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Research article

SCREENING OF RICE GENOTYPES FOR THERMOTOLERANCE BY TIR TECHNIQUE

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ABSTRACT: Production of rice--the world's most important crop for ensuring food security and addressing poverty will be defeated as temperatures increase in rice-growing areas with continued climate change. Climate change needs us to look at various alternatives for more drought tolerant and tougher strains and to develop a technique to screen a large number of genotypes for high temperature tolerance. Adapting temperature induction response (TIR) technique 100 rice genotypes were screened for thermotolerance. Significant variation for acquired thermotolerance was observed in 100 rice lines. From the 100 genotypes 30 were exhibits themotolerance to induced high temperature.
Key words: rice genotypes, seedling survival, thermotolerance

INTRODUCTION

Plants adapt to high temperature stress by inherent basal level tolerance as well as acquired tolerance to severe temperature stress. Acquired thermotolerance is quite rapid and has been shown to be induced during cell acclimation to moderately high temperature periods (Hikosaka et al., 2006; Larkindale et al., 2005; Massie et al., 2003). Temperature affects a broad spectrum of cellular components and metabolism, and temperature extremes impose stresses of variable severity that depend on the rate of temperature change, intensity, and duration. The ability to withstand and to acclimate to supra-optimal temperatures results from both prevention of heat damage and repair of heat-sensitive components (Sung et al 2003; SenthilKumar et al., 2006). Seedlings exposed to a sublethal temperature prior to challenge with severe temperature have better growth recovery than those seedlings challenged directly to severe temperature stress. Many earlier studies have demonstrated that genetic variability for high temperature tolerance is noticed only upon induction treatment prior to severe stress (Burke, 2001; Krishnan et al., 1989; Kumar et al., 1999; Srikanthbabu et al., 2002: Jayaprakash et al., 1998; Kumar et al., 1999; Uma et al., 1995).
The global rise in temperature will also increase the severity of other environmental stresses such as floods and drought. The variation in rainfall will lead to more frequent floods and droughts (Yildiz M and Terzi H. 2008.) which are the most important constraints for deep water and aerobic cropping systems, respectively. Both these extreme conditions (drought and flood), if exceed certain critical period, will have substantial consequences on rice and may lead to complete failure of the rice crop when occur at sensitive stages either in the form of water shortage or excessive submergence. And thus, the changing climate may enforce a shift in the cropping pattern in most parts of the world most probably making rice the most suitable choice for areas with increased water availability but becoming less appropriate for farmers in areas with decreased wetness. So there is a need to adopt a multi-faceted approach while studying the impact of high-temperature stress, also focusing on other environmental stresses, which may be equally detrimental for rice productivity. Acquired tolerance for a specific abiotic stress has been shown to give cross protection for other stresses such as salinity, chilling temperatures, and drought.

MATERIALS AND METHODS

Experimental Details and Treatments

Experimental Details

The experiment was conducted at Phenotyping laboratory, Institute of Frontier Technology, Regional Agricultural Research Station, Tirupati. Using the standardized TIR (Temperature Induction Response) protocol.

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Highly thermo tolerant rice genotypes were screened from 100 rice germplasm obtained from Agricultural Research Station, Nellore, Andhra Pradesh. Which is a lead center for aerobic rice research. This approach of TIR involves first the identification of challenging temperature and induction temperature and later standardizing them before being used for screening germplasm for intrinsic tolerance. Phenotyping of rice genotypes for thermo tolerance using TIR technique was established in this laboratory (Sudhakar et al., 2012) and same protocol is used in this study.

Treatments

Rice seeds were surface sterilized by treating with 0.1 per cent carbendizim for 30 minutes and washed with distilled water for 4 to 5 times followed by 1 per cent sodium hypochlorite for 1 to 2 minutes. Then the seeds were washed with distilled water for 4 to 5 times and kept for germination at 30°C and 60 per cent relative humidity in the incubator. After 42 hours, uniform seedlings were selected in each genotype and sown in aluminium trays (50 mm) filled with soil. These trays with seedlings were subjected to sub-lethal temperatures (gradual temperature increasing from 36°C to 52°C for 5 hours in the environmental chamber ("WGC-450" Programmable Plant Growth Chamber). Later these seedlings were exposed to lethal temperatures (55^{o}C) (induced) for 2 hours. Another sub set of seedlings were directly exposed to lethal temperatures (non induced). Induced and non induced rice seedlings were allowed to recover at 30^{o}C and 60 per cent relative humidity for 48 hours. A control tray was maintained at 30°C, without exposing to sub-lethal and lethal temperatures.

The following parameters were recorded from the seedlings:

a) Per cent survival of seedlings = $\dfrac{\text{No. of seedlings survived at the end of recovery}}{\text{Total number of seedlings sown in the tray}}$

b) Per cent reduction in root growth =

$$\text{Actual root growth of control seedlings} - \frac{\text{Actual root growth of treated seedlings}}{\text{Actual root growth of control seedlings}} \times 100$$

RESULTS

Genetic Variability in Rice for Thermotolerance

Using this technique it was proved that sufficient genetic variability was present among rice genotypes for high temperature tolerance. The genotypes showed significant genetic variability for per cent survival of seedlings, per cent reduction in root growth respectively. The per cent survival of seedlings varied from 0 to 100 per cent with a mean of 80.33 per cent. The per cent reduction in root growth varied from 0 to 73 per cent with a mean of 20.89 per cent (Table .1). Among the 100 rice genotypes 12 (NLR33358, NLR145, NLR33671-6, NLR40024, NLR3042, MTU 1010, NLR33636, NLR3010, NLR33359, NLR40062, NLR40064, NLR40065) genotypes showed highest thermo tolerance in terms of 100 per cent seedlings survival and no reduction in root growth. Four genotypes (NLR 34242, NLR 40066, NLR40059, NLR 40050 also showed higher thermo tolerance with no reduction in root but seedling survival was reduced only by 10 per cent. Thirty rice genotypes which showed 70 to 100 per cent survival of seedlings, 0 to 5.0 per cent reduction in root growth were selected for further pot culture evaluation of genotypes under imposed moisture stress conditions.

DISCUSSION

These results are in conformity with several studies, which showed that acclimated plants survive upon exposure to a severe stress, which otherwise could be lethal and is considered to be as thermo tolerance (Senthil Kumar et al., 2002). Results of this study indicated that the effect of TIR on other genotypes revealed variable results. Such acquired tolerance was variably recorded in other rice genotypes, where either survival of seedlings was affected or root growth alone was affected or only shoot growth was affected. In the genotype NLR 3157 seedling survival and root growth were completely affected despite of recovery conditions maintained after exposing to sub-lethal and lethal temperature (Table 1).

This technique of exposing young seedlings to sub-lethal and lethal temperature has been validated in many crop species (Senthil Kumar et al., 2007). This novel temperature induction response technique has been demonstrated to reveal genetic variability in intrinsic stress tolerance at cellular level. (Sudhakar et al., 2012). The present study also revealed that the Thermo Induced Response (TIR) technique can very well be used in rice crop. The identified 30 genotypes are showed increased cell viability and protein synthesis capacity during alleviation from high temperature stress to possess high level of thermo tolerance.

Table 1. Screening of thermo tolerant rice genotypes through Thermo Induced Response (TIR) treatment

S.NO.	Entries	% survival of seedlings	Root growth (cm)		
			Actual growth in control	Actual growth in treatment	% reduction in root growth
1	ADT-37	70	2.20	1.63	26.01
2	NLR 40054	90	2.97	2.85	4.02
3	NLR 33358	100	0.00	0.00	0.00
4	NLR 145	100	0.00	0.00	0.00
5	NLR 3058	30	1.40	0.97	31.01
6	NLR 3060	50	1.80	1.22	32.01
7	NLR 3062	50	0.00	0.00	0.00
8	NLR 3064	40	4.73	1.28	73.03
9	MTU 1001	90	1.80	1.42	21.01
10	NLR3160	60	0.00	0.00	0.00
11	NLR3159	80	3.03	1.42	53.02
12	NLR3161	70	3.33	1.73	48.02
13	NLR 40078	30	2.33	1.86	20.01
14	IR 64	90	2.37	1.49	37.02
15	NLR33671-6	100	0.00	0.00	0.00
16	NLR40055	90	0.00	0.00	0.00
17	NLR40058	100	0.00	0.00	0.00
18	NLR40024	100	0.00	0.00	0.00
19	NLR3042	100	3.13	3.04	3.00
20	NLR34242	80	0.00	0.00	0.00
21	MTU1010	100	0.00	0.00	0.00
22	NLR33636	90	0.00	0.00	0.00
23	NLR3059	80	3.56	3.49	2.10
24	NLR3157	0	0.00	0.00	0.00
25	NLR34449	90	2.70	1.76	34.82
26	NLR3041	90	0.00	0.00	0.00
27	NLR3010	100	0.00	0.00	0.00
28	NLR33359	100	4.10	3.94	4.00
29	NLR34452	80	2.40	1.76	26.61
30	NLR40062	100	0.00	0.00	0.00
31	NLR3061	80	2.53	2.40	5.13
32	NLR30491	80	3.26	3.16	3.00

Cont..

S.NO.	Entries	% survival of seedlings	Root growth (cm)		
			Actual growth in control	Actual growth in treatment	% reduction in root growth
33	MLR34303	20	1.93	1.20	37.82
34	NLR40064	100	2.73	2.60	4.76
35	NLR40065	100	0.00	0.00	0.00
36	NLR40066	90	0.00	0.00	0.00
37	NLR40067	60	0.00	0.00	0.00
38	NLR40068	70	0.00	0.00	0.00
39	NLR40070	90	1.13	1.12	1.02
40	NLR40072	50	1.77	1.73	2.00
41	NLR40073	70	1.46	0.74	49.54
42	NLR40074	70	0.00	0.00	0.00
43	NLR40045	90	1.45	1.42	2.00
44	NLR40050	90	0.00	0.00	0.00
45	NLR40049	80	0.00	0.00	0.00
46	NLR40059	80	0.00	0.00	0.00
47	NLR20131	70	2.05	1.68	17.88
48	NLR20106-1	60	1.87	1.50	19.91
49	NLR3093	100	1.66	0.77	53.70
50	NLR3094	90	2.15	1.62	24.55
51	NLR3095	90	1.88	0.64	66.13
52	NLR3096	100	1.69	0.90	46.54
53	NLR3097	100	1.43	0.48	66.33
54	NLR3098	90	0.00	0.00	0.00
55	NLR3099	80	2.08	1.22	41.12
56	NLR3100	80	2.11	0.98	53.78
57	NLR3101	100	3.09	1.45	53.14
58	NLR3102	100	3.54	1.50	57.72
59	NLR3103	70	0.00	0.00	0.00
60	NLR3104	80	1.44	0.60	58.44
61	NLR3105	70	1.52	0.80	47.17
62	NLR3106	70	1.58	1.16	26.81
63	NLR3107	80	1.66	0.68	58.81
64	NLR3108	70	1.48	1.12	24.28
65	NLR3109	80	0.00	0.00	0.00
66	NLR3110	70	0.00	0.00	0.00

Cont…

S.NO.	Entries	% survival of seedlings	Root growth (cm)		
			Actual growth in control	Actual growth in treatment	% reduction in root growth
67	NLR34450	60	1.59	1.34	15.67
68	NLR34452	100	2.06	1.56	24.45
69	MDT 1	80	0.00	0.00	0.00
70	MDT 2	90	0.00	0.00	0.00
72	MDT 4	70	2.30	2.25	2.01
74	MDT 6	70	2.60	2.30	11.54
75	BPT5204	100	1.22	1.19	2.76
76	MDT 8	90	0.00	0.00	0.00
77	TELLAHAMSA	90	2.03	1.99	2.00
78	MDT 10	100	2.90	2.84	2.02
79	AL 1	80	3.50	2.40	31.43
80	AL 2	100	4.30	2.60	39.55
81	AL 3	70	3.40	3.00	11.77
82	AL 4	90	4.30	2.10	51.18
83	AL 5	100	4.10	2.20	46.36
84	AL 6	80	4.70	1.80	61.73
85	AL 7	90	4.70	1.80	61.73
86	AL 8	80	4.60	1.80	60.89
87	AL 9	100	4.10	1.80	56.11
88	RNR2458	90	0.00	0.00	0.00
89	PL 3	60	3.90	3.20	17.95
90	PL 10	100	3.00	2.60	13.31
91	PL 13	90	2.90	1.57	45.85
92	PL 15	90	2.90	1.35	53.35
93	PL 16	80	4.50	1.84	59.12
94	JGL1798	70	0.00	0.00	0.00
95	PL 18	80	0.00	0.00	0.00
96	PL 19	90	4.00	3.72	6.89
97	PL 21	60	2.10	1.26	40.02
98	PL 22	50	3.50	2.12	39.49
99	JGL 17	70	2.80	2.40	14.29
100	JGL 385	80	2.60	1.60	38.48
	SEm±	0.03	0.16	0.18	0.47
	CD (P=0.05%)	1.02	0.48	0.53	1.49

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CONCLUSION

The above results suggest that the TIR technique is a powerful and constructive technique to identify genetic variability in high temperature tolerance in rice within a short period of time and it is suitable for screening a large number of genotypes. The identified 30 genotypes of rice can be used as donor source for developing high temperature tolerant rice genotypes to resist global rise temperature.

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