Effect of Brown Manuring on Enhancing Growth, Physiology, and Yield in Direct Wet-Seeded Rice

ABSTRACT

Aim: To evaluate the effect of brown manuring on the growth parameters, physiological attributes, and yield of direct wet-seeded rice. It investigates key agronomic and physiological responses under different brown manuring treatments.

Study design: The study was laid out in a Randomized Block Design (RBD) with ten treatments and three replications, comparing rice alone with different brown manuring treatments.

Place and duration: A field experiment was conducted during the *Rabi* season of 2024 at the Instructional South farm of Karunya Institute of Technology and Sciences, Coimbatore.

Results: The results revealed that, at 30 DAS there was no significant differences observed among the treatments. At 60, 90 DAS and at harvest, the weed-free check (T_9) recorded the highest growth parameters *viz.,* plant height (117.2, 141.5 and 139.0 cm), tiller count (26, 33 and 31 tiller hill^{-1}), and dry matter production (4276, 13732 and 23132 kg ha^{-1}), physiological attributes *viz.,* LAI (3.65, 5.81 and 3.08), CGR (3.84, 11.60 and 9.08 g m^{-2} day^{-1}), and RGR (0.0572, 0.0431 and 0.0229 g g^{-1}day^{-1}) and yield were also significantly higher with a grain yield (6046 kg ha^{-1}) and straw yield (10801 kg ha^{-1}), which was statistically comparable to T_6 (pretilachlor 50% EC at 1.25 L ha^{-1}+ knockdown of *dhaincha* using 2,4-D 38% EC at 1 kg ha^{-1} at 30 DAS) over the unweeded control (T_{10}). This study concludes that integrating brown manuring with a post-emergence herbicide effectively suppressed weeds while the decomposed *dhaincha* residue served as a growth stimulant, ultimately improving crop growth and yield in direct wet-seeded rice.

Keywords: Brown manuring, Direct wet-seeded rice, Growth components, Physiological parameters, and Yield

1. INTRODUCTION

Rice is a staple food crop for over half of the global population, particularly in South and Southeast Asia. It covers approximately 11% of the world's agricultural land, making it the second most widely cultivated crop (Haque *et al.,* 2021). In India, rice is grown on approximately 47.60 million hectares, yielding a total production of 136.7 million tonnes with an average productivity of 2.39 tonnes per hectare in the 2023-2024 (Rao *et al.,* 2024). Transplanting remains a conventional rice cultivation method widely practiced in many rice-growing regions. However, key operations such as nursery preparation and maintenance, seedling uprooting, transportation, distribution in the main field, and transplanting contribute to 30-40% of the total cultivation cost (Aravinth *et al.,* 2022). Direct-seeded rice (DSR) presents a viable alternative to traditional transplanting, offering benefits such as reduced labour demand, water conservation and lower greenhouse gas (GHG) emissions. Weeds are a significant constraint in the DSR system (Ojha *et al.,* 2023). Brown manuring is an effective method to reduce weeds under DSR condition. It is a no-till version of green manuring, where the cover crop is terminated using an herbicide before flowering instead of being incorporated into the soil (Tanwar *et al.,* 2010). It minimizes soil moisture evaporation and adds 20-35 kg N ha^{-1} to the soil, enhancing its physicochemical properties, growth attributes and yield without significantly increasing cultivation costs (Aravinth *et al.,* 2022). Considering this, the present study was undertaken to evaluate the impact of brown manuring on growth components, physiological parameters and yield in direct wet-seeded rice.

2. MATERIALS AND METHODS

2.1 Experimental site

A field experiment was conducted at Karunya Institute of Technology and Sciences, Coimbatore, Tamil Nadu (10°93'N latitude, 76°75'E longitude, and 474 m altitude above MSL) during the *rabi* season of 2024 to evaluate the effect of brown manuring on growth components, physiological parameters, and yield of direct wet-seeded rice.

2.2 Treatment details

The experiment was laid out in Randomized Block Design (RBD) with ten treatments and three replications was given in Table 1. Pre-germinated seeds of the Bhavani rice variety were sown in rows with a spacing of 20 × 15 cm. *Sesbania aculeata* was sown at 20 kg ha^{-1} along with rice seedling and subsequently terminated by using 2,4-D 38%EC. The data collected on various parameters were statistically analysed using ANOVA, described by Gomez and Gomez (2010). The critical difference was calculated at a 5% probability level.

Table 1. Treatment details

	Treatments
T_1	Rice (sole crop): Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence
T_2	Rice (sole crop): 2,4-D 38% EC at 1kg ha^{-1} as early post emergence at 20-25 DAS
T_3	Rice + *Dhaincha* manual incorporation at 30 DAS
T_4	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: *Dhaincha* manual incorporation at 30 DAS
T_5	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 0.5 kg ha^{-1} at 30 DAS
T_6	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1 kg ha^{-1} at 30 DAS
T_7	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1.25 kg ha^{-1} at 30 DAS
T_8	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of Dhaincha by 2,4-D 38% EC at 1.5 kg ha^{-1} at 30 DAS
T_9	Weed free check
T_{10}	Unweeded control

2.3 Growth analysis

The growth components, including plant height, number of tillers and dry matter production were recorded as per the standard observation.

2.4 Physiological parameters

2.4.1 Leaf Area Index (LAI)

The leaf area index was determined using the standard formula (Watson 1952),

$$\mathrm{LAI} = \frac{\text{Total leaf area (sq. cm)}}{\text{Total ground area (sq. cm)}}$$

2.4.2 Crop Growth Rate (CGR)

The crop growth rate (g $m^{-2}day^{-1}$) for each specific stage was calculated using the standard formula proposed by Radford (1967),

$$\mathrm{CGR}\ (\mathrm{g}\ m^{-2}\ day^{-1}) = \frac{\mathrm{W}_2 - \mathrm{W}_1}{P(\mathrm{T}_2 - \mathrm{T}_1)}$$

Where,

W_1 and W_2	-	Dry weight (g) of plants at time T_1 and T_2 respectively
$T_2 – T_1$	-	Interval of time in days
P	-	Land area (m^2) occupied by plants

2.4.3 Relative growth rate (RGR)

The relative growth rate ($g^{-1}g^{-1}day^{-1}$) for each observational stage was determined by applying the corresponding dry matter accumulation values into the formula provided by Radford (1967),

$$\mathrm{RGR}\ (\mathrm{g}^{-1}\mathrm{g}^{-1}\mathrm{day}^{-1}) = \frac{\ln \mathrm{W}_2 - \ln \mathrm{W}_1}{\mathrm{T}_2 - \mathrm{T}_1}$$

Where,

W_1 and W_2	-	Dry weight (g) of plants at time T_1 and T_2 respectively
$T_2 – T_1$	-	Interval of time in days

3. RESULTS AND DISCUSSION

3.1 Growth analysis

3.1.1 Plant height

The effect of brown manuring on plant height was furnished in Table 2. At 30 DAS, there was no significant difference noticed in plant height. At 60, 90 DAS, and harvest, weed-free check (T_9) recorded highest plant height (117.2, 141.5 and 139.0 cm) which was statistically similar to (T_6) pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS. This increase in plant height can be attributed to enhanced nutrient availability from the decomposition of *dhaincha*, which creates a favourable environment for efficient utilization of moisture, light, and nutrients by the crop (Nawaz *et al.,* 2017). The lowest plant height was recorded under unweeded control (T_{10}) and this suppression in crop growth is attributed intense weed competition and limited availability of essential growth factors. These findings are consistent with the results reported by Hassanuzzaman *et al.* (2009).

3.1.2 Number of tillers

The mean data regarding number of tillers was depicted in Figure 1. No significant differences observed among the treatments 30 DAS. At 60, 90 DAS and harvest, the weed-free check (T_9) recorded significantly superior number of tillers hill^{-1} (26, 33 and 31 tillers hill^{-1}) and this was followed by (T_6) pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS. This increase in tiller numbers can be attributed to the gradual release of nitrogen, which promoted auxin development, thereby stimulating lateral bud growth and enhancing tiller formation (Harishankar, 2013). The unweeded control (T_{10}) recorded the lowest total number of tillers, likely due to severe weed competition during the early crop growth stages. These findings are consistent with the results of Sangeetha *et al.* (2009).

3.1.3. Dry matter accumulation

The data on total dry matter production at 30, 60, 90 DAS and harvest was presented in Table 3. There was no significant variation in plant DMP among the treatments at 30 DAS. Weed-free check (T_9) recorded the higher dry matter production at 60, 90 DAS and harvest (4276, 13732 and 23132 kg ha^{-1}) and this was on par with pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS (T_6). This may be due to higher nitrogen availability, which likely stimulated vegetative growth, improved light interception and enhanced photosynthetic efficiency, ultimately leading to increased dry matter accumulation (Prakasha *et al.,* 2018; Sivasakthi *et al.,* 2024). Higher nutrient uptake by weeds and increased weed dry matter production resulted in reduced crop DMP under (T_{10}) unweeded control (Singh *et al.,* 2004).

3.2. Physiological parameters

3.2.1 Leaf Area Index (LAI)

The LAI at different growth stages under brown manuring treatments was presented in Figure 2. At 30 DAS, the treatments did not show any significant differences. The highest LAI at 60, 90 DAS, and harvest was recorded in the weed-free check (T_9) (3.65, 5.81 and 3.08) which was statistically comparable with pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS (T_6). Shalini *et al.* (2017) reported that brown manuring supplied a substantial amount of nitrogen, which played a key role in enhancing the LAI. In contrast, the unweeded control (T_{10}) had the lowest LAI (1.01, 2.61, and 1.48) across all observation stages. This was due to the absence of weed management practices, which led to a higher weed population and intense competition between crop and weeds (Sharmitha *et al.,* 2023).

3.2.2 Crop Growth Rate (CGR)

The CGR at different growth stages under various brown manuring treatments was given in Figure 3. At 30 DAS, the treatments did not exhibit any significant variation. The weed-free check (T_9) recorded the highest CGR at 60, 90 DAS and harvest (3.84, 11.60 and 9.08 g m^{-2} day^{-1}), significantly outperforming all other treatments. It was followed by (T_6) pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS. Brown manuring with *dhaincha* effectively suppressed weeds, reducing competition for water and nutrients, enhanced photosynthetic activity and ultimately increased the CGR (Sharma, 2019). Unweeded control (T_{10}) recorded the lowest CGR (1.96, 4.54, and 3.12 g m^{-2} day^{-1}) likely due to weed interference reducing light availability to the crop canopy and limiting photosynthesis (Lal *et al.,* 2019).

3.2.3 Relative Growth Rate (RGR)

The mean data of RGR at different growth stages were depicted in Figure 4. At 30 DAS, no significant differences were observed among the treatments. At 60, 90 DAS, and harvest, the weed-free check (T_9) exhibited the highest RGR values (0.0572, 0.0431 and 0.0229 g g^{-1}day^{-1}), which were significantly greater than those recorded in other treatments. This was followed by (T_6) pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1 kg ha^{-1} at 30 DAS, and this was due to continuous supply of nitrogen, which enhanced nutrient availability to the plant and promoted higher RGR (Singh *et al.,* 2024). The lowest RGR value (0.0301, 0.0263 and 0.0114 g g^{-1}day^{-1}) was recorded in unweeded control (T_{10}), this was due to the absence of weed control measures and intense weed competition, which restricted the crop from utilizing its full potential by limiting the availability of solar radiation, water and nutrients (Singh, 2020).

3.3 Grain and straw yield

The effect of brown manuring practiced on grain and straw yield was presented in Figure 5, showing notable variations among the treatments. Among different brown manuring treatments, weed-free check (T_9) recorded higher grain and straw yield of 6046 and 10801 kg ha^{-1} which was statistically comparable with (T_6) pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1.0 kg ha^{-1} at 30 DAS. Efficient weed management likely enhanced nutrient availability, soil moisture retention, and other essential growth factors, leading to improved growth and yield attributes of rice, ultimately resulting in higher grain and straw yield (Kumari and Kaur, 2016). Significantly lower grain and straw yield of 3994 and 7996 kg ha^{-1} was observed in unweeded control (T_{10}) and this might be due to intense weed competition caused excessive depletion of moisture, light and nutrients, hindering metabolite translocation and leading to lower yield (Haromuchudi, 2017).

4. CONCLUSION

Although the weed-free check resulted in higher growth components, physiological parameters and yield of rice, maintaining a completely weed-free condition is impractical due to labour shortages and increased cultivation costs. Therefore, the study concluded that the application of pretilachlor 50% EC @ 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC @ 1.0 kg ha^{-1} at 30 DAS effectively enhances the growth components and physiological attributes, leading to increased grain and straw yield. Thus, *sesbania* brown manuring serves as a viable alternative to improve the productivity of direct wet-seeded rice.

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Table 2. Effect of brown manuring on plant height (cm) of direct wet-seeded rice

	Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	Rice (sole crop): Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence	54.8	83.3	113.3	110.9
T_2	Rice (sole crop): 2,4-D 38% EC at 1kg ha^{-1} as early post emergence at 20-25 DAS	54.5	84.3	115.7	113.6
T_3	Rice + *Dhaincha* manual incorporation at 30 DAS	47.2	90.0	119.9	115.7
T_4	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: *Dhaincha* manual incorporation at 30 DAS	49.1	91.7	120.0	117.4
T_5	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 0.5 kg ha^{-1} at 30 DAS	49.6	99.5	125.0	123.1
T_6	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1 kg ha^{-1} at 30 DAS	50.6	113.8	137.5	135.8
T_7	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1.25 kg ha^{-1} at 30 DAS	49.5	95.7	123.3	125.5
T_8	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of Dhaincha by 2,4-D 38% EC at 1.5 kg ha^{-1} at 30 DAS	48.8	93.1	122.0	118.3
T_9	Weed free check	56.3	117.2	141.5	139.0
T_{10}	Unweeded control	44.5	70.4	102.3	97.1
	Mean	50.5	93.9	122.1	119.6
	SE(d)	3.9	6.0	5.2	5.6
	CD (P=0.05%)	NS	12.7	11.1	12.0

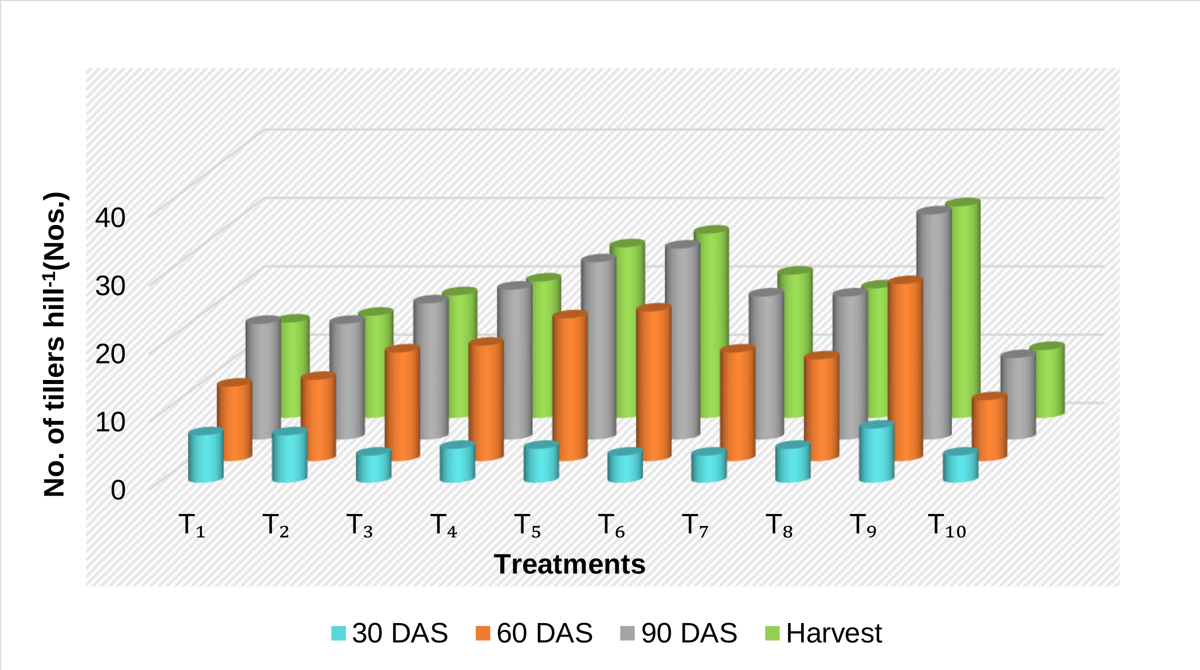

Fig. 1. Effect of brown manuring on number of tillers hill^{-1} of direct wet-seeded rice

Table 3. Effect of brown manuring on dry matter accumulation (kg ha^{-1}) of direct wet-seeded rice

	Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	Rice (sole crop): Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence	911	2920	9257	14824
T_2	Rice (sole crop): 2,4-D 38% EC at 1kg ha^{-1} as early post emergence at 20-25 DAS	904	3024	9421	15222
T_3	Rice + *Dhaincha* manual incorporation at 30 DAS	874	3497	10935	17248
T_4	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: *Dhaincha* manual incorporation at 30 DAS	879	3533	10281	16093
T_5	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 0.5 kg ha^{-1} at 30 DAS	893	3631	12037	20171
T_6	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1 kg ha^{-1} at 30 DAS	898	4157	13487	22197
T_7	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of *Dhaincha* by 2,4-D 38% EC at 1.25 kg ha^{-1} at 30 DAS	888	3608	11844	19541
T_8	Rice + *Dhaincha*: Pretilachlor 50% EC at 1.25 l ha^{-1} as pre-emergence: knockdown of Dhaincha by 2,4-D 38% EC at 1.5 kg ha^{-1} at 30 DAS	885	3578	11184	18084
T_9	Weed free check	918	4276	13732	23132
T_{10}	Unweeded control	862	2634	8357	13428
	Mean	891	3486	11054	17994
	SE(d)	55.7	247.3	677.1	891.0
	CD (P=0.05%)	NS	523.6	1433.5	1886.5

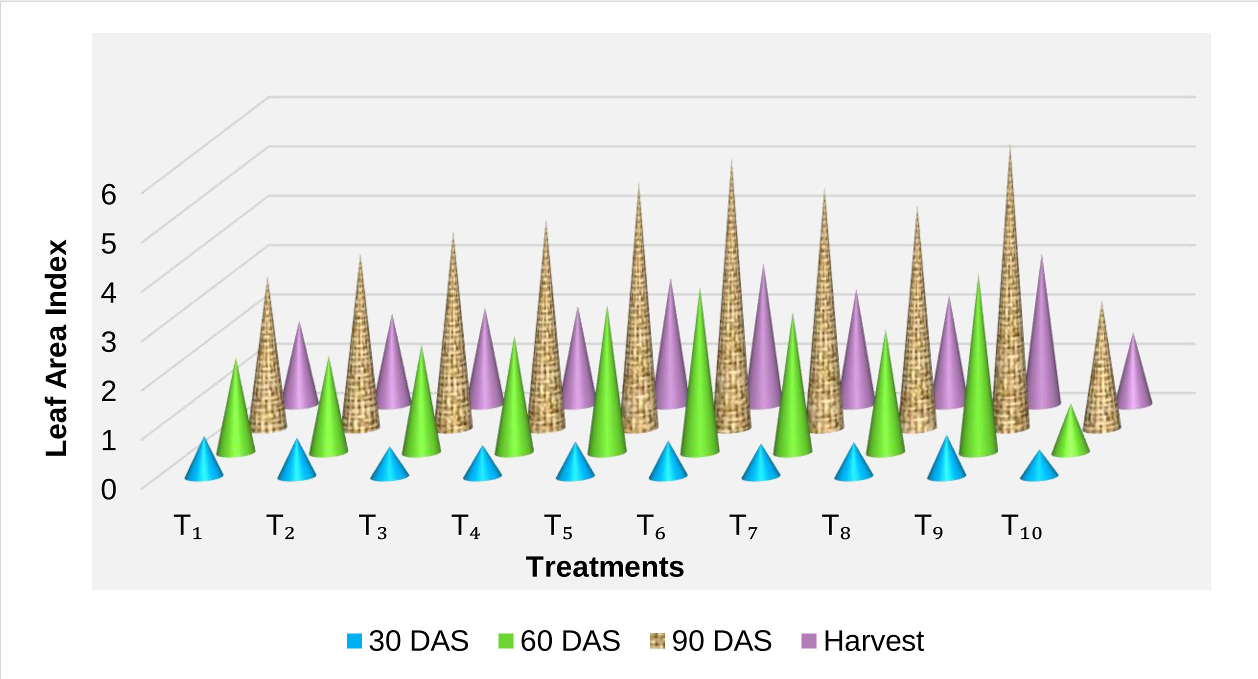

Fig. 2. Effect of brown manuring on leaf area index of direct wet-seeded rice

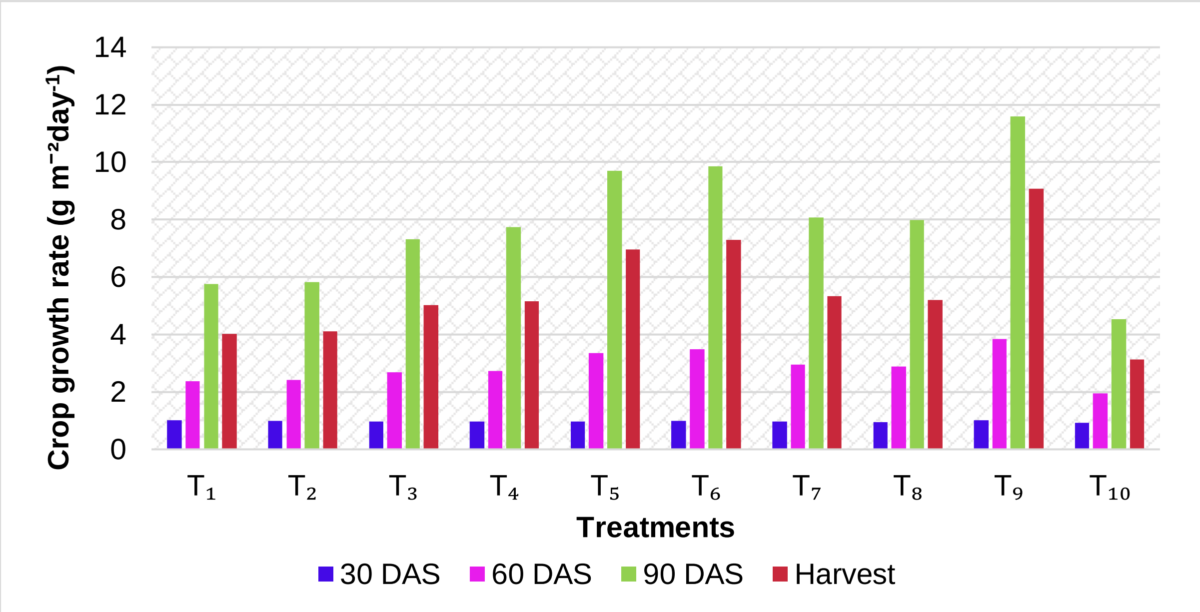

Fig. 3. Effect of brown manuring on crop growth rate (g $m^{-2}day^{-1}$) of direct wet-seeded rice

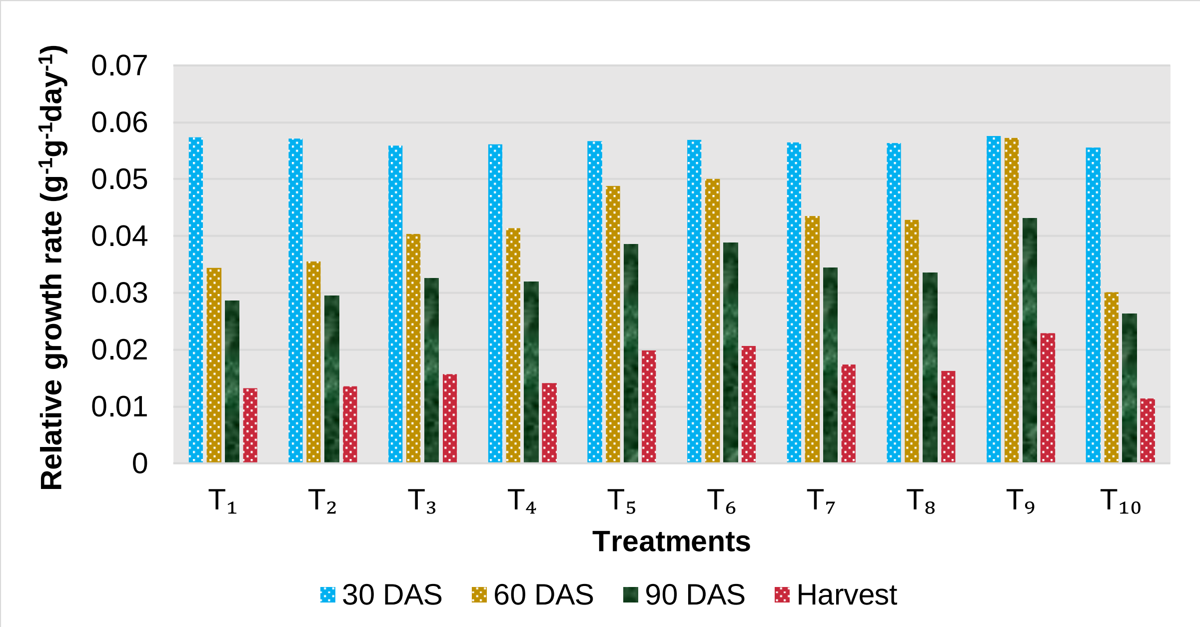

Fig. 4. Effect of brown manuring on relative growth rate ($g^{-1}g^{-1}day^{-1}$) of direct wet-seeded rice

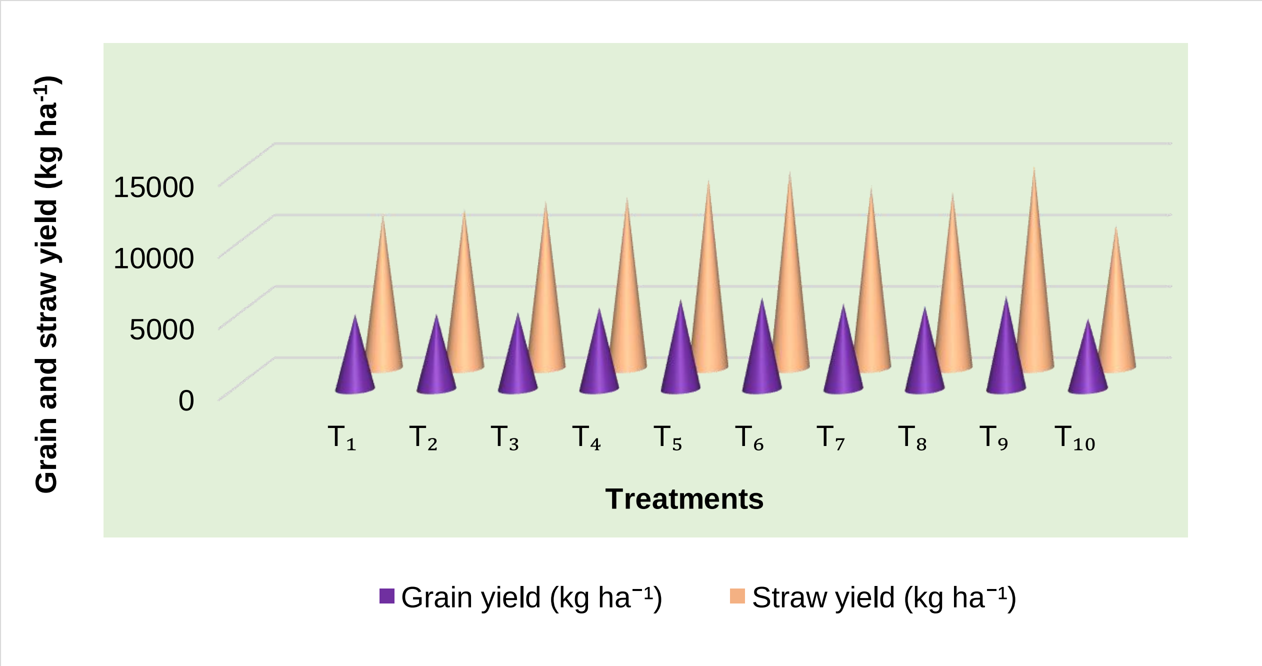

Fig. 5. Effect of brown manuring on grain and straw yield (kg ha^{-1}) of direct wet-seeded rice