Original Research Article

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Physiological Basis of Screening Rice Varieties for Low Temperature Stress Tolerance

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ABSTRACT

A field experiment was conducted at the Regional Research Station, Paiyur main farm with the varieties viz., ADT 38, ADT 39, ADT 43, Anna 4, Bhavani, BPT 5204, CO43, IR 20, IR 42, IR 50, K 429, Karuppunel, Kottanel, MDU 3, MDU 4, MDU 5, Paiyur 1, PS 1, PS 2, PS 3, Savulu samba and White Ponni. The experiment was designed for screening the rice cultivars for low temperature stress tolerance through the physiological and biochemical responses. The experiment was laid out in RBD with three replications and twenty two varieties. The rice seedlings were transplanted in the main field with the spacing of 22.5 x 22.5cm during late sampa season (October 2014). The results of experiment explained that maximum plant height was observed in Kottanel and Doddabayarunel and root length was maximum in ADT 38 and was followed by Paiyur 1 and Bhavani at 0th DAT. At 30 DAT maximum plant height was observed in Kottanel. Root length was maximum in BPT 5204 maximum number of tillers was observed in ADT 38 and was followed by IR 20 which recorded highest number of leaves per plant. At 60 DAT, maximum plant height was observed in Karuppunel. Root length was maximum in Bhavani and maximum number of tillers was observed in IR 20. Anna 4 which recorded highest number of leaves per plant. At 90 DAT, maximum plant height was observed in DBN. Root length was maximum in White ponni and maximum number of tillers was observed in PS 3. Maximum grain yield ha⁻¹ was recorded in the variety MDU 3 and was closely followed by MDU 4 and CO 43 and were on par with each other.

Keywords

Rice, Low temperature, Morphological, Physiological and yield

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Introduction

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 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. 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 rice crop affects germination, formation of seedling, plantlet chlorosis, mortality and prolongs the duration of the crop and it effects the transplanting of subsequent autumn rice crop. Research findings shows that critical low temperatures can be damage germination to maturity stage. The critical temperature for rice is usually below 20°C and varies according to growth stage, for example, for germination, the critical temperature is 10°C and for the reproductive stage, it is 17°C (Li *et al.*, 2011; Mackill and Lei, 1997). A plant can endure through two types of injuries after low temperature exposure. Chilling injury occurs due to lower temperature just above freezing point of water.

This phenomenon remains reversible initially but ultimately causes cell death due to prolonged cold spell. Sometimes the progressive colder temperature beyond critical range may result in hardening and/or acclimatization of plants which can lessen and/or abolish stress injury. Freezing injury is induced by the low temperature below freezing point. The intracellular freezing becomes fatal for the protoplasmic structure when the ice crystals grow large enough to disrupt the cells. In extra cellular freezing, the protoplasm of the plant becomes dehydrated because a water vapour deficit is created as cellular water is transferred to ice crystals formed in the intercellular spaces. Rice crop is more commonly abused by the chilling injury.

Thus, this experiment was designed for screening the rice cultivars for low temperature stress tolerance through the physiological and biochemical responses. Plant height, root length, number of tillers, Crop growth rate and relative growth rate, disintegration of cellular membranes and response of photosynthetic pigments will be

taken in to consideration to assess the response of the various rice cultivars to low temperature condition from this experiment.

Materials and Methods

A field experiment was conducted at the RRS main farm with the varieties *viz.*, ADT 38, ADT 39, ADT 43, Anna 4, Bhavani, BPT 5204, CO43, IR 20, IR 42, IR 50, K 429, Karuppunel, Kottanel, MDU 3, MDU 4, MDU 5, Paiyur 1, PS 1, PS 2, PS 3, Savulu samba and White Ponni with three replications were laid out in Randomized Block Design. The experiment was designed for screening the rice cultivars for low temperature stress tolerance through the physiological and biochemical responses.

The rice seedlings were transplanted in the main field with the spacing of 22.5 x 22.5cm during late sampa season (October 2014). Morphological characters like plant height, root length, number of tillers and number of leaves were recorded at 0, 30, 60 and 90 DAT (Days After Transplanting). The growth attributes characters *viz.*, Crop Growth Rate (CGR) and Relative Growth Rate (RGR) were measured at 0-90 DAT. The straw and grain yield ha⁻¹ was assessed at the time of harvesting.

Results and Discussion

Plants require an optimal temperature range for their growth, development and ultimate survival⁴⁵. Low temperature has a strong impact on growth, survival, reproduction and distribution of plants. The seedlings get severely damaged by cold stress when they are grown in winter environments (Nishiyama, 1985).

In this present study, morphological observations were recorded at 0, 30, 60 and 90 DAT. At 0 DAT, significant difference was

observed among varieties for plant height and root length. Maximum plant height (26.0 cm) was observed in Kottanel and Doddabayarunel. Root length was maximum in ADT 38 (6.6cm) and was followed by Paiyur 1 and Bhavani (5.7 cm) (Table 1).

Rice is still a tropical C3 crop, which yields best under warm temperatures and high solar radiation (Karki *et al.*, 2013). It is been

reported to be more sensitive to cold stress than any other cereal crops, especially during seedling, tillering, panicle development and flowering stages (Mukhopadhyay *et al.*, 2004).

The critical temperature for rice growth diverges with different developmental phases such as 10°C for germination and 17°C for the reproductive stages.

Table.1 Effect of low temperature stress on plant height, root length, number of tillers and number of leaves and yield of rice entries at different stages

Variety	0 DAT		30 DAT			
	Plant height (cm)	Root length (cm)	Plant height (cm)	Root length (cm)	No. of tillers / plant	No. of leaves / plant
ADT 38	22.2	6.6	48.0	22.7	11.7	31.7
ADT 39	19.4	3.3	49.3	15.0	10.0	32.7
ADT 43	12.8	3.5	45.3	18.3	7.0	24.0
Anna 4	17.8	3.0	56.0	16.0	8.0	25.7
Bhavani	23.9	5.7	46.0	15.3	7.7	22.7
BPT 5204	16.1	4.0	55.3	23.0	7.7	25.3
CO 43	14.4	3.8	44.3	16.0	8.3	28.0
IR 20	17.8	2.8	50.7	16.0	10.7	35.0
DBN	26.0	3.7	60.7	15.3	7.3	26.7
IR 50	19.3	3.2	45.3	16.7	9.7	30.0
K 429	23.5	4.1	49.7	17.7	8.0	29.3
Karuppunel	23.4	2.5	54.3	10.3	5.7	23.0
Kottanel	26.0	4.8	63.0	13.3	9.0	29.0
MDU 3	15.0	4.1	44.0	14.3	6.3	25.3
MDU 4	16.8	3.8	51.7	19.0	5.0	19.3
MDU 5	15.6	3.4	42.7	12.7	6.7	24.0
Paiyur 1	19.0	5.7	44.0	13.3	8.0	24.7
PS 1	20.6	3.8	50.0	18.0	6.7	21.0
PS 2	17.5	2.7	53.7	19.0	8.7	27.7
PS 3	23.4	3.5	53.0	17.3	8.7	17.7
Savulu samba	21.0	3.0	62.7	17.7	9.7	32.3
White Ponni	19.6	4.7	50.3	9.0	9.0	24.7
SE (d)	1.4	0.2	4.2	1.0	0.4	2.4
CD 0.05	2.8	0.4	8.4	2.1	0.8	4.9

Table.2 Effect of low temperature stress on plant height, root length, number of tillers and number of leaves and yield of rice entries at different stages

Variety	60 DAT				90 DAT			
	Plant height (cm)	Root length (cm)	No. of tillers / plant	No. of leaves / plant	Plant height (cm)	Root length (cm)	No. of tillers / plant	No. of panicles / plant
ADT 38	58.3	13.0	7.0	27.0	71.3	16.0	7.0	7.0
ADT 39	63.7	11.3	10.3	35.0	69.3	13.0	12.3	10.0
ADT 43	50.0	12.0	9.0	22.7	77.7	12.0	7.0	7.0
Anna 4	70.0	15.7	15.0	49.0	60.7	8.0	10.0	8.3
Bhavani	62.0	20.0	11.3	44.7	90.7	14.0	7.0	7.0
BPT 5204	60.3	13.0	6.0	18.0	64.0	10.3	10.0	8.0
CO 43	61.0	17.0	8.0	36.7	89.3	8.0	7.3	7.0
IR 20	56.3	12.0	16.0	45.0	77.0	16.0	12.0	7.3
DBN	96.0	10.3	8.0	29.7	110.0	13.0	10.0	9.0
IR 50	59.0	16.0	9.3	33.0	60.0	10.3	12.3	8.0
K 429	68.0	14.0	8.0	36.0	89.0	11.0	11.0	11.0
Karuppunel	106.0	8.0	8.0	26.0	90.3	9.0	9.7	8.0
Kottanel	99.3	7.0	7.0	21.3	94.0	12.7	9.0	7.0
MDU 3	66.0	10.3	11.0	39.0	90.0	13.3	14.0	14.0
MDU 4	63.0	14.0	11.7	46.3	84.7	14.3	8.3	8.0
MDU 5	60.3	15.0	8.0	34.3	62.7	11.0	9.0	9.0
Paiyur 1	47.0	15.0	6.0	29.3	65.0	11.0	9.0	7.3
PS 1	83.0	12.0	8.0	33.0	80.0	17.0	8.0	6.3
PS 2	59.0	14.7	9.0	42.0	83.7	14.7	13.0	12.3
PS 3	53.7	11.0	11.7	29.7	62.0	6.0	15.0	13.0
Savulu samba	100.0	12.0	7.7	26.3	102.0	13.3	6.3	6.0
White Ponni	68.0	14.3	11.0	42.0	103.3	20.0	14.0	8.3
SE (d)	5.0	0.6	0.5	2.1	4.9	0.8	0.7	0.5
CD 0.05	10.1	1.2	1.0	4.2	9.9	1.5	1.5	0.9

Table.3 Effect of low temperature stress on growth attributes and yield of rice entries

Variety	CGR (g/m ² /day)	RGR (g/g/day)	Yield per hectare (kg/ha)		Harvest index
	0-90 DAT		Straw yield	Grain yield	
ADT 38	3.667	0.076	7187	4930	40.7
ADT 39	5.320	0.087	4984	2972	37.4
ADT 43	4.206	0.101	8050	4329	35.0
Anna 4	4.456	0.091	6791	2961	30.4
Bhavani	6.179	0.094	8301	4430	34.8
BPT 5204	5.593	0.098	5095	2416	32.2
CO 43	5.532	0.099	8341	5215	38.5
IR 20	5.965	0.098	7601	4279	36.0
DBN	5.630	0.091	8413	3693	30.5
IR 50	3.249	0.090	6692	1404	17.3
K 429	6.117	0.083	6470	2984	31.6
Karuppunel	3.640	0.092	5976	3196	34.8
Kottanel	3.761	0.084	6479	2480	27.7
MDU 3	7.478	0.103	9073	6015	39.9
MDU 4	5.776	0.098	7984	5261	39.7
MDU 5	3.258	0.092	7581	2114	21.8
Paiyur 1	4.667	0.078	6273	2222	26.2
PS 1	4.851	0.088	5261	3236	38.1
PS 2	8.128	0.105	6025	4127	40.7
PS 3	2.799	0.082	6416	2099	24.7
Savulu samba	4.017	0.094	7970	2382	23.0
White Ponni	6.390	0.099	9502	3960	29.4
SE (d)	0.386	0.007	1012	427	-
CD 0.05	0.780	0.014	2044	862	-

Temperature drops to about 10°C during seedling establishment (October to early November) such low temperature significantly reduces seedling growth and establishment (Humphreys *et al.*, 1996). In this present study, At 30 DAT maximum plant height (63.0 cm) was observed in Kottanel. Root length was maximum in BPT 5204 (23.0cm) Maximum number of tillers (11.7) was

observed in ADT 38 and was followed by IR 20 which recorded highest number of leaves per plant.

At 60 DAT, significant difference between the varieties was observed for the parameters studied. Maximum plant height (106.0 cm) was observed in Karuppunel. Root length was maximum in Bhavani (20.0cm). Maximum

number of tillers (16.0) was observed in IR 20 and was closely followed by Anna 4 which recorded highest number of leaves per plant. At 90 DAT, maximum plant height (110.0 cm) was observed in DBN. Root length was maximum in White ponni (20.0cm) Maximum number of tillers (15.0) was observed in PS 3 and was closely followed by White Ponni and MDU 3 (Table 2).

The morphological adaptations with decreasing temperature are often linked to decrease in leaf area ratio (LAR), specific leaf area (SLA) and relative growth rate (RGR). Increase in leaf thickness is an adaptation mechanism to protect the photosynthetic machinery against the cold (Verheulet *al.*, 1996). Rice genotypes having high respiratory homeostasis (H), *i.e.* an ability of the plants to maintain similar respiration rates at growth temperatures, showed greater tolerance and maintained both shoot and root growth under cold conditions.

In this present study, the mean crop growth rate and relative growth rate between 0- 90 DAT was the highest in the variety PS2 and was closely followed by MDU3 (Table 3).

Significant difference was observed for straw yield and grain yield among the varieties tested for low temperature stress tolerance. Straw yield was maximum in White Ponni. However maximum grain yield per hectare was recorded in the variety MDU3 and was closely followed by MDU4 and CO43 and were on par with each other. Among the twenty two varieties tested for low temperature stress tolerance, the variety

MDU3 performed better than other varieties. MDU4 and CO43 were on par with MDU3.

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