

## Research Article

# Response of rice varieties to different temperature regimes

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### Abstract

A laboratory experiment was conducted to find out the influence of temperature on germination traits of various rice varieties. Seeds of ten different rice varieties (IR-6, DR-83, DR-92, Shahkar, Bangelo, IR-8, DR-82, Kangni-27, Shandar and Sarshar) were observed the different germination linked traits influenced by 5 different temperatures regimes (30, 35, 40, 45, 50°C) in germinator. The germinability and related traits of various rice varieties showed significant response to changes in temperatures. The highest seed germination (89.02%) was observed after 48 hours under 40°C temperature. However, 35°C was found to be the most suitable temperature for growth and vigor of seedlings. Whereas, in seedling growth and vigor traits, variety Bangelo showed superiority with highest shoot length, root length, shoot fresh weight, root fresh weight, shoot dry weight, root dry weight, and vigor index. It was concluded that for obtaining higher germination in rice varieties, 35°C proved to be most suitable temperature, while germination and almost all other studied traits were adversely affected with increasing temperature.

**Keywords:** Germination, Rice seed vigor, Temperature stress

### Introduction

Rice (*Oriza sativa* L.) is principal food for about half of the world's population. Moreover, its consumption and demand has increased over the years. It is an essential cash crop and one of the main export items of Pakistan accounting for 6.4 percent of value added in agriculture and 1.6 percent in GDP. Rice is grown in all four provinces of the country however, Punjab and Sindh count for more than 90% production in Pakistan. In Sindh province, Kangni-27, Sonhari Kangni, Kangni × Torhi, Dokri Basmati, Bangalo,

Sugdasi, Lari, Motia Ratria, Irri-6 and Irri-8 are the commonly cultivated varieties. It is a selection from the local indigenous stock with high yielding quality and wide range of adaptability [1].

Rice is grown in irrigated cropping systems with maximum day temperatures either close to or higher than the critical threshold ranging between 33°C and 35°C [2, 3]. Recent global climate models have presented alarming situation for the crop as an increase in mean temperature by 2–4.5°C is predicted, moreover, the rice crop affected

by water stress is also expected to double by the end of this century. In high temperature stress, rice's damage and sensitivity is determined by its growth stage. The highest sensitivity is known to be recorded at the reproductive stage [4].

Seed germination is one of the essential parameters in plant development for ultimately obtaining higher seed yield. However, these traits may strongly decline as a result of drought stress that is perhaps one of the most important stresses which limit the germination as well as growth of the seedlings [5-7]. The difference response by germination of rice again higher temperature day night temperature mentioned. The higher temperature is usually linked with increased rate of respiration percentage that causes low production [8]. While particular level of overlap physiological and biochemical reactions such as reduction in number of pollens on stigma germinated and reduced in pollination with increased in fertility of spikelet in higher day night temperature effects are also reported by [8, 9]. Influence of environment hot and cold temperature effect enhance the reactive oxygen species (ROS) production, at high elevated concentration cause oxidative destruction and death of cell [10]. In order to know that plant respond sense for particular combination of stress is an important part of research [11]. For instance higher level of (ROS) can increase transcriptional changes in cold and hot environmental conditions. While hormones production with signaling can also bring change during the variation of temperature stress [12].

Present study was carried-out to investigate the effect of temperature stress on the germination of rice varieties and to assess the interaction between different varieties and temperature on the related traits of rice seedlings.

## Materials and methods

### Site, experimental design and treatments

Present investigation was performed during the year 2011 to 2012 under the (STL) Seed Testing Laboratory, Department of Agronomy, Faculty of Crop Production, Sindh Agriculture University, Tando Jam. To assess the influence of higher temperature stress of the germination traits of seed of various rice varieties. Experiment was arranged in completely randomized design (CRD) having three replications. Five temperature regimes were used in the experiment including 30°C, 35°C, 40°C, 45°C and 50°C, whereas tested rice cultivars were IR-6, DR-83, DR-92, Shahkar, Bangelo, IR-8, DR-82, Kangni-27, Shandar and Sarshar.

### Experimentation and data recorded

In this study experimental treatments were set out in (complete randomized design with 3 replications. A set with total 50 complete randomly selected seed from all every varieties were kept in the petri dishes with 13.5 cm in diameter fifty germinator model –PL3 at different temperature as described above. The seed were moisten when it was necessary.

Data were observed for several parameters including seed germination, shoot length, root length, shoot fresh weight, shoot dry weight, root dry weight, shoot dry weight and seed vigor index. The seed germinated percentage was recorded after 48 hours, while root and plumule length and their fresh and dry weights were observed after 7 days. The physiological indices of root and shoot growth were also determined. The root and the shoot length were measured through measuring scale, while their fresh weights were recorded using electronic balance. The shoot and root samples were kept separately in paper bags and dried in an electric oven maintaining 65°C temperature for 7 days. After drying, the root and shoot dry weights were recorded by an electric balance.

Seedling vigor index were collected through multiplication of germination percentage and length of seedling in cm.

### Statistical analysis

The collected data were typed on computer and used for statistical analyze variance in means of treatments. The LSD (least significant difference) test was used to find out the statistical difference among the treatment with below described procedure as suggested by Gomez and Gomez (1984).

### Results and discussion

#### Seed germination

Varietal behavior for seed germination in this study indicated that Shandar showed the

highest seed germination (84.28%) after 48 hours, followed by Sarshar (83.83%), Kangni-27 (82.69%) and DR-92 (80.17%). The seed germination was relatively lower in varieties IR-6 (76.50%) and IR-8 (76.67%). The seed germination of various rice varieties were assorted significantly due to temperature stress, whereas the highest seed germination (89.02%) was noted under moderate temperature (40°C), while temperature 30, 35 and 45°C resulted in relatively lower seed germination of 87.71, 87.21 and 73.82%, respectively (Table 1).

**Table 1. Seed germination and related traits of rice cultivars as affected by different temperature regimes**

Treatments		Seed germination (%) after 48 h	Shoot length (cm)	Root length (cm)	Shoot fresh weight(mg)
Varieties	IR-6	76.50 b	4.18 a	2.57 c	338.15 b
	DR-83	79.55 b	4.24 a	3.04 b	352.26 a
	DR-92	80.17 a	3.79 a	2.69 b	316.62 b
	Shahkar	77.22 b	3.95 a	2.90 b	330.83 b
	Bangelo	77.48 b	4.47 a	3.49 a	384.39 a
	IR-8	76.67 b	3.47 a	2.50 c	306.10 b
	DR-82	78.32 b	3.66 a	2.84 b	321.87 b
	Kangni-27	82.69 a	2.84 b	2.13 d	250.79 d
	Shandar	84.28 a	3.01 a	2.25 c	265.47 d
	Sarshar	83.83 a	3.47 a	2.03 d	306.00 b
LSD <sub>0.05</sub>		2.6844	0.4899	0.4084	43.507
Temperature	30°C	87.71 b	4.00 a	2.79 b	348.30 b
	35°C	87.21 b	4.84 a	3.36 a	399.59 a
	40°C	89.02 a	3.57 a	2.70 c	307.50 c
	45°C	73.82 c	3.34 a	2.28 d	287.14 c
	50°C	60.56 d	2.79 b	2.33 c	243.66 d
LSD <sub>0.05</sub>		1.8982	0.3464	0.2888	30.764
LSD <sub>0.05</sub> (V x T)		3.0248	1.0954	0.9132	97.285

Means followed by different letters in each column are significantly different from each other at 5% levels of probability

#### Shoot length

The varietal effect suggested that shoot length in Bangelo variety was the highest (4.47cm), followed by DR-83 (4.24cm) and IR-6 (4.18cm). However, lowest shoot length was observed in variety Kangni-27 (2.84cm). The varieties responding to temperature variably and differences were

slight in shoot length ( $P>0.05$ ) when Bangelo, DR-83-(4.24) and IR-6 (4.18) were compared (Table 1). Among the tested temperature regimes, shoot length variations between 40 and 45°C temperatures were non-significant ( $P>0.05$ ) vs. rest of the temperature treatments. The shoot length was maximum (4.84 cm) under 35°C

temperature, whereas seedlings kept under 30°C temperature showed shoot length of 4.00 cm. Moreover, seedlings under 40 and 45°C temperature recorded the shoot length of 3.57 and 3.34 cm, respectively. Seedlings raised in highest tested temperature (50°C) resulted in lowest shoot length of 2.79 cm.

#### **Root length**

Rice varieties tested in this study were of diversified origin; hence, their response to varying temperature regimes differed significantly from each other, as shown in Table 1. The varietal effect indicated that root length in variety Bangelo was maximum (3.49 cm), followed by DR-83 (3.04 cm) and Shahkar (2.90 cm). Whereas, the lowest root length was observed in variety Sarshar (2.04 cm). Maximum root length (3.36 cm) was observed under 35°C temperature, while seedlings raised under 30°C temperature ranked 2<sup>nd</sup> with root length of 2.79 cm. Moreover, seedlings raised under 40°C and 45°C temperature resulted in root length of 2.70 cm and 2.28 cm, respectively.

#### **Shoot fresh weight**

The analyzed data in Table 1 showed the maximum mean shoot fresh weight of 384.39 mg, in Bangelo followed by 338.15 and 352.26 mg in DR-83 and IR-6, respectively. On the other hand, the lowest shoot fresh weight (250.79 mg) was observed in variety Kangni-27. The highest shoot fresh weight of rice seedlings (399.59 mg) was recorded when kept under 35°C temperature, followed by 30°C, 40°C and 45°C temperatures with shoot fresh weight of 348.30, 307.50 and 287.14 mg, respectively. Whereas, highest tested temperature regime (50°C) resulted in lowest shoot fresh weight of 243.66 mg.

#### **Root fresh weight**

The results (Table 2) showed that the highest root fresh weight (262 mg) was noted in variety Bangelo, followed by DR-83 (228.50 mg), Shahkar (217.50 mg), DR-

82 (213.50 mg) and DR-92 (202.00 mg). However, the lowest root fresh weight was observed in variety Sarshar (152.50 mg). Root fresh weight of rice was maximum (252.25 g) under 35°C temperature, followed by 30, 40 and 45°C temperatures with root fresh weight of 209.50, 203.00 and 171.00 mg, respectively. Further increase in temperature up to 50°C resulted in the lowest root fresh weight of 157.00 mg.

#### **Shoot dry weight**

The highest shoot dry weight (23.44 mg) was recorded by variety Bangelo, followed by DR-83 (21.48 mg), IR-6 (20.62 mg), DR-82 (19.63 mg) and DR-92 (19.31 mg). The shoot dry weight was lower in varieties Shandar (16.19 mg), Sarshar (18.66 mg) and IR-8 (18.66 mg). Whereas, the lowest shoot dry weight (15.29 mg) was observed in variety Kangni-27. The highest shoot dry weight (24.37 mg) was noted when rice seedlings were kept under 35°C temperature, followed by 30, 40 and 45°C temperatures with shoot dry weight of 21.24, 18.75 and 17.51 mg, respectively.

#### **Root dry weight**

It is evident from Table 2 that the highest root weight of 15.50 mg was noted in variety Bangelo, followed by DR-83 (14.39 mg), Shahkar (13.70 mg), DR-82 (13.45 mg) and DR-92 (12.72 mg). However, the lowest root dry weight was observed in variety Sarshar (9.60 mg). The root dry weight 15.89 mg was increased when seeds were kept under 35°C followed by 30 and 40°C with root dry weight of 13.19 and 12.87 mg; however, shoot dry weight of rice seedlings decreases with increasing the temperature further (50°C).

#### **Seed vigor index**

The seed vigor index could show the increase in speed and growth rate of germination, observed on the basis of average germination and shoot length; the results for this trait of rice as influenced by

temperature regimes are presented in Table 2. The effect of temperature, varieties, and their interaction on vigor index was significant ( $P < 0.05$ ). Different rice varieties, showed significant behavior for vigor index amongst each other. Highly significant data showed the maximum vigor index was recorded in Bangelo (270.54), followed by Shahkar (248.36). However, the lowest vigor

index was noted for variety Kangni-27 (173.60). The vigor index was the highest (317.6) at 30°C. whereas, vigor index of seedlings under temperature 30°C, 40°C and 45°C ranked 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> with vigor index of 264.7, 233.9 and 179.8, respectively as shown in Table 2. Moreover, the vigor index of seedlings raised in highest temperature (50°C) was lowest (119.93).

**Table 2. Root fresh weight (mg), shoot fresh weight (mg), root dry weight (mg), and seed vigor index of rice cultivars as affected by different temperature regimes**

Treatments		Root fresh weight (mg)	Shoot dry weight (mg)	Root dry weight (mg)	Seed vigor index
Varieties	IR-6	173.00 c	20.62 b	12.11 c	221.59 b
	DR-83	228.50 b	21.48 a	14.39 b	242.38 a
	DR-92	202.00 b	19.31 b	12.72 c	218.74 b
	Shahkar	217.50 b	20.18 b	13.70 b	248.36 a
	Bangelo	262.00 a	23.44 a	15.50 a	270.54 a
	IR-8	187.50 c	18.66 b	12.81 c	202.85 b
	DR-82	213.50 b	19.63 b	13.45 b	243.40 a
	Kangni-27	160.00 d	15.29 c	10.08 d	173.60 c
	Shandar	169.00 c	16.19 c	10.64 c	186.72 c
	Sarshar	152.50 d	18.66 b	9.60 d	224.56 a
LSD <sub>0.05</sub>		30.628	2.6541	1.9095	29.864
Temperature	30°C	209.50 b	21.24 b	13.19 b	264.70 b
	35°C	252.25 a	24.37 a	15.89 a	317.57 a
	40°C	203.00 b	18.75 c	12.87 b	233.88 c
	45°C	171.00 c	17.51 c	10.68 c	179.83 d
	50°C	157.00 c	14.86 d	9.89 c	119.93 c
LSD <sub>0.05</sub>		21.657	1.8768	1.3502	21.117
LSD <sub>0.05</sub> (V x T)		68.487	5.9348	4.2698	66.779

Means followed by different letters in each column are significantly different from each other at 5% levels of probability

### Discussion

Higher seed germination is essential for achieving optimal seedling numbers that would result in higher seed yield [5]. Similar results were found [13], who described germination percentage was observed positively influenced through temperature as well as other alternative treatments. The low temperature stress at germination level on observed germplasm of rice due to reduction of last germination percentage and coleoptiles and radicle length rat in their

study. Extreme temperature level tested in this experiment (i.e. 50°C) resulted in adverse effects on this trait bringing about 60.56% seed germination. Apart from the varietal effect, lower to moderate temperature (30°C-40°C) proved to be effective in enhancing seed germination when observed after 48 hours, while rising temperature adversely affected the germination. [7] Reported that rice's response to higher level of temperature variation for development stage, with

increased sensitivity was observed at reproductive stage. The differential responses of rice with germination in higher day night temperature have also investigated. Same statement repeated by [14], described that healthy and normal seed start to germinate within the time of 36 hours after the inhibition germinations was fulfilled at seven days under the control temperature 25C but late under other temperature treatments. At high temperature regime (50°C) reduction in root length 1.93 cm was observed. These results are in line with the findings of [15], who reported that the temperature variations effect the growth parameters of the plants, and the responses of rice crop to changing temperatures particularly on root and leaf tissues, depend upon the genotypes under the stress. These results are in conformity with the [16], that temperature and different abiotic effect are reducing the factors for cultivation of crop at different marginal and sub marginal lands, while the production of crop mostly due to environmental changes. It was observed that regardless of the varieties; the shoot fresh weight was straight away higher when sown under 35°C temperature and other than this optimum level of temperature, the shoot fresh weight was adversely affected. Apart from the temperature regimes, variety Bangelo resulted higher shoot fresh weight than rest of the varieties. Irrespective of varietal effect, the root fresh weight was linearly increased when the rice seedlings were kept under 35°C temperature and either lower to the optimum temperature, or under higher temperature, the root fresh weight was negatively influenced [17], Rise in temperature up to 50°C decreased the shoot dry weight(14.86 mg). Moreover, it was also observed that regardless of the varieties, increasing temperature did not suit well for sowing of rice over 35°C.[18], found that both high and low temperature stresses can alter multiple aspects of cellular physiology.

used 15 genotypes of rice crop with 9 fixed temperatures (12°C, 16°C, 20°C, 25°C, 27°C, 30°C, 33°C, 36°C and 40°C) and reported that the effect of genotype, temperature and their interactions on germination characteristics were significant and significant reductions in the germination of rice at temperature less than 16°C and upper than 30°C were observed. [19], argued that for stress of heat and response with expression heat influenced transcripts factors that then enhance the expression various stress linked transcripts. The root dry weight was markedly increased when the rice seedlings were sown under 35°C temperature and reduced with increase or decrease in the temperature. Rice is relatively sensitive to high temperature and germination is generally affected by such variations [20]. The above discussion clearly indicates that temperature plays very important role in the germination of seed, and varieties with diversified origin should be considered for their proper temperature requirement for seed germination, and ultimately, the higher seed yield.

### Conclusions

It was concluded that for obtaining higher seed germination in rice varieties, 35°C proved to be most suitable temperature, while germination and almost all the other growth and vigor traits studied were adversely affected with increasing temperature. Moreover, seed germination was the highest (84.28%) in variety Shandar after 48 hours, but the seedling growth in terms of fresh and dry weight of shoots and roots as well as the seed vigor was markedly higher in variety Bangelo as compared to rest of the varieties.

### Authors' contributions

Conceived and designed the experiments: M Buriro & IH Soomro, Performed the experiments: M Buriro & IH Soomro, Analyzed the data: SK Baloch & NS Soomro, Contributed materials/ analysis/ tools: MT Khan & SK Baloch, Wrote the paper: SK Baloch.

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