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Correlation Studies Between Yield Attributes and Physiological Traits in Rice under Heat Stress

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ABSTRACT

The present research was aimed to analyse the response of 49 rice genotypes under high temperature stress. The objective of this research was to develop a screening approach by correlating yield attributes and physiological traits to yield under heat stress conditions during *Kharif* 2021. Data on physiological traits was utilised to create associations with rice yield. Temperatures observed during the crop growing season and was found that maximum mean monthly temperature is 35.3 °C and minimum monthly temperature is 27.9 °C under heat stress circumstances. Rice yield under stress significantly correlated with physiological traits such as chlorophyll a (0.384**), chlorophyll b (0.648**), total chlorophyll (0.576**) and cell membrane thermo-stability (0.253*). Furthermore, heat tolerant genotypes have significantly higher spikelet fertility. According to the findings of this study, these physiological traits like chlorophyll content, cell membrane thermostability etc., might be employed in the selection of thermo-tolerant rice genotypes.

The combination of climate change with a constraint of arable land and limited water resources severely impedes efforts to produce an estimated 70% increase in food necessary to feed a growing population (FAO 2009; Beddington *et al.,* 2011). Rising air temperatures are a consequence of climate change which was significant threat to crop production. An Inter-Governmental Panel on Climate Change predicted that global surface temperatures will rise by 2 °C between 2046 and 2065. By 2100, global surface temperatures might reach 3.7°C (IPCC, 2012). This is a catastrophe with regards to agriculture production situation because present crop genotypes are lacking acclimatisation to these temperatures.

Rice is differentially susceptible to temperature stress from seedling until grain filling stages with heat stress causing 83, 53 and 11 per cent yield reductions during panicle exertion, early grain filling and late grain filling respectively (Ali *et al.,* 2019). In contrast Kumar *et al.* (2015) showed yield reductions (9-55 percent) in rice genotypes under heat stress conditions from anthesis to maturity. Any rise in temperature (particularly during sensitive periods such as booting) has a direct and negative impact on grain production. Indeed, by the end of the twenty-first century rice yields are expected to fall by 40% due to climate change (Shah *et al.,* 2011). Veronica *et al.* (2019) observed significant cell membrane injury decreased rice yield. Electrolyte leakage and ultrastructural modifications of the cell membrane system were observed as a result of high temperature (Liu *et al.,* 2013). Heat stress caused increase in membrane fluidity and free radical production resulting in membrane stability damage and ion leakage in several agricultural plants (Wahid *et al.,* 2007). Many studies show that elevated temperature injury is produced by an accumulation of reactive oxygen radicals which results in a lower antioxidant enzyme activity and membrane injury in plants (Zhang *et al.*, 2006). Plants that can scavenge and control the level of cellular reactive oxygen species may be able to withstand heat stress (Bita and Gerats, 2013) and naturally higher levels of antioxidant enzymes in a plant may be used to combat high temperature stress (Ramesh *et al.,* 2017). Cao *et al*. (2009) proposed that high levels of ATPase and antioxidant enzyme activity are related with considerably greater yields in heat resistant rice cultivars.

Plant breeders strive to continuously improve simple, efficient and reliable screening methods for identifying thermotolerant plants in segregating populations and germplasm pools. Even if paddy yields are recognized as the best feature for identifying rice under high-temperature conditions but screening for thermo-tolerant rice in the field is time consuming, labour expensive and takes up precious land.

During the early phases of development of rice plants pre-screening under controlled conditions using rapid, efficient and reproducible techniques is perquisite. Screening for heat tolerance in the field is difficult owing to interactions with other environmental conditions and particular genotypes that are adapted to that environment was required which limits screening of exotic germplasm. Despite these limits, a broad set of traits is accessible that may allow for successful field selection (Hall, 2011). Attempts to identify thermo-tolerant genotypes in different crop plants using yield-correlated early-stage traits have already been made (Demirel *et al.*, 2016). Heat tolerance in rice genotypes is essential for proper crop establishment. The aim of the study was to investigate correlations between physiological traits and rice grain yield under heat stress conditions.

MATERIAL AND METHODS

During *kharif*, 2021, 49 rice genotypes were screened for high temperature tolerance. Two sets of genotypes were grown in normal condition up to the vegetative stage in *kharif*, 2021 and later one set of plants were subjected to high temperature immediately after panicle initiation (PI) stage by enclosing them in an artificial polyhouse made of polythene cover supported by poles. The stress was imposed from panicle initiation to maturity. The other set (control) was allowed to grow in non-stress conditions until harvest. Data on chlorophyll content, membrane thermostability, days to 50 per cent flowering, plant height, ear bearing tillers number/plant, number of filled and unfilled grains/panicle, number of total grains/ panicle, spikelet fertility and grain yield were recorded. During the cropping season, the ambient mean monthly maximum temperature was 30.60 °C and mean monthly minimum temperature was 25.84 °C. However, during the period of stress imposition (from panicle initiation to maturity), the mean maximum temperature in ambient conditions was 30.3 °C and mean minimum temperature was 25.4 °C. During this period, inside the polyhouse the mean maximum temperature was 35.3 °C and mean minimum temperature was 27.9 °C. There was an increase of 5.0 °C and 2.5 °C of mean maximum and minimum temperatures under polyhouse, respectively. Sir Francis Galton (1822-1911) proposed the correlation coefficient for statistical analysis.

RESULTS AND DISCUSSION

The correlation coefficient provides, an understanding of the relationship between grain yield per plant and other yield attributing components under control conditions and heat stress. Correlation coefficients among the physiological and yield attributing characters *viz*., plant height, days to flowering, number of filled grains/panicle, number of unfilled grains/panicle, number of total grains/panicle, spikelet fertility, grain yield/plant and ear bearing tillers number per plant under controlled and heat stress conditions were studied and presented in Table 1.

Grain yield per plant recorded positive and significant association with plant height (0.284**), ear bearing tillers number/plant (0.504**), number of filled grains/panicle (0.783**), total number of grains/ panicle (0.354**), spikelet fertility (0.805**), chlorophyll 'a' (0.384**), chlorophyll 'b' (0.648**), total chlorophyll content (0.576**) and membrane thermostability (0.253*). However positive but non-significant correlation was noted with days to 50 per cent flowering (0.152) and negatively significant correlation was observed with number of unfilled grains per panicle (-0.718**)

Membrane thermostability had a positive and significant correlation with spikelet fertility (0.472**) and filled grains/panicle (0.339**). Besides, spikelet fertility also had positive correlation with ear bearing tillers number/plant (0.484**), filled grains per panicle (0.892**) and total grains/panicle (0.281**) and with other physiological traits.

Membrane thermostability had a positive significant correlation with grain yield that indicates that a high yielding genotype must possess a higher membrane thermostability. This trait was used as a screening parameter in many crops (Prasad *et al.*, 2006) due to its highly positive association with grain recorded under temperature stress.

A strong correlation between any two attributes justifies enhancing both of them at the same time. As a result, the proportional value of the qualities should be determined based on which traits have a better link with grain yield. Therefore, choosing genotypes with higher ear bearing tiller number/plant and a higher number of filled grains with higher spikelet fertility would be helpful for improving production under heat stress. These outcomes were consistent with those of Lohitha *et al.* (2019) who examined 14 genotypes under heat stress and concluded that positive significant relation of yield with membrane stability index, spikelet fertility.

Nevertheless, membrane thermostability which was used as screening trait for thermotolerance was also strongly correlated with grain yield. These results were in accordance to Veronica *et. al.* (2019) who examined 60 genotypes and recorded strong correlation between membrane thermostability and grain yield under high temperature conditions.

Sailaja *et al.* (2015) carried out multiple correlation with 11 genotypes to examine the relationship between yield qualities and several biochemical/physiological features investigated under elevated temperature stress. The correlation coefficient results showed a substantial and positive association between spikelet fertility and grain production under elevated temperature stress. Additionally, it can be concluded that grain production under elevated temperature stress had a substantial negative correlation with relative injury per cent.

The correlation coefficients obtained by Durga *et al.* (20121) revealed that there was substantial correlation between several morphological and physiological abiotic stress tolerance features (Durga *et al.*, 2021).

CONCLUSION

The study revealed that positive and significant association of yield with the membrane thermostability indicates the use of this trait stress in selection criteria under high temparature.

LITERATURE CITED

Ali F, Waters D L, Ovenden B, Bundock P, Raymond C A and Rose T J 2019 Australian rice varieties vary in grain yield response to heat stress during reproductive and grain filling stages. *Journal of Agronomy and Crop Science*. 205(2): 179-187.

Beddington J 2011 Achieving food security in the face of climate change, https://cgspace.cgiar.org/bitstream/handle/10568/10701/ Climate_food_commission-SPM-Nov2011.pdf

Bita C E and Gerats T 2013 Plant tolerance to high temperature in a changing environment: scientific fundamentals and production of heat stress-tolerant crops. *Frontiers in plant science*. 4: 273.

Cao Y, Duan H, Yang L, Wang Z, Liu L and Yang J 2009 Effect of high temperature during heading and early grain filling on grain yield of indica rice cultivars differing in heat-tolerance and its physiological mechanism. *Acta Agronomica Sinica*. 35(3): 512-521.

Demirel U, Copur O and Gur A A 2016 Early-stage screening for heat tolerance in cotton. *Plant Breeding*. 135: 80-89.

Durga K V, Satyanarayana P V, Rao V S and Jayalalitha K 2021 Evaluation of F2:3 Population for Seedling Stage Salinity Tolerance in Rice (Oryza Sativa L.). *Andhra Agricultural Journal*. 68(1): 26-32.

Food and Agricultural Organization 2009 How to Feed the World in 2050, http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf

Hall A E 2011 Breeding cowpea for future climates. *Crop adaptation to climate change*. 340-355.

IPCC 2012 Summary for Policy makers, in: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. 1–19.

Kumar N, Kumar N, Shukla A, Shankhdhar, S.C and Shankhdhar, D. 2015. Impact of terminal heat stress on pollen viability and yield attributes of rice (*Oryza sativa* L.). *Cereal Research Communications*. 43(4): 616-626.

Liu QH, Xiu W, Tian L, Jia-Qing M and Xue-Biao Z 2013 Effects of elevated air temperature on physiological characteristics of flag leaves and grain yield in rice. *Chilean journal of agricultural research*. 73(2): 85-90.

Lohitha P, Arun H P and Chandel G 2019 Characterization of Physiological Responses and Deciphering Differential Expression of Heat stress Responsive Candidate Genes in Rice under High Temperature. *International Journal of Bio-resource and Stress Management*. 10(6): 606-615.

Prasad P V V, Boote K J, Allen Jr L H, Sheehy J E and Thomas J M G 2006 Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. *Field crops research*. 95(2-3): 398-411.

Ramesh R, Ramesh T, Rao P R, Shankar V G and Bhave M H V 2017 High temperature stress effected the biochemical parameters of rice (*Oryza sativa* L.) varieties and hybrids. *International Journal of Pure Applied Biosciences*. 5(4): 1478-1490.

Sailaja B, Subrahmanyam D, Sarla N, Vishnukiran T, Venkateswara Rao Y, Vijayalakshmi P, Voleti S R, Bhadana V P and Mangrauthia S K 2015 Integrated physiological, biochemical and molecular analysis identifies important traits and mechanisms associated with differential response of rice genotypes to elevated temperature. *Frontiers in Plant Science*. 6 (1044): 1-13.

Shah F, Huang J, Cui, K, Nie L, Shah T, Chen C and Wang K 2011 Impact of high-temperature stress on rice plant and its traits related to tolerance. *The Journal of Agricultural Science*. 149(5): 545-556.

Tejaswini K L Y, Kumar B R, Mohammad L A and Raju S K 2016 Correlation Studies of F5 Families in Rice (Oryza sativa L.). *Agricultural Journal*. 64(1): 73-76.

Veronica N, Rani Y A, Subrahmanyam D, Rao K L N, Ahamad M L, Rani P P, Yugandhar P and Voleti S R 2019 Screening of rice germplasm with physiological traits for identification of heat tolerant genotypes. *International Journal of Bio-resource and Stress Management*. 10(5): 472-480.

Wahid A, Gelani S, Ashraf M and Foolad M R 2007 Heat tolerance in plants: an overview. *Environmental and experimental botany*. 61(3): 199-223.

Zhang G Z, Liyun C, Shuntang Z, Yinghui X, Zhizhou H and Dongyang L 2006 Effect of high temperature stress on protective enzyme activities and membrane permeability of flag leaf in rice. *Zuo wu xue bao*. 32(9): 1306-1310.

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