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Effect of temperature regimes on physiological traits of rice (*Oryza sativa* L.) genotypes for high temperature tolerance

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Abstract

High temperature stress is the one of the most important environmental factors that influencing growth, development, and yield of rice crop. The present paper studies the effects of temperature regimes on various physiological parameters at different stages of growth for high temperature tolerance using the 50 IRRI and Indian rice genotypes with five check (Local, national and international) varieties were evaluated during normal sown (December-2014) and late sown conditions (January 2015). Result of the experiment reveals that late sowing of genotypes particularly in the month of January has shown the decreased various morpho-physiological responses and yield attributes than the normal sown genotypes. Grain yield was lowest under late sown condition (11.92 per cent reduction) as compared to normal sown condition, which was expected that plant experienced the high temperature stress mainly during flowering and grain filling stages. The results of mean sum of squares due to the genotypes and their interaction were significant for different physiological parameters. Finally, among the screened genotypes EC792239, EC792185, EC792179, EC792240 and EC792316 are identified as heat stress tolerant genotypes. Hence, they are shown better performance for different physiological parameters like photosynthetic rate (24.72 μ mol CO_2 m^{-2} s^{-1}), transpiration rate (6.38 μ mol CO_2 $m^{-2}s^{-1}$), and by maintaining the canopy temperature (25.42 °C). They could be used as potential donors for development of heat stress tolerant variety.

Keywords: rice, high stress, heat tolerance, sowing dates, morpho-physiological, and yield

Introduction

Rice (*Oryza sativa* L.) is a “Global grain” cultivated widely across the world and feeds millions of mankind, is the staple food for more than half of the human population. Asia is considered as “Rice Basket” of the world, as 90 per cent of world’s rice is grown and consumed with 60 per cent of population and where, about two-thirds of world’s poor live (Khush and Virk, 2005) [14]. In India, rice is the second most produced commodity cultivated on an area of 43.95 m ha, with a production and a productivity of 106.54 m t and 2424 kg ha^{-1}, respectively (Anon., 2015) [3].

Global warming is a serious peril to the rice production. The optimum temperature for the normal development of rice ranges from 27 °C to 32 °C. High temperature stress is the one of the most important environmental factors that influencing growth, development, and yield of crop. High temperature (HT) affects almost all the growth stages of rice, *i.e.* from emergence to ripening. The increase in temperature has been striking and can cause irreversible damage to plant growth and development (Wahid *et al.*, 2007) [21]. It has been shown a 7-8% rice yield reduction for each 1 °C increase in daytime temperature from 28 °C to 34 °C (Baker *et al.*, 1992) [4]. However, flowering (anthesis and fertilization) and booting (microsporogenesis) are considered to be the stages of development most susceptible to temperature in rice. High temperatures (≥ 35-40 °C) during anthesis stage of flowering induce spikelet sterility which in turn decreases the rice yield (Bhadana *et al.*, 2014) [5]. Plants possess a number of adaptive, avoidance or acclimation mechanisms to cope with HT situations.

Rice is being cultivated both in *kharif* and summer in Tungabhadra Project (TBP) command area of Karnataka state. Rice is being cultivated in an area of 4.92 lakh ha with a production of 13.6 lakh tonnes and a productivity of 2772 kg ha^{-1}.Due to late sowing of *kharif* crop because of late onset of monsoon harvest will be delayed and summer sowing is also delayed. Late sowing of rice in summer in the month of February lead to reduction the rice yields. The yield reduction is mainly due to late sowing coincide with high temperature during flowering and anthesis period. It is important to screen the rice germplasm for high temperature tolerance.

Hence, with this background the present investigation was followup.

Materials and Methods

A field experiment was conducted at Agriculture research station Gangavati, university of agriculture sciences, Raichur. The paper studies the effects of temperature regimes on various physiological parameters at different stages of growth using 50 IRRI and Indian rice genotypes with five (Local, national and international) check varieties were evaluated durin g*early summer*/Normal sown (07-Dec.-2014) and *late summer/* late sown (20-Jan-2015). The details of genotypes and check verities are given in (Table 1). In our experiments we tried to expose our genotypes to high temperature at different crop growth stages especially during reproductive stage, which is a serious problem of this region. To coincide with the high temperature during reproductive stage of crop two (Normal & Late) different dates of sowing was done. The seedlings were planted in Randomized Block Design (RBD) at Agricultural Research Station, Gangavati. Adopting a spacing of 20 cm × 15 cm, in a plot size of 0.8 m × 3.5 m width and length respectively. The genotypes were replicated twice. In each replication, each genotype was planted in four rows with 20 seedlings or hills per row. During crop growth period (December to May) summer 2014-2015, the maximum and minimum temperature was 41 ºC and 26 ºC, respectively and maximum and minimum relative humidity recorded was 99.5 and 29.7 per cent, respectively it is presented in (Fig. 1).

Five competitive plants were randomly selected from each entry, each replication and from each environment for the recording of the observations. The physiological parameters like leaf temperature (ºC), chlorophyll content (mg/g FW), normalized difference vegetation index values, transpiration rate (mmol (H_2O) $m^{-2}s^{-1}$), stomatal conductance (mol (H_2O) $m^{-2}s^{-1}$), photosynthetic rate (µmol CO_2 $m^{-2}s^{-1}$), light interception (%), leaf area index and grain yield (kg/ha). The genotypes from normal and late sown condition were planted in randomised block design (RBD) with two replications and field observations were recorded during crop growth season.

The data collected from experiments were analysed statistically by following the procedure prescribed by Sundararaj *et al.* (1972). Whenever, 'F' test was found significant the critical difference (CD) values were calculated and the treatment mean were compared at five per cent.

Plant height was recorded at flowering and harvest time from base of the plant up to the last sheath of main shoot. Five plants were randomly selected, tagged and mean values of height was expressed in centimeter. The canopy temperature was recorded with the help of infrared thermometer at 65, 75, 85, 95, 105 days after sowing (DAS) and at harvest. The canopy temperature was recorded in degree Celsius (ºC). It was focused on the canopy targeted by holding gun pistol grip at an angle of 45° and at a distance of 0.5 to 1 m from canopy for taking observation.

Light interception was measured by using an Accu PAR 80 ceptometer (Decagon Devices, Inc., Pullman, WA, USA) between 11:30 am to 3:30 pm during no cloud time. The ceptometer contains 80 individual quantum sensors on the probe and measures PAR readings. PAR readings were taken from the ground to the top of the canopy. The measurements were taken by holding the probe parallel to the ground and recorded above the canopy and below the canopy in each plant to record the incident sunlight. The light interception was calculated by using the formula. The data of light interception was recorded in percentage.

$$\text{Light interception (\%)} = [1-] \frac{\text{Avg. below canopy scores}}{\text{Avg. above canopy scores}}] \times 100$$

Leaf photosynthetic rate, transpiration rate and stomatal conductance was measured by using Infra-Red Gas Analyzer (IRGA), model TPS-2was used for the instantaneous measurements, the TPS-2 passes a measured flow of air over a leaf sealed into a chamber called the leaf cuvette, using a valve, the TPR-2 first samples the CO_2 and H_2O in the air going to the cuvette and then in the air leaving the flow rate and the changing in the CO_2 and H_2O concentration, the assimilation rate of CO_2 and the transpiration rate of water was determined, this is commonly referred to as the "open system method of measurement", this is the method used by the TPS-2 for photosynthetic rate measurements. The data of leaf photosynthetic rate was expressed as µ mol CO_2 $m^{-2}s^{-1}$, transpiration rate mmol (H_2O) m^{-2} $s^{-1}$and stomatal conductance is mol (H_2O) m^{-2} s^{-1}.

From the seed yield of each net plot, 1000 seeds were randomly counted and weight was recorded. This weight was taken as 1000 seed weight and expressed in grams. Grains from corresponding net plots were sun dried and then the weight of grains per net plot was recorded kg ha^{-1} and converted to quintals per hectare.

Table 1: List of rice genotypes used for present study

S. No.	Genotypes	S. No.	Genotypes	S. No.	Genotypes	S. No.	G Genotypes	S. No.	Genotypes
1	EC792216	12	EC792237	23	EC792215	34	EC792233	45	EC792270
2	EC792231	13	EC792267	24	EC792193	35	EC792179	46	EC792286
3	EC792227	14	EC792206	25	EC792185	36	EC792208	47	EC792289
4	EC792177	15	EC792234	26	EC792222	37	EC792219	48	EC792326
5	EC792226	16	EC792201	27	EC792240	38	EC792309	49	EC792217
6	EC792200	17	EC792257	28	EC792195	39	EC792203	50	EC792192
7	EC792224	18	EC792310	29	EC792235	40	EC792214	C1	Gangavatisona
8	EC792239	19	EC792199	30	EC792225	41	EC792176	C2	IR- 64
9	EC792194	20	EC792288	31	EC792316	42	EC792284	C3	MTU-1010
10	EC792236	21	EC792187	32	EC792204	43	EC792218	C4	N-22
11	EC792210	22	EC792205	33	EC792238	44	EC792186	C5	ES-18

Note: C1, C2, C3, C4 and C5 are check (Local, national and international) varieties

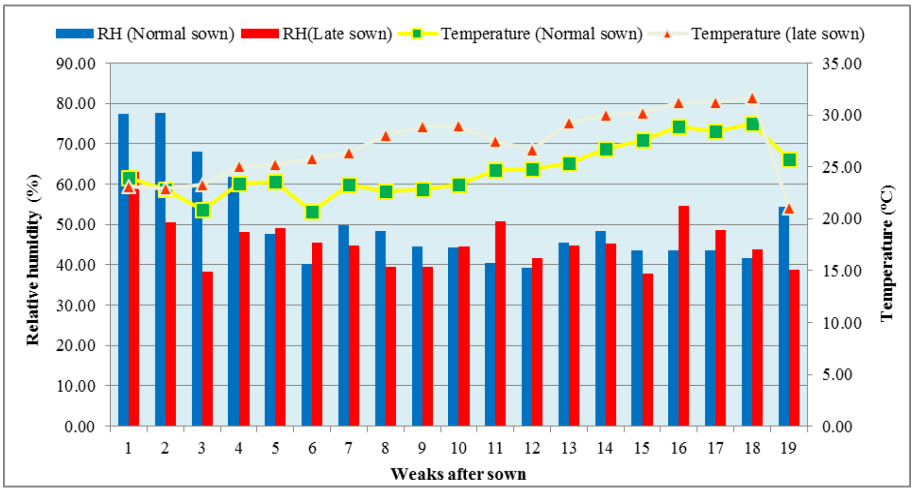

Fig 1: Standard meteorological week's data during the crop growth period (summer 2014-2015).

Results and Discussion

Among normal and late sown condition, significantly higher photosynthetic rate (24.72 µmol CO_2 m^{-2} s^{-1}) in EC792236 genotype was recorded under normal sown condition. But lowest photosynthetic rate 15.80 (µmol CO_2 m^{-2} s^{-1}) in EC792186 genotype under late sown condition during 85 DAS crop growth period. In followed growth period, similar trend was observed. During late sown significantly reduction photosynthetic rate was observed due to high temperature stress. Similar results were obtained by (Rajesh *et al*., 2012) [17] in rice, (Yugandhar *et al*., 2013) [24] in rice and (Alefsi *et al*., 2014) [2] in rice these findings were in confirmative with the findings of Verhulst and Govaerts (2010) [20]. The maximum LAI was recorded in 3.95 in EC792176 genotype under normal sown condition. But lowest LAI was recorded 1.86 EC792234 genotype under late sown condition during 85 DAS crop growth period. Light interception differed significantly among the normal and late sown condition. The results showed that due to congenial environment under normal sown condition recorded higher light interception compared late sown condition. The light interception rate of genotypes ranged from 67.39 (EC792234) to 97.51 per cent (EC792239) with an overall mean of 85.46 per cent under normal sown condition. Whereas, under late sown condition, the light interception rate of genotypes ranged from 56.68 (IR-64) to 88.45 per cent (EC792239) with an overall mean of 75.86 per cent. The lowest values of light interception were recorded under late sown due high temperature stress during crop growth stages. Similar results reported by Stone (2001) reported the acute high temperatures can cause an array of morphological, anatomical, physiological and biochemical changes with/in maize and the most significant factors associated with maize yield reduction include shortened life cycle reduced light interception and increased sterility.

Significantly reduction in leaf stomatal conductance was recorded under the late sown in the genotype EC792192 (1.66 mol (H_2O) $m^{-2}s^{-1}$) compared normal sown condition. But significantly higher leaf stomatal conductance (2.94 mol (H_2O) $m^{-2}s^{-1}$) recorded in the genotype EC792194 under normal sown during 95 DAS crop growth period. The effects of high temperature stress on reduction of leaf stomatal conductance under late sown condition leads reduction in photosynthesis and grain filling varied among genotypes and the developmental stages of plant when exposed to the stress. This result was similar to that of Berry and Bjorkman (1980) [6], Aghaee *et al.* (2011) [1] and Jerry and John (2015) [13]. Leaf transpiration rate was recorded under the late sown in the genotype EC792179 (6.38 µmol CO_2 $m^{-2}s^{-1}$). But significantly higher leaf transpiration rate recorded in the genotype EC792194 N-22 (9.88 µmol CO_2 $m^{-2}s^{-1}$) under normal sown during 85 DAS crop growth period. This result was similar to that of Daubenmire (1974) [8], Shah *et al.* (2011) [19] and Islam (2011) [12]. Santosh and Rawson (2013) [18] reported that in the high-temperature glasshouse (30/25 °C), at 17 days after sowing (DAS) the rate of transpiration was high (0.49 µg cm^{-2} sec^{-1} vpd^{-1}). At 25 days after sowing the rate of transpiration was lower (0.29 µg cm^{-2} sec^{-1} vpd^{-1}). The lower rate of transpiration may have been due to stomatal closure at high vapour pressure deficit at high temperature.

Leaf temperature was recorded significantly reduction in under the late sown in the genotype EC792231 (25.42 °C). But significantly higher leaf temperature recorded in the genotype EC792193 (29.84 °C) under normal sown during 85 DAS crop growth period. High temperature stress on reduction leaf temperature under late sown condition leads reduction in photosynthesis and grain filling varied among genotypes and the developmental stages of plant when exposed to the stress. This result was similar to that of Yalcaum *et al.*, (2011) [23].

The data on the panicle length indicated that it was significantly influenced by temperature regimes, genotypes and their interaction under normal and late sown condition. Among the normal and late sown condition, normal sown condition recorded significantly higher panicle length 22.19 cm compared to late sown, which registered 18.99 cm.

Grain yield in rice was significantly influenced by temperature regimes and significantly higher grain yields recorded under normal sown condition in the genotype EC792239 (6,334 kg ha^{-1}) compared to all other genotypes. However, under late sown condition recorded significantly lower grain yield in the local check ES-18 (1,553 kg ha^{-1}). The normal sown conditions favour maximum production of dry matter accumulation due to non-stressful condition as compared to late sown condition. There was significant reduction in grain weight $plant^{-1}$, Test weight of seeds (1000 seeds) and panicle length due to high temperature stress under late sown condition. Since, there is coincidence of high temperature during peak anthesis stages compared to normal sown condition. Similar results were reported by various researchers like Daubenmire (1974) [8], Muchow *et al.* (1990) [15], Wardlaw *et al.*, 2002 [22], Mian *et al.*, 2007, Prerna *et al.* (2012), Tenorio *et al.* (2013) and Pratap and Dwivedi (2015) [9]. Performance of rice genotypes for yield character under normal and late sown conditions during 2014-2015.

Table 3: Performance of rice genotypes under normal and late sown conditions and percent decrease of late sown over the normal sown condition for different physiological parameters during summer 2014-2015

Characters	Condition	Genotypes showing highest value		Genotypes showing lowest value		Overall mean	Per cent decrease
		Genotypes	Values	Genotype	Values		
Plant height (cm)	Normal	N-22	112.0	EC792240	76.9	92.7	6.26
	Late	EC792227	105.7	EC792205	67.9	86.9	
Test weight of seeds (gm)	Normal	EC792267	29.1	EC792208	17.3	23.35	15.03
	Late	EC792239	24.9	EC792208	13.8	19.84	
Leaf temperature (°C)	Normal	EC792193	29.8	EC792193	26.2	27.8	-2.16
	Late	EC792219	30.5	EC792231	25.4	28.4	
Transpiration rate (mmol (H_2O) $m^{-2}s^{-1}$)	Normal	N-22	9.88	EC792236	5.27	7.31	-9.86
	Late	EC792185	9.84	EC792179	6.38	8.11	
Stomatal conductance (mol (H_2O) $m^{-2}s^{-1}$)	Normal	EC792194	2.96	EC792238	0.94	1.84	-28.26
	Late	EC792225	2.92	EC792192	1.80	2.36	
Photosynthetic rate (μmol CO_2 $m^{-2}s^{-1}$)	Normal	EC792236	24.72	EC792199	19.72	22.38	18.77
	Late	EC792186	19.76	EC792199	15.80	18.18	
Light interception (%)	Normal	EC792239	97.51	EC792234	67.39	85.46	11.23
	Late	EC792239	88.45	IR-64	56.68	75.86	
Panicle length (cm)	Normal	EC792204	26.6	EC792227	17.4	22.19	14.42
	Late	EC792219	24.8	EC792226	13.4	18.99	
Grain yield (kg/ha)	Normal	EC792239	6,334	MTU-1010	2,557	3,671	14.94
	Late	EC792239	5,713	ES-18	1,553	3,123	

Conclusion

In all the cases, differences between the sowing dates and genotypes were observed in the present investigation. All physiological parameters shows significant differences for genotypes, sowing conditions and their interaction. Among the sowing conditions, late sown (heat stress) having elevated temperature shows the decreased values for all yield traits of rice genotypes as compared to the normal sown condition.

Genotypic variability was observed for physiological, morphological traits and yield for heat stress tolerance under normal and late sown conditions. Among the normal and late sown conditions, normal sown crops perform better for various morphological, physiological and yield attributes compared to late sown crops due to high temperature stress. Among the genotypes EC792239, EC792185, EC792179, EC792240 and EC792316 were responded better to heat stress in terms of morphological, physiological and yield parameters under both normal and late sown conditions. Thus the genotypes indicating the high temperature tolerance. Selected high temperature tolerant genotypes can be directly used as tolerant verity for summer sowing of paddy and also used for further heat tolerance breeding study.

The identified heat stress tolerant genotypes *viz.*, EC792239, EC792185, EC792179, EC792240 and EC792316 could be used as potential donors for development of heat stress tolerant variety. The genetic nature of heat stress tolerance could be studied by utilizing the identified heat stress susceptible and heat stress tolerant genotypes. Further specific molecular markers associated with heat stress tolerance could be identified using identified variability for marker assisted selection. The identified heat stress tolerant genotypes *viz.*, EC792239, EC792185, EC792179, EC792240 and EC792316 could be used for further breeding purpose or directly used for release as a variety to formers for late sown cultivation. The identified suitable heat tolerant donors may be used for development high yielding heat tolerant varieties.

References

1. Aghaee AF, Moradi HZ, Zarinkamar M, Irandoost F, HP. Sharifi P. Physiological responses of two rice (*Oryza sativa* L.) genotypes to chilling stress at seedling stage. Afric. J Bio. tech. 2011; 10(39):7617-7621.
2. Alefsi DS, Gabriel GV, Hermann RD, Biochemical and physiological characterization of three rice cultivars under different daytime temperature conditions. Chil. J Agri. Res. 2014; 74(4):373-379.
3. Anonymous. Agricultural statistics at a glance. Oxford university press. 2015, 72-73.
4. Baker JT, Allen J, Boote KJ. Temperature effects on rice at elevated CO_2 concentration. J Exp. Bot. 1992; 43:959-964.
5. Bhadana VP, Shobha RN, Senguttuvel P, Kumaraswamy M, Sravaraju N, Motilal Srikanth, *et al*. Breeding heat tolerant rice varieties to mitigate the impact of climate change in National Conference on Emerging Problems and Recent Advances in Applied Science: Basic to Molecular Approaches (EPRAAS -2014), 2014.
6. Bjorkman O, Berry J. Photosynthetic response and adaptation to temperature in high plants. Ann. Rev. Plant. Physiol. 1980; 31:491-543.
7. Burker JJ. High temperature stress and adaptation in crops. In: stress Responses Plants: Adaptation and acclimation Mechanisms, eds. Alscher, R.G. and Cumming. J.R., New York: Wiley-Liss, Inc. 1990, 295-309.
8. Daubenmire RF. Plants and environment. A Textbook of Plant Autoecology. ed. John Wiley and Sons, New York.
9. Dwivedi, P and Padmanabh., 2015, Morphophysiological responses of wheat (*Triticumaestivum* L.) genotypes under late sown condition. www. vegetosindia. org., 1974; 28(1):16-25.
10. Gerson MSS, Enio MF, Teixeira NJ, Gomes FCFA, Lucas LC, Mauricio LO. Physiological responses of rice cultivars exposed to different temperatures and flood depths in a water seeded system. Aust. J crop. sci. 2015; 9(4):344-354.
11. Hae-Ran Kim, Young-Han You. the effects of the elevated CO_2 concentration and increased temperature on growth, yield and physiological responses of rice (*Oryza sativa* L. cv. Junam). Adv. Bio. Res. 2010; 1(2):46-50.
12. Islam MT. Effect of temperature on photosynthesis, yield attributes and yield of aromatic rice genotypes. Int. J Sustain. Crop Prod. 2011; 6(1):14-16.
13. Jerry LH, John HP. Temperature extremes: Effect on plant growth and development. Weather and Climate Extremes. 2015; 10:4-10.

14. Khush GS, Virk PS. Rice breeding achievements and future strategies. Crop Improv. 2005; 27:115-144.
15. Muchow RC, Sinclair TR, Bennett JM. Temperature and solar radiation effects on potential maize yield across locations. Argon. J. 1990; 82(2):333-343.
16. Prasanth VV, Chakravarthi DVN, Vishnu TK, Venkateswara YR, Madhusmita P, Mangrauthia SK, *et al*. Evaluation of rice germplasm and introgression lines for heat tolerance, Annl. Bio. Res. 2012; 3(11):5060-5068.
17. Rajesh K, Swamy KN, Chakravarthi DVN, Vishnuprasanth V, Rao YV, Rao PR, *et al*., crop stress and its management: Perspectives and strategies. Ann. Bio. Res. 2012; 3(11):903.
18. Santosh K, Rawson HM. Temperature, vapour pressure deficit and water stress interaction on transpiration in wheat. Int. J Sci. Res., 2013; 2(3):2277-8179.
19. Shah F, Huang J, Cui K, Nie L, Shah T, Chen C, *et al*., Climate change and agriculture paper: impact of high-temperature stress on rice plant and its traits related to tolerance. J Agri. Sci. 2011; 149(5):545-556.
20. Verhulst N, Govaerts B. the normalized difference vegetation index (NDVI) Green Seeker TM handheld sensor: toward the integrated evaluation of crop management. Part A: Concepts and case studies. Mexico, D.F. CIMMYT, 2010.
21. Wahid A, Gelani S, Ashraf M, Foolad MR. Heat tolerance in plants: an overview. Environ. Exp. Bot. 2007; 61:199-233.
22. Wardlaw IF, Blumenthal C, Larroque O, Wrigley CW. Contrasting effects of chronic heat stress and heat shock on grain weight and flour quality in wheat. Functional Plant Biol. 2002; 29:25-34.
23. Yalcaum C, Ayşe C, Ufuk D, Mustafa O. Physiological response of maize (*Zea mays* L.) to high temperature stress. Aus., J Crop Sci. 2011; 5(8):966-972.
24. Yugandhar P, Ramana KB, Madhusmita P, Vishnu PV, Nageswara RD, Sitapathi RV, *et al*. Characterization of a N-22 rice mutant for heat tolerance and mapping of yield traits. Rice. 2013; 6:36.