular emphasis on growth attributes of rice.

Materials and Methods

The present investigation was carried out in the Agricultural College Farm, Bapatla, Andhra Pradesh during kharif season, 2024 and 2025. The experimental site is situated at an altitude of 5.49 meters above the mean sea level, with 15 ° 54, North latitude, 80 ° 25 ' East longitude and about 8 km away from the Bay of Bengal in the Krishna Agro-Climatic Zone of Andhra Pradesh state in India. It is located in upland coastal area of the Krishna Agro Climatic Zone of Andhra Pradesh. The experiment was laid out in randomized block design and it was replicated thrice. A total of seven treatments was employed under the study which includes M₁ - 100% RDN, M₂-75% RDN + Brown manuring with sunnhemp at 30 DAS, M₃-100% RDN + Brown manuring with sunnhemp at 30 DAS, M₄-125% RDN + Brown manuring with sunnhemp at 30 DAS, M₅-75% RDN + Brown manuring with sunnhemp at 45 DAS, M₆-100% RDN + Brown manuring with sunnhemp at 45 DAS and M₇-125% RDN + Brown manuring with sunnhemp at 45 DAS as treatments. The results of the soil analysis revealed that the experimental soil was sandy clay loam in texture, neutral in reaction, non-saline, low in organic carbon content, low in available nitrogen,

medium in available phosphorous, medium in available potassium. The variety used in the study was BPT-5204. Sunnhemp was grown as a co-crop with direct-seeded rice for brown manuring. Seeds were manually broadcast in the respective treatment plots after rice sowing, and the crop was terminated by spraying 2,4-D at 0.5 kg ha⁻¹ at 30 or 45 DAS using a spray volume of 500Lha⁻¹, as per the treatments. The recommended dose of fertilizer for paddy was 120-60-40 kg NPK ha⁻¹. The nitrogen was applied as per the doses in respective treatments. Plant height and tiller number per m² was recorded from five randomly tagged plants in each treatment in all three replications. At harvest, the height was recorded from base of the plant to the tip of the panicle. The mean values were computed and expressed as plant height in cm. Total number of tillers per sampled plant was calculated in each treatment at harvest using quadrants and then averaged to obtain number of tillers m⁻²

Results and Discussion

Plant height(cm)

Significantly the highest plant height at harvest (Table 1) was recorded with 125% RDN + brown manuring of sunnhemp at 30 DAS (M₄) i.e., 113.9, 117.1 and 115.5 cm during 2024, 2025 and in pooled data respectively. 100% RDN + brown manuring of sunnhemp at 30 DAS (M₃) and 125% RDN + brown manuring of sunnhemp at 45 DAS (M₇) showed similarity with each other and were significantly inferior to M₄. The inferior performance with respect to plant height was noticed with M₅-75% RDN+ brown manuring of sunnhemp at 45 DAS (69.8, 76.0 and 72.9 cm).

Table 1: Plant height (cm) at harvest of direct seeded rice as influenced by time of brown manuring and varied nitrogen levels during kharif 2024, 2025 and in pooled data

Treatments	2024	2025	Pooled data
M ₁ -100% RDN	69.8	76.0	72.9
M ₂ -75% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	66.8	74.6	70.7
M ₃ -100% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	99.2	103.9	101.5
M ₄ -125% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	113.9	117.1	115.5
M ₅ -75% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	64.6	72.5	68.6
M ₆ -100% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	84.2	89.3	86.7
M ₇ -125% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	98.3	102.9	100.6
S. Em±	4.2	4.0	4.1
CD (p=0.05)	13.0	12.3	12.6
CV (%)	8.6	7.6	8.0

The greater plant height of rice under M₄ may be attributed to the combined effect of higher nitrogen availability and brown manuring, which ensured a sustained supply of nutrients during the vegetative phase. The decomposition of sunnhemp biomass following its knockdown improved nitrogen availability, suppressed weed competition and promoted vigorous vegetative growth, resulting in increased plant height. Similar findings were reported by Chaudhary *et al.* (2022) [3], who observed significantly greater growth and productivity of direct-seeded rice under sunnhemp brown manuring and by Singh *et al.* (2023) [4], who reported enhanced crop growth under integrated nitrogen and brown manuring practices in dry direct-seeded rice.

Tiller number per m²

125% RDN + brown manuring of sunnhemp at 30 DAS (M₄) registered maximum tillers of 418, 452 and 435 m⁻² during 2024, 2025 and in pooled analysis during the harvest of rice

crop. This was followed by 100% RDN + brown manuring of sunnhemp at 30 DAS and 125% RDN + brown manuring of sunnhemp at 45 DAS which showed similarity with each other and was superior to 100% RDN + brown manuring of sunnhemp at 45 DAS.

The lower tiller number of 260, 279 and 270m⁻² was realized when the rice crop was treated with 75% RDN + brown manuring of sunnhemp at 45 DAS (M₅) and it showed similarity with 75% RDN + brown manuring of sunnhemp at 30 DAS and 75% RDN + brown manuring of sunnhemp at 45 DAS (Table 2).

The higher number of tillers under M₄ may be attributed to the timely termination of the brown manure crop at 30 DAS, which synchronized nutrient release with the active tillering phase of rice.

The decomposition of sunnhemp biomass supplemented the applied nitrogen and improved nitrogen availability during the critical period of tiller initiation, thereby enhancing the

emergence and survival of productive tillers. In addition, early brown manuring effectively suppressed weeds, minimizing

competition for light, moisture and nutrients and enabling greater assimilate allocation to tiller development.

Table 2: Number of tillers m⁻² at harvest of direct seeded rice as influenced by time of brown manuring and varied nitrogen levels during kharif 2024, 2025 and in pooled data

Treatments	2024	2025	Pooled data
M ₁ -100% RDN	281	298	290
M ₂ -75% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	268	294	281
M ₃ -100% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	370	401	386
M ₄ -125% RDN+BrownmanuringwithsunnhempaT ₃ 0DAS	418	452	435
M ₅ -75% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	260	279	270
M ₆ -100% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	325	348	336
M ₇ -125% RDN+BrownmanuringwithsunnhempaT ₄ 5DAS	369	397	383
S.E.m±	13.6	15.6	13.9
CD (p=0.05)	42	48	43
CV (%)	7.2	7.6	7.1

Singh *et al.* (2023) [4] reported that integrating brown manuring with appropriate nitrogen management significantly improved crop growth and productive tillering in direct-seeded rice. Chaudhary *et al.* (2022) [3] also observed that sunnhemp brown manuring enhanced tiller production through improved nutrient availability and reduced weed interference. Further, De *et al.* (2024) [5] attributed higher tiller numbers under brown manuring to improved crop vigor resulting from timely biomass decomposition and nutrient release, while Sahoo *et al.* (2024) [6] emphasized that effective weed suppression under brown manuring improved resource-use efficiency and increased productive tillers in rice-based cropping systems.

Drymatter Accumulation (kg ha⁻¹)

Drymatter accumulation (Fig. 1) at harvest of rice crop was influenced prominently by the various brown manuring practices tested under the current study. At harvest (13238, 13851 and 13544 kg ha⁻¹) treatment 125% RDN + brown manuring of sunnhemp at 30 DAS (M₄) significantly highest drymatter accumulation during 2024, 2025 and in pooled data respectively. The lowest values were recorded in M₅(75% RDN + brown manuring of sunnhemp at 45 DAS) during both the years of the study.

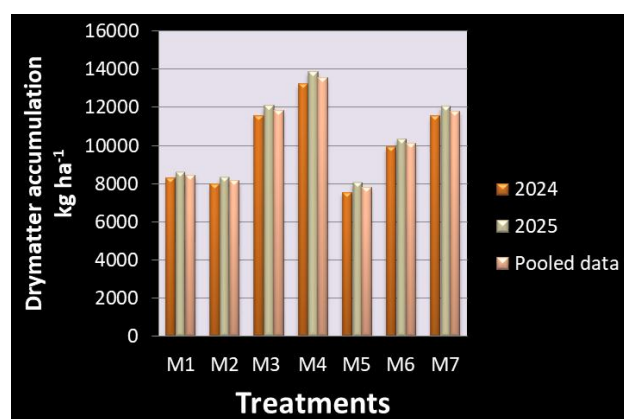


Fig 1: Drymatter accumulation at harvest of direct seeded rice as influenced by time of brown manuring and varied nitrogen levels during kharif 2024, 2025 and in pooled data

The significantly higher dry matter accumulation under supra-optimal nitrogen application (125% RDN) combined with brown manuring of sunnhemp at 30 DAS could be attributed to synchronized nitrogen availability from inorganic fertilizer and the rapid mineralization of young sunnhemp residues, which

enhanced chlorophyll synthesis, leaf area expansion, photosynthetic efficiency, and assimilate production.

Early brown manuring also minimized crop–green manure competition while stimulating microbial activity and nutrient cycling, thereby promoting greater biomass accumulation. Similar findings were reported by Choudhary *et al.* (2018) [7] observed enhanced biomass production in direct-seeded rice with early brown manuring due to improved nutrient synchronization and. Adequate nitrogen availability coupled with green manuring significantly increased dry matter accumulation by improving nutrient use efficiency and photosynthetic capacity (Choudhary *et al.*, 2019) [8]. Likewise, Sun *et al.* (2019) [9] demonstrated that decomposition of crop residues accelerated phosphorus mineralization, microbial activity, and overall crop growth.

The lowest dry matter accumulation under sub-optimal nitrogen application (75% RDN) combined with brown manuring of sunnhemp at 45 DAS might be attributed to inadequate nitrogen availability, prolonged crop–sunnhemp competition, and delayed nutrient mineralization from relatively mature residues with a wider C ratio, which collectively restricted nutrient uptake, photosynthesis, and biomass production. Similar findings were reported by Gentile *et al.* (2008) [10] and Mohanty *et al.* (2022) [11], who observed that reduced nitrogen supply and slower decomposition of mature crop residues lowered dry matter accumulation due to poor synchronization between nutrient release and crop demand.

Conclusion

Brown manuring in conjunction with appropriate nitrogen management significantly improved the growth of direct-seeded rice. Brown manuring at 30 DAS along with 125% RDN (M₄) recorded the greatest plant height, maximum number of productive tillers, and drymatter accumulation indicating that timely brown manure termination synchronized nutrient release with the crop's vegetative demand while reducing crop–weed competition. These findings demonstrate that integrating brown manuring with optimum nitrogen fertilization is an effective strategy for promoting vigorous crop growth and improving the establishment of yield-contributing traits in direct-seeded rice.

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