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Response of Rice Genotypes for Heat Stress during Summer Season in the Northern Parts of Karnataka

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Abstract

Global warming results in high temperature-induced floret sterility in rice. The anticipated high temperature will induce floret sterility and increase the instability of rice yield even in temperate regions. In the Tungabhadra command area of Karnataka, India, the rice is being grown to an extent of 3.5 lacks ha during summer season, the temperature in the months of April and May rise upto 40^{o}C, during which the crop suffer from terminal heat stress and leads to more spikelet sterility resulting the chaffyness of grains. Hence in the present investigation, as the part of development of rice varieties for high temperature tolerance, forty rice accessions were screened for heat tolerance. The experiment was carried out at the Agriculture Research Station Gangavathi, University of Agricultural Sciences, Raichur during *summer* season 2014 to screen the forty rice accessions received from the IRRI, India office, ICRISAT Hyderabad, with Gangavati sona, IR-64, MTU 1010 and N-22 as checks. Transplanting was taken up with a row spacing of 20 cm between rows and 15 cm between plants. Among the forty accessions screened for heat tolerance, the check N-22 (66.00 days) was the earliest to days to 50 per cent flowering followed by the accessions EC792177 and EC792206. Number of tillers per plant at maturity was significantly highest (22.50) in the accession EC792195 followed by the accessions EC792203 and EC792178 (17.30) which were on par with each other. Significantly highest thousand grain weight was recorded in the accessions EC792200 and EC792286 (25.00g). The significantly minimum per cent of chaffyness (0.40%) was recorded in the accession EC792183 followed by the accessions EC792179 (0.80%) and EC792216 (1.20%). The highest grain yield of 6167 kg/ha was recorded by accession EC792239 followed by EC792285 (5777 kg/ha) and EC792185 (5333 kg/ha), as against the checks MTU-1010(2520 kg/ha), N-22 (2400 kg/ha), IR-64 (2283 kg/ha) and Local check Gangavati sona (1490 kg/ha).

Keywords: Heat tolerance, rice, genotypes, summer

Introduction

Rice has been cultivated under a wide range of climatic conditions. Almost 90% of the World's rice is grown and consumed in Asia, where 50% of the population depends on rice for food. However, the rice crop during the sensitive flowering and early grain-filling stages is currently exposed top temperatures higher than the critical threshold of 33^{o}C in South Asia (Bangladesh, India) and South east Asia (Myanmar, Thailand) (Wassmann *et al*., 2009). Since the 1980s, the increase in the atmospheric concentration of greenhouse gases, such as carbon dioxide, is believed to cause the increase in air temperature (Hansen *et al.*, 1984). Global warming results in high temperature- induced floret sterility in rice. Jagadish *et al.* (2012) reported that high temperature stress negatively affects rice production, especially in vulnerable regions in South and Southeast Asia. High temperature stress is a major constraint in rice production in tropical and subtropical regions. Crop scientists have attempted to assess the effects of increasing temperature and high carbon dioxide concentration in the atmosphere on the growth and yield of rice using simulation models (Boote *et al*., 1994; Horie *et al.*, 1996, 1997; Matthews *et al.*, 1997). Many reports confirmed that high temperature affects all rice growth stages, from emergence to ripening. However, the flowering stage and, to a lesser extent, the booting stage are the most sensitive to temperature (Imaki *et al.*, 1982; Shah *et al.*, 2011). Horie *et al.* (1996) suggested that the anticipated high temperature will induce floretsterility and increase the instability of rice yield even in temperate regions. The main cause of floret sterility, which is induced by high temperature at the flowering stage, is anther indehiscence (Satake and Yoshida, 1978; Mackill *et al.*, 1982; Matsui *et al.*, 1997, 2001). Anthers of heat tolerant cultivars dehisce more easily than those of heat-susceptible cultivars and contribute to pollination under high temperature conditions

(Satake and Yoshida, 1978; Mackill *et al.*, 1982; Matsui *et al*, 2000, 2001). Rice yields are estimated to be reduced by 41% due to high temperatures by the end of the 21st century (Ceccareli *et al.*, 2010). Increasing severity of the problem in rice-growing areas in Asia is due to rising temperatures (Catherine *et al.*, 2012). Global temperatures are estimated to rise by 1.1°C to 6.4°C during the next century (IPCC, 2012), thereby threatening rice production. The development of rice varieties for high temperature tolerance has received little attention in the past. With climate change, breeding for heat tolerance is one of the key research areas that may address problems related to temperature increase (Manigbas and Sebastian, 2007; Redona *et al.*, 2009). Hence in the present investigation, as the part of development of rice varieties for high temperature tolerance, forty rice accessions were screened for heat tolerance during summer season.

Materials and Methods

The experiment was carried out in the Agriculture Research Station Gangavathi, University of Agricultural Sciences, Raichur during *summer* seaso n 2014 to screen the forty rice accessions received from the IRRI, India office, ICRISAT Hyderabad, with GGV-05-01 (Gangavati sona), IR-64, MTU 1010 and N-22 as checks. Nursery sowing was taken up on 26/01/2014 and transplanted on 22/02/2014 in 4 rows of three meters length with a row spacing of 20 cm between rows and 15 cm between plants in a randomized block design with three replications (Fig. 1(a) Agronomic practices followed as per the recommendations. The flowering stage of the crop was coincided with hottest month (April & May), recorded weather data of the testing location (Fig. 1 (b). The mean data was statistically analysed by adopting the appropriate methods outlined by Panse and Sukhatme (1978) and Sundarajan *et al.* (1972). The critical differences were calculated at five per cent level of probability, wherever 'F' test was significant.

Fig. 1a: Field view of heat tolerant experiment at Agriculture Research Station, Gangavathi

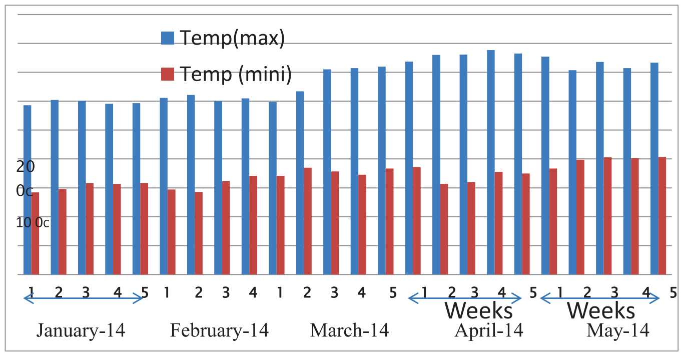

Fig. 1b: Temperature pattern during summer season 2014, Agriculture Research Station, Gangavathi

Results and Discussion

Among the forty accessions screened for heat tolerance, the check N-22 (66.00 days) was the earliest to days to 50 percent flowering followed by the accessions EC792177, EC792206, EC792239, EC792193 and EC792235 (80.00 days). The local check gangavathi sona (105.00 days) was late to days to 50 per cent flowering. The results obtained on plant height are presented in Table 01. Among the forty accessions screened for heat tolerance, the check N-22 recorded significantly highest plant height (102.97cm) followed by the accessions EC792310 (102.30), EC792239 (101.60 cm) and the significantly lowest plant height (77.60 cm) was in the accessions EC792216 and EC792238.

Number of tillers per plant at maturity was significantly highest (22.50) in the accession EC792195 followed by the accessions EC792203 and EC792178 (17.30) which were on par with each other. The accession EC792233 recorded significantly lowest (9.30) number of tillers per plant among the accessions screened for heat tolerance which was on par with the accessions EC792270, EC792230 and EC792204 (10.00). The data on average weight of five panicles of forty accessions screened for heat tolerance are presented in the Table 1. The accession EC792284 recorded significantly maximum (35.40g) average weight of five panicles among the accessions which was on par with the accessions EC792286 (27.50g) and EC792237 (26.40g). The accession EC792178 recorded significantly minimum (12.50g) average weight of five panicles followed by EC792183 (14.70g) and EC792231 (15.10g).

Significant differences on grain yield per plot were recorded among the forty accessions screened for heat tolerance Table 1. The grain yield per hectare recorded in screening of the forty accessions showed significant differences. The accession EC792239 recorded significantly higher grain yield per hectare (6166.67kg) followed by the accessions EC792285 (5776.67kg) and EC792185 (5333.33kg) which were on par with each other. The check gangavathi sona recorded significantly lowest grain yield per hectare (1490.00kg) followed by the check IR-64 (2283.00kg) which were on par with each other.Significantly highest thousand grain weight was recorded in the accessions EC792200 and EC792286 (25.00g) among the accessions screened followed by the accessions EC792310, EC792186, EC792316 and EC792222 (24.00g) which were on par with each other (Table 1). The check gangavathi sona recorded significantly minimum (12.80g) thousand grain weight followed by the accession EC792193 (15.00g) which were on par with each other (Figure 01). The observations recorded on per cent of chaffyness are presented in Table 01. The per cent of chaffyness was recorded significant differences among the accessions screened for heat tolerance. The significantly minimum per cent of chaffyness (0.40%) was recorded in the accession EC792183 followed by the accessions EC792179 (0.80%) and EC792216 (1.20%). The accessions EC792286, EC792192 and EC792284 recorded significantly maximum (14.40%) per cent of chaffyness followed by the accessions EC792288 and EC792193 (12.00%). Among the forty accessions screened along with the four checks for heat tolerance, sixteen accessions showed the long bold grain size, eleven accessions showed the short bold grain size, sixteen accessions showed the long slender grain size and only one genotype showed the medium slender grain size (Table 01). Popular varieties in Asia, particularly in the India, have high yields, good grain quality, and resistance to pests and diseases. However, they lack heat tolerance. Due to the advent of climate change caused by global warming, breeding for heat-tolerant varieties has become important. New rice varieties should possess adaptability to rising temperatures in addition to the desirable traits that a variety should have. The breeding populations created through a regional collaboration project need to adapt to increasing temperatures in specific locations.

Genetic variability in any crop is pre-requisite for selection of superior genotypes over the existing cultivars. Variation was observed for all the characters among the genotypes studied, indicating the existence of sufficient amount of variability. These results were in conformity with the findings of Dhanwani *et al.* (2013), Dhurai *et al.* (2014) and Kavitha *et al.* (2015).Yield data were obtained from screening of the rice accessions showed the genotypic difference. The highest yield was produced by the accessions EC792239, EC792285 and EC792185 which had heat tolerance. An increase in panicle length, number of panicles, number of tillers per plant, average weight of five panicles and minimum per cent of chaffyness observed and this increase resulted in high yields even with high temperature compared with other accessions.

Tolerance is a combined reaction of the plant ability to survive the stress conditions and to complete its developmental stages before, during or later the stress period (Levitt, 1980). This was clear that the few lines having passed through the period of high temperature are tolerant to high temperature stress. The present results support Liu *et al.* (1981), Chen *et al.* (1982) and Mohammad Sarwar and Ghulam Mustafa Avesi (1985). Factors responsible for the induction of sterility by high temperature during anthesis were not studied during the present study but it is likely that the tolerant lines were able to shed sufficient amount of viable pollen for self-pollination (Mackill *et al.*, 1982). During heading the average atmospheric temperature was ranged from 35^{o}C to 38^{o}C which was high enough to induce spikelet sterility.

Conclusion

Breeding heat-tolerant rice is one of the strategies used to mitigate the effects of climate change, particularly in high temperature regions where the majority of rice is grown. The screening and selection strategies that we developed for breeding under heat prone conditions could differentiate the germplasm accessions according to heat tolerance traits. In view of the same, in the present study forty rice accessions along with the four checks were screened and few promising heat tolerant accessions were selected based on their grain yield performance

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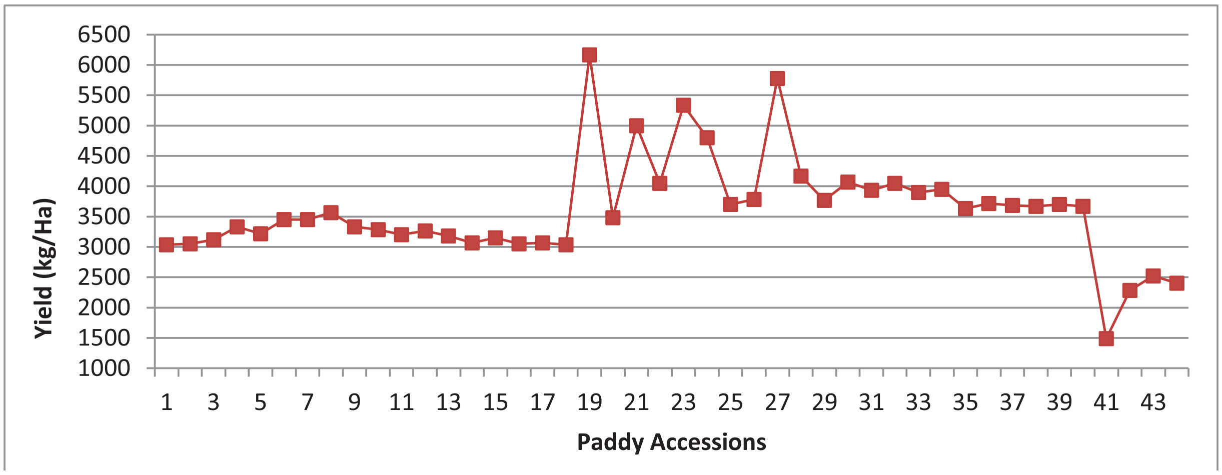

Figure 2: Grain yield (kg/ha) of forty four genotypes evaluated for heat tolerance

Sl. No	Accession	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Total number of tillers	Av. Wt. of five panicles (g)	Yield (kg/ha)	1000 grain wt.	Per cent choffyness	Grain type
1	EC792270	84.00	93.60	23.30	10.00	20.50	3033.33	22.00	2.80	SB
2	EC792199	84.00	82.60	22.30	11.60	23.60	3050.00	20.00	1.60	LS
3	EC792231	81.00	83.60	21.00	10.60	15.10	3116.67	18.00	2.80	SB
4	EC792310	87.00	102.30	23.00	15.60	25.80	3333.33	24.00	4.40	LB
5	EC792200	84.00	86.60	20.00	15.00	22.00	3216.67	25.00	6.40	LB
6	EC792227	83.00	94.60	25.00	10.30	17.90	3450.00	21.10	4.00	LB
7	EC792183	85.00	86.30	20.00	14.60	14.70	3450.00	20.00	0.40	SB
8	EC792286	90.00	94.30	24.00	12.30	27.50	3566.67	25.00	14.40	LS
9	EC792186	90.00	80.30	19.60	16.00	21.00	3333.33	24.00	4.40	LB
10	EC792216	85.00	77.60	22.00	15.60	21.00	3283.33	22.00	1.20	LB
11	EC792230	85.00	85.60	21.30	1.00	21.50	3200.00	18.50	3.90	LS
12	EC792177	80.00	85.30	21.60	11.00	19.90	3266.67	19.00	2.80	SB
13	EC792237	81.00	84.00	23.60	13.00	26.40	3183.33	23.00	3.20	LS
14	EC792210	85.00	85.00	21.60	15.00	18.70	3066.67	22.00	2.80	LB
15	EC792288	83.00	81.30	23.00	11.30	22.50	3150.00	23.00	12.00	LB
16	EC792198	83.00	94.30	23.00	12.00	25.60	3050.00	21.00	5.00	LS
17	EC792206	80.00	84.00	21.00	12.30	20.30	3066.67	19.00	2.80	SB
18	EC792187	81.00	91.30	22.60	12.30	20.90	3033.33	19.00	1.60	LB
19	EC792239	80.00	101.60	22.30	11.60	21.80	6166.67	20.00	2.00	SB
20	EC792192	81.00	86.30	22.60	15.60	22.30	3483.33	22.00	14.40	LS
21	EC792179	81.00	88.60	23.60	12.30	20.90	5000.00	19.00	0.80	LS
22	EC792236	90.00	91.00	24.00	13.00	20.00	4050.00	21.00	8.40	SB
23	EC792185	84.00	86.60	22.00	12.60	18.30	5333.33	19.00	1.60	LB
24	EC792240	84.00	81.30	22.00	10.30	24.20	4800.00	20.00	3.20	LB
25	EC792225	81.00	88.60	23.00	11.30	19.90	3700.00	19.00	3.20	LS
26	EC792193	80.00	92.00	22.00	14.60	17.50	3783.33	15.00	12.00	LS
27	EC792285	92.00	80.00	19.00	11.00	16.00	5776.67	22.00	4.80	LS
28	EC792316	84.00	92.00	24.00	12.00	23.60	4166.67	24.00	7.60	LS
29	EC792203	83.00	91.60	23.00	17.30	23.30	3766.67	21.00	2.00	SB

30	EC792222	85.00	90.00	21.00	13.00	18.60	4066.67	24.00	2.40	LB
31	EC792178	84.00	89.00	22.60	17.30	12.50	3933.33	21.00	2.40	LB
32	EC792235	80.00	87.60	21.00	12.00	20.30	4050.00	22.00	2.00	LB
33	EC792195	83.00	92.00	22.00	20.00	16.50	3900.00	20.00	2.40	LS
34	EC792238	81.00	77.60	20.00	13.30	18.40	3950.00	19.00	5.60	SB
35	EC792233	81.00	88.60	23.00	9.30	21.90	3633.33	19.00	2.80	LS
36	EC792217	85.00	85.30	21.00	11.00	19.30	3716.67	22.00	10.40	LS
37	EC792224	84.00	86.60	23.30	14.60	19.40	3683.33	17.00	2.40	LB
38	EC792284	91.00	91.60	23.00	14.60	35.40	3666.67	21.00	14.40	SB
39	EC792208	84.00	91.00	23.00	15.60	17.90	3700.00	19.30	3.30	LS
40	EC792204	83.00	88.60	22.60	10.00	19.90	3666.67	22.00	2.00	LS
41	G sona	105.00	97.08	24.27	11.45	18.43	1490.00	12.80	11.80	MS
42	IR-64	87.83	101.58	24.83	10.87	20.93	2283.00	23.80	8.20	LB
43	MUT-1010	87.00	96.13	24.32	11.47	22.72	2520.00	21.40	6.36	LB
44	N-22	66.00	102.97	24.25	10.18	21.90	2400.00	21.70	6.00	SB
	Mean	84.04	89.04	22.40	12.63	20.84	3603.10	20.76	4.98	
	S.Em±	1.88	2.42	1.99	1.49	3.01	329.80	1.09	0.61	
	CD (5%)	5.29	6.81	3.37	4.21	9.28	927.19	3.09	1.72	