***Original Research Article***

**Influence of salinity on morpho-phenological parameters of rice genotypes (*Oryza sativa* L.)**

**ABSTRACT**

A field experiment was conducted during the *Kharif* seasons of 2021 and 2022 at the Agricultural Research Station (ARS), Gangavathi, under the University of Agricultural Sciences, Raichur, Karnataka, to evaluate the Influence of salinity on morpho-phenological parameters of different rice genotypes (*Oryza sativa* L.). The site had saline soil conditions with pH values of 8.13 and 8.17, and electrical conductivity (ECe) of 10.90 and 10.77 dSm⁻¹ in 2021 and 2022, respectively. Thirty-six genotypes, including four checks, were evaluated using a randomized block design with two replications. Significant variation was observed among genotypes for morpho-phenological traits such as plant height, tiller number, leaf area, leaf area index, dry matter accumulation, days to 50% flowering and days to physiological maturity. Salinity stress reduced growth, suppressed tillering, decreased biomass, and delayed flowering and maturity in sensitive genotypes due to osmotic stress, ion toxicity, and disrupted physiological processes. In contrast, tolerant genotypes maintained growth through mechanisms like osmotic adjustment and ion compartmentalization. Based on performance, genotypes were categorized as highly tolerant (9), tolerant (8), moderately tolerant (12), sensitive (4), and highly sensitive (3). The tolerant groups offer potential for cultivation in salt-affected areas and can be used as donors in breeding programs to enhance salinity tolerance in rice.

*Keywords: pH, EC, Genotypes, Salinity stress, Photosynthetic efficiency, Nutrient uptake*

**1.INTRODUCTION**

Rice (*Oryza sativa* L.) is one of the world’s most important staple crops, serving as a primary calorie source for over half of the global population (Swaminathan, 1984). Of the 24 known species in the genus *Oryza* (2n = 24), *O. sativa* and *O. glaberrima* are the two cultivated types. According to USDA (2024), global rice production in 2023/24 is projected at 515.53 million metric tons (milled basis), cultivated over 165.98 million hectares. India contributes approximately 134 million metric tons from 48 million hectares, with major rice-growing states including West Bengal, Punjab, Uttar Pradesh, Andhra Pradesh, Bihar, Madhya Pradesh, Tamil Nadu, Telangana, and Karnataka.

With rising global population and limited scope for expanding cultivation areas due to urbanization and climate change, improving rice productivity is essential. To meet future food demands, yields must increase by 1.2–1.5% annually, adding 8–10 million tons of rice each year-particularly in densely populated nations like India (USDA, 2024).

Among the abiotic stresses threatening rice productivity, salinity is one of the most detrimental, especially in arid, semi-arid, and coastal regions. Salinity adversely affects plant growth and development through osmotic stress, ion toxicity, and nutrient imbalance, impairing key morpho-physiological and phenological traits that directly influence yield.

Understanding genotypic responses to salinity is crucial for developing salt-tolerant cultivars. Morphological traits such as plant height, tiller number, leaf area, and leaf area index (LAI) reflect vegetative growth and canopy structure, which impact photosynthesis and biomass production. Likewise, crop growth rate (CGR) and dry matter distribution in leaves, stems, and panicles provide insight into physiological efficiency and source-sink dynamics under stress.

Phenological traits like days to 50% flowering and physiological maturity are vital indicators of developmental progress and adaptability to salinity. Stress-induced changes in these stages may influence grain filling and harvest index.

This study evaluates the effects of salinity on key morpho-phenological traits in diverse rice genotypes. By analysing variation in growth, biomass accumulation, and developmental timing, the research aims to identify salt-tolerant genotypes and provide a physiological basis for their use in breeding programs.

**2. MATERIAL AND METHODS**

A field experiment was conducted during the *Kharif* seasons of 2021 and 2022 at the Agricultural Research Station (ARS), Gangavathi, to evaluate rice genotypes for salinity tolerance. The study assessed 36 rice genotypes, including four check varieties-two salt-tolerant (CSR22 and GANGAVATHI SONA) and two salt-sensitive (MTU1010 and BPT5204). Observations were recorded at 60 and 90 days after transplanting (DAT), and at harvest, focusing on morphological and phenological traits to evaluate salinity stress responses. Surface soil samples (0–15 cm) were collected, air-dried, and sieved (2 mm) for analysis. The soil pH was recorded at 8.13 (2021) and 8.17 (2022), while the electrical conductivity (ECe) was 10.90 dSm⁻¹ and 10.77 dSm⁻¹, respectively, indicating highly saline conditions. Plant height was measured from the base to the tip of the last sheath of the main shoot. Tillers per square meter were counted in a randomly selected area within the net plot. Leaf area was estimated by recording the number of leaves per plant and measuring the length and width of each leaf on the middle tiller. The Leaf Area Index (LAI) was calculated as the ratio of total leaf area to the land area occupied by a single plant. Dry matter production was determined by uprooting five plants from each plot (excluding border rows), separating leaves, stems, and panicles, and drying them at 65°C for 72 hours until a constant weight was achieved. The dry weights were expressed in grams per hill. Days to 50% flowering were recorded as the number of days from transplanting until 50% of the plants in each plot initiated flowering. Physiological maturity was assessed as the number of days from transplanting until 50% of the panicles exhibited golden yellow grains with senescence of lower leaves. This study aimed to identify genotypes capable of maintaining growth and development under saline field conditions. By evaluating traits such as plant height, tillering, LAI, dry matter accumulation, and phenological development, the experiment sought to pinpoint salt-tolerant genotypes with promising adaptive traits for cultivation in salt-affected areas.

**3. RESULTS AND DISCUSSION**

Results on morphological parameters such as plant height, number of tillers, leaf area, leaf area index, crop growth rate and total dry matter differed significantly among the genotypes under salinity stress.

Significant variation in plant height was observed among rice genotypes under salinity stress at 60 DAT, 90 DAT, and at harvest during the 2021 and 2022 *Kharif* seasons. At 60 DAT, the pooled data showed significantly highest plant height was observed in FL478 (95.92 cm), followed by IET 28608 (95.38 cm), and CSR10 (94.35 cm) exhibiting the tallest plants at 60 DAT, indicating strong early vigor. At 90 DAT, pooled data recorded the significantly highest plant height was recorded in, IET 28608 (112.21 cm), SIRI 1253 (109.64 cm), and CSR22 (107.23 cm) maintained superior growth, and by harvest, pooled data indicated that the genotype IET 28608 (116.31 cm), exhibited the significantly highest plant height, along with SIRI 1253 (113.83 cm), and FL478 (110.41 cm) remained the tallest. In contrast, GNV 1810, GNV 1804, and GNV 1802 consistently showed the shortest stature under salinity. Salinity stress reduces plant height primarily due to osmotic stress, ion toxicity, and hormonal imbalances that restrict water uptake and cell elongation while disrupting nutrient absorption (Munns & Tester, 2008; Zhu, 2001). Hormonal shifts, including decreased gibberellin and increased ABA levels, further limit stem elongation (Quamruzzaman *et al*., 2021). Genotypes like FL478, IET 28608, and CSR23 likely possess adaptive mechanisms such as osmotic adjustment and ion exclusion, enabling sustained growth. Conversely, genotypes like MTU1010 and GNV 1804 that promote resource efficiency under stress (Yamaguchi, 2008). Moderate height with robust culms, as observed in CSR10 and CSR23, supports lodging resistance and contributes to yield stability under saline conditions (Ramezani *et al*., 2017; Hafeez *et al*., 2019).

Significant differences in tiller number per hill were observed among rice genotypes across growth stages (60 DAT, 90 DAT, and harvest) under salinity stress. Tiller numbers increased from 60 to 90 DAT and stabilized or slightly declined at harvest. At 60 DAT, pooled data showed significantly the highest tillers number was recorded in IET 28608 (34.24), as compared to CSR23 (32.84), and GNV 1109 (32.73) recorded the highest tiller numbers. At 90 DAT, pooled data indicated that the tiller count increased across genotypes, in which among CSR 36 (44.93) recorded a significantly highest number of tillers per plant, notably genotypes such as GNV 1801 (43.72), GNV 1806 (42.71), At harvest, CSR36 (46.35), GNV 1801 (44.57), and FL478 (43.01) maintained high tiller numbers. In contrast, genotypes such as IET 29354, MTU1010, and IET 28606 consistently recorded the lowest tiller counts, indicating poor performance under salinity. Tillering is a critical physiological trait contributing directly to grain yield. Under salinity stress, osmotic and ionic imbalances limit water and nutrient uptake, negatively affecting growth. However, genotypes like CSR36, FL478, and GNV 1801 demonstrated higher tiller numbers, suggesting superior genetic resilience and efficient stress management mechanisms. This aligns with findings by Patel *et al*. (2018) and Sharma *et al*. (2017), who emphasized the importance of tiller production in salinity tolerance. Moderate tillering, as seen in FL478, supports better resource allocation and stress adaptation, especially in direct-seeded systems (Kumar & Sood, 2021). Furthermore, higher tiller numbers enhance resource capture and nutrient use efficiency, supporting sustained photosynthesis and yield. Singh *et al*. (2020) also reported a positive correlation between high tiller count and grain yield under salinity, reinforcing its role in maintaining productivity in salt-affected environments.

Significant differences in leaf area (m² per hill) among rice genotypes at 60 DAT, 90 DAT, and harvest under salinity stress across two years. Leaf area increased from 60 to 90 DAT, then declined slightly at harvest. At 60 DAT, pooled data revealed that the significantly highest leaf area was observed in SIRI 1253 (0.080) as compared to GNV 1109 (0.074), CSR23 (0.073), CSR 22 (0.072) and FL478 (0.071) their superior leaf expansion capacity under saline conditions. Conversely, IET 28606 (0.049) and MTU 1010 (0.054) had the lowest values By 90 DAT, pooled data on leaf area increased significantly, genotype GNV 1109 (0.098), along with GNV 1806 (0.097), GNV 1801 (0.096) and SIRI 1253 (0.095) exhibiting the highest leaf area. At harvest, CSR 36 (0.077) and IET 28608 (0.067) retained higher leaf areas, reflecting their adaptability to prolonged stress. Genotypes like CSR 36, GNV 1109, and SIRI 1253 showed superior leaf area retention, indicating genetic adaptability and efficient resource use. As supported by Sharma *et al.* (2019) and Singh *et al*. (2020), sustained leaf area under salinity enhances photosynthetic efficiency and yield. These findings emphasize the importance of leaf area retention in identifying salt-tolerant, high-yielding rice genotypes.

Significant variation in Leaf Area Index (LAI) was observed among rice genotypes at 60 DAT, 90 DAT, and harvest under salinity stress during 2021-2022. At 60 DAT, the pooled data of various rice genotypes showed that the highest LAI was recorded in SIRI 1253 (3.524), and GNV 1109 (3.246). At 90 DAT, significantly highest values were recorded in GNV 1109 (4.370) and SIRI 1253 (4.240) maintained superior canopy development. By harvest, LAI declined, but significantly highest values were recorded in CSR 36 (3.417), GNV 1109 (2.889), and CSR10 (2.831) retained higher LAI values, indicating sustained vigor under salinity. In contrast, genotypes like IET 28606 and MTU 1010 exhibited consistently lower LAI, indicating sensitivity to salt stress. Salinity impairs LAI by causing osmotic stress and ion toxicity, leading to reduced cell expansion and early senescence (Munns & Tester, 2008; Ganapati *et al*., 2022). Tolerant genotypes maintain higher LAI via efficient osmotic adjustment and better water and nutrient uptake (Gupta *et al*., 2021; Yadav *et al*., 2020). High LAI supports greater photosynthetic capacity, light interception, and yield stability under stress (Huanhe *et al*., 2024; Chakraborty *et al*., 2018). These findings suggest that genotypes such as GNV 1109, CSR 36, and SIRI 1253 are promising candidates for salinity-prone environments and breeding programs targeting salt tolerance.

Significant variation in crop growth rate (CGR) was observed among rice genotypes at 60 DAT, 90 DAT, and harvest under salinity stress across 2021 and 2022. At 60 DAT, significantly highest values were recorded in genotypes like GNV 1109 (29.17 g/m²/day), CSR22 (29.10), and IET 28608 (28.96) showed vigorous early growth. At 90 DAT, significantly highest values were recorded in GNV 1109 (59.85), CSR22 (57.08), and SIRI 1253 (56.68) maintained superior CGR. However, genotypes such as MTU 1010 and IET 28606 consistently exhibited poor growth under salinity. By harvest, CGR declined across all genotypes, but significantly highest values were recorded in GNV 653 (2.84), GNV 1806 (2.26), and CSR23 (1.38) sustained moderate growth, reflecting their resilience. Salinity stress impairs crop growth by disrupting ion balance, water uptake, and photosynthesis (Zhang *et al*., 2018). Tolerant genotypes like GNV 1109 and CSR 36 likely employ mechanisms such as ion compartmentalization and antioxidant activity to maintain growth (Singh *et al*., 2019; Ali *et al*., 2020). These mechanisms help sustain biomass production and yield under stress. According to Sharma *et al*. (2021), consistent CGR across stages is critical for yield stability, while Ahmed *et al*. (2022) link higher CGR with improved salt stress escape, suggesting these genotypes are valuable for saline-prone environments.

Significant variation in leaf dry matter (g/hill) was observed among rice genotypes at 60 DAT, 90 DAT, and harvest across two years under salinity stress. At 60 DAT, pooled data on leaf dry matter was significantly highest observed in CSR 36 (13.65 g/hill), IET 28608 (12.77), and GNV 1801 (12.76) showed superior early growth. At 90 DAT, pooled data on leaf dry matter was significantly highest observed in IET 28608 (27.31), GNV 1109 (27.10), and CSR 23 (26.39) maintained high biomass, while MTU 1010 and PUSA 44 consistently recorded the lowest values. At harvest, pooled data on leaf dry matter was significantly highest observed in IET 28608 (22.55), GNV 1109 (22.49), and CSR 23 (22.27) retained higher leaf biomass, reflecting strong stress resilience.

Salinity impairs biomass accumulation through osmotic imbalance and ionic toxicity, reducing photosynthesis and turgor pressure (Sajid *et al*., 2020; Khan *et al*., 2022). Genotypes like IET 28608, CSR 36, and GNV 1109 likely possess adaptive traits such as efficient osmotic adjustment, ion compartmentalization, and sustained photosynthetic activity (Hassan *et al*., 2021; Ali *et al*., 2023). These traits support better leaf biomass retention and are linked to improved grain yield (Jha *et al*., 2021; Shah *et al*., 2019). Thus, leaf dry matter serves as a vital physiological indicator for selecting salt-tolerant, high-yielding rice genotypes in saline environments (Kumar *et al*., 2020; Jamil *et al*., 2021).

Significant genotypic variation was observed in stem dry matter (g/hill) across growth stages under saline conditions. At 60 DAT, the pooled data on stem dry matter was significantly highest observed in SIRI 1253 (16.51), FL478 (16.38), and CSR 10 (16.37) showed the highest biomass. By 90 DAT, the pooled data on stem dry matter was significantly highest observed in, CSR 22 (40.86), FL478 (40.35), and CSR 36 (40.03) exhibited superior accumulation. At harvest, the pooled data on stem dry matter was significantly highest observed in CSR 22 (42.95), FL478 (42.78), and SIRI 1253 (41.90) maintained high stem dry matter, while IET 28606 and IET 29354 consistently recorded the lowest values across stages, indicating stress sensitivity. Salinity stress impairs stem biomass by disrupting photosynthesis, reducing nutrient uptake, and causing ionic toxicity (Kumar *et al*., 2020; Chen *et al*., 2022). Tolerant genotypes like CSR 22, SIRI 1253, and CSR 10 likely possess mechanisms such as osmotic adjustment, Na⁺ exclusion, and efficient ion homeostasis (Gupta *et al*., 2023). These adaptations help sustain stem growth, crucial for nutrient translocation and yield maintenance under stress (Patel *et al*., 2020). Genotypes with higher stem dry matter under salinity, like CSR 22 and FL478, often correlate with greater yield stability (Khan *et al*., 2021; Sharma *et al*., 2021), highlighting the importance of selecting such traits in breeding salt-tolerant rice cultivars.

Significant variation in panicle dry matter (g/hill) was observed among rice genotypes across all growth stages under salinity stress. At 60 DAT, pooled data on panicle dry matter was recorded the significantly highest in CSR23 (9.26) and CSR36 (9.23) recorded the highest values, while IET 28606 (5.87) had the lowest. At 90 DAT, pooled data on panicle dry matter was recorded the significantly highest in CSR23 (10.76) and SIRI 1253 (10.75) outperformed others, whereas IET 28606 (7.89) and GNV1805 (8.43) showed reduced performance. At harvest, pooled data on panicle dry matter was recorded the significantly highest in GNV1109 (13.87), GNV1801 (13.72), and IET 28608 (13.48) maintained high panicle dry matter, while IET 28606 (10.53) and MTU1010 (11.06) showed the lowest accumulation. Salinity stress limits photosynthesis, nutrient uptake, and water availability, reducing carbon allocation to reproductive organs (Flowers, 2004; Munns & Tester, 2008). Tolerant genotypes such as CSR23, GNV1801, and IET 28608 likely possess enhanced physiological traits like osmotic adjustment and ion homeostasis (Shannon *et al*., 1998). In contrast, sensitive genotypes like IET 28606 struggle with water and nutrient stress, limiting panicle development (Rajendran *et al*., 2012). Efficient dry matter partitioning to panicles is crucial for yield under salinity, and genotypes maintaining higher panicle biomass are more likely to sustain productivity in saline environments (Ghoulam *et al*., 2002).

Salinity stress significantly influenced total dry matter (TDM) accumulation in rice genotypes across growth stages, with substantial genotypic variation. At 60 DAT, the pooled data on total dry matter was recorded significantly highest in CSR36 (38.63 g/hill) and CSR10 (37.72 g/hill) recorded the highest TDM, while IET 29354 (22.19 g/hill) showed the lowest. By 90 DAT, the pooled data on total dry matter was recorded significantly highest in GNV1109 (77.24 g/hill), CSR36, and IET 28608 demonstrated robust biomass accumulation, contrasting sharply with MTU1010 (45.86 g/hill) and IET 28606 (47.10 g/hill). At harvest, the pooled data on total dry matter was recorded significantly highest in GNV1109 (77.00 g/hill), CSR22, and CSR23 maintained high TDM, while PUSA44 (49.74 g/hill) and MTU1010 remained lowest. Salinity hampers water uptake, nutrient absorption, and photosynthesis, leading to reduced growth (Munns, 2002; Hasegawa *et al*., 2000). Tolerant genotypes like GNV1109 and IET 28608 likely possess superior root systems, ion regulation, and antioxidative defense, allowing them to sustain TDM under stress (James *et al*., 2006; Flowers, 2004). In contrast, susceptible genotypes accumulate toxic ions and fail to maintain metabolic processes (Zhu *et al*., 2001). TDM is closely linked to yield potential, serving as a critical indicator of salinity resilience (Blum *et al*., 2011). Hence, genotypes with consistently higher TDM, such as CSR36 and IET 28608, are strong candidates for cultivation in saline environments (Kader *et al*., 2017).

Revealed that salinity had minimal influence on the days to 50% flowering among rice genotypes, with flowering ranging narrowly from 88 to 97 days. Genotypes like IET 28608 and IET 27807 consistently flowered earlier (90-91 days), suggesting inherent tolerance to salinity-induced delays. In contrast, genotypes such as GNV 1804 and FL478 flowered slightly later (96-97 days), but differences were not statistically significant. The overall pooled mean was 92.37 days, indicating phenological stability across genotypes and years. Although salinity can delay flowering by disrupting hormone balance, nutrient uptake, and photosynthesis (Munns & Tester, 2008), the genotypes studied demonstrated resilience. Consistent flowering under saline conditions suggests the presence of adaptive traits like osmotic adjustment, ion regulation, and efficient root systems (Shah *et al*., 2015; Zhang *et al*., 2011). These mechanisms enable timely transition to the reproductive stage, critical for yield preservation under stress (Mahajan & Tuteja, 2005). Stable flowering time under salinity stress, as seen in IET 28608 and CSR 36, reflects genetic adaptability and is often associated with better grain filling and yield maintenance (Siddiqui *et al*., 2017). Thus, flowering time serves as a reliable indicator of genotypic tolerance to salinity.

Significant variation in days to physiological maturity among rice genotypes under salinity stress, ranging from 97.25 to 116.25 days, with a mean of 110.86 days. Genotypes like IET 28608 (115.00 days) and IET 27823 (115.75 days) exhibited delayed maturity, possibly due to salinity-induced stress prolonging the vegetative phase (Munns, 2005). Such delays may reflect greater resource allocation to vegetative maintenance rather than reproduction, a pattern noted by Almodares *et al*. (2008). In contrast, CSR 23 matured earliest (97.25 days), likely employing an escape strategy under stress, hastening reproductive transition to minimize salt exposure during critical grain-filling stages (Flowers, 2004).. Salinity stress disrupts nutrient uptake, water balance, and photosynthesis, often delaying plant development (Greenway & Munns, 1980). However, genotypes with traits like osmotic adjustment, ion exclusion, and oxidative stress tolerance can sustain growth and yield despite longer maturity periods (Yeo *et al*., 1999; Shannon, 1997). Early or stable maturity under salinity, as in CSR 23, is advantageous for maintaining yield under adverse conditions

**Table 1. Influence of salinity on plant height (cm), Number of tillers (hill-1), Leaf area (m2) of different rice genotypes during different growth stages**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl.****No.** | **Genotypes** | **Plant height (cm)** | **Number of tillers (hill-1)** | **Leaf area (m2)** |
| **Days after transplanting (DAT)** |
| **Pooled** | **Pooled** | **Pooled** |
| **60** | **90** | **At harvest** | **60** | **90** | **At harvest** | **60** | **90** | **At harvest** |
| 1 | **IET 28608** | 95.38 | 112.21 | 116.31 | 34.24 | 41.33 | 42.62 | 0.070 | 0.091 | 0.067 |
| 2 | **IET 27077** | 91.43 | 92.76 | 96.01 | 27.08 | 39.99 | 41.45 | 0.067 | 0.075 | 0.060 |
| 3 | **IET 27823** | 87.30 | 88.68 | 95.95 | 24.93 | 34.15 | 35.16 | 0.058 | 0.086 | 0.045 |
| 4 | **IET 28606** | 81.86 | 88.88 | 90.40 | 28.01 | 26.31 | 27.03 | 0.049 | 0.063 | 0.041 |
| **5** | **CSR 36** | 92.96 | 103.09 | 106.15 | 31.52 | 44.93 | 46.35 | 0.067 | 0.090 | 0.077 |
| 6 | **IET 27807** | 84.75 | 90.83 | 94.34 | 26.36 | 27.52 | 28.29 | 0.059 | 0.076 | 0.055 |
| 7 | **IET 29356** | 85.07 | 92.41 | 95.35 | 29.29 | 32.75 | 33.71 | 0.060 | 0.080 | 0.059 |
| 8 | **IET 29365** | 84.80 | 92.08 | 94.82 | 29.91 | 27.16 | 27.92 | 0.059 | 0.073 | 0.056 |
| 9 | **CSR23** | 93.10 | 104.16 | 107.70 | 32.84 | 37.43 | 38.56 | 0.073 | 0.087 | 0.064 |
| 10 | **IET 29354** | 84.01 | 96.58 | 101.19 | 20.74 | 26.55 | 26.93 | 0.051 | 0.072 | 0.040 |
| 11 | **IET 29360** | 88.44 | 96.32 | 98.99 | 24.33 | 37.00 | 38.12 | 0.054 | 0.077 | 0.043 |
| 12 | **CSR10** | 94.35 | 102.49 | 106.50 | 31.98 | 38.33 | 39.50 | 0.070 | 0.088 | 0.064 |
| 13 | **IET 29361** | 86.61 | 96.75 | 100.60 | 28.43 | 34.38 | 35.40 | 0.062 | 0.084 | 0.052 |
| 14 | **IET 29364** | 88.64 | 92.77 | 95.96 | 30.18 | 32.43 | 33.38 | 0.060 | 0.085 | 0.048 |
| 15 | **FL478** | 95.92 | 106.29 | 110.41 | 31.91 | 41.71 | 43.01 | 0.071 | 0.091 | 0.061 |
| 16 | **IET 29366** | 87.27 | 85.07 | 88.50 | 23.35 | 27.96 | 28.74 | 0.055 | 0.068 | 0.040 |
| 17 | **IET 29358** | 84.75 | 95.27 | 98.62 | 29.12 | 33.21 | 34.19 | 0.065 | 0.079 | 0.053 |
| 18 | **PUSA44** | 83.03 | 86.11 | 89.08 | 22.10 | 28.63 | 29.07 | 0.054 | 0.072 | 0.046 |
| 19 | **IET 29353** | 84.69 | 92.17 | 95.53 | 26.71 | 31.16 | 32.07 | 0.059 | 0.083 | 0.048 |
| 20 | **SIRI 1253** | 91.09 | 109.64 | 113.83 | 31.13 | 40.98 | 41.76 | 0.080 | 0.095 | 0.061 |
| 21 | **GNV 1806** | 91.18 | 104.68 | 112.81 | 32.39 | 42.71 | 43.53 | 0.070 | 0.097 | 0.064 |
| 22 | **GNV 1807** | 80.97 | 91.44 | 96.13 | 26.76 | 38.70 | 39.41 | 0.062 | 0.082 | 0.053 |
| 23 | **GNV 1801** | 93.37 | 104.61 | 108.17 | 31.14 | 43.72 | 44.57 | 0.070 | 0.096 | 0.063 |
| 24 | **GNV 1812** | 84.34 | 89.27 | 94.48 | 30.17 | 35.74 | 36.38 | 0.059 | 0.086 | 0.050 |
| 25 | **GNV 1803** | 80.46 | 93.57 | 97.41 | 25.88 | 34.52 | 35.13 | 0.061 | 0.085 | 0.054 |
| 26 | **GNV 1802** | 80.22 | 97.59 | 101.89 | 28.37 | 32.22 | 32.77 | 0.064 | 0.080 | 0.049 |
| 27 | **GNV 1109** | 90.87 | 105.05 | 109.11 | 32.73 | 41.32 | 42.11 | 0.074 | 0.098 | 0.065 |
| 28 | **GNV 1805** | 82.99 | 92.85 | 96.14 | 28.12 | 28.85 | 29.30 | 0.062 | 0.078 | 0.047 |
| 29 | **GNV 1804** | 77.44 | 93.00 | 97.33 | 27.68 | 34.28 | 34.88 | 0.056 | 0.065 | 0.041 |
| 30 | **GNV 1808** | 81.10 | 101.56 | 106.33 | 28.84 | 33.40 | 33.98 | 0.062 | 0.089 | 0.052 |
| 31 | **GNV 1810** | 75.01 | 93.98 | 102.40 | 29.80 | 31.41 | 31.94 | 0.063 | 0.077 | 0.053 |
| 32 | **GNV 653** | 89.23 | 97.67 | 101.48 | 29.64 | 30.02 | 30.51 | 0.061 | 0.087 | 0.055 |
| 33 | **MTU 1010** | 80.32 | 87.09 | 90.98 | 27.48 | 27.70 | 28.47 | 0.054 | 0.071 | 0.038 |
| 34 | **BPT 5204** | 86.22 | 99.74 | 105.20 | 21.25 | 40.16 | 41.41 | 0.062 | 0.079 | 0.057 |
| 35 | **GANGAVATHI SONA** | 84.95 | 94.87 | 100.10 | 26.31 | 33.50 | 34.08 | 0.053 | 0.085 | 0.049 |
| 36 | **CSR 22** | 87.98 | 107.23 | 110.94 | 28.09 | 34.11 | 35.12 | 0.072 | 0.090 | 0.062 |
|  | **Mean** | **86.45** | **96.63** | **100.75** | **28.30** | **34.62** | **35.47** | **0.062** | **0.082** | **0.054** |
|  | **S.Em (±)** | **3.32** | **4.36** | **3.51** | **0.93** | **1.76** | **2.07** | **0.002** | **0.003** | **0.002** |
|  | **C.D.(p=0.05)** | **10.07** | **13.21** | **10.64** | **2.79** | **5.29** | **6.20** | **0.007** | **0.010** | **0.007** |

**Table 2. Influence of salinity on leaf area index, crop growth rate (g/m2/day), leaf dry matter, (g/hill) of different rice genotypes during different growth stages**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl.****No.** | **Genotypes** | **Leaf Area Index** | **Crop growth rate (g/m2/day-1)** | **Leaf dry matter (g/hill)** |
| **Days after transplanting (DAT)** |
| **Pooled** | **Pooled** | **Pooled** |
| **60** | **90** | **At harvest** | **60** | **90** | **At harvest** | **60** | **90** | **At harvest** |
| 1 | **IET 28608** | 3.112 | 4.041 | 2.992 | 28.96 | 56.77 | 0.75 | 12.77 | 27.31 | 22.55 |
| 2 | **IET 27077** | 2.989 | 3.347 | 2.678 | 19.29 | 42.15 | 1.11 | 11.33 | 22.79 | 18.07 |
| 3 | **IET 27823** | 2.587 | 3.826 | 1.993 | 18.06 | 38.35 | 0.90 | 10.12 | 20.58 | 16.51 |
| 4 | **IET 28606** | 2.186 | 2.790 | 1.843 | 17.70 | 35.50 | 1.77 | 8.21 | 17.13 | 13.24 |
| **5** | **CSR 36** | 2.967 | 3.985 | 3.417 | 27.49 | 55.51 | 1.42 | 13.65 | 25.48 | 20.66 |
| 6 | **IET 27807** | 2.665 | 3.391 | 2.423 | 21.55 | 43.37 | 1.76 | 9.56 | 21.29 | 17.38 |
| 7 | **IET 29356** | 2.665 | 3.559 | 2.630 | 21.71 | 45.55 | 1.04 | 10.66 | 23.39 | 19.36 |
| 8 | **IET 29365** | 2.643 | 3.256 | 2.499 | 23.96 | 48.74 | 1.22 | 9.11 | 22.70 | 18.70 |
| 9 | **CSR23** | 3.246 | 3.861 | 2.849 | 28.72 | 56.74 | 1.38 | 12.27 | 26.39 | 22.27 |
| 10 | **IET 29354** | 2.264 | 3.180 | 1.793 | 19.12 | 40.17 | 2.36 | 6.95 | 16.44 | 13.23 |
| 11 | **IET 29360** | 2.398 | 3.407 | 1.893 | 25.59 | 50.47 | 0.89 | 9.91 | 22.70 | 18.57 |
| 12 | **CSR10** | 3.134 | 3.905 | 2.831 | 28.04 | 55.10 | 0.87 | 12.83 | 25.98 | 21.15 |
| 13 | **IET 29361** | 2.766 | 3.746 | 2.291 | 20.61 | 43.74 | 0.99 | 10.96 | 22.70 | 18.20 |
| 14 | **IET 29364** | 2.688 | 3.758 | 2.142 | 23.53 | 46.46 | 0.67 | 9.09 | 21.56 | 17.44 |
| 15 | **FL478** | 3.156 | 4.065 | 2.690 | 27.82 | 53.68 | 1.37 | 11.96 | 22.70 | 18.55 |
| 16 | **IET 29366** | 2.465 | 3.029 | 1.793 | 21.44 | 40.92 | 2.05 | 7.45 | 16.40 | 13.30 |
| 17 | **IET 29358** | 2.900 | 3.515 | 2.341 | 20.21 | 43.42 | 0.58 | 10.56 | 22.39 | 18.23 |
| 18 | **PUSA44** | 2.365 | 3.188 | 2.042 | 17.02 | 34.00 | 4.04 | 7.42 | 14.36 | 11.45 |
| 19 | **IET 29353** | 2.621 | 3.684 | 2.142 | 24.60 | 46.61 | 1.29 | 9.93 | 20.43 | 16.78 |
| 20 | **SIRI 1253** | 3.524 | 4.240 | 2.690 | 27.03 | 56.68 | 0.65 | 11.04 | 24.30 | 20.05 |
| 21 | **GNV 1806** | 3.145 | 4.316 | 2.839 | 27.92 | 53.93 | 2.26 | 12.65 | 24.07 | 20.23 |
| 22 | **GNV 1807** | 2.744 | 3.666 | 2.341 | 22.47 | 48.03 | 0.28 | 10.42 | 24.46 | 20.46 |
| 23 | **GNV 1801** | 3.112 | 4.248 | 2.790 | 28.12 | 56.86 | 0.04 | 12.76 | 26.46 | 21.67 |
| 24 | **GNV 1812** | 2.632 | 3.808 | 2.242 | 23.15 | 49.19 | 0.38 | 9.07 | 22.76 | 18.30 |
| 25 | **GNV 1803** | 2.710 | 3.766 | 2.391 | 23.95 | 51.00 | 0.49 | 9.67 | 24.97 | 20.83 |
| 26 | **GNV 1802** | 2.866 | 3.539 | 2.192 | 24.65 | 49.91 | 0.24 | 9.29 | 20.73 | 16.27 |
| 27 | **GNV 1109** | 3.246 | 4.370 | 2.889 | 29.17 | 59.85 | 0.36 | 12.13 | 27.10 | 22.49 |
| 28 | **GNV 1805** | 2.744 | 3.487 | 2.092 | 21.09 | 44.93 | 0.25 | 9.61 | 20.73 | 16.36 |
| 29 | **GNV 1804** | 2.476 | 2.869 | 1.843 | 18.24 | 38.32 | 2.04 | 7.45 | 16.44 | 13.10 |
| 30 | **GNV 1808** | 2.777 | 3.937 | 2.291 | 22.69 | 49.62 | 0.80 | 9.00 | 22.85 | 18.53 |
| 31 | **GNV 1810** | 2.811 | 3.431 | 2.341 | 22.15 | 45.15 | 2.18 | 9.13 | 18.82 | 15.41 |
| 32 | **GNV 653** | 2.732 | 3.885 | 2.441 | 23.33 | 47.81 | 2.84 | 10.34 | 24.07 | 20.88 |
| 33 | **MTU 1010** | 2.442 | 3.138 | 1.694 | 15.87 | 31.79 | 2.38 | 7.43 | 13.76 | 10.86 |
| 34 | **BPT 5204** | 2.755 | 3.507 | 2.540 | 24.04 | 48.44 | 1.43 | 10.27 | 23.50 | 19.79 |
| 35 | **GANGAVATHI SONA** | 2.376 | 3.758 | 2.192 | 25.60 | 47.42 | 1.17 | 9.68 | 21.62 | 17.36 |
| 36 | **CSR 22** | 3.201 | 4.013 | 2.740 | 29.10 | 57.08 | 1.50 | 12.57 | 24.39 | 20.68 |
|  | **Mean** | **2.781** | **3.653** | **2.384** | **23.44** | **47.59** | **1.21** | **10.20** | **22.05** | **18.02** |
|  | **S.Em (±)** | **0.122** | **0.128** | **0.104** | **0.73** | **1.66** | **0.09** | **0.36** | **0.87** | **0.53** |
|  | **C.D.(p=0.05)** | **0.371** | **0.389** | **0.316** | **2.19** | **4.99** | **0.29** | **1.07** | **2.59** | **1.59** |

**Table 3. Influence of salinity on stem dry matter (g/hill), panicles dry matter (g/hill), total dry matter (g/hill) of different rice genotypes during different growth stages**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl.****No.** | **Genotypes** | **Stem dry matter (g/hill)** | **Panicles dry matter (g/hill)** | **Total dry matter (g/hill)** |
| **Days after transplanting (DAT)** |
| **Pooled** | **Pooled** | **Pooled** |
| **60** | **90** | **At harvest** | **60** | **90** | **At harvest** | **60** | **90** | **At harvest** |
| 1 | **IET 28608** | 15.49 | 38.07 | 40.20 | 9.14 | 10.34 | 13.48 | 37.40 | 75.72 | 76.23 |
| 2 | **IET 27077** | 13.20 | 29.39 | 31.22 | 8.12 | 8.92 | 12.56 | 32.65 | 61.10 | 61.85 |
| 3 | **IET 27823** | 11.51 | 25.38 | 27.41 | 7.80 | 9.37 | 12.01 | 29.43 | 55.33 | 55.93 |
| 4 | **IET 28606** | 9.06 | 22.08 | 24.53 | 5.87 | 7.89 | 10.53 | 23.14 | 47.10 | 48.30 |
| **5** | **CSR 36** | 15.75 | 40.03 | 42.31 | 9.23 | 10.60 | 13.24 | 38.63 | 76.11 | 76.21 |
| 6 | **IET 27807** | 12.20 | 28.46 | 30.92 | 7.12 | 8.40 | 11.04 | 28.88 | 58.15 | 59.34 |
| 7 | **IET 29356** | 13.05 | 29.56 | 31.65 | 8.64 | 10.25 | 12.89 | 32.97 | 63.71 | 64.41 |
| 8 | **IET 29365** | 11.22 | 29.08 | 31.26 | 8.17 | 9.62 | 12.26 | 28.50 | 61.40 | 62.22 |
| 9 | **CSR23** | 16.37 | 38.94 | 41.35 | 9.26 | 10.76 | 13.40 | 37.28 | 75.58 | 76.51 |
| 10 | **IET 29354** | 8.52 | 24.18 | 26.35 | 6.72 | 8.69 | 11.33 | 22.19 | 49.31 | 50.91 |
| 11 | **IET 29360** | 11.55 | 31.08 | 33.16 | 7.47 | 9.23 | 11.87 | 28.93 | 63.01 | 63.60 |
| 12 | **CSR10** | 16.37 | 39.33 | 41.10 | 8.52 | 9.61 | 13.25 | 37.72 | 74.92 | 75.50 |
| 13 | **IET 29361** | 13.13 | 29.21 | 31.73 | 7.55 | 9.26 | 11.90 | 31.64 | 61.17 | 61.83 |
| 14 | **IET 29364** | 12.43 | 30.26 | 32.19 | 8.34 | 9.40 | 12.04 | 29.86 | 61.22 | 61.67 |
| 15 | **FL478** | 16.38 | 40.35 | 42.78 | 8.92 | 10.45 | 13.09 | 37.26 | 73.50 | 74.42 |
| 16 | **IET 29366** | 9.21 | 26.20 | 28.05 | 6.60 | 8.29 | 10.93 | 23.26 | 50.89 | 52.28 |
| 17 | **IET 29358** | 13.23 | 29.37 | 31.29 | 8.11 | 9.44 | 12.08 | 31.90 | 61.20 | 61.60 |
| 18 | **PUSA44** | 9.10 | 23.76 | 26.76 | 7.54 | 8.89 | 11.53 | 24.06 | 47.01 | 49.74 |
| 19 | **IET 29353** | 12.16 | 32.07 | 33.95 | 7.43 | 8.48 | 11.12 | 29.52 | 60.98 | 61.85 |
| 20 | **SIRI 1253** | 16.51 | 39.85 | 41.90 | 9.09 | 10.75 | 13.39 | 36.64 | 74.90 | 75.34 |
| 21 | **GNV 1806** | 15.89 | 39.47 | 42.19 | 9.17 | 10.57 | 13.21 | 37.71 | 74.11 | 75.63 |
| 22 | **GNV 1807** | 13.07 | 30.10 | 31.64 | 8.89 | 10.25 | 12.89 | 32.38 | 64.81 | 64.99 |
| 23 | **GNV 1801** | 15.48 | 38.62 | 40.38 | 9.18 | 10.72 | 13.72 | 37.42 | 75.80 | 75.77 |
| 24 | **GNV 1812** | 11.91 | 29.97 | 32.04 | 7.84 | 9.31 | 11.95 | 28.82 | 62.04 | 62.29 |
| 25 | **GNV 1803** | 12.13 | 29.50 | 31.33 | 7.57 | 9.33 | 11.97 | 29.37 | 63.80 | 64.13 |
| 26 | **GNV 1802** | 11.92 | 32.72 | 34.70 | 8.58 | 10.03 | 12.67 | 29.79 | 63.48 | 63.64 |
| 27 | **GNV 1109** | 15.74 | 39.55 | 40.64 | 8.98 | 10.59 | 13.87 | 36.85 | 77.24 | 77.00 |
| 28 | **GNV 1805** | 11.83 | 29.49 | 31.39 | 6.88 | 8.43 | 11.07 | 28.32 | 58.65 | 58.82 |
| 29 | **GNV 1804** | 9.18 | 24.27 | 26.35 | 6.69 | 8.49 | 11.13 | 23.32 | 49.20 | 50.58 |
| 30 | **GNV 1808** | 12.16 | 29.80 | 32.01 | 7.40 | 9.41 | 12.05 | 28.56 | 62.06 | 62.59 |
| 31 | **GNV 1810** | 11.60 | 30.72 | 32.96 | 7.55 | 9.23 | 11.87 | 28.28 | 58.77 | 60.24 |
| 32 | **GNV 653** | 13.21 | 29.94 | 32.40 | 8.34 | 10.16 | 12.80 | 31.89 | 64.17 | 66.08 |
| 33 | **MTU 1010** | 10.18 | 23.68 | 25.55 | 6.78 | 8.42 | 11.06 | 24.39 | 45.86 | 47.47 |
| 34 | **BPT 5204** | 13.62 | 31.50 | 33.54 | 8.44 | 10.03 | 12.67 | 32.33 | 65.03 | 66.00 |
| 35 | **GANGAVATHI SONA** | 12.53 | 31.07 | 33.48 | 7.37 | 8.90 | 11.54 | 29.58 | 61.59 | 62.38 |
| 36 | **CSR 22** | 15.88 | 40.86 | 42.95 | 8.92 | 10.65 | 13.29 | 37.37 | 75.90 | 76.92 |
|  | **Mean** | **12.85** | **31.61** | **33.71** | **8.00** | **9.53** | **12.27** | **31.06** | **63.19** | **64.01** |
|  | **S.Em (±)** | **0.52** | **0.92** | **1.02** | **0.27** | **0.26** | **0.42** | **1.30** | **2.35** | **2.09** |
|  | **C.D.(p=0.05)** | **1.55** | **2.74** | **3.07** | **0.80** | **0.78** | **1.26** | **3.90** | **7.04** | **6.28** |

**Table 4. Influence of salinity on days to 50 % flowering and days to physiological maturity of different rice genotypes**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl.****No.** | **Genotypes** | **Days to 50 % flowering** | **Days to physiological maturity** |
| **2021** | **2022** | **Pooled** | **2021** | **2022** | **Pooled** |
| 1 | **IET 28608** | 96.50 | 90.00 | 93.25 | 116.50 | 113.50 | 115.00 |
| 2 | **IET 27077** | 90.00 | 91.50 | 90.75 | 115.50 | 106.00 | 110.75 |
| 3 | **IET 27823** | 91.50 | 92.00 | 91.75 | 113.50 | 118.00 | 115.75 |
| 4 | **IET 28606** | 91.50 | 91.00 | 91.25 | 106.00 | 114.00 | 110.00 |
| 5 | **CSR 36** | 91.00 | 90.50 | 90.75 | 109.50 | 110.00 | 109.75 |
| 6 | **IET 27807** | 95.50 | 93.50 | 94.50 | 113.50 | 113.50 | 113.50 |
| 7 | **IET 29356** | 92.50 | 94.00 | 93.25 | 113.50 | 107.00 | 110.25 |
| 8 | **IET 29365** | 94.00 | 92.00 | 93.00 | 106.00 | 114.00 | 110.00 |
| 9 | **CSR23** | 92.00 | 93.00 | 92.50 | 88.50 | 106.00 | 97.25 |
| 10 | **IET 29354** | 88.00 | 90.00 | 89.00 | 106.00 | 114.00 | 110.00 |
| 11 | **IET 29360** | 90.00 | 90.50 | 90.25 | 112.50 | 117.00 | 114.75 |
| 12 | **CSR10** | 91.50 | 91.00 | 91.25 | 88.50 | 109.50 | 99.00 |
| 13 | **IET 29361** | 91.00 | 90.00 | 90.50 | 113.50 | 113.00 | 113.25 |
| 14 | **IET 29364** | 91.50 | 92.00 | 91.75 | 109.50 | 108.00 | 108.75 |
| 15 | **FL478** | 91.50 | 97.00 | 94.25 | 108.00 | 112.00 | 110.00 |
| 16 | **IET 29366** | 91.00 | 92.00 | 91.50 | 117.00 | 115.00 | 116.00 |
| 17 | **IET 29358** | 94.00 | 95.50 | 94.75 | 106.00 | 113.50 | 109.75 |
| 18 | **PUSA44** | 91.50 | 93.50 | 92.50 | 108.00 | 121.50 | 114.75 |
| 19 | **IET 29353** | 92.00 | 93.00 | 92.50 | 114.00 | 108.00 | 111.00 |
| 20 | **SIRI 1253** | 92.50 | 95.50 | 94.00 | 112.00 | 104.50 | 108.25 |
| 21 | **GNV 1806** | 95.00 | 95.50 | 95.25 | 113.00 | 113.00 | 113.00 |
| 22 | **GNV 1807** | 97.00 | 92.00 | 94.50 | 107.00 | 109.50 | 108.25 |
| 23 | **GNV 1801** | 93.50 | 93.00 | 93.25 | 114.00 | 114.00 | 114.00 |
| 24 | **GNV 1812** | 90.00 | 97.00 | 93.50 | 106.00 | 105.50 | 105.75 |
| 25 | **GNV 1803** | 93.00 | 90.50 | 91.75 | 115.00 | 117.50 | 116.25 |
| 26 | **GNV 1802** | 90.50 | 90.00 | 90.25 | 113.50 | 116.00 | 114.75 |
| 27 | **GNV 1109** | 95.00 | 92.50 | 93.75 | 109.50 | 99.50 | 104.50 |
| 28 | **GNV 1805** | 95.50 | 91.50 | 93.50 | 113.00 | 116.50 | 114.75 |
| 29 | **GNV 1804** | 97.00 | 94.00 | 95.50 | 108.00 | 99.50 | 103.75 |
| 30 | **GNV 1808** | 91.00 | 92.00 | 91.50 | 112.00 | 112.00 | 112.00 |
| 31 | **GNV 1810** | 89.00 | 90.00 | 89.50 | 115.00 | 113.00 | 114.00 |
| 32 | **GNV 653** | 90.00 | 90.00 | 90.00 | 113.50 | 112.50 | 113.00 |
| 33 | **MTU 1010** | 95.00 | 92.00 | 93.50 | 111.00 | 115.00 | 113.00 |
| 34 | **BPT 5204** | 95.00 | 90.00 | 92.50 | 110.00 | 113.00 | 111.50 |
| 35 | **GANGAVATHI SONA** | 90.00 | 93.50 | 91.75 | 113.50 | 112.00 | 112.75 |
| 36 | **CSR 22** | 93.50 | 90.50 | 92.00 | 118.00 | 106.00 | 112.00 |
|  | **Mean** | **92.47** | **92.26** | **92.37** | **110.26** | **111.46** | **110.86** |
|  | **S.Em (±)** | **3.62** | **2.74** | **2.23** | **4.81** | **5.65** | **4.27** |
|  | **C.D.(p=0.05)** | **NS** | **NS** | **NS** | **14.59** | **17.15** | **12.95** |

**4. CONCLUSIONS**

This study demonstrated significant physiological variation among 36 rice genotypes grown under high salinity stress during the *Kharif* seasons of 2021 and 2022. Key physiological parameters- including plant height, tillering ability, leaf area, leaf area index (LAI), dry matter partitioning, crop growth rate (CGR), and phenological traits revealed clear distinctions between salt-tolerant and salt-sensitive genotypes.

Genotypes such as IET 28608, CSR 23, FL478, GNV 1801, GNV 1109, CSR 22, CSR 10, SIRI 1253, and GNV 1806 consistently maintained superior physiological function under salinity stress. These genotypes exhibited higher LAI and leaf area, facilitating sustained photosynthetic activity. Greater tiller production and plant height in these genotypes also suggest enhanced carbon assimilation and efficient light interception. High CGR and total dry matter (TDM) accumulation in genotypes like GNV 1109, CSR 22, and CSR 36 indicated better metabolic efficiency, water-use optimization, and ionic homeostasis.

In contrast, sensitive genotypes such as MTU 1010 and IET 28606 exhibited reduced photosynthetic area, impaired biomass accumulation, and lower CGR-likely due to osmotic stress, ion toxicity, and inhibited nutrient uptake. Salinity-induced stress in these genotypes may have disrupted stomatal function and enzymatic activity, reducing growth and dry matter allocation, particularly in reproductive structures like panicles.

Phenological stability was evident in salt-tolerant genotypes, which maintained relatively consistent days to 50% flowering and physiological maturity, ensuring proper grain filling and reproductive success. Early-maturing genotypes like CSR 23 possibly employed a salt-escape mechanism, minimizing exposure to prolonged stress.

These findings suggest that genotypes exhibiting sustained photosynthesis, efficient biomass allocation, and stable phenological responses possess adaptive physiological traits crucial for salinity tolerance.

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