Impact of Low Temperature Tolerance at Seedling Stage on Rice Genotypes

Abhilasha Sahu[1], R. K. Verma[1*], A.K. Sarawgi[1], S.B. Verulkar[2], Arti Guhey[3] and Ravi R. Saxena[4]

[1]Department of Genetics and Plant Breeding, [2]Department of Plant Molecular Biology and Biotechnology, [3]Crop Physiology, Agricultural Biochemistry and Herbal Science [4]Agricultural Statistics and Social Science (Language). Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh

Abstract

The experiment was carried out at the quality laboratory of Genetics and Plant Breeding department, IGKV, Raipur. The experimental material comprised of 50 rice genotypes, received from IRRI, Philippines, along with four local checks. The experiment was laid out in RCBD with two replications and 54 treatments. The results of experiment explained that root length varies from 0.1cm to 0.8 cm. One of the genotype HHZ 5-DT1-DT1 had 0.8 cm root length at 15º C and its germination percentage is also 86.66 %, therefore this genotype is supposed to be good for summer paddy since it has cold tolerance. It was also observed that the root and shoot length were similar in most of the genotypes at 15º C as well as 28 ºC. The maximum shoot length recorded was9.3 cm in HHZ 12-SAL 8-Y1-SAL1 genotype. The genotypes which showed 100 per cent germination were IR 10C132 followed by IR 10C153, HHZ 8-SAL6-SAL3-Y2 and HHZ 17-DT6-Y1-DT1. These genotypes exhibited tolerance for cold temperature for germination. The genotypes which come under 40 to 80 per cent germination can be considered as tolerant for cold temperature. The genotypes HHZ 5-Y3-Y1-DT1, HHZ 5-DT20-DT2-DT1 and HHZ 12-SAL 8-Y1-Y2 recorded germination percentage below 40 per cent are considered as susceptible for germination under cold and not recommended for growing.

Key words: Germination, cold temperature, rice, genotype.

Rice (*Oryza sativa* L.) is an important food crop of India. The cultivated rice originated in the South East Asia. Rice is the most important cereal crop because of its use as prime food in many countries of world. Rice is mainly grown during *kharif,*

*corresponding author: rvermaigau@yahoo.com

but in some areas it is also grown during *rabi*. *Rabi* paddy is usually sown in the month of November to January that coincides with winter season in North India, and the cold adversely affect the *rabi* rice germination, growth at seedling stages, tillers formation and fertility and ultimately affecting yield.

In North India, rice is grown as second crop during summer also known as summer paddy. The sowing of summer paddy are taken up during January, that coincides with very low atmospheric temperature as winter season in this region is at peak during this period. During this period, germination of rice is drastically affected due to low temperatures. Rice plants are susceptible to low temperature during the young microspore primordial stage, which occurs 10–12 days before heading. Low temperature during seedling and vegetative growth stage of summer rice crop affects germination, establishment of seedling, seedling chlorosis, mortality and prolongs the duration of the crop and it effects the transplanting of subsequent autumn rice crop. Low temperature stress is an important factor affecting the growth and development of rice during germination and seedling stage mainly on *rabi* (summer rice). Cold temperature during juvenile phase affects yield contributing traits and spikelet fertility. Low temperature at this stage increases spikelet sterility which can cause massive yield loss. The spikelet sterility may be the cause of improper development of male and female organs, which ultimately affects the economic produce and farmer's income.

Materials and Methods

The experimental material comprised of 50 rice genotypes, received from IRRI, Philippines, along with four local checks. The experiment was conducted under lab condition in the germinator under different temperature.

About 30 quality seeds of 50 rice genotypes and 4 local checks were placed on wet filter papers in Petri dishes at 15 ^{o}C for germination. After a cold treatment for two weeks, the germination percentage (Gper15), shoot length (SL15) and root length (RL15) of the seedlings were measured. Then temperature was increased to 28ºC to initiate the growth of seedling recovery. One week later, the germination percentage (Gper28), shoot length (SL28) and root length (RL28) of the seedlings were again recorded. The experiment was conducted in two replications to observe the germination percentage and seedling growth at 15ºC as well as at 28 ºC. Root and shoot lengths were measured for growth at both temperatures under controlled conditions (Sun *et al*., 2012).

Results and Discussion

Highest 100 per cent seed germination was recorded in varieties named IR 10C132 followed by IR 10C153, HHZ 8-SAL6-SAL3-Y2 and HHZ 17-DT6-Y1-DT1. These genotypes exhibited tolerance for cold temperature for germination whereas genotypes which showed germination of 40 to 80 per cent can be considered as tolerant for cold temperature. The genotypes HHZ 5-Y3-Y1-DT1, HHZ 5-DT20-DT2-DT1 and HHZ 12-SAL 8-Y1-Y2 recorded germination percentage below 40 percent are considered as susceptible for germination under cold and not recommended for summer paddy (Table 1 & Fig. 1-7).

The root length development at 15ºC was very poor in many varieties. It ranged from 0.1 to 0.8 cm. Genotype HHZ 5-DT1-DT1 had 0.8 cm root length at 15º C and its germination percentage is also 86.66 per cent, therefore this genotype is supposed to be good for summer paddy. This is followed by HHZ8-SAL6-SAL3-Y2 having 0.7 cm root length at 15º C with 100 per cent germination, IR 10G103 with 0.7 cm root length with 96.66 per cent germination and IR 10C157 with 0.7 cm root length and 90 per cent germination (Table 1 & Fig. 1-7).

It is observed that the root and shoot development is similar in most of the genotypes at 15ºC as well as at 28ºC. Genotypes HHZ 12-Y4-Y1-DT1, HHZ 5-SAL 14-SAL 2-Y2, IR 64197-3B-15-2 and HHZ 5-SAL 14-SAL 2-Y1 exhibited 0.1cm shoot expansion at 15ºC whereas in 28ºC they have shown 8.5cm shoot length. The maximum shoot length recorded was 9.3 cm in HHZ 12-SAL 8-Y1-SAL1 genotypes (Table 1 & Figs. 1-7).Ye *et al.* (2008) revealed that the cold tolerance at germination stage was correlated with those at seedling, booting and flowering stage and the cold tolerance at seedling stage was also correlated with those at booting stage. This suggests that selection at germination and early seedling stage may be useful in rice breeding programs focused on cold tolerance. Similar studies were reported by Xiong *et al.* (1990), Nilanjaya *et al.* (2003), Cruz and Milach (2004) and Xia *et al.* (2006).

Conclusion

The results of experiment explained that one of the genotypes HHZ 5-DT1-DT1 had 0.8 cm root length at 15º C and its germination percentage is also 86.66 per cent, therefore this genotype is supposed to be good for summer paddy since it has cold tolerance. It was also observed that the root and shoot length were similar in most of the genotypes at 15º C as well as 28 ºC. The maximum shoot length recorded was 9.3 cm in HHZ 12-SAL 8-Y1-SAL1 genotype. The genotypes which come under 40 to 80 per cent germination can be considered as tolerant for cold temperature. The genotypes HHZ 5-Y3-Y1-DT1, HHZ 5-DT20-DT2-DT1 and HHZ 12-SAL 8-Y1-Y2 recorded germination percentage below 40% are considered as susceptible for germination under cold and not recommended for growing.

References

Cruz R. P. D. and Milach S. C. K. 2004. Cold tolerance at the germination stage of rice: methods of evaluation and characterization of genotypes. *Scientia Agricola.* 61 (1): 1-8.

Nilanjaya., Thakur. R., Singh. J. R. P and Singh N. K. 2003. Evaluation of germination, cold tolerance, and seedling vigor of boro rice germplasm. *International Rice Research Notes* 28 (1) : 19-20.

Sun P., Liu F., Tan L., Zhu Z., Fu Y., Sun C. and Cai H. 2012. Quantitative trait loci (QTLs) for potassium chlorate resistance and low temperature tolerance in seedling stage in rice (Oryza sativa L.). *Indian Journal of Genetics* 72(4): 405-414.

Xia L., Chuan Chao D., Yu. C., Ting C and De Mao J. 2006. Identification for cold tolerance at different growth stages in rice (Oryza sativa L.) and physiological mechanism of differential cold tolerance. *Acta Agronomica Sinica* 32 (1): 76.83.

Xiong Z.M., Min S.K.,Wang G.L., Cheng S.H and Cao L.Y. 1990 Genetic analysis of cold tolerance at the seedling stage of early rice (O. sativa L. subsp. Indica). Chinese *Journal of Rice Science* 4 (2) : 75-78.

Ye C., Fukai S., Reinke R. Godwin I., Snell P and Basnayake J. 2008. Screening of rice genetic resources for cold tolerance at different growth stages. *In*: Proceedings of the 14th Australian Society of Agronomy Conference, Adelaide, South Australia, 21-25 September 2008.

Table 1: Observations were recorded at 15ºC and 28ºC

S.NO	I.C.NO. / DESIGNATION (TEMPERATURE)	GERMINATION (%)	ROOT LENGTH (cm)		SHOOT LENGTH (cm)	
		15 ºC	15 ºC	28ºC	15 ºC	28ºC
1.	IR 10C103	93	0.2	8.5	0.4	7.0
2.	IR 10C173	83	0.2	8.3	0.3	8.0
3.	IR 10C179	83	0.4	8.2	0.3	7.5
4.	HHZ 5-Y3-SAL2-SUB 1	83	0.3	8.5	0.3	7.8
5.	IR 10C136	63	0.3	8.7	0.3	7.7
6.	HHZ 12-Y4-Y1-DT1	50	0.2	8.8	0.1	8.5
7.	HHZ 5-SAL 14-SAL 2-Y2	70	0.1	8.3	0.1	8.5
8.	HHZ 8-SAL 6-SAL-3-SAL 1	63	0.1	8.1	0.3	8.5
9.	HHZ 8-SAL 6-SAL 3-Y 1	56	0.1	8.5	0.2	6.0
10.	HHZ 5-Y3-Y1-DT1	20	0.3	7.5	0.5	6.5
11.	IR 10C174	80	0.4	8.6	0.3	9.0
12.	HHZ 12-SAL 8-Y1-SAL 1	70	0.4	8.8	0.5	9.3
13.	N 22	80	0.5	8.8	0.2	8.9
14.	IR 83141-B-32-B	80	0.2	8.2	0.3	7.5
15.	HHZ 5-DT20-DT2-DT1	23	0.4	5	0.2	8.7
16.	HHZ 12-SAL 2-Y3-Y2	63	0.5	6.8	0.3	8.5
17.	IR 10C132	100	0.2	8.5	0.4	8.8
18.	HHZ 5-SAL10-DT3-Y2	46	0.4	8.2	0.4	8.6
19.	HHZ 17-DT 16-Y3-Y1	86	0.3	8	0.4	7.8
20.	IR 64197-3B-15-2	76	0.3	6.3	0.1	8.4
21.	IR 10C113	66	0.4	8.5	0.3	8.8
22.	IR 10C153	100	0.4	8.4	0.5	8.7
23.	HHZ 8-SAL 6-SAL 3-Y 2	100	0.7	8.4	0.5	8.3
24.	HHZ 11-DT7-SAL 1-SAL 1	86	0.5	8.2	0.4	8.0
25.	IR 10C110	50	0.6	8.5	0.5	8.8
26.	HHZ 8-SAL 12-Y2-DT 1	83	0.6	8.8	0.4	7.8
27.	IR 10C167	66	0.5	7.5	0.3	8.0
28.	HHZ 5-SAL14-SAL2-Y1	80	0.4	8	0.1	8.5
29.	HHZ 12-SAL 8-Y1-Y2	33	0.4	8.5	0.3	8.5
30.	IR 10C108	46	0.5	8	0.3	8.0
31.	IR 10C139	73	0.7	8.6	0.4	8.5
32.	LOCAL CHECK	76	0.7	7	0.8	9.0
33.	IR 10C137	76	0.6	8.5	0.5	8.0
34.	IR 83143-B-51-B	93	0.6	8.5	0.7	8.6
35.	IR 10G103	96	0.7	7.7	0.7	8.6
36.	HHZ 5-DT1-DT1	86	0.8	8.2	0.7	8.7
37.	DULAR(ACC 32561)	83	0.3	8.2	0.5	8.5
38.	IR 10C114	86	0.4	8.7	0.3	8.7
39.	HHZ 17-DT6-Y1-DT1	100	0.4	8.8	0.7	8.0
40.	IR 83142-B-36-B	90	0.6	8.8	0.4	8.4
41.	IR 10C161	96	0.6	8.8	0.6	8.5
42.	HHZ 12-Y4-DT1-Y2	76	0.4	6.6	0.4	7.8

43.	IR 10C157	90	0.7	8.5	0.4	8.8
44.	IR 10C126	93	0.6	8.4	0.6	7.5
45.	IR 10C172	93	0.8	8	0.4	8.3
46.	IR 10C138	70	0.8	8.3	0.8	8.9
47.	HHZ 5-SAL8-DT2-SAL 1	53	0.7	8.1	0.3	8.9
48.	HHZ 17-Y16-Y3-Y2	86	0.7	6.5	0.5	8
49.	HHZ 12-Y4-DT1-Y3	76	0.8	8.8	0.6	8.3
50.	HHZ 8-SAL 14-SAL 1-SUB 1	83	0.8	8.5	0.5	7.9
C-1	POORNIMA	60	0.7	8	0.8	8.7
C-2	KARMA MAHSURI	73	0.8	8.7	0.5	4.8
C-3	IGKV-R1	90	0.6	8.7	0.8	7
C-4	MAHESHWARI	76	0.6	8.2	0.8	5.5
	AVERAGE	**75.37**	**0.49**	**8.16**	**0.43**	**8.13**

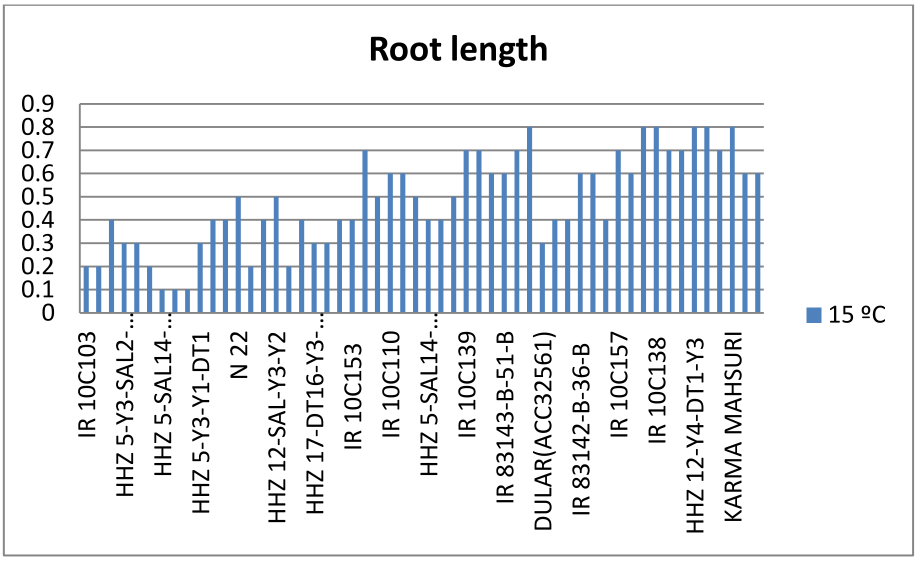

Figure 1: Root length at 15 ºC for 2 weeks

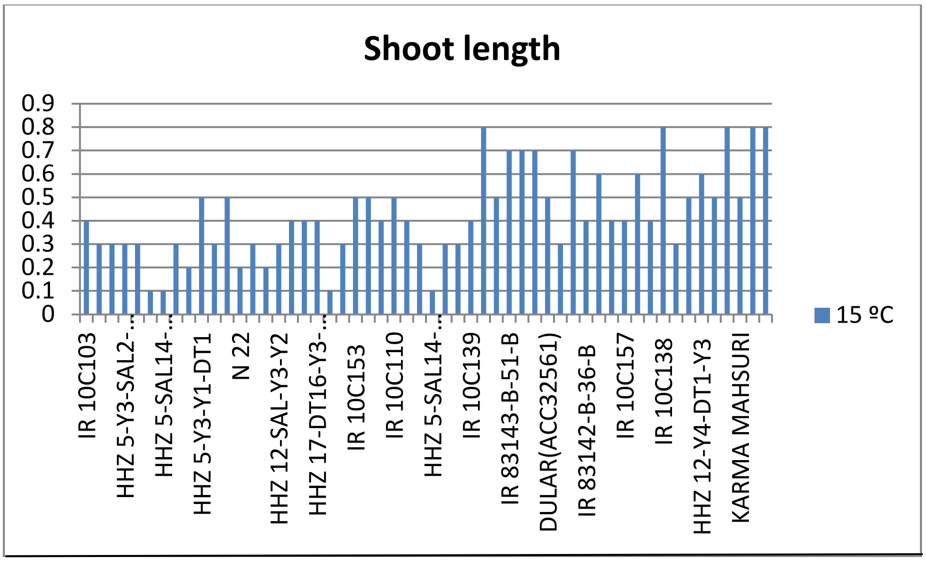

Figure 2: Shoot length at 15 ºC for 2 weeks

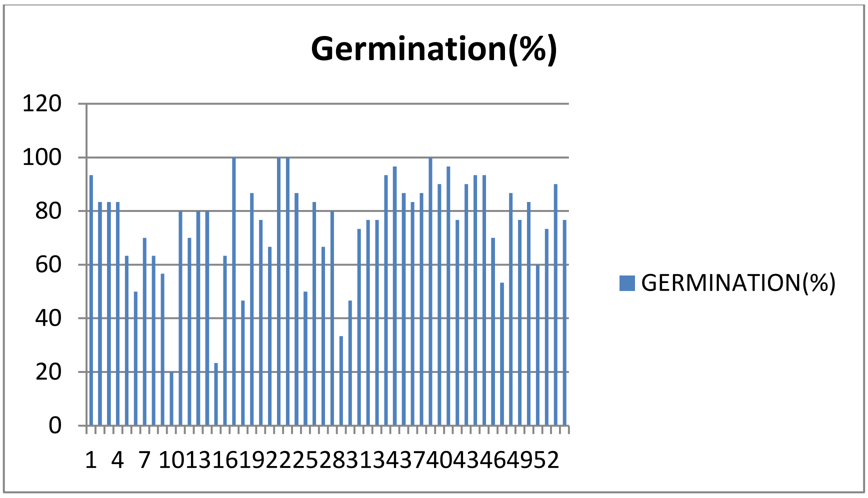

Figure 3: Germination (%) after 2 weeks

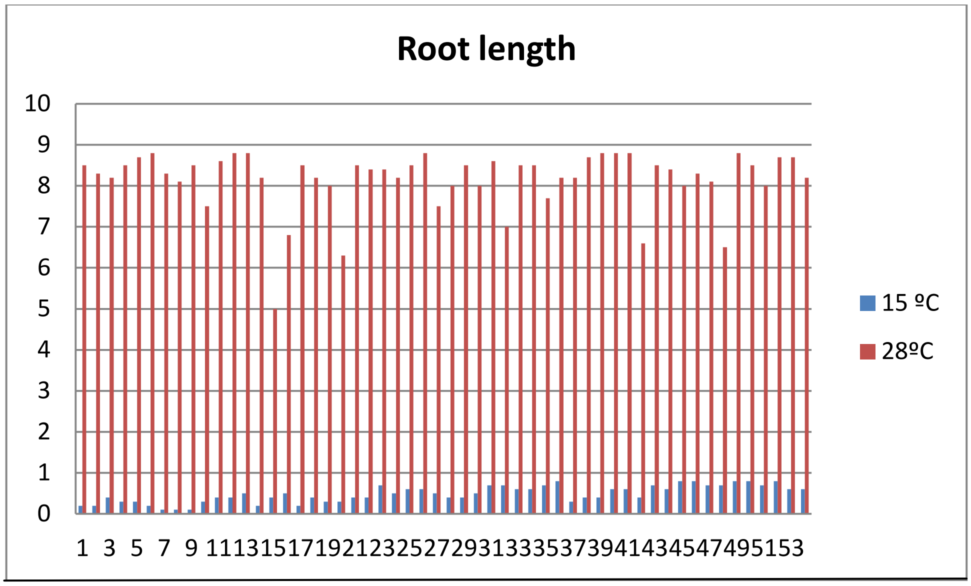

Figure 4: Root length at 15 ºC for 2 weeks and then at 28ºC for a week

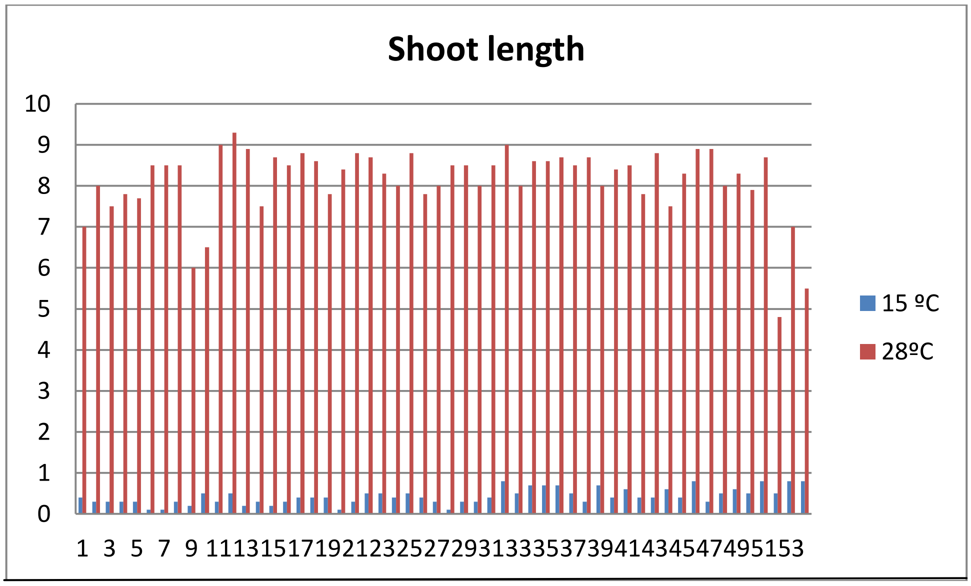

Figure 5: Shoot length at 15 ºC for 2 weeks and then at 28ºC for a week

Figure 6: Germination of seedlings after 2 weeks

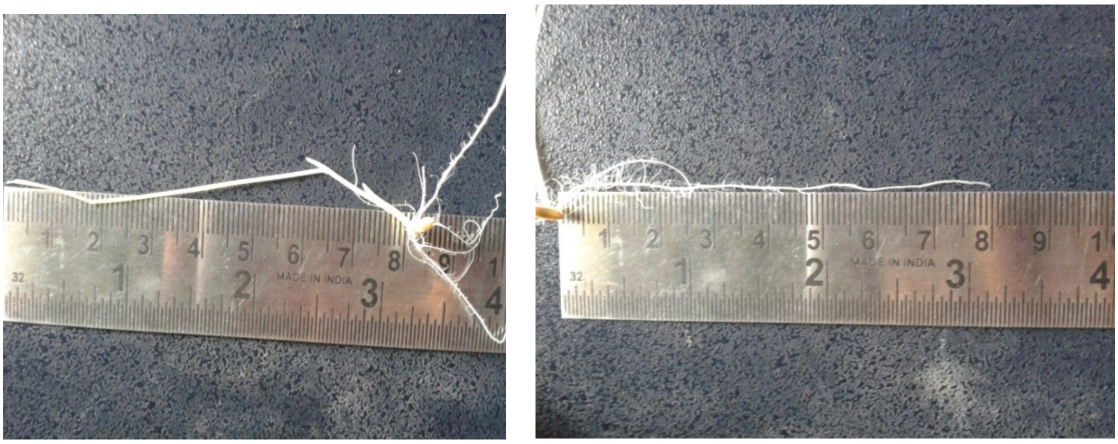

Figure 7: Maximum root and shoot length