***Short Research Article***

**Study on Growth Behaviours of Rice Cultivars under Dry Direct Seeded *Co*nditions during *Samba* Season**

**ABSTRACT**

|  |
| --- |
| **Aim:** To evaluate the performance of different rice cultivars under dry direct-seeded rice (DDSR) *Co*nditions by assessing plant height, tiller number per hill, and dry matter production at key growth stages and yield potential with the aim of identifying cultivar suitable for water-limited, non-puddled rice cultivation systems.**Study design:** The experiment was *Co*nducted using a randomized block design with fifteen varieties as treatments, which was replicated three times.**Place and Duration of Study:** The field experiment was *Co*nducted at the instructional farm of the School of Agricultural Sciences, Karunya Institute of Technology and Sciences, *Co*imbatore, during the *Samba* 2024-25 cropping season.**Methodology:** Fifteen rice varieties were sown under DDSR *Co*nditions using uniform spacing and agronomic practices. Data were *Co*llected at active tillering, panicle initiation, heading and harvest stages on plant height, tiller number per hill, and dry matter production. Statistical analysis was performed using ANOVA were assessed for significance.**Results:** Significant differences (*P* < 0.05) were observed among cultivars for all studied parameters. *Karuppukavuni* (T10) *Co*nsistently re*Co*rded the highest plant height (80.54 cm), while *Co* 57 and *Co* 56 exhibited superior tiller numbers per hill (26,25 respectively). *Paiyur*1 (T15) achieved the highest dry matter production (15876 kg/ha), indicating robust vegetative growth. In *Co*ntrast, *BPT* 5204 (T14) and T10 displayed lower performance in certain traits, particularly in dry matter accumulation and tiller retention.***Co*nclusion:** Specific rice varieties such as *Co* 57, *Co* 56, and *Paiyur*1 exhibit favorable traits for DDSR systems, characterized by early vigor, effective tillering, and high biomass accumulation. Varietal selection plays a critical role in enhancing productivity and resource-use efficiency under DDSR. Future research should focus on integrating phenotypic data with molecular breeding tools to develop varieties optimized for dry-seeded *Co*nditions. |

*Key words: Rice, rice cultivars, dry direct-seeded rice, Samba Season,* *Growth Behaviours*

**1. INTRODUCTION**

Rice (Oryza sativa L.) is a staple food crop for most of the world’s population due to its valuable nutritional benefits (Birla *et al*., 2022). Over 50 % of the world’s population *Co*nsumes rice for their food (Phapumma *et al*., 2020). The phrase “Rice is life” was used for the International Year of Rice (2004) because it captures the essence of rice as a source of sustenance and as a way of life. In India overall rice production was 135 million metric tons in 2023 and Tamil Nadu about 41.45 lakh tons and overall, third rank. As a result, one of the most significant agricultural environments in Asia is that of irrigated lowland rice. The majority of the population’s depends on rice for food security now and in the future. It is also the most water intensive crop, *Co*nsuming about 30 % of Global total freshwater resources (N’guessan *et al*., 2023). India supports 18 % of the global population and the per capita water availability in terms of average usable water sources is decreasing at a fast rate, which was 5247 m3 in 1951 (presently 1453 m3) and is expected to diminish down to 1170 m3 by 2050 (Chaudhary *et al*., 2023).

 Puddled transplanted rice system (TPR) is the growing of rice seedling in the nursery and transplanting into the puddled and leveled fields at 25 to 30 DAS. Nearly, 1357-1666 mm of irrigation water is required in TPR (Brar *et al*., 2015). The viability of this system however appears to be threatened by diminishing water supplies. This has led to over exploitation of available water resources and groundwater led to decline in water table at a rate of 0.33 m per year (Narjary *et al*., 2014) and methanogenesis, a biological process that results from methanogens in anaerobic soil and producing methane as a byproduct of their metabolism

is also caused by *Co*ntinuous flooding of rice field. The puddled transplanted rice cultivation is laborious and tedious because of nursery care and management, puddling and transplanting operation. Using alternate water-saving methods such as dry seeded rice reduces the water requirement of the crop. The last two decades have seen a sharp increase in the adoption of water saving technologies in the place of *Co*ntinuous flooding in rice cultivation.

 Dry Seeded Rice (DSR) under unpuddled *Co*ndition is a method of rice cultivation that involves sowing rice seeds directly into the main unpuddled field, eliminating the need for nursery raising and transplanting (Sarma & Paul, 2024). Dry direct-seeded rice (DDSR) uses 15.3 % less water than transplanted-flooded rice (Liu *et al*., 2015) and effectively improve O2 diffusion into the soil, hence reducing CH4 emission (Xu *et al.,* 2019). At present, 23 % of rice is direct-seeded globally. In India 12-million-hectare area is occupied by direct seeded rice and 28 % to the total rice area (Muthuramu & Ragavan, 2022). The DSR system reduces labour input by eliminating various field operations such as nursery raising, removing plants from the nursery, transplanting and puddling operation (Soriano *et al*., 2018).

**2. material and methods**

A field experiment was carried out at the experimental farm at Karunya Institute of technology and sciences, *Co*imbatore during the *Samba* season during 2024-25.the experiment field was positioned at latitude of 10.935 N and longitude of 76.75 E, with an elevation of 467 m above the mean sea level, western zone of Tamil Nadu. The study was carried out to evaluate the different cultivars of rice under Dry-DSR using randomized block design with three replications and fifteen treatment namely T1 : *Bhavani* (check variety), T2 : *TV* 472, T3: *CR 1009 sub 1*, T4 : *Improved White Ponni*, T5: *TRY* 3, T6: *TKM* 13, T7: *Co* 52, T8: *Co* 56, T9: *Co* 57, T10: Karuppu kavuni, T11:*ADT* 54, T12: *ADT* 52, T13: *KKLR* 2, T14: *BPT* 5204 and T15: *Paiyur* 1.

 The seeds have been line sown at a spacing of 20 cm x 15 cm at a seed rate of 75 kg ha-1 and placing two to three seeds hill-1. Organic manure FYM was applied @ 12.5 t ha-1 before sowing and fertilizers were applied at a dose of 75:50:37.5 kg ha-1 at four splits. The initial soil sample were analysed to estimate available nitrogen (210.75 kg ha-1), available phosphorous (12.24 kg ha-1) and available Potassium (174.36 kg ha-1) by Alkaline permanganate method, Olsens’s method and Flame photo metre method respectively. The growth parameters like plant height, number of tillers, Leaf area index, Dry Matter Production (kg ha-1) were re*Co*rded at different growth stages.

$$DMP (kg /ha) =\frac{Dry weight of the plants X Plant population per ha}{5 X 1000}$$

The matured plants are carefully harvested from the experimental field and bundled and threshed against the hard surfaces to remove grains from straws. The straw yeild and grain yield were separately weighed and re*Co*rded

**3. results and discussion**

**3.1.** **Plant height**

 Under DDSR the olant height of evaluated fifteen varieties varied significantly. The traditional variety karuppu kavuni performed superiorly over the other varieties by resulting in higher plant height throughout all stages with a peak of 41.47 cm in active tillering to 87.17 cm in harvest stage. Meanwhile the varieties *Paiyur* 1 and *ADT* 54 also reaching the height of 74.23 cm and 68.87 cm suggesting the adaptability and vigorous canopy establishment under DDSR sytem. The lowest plant height registered by variety *BPT* 5204 and hybrid *TV*472 with only 48.41 cm and 49.14 indicates the lower *Co*mpetitive ability of the varieties under DDSR.the vigorous growth of traditional variety *Karuppukavuni* aligns with the prior research findings by (Vinothana *et al*., 2024) that genetic variability plays a critical role in morphological traits. Moreover, the plant height is influenced by both genetic and environmental factors under DDSR (Subedi *et al*.,2019). Taller varieties with early canopy establishment and weed suppression may improve the grain yielding potential (sandhu *et al*., 2019; Kumar *et al*., 2021). The varieties with poor height performance may restrict the suitability of that variety under DDSR (Sagare *et al*., 2020).

**Table 1. Plant height of different rice cultivars at various growth stages under DDSR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Active tillering | Panicle initiation | Heading | Harvest |
| T1 | *Bhavani* | 32.44 | 47.76 | 56.49 | 60.87 |
| T2 | *TV* 472 | 26.77 | 39.27 | 45.85 | 49.14 |
| T3 | *CR* 1009 *sub*1 | 30.35 | 40.58 | 50.81 | 55.92 |
| T4 | *IWP* | 32.21 | 44.65 | 57.15 | 63.40 |
| T5 | *TRY* 3 | 37.26 | 56.61 | 62.27 | 65.10 |
| T6 | *TKM* 13 | 26.69 | 35.68 | 52.73 | 61.25 |
| T7 | *Co* 52 | 29.19 | 41.47 | 56.93 | 64.66 |
| T8 | *Co* 56 | 31.55 | 45.33 | 54.89 | 59.67 |
| T9 | *Co* 57 | 28.01 | 47.60 | 57.45 | 62.37 |
| T10 | *Karuppukavuni* | 41.47 | 67.28 | 80.54 | 87.17 |
| T11 | *ADT* 54 | 31.53 | 49.43 | 62.39 | 68.87 |
| T12 | *ADT* 52 | 28.77 | 48.73 | 57.22 | 61.47 |
| T13 | *KKLR* 2 | 32.74 | 43.73 | 54.23 | 59.49 |
| T14 | *BPT* 5204 | 22.95 | 38.58 | 45.13 | 48.41 |
| T15 | *Paiyur* 1 | 36.06 | 60.33 | 68.40 | 72.43 |
| SE(d) | 1.63 | 2.46 | 3.01 | 3.28 |
| CD(P=0.05) | 3.34 | 5.05 | 6.16 | 6.73 |



**Fig. 1. Plant height of different rice cultivars at various growth stages under DDSR**

**3.2. Number of tills hill-1**

The number of tillers per hill is a crucial growth parameter reflecting the productive capacity and tillering ability of rice cultivars. Data on tiller *Co*unt at active tillering and heading stages are presented in Figure 2. Among the varieties, *Co* 57 re*Co*rded the highest number of tillers per hill with values of 18 and 26 tillers hill-1 at active tillering and heading stage. This was followed closely by *Co* 56, which also showed vigorous tillering performance (17 and 25). *TV* 472 and *karuppukavuni* demonstrated strong tillering as well, with a significantly higher number of tillers at heading *Co*mpared to active tillering, indicating good tiller retention and development. In *Co*ntrast, CR 1009 sub1, TRV 3, *TKM* 13, and *ADT* 54 showed lower tiller numbers at both stages, indicating relatively weaker tillering ability under the given *Co*nditions. Overall, most varieties showed an increase in tiller number from active tillering to heading stage, highlighting effective tiller survival. These findings align with previous studies that report *Co*nsiderable genotypic variability in tiller production under DDSR. For instance, WGL 44 re*Co*rded the maximum productive tillers among a set of genotypes evaluated under DDSR, highlighting the importance of genetic background in determining tiller number (Vinoothna *et al*., 2024). Similarly, MTU-1010 was found to *Co*nsistently outperform others in producing a high number of productive tillers under DSR *Co*nditions, *Co*ntributing to its high yield potential. Genetic studies further support these observations. Genome-wide association studies (GWAS) have identified specific genomic regions and markers linked to morphological traits including tillering, which can be targeted in breeding programs to enhance adaptability and yield under DDSR *Co*nditions (Subedi *et al*., 2019). *Co*nversely, varieties such as CR 1009 sub1, TRV 3, *TKM* 13, and *ADT* 54 showed lower tiller numbers, indicating limited tillering capacity under DDSR. This may be due to poor early vigor or genetic *Co*nstraints affecting tiller initiation and survival. Other studies also found that certain inbred lines under DDSR had fewer tillers *Co*mpared to hybrids, which maintained yield through enhanced tillering even at low sowing rates.

**Fig. 2. No of tillers per hill of different rice cultivars at various growth stages under DDSR**

**3.3. Dry Matter Production (kg ha-1)**

 Dry matter production (DMP) reflects the overall biomass accumulation of rice plants and is a key indicator of growth performance and potential yield. The DMP of different rice cultivars was re*Co*rded at four critical growth stages viz., active tillering, panicle initiation, heading, and harvest under DDSR *Co*nditions, and the results are presented in Table 2 and Figure 3. Among the treatments, T15 *Co*nsistently re*Co*rded the highest dry matter production, reaching 2427 kg ha⁻¹ at active tillering, 5359 kg ha⁻¹ at panicle initiation, 12701 kg ha⁻¹ at heading, and 15876.25 kg ha⁻¹ at harvest, significantly surpassing all other treatments. This indicates vigorous growth and superior biomass accumulation under DDSR. T15, treatments T7 and T11 also showed excellent performance with dry matter values exceeding 12400 kg ha⁻¹ at harvest, reflecting their strong vegetative and reproductive growth phases. On the other hand, T10 re*Co*rded the lowest DMP at all stages, with only 1133 kg ha⁻¹ at active tillering and 2656.25 kg ha⁻¹ at harvest, suggesting poor biomass accumulation. Similarly, T12 also exhibited *Co*mparatively low DMP across the stages. These results align with earlier studies demonstrating significant genotypic variability in DMP under DDSR. For instance, MTU-1010 was found to have superior dry matter accumulation, leaf area, and tiller number, which *Co*ntributed to its high yield under DSR systems. Similarly, genotypes such as WGL 915 and JGL 24423 performed well in terms of DMP and associated yield traits, highlighting the impact of genetics on biomass development (Vinoothna *et al*., 2024). Genomic studies further support this phenotypic evidence. Marker-trait associations identified through genome-wide association studies (GWAS) have linked traits like shoot and root biomass, nutrient uptake, and grain yield under DDSR *Co*nditions, suggesting that DMP is governed by key genetic loci that can be targeted for breeding DDSR-adapted cultivars (Subedi *et al*., 2019) and (Sandhu *et al*., 2019). *Co*nversely, varieties like T10 and T12 re*Co*rded the lowest DMP at all stages, reflecting poor biomass accumulation and possibly limited photosynthetic efficiency or nutrient uptake. These limitations may translate to lower grain yields, as low DMP has been associated with reduced panicle and spikelet development in DDSR systems (Mahajan *et al*., 2012).

**Table 2. Dry Matter Production (kg ha-1) of different rice cultivars at various growth stages under DDSR**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Treatment | Active tillering | Panicle initiation | Heading | Harvest |
| T1 | *Bhavani* | 2902.00 | 5785.00 | 6792.00 | 9240.00 |
| T2 | *TV* 472 | 2244.00 | 4937.00 | 5586.00 | 6982.50 |
| T3 | CR 1009 sub1 | 2741.00 | 5031.00 | 8290.00 | 11612.50 |
| T4 | *IWP* | 1975.00 | 4340.00 | 6150.00 | 7687.50 |
| T5 | *TRY* 3 | 2061.00 | 4535.00 | 9762.00 | 12202.50 |
| T6 | *TKM* 13 | 2505.00 | 5511.00 | 9460.00 | 11825.00 |
| T7 | *Co* 52 | 2610.00 | 5733.00 | 10266.00 | 12832.50 |
| T8 | *Co* 56 | 2414.00 | 5309.00 | 7730.00 | 9662.50 |
| T9 | *Co* 57 | 2491.00 | 5479.00 | 7306.00 | 9132.50 |
| T10 | *Karuppukavuni* | 1133.00 | 1692.00 | 2125.00 | 2656.25 |
| T11 | *ADT* 54 | 2461.00 | 5415.00 | 9950.00 | 12437.50 |
| T12 | *ADT* 52 | 1320.00 | 2452.00 | 3681.00 | 4601.25 |
| T13 | *KKLR* 2 | 2485.00 | 5477.00 | 6211.00 | 7763.75 |
| T14 | *BPT* 5204 | 2213.00 | 4888.00 | 8458.00 | 10572.50 |
| T15 | *Paiyur* 1 | 2427.00 | 5359.00 | 12701.00 | 15876.25 |
| SE(d) | 1.63 | 116.22 | 241.23 | 381.93 |
| CD(P=0.05) | 3.34 | 238.07 | 494.15 | 782.35 |



**Fig. 3. Dry Matter Production (kg ha-1) of different rice cultivars at various growth stages under**

**DDSR**

**3.4. Grain and Straw yield (t ha-)**

Under straw and grain yield the performance of 15 varieties varied significantly (Fig. 4). *Co* 56 yielded a higher grain yeild of 3.50 t ha- than the other varieties, followed by varieties *Co* 57 and *Bhavani* (3.39 and 3.08 t ha-1). Meanwhile, in straw yield variety *Paiyur* 1 was dominating with 6.6 t ha-1, followed by *Co* 52 and *TRY* 3 with 6.07 and 5.73 t ha-1, which emphasizes variety like *Co* 57 may be benefitable in grain production while varieties like *Paiyur* 1 and *TRY* 3 may serve as dual purpose rice varieties. This result was aligning with the findings reported by (Shrestha *et al*., 2021) under the study of evaluation of growth and yield traits in rice genotypes and Latha *et al*., (2019) studied the variability in growth and yield attributes among different rice varieties.

**Fig. 4. Grain yield and Straw yield (t ha-1) of different rice cultivars at various growth stages under DDSR**

**4. *Co*nclusion**

Under DDSR, clear variations were noted among the 15 studied cultivars in groeth and yield parameters. Traditional variety stand out as atall plant, while *Co* 56 and *Co* 57 varieties performed superior in tiller production, *Paiyur* 1 was superior among the 15 varieties in biomass accumulation, representing its strong vegetative growth. Meanwhile, when it *Co*mes to grain yield varieties *Co*56, *Co* 57 and *Bhavani* excelled over other varieties, on other hand varieties *Paiyur* 1, *Co* 52 and *TRY* 3 led in straw yield make it as a potential source for dual purpose in grain and fodder production system.

***Co*mpeting interests**

Authors have declared that no *Co*mpeting interests exist.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, *CO*PILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References**

Birla, D. S., Malik, K., Sainger, M., Chaudhary, D., Jaiwal, R., & Jaiwal, P. K. (2022). Progress and challenges in improving the nutritional quality of rice (Oryza sativa L.). *Critical Reviews in Food Science and Nutrition*, *57*(11), 2455–2481. https://doi.org/10.1080/10408398.2015.1084992

Brar, A. S., Buttar, G. S., Jhanji, D., Sharma, N., Vashist, K. K., Mahal, S. S., Deol, J. S., & Singh, G. (2015). Water productivity, energy and economic analysis of transplanting methods with different irrigation regimes in Basmati rice (Oryza sativa L.) under north-western India. *Agricultural Water Management*, *158*, 189–195. https://doi.org/10.1016/j.agwat.2015.04.018

Chaudhary, A., Venkatramanan, V., Kumar Mishra, A., & Sharma, S. (2023). Agronomic and Environmental Determinants of Direct Seeded Rice in South Asia. *Circular Economy and Sustainability*, *3*(1), 253–290. https://doi.org/10.1007/s43615-022-00173-x

Latha, H. S., Prakash, K. V., Veerangouda, M., Maski, D., & Ramappa, K. T. (2019). Development of Bullock Cart Mounted Electricity Generation Unit. *International Journal of Current Microbiology and Applied Sciences*, *8*(02), 1235–1242. https://doi.org/10.20546/ijcmas.2019.802.144

Liu, H., Hussain, S., Zheng, M., Peng, S., Huang, J., Cui, K., & Nie, L. (2015). Dry direct-seeded rice as an alternative to transplanted-flooded rice in Central China. *Agronomy for Sustainable Development*, *35*(1), 285–294. https://doi.org/10.1007/s13593-014-0239-0

Mahajan, G., Timsina, J., Jhanji, S., Sekhon, N. K., & Kuldeep-Singh. (2012). Cultivar Response, Dry-Matter Partitioning, and Nitrogen-Use Efficiency in Dry Direct-Seeded Rice in Northwest India. *Journal of Crop Improvement*, *26*(6), 767–790. https://doi.org/10.1080/15427528.2012.686473

Muthuramu, S., & Ragavan, T. (2022). Ammi Analysis for Yield and Stability in Direct Seeded Rainfed Rice. *Bangladesh Journal of Botany*, *51*(3), 469–475. https://doi.org/10.3329/bjb.v51i3.61993

N’guessan, K. J. Y., Adahi, B., Konan-Waidhet, A. B., Masayoshi, S., & Assidjo, N. E. (2023). Assessment of Climate Change Impact on Water Requirement and Rice Productivity. *Rice Science*, *30*(4), 276–293. https://doi.org/10.1016/j.rsci.2023.03.010

Narjary, B., Kumar, S., Kamra, S. K., Bundela, D. S., & Sharma, D. K. (2014). Impact of rainfall variability on groundwater resources and opportunities of artificial recharge structure to reduce its exploitation in fresh groundwater zones of Haryana. *Current Science*, *107*(8), 1305–1312.

Phapumma, A., Monkham, T., Chankaew, S., Kaewpradit, W., Harakotr, P., & Sanitchon, J. (2020). Characterization of indigenous upland rice varieties for high yield potential and grain quality characters under rainfed conditions in Thailand. *Annals of Agricultural Sciences*, *65*(2), 179–187. https://doi.org/10.1016/j.aoas.2020.09.004

Sandhu, N., Subedi, S. R., Singh, V. K., Sinha, P., Kumar, S., Singh, S. P., Ghimire, S. K., Pandey, M., Yadaw, R. B., Varshney, R. K., & Kumar, A. (2019). Deciphering the genetic basis of root morphology, nutrient uptake, yield, and yield-related traits in rice under dry direct-seeded cultivation systems. *Scientific Reports*, *9*(1), 1–16. https://doi.org/10.1038/s41598-019-45770-3

Sarma, H. H., & Paul, A. (2024). *Diversification of Establishment Techniques in Direct Seeded Rice*. *May*.

Shrestha, J., Subedi, S., Kushwaha, U. K. S., & Maharjan, B. (2021). Evaluation of growth and yield traits in rice genotypes using multivariate analysis. *Heliyon*, *7*(9), e07940. https://doi.org/10.1016/j.heliyon.2021.e07940

Soriano, J. B., Wani, S. P., Rao, A. N., Sawargaonkar, G. L., & Gowda, J. A. C. (2018). Comparative evaluation of direct dry-seeded and transplanted rice in the dry zone of Karnataka, India. *Philippine Journal of Science*, *147*(1), 165–174.

Subedi, S. R., Sandhu, N., Singh, V. K., Sinha, P., Kumar, S., Singh, S. P., Ghimire, S. K., Pandey, M., Yadaw, R. B., Varshney, R. K., & Kumar, A. (2019). Genome-wide association study reveals significant genomic regions for improving yield, adaptability of rice under dry direct seeded cultivation condition. *BMC Genomics*, *20*(1), 1–20. https://doi.org/10.1186/s12864-019-5840-9

Vinoothna, S., Parimala, K., Pallavi, M., & Bharathi, Y. (2024). Agronomic Performance of Rice Genotypes under Direct Seeded Rice (Oryza sativa L.). *International Journal of Environment and Climate Change*, *14*(4), 93–99. https://doi.org/10.9734/ijecc/2024/v14i44100

Xu, L., Li, X., Wang, X., Xiong, D., & Wang, F. (2019). Comparing the grain yields of direct-seeded and transplanted rice: A meta-analysis. *Agronomy*, *9*(11). https://doi.org/10.3390/agronomy9110767