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Effect of low temperature on germination percentage, germination relative index and vigour index of various genotypes of boro rice (*Oriza sativa* L.)

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ABSTRACT
Boro rice crop exposed to adverse effect of low temperature during seed germination and seedling growth stage. High mortality of plants and severe yield loss under such conditions are the recurrent feature of rice ecosystem during boro season. In order to understand the impact of low temperature stress, six genotypes viz. Gautam, Richharia and Dhanlaxmi from cold tolerant group and Turauta, Jaya and Heera from susceptible group were selected for detailed study. A general decline in germination percentage, germination relative index and vigour index of germinating seeds in low temperature stress condition than under non stress condition was observed. Minimum values were recorded for Turanta, Jaya and Heera while the Gautam, Riccharia and Dhanlaxmi were affected relatively less. Electrical conductivity of the exudates obtained from low temperature stressed germinating seeds was higher than that obtained from germinating seeds under control, reflecting a damage to the integrity of the cell membrane affecting the metabolite retention potential of the genotypes. The reduction in the mobilization efficiency of germinated seeds in low temperature as compared to that in control indicated the adverse effect of low temperature stress on the overall turnover of metabolites between endosperm and embryonic axis with adverse consequence for establishment of the seedlings of the vigour in the field.

Key words : Boro rice, Seed, Cold, Germination

INTRODUCTION

Boro rice crop sown in November and December after the recession of flood water in deep water areas is benefited on account of the favourable residual moisture, fertility and chemical changes that take place in soil due to long submergence, high radiation, favourable ripening time and low insect and disease attack. As a result boro season rice produces more yields (2.5-4.5 t/ha) than the Kharif rice (1.5-2.7 t/ha) in the same ecology (Chatterjee *et al*., 1996). In Bihar average productivity is about 4 t/ha and the yield of 8.10 t/ha from high yielding varieties on farmers field have been reported

(Thakur *et al*., 1994). Among the problems, low temperature at germination and seedling stage has been identified as predominant abiotic stress affecting the sustainability of boro rice cultivation. Seedling survival is a serious problem under temperature below 10^{o}C. Therefore, the present study of chilling response to seed germination and early seedling growth for their basic morphological and physiological parameters of tolerant and susceptible genotypes were undertaken for utilization of suitable characteristics in the breeding for improved varieties of boro rice.

MATERIALS AND METHODS

The experiment was conducted in rabi season during November to January of 2000-2001 and 2001-2002 at Rajendra Agricultural University Campus Pusa (Bihar) situated on the bank of the river Burhi Gandak at an altitude of 52.92 meters above Mean Sea Level and between 25^{o}39'N and 80^{o}40'E. The maximum and minimum temperature during the period ranged between 27.74 to 11.06^{o}C in 2000-2001 and 23.53 to 11.88^{o}C in 2001-02. During this period relative humidity at 700 hr ranged between 93-88 per cent and 1400 hr between 63-30 per cent in 2000-2001 while in 2001-2002 was 94 to 88 per cent and 82 to 46 per cent respectively. 26 genotypes of rice were obtained from rice section department of Plant Breeding, Rajendra Agril. University, Pusa and subjected to preliminary screening under Boro season. Genotypes were selected on the basis of their differential ability to tolerate cold condition at seedling stage. For detailed study six genotypes V_1 (Gautam), V_2 (Richharia), V_3 Dhanlaxmi were from tolerant and V_4 (Turanta), V_5 (Jaya), V_6(Heera) from susceptible type were selected on the basis of their cold tolerance score. The data presented in the mean value of the two years experiment. Seed germination was studied in January (T_2) under low temperature (3.22-16.6^{o}C) and in November (T_1) under non-chilling low temperature (14.7-22.4^{o}C).

RESULTS AND DISCUSSION

Result showed that germination was more in November which was significantly reduced on account of chilling temperature in January. The significant impact of low temperature was apparent in two ways germination inhibition and delay in germination. The values obtained for per cent germination (Table-1) and germination relative index (Table- 2) under the prevailing low temperature in January were, on the whole, lower by 31.52 per cent and 50.33 per cent than in November, respectively. Low temperature induced decline in germination has been attributed to (a) killing of imbibed seeds (b) structural lessons in the radicle during initial hydration (c) abortion of radicle and (d) disruption in metabolic process. It has been postulated that retarded flow of water at temperature below 9 to 27^{o}C leads to low respiratory rate and the energy limitation results in very slow germination (Aleshin and

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Table 1: Effect of low temperature on germination percentage (%) of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	96.50	98.00	99.00	98.75	92.25	96.00	96.75
T_2	81.50	72.75	80.00	55.00	60.00	48.25	66.25
	(-15.54)	(-25.76)	(-19.19)	(-44.30)	(-34.96)	(-49.74)	(-31.52)
Mean	89.00	85.37	89.50	76.87	76.12	72.12	81.50
		V	T	VxT			
	S.Em(±)	1.128	0.651	1.595	V_1, V_2 & V_3-	Tolerant group	
	C.D.(P=0.05)	3.237	1.869	4.577	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent decrease (-) over T_1(control)

Aprod, 1960). The variation in germination among the rice cultivars becomes pronounced at low temperature (11^{o}C) but these cultivars do not show much variation in germination at favourable temperature between 25-27^{o}C. The data obtained in the present investigation support this in as much as the rain between the minimum and maximum germination among the varieties was 0.93 in November (T_1) and 0.59 in January (T_2). The values approaching 1 are indicative of little genotypic variation but wider variability reduces the value. Thus, the lower values of the ratio in January, in comparison to that obtained in November temperature provides a simple and convenient method of screening cultivars for cultivation in winter. Based on this view, genotypes Gautam, Richharia and Dhanlaxmi could be categorized as tolerant while Turanta, Jaya and Heera genotypes would be susceptible to low temperature stress.

The vigour index in January (T_2) was relatively less than that obtained in November (T_1). The mean values of vigour index of different genotypes varied between 1738.95 to 1078.95 (Table- 3). The variations among genotypes were significant, depicting that the six varieties of rice studied in the present investigation possessed seeds of varied vigour.

Table 2: Effect of low temperature on germination relative index (GRI) of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	1401.00	1072.84	1520.00	1230.76	990.54	1124.25	1223.23
T_2	930.00	720.36	783.64	308.42	621.96	266.00	605.66
	(-33.62)	(-32.85)	(-48.45)	(-74.94)	(-37.21)	(-76.34)	(-50.53)
Mean	1165.50	896.60	1151.82	769.59	806.25	695.12	914.14
		V	T	VxT			
S.Em(±)		22.978	13.266	32.495	V_1, V_2 & V_3-	Tolerant group	
C.D.(P=0.05)		65.946	38.074	93.261	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent decrease (-) over t_1(control)

reflected the distinct variation among the genotypes for germination caused by low temperature. The range in germination percentage of 72.75-81.50 depicted by Gautam, Richharia and Dhanlaxmi in January was relatively low and the values were more than those obtained for Turanta, Jaya and Heera genotypes where in the values were relatively less and depicting a wider range of 48.25-60.00. In comparison to the germination observed in non-stress condition (T_1) the former three genotypes depicted a decline of 15.54-25.76 per cent only as against the decline of 34.96-49.74 per cent shown by the latter three genotypes (Table 1). The significant differences among the genotypes are a reflection of the genotypic variability in the trait. Variable varietal response to cold stress is suggestive of the level of cold resistance/ sensitivity of a cultivar and reflects the genetic variation. Good germination ability of rice at low Genotypic variation in terms of the seedling vigour revealed that genotypes with higher vigour index in November maintained their superiority in January also. However, low temperature reduced the vigour index. Ellison *et al*. (1983) observed that rapid water uptake was associated with imbibitional injury, death of cells and high solute leakage in low vigorous seeds. Since imbibition is a genotypic characteristics, the variation in the vigour index obtained in the present study, reflects the variation in this character among the variety studied.

The seedling vigour ranged between 72.49 to 172.54 in January and 372.70 to 282.60 in November (Table- 4) while electrical conductivity ranged between 0.80 to 0.37 mmhos/cm in January and 0.41 to 0.27 mmhos/cm in November, respectively (Table-6), which showed that an increase in the exudation of metabolites under stress to be

Table 3: Effect of low temperature on vigour index of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	1949.90	1688.36	2016.84	1885.20	1530.50	1758.75	1804.92
T_2	1528.00	1298.25	1340.92	412.47	802.68	398.16	963.41
	(-21.64)	(-23.10)	(-33.51)	(-78.12)	(-47.55)	(-77.56)	(-46.62)
Mean	1738.95	1493.30	1678.88	1148.83	1166.59	1078.45	1384.17
		V	T	VxT			
	S.Em(±)	16.129	9.311	22.809	V_1, V_2 & V_3-	Tolerant group	
	C.D.(P=0.05)	46.289	26.725	65.463	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent decrease (-) over T_1(control)

Table 4: Effect of low temperature on seedling vigour of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	360.83	294.52	372.70	345.60	304.21	282.60	326.74
T_2	172.54	129.00	144.36	86.43	102.54	72.49	117.89
	(-52.18)	(-56.20)	(-61.27)	(-74.99)	(-66.29)	(-74.35)	(-63.92)
Mean	266.68	211.76	258.53	216.01	203.37	177.54	222.31
		V	T	VxT			
S.Em(±)		5.389	3.111	7.621	V_1, V_2 & V_3-	Tolerant group	
C.D.(P=0.05)		15.465	8.929	21.871	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent decrease (-) over T_1(control)

Table 5: Effect of low temperature on mobilization efficiency (%) of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	38.36	33.00	40.72	36.50	30.24	34.10	35.49
T_2	23.68	17.56	20.84	10.32	14.78	9.00	16.03
	(-38.27)	(-46.79)	(-48.82)	(-71.73)	(-51.12)	(-73.61)	(-54.83)
Mean	31.02	25.28	30.78	23.41	22.51	21.55	25.76
		V	T	VxT			
S.Em(±)		0.682	0.394	0.964	V_1, V_2 & V_3-	Tolerant group	
C.D.(P=0.05)		1.956	1.129	2.767	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent decrease (-) over T_1(control)

Table 6 : Effect of low temperature on electrical conductivity of exudates (mm hos/cm) of various rice genotypes.

Variety/ Treatment	V_1	V_2	V_3	V_4	V_5	V_6	Mean
T_1	0.31	0.39	0.27	0.34	0.38	0.41	0.35
T_2	0.37	0.52	0.48	0.77	0.63	0.80	0.59
	(+19.35)	(+33.34)	(+77.78)	(+ 126.47)	(+65.79)	(+95.12)	(+68.57)
Mean	0.34	0.45	0.37	0.56	0.50	0.60	0.47
		V	T	VxT			
S.Em(±)		0.014	0.008	0.022	V_1, V_2 & V_3-	Tolerant group	
C.D.(P=0.05)		0.042	0.0241	0.064	V_4, V_5 & V_6-	Susceptible group	

Figures in parentheses indicate per cent increase (+) over T_1 (control) associated with reduced seedling vigour. Chilling increased the amount of materials which subsequently got leached out and the leachates have been found to contain reduced sugar and ninhydrin positive materials (Guinn, 1971), K^+ ions (Liebermann *et al.,*1958), carbohydrates and glycine (Christiansen, 1979). Though the metabolic concentrations in the leachates, in the present study has not been determined, the loss of vital cell components in suggestive of sever consequence on the seedling vigour.

Germination of rice seeds under chilling temperature in January has been found to cause an increase in the electrolyte leakage. The leakage of metabolites in germination medium was, on an average, 68.57 per cent more under low temperature than the value obtained for November germinated seeds. This indicates that chilling injury of the germinating seeds of the genotypes studied in the present investigation involved an increase in the permeability of membrane under low temperature stress. Similar views have been put forth by Vedralova and Segeta (1970). Embryo and reserve food materials play an important role in the seedling growth. Taking the data of mobilization efficiency of germinated seeds into consideration, it is apparent that the turn over of stored food in the endosperm to the growing axis was affected under low temperature stress (Table-5). The status of the overall physiological and biochemical turnover of stored reserves, as reflected by mobilization efficiency of T_1 and T_2 treated germinated seeds showed that the low temperature is adversely affecting the accumulation of metabolites in the elongating tissue either due to reduced utilization of food reserve or the supply of energy for anabolism under stress is less than its demand.

Close relationship between electrolyte leakage and mobilization efficiency has been found which indicates altered membrane characteristics which could be visualized to have modified the mitochondrial respiration along with the possibility of an altered activity of AT Pase system. However, these possibilities need to be worked out in greater extent to obtain the direct evidence as to the extent to which the energy supply becomes limiting and its role in modifying the metabolic activities.

Looking to the over all performance of the seeds during germination up to 15 days under optimum (November) and low temperature stress (January) conditions, it was evident that the germination under chilling condition reduced the germination percentage and germination relative index and adversely affected the mobilization efficiency and seedling vigour. However the degree to which these parameters were affected varied significantly among the six genotypes studied. On the whole, germination parameters were severely affected in Jaya, Turanta and Heera and relatively less in Gautam, Richharia and Dhanlaxmi. Such a response is further supportive of the degree of genotypic sensitivity to cold stress. Several workers have also reported varietal difference in adjustment to abiotic stress in rice (Selvakumar *et al*., 1987, Kaw, 1991 ect.). Such a variation affords opportunities for selection of resistant plants and parents for modifying chilling sensitivity by breeding and bio-technological methods. Since germination percentage and electrolyte leakage were negatively correlated with each other (r=0.95) and showing a trend similar to germination relative index, seedling vigour and mobilization efficiency these parameters could be used to screen the available varieties against the chilling stress.

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