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MORPHOPHYSIOLOGICAL CHARACTERISTICS OF RICE (Oryza sativa L.) AFFECTED BY MOISTURE DEFICIT STRESS AT TWO DEVELOPMENTAL STAGES

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Abstract: Moisture stress was imposed at tillering and anthesis stages in rice for analysis of the different growth and developmental traits which contribute the biomass as well as economic yield. The varieties taken for sowing *viz.* NAUR-1, Purna, GNR-6, NVSR-2227, NVSR-3093, NVSR-2285, NVSR-2278, NVSR-2852, NVSR-2601 and NVSR-2927. These varieties were sown in pot with deficit of water and different traits were studied after anthesis stage. The number of panicles per plant, panicle length, relative water content, chlorophyll content, leaf area index, grain filling duration, harvest index and test weight were higher in Purna among these varieties. However, numbers of stomata per micrometer were lower in Purna as compared to other treated varieties. Thus, morphophysiological traits supportive in keeping yield potential as well as hydration in cell during moisture stress were higher in Purna among these varieties.
Keywords: Anthesis, deficit, moisture, rice, stress.

Introduction

Rice is the staple crop which consumes more water among cereals hence the deficit of moisture results in loss of yield and total biomass. The moisture stress is common in rice at the tillering and flowering stage under rain fed condition resulted in reduction in yield and biomass (Mishra and Chaturvedi, 2018). Reproductive development is the critical stage of rice where moisture stress has great impacts on growth, development and ultimately the yield (Pandey and Shukla, 2015). The reduction in leaf area index and leaf rolling minimize the water loss under moisture stress by decreasing transpirational loss and surface area of the plant. The number of fertile pollen grains reduced, the flowering period prolonged, and causes the abnormal anther cracking which lead to premature leaf senescence, reduced panicle length, shortened grain filling duration and grain number, limited supply of assimilates, and reduced test weight (Berahim et al. 2021). Indeed moisture stress at any stage of growth in rice reduced its production but their impacts on different traits vary in different stages of growth (Kumar et al. 2021). The upland and lowland rice, during time of flowering

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stage generally in rain fed condition face water deficit stress and greatly affects rice production (Mishra and Chaturvedi, 2018). Stomatal closure and opening depend on the hydration in rhizosphere as well as guard cell which is regulated by the abscisic acid (Kant, 2023). The moisture stress first sense in soil by root and transmits to the leaf for closing the stomata and reduces transpirational loss as well as reduction of stomatal conductance. Stomatal performance affects the photosynthetic activity that allow efficient exchange of water vapour and CO_2 which leads to initiation of Calvin cycle for biomass production (Kumar et al. 2021). The photosynthetic activity affected by the content of chlorophyll in leaves and it decreases during stress due to lower activity of its biosynthetic pathway. The genotype/variety of rice that maintain higher chlorophyll content under moisture deficit stress would be expected to have drought resistance variety and might be utilized in rainfed condition for better yield (Mishra et al. 2019).

Materials and Methods

The seeds of ten rice varities (NAUR-1, Purna, GNR-6, NVSR-2227, NVSR-3093, NVSR-2285, NVSR-2278, NVSR-2852, NVSR-2601, NVSR-2927) subspecies *Indica* group sown in the pot filled with soil and FYM in the ratio of 2:1 after soaking in water for 12 hours and immersing in carbendazim 50% WP for 10 minutes. The whole set up were put in greenhouse of N. M. College of Agriculture, Navsari Agricultural University, Navsari. Water stress was imposed during tillering and anthesis stages for seven days in which field capacity kept near about 60%. The temperature and relative humidity recorded 30-32^{0}C and 75±1%, respectively. The number of panicles and length of panicle per plant was counted and measured in centimeter, and the average was worked out. Relative water content calculated following the method described by R. K. Sairam (1994). Floated the leaf discs in water for four hours to attain full turgid thereafter taken out the leaf discs from water and wipe out the water droplets sticking on the leaf surface by using filter paper, and recorded the turgid weight (Tw). Transferred the leaf discs to a butter paper cover and then keeps the cover in hot air oven at 80°C for 48 hours. Removed from the Oven and recorded the dry weight (Dw). RWC = Fw-Dw/Tw-Dw×100. Chlorophyll content measured with SPAD meter. The leaf area index (LAI) was calculated dividing the leaf area per plant by land area occupied by the plant. Harvest index was measured in percentage. Harvest index (%) = Economic yield/Biological yield×100. The grain filling duration was calculated from flowering to the time when almost maximum grain weight was attained and expressed in days. The thousand filled grains were counted and weighed on electronic balance to record test weight and expressed in gram.

Statistical analysis

Data represent the mean and ± SD of mean, and the experimental design was completely randomized. Data were further subjected to analysis of variance and means were compared using least significance difference (LSD) at the $P \leq 0.05$ level.

Results and Discussion

Moisture stress under rain fed condition generally faced by the direct seeded rice at different developmental stages lead to reduction in yield and seed set in the plant. Varities/genotypes having the tolerance mechanism against the drought would be suitable for growing in rainfed condition for moisture stress. The number of panicle per plant, length of panicle, relative water content (RWC), chlorophyll content and leaf area index (fig. 1-A, B, C, D, E) recorded higher in Purna among treated varieties as compared to other varieties under moisture deficit stress. These traits allowed increased photosynthetic rate and translocation of photosynthates under stress in Purna as compared to other nine varieties. The reduction in leaf area and modification in leaf shape facilitated to increase the tolerance against drought in rice (Rolling et al. 2013). The plant height and leaf area affected with alternate dry and wet during growth and development of rice. The changes in these traits resulted in decreased biomass and early maturity of the crops (Mishra and Panda, 2017). The plant with profuse branches and high root-to-shoot ratio more successful under drought as reported in rice (Kim et al. 2020). Zhu et al. (2020) reported that negative impacts of drought on these traits resulted in severe damage of crops due to loss of net photosynthetic rate, net assimilation rate and number of grains. The leaf area and stomatal frequency regulate exchange of gases (CO_2 and water vapor) and sustainability of photosynthetic rate and eventually the production of biomass and yield. They have the great influence on drought tolerance and phenotyping of crops in the drought prone area provided higher impact on yield and ecosystem (R. Tuberosa 2012). It has been suggested that reduction in content of these traits under drought indirectly affects the translocation and partitioning of assimilate to the growing region, flower and seed that eventually affect the biomass of the plant (Mishra et al. 2018). The low water potential/RWC under drought affects the anatomy of leaves and their ultrastructure highly influenced under low RWC, lead to rolling of leaf and shrinkage of leaf area (Upadhyay and Panda, 2019). It has been reported that short period of drought in rice

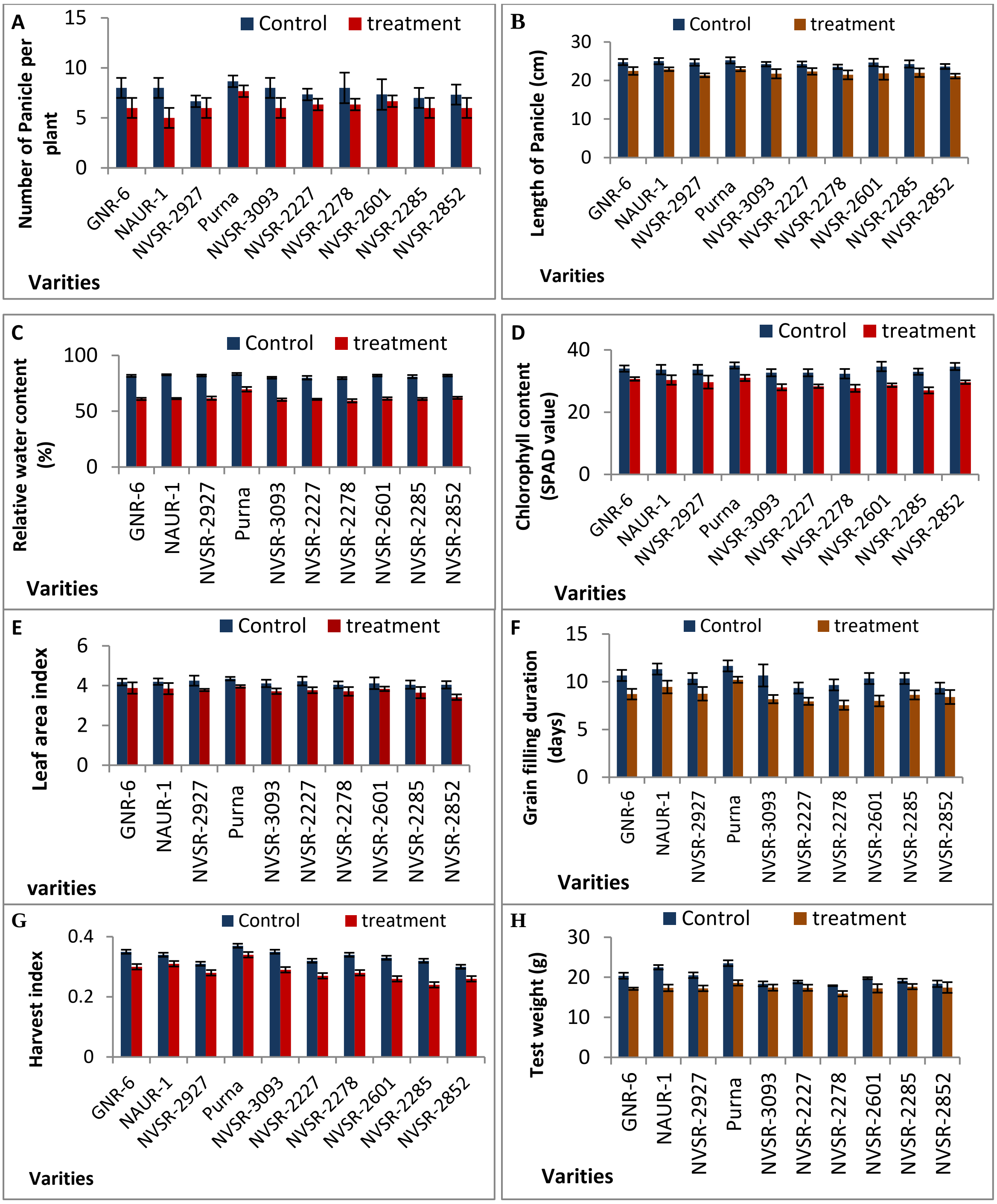

Fig. 1: Post anthesis value of different traits: (A). Number of panicle (B), Length of panicle (cm), (C) Relative water content (%), (D) Chlorophyll content (SPAD value), (E) Leaf area index (F) Grain filling duration (days), (G) Harvest index (%) and (H) Test weight (Gram). ± Bars indicate SD (n = 10)

reduced panicle length and grain filling duration resulted in loss in grain yield as well as harvest index (Panda et al. 2021). In present study, grain filling duration, harvest index, test weight (Fig. 1- F, G, H) showed that Purna performed better during tillering and anthesis stage water stress among 10 treated varieties while in control all the parameters were higher in all 10 varieties compared to treated plants (Fig. 1). Kadam et al. (2017) reported that water deficit stress delayed panicle initiation, increased ionic leakage lead to membrane damage, decreased respiration as well as ATP production in rice. The decline in panicle length and early flowering leads to reduction in grain filling duration and lower harvest index in rice (Singh et al. 2012). The decreased panicle length, lower number of stomata and their lower conductance resulted in poor seed setting and reduced grain size in rice (Wei et al. 2017). It has been suggested that even mild drought stress during reproductive development lead to sharp decline in grain yield of rice (Venuprasad et al. 2008). Reduction in test weight in rice occurs due to decreased grain filling duration, shortened panicle length and reduced synthesis of starch. The water deficit during anthesis resulted in mild reproductive development and incomplete grain filling. The starch synthesis reduced in endosperm of grain from partioning of sucrose. Hence, relocation of photosynthates and accumulation of starch reduced in seed under limited water supply (Ray et al. 2015).The reduced grain weight due to reduced photosynthesis in leaf and flag leaf which also influenced the grain size and weight when plant face water deficit during reproductive development (Raman et al. 2012).

Conclusion

The selection of the variety having the better mechanism to resist short term drought is suitable to grow under rain fed condition. The variety Purna performed better among the ten rice varieties after facing short term moisture deficit stress.

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