

Original Research Article

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## Assessment of Temperature Stress on Rice at Grain Filling Stage in Raipur District of Chattisgarh, India

R. K. Verma\* and Mithlesh Kumar Kanwar

Department of genetics and plant breeding, Indira Gandhi Krishi Vishwavidyalaya,  
Raipur (C.G), 492012, India

\*Corresponding author

### ABSTRACT

Rice is sensitive to high temperature, especially at the reproductive stage, which causes spikelet sterility and yield losses. The increase in both frequency and intensity of high temperature, along with its large variability, is emerging as a potential threat to the sustainability of rice production. The predicted 2–4°C increment in temperature by the end of the 21st Century poses a threat to rice production. The impact of high temperatures at night is more devastating than day-time or mean daily temperatures. Booting and flowering are the stages most sensitive to high temperature, which may sometimes lead to complete sterility. Recent data reveal an abnormal increase in diurnal temperatures, with night temperature increasing at a much faster rate than day temperature. To identify heat-tolerant genetic resources for future genetic studies and breeding 29 rice genotypes were screened at Raipur in the summer season (2015).

#### Keywords

Heat tolerance,  
frequency and  
intensity

#### Article Info

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### Introduction

Global warming has become one of the most complicated problems affecting agricultural productivity. It was reported that global emissions of carbon dioxide caused by human activities reached a record high in 2011 and will likely increase in succeeding years, thus contributing to the global increase in temperature (Maraseni *et al.*, 2009; Smith and Olesen, 2010). The increase in temperature has been striking and can cause irreversible

damage to plant growth and development (Wahid *et al.*, 2007). 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). In future climate, it was predicted that yield of current varieties in southern Japan would reduce by up to 40% (Horie *et al.*, 1996).

Rice with relatively higher tolerance at the vegetative stage is extremely sensitive to high temperature during the reproductive stage,

particularly at flowering (Prasad *et al.*, 2006; Yoshida *et al.*, 1981; Jagadish *et al.*, 2007, 2008, 2010a,b).

Spatial analysis using cropping pattern data from the Rice almanac (Maclean *et al.*, 2002) showed susceptible stages of rice (i.e., flowering and early grain filling) coinciding with high-temperature conditions in Bangladesh, eastern India, southern Myanmar, and northern Thailand (Wassmann *et al.*, 2009b).

Although the global mean temperature could increase by 2.0–4.5 °C by the end of this century, it has been predicted that minimum night temperature will increase at a much faster rate than maximum day temperature (IPCC 2007).

Rice, with its widely diverse genetic traits early-morning flowering (EMF) to escape higher temperature during the later hours of the morning (Ishimaru *et al.*, 2010) and high-temperature avoidance through transpiration cooling (Weerakoon *et al.*, 2008) is better equipped to withstand high day temperature, provided that sufficient water is available. However, the limited stomatal activity at night makes rice extremely vulnerable to rapidly increasing night temperature.

Further, increases in CO<sub>2</sub> concentration and other climatic factors such as solar radiation and relative humidity influence the degree to which high temperature affects rice productivity. The contribution of these variables to yield variation has received less attention.

Diurnal temperature change can significantly affect rice production. Day temperatures beyond the critical level can adversely affect photosynthesis, by changing the structural organization of thylakoids and disrupting photosynthetic system II (Karim *et al.*, 1997, Zhang *et al.*, 2005). This will, in turn,

increase the generation of reactive oxygen species, leading to the loss of cell membrane integrity, cell content leakage, and, ultimately, death of cells (Schoffl *et al.*, 1999, Howarth 2005).

## **Materials and Methods**

The present study was conducted at Research cum Instructional Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh, India. The experiment was conducted during Rabi (summer season) 2015.

During Rabi 2015 maximum temperature were 42.0°C and minimum temperature 19°C were recorded during crop season. The experimental material consists of 29 rice genotypes along with three checks namely N-22, Samleswari, IGKV R-1 and they were screened for heat tolerance under natural conditions. The 29 rice genotypes used in the present investigation and 26 rice genotype were received from the IRRI Philippines.

## **Method**

The experiment was conducted in Randomized Block Design with three replications. The 29 rice genotypes including local checks were evaluated during summer 2015 for heat tolerance. The experimental field was divided into three blocks for heat tolerant experiments. The row-to row and plant-to-plant distance was 20 cm and 15 cm, respectively. Transplanting of the material was done manually keeping single seedling per hill with 21 days old seedling. Standard 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 at the time of field preparation and the remaining nitrogen were applied in two split doses at twenty days interval in the standing crop.

**Results and Discussion**

**Screening of rice genotypes on the basis of spikelet fertility**

The spikelet fertility is an important and useful character for evaluation of genotypes. In present study 14 rice genotypes were recorded more than 80% spikelet fertility and 13 rice genotypes sowed between 61 - 80% spikelet fertility and 1 rice genotypes noted 11 – 40% spikelet fertility. Among 29 rice genotypes, 27 rice genotypes found to be superior for high temperature tolerance.

The spikelet fertility is an important and useful character for evaluation of genotypes. From Table the rice genotypes were evaluated as at which temperature which genotype shows good spikelet fertility percentage by comparing the date of flowering with the

maximum temperature. At 21th April, the maximum temperature is 42 °C and the spikelet fertility percentage in genotype IR 11C114 is 81.30%.

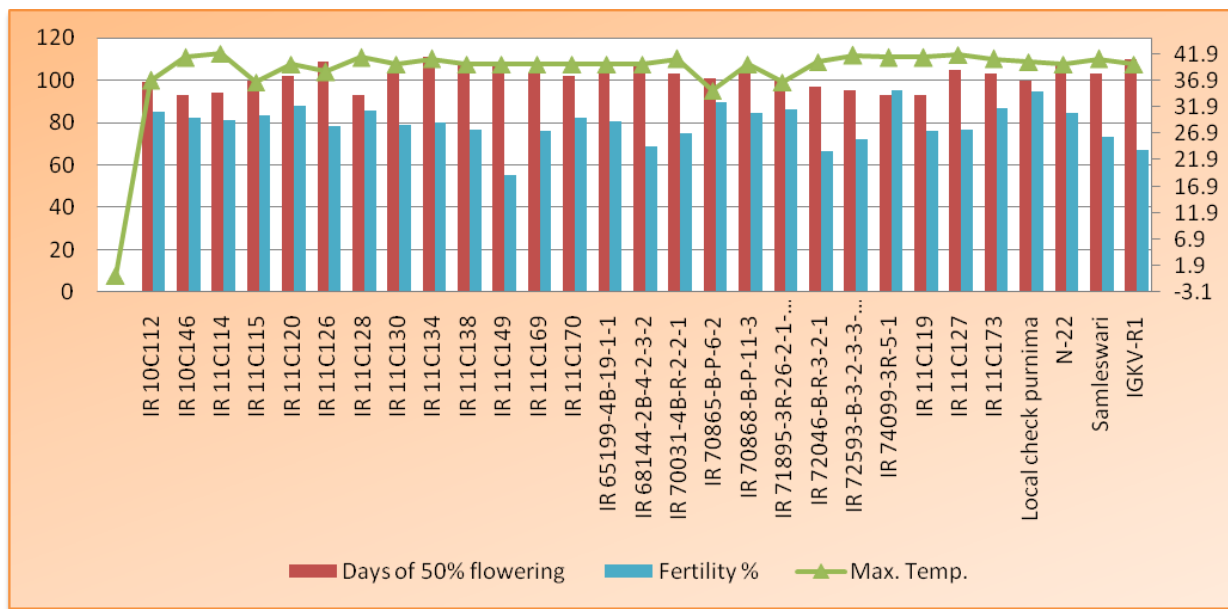
At 20 th April, the maximum temperature is 41.3°C and the spikelet fertility percentage ranges from 85.77 % (IR 11C128) . Other genotypes IR 74099-3R-5-1 and IR 11C119 have 95.04 % and 76.36% spikelet fertility percentage. At 22th April, the maximum temperature is 41.7 °C and the spikelet fertility percentage in genotype IR 72593-B-3-2-3-3-2B-1 is 72.38 %. At 24th April, the maximum temperature is 40.5 °C and the spikelet fertility percentage in genotype IR 72046-B-R-3-2-1 and IRHTN 126 is 66.45 % and 94.51, At 26 April, the maximum temperature is 37 °C and the spikelet fertility percentage in genotype IR 10C112 is 85.10 %.

**Table.1** Screening of rice genotypes on the basis of spikelet fertility

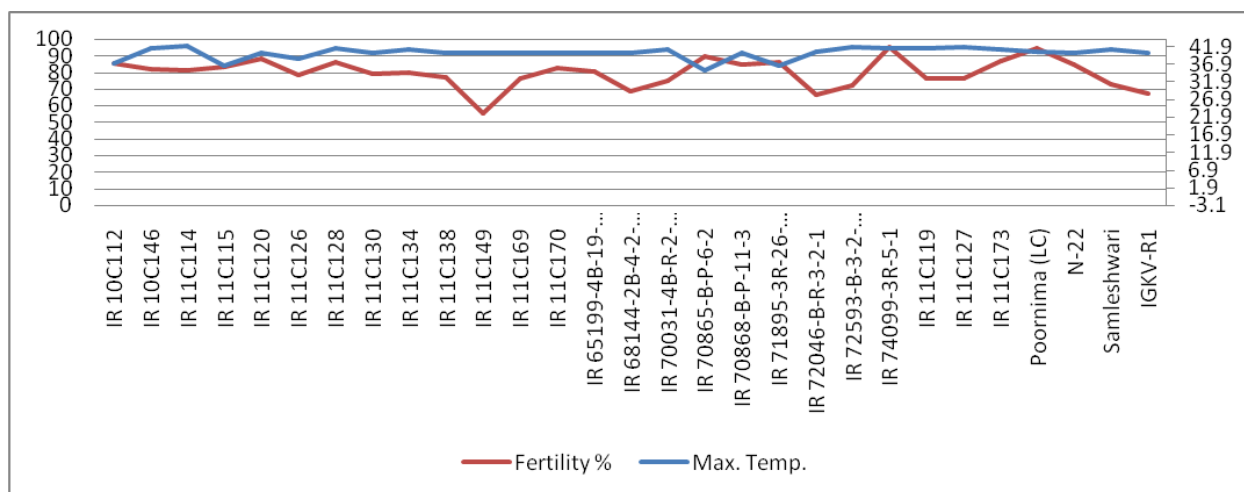
SCORE	STATE	GENOTYPES	TOTAL
1	More than 80%	IR 10C112, IR 11C114, IR 11C115, IR 11C120, IR 11C128, IR 11C170, IR 65199-4B-19-1-1, IR 70868-B-P-11-3, IR 70865-B-P-6-2, IR 71895-3R-26-2-1-2B-2, IR 74099-3R-5-1, IR 11C173, IRHTN 126,N-22;IR 10C146,	15
2	61-80%	IR 11C134, IR 11C130, IR 11C126, IR 11C138, IR 11C169, IR 70031-4B-R-2-2-1, IR 68144-2B-4-2-3-2, IR 72046-B-R-3-2-1, IR 72593-B-3-2-3-3-2B-1, IR 11C119, IR 11C127, Samleswari, IGKV-R1	13
3	41-60%	IR 11C149	1
4	11-40%		0
5	Less than 11%		0

**Table.2** Performance of rice genotypes at maximum temperature related to spikelet fertility percentage

S.No.	Variety	Date of 50% flowering	Days of 50% flowering	Max. Temp.	Min. Temp.	Fertility %
1.	IR 10C112	26/4/2015	99	37	21	85.10
2.	IR 10C146	20/4/2015	93	41.3	26.8	82.10
3.	IR 11C114	21/4/2015	94	42	26.4	81.30
4.	IR 11C115	27/4/2015	100	36.6	19	83.33
5.	IR 11C120	29/4/2015	102	40	26.2	88.05
6.	IR 11C126	6/5/2015	109	38.6	24.5	78.57
7.	IR 11C128	20/4/2015	93	41.3	26.8	85.77
8.	IR 11C130	1/5/2015	104	40	24.3	79.10
9.	IR 11C134	8/5/2015	111	41	25.2	80
10.	IR 11C138	4/5/2015	107	40	23	76.93
11.	IR 11C149	4/5/2015	107	40	23	55.20
12.	IR 11C169	1/5/2015	104	40	24.3	76.15
13.	IR 11C170	29/4/2015	102	40	26.2	82.45
14.	IR 65199-4B-19-1-1	1/5/2015	104	40	24.3	80.45
15.	IR 68144-2B-4-2-3-2	4/5/2015	107	40	23	68.61
16.	IR 70031-4B-R-2-2-1	30/4/2015	103	41	27.6	75.23
17.	IR 70865-B-P-6-2	28/4/2015	101	35	25	89.62
18.	IR 70868-B-P-11-3	1/5/2015	104	40	24.3	84.41
19.	IR 71895-3R-26-2-1-2B-2	27/4/2015	100	36.6	19	86
20.	IR 72046-B-R-3-2-1	24/4/2015	97	40.5	26.2	66.45
21.	IR 72593-B-3-2-3-3-2B-1	22/4/2015	95	41.7	28.5	72.38
22.	IR 74099-3R-5-1	20/4/2015	93	41.3	26.8	95.04
23.	IR 11C119	20/4/2015	93	41.3	26.8	76.36
24.	IR 11C127	2/5/2015	105	41.8	28	76.41
25.	IR 11C173	30/4/2015	103	41	27.6	86.87
26.	Poornima (LC)	24/4/2015	100	40.5	26.2	94.51
27.	N-22	4/5/2015	107	40	23	84.67
28.	Samleshwari	30/4/2015	103	41	27.6	73.07
29.	IGKV-R1	7/5/2015	110	40	22.8	67.25



**Fig.1** Performance of rice genotypes at maximum temperature related to spikelet fertility (%)



**Fig.2** Performance of rice genotypes at maximum temperature related to spikelet fertility percentage

At 27th March, the maximum temperature is 36.6 °C and the spikelet fertility percentage ranges from 83.33% IR 11C115 to 86.0 % (IR 71895-3R-26-2-1-2B-2 , At 28 April the maximum temperature is 35 °C and spikelet fertility percentage in genotype IR 70865-B-P-6-2 is 89.62 %. At 29th April, the maximum temperature is 40 °C and the spikelet fertility percentage in IR 11C170 is 82.45 % and IR 11C120 is 88.05 %, At 30th April, the maximum temperature is 41°C and

the spikelet fertility percentage ranges from 73.07 % (samleswari) to 75.23% (IR 70031-4B-R-2-2-1).

1<sup>st</sup> March the maximum temperature is 40 °C and spikelet fertility percentage in IR 11C130 is 79.10 and IR 11C169 is 76.15 and two genotype IR65199-4B-19-1-1 and IR 70868-B-P-11-3 fertility percentage is 80.45% and 84.41%,at 2 nd march the maximum temperature is 41.8 and the spikelet fertility

percentage in genotype IR 11C127 is 76.41%. At 4 th march, the maximum temperature is 40 °C and the spikelet fertility for genotype IR 11C138 is 76.93 % and genotype IR 10C149 is 55.20 % and genotype IR 68144-2B-4-2-3-2 is 68.61%, genotype N-22 is 84.67%.

At 6 th march the maximum temperature is 38.6 °C and the fertility percentage is genotype IR 11C126 is 78.57%, and at 7 th march the maximum temperature is 40 °C the fertility percentage is genotype IGKV-R1 is 67.25% ,at 8th march the maximum temperature is 41 °C and the spikelet fertility for genotype IR 11C134 is 80%,

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