***Short Research Article***

**Evaluation of Rice Cultivars for Agronomic Performance under Dry Direct-Seeded Conditions**

**ABSTRACT**

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| **Aim:** To evaluate the performance of different rice cultivars under dry direct-seeded rice (DDSR) conditions by assessing plant height, tiller number per hill, and dry matter production at key growth stages, with the aim of identifying cultivar suitable for water-limited, non-puddled rice cultivation systems.  **Study design:** The experiment was conducted using a randomized block design with fifteen varieties as treatments, which was replicated three times.  **Place and Duration of Study:** The field experiment was conducted at the instructional farm of the School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore, during the *Samba* 2024-25 cropping season.  **Methodology:** Fifteen rice varieties were sown under DDSR conditions using uniform spacing and agronomic practices. Data were collected 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) consistently recorded the highest plant height (80.54 cm), while Co 57 and Co 56 exhibited superior tiller numbers per hill (26,25 respectively). Paiyur1 (T15) achieved the highest dry matter production (15876 kg/ha), indicating robust vegetative growth. In contrast, BPT 5204 (T14) and T10 displayed lower performance in certain traits, particularly in dry matter accumulation and tiller retention.  **Conclusion:** Specific rice varieties such as Co 57, Co 56, and Paiyur1 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 conditions. |

**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 consumes 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, consuming 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 continuous 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 continuous flooding in rice cultivation.

Dry Seeded Rice (DSR) under unpuddled condition 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, Coimbatore 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 recorded at different growth stages.

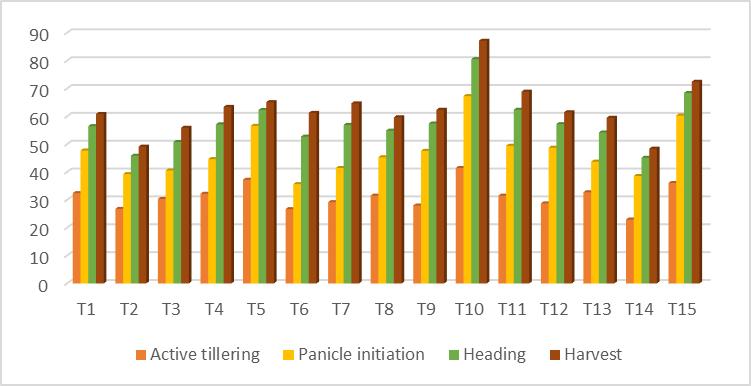
**3. results and discussion**

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

Plant height, a key indicator of crop growth and vigor, varied significantly among treatments under dry direct seeded rice (DDSR). In this study, landrace karuppukavuni (T10) consistently produced the tallest plants at all growth stages, indicating superior vegetative growth. Paiyur1 (T15) and T11 followed closely with comparatively high plant heights. In contrast, BPT 5204 (T14) and TV 472 (T2) recorded the shortest plants, reflecting lower growth potential. These results underscore clear varietal differences in plant height performance under DDSR conditions. The observed variation in plant height among rice cultivars under dry direct-seeded rice (DDSR) cultivation highlights important varietal differences in vegetative growth potential. In this study, the landrace Karuppukavuni (T10) consistently produced the tallest plants, suggesting superior vigor and adaptability to DDSR conditions. This is consistent with prior findings showing that genotypic variability strongly influences plant morphological traits, including plant height, under DDSR systems (Vinoothna et al., 2024). Plant height under DDSR is a complex trait regulated by genetic and environmental factors. Genome-wide association studies have identified significant marker-trait associations for plant height and other morphological traits, suggesting that specific genetic loci contribute to enhanced adaptability under DDSR systems (Subedi et al., 2019). These genetic associations also correlate with yield components, indicating that taller plants may also support improved grain yield if accompanied by strong stem structure to prevent lodging (Sandhu et al., 2019). The superior height performance of varieties like Paiyur1 (T15) and T11 aligns with findings from other DDSR evaluations that reported certain lines like WGL 915 and JGL 24423 exhibiting significantly greater plant height and overall vigor (Vinoothna et al., 2024). These traits are crucial under DDSR conditions, where early vigor and rapid canopy development help suppress weeds and improve resource use efficiency. In contrast, BPT 5204 (T14) and TV 472 (T2) recorded shorter plant stature, indicating their lower adaptability to DDSR conditions. Such reduced growth may limit their competitiveness in the early growth stages and contribute to reduced biomass and yield, as previously noted in genotype screening studies for DDSR suitability (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 sub1 | 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 count at active tillering and heading stages are presented in Figure 2. Among the varieties, Co 57 recorded the highest number of tillers per hill at both stages, with values peaking above 25 at heading. This was followed closely by Co 56, which also showed vigorous tillering performance. TV 472 and karuppukavuni demonstrated strong tillering as well, with a significantly higher number of tillers at heading compared to active tillering, indicating good tiller retention and development. In contrast, 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 conditions. Overall, most varieties showed an increase in tiller number from active tillering to heading stage, highlighting effective tiller survival. The variations among cultivars point to significant varietal differences in tillering potential under the experimental conditions. Tiller number is a critical trait in rice that significantly influences crop productivity, particularly under dry direct-seeded rice (DDSR) systems. In this study, Co 57 demonstrated the highest number of tillers per hill at both active tillering and heading stages, indicating a strong tillering ability and good tiller survival. Co 56, TV 472, and Karuppukavuni also exhibited vigorous tillering, particularly with increased tiller numbers at heading, suggesting efficient tiller retention and development.

These findings align with previous studies that report considerable genotypic variability in tiller production under DDSR. For instance, WGL 44 recorded 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 consistently outperform others in producing a high number of productive tillers under DSR conditions, contributing 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 conditions (Subedi et al., 2019). Conversely, 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 constraints affecting tiller initiation and survival. Other studies also found that certain inbred lines under DDSR had fewer tillers compared to hybrids, which maintained yield through enhanced tillering even at low sowing rates.

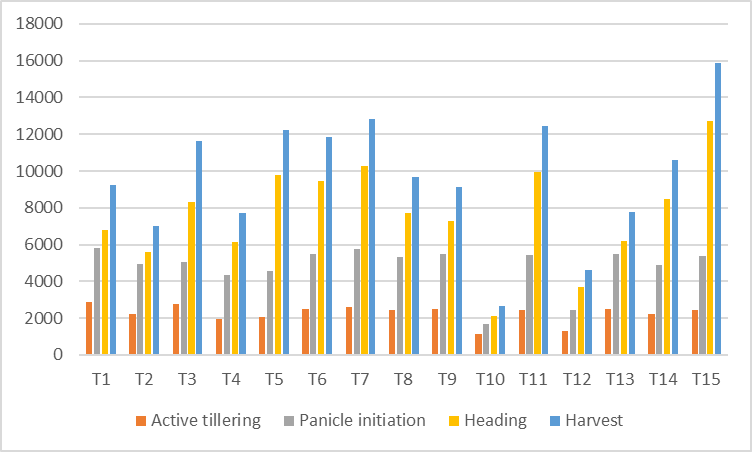
**Fig. 2. No of tillers per hill of different rice cultivars at various growth stages under DDSR**

**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 recorded at four critical growth stages viz., active tillering, panicle initiation, heading, and harvest under DDSR conditions, and the results are presented in Table 2 and Figure 3. Among the treatments, T15 consistently recorded 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 recorded 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 comparatively low DMP across the stages. Most cultivars showed a consistent increase in DMP from active tillering through harvest, with sharp increases observed after panicle initiation, indicating active vegetative and reproductive growth. The significant differences among treatments emphasize the influence of cultivars on dry matter production under DDSR conditions. 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 contributed 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 conditions, 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). Conversely, varieties like T10 and T12 recorded 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**

**4. Conclusion**

The evaluation of rice cultivars under dry direct-seeded rice (DDSR) conditions revealed significant varietal differences in key growth traits such as plant height, number of tillers per hill, and dry matter production. Landrace Karuppukavuni (T10) exhibited superior plant height, indicating strong vegetative growth, while Co 57 and Co 56 stood out for their high tillering capacity, essential for productivity in DDSR systems. T15 demonstrated the highest dry matter production across all growth stages, reflecting vigorous biomass accumulation and potential for high yield. These results underscore the importance of varietal selection for DDSR adaptability, with traits like early vigor, efficient tillering, and biomass accumulation playing crucial roles in enhancing performance. Integrating these findings with genomic insights can support targeted breeding strategies to develop high-performing DDSR-adapted rice cultivars.

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**Competing interests**

Authors have declared that no competing interests exist.

**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

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

Sagare, D. B., Abbai, R., Jain, A., Jayadevappa, P. K., Dixit, S., Singh, A. K., Challa, V., Alam, S., Singh, U. M., Yadav, S., Sandhu, N., Kabade, P. G., Singh, V. K., & Kumar, A. (2020). More and more of less and less: Is genomics-based breeding of dry direct-seeded rice (DDSR) varieties the need of hour? *Plant Biotechnology Journal*, *18*(11), 2173–2186. https://doi.org/10.1111/pbi.13454

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*.

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