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Natural Response of Rice Seedlings under Cold Conditions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice (*Oryza sativa* L., Poaceae) is the primary source of food for billions of people throughout the world and around 90% of the cultivated area under rice is in Asia. Rice is the majorly grown during both seasons and in *Rabi* season the seedlings are raised in exposure to the cold months and hence, cold tolerant rice varieties are the prerequisite for rice cultivation. Among the districts of Telangana, Nizamabad, records the lowest mean minimum temperature ranging from 11-16°C over past ten years. The main aim of the study was to identify cold tolerant genotypes. The experiment was conducted to evaluate 35 genotypes of rice for cold tolerance under field conditions. Sprouted seeds of these genotypes were sown in nursery during *Rabi* 2017-18. The germination percentage was recorded at 15 days after sowing (DAS) and 30 DAS, scoring for cold was done and chlorophyll content through SPAD meter were taken. Akshaydhan and Krishna Hamsa were least affected by cold and scored 1 considering them as cold tolerant and can be used as donors in crossing programs.

Keywords: Cold tolerance; germination percentage; rice; seedling stage.

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1. INTRODUCTION

Rice is more sensitive to cold stress than other cereal crops due to its origin in tropical and subtropical regions. Of all the rice species cultivated Asian rice (*Oryza sativa* L.) is more sensitive to prolonged low temperatures. Optimum temperature range for rice germination lies between 20–35°C and temperature of 10°C is cited as minimum critical value below which rice does not germinate [1]. Exposure of rice seedlings to low temperature results in poor germination, seedling mortality, leaf chlorosis or withering, reduced tillering, delayed inflorescences development and spikelet sterility [2,3]. Low temperature is a major climatic problem for rice growing in 25 countries [4]. Breeding of rice cultivars with improved cold tolerance is largely focused on the seedling and reproductive developmental stages which have the most significant impact on yield [5].

Among the districts of Telangana, Nizamabad is one of the major rice producing districts with an area of 86,923 hectares and productivity of 6012 kg ha^{-1}. This district is most affected by cold temperatures during *Rabi* season. Mostly temperatures fall below 13°C from second fortnight of November to December second fort night coinciding with nursery growing period. Farmers of this district mostly prefer to sow nurseries during this period to curtail water scarcity problem during reproductive period of crop. But prevailing low temperatures during this period affect germination and growth causing yellowing and withering of seedlings due to which farmers are transplanting overaged seedlings which is finally affecting yield of crop. Over the past 10 years the average minimum temperature ranged from 11-16^{o}C during seedling stage. Hence there is need to identify the rice varieties which can withstand low temperature at seedling stage. Visual assessment following direct exposure to low temperatures is the most common method of evaluating cold tolerance in rice seedlings [6]. Hence, the experiment was planned to identify cold tolerant genotypes, which can be further used as donors in breeding program.

2. MATERIALS AND METHODS

A total of 35 Rice genotypes (Table 1) consisting of released varieties and pre-release cultures were grown during *Rabi* 2017-18 at Regional Sugarcane and Rice Research Station (RS & RRS), Rudrur, Nizamabad, Telangana, India. Nursery seed bed was prepared and sprouted genotypes were sown on 27th November to expose the seedlings to low temperature. The germination percentage was recorded at 15 days after sowing (DAS) and 30 DAS. The maximum and minimum temperatures and relative humidity during this period were recorded. Chlorophyll content through SPAD meter was recorded at 15 DAS and 30 DAS was taken to assess leaf chlorophyll concentration. Scoring for cold tolerance was done before uprooting the seedlings for transplanting at 15 DAS and 30 DAS, according to the Standard Evaluation System for Rice [7]. The scale for seedling cold tolerance ranged from 1-9.

3. RESULTS AND DISCUSSION

The focus of the experiment was to screen the rice genotypes which can tolerate cold temperatures at seedling stage. The last ten years weather parameters during the period cold occurrence *i.e*., last week of November to January first week had been taking into consideration which shows the average of minimum temperature ranged from 14.0^{o}C (2007) to 14.7°C (2017), mean of maximum temperature ranged from 30.7°C (2007) to 24.2°C (2017) and Relative humidity ranged from 78.5% (2007) to 73.5% (2017) as shown in Fig. 1. Percentage of seedlings in the nursery were recorded at 15 DAS, the variety Akshaydhan (92.0%) recorded highest germination percentage followed by Krishna Hamsa (87.0%), WGL 915 (87.0%) and JGL 11727 (86.0%). IR 64 (21.0%) recorded lowest germination percentage Table 2. Reduction in seedling number in the nursery is due to low temperatures during seedling stage.

The minimum and maximum temperatures and relative humidity in present study varied from the date of sowing in nursery bed to 30DAS as represented in Fig. 2. At 15 DAS, the maximum mean temperature was 29.6°C and the minimum temperature was 15.0°C. After 30 DAS, the temperature came down to 24.4°C and 13°C with decrease in the temperature seedling mortality was observed in all the genotypes. Lowest reduction in seedling number was recorded in Akshaydhan (3%) and Krishna Hamsa (5%). Whereas IR 64, Triguna and NDR 359 showed highest reduction in seedling number as shown in Fig. 3. In order to enhance and ensure uniform establishment of rice seedlings in the early season, cold tolerance during this time is vital [8]

Table 1. Details of genotypes

S. no.	Genotype	Parentage	Remarks
1	Bhadrakali	Phalguna / IR 36	Released variety
2	Prasanna	IRAT 8 / N 22	Released variety
3	Triguna	Swarnadhan / RP 1579-38	Released variety
4	Rajendra	IJ 52 / T(N)1	Released variety
5	Aditya	M 63-83 / Cauvery	Released variety
6	Mashuri	Taichung 65/mayang ebos 60080/2	Released variety
7	MTU 1010	Krishnaveni/IR64	Released variety
8	MTU 1001	MTU 5249 x MTU 7014	Released variety
9	MTU 1075	MTU 2716/MTU 1010	Released variety
10	Suraksha	Sasyasree / MR 1523	Released variety
11	Krishna Hamsa	Rasi / Fine Gora	Released variety
12	JGL 24423	(MTU 1010 x NLR 34449) x MTU 1010	Pre-release variety
13	JGL 18222	JGKL 3855/JGL 7046	Released variety
14	Sampada	Vijaya / C 14-8	Released variety
15	Erramallelu	BC 5-55 / W 12708	Released variety
16	Indursamba	BPT 5204 x Surekha	Released variety
17	Jaldhidhan 6	Dular Mutant/ Nagina 22 mutant	Released variety
18	KNM 118	MTU 1010 / JGL 13595	Released variety
19	IR 64	Derived from traditional rice varieties	Released variety
20	JGL 1798	BPT 5204 / Kavya	Released variety
21	Dhanrasi	C-11-A-41	Released variety
22	NDR 359	BG-90-2-4 / 08677	Released variety
23	CSR 36	*CSR* 13/Panvel-. 2/ IR-*36*	Released variety
24	JGL 21002	MTU 1010/ JGL11727	Released variety
25	Jarava	B 32 Sel 4/ O.rufipogon 4/B 29-6	Released variety
26	WGL 915	SN 22R x IRBBN 39	Pre-release variety
27	JGL 11727	JGL420 / MTU1010	Released variety
28	Varalu	WGL 20471 / CR 544-1-2	Released variety
29	JGL 11470	JGL 418 / Gedongbetan	Released variety
30	WGL 44	BPT 5204 / ARC 5984 // Kavya / BPT 5204	Released variety
31	Krishna	Chandan / BPT 5204	Released variety
32	JGL 18047	MTU 1010 / JGL 13595	Released variety
33	Akshaydhan	BR 827-35/ SC 109-2-2	Released variety
34	Ravi	M 63-83 / / RP 79-5 / Rikotu Norin 21	Released variety
35	Naveen	Sattari X Jaya	Released variety

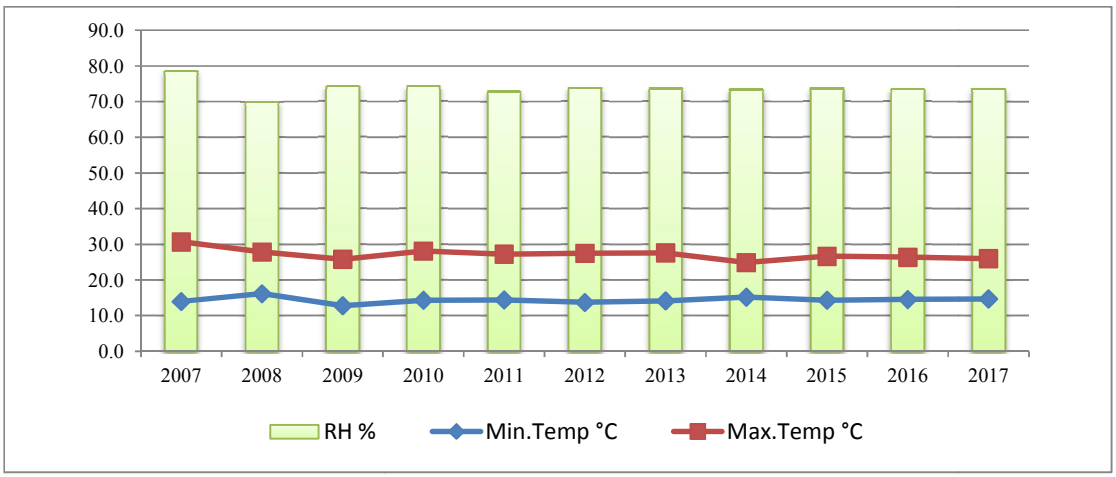

Fig. 1. Average weather parameters over past ten years at RS & RRS, Rudrur

The t-test results showed that there is significant difference in the mean number of seedling percentage at 15 DAS and 30 DAS as shown in Table 2.

Scoring for cold tolerance under field conditions and chlorophyll content through SPAD meter readings were taken at 15 DAS and 30 DAS. Score of 1 and 3 is given to genotypes with dark green and light green seedlings respectively. They are supposed to be cold tolerant [7]; score of 5 and 7 for yellow and brown seedlings respectively and 9 for dead seedlings as shown in Table 3. Akshaydhan and Krishna Hamsa scored 3 with a chlorophyll content ranging from 32.3-28.6. These two genotypes can be considered as cold tolerant and can be used as donors for cold tolerance in breeding programs. Any variety to ideally fit for cold conditions must have tolerance at seedling stage [9].

Massardo et al. [10] reported evaluation of rice seed germination rate and new plant traits under more than one temperature treatments are

Table 2. Number of seedlings (%) at 15 DAS and 30 DAS

Genotypes	Seedling % @ 15 DAS	Seedling % @ 30 DAS	% change in seedling over 15 DAS
Sampada	77	59	23
MTU 1010	83	71	11
Erramallelu	79	57	28
Jarava	79	53	33
Suraksha	80	62	22**
JGL 11470	80	64	20
JGL 18047	81	68	16
JGL 21002	82	67	18
IR 64	21	7	67**
Prasanna	81	58	28
Aditya	80	68	15**
MTU 1001	83	70	16**
JGL 18222	81	64	21**
Triguna	37	13	65**
NDR 359	42	25	40
Bhadrakali	84	72	14
JGL 24423	84	70	16
WGL 44	84	76	10
JGL 11727	86	73	15**
Krishna hamsa	87	82	6
WGL 915	87	79	9
Naveen	68	47	31**
KNM 118	70	58	17
Ravi	71	47	34
Akshaydhan	92	89	3
CSR 36	56	34	39
MTU 1075	77	63	18
Indursamba	74	62	16**
Dhanrasi	59	31	47**
Jaldhidhan 6	67	46	31**
Krishna	68	42	38
Rajendra	74	52	30
JGL 1798	82	67	18
Mashuri	75	61	19
Varalu	76	64	16

***1% level of significance*

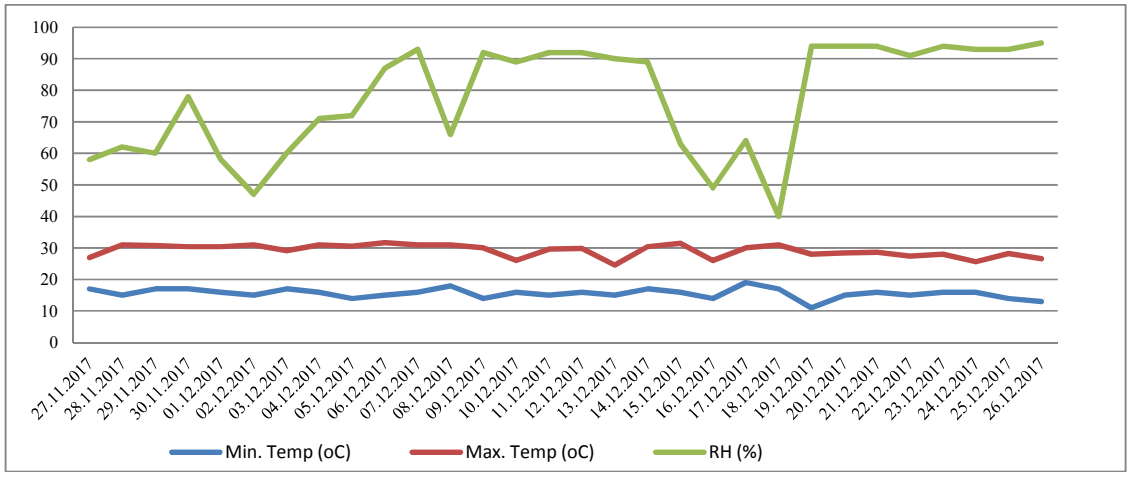

Fig. 2. Average weather parameters from date of sowing to 30 DAS at RS & RRS, Rudrur

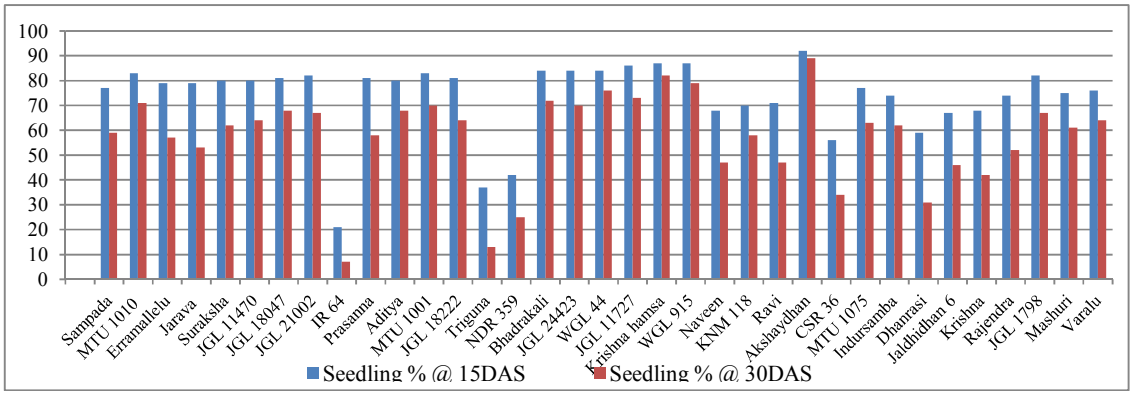

Fig. 3. Number of seedlings (%) at 15 DAS and 30 DAS

Table 3. Scoring of genotypes and recording SPAD readings

Scores (SES scale, IRRI 2002)	Genotypes	Range of SPAD meter readings
1	----	
3	Akshaydhan and Krishna Hamsa	32.3 – 28.6
5	Bhadrakali, Varalu , JGL 21002 Prasanna, Naveen, JGL 18047, Ravi, Mashuri, WGL 915, WGL 44, JGL 24423, RDR 763 and MTU 1010	25.7 – 14.1
7	CSR 36, MTU 1001, MTU 1075, Aditya, Suraksha, JGL 1798, JGL 18222, JGL 11727, NDR 359, Dhanrasi, Krishna and KNM 118	12.4-6.4
9	Triguna, Jarava, Sampada, Rajendra, MTU 1156, Erramallelu, IR 64 and Jaldhidhan 6	4.0 – 1.8

necessary to distinguish cold tolerant genotypes from cold susceptible genotypes. Changrong et al. [11] reported that the seeds from the few varieties could germinate quickly at low temperature but, the seedling growth was severely delayed by low temperature stress. They also reported that cold tolerance at germination and seedling stage were correlated.

4. CONCLUSION

Among 35 genotypes under study, two genotypes Akshaydhan and Krishna Hamsa had high seedling germination and low seedling mortality with tolerance to cold conditions. These genotypes can be used as donors in

crossing programme to develop cold tolerant varieties.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Yoshida S. Climatic environment and its influence. Fundamentals of rice crop science. Los Baños: IRRI. 1981;2:65-110.
2. Kaneda C, Beachell HM. Response of indica–japonica rice hybrids to low temperatures. *SABRAO* Journal. 1974;6: 17–32.
3. Mackill DJ, Lei X. Genetic variation for traits related to temperate adaptation of rice cultivars. Crop Science. 1997;37: 1340–1346.
4. Cruz RP, Sperotto RA, Cargnelutti D, Adamski JM, FreitasTerra T, Fett JP. Avoiding damage and achieving cold tolerance in rice plants. Food Energy Security. 2013;2:96–119.
5. Fujino K, Sekiguchi H, Sato T, Kiuchi H, Nonoue Y, Takeuchi Y, Ando T, Line SY, Yano M.Mapping of quantitative trait loci controlling low-temperature germinability in rice (*Oryza sativa* L.). Theoretical and Applied Genetics. 2004;108:794–799
6. Bertin P, Kinet JM, Bouharmont J. Evaluation of chilling sensitivity in different rice varieties, relationship between screening procedures applied during germination and vegetative growth. *Euphytica*. 1996;89:201–210.
7. System of evaluation; 2002. Available:www.irri.org
8. Sato Y, Murakami T, Funatsuki H, Matsuba S, Saruyama H. Heat shockmediated APX gene expression and protection against chilling injury in rice seedlings. Journal of Experimental Botany. 2001;52:145-151.
9. Dutta D, Pathak PK. Response of Assam rice varieties to low temperature stress. Journal of Plant Genetic Resources. 2007; 20:57-63.
10. Massardo F, Corcuera L, Alberdi M. Embyro pysiological responces to cold by two cultivars of oat during germination. Crop Science. 2000;40:1694-1701.
11. Changrong Ye, Shu Fukai, Russell Reinke, Ian Godwin, Peter Snell and Jaya Basnayake. Screening rice genetic resources for cold tolerance at different growth stages. Global Issues Paddock Action. Proceedings of the 14th Australian Agronomy Conference. September 2008, Adelaide South Australia; 2008.

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