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Morpho-Physiological Responses of Rice (*Oryza sativa* L.) Varieties and Hybrids to High Temperature Stress

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ABSTRACT

Morpho-physiological responses of 21 rice (Oryza sativa L.) cultures including varieties and hybrids were assessed under control and high temperature stress. Physiological and growth parameters were recorded in both control and high temperature stress conditions. The statistical analysis revealed significant differences among varieties for various traits associated with high temperature stress. Temperature had positive significant correlation with SCMR values, spikelet fertility. It recorded negative significant correlation with leaf dry weight, total dry matter, pollen viability, stigma exertion, spikelet sterility and 1000 grain weight. Grain yield registered positive significant correlation with panicle dry weight, total dry matter, chlorophyll fluorescence, stigma exertion, spikelet fertility panicle number, grain number and harvest index under elevated temperature. Hence, these characters could be considered as criteria for selection for higher yield.

Key words: *SCMR, Pollen viability, grain yield, Temperature.*

INTRODUCTION

Rice is a staple food for more than half the world's population. It is grown worldwide over an area of 153 million hectares with an annual production of 600 million tonnes. It is cultivated in 114 of the 193 countries of the world. Among all the crops it is highest in global production but second to wheat (214 million ha.) in global area. Rice is one of the most important cereal crops and occupies second position in global agriculture. It is the foremost crop of India belonging to the family poaceae. Rice accounts for about 42 percent of total food grain production and >55 percent of diet in India. It is widely grown in India due to its wide adaptability.

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In India, rice is grown in an area of 44.1 m ha producing 106.7 m tones with a productivity of 2.42 t ha^{-1}. In Telangana, it covers an area of 2.01 m ha with a production of 6.62m tones with average productivity of 3.29 t ha^{-1} [2].Grain yields of rice declined by 10 percent for 1^{o}C increase in minimum temperature during the growing-season [15]. Previous, studies have shown a 7-8 percent yield decrease in rice for each 1^{o}C increase day time maximum / night time minimum in temperature from 28/21 to 34/27^{o}C [1]. Most of the rice is currently grown in regions where temperatures are close to the optimal for growth (28/22^{o}C); therefore, any further increase in mean temperature or episodes of high temperature during sensitive stages may reduce rice yields. Thus, identifying and developing heat-tolerant cultivars is essential to develop new tolerant varieties to meet the demand for food in future climates. Keeping in view, the above fact, the present study was undertaken to study the Morpho-physiological responses in rice to high temperature stress.

MATERIAL AND METHODS

The present investigation was conducted during *kharif*, 2012 and 2013 at Indian Institute of Rice Research farm, Rajendranagar, Hyderabad. The farm is geographically situated at an altitude of 542.7 m above mean sea level on 17^o 19' N latitude and 78^o 29' E longitude. It comes under the Southern Telangana agro-climatic region of Telangana. Weather data recorded at the meteorological observatory of IIRR, Rajendranagar during the crop growth period. From the day of imposition of high temperature, daily weather parameters such as temperature and RH was recorded using the maximum and minimum thermometers and also by the portable weather recorder in both control and treated plots. Soil samples were drawn from the experimental site from top 0-30 cm depth. The composite soil sample was air-dried and ground to pass through 2 mm sieve. The sample was analyzed for different physio-chemical properties by adopting standard procedures. The rice crop during wet season is grown under normal, recommended package of practices with plant protection methods. The experiment conducted in Split-Plot design with treatments (Normal temperature and Temperature stress) as main plot treatments and genotypes as sub-plot with 3 replications. Each sub plot measured 1.5×0.6 m 2 and a spacing of 20×10 cm was followed. When the crop attained maximum tillering stage (50 days after transplanting-DAT) in one of the crop sets heat stress was imposed by enclosing the crop with transparent polyethylene sheet supported by metal or bamboo frame. To reduce relative humidity accumulation in the enclosure, at regular intervals openings were made to allow free flow of air.

Genetic materials used in the Experiment:

The following are the 21 rice cultures with Nagina-22 as check Genotypes used in evaluation studies.

Varieties (14): IET- 21404, IET- 21411, IET-21415, IET -21515, IET-21577, IET -22100, IET -22116, IR-64, MTU-1010, PR-113, US-312, US-382

Hybrids (7): IET- 21582, IET- 22218, LALAT, PA- 6129, PA-6201, KPH-2, PA-6444, PHB-71, DRRH-3.

Check (1): Nagina-22.

Experimental Observation:

The characters like Days 50% flowering, Days to maturity, Leaf dry weight, Stem dry weight, Shoot dry weight, Panicle dry weight, Total dry matter, Chlorophyll fluorescence [24], SCMR Values[7&10], Photosynthetic rate, Transpiration rate, Stomatal conductance, Pollen viability[16], Stigma exertion [27], Spikelet fertility, Spikelet sterility, Panicle number, Grain number, Spikelet number, 1000 test weight, Grain yield, Harvest index [3] were recorded.

Statistical analysis:

The experimental data were analyzed statistically by following standard procedure outlined by Panse and Sukhatme (1985)[12].

Significance was tested by comparing "F" value at 5 per cent level of probability. The percentage values were transferred. The data of traits were utilized for the computation of correlation coefficients between grain yields with other traits for all the genotypes. To test the significance of correlation coefficients, the estimated values were compared with the table values of correlation coefficients [25] at 5 per cent and 1 per cent levels of significance with (n-2) degrees of freedom, where, "n" denotes the total number of observations used.

RESULTS AND DISCUSSIONS

Crop yield is the end product of the interaction of a number of other, often interrelated attributes. A thorough understanding of the interaction of characters among themselves had been of great use in plant breeding. The efficiency of selection for yield mainly depends on the direction and magnitude of association between yield and its component characters and also among themselves. Character association provides information on the nature and extent of association between pairs of metric traits and helps in selection for the improvement of the character. Correlation coefficients were worked out on yield and its component characters and the results have been presented in Table 1 at ambient temperature and Table 2 at elevated temperature.

Correlations among morpho-physiological parameters and temperature in pooled-control

Temperature registered positive significant correlation with stem dry weight (0.24*), transpiration rate (0.26*) and harvest index (0.34**). Negative significant correlation was expressed with shoot dry weight (-0.45**), panicle dry weight (-0.32**), total dry matter (-0.53**), stigma exertion (-0.43**) and 1000 grain weight (-0.32**) (Table 1). Grain yield had positive significant correlation with panicle dry weight (0.92**), total dry matter (0.47**), photosynthetic rate (0.68**), stomatal conductance (0.32**), pollen viability (0.28*), spikelet fertility (0.52**), grain number (0.24*) and harvest index (0.51**). Ranwake and Amarasighe (2014)[19] for panicle dry weight, Ramanjaneyulu *et al.*, (2014)[18], Kumar and Verma (2015)[6] for total dry matter, Naseer *et al.*, (2015)[11] for spikelet fertility, Naseer *et al.*, (2015)[11] and Ratna *et al.*, (2015)[21] for grain number, Kumar and Verma (2015)[6] for harvest index recorded positive significant association with grain yield. This character showed negative significant correlation with spikelet sterility (-0.52**). Mishu *et al.*, (2016)[9] reported negative significant association of grain yield with spikelet sterility.Days to 50% flowering recorded positive significant correlation with days to maturity (0.95**), leaf dry weight (0.22*), stem dry weight (0.52**), SCMR values (0.22*) and 1000 grain weight (0.34**). Certain researchers like Ravi *et al.*, (2014)[22] for days to maturity and Patel *et al.*, (2014)[14] for 1000 grain weight recorded positive significant association with days to 50% flowering. Negative significant correlation of this character was recorded with shoot dry weight (-0.27*), total dry matter (-0.31**), photosynthetic rate (-0.35**), stigma exertion (-0.38**) and panicle number (-0.58**). Khare *et al.*, (2014)[5] reported negative significant association of days to 50% flowering with panicle number.The character days to maturity had positive significant correlation with leaf dry weight (0.30**), stem dry weight (0.51**) and 1000 grain weight (0.38**). This trait also recorded negative significant correlation with shoot dry weight (-0.23*), total dry matter (-0.25*), photosynthetic rate (-0.28*), stomatal conductance (-0.26*), stigma exertion (-0.39**) and panicle number (-0.51**). Kumar and Verma (2015)[6] reported the same result of positive significant association of days to maturity with 1000 grain weight. They also reported the negative significant association with panicle number.Leaf dry weight registered positive significant correlation with stem dry weight (0.81**), photosynthetic rate (0.26*), stomatal conductance (0.21*) and panicle number (0.30**). Negative significant correlation was recorded with SCMR values (-0.21*), stigma exertion (-0.29**) and 1000 grain weight (-0.21*). Stem dry weight had negative significant correlation with stigma exertion (-0.25*). Shoot dry weight recorded positive significant correlation with total dry matter (0.88**) and photosynthetic rate (0.25*). Negative significant correlation was registered with transpiration rate (-0.47**) and harvest index (-0.79**). Panicle dry weight registered positive significant correlation with total dry matter (0.54**), photosynthetic rate (0.73**), stomatal conductance (0.26*), spikelet fertility (0.22*), grain number (0.31**), spikelet number (0.23*) and harvest index (0.33*). Similar result of positive and significant association of panicle dry weight with total dry matter and spikelet fertility was reported by Soni *et al.*, (2013)[26]. Negative significant correlation was expressed with spikelet sterility (-0.22*). Total dry matter had positive significant correlation with photosynthetic rate (0.55**), stomatal conductance (0.27*), grain number (0.23*) and spikelet number (0.23*). Negative significant correlation was registered with transpiration rate (-0.40**) and harvest index (-0.51**). Patel *et al.*, (2014)[14] and Mishra *et al.*, (2014)[8] reported negative significant association of total dry matter with harvest index.Chlorophyll fluorescence registered negative significant correlation with transpiration rate (-0.33**) and pollen viability (-0.21*). SCMR values recorded positive significant correlation with stomatal conductance (0.39**), grain number (0.42**), spikelet number (0.30**) and harvest index (0.22*). This trait registered negative significant correlation with panicle number (-0.39**). Photosynthetic rate had positive significant correlation with stomatal conductance (0.30**) and panicle number (0.34**). Transpiration rate recorded positive significant correlation with spikelet fertility (0.27*) and harvest index (0.40**). Negative significant correlation was recorded with spikelet sterility (-0.27*) and spikelet number (-0.24*). Stomatal conductance had positive significant correlation with pollen viability (0.31**), grain number (0.42**) and spikelet number (0.37**). Negative significant correlation was recorded with 1000 grain weight (-0.38**).Pollen viability registered positive significant correlation with spikelet fertility (0.30**), panicle number (0.26*) and harvest index (0.24*). Negative significant correlation was recorded with spikelet sterility (-0.30**). Stigma exertion recorded negative significant correlation with grain number (-0.23*), spikelet number (-0.26*) and harvest index (-0.22*).Spikelet fertility had positive significant correlation with panicle number (0.31**), 1000 grain weight (0.22*) and harvest index (0.52**). Panwar (2006)[13] reported the similar result of positive significant correlation of spikelet fertility with harvest index. Negative significant correlation was recorded with grain number (-0.27*) and spikelet number (-0.49**).Spikelet sterility recorded positive significant correlation with grain number (0.27*), spikelet number (0.49**). Negative significant correlation was reported with panicle number (-0.31**), 1000 grain weight (-0.22*) and harvest index (-0.52**). Roy *et al.*, (2015)[23] reported negative significant association of spikelet sterility with harvest index.Panicle number registered negative significant correlation with grain number (-0.52**), spikelet number (-0.48**) and 1000 grain weight (-0.39**). Rao *et al.*, (2014)[20] and Rahman *et al.*, (2014)[17] had the similar result of negative significant association of panicle number with grain number and 1000 grain weight respectively.Grain number had positive significant correlation with spikelet number (0.92**) and negative significant correlation with 1000 grain weight (-0.34**). Ratna *et al.*, (2015)[21] recorded the similar result of negative significant correlation with 1000 grain weight. Spikelet number recorded negative significant correlation with 1000 grain weight (-0.41**).

Correlations among morpho-physiological parameters and temperature in pooled-stress:

Temperature had positive significant correlation with SCMR values (0.26*), spikelet fertility (0.30**). It recorded negative significant correlation was with leaf dry weight (-0.36**), total dry matter (-0.21*), pollen viability (-0.28*), stigma exertion (-0.38**), spikelet sterility (-0.30**) and 1000 grain weight (-0.48**)(Table 2).Grain yield registered positive significant correlation with panicle dry weight (0.96**), total dry matter (0.68**), chlorophyll fluorescence (0.27*), stigma exertion (0.33**), spikelet fertility (0.21*), panicle number (0.25*), grain number (0.59**) and harvest index (0.83**). Several workers such as Ranwake and Amarasighe (2014)[19] for panicle dry weight, Ramanjaneyulu *et al.*, (2014)[18], Kumar and Verma (2015)[6] for total dry matter, Naseer *et al.*, (2015)[11] for spikelet fertility, Golam *et al.*, (2015)[4] for panicle number, Naseer *et al.*, (2015)[11] and Ratna *et al.*, (2015)[21] for grain number, Kumar and Verma (2015)[6] for harvest index recorded positive significant association with grain yield. Negative significant correlation of this character was recorded with stem dry weight (-0.29**), SCMR values (-0.59**), photosynthetic rate (-0.29**) and spikelet sterility (-0.21*) at elevated temperature in pooled. Mishu *et al.*, (2016)[9] reported negative significant association of grain yield with spikelet sterility. Days to 50% flowering recorded positive significant correlation with days to maturity (0.85**), leaf dry weight (0.43**), stem dry weight (0.42**), stigma exertion (0.22*), spikelet sterility (0.36**) and 1000 grain weight (0.23*). Ravi *et al.*, (2014)[22] for days to maturity, Patel *et al.*, (2014)[14] for 1000 grain weight recorded positive significant association with days to 50% flowering. Negative significant correlation was with spikelet fertility (-0.36**), panicle number (-0.53**) and harvest index (-0.34**). Days to maturity had positive significant correlation with leaf dry weight (0.42**), stem dry weight (0.53**) and 1000 grain weight (0.26*). Kumar and Verma (2015)[6] recorded the positive significant association of days to maturity with 1000 grain weight. Negative significant correlation was recorded with panicle number (-0.33**) and harvest index (-0.31**). Panwar (2006)[13] reported negative significant association of this character with harvest index.Leaf dry weight recorded positive significant correlation with stem dry weight (0.63**), shoot dry weight (0.37**), total dry matter (0.21*), stigma exertion (0.53**), spikelet sterility (0.28*) and 1000 grain weight (0.26*). This trait recorded negative significant correlation with chlorophyll fluorescence (-0.41**), spikelet fertility (-0.28*), panicle number (-0.38**) and harvest index (-0.28*). Stem dry weight registered positive significant correlation with shoot dry weight (0.23*), pollen viability (0.37**) and stigma exertion (0.24*). Negative significant correlation of this character was recorded with panicle dry weight (-0.27*), chlorophyll fluorescence (-0.35**), panicle number (-0.27*) and harvest index (-0.37**). Shoot dry weight recorded positive significant correlation with total dry matter (0.63**), stigma exertion (0.36**) and spikelet number (0.40**). Negative significant correlation was reported with SCMR values (-0.26*), stomatal conductance (-0.23*), 1000 grain weight (-0.30**) and harvest index (-0.47**). Panicle dry weight had positive significant correlation with total dry matter (0.82**), chlorophyll fluorescence (0.29**), stigma exertion (0.38**), grain number (0.68**), spikelet number (0.23*) and harvest index (0.68**). Positive significant association of this character with total dry matter and grain number was reported by Soni *et al.*, (2013)[26] and Ranwake and Amarasighe (2014)[19] respectively. Negative significant correlation was with SCMR values (-0.61**) and photosynthetic rate (-0.21*). Total dry matter registered positive significant correlation with stigma exertion (0.50**), grain number (0.60**), spikelet number (0.40**) and harvest index (0.26*). Ramanjaneyulu *et al.*, (2014)[18] reported positive significant association of this character with harvest index. Negative significant correlation was expressed with SCMR values (-0.62**) and 1000 grain weight (-0.21*).Chlorophyll fluorescence recorded positive significant correlation with panicle number (0.23*) and harvest index (0.24*). Negative significant correlation was with SCMR values (-0.34**). SCMR values had positive significant correlation with photosynthetic rate (0.30**), transpiration rate (0.39**), stomatal conductance (0.35**) and spikelet sterility (0.40**). Negative significant correlation was recorded with stigma exertion (-0.23*), spikelet fertility (-0.40**), panicle number (-0.35**), grain number (-0.27*) and harvest index (-0.46**). Photosynthetic rate recorded positive significant correlation with spikelet sterility (0.31**) and spikelet number (0.21*). Negative significant correlation was registered with spikelet fertility (-0.31**) and harvest index (-0.36**). Transpiration rate registered positive significant correlation with stomatal conductance (0.29**), spikelet sterility (0.44**), grain number (0.26*) and spikelet number (0.32**). Negative significant correlation was with spikelet fertility (-0.44**) and panicle number (-0.25*). Stomatal conductance recorded positive correlation with panicle number (0.22*). Negative significant correlation was recorded with grain number (-0.34**) and spikelet number (-0.43**).Pollen viability had positive significant correlation with 1000 grain weight (0.47**) and negative significant correlation with grain number (-0.23*). Stigma exertion registered positive significant correlation with spikelet sterility (0.27*), grain number (0.52**), spikelet number (0.30**) and 1000 grain weight (0.22*). Negative significant correlation was recorded with spikelet fertility (-0.27*) and panicle number (-0.46**). Spikelet fertility recorded positive significant correlation with panicle number (0.65**) and harvest index (0.45**). Panwar (2006)[13] reported the positive significant association of this character with harvest index. Negative significant correlation was expressed with grain number (-0.27*) and spikelet number (-0.38**). Spikelet sterility registered positive significant correlation with grain number (0.27*) and spikelet number (0.38**). Negative significant correlation was recorded with panicle number (-0.65**) and harvest index (-0.45**). Roy *et al.*, (2015)[23] reported negative association of spikelet sterility with harvest index. Panicle number had positive significant correlation with harvest index (0.56**). Ramanjaneyulu *et al.*, (2014)[18] reported positive significant association of panicle number with harvest index. Negative significant correlation was registered with grain number (-0.48**) and spikelet number (-0.60**). Rao *et al.*, (2014)[20] reported negative significant association of this character with grain number. Grain number recorded positive significant correlation with spikelet number (0.73**) and harvest index (0.22*). Panwar (2006)[13] reported positive significant association with harvest index. Negative significant correlation was recorded with 1000 grain weight (-0.22*). Ratna *et al.*, (2015)[21] reported negative significant association with 1000 grain weight. Spikelet number registered negative significant correlation with 1000 grain weight (-0.42**) and harvest index (-0.35**).Temperature had positive significant correlation with SCMR values, spikelet fertility. It recorded negative significant correlation was with leaf dry weight, total dry matter, pollen viability, stigma exertion, spikelet sterility and 1000 grain weight.Grain yield registered positive significant correlation with panicle dry weight, total dry matter, chlorophyll fluorescence, stigma exertion, spikelet fertility panicle number, grain number and harvest index under elevated temperature. Hence, these characters could be considered as criteria for selection for higher yield as these were mutually and directly associated with grain yield.

Table 1: Correlations among morpho-physiological parameters and temperature in pooled-control

S.No.	Parameter	Days 50%F	Days to M	LDW	SDW	Sh. DW	PDW	TDM	F_v/F_m	SCMR	PR	TR	SC
1	**Days 50%F**	1.00	0.95**	0.22*	0.52**	-0.27*	-0.17	-0.31**	-0.07	0.22*	-0.35**	0.08	-0.18
2	**Days to M**		1.00	0.30**	0.51**	-0.23*	-0.11	-0.25*	-0.07	0.11	-0.28*	-0.04	-0.26*
3	**LDW**			1.00	0.81**	0.02	0.04	0.04	0.10	-0.21*	0.26*	-0.03	0.21*
4	**SDW**				1.00	-0.04	-0.18	-0.12	-0.07	0.03	-0.01	0.12	0.17
5	**Sh. DW**					1.00	0.09	0.88**	-0.02	-0.12	0.25*	-0.47**	0.17
6	**PDW**						1.00	0.54**	-0.09	0.03	0.73**	-0.02	0.26*
7	**TDM**							1.00	-0.06	-0.09	0.55**	-0.40**	0.27*
8	**F_v/F_m**								1.00	-0.06	0.08	-0.33**	-0.01
9	**SCMR**									1.00	-0.14	0.03	0.39**
10	**PR**										1.00	-0.07	0.30**
11	**TR**											1.00	0.06
12	**SC**												1.00

*Significant at 5 percent level: ** Significant at 1 percent level

(Contd.). Table 1: Correlations among morpho-physiological parameters and temperature in pooled-control

S.No.	Parameter	PV	SE	SF	SS	Panicle No.	Grain no.	Spikelet no.	1000 GW	HI	Grain yield	Temp.
1	**Days 50%F**	-0.12	-0.38**	-0.13	0.13	-0.58**	0.11	0.09	0.34**	0.12	-0.18	0.03
2	**Days to M**	0.00	-0.39**	-0.16	0.16	-0.51**	0.07	0.05	0.38**	0.13	-0.12	-0.05
3	**LDW**	0.08	-0.29**	0.02	-0.02	0.30**	-0.05	-0.02	-0.21*	-0.05	0.01	0.10
4	**SDW**	-0.01	-0.25*	0.03	-0.03	0.02	-0.02	-0.08	-0.12	-0.04	-0.14	0.24*
5	**Sh. DW**	-0.02	0.20	-0.12	0.12	-0.06	0.10	0.15	-0.01	-0.79**	0.04	-0.45**
6	**PDW**	0.17	-0.16	0.22*	-0.22*	0.15	0.31**	0.23*	0.02	0.33**	0.92**	-0.32**
7	**TDM**	0.06	0.09	0.00	0.00	0.02	0.23*	0.23*	0.00	-0.51**	0.47**	-0.53**
8	**F_v/F_m**	-0.21*	-0.13	-0.19	0.19	0.08	0.08	0.11	-0.17	-0.10	-0.16	0.15
9	**SCMR**	-0.16	-0.12	0.14	-0.14	-0.39**	0.42**	0.30**	0.05	0.22*	0.15	-0.08
10	**PR**	0.19	-0.05	0.20	-0.20	0.34**	0.15	0.02	-0.12	0.08	0.68**	-0.18
11	**TR**	-0.15	0.15	0.27*	-0.27*	-0.02	-0.16	-0.24*	0.05	0.40**	0.02	0.26*
12	**SC**	0.31**	-0.10	0.20	-0.20	0.12	0.42**	0.37**	-0.38**	0.01	0.32**	-0.03
13	**PV**	1.00	-0.14	0.30**	-0.30**	0.26*	0.03	-0.01	-0.15	0.24*	0.28*	0.14
14	**SE**		1.00	-0.16	0.16	0.05	-0.23*	-0.26*	0.15	-0.22*	-0.18	-0.43**
15	**SF**			1.00	-1.00	0.31**	-0.27*	-0.49**	0.22*	0.52**	0.52**	0.16
16	**SS**				1.00	-0.31**	0.27*	0.49**	-0.22*	-0.52**	-0.52**	-0.16
17	**Panicle No.**					1.00	-0.52**	-0.48**	-0.39**	0.16	0.19	0.08
18	**Grain no.**						1.00	0.92**	-0.34**	0.00	0.24*	0.05
19	**Spikelet no.**							1.00	-0.41**	-0.18	0.06	0.00
20	**1000 GW**								1.00	0.14	0.13	-0.32**
21	**HI**									1.00	0.51**	0.34**
22	**Grain yield**										1.00	-0.19
23	**Temperature**											1.00

*Significant at 5 percent level: ** Significant at 1 percent level

Table 2: Correlations among morpho-physiological parameters and temperature in pooled- stress

S.No	Parameter	Days 50%F	Days to M	LDW	SDW	Sh. DW	PDW	TDM	F_v/F_m	SCMR	PR	TR	SC
1	**Days 50%F**	1.00	0.85**	0.43**	0.42**	-0.12	-0.15	-0.18	0.06	0.19	-0.11	0.18	0.11
2	**Days to M**		1.00	0.42**	0.53**	0.02	-0.13	-0.09	0.09	0.11	-0.01	0.07	0.06
3	**LDW**			1.00	0.63**	0.37**	-0.01	0.21*	-0.41**	-0.06	-0.02	0.05	0.10
4	**SDW**				1.00	0.23*	-0.27*	-0.08	-0.35**	0.13	-0.11	0.07	0.01
5	**Sh. DW**					1.00	0.08	0.63**	-0.09	-0.26*	0.09	-0.05	-0.23*
6	**PDW**						1.00	0.82**	0.29**	-0.61**	-0.21*	0.16	-0.04
7	**TDM**							1.00	0.18	-0.62**	-0.11	0.09	-0.16
8	**F_v/F_m**								1.00	-0.34**	-0.17	-0.10	-0.14
9	**SCMR**									1.00	0.30*	0.39**	0.35**
10	**PR**										1.00	0.04	-0.11
11	**TR**											1.00	0.29**
12	**SC**												1.00

*Significant at 5 percent level: ** Significant at 1 percent level

(Contd.). Table 2: Correlations among morpho-physiological parameters and temperature in pooled- stress

S.No.	Parameter	PV	SE	SF	SS	Panicle No.	Grain no.	Spikelet no.	1000 GW	HI	Grain yield	Temp.
1	**Days 50%F**	0.03	0.22*	-0.36**	0.36**	-0.53**	0.08	0.12	0.23*	-0.34**	-0.19	-0.12
2	**Days to M**	0.18	0.09	-0.14	0.14	-0.33**	-0.13	-0.03	0.26*	-0.31**	-0.19	-0.14
3	**LDW**	0.19	0.53**	-0.28*	0.28*	-0.38**	0.05	0.06	0.26*	-0.28*	-0.05	-0.36**
4	**SDW**	0.37**	0.24*	0.11	-0.11	-0.27*	-0.15	-0.04	0.11	-0.37**	-0.29**	0.00
5	**Sh. DW**	0.18	0.36**	-0.11	0.11	-0.19	0.12	0.40**	-0.30**	-0.47**	-0.11	-0.14
6	**PDW**	-0.08	0.38**	0.12	-0.12	0.13	0.68**	0.23*	-0.05	0.68**	0.96**	-0.17
7	**TDM**	0.04	0.50**	0.03	-0.03	-0.01	0.60**	0.40**	-0.21*	0.26*	0.68**	-0.21*
8	**F_v/F_m**	0.01	-0.13	0.08	-0.08	0.23*	0.06	-0.02	0.06	0.24*	0.27*	-0.19
9	**SCMR**	-0.13	-0.23*	-0.40**	0.40**	-0.35**	-0.27*	-0.07	0.06	-0.46**	-0.59**	0.26*
10	**PR**	0.01	-0.05	-0.31**	0.31**	-0.16	-0.05	0.21*	0.13	-0.36**	-0.29**	-0.07
11	**TR**	0.16	-0.14	-0.44**	0.44**	-0.25*	0.26*	0.32**	-0.18	-0.12	0.08	0.07
12	**SC**	-0.06	-0.02	-0.02	0.02	0.22*	-0.34**	-0.43**	0.11	0.09	-0.01	-0.14
13	**PV**	1.00	0.06	0.04	-0.04	-0.09	-0.23*	-0.07	0.47**	-0.18	-0.11	-0.28*
14	**SE**		1.00	-0.27*	0.27*	-0.46**	0.52**	0.30**	0.22*	-0.02	0.33**	-0.38**
15	**SF**			1.00	-1.00	0.65**	-0.27*	-0.38**	-0.05	0.45**	0.21*	0.30**
16	**SS**				1.00	-0.65**	0.27*	0.38**	0.05	-0.45**	-0.21*	-0.30**
17	**Panicle No.**					1.00	-0.48**	-0.60**	-0.19	0.56**	0.25*	0.20
18	**Grain no.**						1.00	0.73**	-0.22*	0.22*	0.59**	-0.03
19	**Spikelet no.**							1.00	-0.42**	-0.35**	0.03	-0.02
20	**1000 GW**								1.00	0.07	0.03	-0.48**
21	**HI**									1.00	0.83**	0.10
22	**Grain yield**										1.00	-0.08
23	**Temperature**											1.00

*Significant at 5 percent level: ** Significant at 1 percent level

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REFERENCES

1. Baker, J.T., Allen, L.H. Jr and Boote, K.J., Responses of rice to carbon dioxide and temperature. *Agricultural and Forest Meteorology*. **60:** 153-166 (1992).
2. CMIE., Area, production and productivity of rice in India and Andhra Pradesh. Centre for Monitoring Indian Economy Pvt. Ltd. Mumbai(2016.).
3. Donald, C.M., In search of yield. *Journal of Australian Institute Agricultural Sciences*. **28:** 171-178 (1962).
4. Golam, S., Md. Harun-Ur-R, Shahanaz, P and Md. Sarowar, H., Correlation and Genotypes (*Oryza sativa* L.). *Advances in Bioresearch.* **6(4):** 40-47 (2015).
5. Khare, R., Singh, A.K., Eram, S and Singh, P.K., Genetic variability, association and diversity analysis in upland rice (*Oryza sativa* L.). *Journal of Agriculture*. **12(2):** 40-51 (2014).
6. Kumar, A and Verma, O.P., Correlation and path coefficient analysis in certain quantitative traits in rice (*Oryza sativa* L.) under saline-alkaline condition. *Research in Environment and Life Sciences.* **8(3):** 443-446 (2015).
7. Minolta, C., Manual for Chlorophyll meter SPAD-502. Minolta Cameraco., Osaka, Japan(1989).
8. Mishra, V.K., Dwivedi, D.K and Pramila, P., Consequence of salinity on biological yield, grain yield and harvest index in rice (*Oryza sativa* L.) Cultivars. *Environment and Ecology* . **32(3):** 964-968(2014).
9. Mishu, F.K., Md. Rahman, W., Md. Abul, K.A., Biswas, B.K., Md. Aminul, I.T., Md. Omar, K., Md. Rafiqul, I and Md. Rakibul, A., Study on genetic variability and character association of aromatic rice (*Oryza sativa* L.) Cultivars. *International Journal of Plant and Soil Science.* **9(1):** 1-8(2016).
10. Monje, O. A and Bughree., Inherent limitation of non-destructive chlorophyll meters. A comparison of two types of meters. *Horticultural Science.* **27:** 71-89 (1992).
11. Naseer, S., Kashif, M., Ahmad, H.M. Iqbal, M.S., and Qurban Ali, Q., Estimation of genetic association among yield contributing traits in aromatic and non-aromatic rice (*Oryza sativa* L.) cultivars. *Life Science Journal*. **12(4):** 68-73 (2015).
12. Panse, V.G and Sukhatme, P.V., Statistical methods for agricultural workers, ICAR, New Delhi(1985).
13. Panwar, L.L., Character association and path analysis in rice (*Oryza sativa* L.).*Annals of Agricultural Research.* **27(3):** 257-260 (2006).
14. Patel, J.R., Saiyad, M.R., Prajapati, K.N., Patel, R.A and Bhavani, R.T., Genetic variability and character association studies in rainfed upland rice (*Oryza sativa* L.). *Electronic Journal of Plant Breeding*. **5(3):** 531-537 (2014).
15. Peng, S., Jianliang, H., Sheehy, J. E., Laza, R.C., Visperas, R. M., Xuhua, Z., Centeno, H.G.S., Khush, G.S and Cassman, K.G., Rice yields decline with higher night temperature from global warming. *Proceedings of the National Academy of Sciences*. **101:** 9971-9975 (2004).
16. Prasad, P.V.V., Boote, K.J., Allen, L.H.J., Sheehy, J.E and Thomas, J.M.G., Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress. *Field Crops Research*. **95:** 398-411 (2006).
17. Rahman, M.A., Hossain, M.S., Chowdhury, I.F., Matin, M.A and Mehraj, H., Variability study of advanced fine rice with correlation, path co-efficient analysis of yield and yield contributing characters. *International Journal of Applied Science and Biotechnology* **2(3):** 364-370 (2014).
18. Ramanjaneyulu, A.V., Gouri shankar, V., Neelima, T.L and Shashibhusahn, D.,

Genetic analysis of rice (*Oryza sativa* L.) genotypes under aerobic conditions on alfisols. *SABRAO Journal of Breeding and Genetics*. **46(1):** 99-111 (2014).
19. Ranawake, A.L and Amarasinghe, U.G.S., Relationship of yield and yield related traits of some traditional rice cultivars in sri lanka as described by correlation analysis. *Journal of Scientific Research & Reports.* **3(18):** 2395-2403 (2014).
20. Rao, V.T., Mohan, Y.C., Bhadru, D., Bharathi, D and Venkanna, V., Genetic variability and association analysis in rice. *International Journal of Applied Biology and Pharmaceutical Technology*. **5(2):** 63-65 (2014).
21. Ratna, M., Begum, S., Husna, A., Dey, S.R and Hossain, M.S., Correlation and path coefficients analyses in basmati rice. *Bangladesh Journal of Agricultural Research*. **40(1):** 153-161 (2015).
22. Ravi, K., Suresh, B.G., Lavanya, G.R., Satish, K.R., Sandhya and Bandana, D.L., Genetic variability and character association among biometrical traits in F3 generation of some rice crosses. *International Journal of Food, Agriculture and Veterinary Sciences.* **4(1):** 155-159 (2014).
23. Roy, R.K., Ratna, R.M., Shahanaz, S., Hoque, M.E and Ali, M.S., Genetic variability, correlation and path coefficient analysis for yield and yield components in transplant aman rice (*Oryza Sativa* L.). *Bangladesh Journal of Botany*. **44(4):** 529-535(2015).
24. Smillie, R. M and Hetherington, S. E., Screening for salt tolerance by chlorophyll fluorescence. In: Y Hashimoto *et al.*, (eds) *Measurement Techniques in Plant Science.* pp. 229-261. Academic Press, San Diego (1990).
25. Snedecor, G.W and Cochran, W.G., Statistical Methods. 6th ed. Ames, Iowa. 327 (1967).
26. Soni, S.K., Yadav, V.K., Pratap, N., Bhadana, V.P and Ram, T., Selection criteria, yield relationship with component traits and grouping of tropical japonica, indica lines and derived hybrids of rice (*Oryza sativa* L.). *Journal of Agriculture.* **11(2):** 17-32 (2013).
27. Yan, W. G., Li, Y., Agrama, H. A., Luo, D., Gao , F., Lu , X., Ren, G., Association mapping of stigma and spikelet characteristics in rice (*Oryza sativa* L.). *Mol Breeding* **24:** 277–292 (2009).