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SCREENING OF RICE GENOTYPES AGAINST HIGH TEMPERATURE STRESS

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ABSTRACT

The effect of high temperature at reproductive stage on spikelet fertility per cent was studied on 47 rice genotypes including 1 local check variety during *Rabi* season 2012. All the 47 rice genotypes are laid out in the Randomized Completely Block Design (RCBD) with three replications. Screening of rice genotypes against high temperature stress, spikelet fertility is a more powerful indicator for screening at the reproductive stage then other stages. Based on spikelet fertility percentage all the 47 rice genotypes were evaluated for spikelet fertility percentage, out of 26 genotypes were observed more than 80% spikelet fertility, 13 genotypes were observed 61-80% spikelet fertility, 7 genotypes were observed 41-60% spikelet fertility and 1 genotype were observed 11-40% spikelet fertility. Among 26 genotypes namely; IR 61336-4B-14-3-2 (PSB RC 94), AS 996-HR 1, GUANG JIANG 1 (ACC 82336), BALILLA, JATTA, CR 547-1-2-3, NAN-GUANG-ZHAN (ACC 59316), GANJAY (ACC 76349), MALA, DULAR (ACC 32561), BR 26, IR 50, BR 7414-22-1, BR 7232-6-2-3, IR 72, KALAHITTA, DARIAL, IR 28, BRRI DHAN 48, JAMREE, IR 6 (ACC 51504), WAB 96-1-1, IR 8866-30-3-1-4-2, KHARA GANJA (ACC 76363), POORNIMA and PEH-KUHTSAO- TU (ACC 8237) there have >80% spikelet fertility. All these 26 rice genotypes were performed superior against high temperature conditions.

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INTRODUCTION

Rice (*O. sativa* and *O. glaberrima*) is one of the world's most important cereal crops, particularly in Asia, but increasingly so in Africa and Latin America as well. Rice is extensively grown in irrigated cropping systems, allowing production in the warmer, high radiation post-monsoon and summer months. Rice with 2n=24, is autogamous annual cereal crop in India, generally grown during *kharif* season (Ahamed *et al.,* 2014). Assam and adjoining states is the primary centre (The Hindustan Centre of Origin, which includes Myanmar, Assam, Malaya Archipelago, Java, Borneo, Sumatra and Philippinese) of origin of rice (Roy *et al.,* 2013). Rice production has also intensified in rainfed-lowland and dryland (upland) cropping systems, many of which are prone to drought and high temperature (Coffman, 1977). Furthermore, global climate change is likely to exacerbate the current vulnerability of the crop to climate, with a projected global average surface temperature increase of 1.4-5.8ºC by 2100 and the possibility of increased variability about this mean (IPCC, 2001).

Rice is grown mainly in tropical and sub-tropical zones, where environmental temperatures exceeding 35ºC at flowering can induce floret sterility and reduce grain yield (Satake and Yoshida, 1978; Matsushima *et al.,* 1982). Jagadish *et al.,* (2012) reported that high temperature stress negatively affects rice production, especially in vulnerable regions in South and Southeast Asia. Rice is a temperature-sensitive crop; during the early growth stages of rice, the occurrence of low temperature stress inhibits seedling establishment and eventually leads to non uniform crop maturation. Good heat tolerance at the seedling stage is an important character for stable rice production. Developing heat-tolerant genotype is one of the most effective ways to avoid the high-temperature damage (Lou *et al.,* 2007).

High temperature at any stage of crop growth can limits productivity of crops, as it is a sensitive crop to temperature and stress injury (Satbhai *et al.,* 2013). High temperatures cause an array of morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development and may lead to a drastic reduction in economic yield. Flowering and booting are the most susceptible stages of development to temperature in rice (Farrell *et al.,* 2006). Satake and Yoshida (1978), have shown that spikelets at anthesis that are exposed to temperatures>35ºC for about 5 d during the flowering period are sterileand no seed set. Sterility is caused by poor anther dehiscence and low pollen production and hence low numbers of germinating pollen grains on the stigma. High temperatures at the flowering stage inhibit pollen grain swelling (Matsui *et al.,* 2000), which triggers anther dehiscence in rice. Anthers of heat tolerant cultivars dehisce more easily than those of heat-susceptible cultivars and contribute to pollination under high temperature conditions.

Heat stress due to increased temperature is an agricultural problem in many areas in the world. High temperatures usually occur from mid-April to mid-May when temperatures can reach 38.0ºC to 39.9ºC (Manigbas and Sebastian, 2007). At this temperature range, empty grains are produced in the panicles, leading to a reduction in yield. Rice yields are estimated to be reduced by 41% due to high temperatures by the end of the 21st century (Ceccarelliet *al.,* 2010).

There is genotypic variation in spikelet sterility at high temperature that can be defined by different temperature thresholds (Nakagawa *et al.,* 2002). It has been suggested that indica spp. are more tolerant to higher temperatures than japonica spp. (Satake and Yoshida, 1978; Matsui *et al.,* 2000), although heat tolerant genotypes have been found in both subspecies (Prasad *et al.,* 2006). High temperature stress is also expected to become more frequent in the future due to human-induced climate change because of a warmer mean climate and an increase in the variability of climate (IPCC, 2007). It is therefore necessary to understand the crop response to high temperature stress, identify sources of tolerance in current crop germplasm and to model the response in order to study crop vulnerability under climate variability and change.

Studies the genetic approaches to identify and map genes (or QTLs) conferring thermo-tolerance will not only facilitate marker-assisted breeding for heat tolerance but also pave the way for cloning and characterization of underlying genetic factors which could be useful for engineering plants with improved heat tolerance. We need to the development of high temperature tolerance rice cultivars will considerably improve the rice production in rainfed and water scarce low land conditions. Breeding for heat tolerance is one ofthe key research areas that may address problems related to high temperature stress.

The present investigation was conducted to achieve objectives to screen rice genotypes with good phenotypic acceptability and good spikelet fertility, to screen genotypes having better tolerance to high temperature and to have a preliminary understanding about the nature of tolerance of genotypes with respect to high temperature.

MATERIALS AND METHODS

The experimental material comprises of the forty seven rice genotypes laid out in randomized completely block design (CRBD) with three replications at the Field of Research Cum Instructional Farm, Department of Genetics and Plant Breeding, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (CG) during *Rabi* 2012. These genotypes were received from International Rice Research Institute, Manila (Philippines). The list of experimental material used in the present study is given in Table 3.1.

The experimental field was divided into three replication, spacing between row to row was 20 cm, plant to plant was 15 cm and plot size 3.30m x 1.20m. Transplanting of the material was done manually, keeping single seedling per hill with 30 days old seedling. A fertilizer dose of 80N:50P:30K kg/ha was applied. The entire dose of phosphorus and potassium along with half dose of nitrogen was applied as basal dose at the time of field preparation and the remaining nitrogen dose were applied in two splits at twenty days interval in the standing crop.

High temperature stress screening under field conditions

The spikelet fertility per cent is a more powerful indicator for screening of high temperature at the reproductive stage than other stages. The effect of high temperature at anthesis on spikelet fertility was measured in forty seven rice genotypes during *Rabi* 2012 under field condition. At the time of screening the maximum temperature 45.8°C and minimum temperature 10.5°C was recorded during the crop growth season.The meteorological data during rice crop growth period of *Rabi* season 2012 is given in Table 3.2.

Screening for high temperature stress in rice ishighly complex, because responses to high temperature differ between varieties, growth stages and actual temperatures used. For effective selection, the standard screening methods and facilities used need to be reliable in providing the required low air and water temperatures. In such investigation appropriate cultural practices for fertilization and water management was applied time to time, to minimize high temperature stress damage.

RESULTS AND DISCUSSION

The spikelet fertility is a more powerful indicator for screening of high temperature at the reproductive stage than other stages. In present study forty seven rice genotypes are classified on the basis of spikelet fertility per cent, 26 genotypes were observed more than 80%, 13 genotypes 61-80%, 7 genotypes

Table 3.1: List of forty seven rice genotypes used for high temperature stress study

S.N.	Entry	Genotypes Name	Origin
1	101	N 12 (ACC 6298)	INDIA
2	102	IR 61336-4B-14-3-2 (PSB RC 94)	IRRI
3	103	TOOR THULLA (ACC 76420)	PAKISTAN
4	104	JIJAI NIKI (ACC 76358)	PAKISTAN
5	105	AS 996-HR 1	BANGLADESH
6	106	GUANG JIANG 1 (ACC 82336)	CHINA
7	107	FIROOZ (ACC 39261)	IRAN
8	108	BALILLA	ITALY
9	109	CO 18 (ACC 6331)	INDIA
10	110	JATTA	BANGLADESH
11	111	TAK RATIA (ACC 76415)	PAKISTAN
12	112	CR 547-1-2-3	EGYPT
13	113	RJT 74 (ACC 53688)	INDIA
14	114	IR 70031-4B-R-9-3-1	IRRI
15	115	RATRIA (ACC 28500)	PAKISTAN
16	116	TAM CAU 9 A (ACC 8228)	VIETNAM

Table 3.1:

S.N.	Entry	Genotypes Name	Origin
17	117	NAN-GUANG-ZHAN (ACC 59316)	CHINA
18	118	BRRI DHAN 28	BANGLADESH
19	119	PADI HOJONG (ACC 8192)	INDONESIA
20	120	GANJAY (ACC 76349)	PAKISTAN
21	121	MALA	BANGLADESH
22	122	DULAR (ACC 32561)	INDIA
23	123	BR 26	BANGLADESH
24	124	IR 50	IRRI
25	125	BR 7414-22-1	BANGLADESH
26	126	XUE HE (ACC 76826)	CHINA
27	127	IR 72049-B-R-8-3-1-1-1	IRRI
28	128	ARC 15210 (ACC 41956)	INDIA
29	129	BR 7232-6-2-3	BANGLADESH
30	131	GANJA RANGWALA (ACC 76346)	PAKISTAN
31	132	IR 71864-3R-1-1-3-1	IRRI
32	133	IR 72	IRRI
33	134	CUIABANA	BRAZIL
34	135	KALAHITTA	BANGLADESH
35	136	DARIAL	BANGLADESH
36	137	IR 2307-247-2-2-3	IRRI
37	138	IR 28	IRRI
38	139	SADRI (ACC 32331)	IRAN
39	140	BRRI DHAN 48	BANGLADESH
40	142	JAMREE	BANGLADESH
41	143	IR 6 (ACC 51504)	IRRI
42	144	WAB 96-1-1	AFRICA RICE CENTER
43	145	IR 8866-30-3-1-4-2	IRRI
44	146	KHARA GANJA (ACC 76363)	PAKISTAN
45	147	POORNIMA	INDIA
46	148	PEH-KUH TSAO-TU (ACC 8237)	TAIWAN
47	150	BAKTULSHI	BANGLADESH

Table 3.2: Meteorological data during rice crop growth period of *Rabi* season 2012 *Station: Labhandi, Raipur; Weekly Meteorological Data: 2012*

Week No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain-fall (mm)	Rainy days	Relative Humidity (%)		Vapour Pressure (mm of Hg)		Wind Velocity (Kmph)	Evapo-ration (mm)	Sun Shine (hours)
						I	II	I	II			
52	Dec 24-31	27.5	11.5	0.0	0	85	36	10.1	9.5	1.4	3.4	8.0
1	Jan 01-07	26.3	18.7	34.1	2	96	72	16.2	17.6	0.7	12.6	0.9
2	08-14	24.2	11.0	20.6	1	94	39	10.3	8.3	0.6	19.8	6.7
3	15-21	26.9	10.5	0.0	0	86	31	9.1	18.7	1.5	24.4	9.0
4	22-28	25.7	12.5	0.0	0	86	42	10.2	10.4	0.6	19.9	5.2
5	29-04	25.4	13.1	5.4	1	87	47	10.7	10.9	1.0	18.3	4.5
6	Feb05-11	29.7	12.4	0.0	0	78	27	9.1	7.9	0.7	26.0	9.1
7	12-18	30.1	16.2	0.0	0	85	44	12.8	14.6	2.4	26.4	7.9
8	19-25	33.2	14.9	0.0	0	78	25	10.9	9.2	2.2	31.8	9.3
9	26-04	33.5	15.2	0.0	0	77	23	11.2	8.8	2.6	41.3	8.4
10	Mar 05-11	33.6	15.9	0.0	0	71	19	10.6	7.1	3.6	46.0	8.8
11	12-18	34.6	17.5	0.0	0	70	21	11.9	8.6	3.8	45.8	8.0
12	19-25	37.9	17.4	0.0	0	68	19	11.5	9.1	2.5	52.2	8.4
13	26-01	38.5	20.1	0.0	0	57	16	11.7	8.1	2.7	51.9	8.1
14	Apr 02-08	39.2	23.5	0.0	0	57	21	13.5	10.6	5.6	65.0	8.3
15	09-15	39.6	23.9	9.2	2	57	20	15.1	10.3	6.3	69.8	8.5
16	16-22	40.2	24.8	0.0	0	48	16	13.3	8.7	3.6	66.3	9.4
17	23-29	39.1	25.2	6.6	1	68	25	18.7	12.9	5.6	70.0	8.5
18	30-06	40.9	25.5	0.0	0	59	14	17.0	7.5	5.9	77.5	10.4
19	May07-13	41.1	27.4	0.0	0	43	19	13.6	11.0	4.6	75.3	8.1
20	14-20	43.3	27.6	0.0	0	43	13	14.4	8.4	4.5	85.8	9.4
21	21-27	44.6	28.5	0.0	0	34	11	12.3	7.7	3.7	85.5	8.0
22	28-03	45.8	28.4	2.2	0	29	13	11.8	8.1	5.2	93.6	7.8
23	Jun 04-10	43.4	30.8	0.0	0	43	22	16.0	13.2	8.7	107.9	9.0
	Mean/Total	35.18	19.67	78.1	7	90.81	58.77	18.43	17.99	3.82	607.5	5.32

Table 4.1: Classification of forty seven rice genotypes on the basis of spikelet fertility score (SES, IRRI 1996)

Score	State	Genotypes	Total
1	More than 80%	IR 61336-4B-14-3-2 (PSB RC 94), AS 996-HR 1, GUANG JIANG 1 (ACC 82336), BALILLA, JATTA, CR 547-1-2-3, NAN-GUANG-ZHAN (ACC 59316), GANJAY (ACC 76349), MALA, DULAR (ACC 32561), BR 26, IR 50, BR 7414-22-1, BR 7232-6-2-3, IR 72, KALAHITTA, DARIAL, IR 28, BRRI DHAN 48, JAMREE, IR 6 (ACC 51504), WAB 96-1-1, IR 8866-30-3-1-4-2, KHARA GANJA (ACC 76363), POORNIMA, PEH-KUH-TSAO-TU (ACC 8237).	26
3	61-80%	N 12 (ACC 6298), JIJAI NIKI (ACC 76358), FIROOZ (ACC 39261), RJT 74 (ACC 53688), IR 70031-4B-R-9-3-1, RATRIA (ACC 28500), TAM CAU 9 A (ACC 8228), BRRI DHAN 28, ARC 15210 (ACC 41956), IR 71864-3R-1-1-3-1, IR 2307-247-2-2-3, SADRI (ACC 32331), BAKTULSHI.	13
5	41-60%	TOOR THULLA (ACC 76420), TAK RATIA (ACC 76415), PADI HOJONG (ACC 8192), XUE HE (ACC 76826), IR 72049-B-R-8-3-1-1-1, GANJA RANGWALA (ACC 76346), CUIABANA.	7
7	11-40%	CO 18 (ACC 6331)	1
9	Less than 11 %		0

41- 60% and 1 genotype 11-40% spikelet fertility per cent. Among 26 rice genotypes performance found to be superior against high temperature stress. The spikelet fertility score of forty seven rice genotypes is presented in Table 4.1.

The results on effect of high temperature on spikelet fertility of rice suggested that high temperature significantly decreased spikelet fertility. Based on spikelet fertility per cent, the genotypes IR 61336-4B-14-3-2 (PSB RC 94), AS 996-HR 1, GUANG JIANG 1 (ACC 82336), BALILLA, JATTA, CR 547-1-2-3, NAN-GUANG-ZHAN (ACC 59316), GANJAY (ACC 76349), MALA, DULAR (ACC 32561), BR 26, IR 50, BR 7414-22-1, BR 7232-6-2-3, IR 72, KALAHITTA, DARIAL, IR 28, BRRI DHAN 48, JAMREE, IR 6 (ACC 51504), WAB 96-1-1, IR 8866-30-3-1-4-2, KHARA GANJA (ACC 76363), POORNIMA and PEH-KUH-TSAO-TU (ACC 8237) were found to performance best on high temperature. Similar results finding has been reported by Satake and Yoshida (1978) based on decrease in spikelet fertility at high temperature. Satbhai *et al.* (2014) also reported that high temperature at any stage of crop growth can limit crop productivity.

During the screening, found highest spikelet fertility >90% at 38 to 45°C were POORNIMA, BRRI DHAN 48, PEH-KUH-TSAO-TU (ACC 8237), BR 26, IR 8866-30-3-1-4-2, MALA, IR 6 (ACC 51504), JATTA, KHARA GANJA (ACC 76363), GANJAY (ACC 76349), GUANG JIANG 1 (ACC 82336) and DULAR (ACC 32561), while the most susceptible genotypes were CO 18 (ACC 6331) and IR 72049-B-R-8-3-1-1-1 which had poor spikelet fertility<50% at 38 to 45ºC. Therefore, 6 hr of high temperature for a day was ideal for screening rice genotypes for true tolerance to high temperatures at anthesis.

The some genotypes *viz.,* POORNIMA, BRRI DHAN 48, PEH-KUH-TSAO-TU (ACC 8237) was highly tolerant, while some genotypes were tolerance, some genotypes were susceptible and some genotypes were moderate susceptible against high temperature. Jagadish *et al.* (2007), Chakrabarti *et al.* (2010), Liu *et al.* (2013) and Kavitha *et al.* (2015) also agreed with spikelet fertility was decreases to high temperature.

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REFERENCES

Ahamed, A., Singh, V. K., Sharma, V. and Paswan, S. K. 2014. Genetic Divergence Analysis in Rice (*Oryza sativa* L.) Germplasm in Sodic Soil Condition. *The Ecoscan.* **6:** 51-54.

Ceccareli, S., Grando, S., Maatougui, M., Michael, M., Slash, M., Haghparast, R., Rahmanian, M., Taheri, A., Al-Yassin, A., Benbelkacem, A., Labdi, M., Mimoun, H. and Nachit, M. 2010. Plant breeding and climate changes. *J. Agric. Sci.* **148:** 627-637.

Chakrabarti, B., Aggarwal, P. K., Singh, S. D., Nagarajan, S. and Pathak, H. 2010. Impact of high temperature on pollen germination and spikelet sterility in rice: comparison between basmati and non-basmati varieties. *Crop* and *Pasture Sci.* **61:** 363-368.

Coffman, W. R. 1977. Rice varietal development for cropping systems at IRRI.Proceedings of symposium on cropping systems research and development for the Asian rice farmer. *Philippines: IRRI.* pp. 359-371.

Farrell, T. C., Fox, K. M., Williams, R. L. and Fukai, S. 2006. Genotypic variation for cold tolerance during reproductive development in rice: screening with cold air and cold water. *Field Crops Res.* **98:** 178-194.

IPCC 2001. Summary for policy makers. In: Climate change 2001. The scientific basis. *Cambridge University Press.* p. 13.

IPCC 2007. Summary for Policymakers, In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., Tignor, M. and Miller, H. L. (Eds)] Cambridge University Press, Cambridge, UK.

Jagadish, S. V. K., Craufurd, P. Q. and Wheeler, T. R. 2007. High temperature stress and spikelet fertility in rice (*Oryza sativa* L.). *J. Exp. Bot.* **58:** 1627-1635.

Jagadish, S. V. K., Septiningsih, E. M., Kohli, A., Thomson, M. J., Ye, C., Redoña, E., Kumar, A., Gregorio, G. B., Wassmann, R., Ismail, A. M. and Singh, R. K. 2012. Genetic advances in adapting rice to a rapidly changing climate. *J. Agron. Crop Sci.* **198(5):** 360-373.

Kavitha, K., Reddy, Y. S. K., Rajarajeswari, V. And Sudhakar, P. 2015. Relationship of Water Use Efficiency and Heat Tolerance Traits with Grain Yield in Elite Paddy Genotypes Under Aerobic Cultivation. *The Ecoscan.* **9(1&2):** 601-604.

Liu, Q., Wu, X., Ma, J., Li, T., Zhou, X. and Guo, T. 2013. Effects of high air temperature on rice grain quality and yield under field condition. *Agron. J.* **105(2):** 446-454.

Lou, Q., Chen, L., Sun, Z., Xing, Y., Li, J., Xu, X., Mei, H. and Luo, L.

2007. A major QTL associated with cold tolerance at seedling stage in rice (*Oryzasativa* L.). *Euphytica*. **158:** 87-94.

Manigbas, N. L. and Sebastian, L. S. 2007. Breeding for High Temperature Tolerance in the Philippines: Proceedings of the International Workshop on Cool Rice for a Warmer World.Huazhong Agricultural Univeristy, Wuhan, Hubei, China. March 26-30, 2007.

Matsui, T., Omasa, K. and Horie, T. 2000. High temperature at flowering inhibit swelling of pollen grains, a driving force for thecae dehiscence in rice (*Oryza sativa* L.). *Plant Prod. Sci*. **3:** 430-434.

Matsushima, S., Ikewada, H., Maeda, A., Honda, S. and Niki, H. 1982. Studies on rice cultivation in the tropics: 1. Yielding and ripening responses of the rice plant to the extremely hot and dry climate in Sudan. *Jpn. J. Trop. Agric*. **26(1):** 19-25.

Nakagawa, H., Horie, T. and Matsui, T. 2002. Effects of climate change on rice production and adaptive technologies. Rice science: innovations and impact for livelihood. *China: International Rice Research Institute*. pp. 635-657.

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 Res*. **95:** 398-411.

Roy, B., Surje, D. T. and Mahato, S. 2013. Biodiversity of Farmers' Varieties of Rice (*Oryza sativa* L.) at Repository of Uttar BangaKrishiViswavidyalaya: A Reservoir of Important Characters. *The Ecoscan*. **4:** 145-151.

Satake, T. and Yoshida, S. 1978. High temperature induced sterility in indicarices at flowering. *Jpn. J. Crop Sci*. **47:** 6-17.

Satbhai, R., Kale, A. and Naik, R. 2014. Cell Viability, Time Laps Study and Membrane Stability Index During Temperature Induction Response in Wheat. *The Ecoscan*. **6:** 245-252.