SHORT COMMUNICATION

SABRAO Journal
of Breeding and Genetics
47 (2) 185-190, 2015

RESPONSE OF RICE SEEDLINGS TO COLD TOLERANCE UNDER BORO CONDITIONS

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SUMMARY

Boro rice cultivation is an important cropping pattern in Eastern India. It is a winter crop and seedlings are raised in cold months. Hence, cold tolerance at seedling stage is a primary requirement of boro rice cultivars. Twenty-five cultivars were evaluated for cold tolerance during seedling stage in laboratory and field conditions. Seeds of these cultivars were sown in nursery during rabi season 2013-14. The germination percentage was recorded at 15 DAS, 30 DAS, 45 DAS and 60 DAS. At 60 DAS and before transplanting, scoring for cold tolerance was done. Out of 25 genotypes, Jaya, Gautam and Krishna Hamsa, had the highest germination percentage. These genotypes were also least affected by the low temperature stress and scored in cold tolerant group along with Shalimar-1, Shalimar-2, Begum, Quadir, Mehvam, Mushkbudgi, Mahzat and Kamad. IR 64 showed the lowest germination percentage and was found highly susceptible to cold at seedling stage. The study aimed to identify tolerant genotypes to low temperature during seedling stage. These cold tolerant genotypes can be used in specific breeding programs for developing boro rice varieties.

Key words: Boro rice, cold tolerance, germination index, seedling stage

Key findings: The genotypes Gautam, Krishna Hamsa and Jaya can be used as cold tolerant donors. The genotypes Begum, Quadir, Mehvam, Mushkbudgi, Mahzat and Kamad are small grain and aromatic. These can be used as parents for crossing in specific breeding programmes for developing cold tolerant aromatic varieties.

Manuscript received: September 28, 2014; Decision on manuscript: December 13, 2014; Manuscript accepted: April 4, 2014

Communicating Editor: Bertrand Collard

INTRODUCTION

'Boro' is a Bengali language word derived from a Sanskrit word 'borob'. This means a special type of rice cultivation on residual or stored water in low-lying areas after the harvest of *kharif* rice (Singh, 2002). Boro rice is an emerging cropping pattern in Eastern India region. This winter crop is popular in flood prone areas, where *kharif* season is wasted due to flood and farmers could not take a crop due to prolonged water stagnation. It utilizes the residual soil moisture and gives additional crop to farmers. Boro rice is known for its high productivity but there is a lack of varieties bred specifically for boro conditions. Most of the rice varieties bred for *kharif* season are tested for boro and if found suitable, may be adopted as a variety for the boro season. Gautam, Prabhat, Joyamati, Vishnu Prasad, Jyoti Prasad and Chinsura are some rice varieties which perform well in boro season. Rice is very sensitive to prolonged exposure to lower temperatures. Cold tolerance at seedling stage is a primary requirement of boro cultivars as seedlings are raised during the cold months of November and December (Tiwari *et al*., 2009). Low temperature during seedling stage causes poor germination, stunted seedling growth and seedling mortality which directly affects the yield (Pathak *et al*., 2003). The stunted seedling growth also affects manual uprooting and transplanting. The rice species (*Oryza sativa* L.) has wide adaptability to cold, and cold-tolerant ecotypes are available for breeding. Japonica genotypes show higher cold tolerance at the germination stage than indica genotypes, although variability for this trait within both subspecies has been reported (Cruz and Milach, 2013). Keeping in view the above mentioned facts, an experiment was conducted in laboratory and field condition to screen and identify cold tolerant genotypes which can give optimum germination and less seedling mortality at vegetative stage. Cold tolerant genotypes can be utilized in future breeding programs for development of boro rice varieties.

MATERIALS AND METHODS

Twenty-five genotypes of rice including improved varieties and landraces were grown in *rabi* season of 2013-14 at the Agricultural Sciences Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh, India. The genotypes were collected from AICRIP, Department of Genetics and Plant Breeding, Banaras Hindu University and Rice Research and Regional Station, SKUAST-K, Khudwani. Nursery seed bed was prepared and sprouted seeds were sown on 15th November so that the genotypes face low temperature at seedling stage. The germination percentage was recorded at 15 DAS, 30 DAS, 45 DAS and 60 DAS and the maximum and minimum temperature was recorded. Scoring for cold tolerance was done before uprooting the seedlings for transplanting at 60 DAS, according to the Standard Evaluation System for Rice (IRRI, 2002). The scale for seedling cold tolerance ranged from 1-9.

To assess cold tolerance of genotypes in laboratory, seeds of 25 rice genotypes were germinated under 2 conditions: 13 °C for 28 days (cold) and 28 °C for 7 days (control). Seeds were first sterilized with 70% ethanol for 30 seconds and 5% sodium hypochlorite for 20 minutes, and washed 6 times with sterile distilled water. Seeds were placed on Petri dishes containing 2 layers of germination paper, wet with distilled water and 1 ml of 2.5 ppm Benomyl solution to avoid contamination. The experiment was conducted in a randomized block design with 3 replications. Each Petri dish contained 20 seeds, and the average of these seeds was used as a replication. Evaluation of the genotypes for cold tolerance was done based on their Germination index (GI):

$$GI = (N14+N21/2) / 20 \times 100$$

Where, N14 = number of germinated seeds 14 days after the beginning of the cold treatment; N21 = number of germinated seeds 21 days after the beginning of the cold treatment; 20 being the total number of seeds per genotype per replication (Cruz and Milach, 2004).

A t-test was performed to compare the significance of mean differences of number of seedlings at 15 DAS and 30 DAS in field and germination index at 13 °C for 28 days (cold) and 28 °C for 7 days (control) in laboratory. The calculated ‘t’ value was compared with ‘t’ tabulated at 0.05 levels of significance and appropriate degrees of freedom. Correlation between laboratory and field screening was studied.

RESULTS AND DISCUSSION

Selection or screening for cold tolerance in field is not always efficient due to weather instability. Screening in laboratory is more reliable as the intensity and duration of cold stress can be adjusted. Laboratory tests eliminate the chances of interference of other biotic and abiotic factors and give more accurate results.

The aim of the experiment was to screen out rice genotypes able to tolerate low temperature at seedling stage. At 15 DAS, germination of seeds in the nursery was recorded. Jaya (82.3%) recorded the highest germination followed by Gautam (78.1%) and Krishna Hamsa (76.4%). IR 64 recorded lowest germination (10%). Low temperature during seedling stage showed reduction in seedling number in the nursery. At 15 DAS, the maximum mean temperature was 26.4 °C and the minimum temperature recorded was 13.7 °C. After 30 DAS, the temperature came down to 24 °C and 10.6 °C (maximum and minimum respectively).

It was observed that as the temperature reduced, seedling mortality was noticed in all of the genotypes. Genotypes Jaya (2.7%), Gautam (2.8%,) Shalimar-1 (3%) and Krishna Hamsa (3.3%) showed least percent reduction in seedling number whereas HUR-1301 (16.9%), IR 8 (15%), HUR-1304 (14.9%) and IR 36 (12%) showed highest reduction in seedling percentage (Figure 1). At 30 DAS, all the seedlings of IR 64 died. The t-test results showed that there is significant difference in the mean number of seedling percentage at 15 DAS and 30 DAS at % level of significance (Table 1) in case of HUR 1301, HUR 1304, HUR 1309, IR 8, IR 36 and MTU 1010. These genotypes showed susceptibility towards cold which resulted in significant decrease in seedling number. Decrease in seedling number may lead to reduction in yield.

Under field conditions, scoring for cold tolerance was done at 60 DAS. The genotypes having dark green seedlings and light green seedlings were scored as 1 and 3 respectively and are supposed to be cold tolerant (SES; IRRI, 2002). Shalimar-1, Shalimar-2, Begum, Quadir, Mehvam, Mushkbudgi, Mahzat, Kamad, Gautam, Jaya, Krishna Hansa, Annada and Pusa 44 showed tolerance towards cold and were scored in group 1 and 3. Genotypes in these 2 groups may be used as donor for cold tolerance in breeding programs for boro situation. Any variety to be ideally fitted in the boro rice season must have cold tolerance at the vegetative stage of growth (Dutta and Pathak, 2007). Genotypes which showed yellow colored seedling were scored as 5. This group showed intermediate reaction for cold tolerance. Genotypes HUR-917, HUR-1301, HUR-1304, HUR-1309, HUR-921, IR 8 and IR 36 showed the score of 7. IR 64 was susceptible and recorded a score of 9 (Table 2).

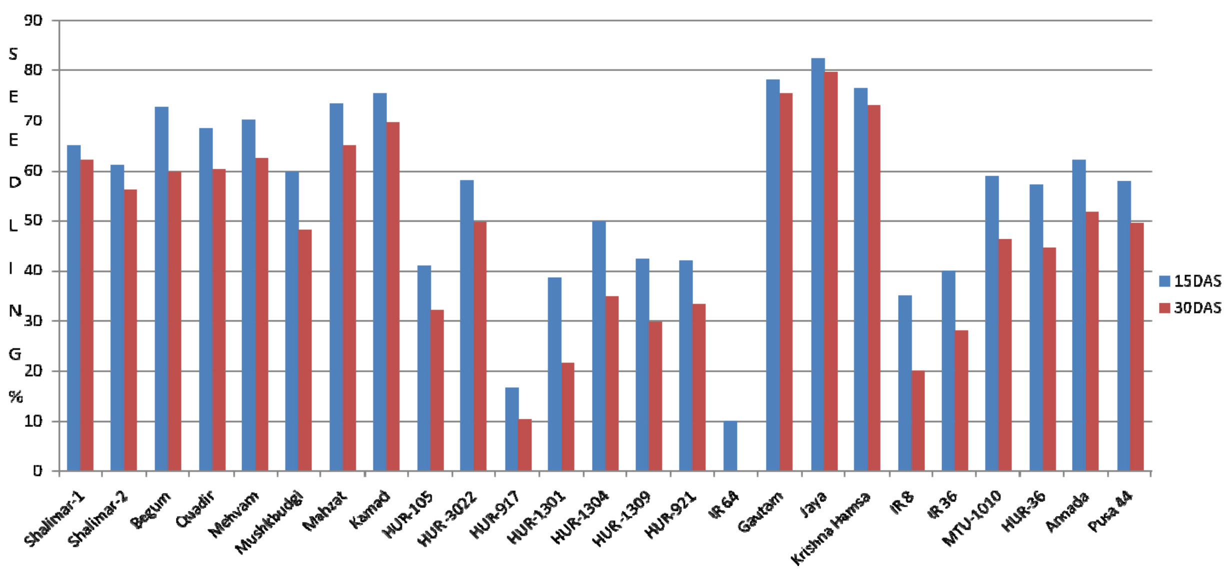

Figure 1. Number of seedlings (%) at 15 DAS and 30 DAS.

Table 1. Number of seedlings (%) at 15 DAS and 30 DAS.

Genotypes	Seedling % at 15 DAS	Seedling % at 30 DAS	% change in seedling over 15 DAS
Shalimar-1	65.0	62.0	4.6
Shalimar-2	61.0	56.0	8.2
Begum	72.5	59.7	17.7
Quadir	68.3	60.3	11.7
Mehvam	70.1	62.4	11.0
Mushkbudgi	59.6	48.1	19.3
Mahzat	73.4	65.0	11.4
Kamad	75.3	69.5	7.7
HUR-105	41.0	32.0	21.9
HUR -3022	58.1	49.6	14.6
HUR-917	16.7	10.2	38.9
HUR-1301	38.0	21.5	44.0*
HUR-1304	49.8	34.9	29.9**
HUR -1309	42.3	29.8	29.5*
HUR-921	42.0	33.2	20.9
IR 64	10.0	0.0	100.0
Gautam	78.1	75.3	3.6
Jaya	82.3	79.6	3.3
Krishna Hamsa	76.4	73.1	4.3
IR 8	35.0	20.0	42.9*
IR 36	40.0	28.0	30.0*
MTU-1010	58.9	46.3	21.4*
HUR-36	57.0	44.5	21.9
Annada	62.0	51.5	16.9
Pusa 44	58.0	49.3	15.0

**1% level of significance *5% level of significance

Table 2. Genotypes scored for cold tolerance in field condition.

Genotypes showing cold tolerance score	Genotypes
Score 1	Shalimar-1, Shalimar-2, Begum, Quadir, Mehvam, Mushkbudgi, Mahzat and Kamad
Score 3	Gautam, Jaya, Krishna Hamsa, Annada, Pusa44
Score 5	HUR-36, HUR-105, HUR-3022, MTU-1010
Score 7	HUR-917, HUR-1301, HUR-1304, HUR-1309, HUR- 921, IR 8, IR 36
Score 9	IR 64

Variation in weather conditions is an important limiting factor for field screening. In laboratory condition at 13 °C for 28 days, Gautam (69.7%) showed highest germination index followed by Krishna Hamsa (67.2%) and Jaya (65%). IR 64 (23.2%) followed by HUR-1301(24%), HUR-1309 (26.5%), HUR-1304 (27.7%), IR 36 (29.9%) and IR 8 (31.2%) recorded lower germination index.

All the genotypes showed a higher germination index in control condition (28 °C for 7 days) which indicated that low temperatures suppress germination (Figure 2). T-test showed that there was a significant difference in mean germination index at 13 °C for 28 days and at 28 °C for 7 days (control) in laboratory condition for all the genotypes at 5% level of significance (Table 3).

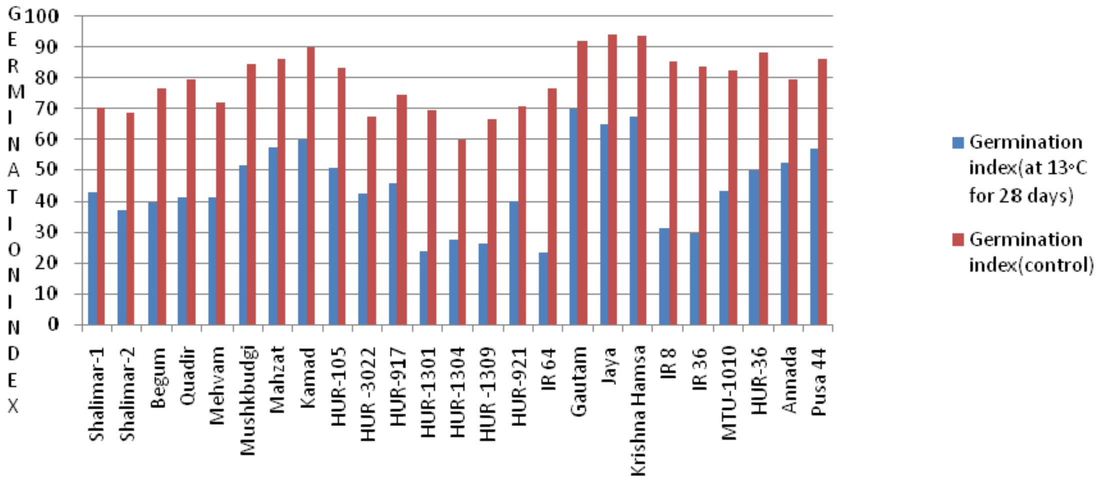

Figure 2. Germination index at 13 °C for 28 days and in control condition.

Table 3. Germination index at 13 °C for 28 days and in control condition.

Genotypes	GI (13 °C for 28 days)	GI (28 °C for 7 days i.e. control)	Effect (%) in GI due to cold treatment over control
Shalimar-1	43.2	70.5	38.6**
Shalimar-2	37.2	68.5	45.6**
Begum	39.7	76.5	48.0*
Quadir	41.5	79.4	47.7*
Mehvam	44.5	71.9	38.1*
Mushkbudgi	51.5	84.6	39.2*
Mahzat	57.2	86.2	33.6**
Kamad	60.0	89.9	33.3**
HUR-105	50.7	83.4	39.2**
HUR -3022	42.5	67.3	36.9**
HUR-917	45.7	74.3	38.4**
HUR-1301	24.0	69.3	65.4**
HUR-1304	27.7	59.7	53.5*
HUR -1309	26.5	66.7	60.3**
HUR-921	40.0	70.9	43.6**
IR 64	23.2	76.4	69.6**
Gautam	69.7	92.0	24.2*
Jaya	65.0	94.3	31.1**
Krishna Hamsa	67.2	93.8	28.3**
IR 8	31.2	85.4	63.5**
IR 36	29.9	83.9	64.3**
MTU-1010	43.7	82.6	47.1**
HUR-36	49.6	88.2	43.8*
Annada	52.2	79.7	34.4*
Pusa 44	56.7	86.2	34.2*

** 1% level of significance   * 5% level of significance

Table 4. Correlation between laboratory and field screening.

	Germination % in laboratory after 30 days	*Seedling % in Field after 30 days*
Germination% in Laboratory after 30 days	1	
Seedling % in Field after 30 days	0.751**	1

** 1% level of significance

The correlation coeficient (0.751) showed in Table 4 indicates that there is highly significant and positive correlation between the laboratory and field screening. If there is land constraint and one have to screen a large number of germplasms, then laboratory tests can be adopted for screening cold tolerance.

CONCLUSION

Out of the 25 genotypes under study, Gautam, Krishna Hamsa and Jaya has recorded highest germination index in laboratory and field conditions. These varieties showed least significant percentage change in their Germination index in laboratory conditions and these genotypes can be used as cold tolerant donors. IR 8, IR 36, IR 64 and HUR-1301 and HUR-1309 has showed sensitiveness towards cold resulted in less germination percentage both in field and laboratory conditions. The genotypes Begum, Quadir, Mehvam, Mushkbudgi, Mahzat and Kamad are small grain and aromatic. These genotypes can be used as parents for crossing in specific breeding programmes for developing cold tolerant aromatic varieties.

ACKNOWLEDGEMENTS

We acknowledge Dr. G. A. Parray, Associate Director of Research, Rice Research and Regional Station, SKUAST-K, Khudwani for providing the requisite research material.

REFERENCES

Cruz RP, Milach SCK (2004). Cold tolerance at the germination stage of rice: methods of evaluation and characterization of genotypes. *Sci. Agric*. 61:1–8.

Cruz RP, Sperotto RA, Cargnelutti D, Adamski JM (2013). Avoiding damage and achieving cold tolerance in rice plants (2013). *Food and Energy Security* 2(2):96-119.

Dutta D, Pathak PK (2007). Response of assam rice varieties to low temperature stress. *Journal of Plant Genetic Resources.* 20(1):57-63.

Pathak AK, Pathak PK, Sharma KK (2003). Recent Development in Boro Rice Improvement and Production for Raising Rice Yield in Assam. *Boro Rice*. Edi. Singh RK, Hossain M and Thakur R Intl. Rice Res. Inst. India Office, Pusa Campus, New Delhi-110012, India, pp.73-80.

Singh UP (2002). Boro Rice in Eastern India. Rice-Wheat Consortium Regional Technical Coordination Committee Meeting. 10-14 February 2002. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Standard evaluation system for rice (2002). IRRI, Los Baños, Philippines.

Tiwari V, Rautaray SK, Singh UD (2009). Response of rice genotypes to cold temperature in boro season. *Rice Genetics Newsletter*. Vol. 25.