Cover Image: Direct-seeded rice (DSR) cultivation

**International Journal of Research in Agronomy** 2024; 7(7): 144-149

**Evaluation of genotype suitability for direct seeded rice (DSR) cultivation**

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**DOI:** https://doi.org/10.33545/2618060X.2024.v7.i7b.998

**Abstract**

Direct-seeded rice (DSR) is gaining interest as an alternative to traditional transplanted rice, offering benefits like reduced water and labor requirements. However, poor crop establishment due to environmental stresses hinders DSR success. This study evaluates 17 rice genotypes under DSR for growth, yield parameters and suitability. The plant height, leaf area, dry matter production, yield attributes like productive tillers, panicle length, seed yield and duration to maturity were assessed. Significant genotypic variations were observed for most parameters except unfilled spikelets per panicle. MTU-1010 demonstrated consistently superior field emergence, plant height, leaf area, dry matter accumulation and number of productive tillers compared to other genotypes. It also had highest seed yield (64.08 q/ha) across years. The results emphasize the importance of traits like vigorous seedling growth and tillering ability in determining DSR success. Flowering duration showed significant differences among genotypes, with early varieties being desirable for uniform fields and climate resilience. However, very early maturity may compromise yield potential. MTU-1010 had moderately late flowering and maturity while producing top yields, indicating a complex relationship between these traits under stress. The findings identify MTU-1010 as a promising genotype for DSR cultivation, with potential for further improvement through breeding efforts enhancing its useful traits. The study underscores need for varieties combining high yield potential, vigorous early growth and improved storage ability. Continued research on genotypes, agronomic management and sustainable practices is imperative to make DSR a viable alternative to transplanted rice. Overall, this study provides valuable insights into rice genotypes suitability for DSR and traits influencing productivity, supporting informed varietal selection and breeding strategies for wider DSR adoption.

**Keywords:** Direct seeded rice (DSR), rice genotypes, MTU-1010, seed yield

1. Introduction

Rice (*Oryza sativa* L.) holds a distinctive status as both a staple food for humans and fodder (Swaminathan, 1984). Classified under the genus *Oryza*, which comprises two cultivated and 22 wild species, *Oryza sativa* and *Oryza glaberrima* are the cultivated species within the family Poaceae, featuring a chromosome number of 2n=24. USDA’s Global rice production in 2023/24 is projected to 515.53 million metric tons (milled basis) with an area of 165.98 million hectares (USDA report 2024). In India, rice cultivation spans 48 million hectares, producing 134 million metric tons (milled basis). Major rice-growing states in India include West Bengal, Punjab, Uttar Pradesh, Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu, Telangana, and Karnataka. Notably, Asian rice consumption is anticipated to contribute significantly, despite declining per capita consumption in China and India. The rising population poses challenges to global food requirements, especially with limitations on area expansion for rice cultivation due to urbanization, climate change, and high-value agriculture. In this context, enhancing rice yields becomes imperative, with an annual increase of 1.2 to 1.5 per cent over the next decade, requiring an additional 8-10 million tons each year. This increase aims to meet the escalating population's rice needs, particularly in countries like India. The global adoption of DSR, particularly in rainfed lowlands, uplands, and flood-prone areas, is acknowledged (Azmi et al., 2005; De Dios et al., 2005) [9,10]. Environmental benefits, such as reduced methane emissions and the potential resolution of edaphic conflicts, make DSR an appealing option (Farooq et al., 2008) [10].

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Continued research and the development of cost-effective and ecologically sound production technologies, along with rice varieties exhibiting drought tolerance and higher yield potential, are essential for establishing direct seeding as a prominent production system in the Kalyana-Karnataka region’s rice belt. Considering this context efforts have been made to promote DSR technology, with scientists focusing on developing suitable varieties and agronomic packages to optimize DSR cultivation (Pathak et al., 2011) [21]. Despite its potential, ongoing research is necessary to address challenges, improve varietal suitability, and promote sustainable practices for broader DSR adoption.

2. Materials and Methods
Field experiments conducted during the kharif seasons of 2015-16 and 2016-17 at Vijayanagar camp, Raichur taluka, Karnataka state which lies in the tail end of the Tungabhadra Project (TBP) Command area. The location, situated at 16°11′ North latitude, 77°13′ East longitude, and 393 meters above mean sea level, belongs to the North Eastern Dry Zone (Zone-2) of Karnataka. Soil characteristics analysis revealed a deep black clay texture with specific physico-chemical properties. The soil pH was 8.20, electrical conductivity 0.69 dS m⁻¹, and medium organic carbon content (6.82 g kg⁻¹). The area experiences an average annual rainfall of 597 mm, with deviations in peak rainfall during the crop growth period. A total of 17 rice genotypes were studied, with 15 obtained from Agriculture Research Station, Gangavati, and 2 Marker assisted lines (MAS) from UAS, GKVK Bengaluru. The experiment employed a Simple Randomized Complete Block Design (RCBD) with three replications. Recommended fertilizer application practices were followed, with detailed procedures outlined for land preparation, irrigation, weed management, and pest control. Harvesting occurred in December 2015 and January 2016, with treatment-wise seed yield recorded and expressed in quintals per hectare. Observations on growth parameters were made at distinct stages of crop growth, and data on yield parameters were recorded at harvest.

3. Results
Genotypic variations were observed in all plant growth parameters, except for the number of unfilled spikelets per panicle, which showed non-significant differences. At harvest, G13: MTU-1010 maintained the tallest plants (109.98 cm), while G16: MAS-946-1 had the lowest plant height (70.83 cm) in the pooled data. G13: MTU-1010 also produced the maximum leaf area (483.53 cm² hill⁻¹) at all growth stages, with G11: IET-18299 consistently having the minimum leaf area (297.73 cm² hill⁻¹). In terms of leaf area index, G13: MTU-1010 consistently had the highest values (2.418), while G11: IET-18299 had the lowest (1.489) at all growth stages. Days to 50% flowering varied significantly among genotypes, with G15: IET-19251 flowering earliest (86.1 days) and G10: BPT-5204 flowering latest (112.1 days). G17: MAS-946-1 had the shortest maturity duration (119.50 days). Dry matter production per plant was significantly higher in G13: MTU-1010 (73.42 g), followed by G12: MT-4420 (68.63 g), G7: MT-4253 (62.89 g), G5: GNV-1089 (49.84 g), G4: GNV-1301 (59.78 g), and G5: GNV-05-01 (52.72 g) during the pooled mean year. At harvest, G13: MTU-1010 registered the highest number of tillers per hill (23.27), while G11: IET-18299 had the lowest (18.50). G13: MTU-1010 also recorded the highest number of productive tillers per hill (20.7). Regarding yield components, G13: MTU-1010 (25.00 cm and 3.20 g) and G12: MT-4420 (24.30 cm and 3.11 g) produced the longest panicles and heaviest panicle weights respectively.

G15: MTU-1010 also had the maximum number of seeds per panicle (151.5) and filled seeds per panicle (140.2). G11: IET-18299 consistently displayed the lowest values for seed yield per ha (37.13), and test weight (12.95 g), while G13: MTU-1010 consistently showed the highest values for these parameters during both individual years and the pooled mean.

4. Discussion
Plant height is a crucial trait in crops because it is often linked to the likelihood of lodging under unfavorable conditions. Plant height typically increases from the tillering stage to flowering and then stabilizes until maturity. Breeders should aim to develop varieties with strong culms to resist lodging and that are fertilizer-responsive to enhance yield. Plant height varied among genotypes, with MTU-1010 reaching the highest (109.98 cm) and MAS-26 the lowest (70.83 cm). This variation is due to differences in internodal length. Previous studies by Muhammad Yaqoob et al. (2012) [20], Kumar et al. (2013) [13], and Kavitha and Giri et al. (2016) [18] reported similar increases in plant height in rice varieties. Higher plant height in MTU-1010 may be due to longer internodal length, while the lower height in MAS-26 could be due to constraints in cell elongation, leading to shorter internodal length. These findings are consistent with Ashrafuzzaman et al. (2009)p [1]. Differences in plant height among genotypes are attributed to their genetic characteristics, including growth rates and inherent height (Enujeke, 2013) [8]. Leaf area per plant increased gradually from 30 to 90 DAS, then declined across all genotypes. Leaf area index (LAI) is particularly important during the reproductive stage for determining dry matter production and grain yield in rice (Yoshida, 1981) [14]. In this study, MTU-1010 having the highest leaf area (483.53 cm² Hill⁻¹) and LAI (2.418), and IET-18299 the lowest in both metrics. Renuka Devi et al. (2013) [12] and Kavitha et al. (2015) [11] reported a similar pattern of leaf area increase from 30 to 75 DAS, followed by a decline under aerobic conditions. Dahiphale and Khandagale (2008) [6] also found a significant positive correlation between leaf area and chlorophyll content at flowering with yield in upland rice genotypes. The reduction in LAI might be due to a rapid decline in leaf elongation as observed by Lilley and Fukai (1994) [17]. Similar genotypic variation in LAI was reported by Gowri (2005) [10] and Sritharan et al. (2015) [25] under aerobic cultivation.

Flowering and maturity duration are key characteristics for the commercial release of a variety. Early maturing varieties are important for rice improvement and climate mitigation as a drought escape mechanism. Variation in flowering and maturity among genotypes can be effective for selection in areas with bimodal rainfall, like India. Late flowering can be beneficial if genotypes flower near the end of the rainy season. In this study, IET-19251 had the shortest flowering and maturity durations (86.1 and 121.00 days), while BPT-5204 had the longest (112.10 and 146.00 days). Similar results were reported by Mahantashivayogaya et al. (2016) [18] and Sandhu et al. (2019) and Kavya and Vasudevan (2012) [22]. The extent of delay indicates drought tolerance, with more delay suggesting less tolerance (Lafitte et al., 2002) [106]. In this study, early-maturing genotypes recorded lower yields compared to others. Dry matter production increased throughout the crop growth period until maturity and varied significantly among genotypes. Similar variability in dry matter under stress was reported in rice (Chauhan et al., 1996) [5]. Among the genotypes, MTU-1010 had the highest dry matter accumulation (73.42 g), followed by MT-
4420 (68.63 g), while IET-18299 had the lowest (42.96 g). High dry matter was linked to higher photosynthetic area and yield, consistent with Kavitha et al. (2015) [11]. Higher dry matter accumulation correlates with grain yield in rice under rainfed upland conditions (Chauhan et al., 1996; Wu Gui Cheng et al., 2010) [6, 3].

Tillering ability is a crucial trait for seed production in rice, significantly influencing yield. Fewer tillers result in fewer panicles, while excess tillers cause high mortality, small panicles, poor seed filling, and reduced yield. The number of tillers per plant is an important morpho-physiological trait for grain yield in rice (Tao et al., 2002) [21]. In this study, MTU-1010 produced the highest number of total and productive tillers per plant (23.27 and 20.7), while IET-18299 had the lowest (18.50 and 15.3). Similar results were observed by Kavitha et al. (2015) [11], and Kumar et al. (2017) [15]. Genotypic variability in tiller production was also reported by Mahantashivayogayya et al. (2016) [18], Kavya and Vasudevan (2022) [12] under limited moisture conditions. Productive tillers highly correlate with grain yield, making them a key trait for high yield in aerobic rice production (Malarvizhi et al., 2010; Tiwari et al., 2011) [19, 20]. Varieties with higher productive tillers also show higher physiological efficiency and drought tolerance (Muhammad Yaqoob et al., 2012) [20]. Selecting aerobic rice varieties with increased productive tillers could be a promising strategy for enhancing grain yield (Atlin et al., 2005) [2]. The longest panicle (25.0 cm) and highest weight (3.20 g) recorded in MTU-1010, while IET-18299 had the shortest (19.1 cm) and lowest weight (2.04 g). Similar findings were reported by Ashrafuzzaman et al. (2009) [1], Mahantashivayogayya et al. (2016) [15], Kavya and Vasudevan (2022) [21]. Genotypic differences influenced these traits, with longer panicles supporting more seeds. Significant differences were also observed in the total number of seeds per panicle, filled seeds, and unfilled spikelets. MTU-1010 had the most seeds per panicle (151.5), filled seeds (140.2), and the fewest unfilled spikelets (11.4). IET-18299 had the least seeds per panicle (101.8) and filled seeds (84.3). Genotypes with lower spikelet sterility had better root attributes and stress tolerance. Seed yield varied among genotypes, with MTU-1010 recording the highest yield (64.08 q/ha), closely followed by MT-4420 and MT-4253. IET-18299 had the lowest yield (37.13 q/ha). Moisture stress during flowering and grain filling significantly reduced yield (Boonjung and Fukai, 1996) [4]. Genotypic variability in yields under aerobic conditions was also reported by Sridhara et al. (2012) and Renuka Devi et al. (2013) [22]. Significantly, highest 1000 seed weight was recorded in MT-4021 (23.12 g) and lowest was in GNV-1405 (12.87 g). Such variability among rice genotypes was also reported by Kavitha et al. (2015) [11], Mahantashivayogayya et al. (2016) [15] and Kavya and Vasudevan (2022) [21] in rice under DSR. The increased 1000 seed weight in few genotypes is attributed to genetic character of the genotype and also better supply of photosynthates during seed filling period. However, less test weight might occur due to poor translocation of photosynthates at seed filling.

**Fig 1:** Plant height, leaf area, days to 50% flowering and days to maturity as influenced by rice genotypes under DSR method
Fig 2: Seed yield per plot, total number of seeds per panicle, panicle length, panicle weight and total number of tillers per plant as influenced by rice genotypes under DSR method.

Table 1: Plant height, Leaf area per hill, Leaf area index, Days to 50% flowering, Days to maturity and Dry matter production per plant as influenced by rice genotypes under direct seeded rice (DSR) method

<table>
<thead>
<tr>
<th>Genotypes</th>
<th>Plant height (cm)</th>
<th>Leaf area per hill (cm² hill⁻¹)</th>
<th>Leaf area index</th>
<th>Days to 50% flowering</th>
<th>Days to maturity</th>
<th>Dry matter production per plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1: RYC-230</td>
<td>85.33</td>
<td>412.27</td>
<td>2.063</td>
<td>109.8</td>
<td>138.50</td>
<td>48.57</td>
</tr>
<tr>
<td>G2: GNV-1405</td>
<td>78.58</td>
<td>427.91</td>
<td>2.164</td>
<td>100.8</td>
<td>134.10</td>
<td>49.48</td>
</tr>
<tr>
<td>G3: GNV-1089</td>
<td>101.32</td>
<td>459.43</td>
<td>2.297</td>
<td>88.7</td>
<td>136.17</td>
<td>49.84</td>
</tr>
<tr>
<td>G4: GNV-1301</td>
<td>79.02</td>
<td>453.75</td>
<td>2.269</td>
<td>104.5</td>
<td>133.25</td>
<td>59.78</td>
</tr>
<tr>
<td>G5: GNV-05-01</td>
<td>94.87</td>
<td>448.57</td>
<td>2.243</td>
<td>99.7</td>
<td>132.83</td>
<td>52.72</td>
</tr>
<tr>
<td>G6: GNV-1109</td>
<td>99.32</td>
<td>440.55</td>
<td>2.203</td>
<td>103.7</td>
<td>140.00</td>
<td>57.58</td>
</tr>
<tr>
<td>G7: MT-4253</td>
<td>91.98</td>
<td>466.25</td>
<td>2.331</td>
<td>98.7</td>
<td>125.50</td>
<td>62.89</td>
</tr>
<tr>
<td>G8: IET-22066</td>
<td>89.38</td>
<td>411.65</td>
<td>2.057</td>
<td>93.5</td>
<td>131.50</td>
<td>52.17</td>
</tr>
<tr>
<td>G9: MT-4021</td>
<td>86.92</td>
<td>401.92</td>
<td>2.010</td>
<td>89.2</td>
<td>129.00</td>
<td>50.72</td>
</tr>
<tr>
<td>G10: BPT-5204</td>
<td>75.08</td>
<td>418.90</td>
<td>2.094</td>
<td>112.1</td>
<td>146.00</td>
<td>47.87</td>
</tr>
<tr>
<td>G11: IET-18299</td>
<td>96.32</td>
<td>297.73</td>
<td>1.489</td>
<td>91.3</td>
<td>128.00</td>
<td>42.96</td>
</tr>
<tr>
<td>G12: MT-4420</td>
<td>81.13</td>
<td>473.03</td>
<td>2.365</td>
<td>88.9</td>
<td>129.67</td>
<td>68.63</td>
</tr>
<tr>
<td>G13: MTU-1010</td>
<td>109.98</td>
<td>483.53</td>
<td>2.418</td>
<td>87.7</td>
<td>128.17</td>
<td>73.42</td>
</tr>
<tr>
<td>G14: MT-4541</td>
<td>100.87</td>
<td>426.92</td>
<td>2.122</td>
<td>89.3</td>
<td>124.67</td>
<td>56.06</td>
</tr>
<tr>
<td>G15: IET-19251</td>
<td>95.45</td>
<td>368.05</td>
<td>1.840</td>
<td>86.1</td>
<td>121.00</td>
<td>46.73</td>
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<tr>
<td>G16: MAS-26</td>
<td>70.83</td>
<td>445.13</td>
<td>2.326</td>
<td>99.5</td>
<td>123.50</td>
<td>58.5</td>
</tr>
<tr>
<td>G17: MAS-946-1</td>
<td>78.63</td>
<td>424.37</td>
<td>2.110</td>
<td>95.1</td>
<td>119.50</td>
<td>60.14</td>
</tr>
<tr>
<td>Mean</td>
<td>89.12</td>
<td>427.06</td>
<td>2.141</td>
<td>96.38</td>
<td>130.67</td>
<td>55.18</td>
</tr>
<tr>
<td>S.E.M ±</td>
<td>0.73</td>
<td>15.42</td>
<td>0.077</td>
<td>1.72</td>
<td>1.44</td>
<td>2.44</td>
</tr>
<tr>
<td>CD @ 5%</td>
<td>1.65</td>
<td>34.91</td>
<td>0.175</td>
<td>3.9</td>
<td>5.53</td>
<td>3.26</td>
</tr>
</tbody>
</table>
5. Conclusion
This study provides significant insights into genotypes suitability and traits influencing DSR success. MTU-1010 emerges as a promising variety, displaying superior performance across parameters like emergence, height, leaf area, dry matter, and productive tillers, coupled with top seed yields. However, early maturity may compromise yield potential, underscoring the need to balance this relationship. The findings suggest further improving MTU-1010 through targeted breeding to enhance useful traits. Additionally, continued research efforts in genotypes, management practices and sustainable approaches are imperative to establish DSR as an efficient alternative to transplanted rice. Overall, this study offers a foundation for informed varietal selection and strategies to drive wider DSR adoption.

6. Acknowledgements
I, extend my deepest gratitude to my chairman Dr. S. N. Vasudevan for his invaluable guidance, unwavering support and insightful advice throughout the course of my PhD journey. The author acknowledges the Department of Social Justice and Empowerment, Ministry of Social Justice and Empowerment, Government of India for providing National Fellowship and Department of Seed Science & Technology, UAS, Raichur for providing laboratory facilities to carry out research work.

7. References


~ 149 ~