

PHYSIOLOGICAL INDICES FOR COLD TOLERANCE IN RICE

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Forty rice varieties were screened for cold tolerance by employing LTG and estimating the content of P and K in shoots and grains at the sub-centre for cold tolerance breeding, Keelagudalur. Estimation of LTG might be useful to screen varieties for early stage low temperature tolerance and the varieties TNAU 20112, KMP 47, Wynad II, Kattathondi, Peruvaya, Madhu and Intan were highly cold tolerant, while Adakkan 49, AMBT 2, TNAU 4372, TNAU 20105, IET 7024, TNAU 20107, HR 35 and DPI 583 were moderately tolerant at early stage. Adakkan 49, Wynad II, Kattathondi and Peruvaya also contained more of P and K in their shoot at vegetative stage. IET 7024, DPI 583, Rajumeni, Gandhakasala and Puspha contained higher P in their grains showing their flowering stage cold tolerance.

Low temperature of air and water in irrigated rice and temperature of air and soil in upland rainfed rice caused various types of cold injuries at different growth stages (Sahi, 1981). Injury due to low temperature is a major constraint to rice production in the hilly zones (Hamdani, 1979) and such is the case in the plains of Cumbum valley, Krishnagiri and Hosur area of Tamil Nadu, where the second season rice crop experiences cold temperature during November to January. Hence it becomes necessary to screen the varieties and cultures used in breeding for cold tolerance by physiological methods such as (1) low temperature germinability and early vigour (2) Potassium and phosphate content of the plant during cold season.

Root growth of rice plant was favoured under warmer temperatures facilitating better nutrient uptake (Inada, 1967). Decreased absorption of all nutrients was observed under cold

conditions (Takahashi *et al.*, 1954). In resistant varieties, the uptake of nutrients particularly potassium was more as compared to susceptible varieties (Im and Oh, 1975). The uptake and translocation of phosphorus was higher in cold tolerant (*japonica*) varieties than in susceptible (*indica*) varieties (Reddy and Madhusudhan Rao, 1976). Higher phosphate content was associated with low temperature tolerance. Hence it is envisaged in this study to screen the varieties and types used in breeding programme for cold tolerance by low temperature germinability and the content of potassium and phosphates in shoot and grain sample.

MATERIALS AND METHODS

Thirty nine cultivars of rice with a standard check IR 20 maintained by the Department of Agricultural Botany, Agricultural College and Research Institute, Madurai formed the material for the study.

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Table-1 : Germination of rice varieties subjected to low temperature 15°C treatment under laboratory condition

Variety	Germination (per cent)					
	Control (room temperature)	At 15°C treated for			Percent of reduction over control	
		3 days	6 days		3 days	6 days
TNAU 4372	100.00	98.33	45.00	1.67	55.00	
TNAU 20105	100.00	96.67	26.67	3.33	73.33	
TNAU 20107	100.00	95.00	16.67	5.00	83.33	
TNAU 20112	100.00	76.67	56.67	23.33	43.33	
TNAU 20114	100.00	70.00	43.33	30.00	56.67	
TNAU 20115	98.33	70.00	48.33	28.81	50.85	
TNAU 20147	100.00	86.67	21.67	13.33	78.33	
TNAU 20991	96.67	73.33	8.33	24.14	91.38	
TNAU 20997	95.00	65.00	6.67	31.58	92.98	
TNAU 1142/17	98.33	45.00	16.67	55.24	83.05	
TNAU 15869/2	95.00	76.67	21.67	19.29	77.19	
IET 2938	100.00	68.33	10.00	31.67	90.00	
IET 6187	33.33	60.00	23.33	35.72	75.00	
IET 6551	100.00	66.67	23.33	33.33	76.67	
IET 6727	100.00	68.33	46.67	31.67	53.33	
IET 7011	100.00	65.00	45.00	35.00	55.00	
IET 7013	100.00	65.00	45.00	35.00	55.00	
IET 7024	100.00	96.67	23.33	3.33	76.67	
DPI 335	0.00	83.33	40.00	16.67	60.00	
DPI 583	0.00	90.00	45.00	10.00	55.00	
DPI 662	0.00	61.67	20.00	38.33	80.00	
KMP 41	0.00	61.67	35.00	28.33	65.00	
KMP 47	8.33	90.00	68.33	8.47	30.51	
Adakkan 49	100.00	100.00	33.33	0.00	66.67	
Wynad II	0.00	98.33	78.33	1.67	21.67	
AMBT 2	0.00	98.33	45.00	1.67	55.00	
Rajumani	0.00	46.67	11.67	53.33	88.33	
Kattathondi	100.00	93.33	75.00	6.67	25.00	
Gandhakasala	100.00	75.00	25.00	25.00	75.00	
Peruvaya	100.00	86.67	65.00	13.33	35.00	
HR 35	100.00	93.33	23.33	6.67	76.67	
Sona	96.67	35.00	23.44	63.79	75.87	
Phalguni	98.33	66.67	10.00	32.20	89.83	
Madhu	100.00	61.67	55.00	38.33	45.00	
Pragathi	100.00	31.67	20.00	68.33	80.00	
Vikram	98.33	61.67	33.33	47.45	66.10	
Pushpa	96.67	70.00	30.00	27.59	68.97	
Intan	100.00	71.67	55.00	28.33	45.00	
Mangala	95.00	73.33	26.67	22.81	71.93	
IR 20	100.00	71.67	36.67	28.33	63.33	
Grand mean	99.00	74.12	34.58			
S. E. (D)	3.31	9.69	2.12			
C. D.	6.57	19.30	4.22			

Correlation coefficient between period of low temperature treatment and germination = 0.03347**

** Significant at 1 per cent level.

Table 2: Shoot length of seven day old seedlings of rice varieties subjected to low temperature (15°C) treatments.

Variety	Shoot length (cm)					
	Control (room temperature)	At 15° treated for			Per cent of reduction over control	
		3 days	6 days		3 days	6 days
TNAU 4372	10.61	8.62	8.69	18.76	74.65	
TNAU 20105	12.59	9.67	1.78	23.19	86.86	
TNAU 20107	12.79	10.15	2.37	17.41	80.72	
TNAU 20112	11.46	9.73	2.97	15.10	74.08	
TNAU 20114	10.54	7.93	2.03	24.76	80.74	
TNAU 20115	11.66	9.65	1.87	15.79	83.68	
TNAU 20147	9.34	7.09	1.88	24.09	79.87	
TNAU 20991	9.67	6.55	1.23	23.93	85.71	
TNAU 20997	10.09	8.37	0.99	17.05	90.19	
TNAU 1142/17	8.67	7.05	0.93	18.69	89.27	
TNAU 15869/2	9.74	7.35	2.28	24.54	75.59	
IET 2938	9.79	7.41	1.93	24.31	80.29	
IET 6187	8.56	6.31	2.29	26.29	73.25	
IET 6551	10.63	8.31	1.17	21.83	88.99	
IET 6727	8.26	7.37	2.45	11.50	70.34	
IET 7011	8.67	7.18	1.73	17.19	80.05	
IET 7013	9.61	8.22	3.45	14.46	64.10	
IET 7024	10.36	8.34	1.84	19.50	82.24	
DPI 335	10.48	8.97	2.62	17.27	74.00	
DPI 583	9.97	8.11	3.40	18.66	65.90	
DPI 662	10.39	8.03	1.17	22.97	88.67	
KMP 41	9.13	6.85	2.16	24.97	76.34	
KMP 47	12.72	10.74	3.54	15.57	72.17	
Adakkan 48	12.39	10.99	3.00	11.30	15.79	
TNAU 20997	10.09	8.37	0.99	17.05	90.19	
Wynad II	13.04	11.49	3.23	11.99	75.23	
AMBT II	14.17	12.47	2.30	12.00	83.77	
Rajamani	8.63	6.19	1.02	28.02	88.14	
Kattothondi	14.91	12.25	5.37	17.84	63.98	
Gandhaksala	10.18	8.49	2.15	16.60	78.88	
Peruvaya	13.54	12.20	5.07	6.90	62.59	
HR 35	11.55	9.73	2.25	15.76	80.52	
Sona	7.51	5.85	1.92	22.10	74.43	
Phalguni	9.57	7.83	1.35	18.18	85.89	
Madhu	10.36	8.17	2.47	21.14	77.16	
Pragathi	9.25	7.13	2.90	22.99	68.65	
Vikram	8.87	6.89	1.95	22.32	78.02	
Pushpa	9.81	7.56	3.76	22.94	61.67	
Intan	12.09	10.32	3.13	14.94	74.11	
Mangala	10.67	8.32	2.39	22.02	77.60	
IR. 20	8.81	7.47	2.58	15.21	70.72	
Grand mean	10.48	8.52	2.36			
S. E. (D)	0.99	1.06	0.37			
C. D.	1.98	2.11	0.73			

Correlation co-efficient between period of low temperature treatment and shoot length = -0.2011*

* Significant at 5 per cent level.

Table 3 : Root length, of seven day old seedlings of rice varieties subjected to low temperature (15°C) treatments.

Varieties	Root length (cm)				
	Contol (room temperature)	At 15°C treated for			Per cent of reduction over control
		3 days	6 days		
				3 days	6 days
TNAU 4372	19.49	13.93	0.84	29.04	96.69
TNAU 20105	15.15	13.20	0.75	12.87	95.05
TNAU 20107	16.55	13.07	1.04	21.03	93.72
TNAU 20112	13.87	11.52	1.58	16.95	88.61
TNAU 20114	16.45	11.61	1.22	29.42	92.58
TNAU 20115	14.62	13.55	1.95	7.32	86.66
TNAU 20147	14.33	11.54	0.97	19.47	93.23
TNAU 20991	11.43	9.27	0.91	18.90	92.04
TNAU 20997	12.48	8.48	0.79	32.05	93.67
TNAU 1142/17	14.72	8.63	0.33	41.37	97.76
TNAU 15869/2	13.89	11.14	0.71	19.80	94.89
IET 2938	15.75	11.42	0.77	27.49	95.11
IET 6187	18.38	12.37	1.09	32.70	94.07
IET 6551	10.63	8.74	1.13	17.78	89.37
IET 6727	18.44	12.82	1.47	30.48	92.03
IET 7011	13.87	9.09	1.13	34.46	91.85
IET 7013	16.45	13.54	0.83	17.69	94.95
IET 7024	17.39	11.19	1.02	35.65	94.13
DPI 335	17.57	17.36	1.06	23.96	93.97
DPI 583	16.29	13.22	1.53	18.85	90.61
DPI 662	12.08	7.69	0.75	36.34	93.79
KMP 41	16.53	12.55	0.79	24.08	95.22
KMP 47	16.47	13.64	1.94	17.18	88.22
Adakkan 49	19.55	14.75	0.94	24.55	95.19
Wynad II	16.61	14.75	3.10	11.20	81.34
AMBT II	19.87	16.30	1.71	17.97	91.39
Rajumani	11.77	7.83	0.81	33.47	93.12
Kattathondi	19.97	16.05	2.29	19.63	88.54
Gandhakasala	15.39	10.94	2.13	28.91	86.16
Peruvaya	19.82	16.93	1.15	14.59	94.20
HR 35	11.94	10.10	1.51	15.41	87.35
Sona	14.07	10.42	0.80	25.94	94.31
Phalguni	17.18	14.05	1.01	18.22	94.12
Madhu	17.36	13.10	1.54	24.54	93.13
Pragathi	17.54	13.08	1.22	25.43	91.04
Vikram	18.16	12.69	1.73	30.12	90.47
Pushpa	16.61	12.67	1.59	23.22	90.43
Intan	14.57	10.59	0.60	27.72	95.88
Mangala	17.69	13.69	1.25	22.61	92.93
IR. 20	13.69	10.04	1.30	26.66	90.50
Grand mean	15.87	12.09	1.23		
S. E. (D)	0.89	1.53	0.20		
C. D.	1.77	3.04	0.41		

Correlation co-efficient between, period of low temperature treatment and root length = -0.3568**

* Significant at 1 per cent level.

Low temperature germinability test

The forty cultivars were tested for low temperature germinability by subjecting the seeds to 15°C maintained in a growth chamber for different periods and the treatments are detailed below: i) at low temperature (15°C) for 3 days, ii) at low temperature (15°C) for 6 days, iii) at room temperature for seven days. After the period of low temperature treatments, the seeds were allowed to germinate under room temperature upto seven days. Twenty seeds were arranged in a moisture roll towel and kept in growth chamber for low temperature treatments. There were three replications. The germination percentage, shoot length and root length (IRRI, 1980) were recorded on the 7th day.

Phosphate and potassium content in shoot samples.

The trial was laid out at the sub-centre for cold tolerance breeding, Keelagudalur in Cumbam valley during October, 1981 to February, 1982. Twenty five day old seedlings were transplanted in plots of 4.5 x 1.2 m with two seedlings per hill with a spacing of 20 x 10 cm. Fertilization was done at 100 kg N + 50 kg P₂O₅ + 50 kg K₂O/ha, half nitrogen as basal and the rest in two equal splits on 15th and 30th day after planting. The experiment was laid out in a randomized block design with three replications.

Plant samples were collected from five plants per replication on the 25th day from date of transplantation. The samples were dried in the hot-air oven, powdered and analysed for P and K contents as per Jackson (1973).

RESULTS AND DISCUSSION

Low temperature germinability (LTG) and seedling growth

The mean performance of the forty varieties of rice for germination, shoot length and root length are presented in tables 1, 2 and 3. The results revealed that low temperature content of seeds adversely influenced germination and root length of seven day old seedlings as indicated by the significant negative correlation between the period of low temperature treatment and each of the above parameters (Table 4). There was positive correlation between LTG and shoot and root length of seedlings which was in accordance with the work of Sasaki (1968) and Sasaki and Yamazaki (1971). The least reduction in germination under 6 day low temperature (15°C) treatments noticed in the varieties TNAU 20112, KMP 47, Wynad II, Kattathondi, Peruvaya, Madhu and Intan indicated their low temperature tolerance in the germinating stage itself. Varieties Adakkan 49, IET 7024, AMBT 2, TNAU 4372, TNAU 20107, HR 35, and DPI 583 which showed considerable reduction in germination under 3 day low temperature (15°C) treatment only might be rated as moderately tolerant to low temperature. On the other hand, drastic reductions in LTG in varieties TNAU 20991, TNAU 20997 and IET 2938 under 6 day treatment and TNAU 1142/17, Rajumani, Sona and Pragathi under 3 day treatment at 15°C indicated their susceptibility to low temperature at germination stage.

The reduction in shoot and root length of seedlings under 3 day or 6 day low temperature (15°C) treatments varied with varieties. Varieties such as Peruvaya, Kattathondi and wynad II

Table 4 : Correlation between germination percentage and seedling parameters of rice varieties subjected to low temperature treatments under laboratory condition.

Treatments	Germination percentage versus	
	Shoot length (r)	Root length (r)
Control (at room temperature)	0.1960*	0.2994**
Low temperature (15°C) treatment for 3 days	0.5274**	0.3463**
Low temperature (15°C) treatment for 6 days	0.6830**	0.5705**

*Significant at 5 per cent level ;

**Significant at 1 per cent level

which showed drastic reduction in LTG also exhibited minimum reduction in shoot and root length. In general, the reduction in shoot and root length of different varieties under low temperature (15°C) treatments was linear with the reduction in LTG as indicated by the positive correlation coefficient between LTG and root-shoot length.

Since low temperature germinability and root-shoot length were positively correlated, estimation of LTG (6 day of 15°C) might serve as a useful parameter to screen varieties for early stage of low temperature tolerance. LTG and root shoot length of the seedling had been used as indices to assess cold tolerance of rice varieties (Sasaki, 1968; Chin *et al.*, 1977).

The uptake of P and K under low temperature conditions

In the present study, most of the rice varieties such as Adakkan 49, wynad II, Kattathondi and Peruvaya which were found to be tolerant to low

temperature based on LTG and seedling growth were higher in P and K contents in the vegetative phase (Table 5). The correlation between P and K contents of rice plant at the vegetative phase was significant and positive, whereas the correlation between P and K contents of the grains was not significant. Most of the varieties such as IET 7024, DPI 583, Rajumeni, Gandhakasala and Puspha were found to be tolerant to cold weather at the flowering stage with low pollen sterility and chaff percentage and were with high P content of grains while in consistent with K content of grains. These results indicated that in screening varieties for cold tolerance, estimation of P or K contents in the vegetative stage for early tolerance and the estimation of P content of grains for late tolerance or flowering phase tolerance might be useful. Reddy and Madhusudhan Rao (1976) reported that uptake and translocation of P was high in the cold tolerant varieties, while Satake (1970) reported that P content was associated with low temperature tolerance.

Table 5 : Phosphorus and potassium content in forty cultivars of rice.

Variety	Phosphorus content %		Uptake per plant (g)	Potassium content		Uptake per plant (g)
	At vegetative stage in plant	Grain		At vegetative stage in plant	Grain	
TNAU 4372	0.06	0.26	0.03	2.54	0.19	0.02
TNAU 20105	0.07	0.42	0.05	2.33	0.18	0.02
TNAU 20107	0.07	0.32	0.07	2.43	0.20	0.04
TNAU 20112	0.07	0.51	0.07	2.47	0.20	0.02
TNAU 20114	0.07	0.38	0.07	2.32	0.19	0.04
TNAU 20115	0.06	0.48	0.07	2.34	0.21	0.03
TNAU 20147	0.07	0.32	0.05	2.54	0.22	0.04
TNAU 20991	0.06	0.32	0.04	2.44	0.20	0.02
TNAU 20997	0.08	0.42	0.05	2.60	0.19	0.02
TNAU 1142/17	0.07	0.29	0.04	2.46	0.21	0.03
TNAU 15869/2	0.06	0.26	0.04	2.50	0.21	0.03
IET 2938	0.07	0.32	0.05	2.54	0.22	0.04
IET 6187	0.06	0.26	0.02	2.44	0.19	0.02
IET 6551	0.07	0.29	0.03	2.35	0.20	0.02
IET 6727	0.07	0.96	0.13	2.39	0.20	0.03
IET 7011	0.07	0.99	0.08	2.46	0.20	0.02
IET 7013	0.07	1.09	0.10	2.41	0.18	0.02
IET 7024	0.08	1.15	0.17	2.66	0.20	0.03
DPI 335	0.06	1.06	0.10	2.46	0.19	0.02
DPI 583	0.07	1.09	0.11	2.34	0.19	0.02
DPI 662	0.07	1.02	0.11	2.36	0.20	0.02
KMP 41	0.06	0.96	0.12	2.46	0.19	0.02
KMP 47	0.06	1.09	0.09	2.44	0.20	0.02
Adakkan 49	0.09	0.90	0.07	2.87	0.20	0.02
Wyned II	0.09	0.96	0.09	2.81	0.19	0.02
AMBT 2	0.10	0.70	0.04	2.83	0.18	0.01
Rajumani	0.09	1.22	0.10	2.89	0.16	0.01
Kattathondr	0.09	0.99	0.09	2.89	0.22	0.02
Gandhakasala	0.09	1.18	0.16	2.79	0.19	0.02
Peruvaya	0.09	1.15	0.16	2.92	0.20	0.03
HR 35	0.09	1.02	0.14	2.57	0.18	0.02
Sona	0.06	0.77	0.09	2.36	0.26	0.03
Phalguna	0.09	0.83	0.11	2.63	0.20	0.03
Madhu	0.06	0.99	0.13	2.39	0.20	0.02
Pragathi	0.07	0.99	0.13	2.57	0.24	0.03
Vikram	0.08	0.90	0.09	2.56	0.21	0.02
Pushpa	0.06	1.02	0.07	2.38	0.22	0.02
Intan	0.08	0.96	0.12	2.60	0.22	0.03
Mangala	0.06	0.93	0.06	2.37	0.20	0.01
IR 20	0.06	1.83	0.13	2.43	0.20	0.03
Grand mean	0.072	0.765	0.09	2.52	0.20	0.02
S. E. (D)	0.006	0.018	0.01	0.10	0.01	0.005
C. D.	0.012	0.035	0.02	0.20	0.02	0.01

	Correlation coefficient
P content at vegetative stage and in grains	0.3355*
K content at vegetative stage and in grains	0.1663
P and K content at vegetative stage	0.8280**
P and K contents in the grains	0.1111
Uptake of P and P content in grains	0.7176**
Uptake of K and K content in grains	0.4915**

* Significant at 5 per cent level.

** Significant at 1 per cent level

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