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SCREENING OF THERMO TOLERANT FOXTAIL MILLET GENOTYPES AT SEEDLING STAGE USING THERMO INDUCTION RESPONSE TECHNIQUE (TIR)

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ABSTRACT

A novel temperature induction response (TIR) technique was standardized for foxtail millet crop. The sub lethal i.e. challenging temperatures as 38-58ºC (for 5 hours) and lethal temperatures as 59ºC (for 2 hours) was standardized. Using this standardized TIR protocol, highly thermo tolerant foxtail millet genotypes were screened from 60 foxtail millet germplasm. Among the genotypes, Prasad, SiA 3580, SiA 3604, SiA 3618, SiA 3623, SiA 3625 showed high thermo tolerance in terms of 70-100 per cent seedlings survival and 2-15% reduction in root and 7-18% reduction in shoot growth. These genotypes have intrinsic heat tolerance and they can be explored as donar source for developing high temperature tolerant foxtail millet genotypes.

KEYWORDS: TIR, foxtail millet, heat tolerance

INTRODUCTION

Foxtail millet (*Setaria italica* L.) is one of the oldest cultivated small millets both for food and fodder. It ranks second in the total world production of small millets and it continues to have an important place in world agriculture providing food for millions of people in arid and semiarid regions. It is native to China, India and Pakistan with the rainfall ranging from 150-700 mm and regarded as an elite drought tolerant crop. In India, it is cultivated in Andhra Pradesh, Karnataka, Maharastra, Tamilnadu, Odissa, Rajasthan and Madhya Pradesh for staple food as well as fodder. In India, foxtail millet is cultivated in 98,000 ha. area with a production of 56 t ha^{-1} and productivity of 565 kg ha^{-1} and in Andhra Pradesh, it is cultivated in an area of 23,005 hectares with a production of 28,348 tonnes and productivity of 1232 kg ha^{-1} (Anonymous, 2015).

Heat stress due to high ambient temperatures is a serious threat to crop production worldwide (Hall, 2001). High temperature stress affects all growth stages of crops and ultimately affects the yields. This is further aggravated by other environmental stresses like intermittent drought and high light. Management options are few, hence developing intrinsically tolerant lines is essential to combat the situation. With this background, foxtail millet genotypes were screened for high temperature tolerance using temperature induction response (TIR) technique. This approach is based on the fact that temperature stress develops gradually from sub lethal to lethal levels. An array of response events were expressed during sub lethal temperatures and gave cellular protection at lethal temperatures (Abdullah *et al.* 2001).

MATERIAL AND METHODS

Present investigation was conducted at Institute of Frontier Technology, Acharya N. G. Ranga Agricultural University. Tirupati, Andhra Pradesh with 60 foxtail millet genotypes obtained from Agricultural Research Station, Nandyal, Andhra Pradesh (Table 1).

Identification of lethal temperature treatment

To assess the challenging temperatures for 100 per cent mortality, 24 hour old foxtail millet seedlings were exposed to different lethal temperatures (55°C, 56°C, 57°C, 58°C and 59°C) for the same duration (2 hours) without prior induction. Thus, exposed seedlings were allowed to recover at 30^0C and 60 per cent relative humidity for 48 hours. At the end of recovery period the temperature at which 90% mortality of the seedlings occurred was taken as the challenging temperature in order to assess the genetic variability for seedling survival. Per cent mortality of foxtail millet genotypes after recovery was recorded (Table 2). The lethal temperature of 59°C for 2 hours was considered in this context, as maximum mortality (100%) of seedlings.

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Identification of sub lethal (induction) temperature

During the induction treatment, the seedlings were exposed to a gradual increase in temperature for a specific period. The temperature regimes and duration varies from crop to crop and need to be standardized. The germinated foxtail millet seedlings (24 hour old seedlings) were subjected to gradually increasing temperatures for a period of five hours. After this induction treatment, seedlings were exposed to lethal temperature *i.e.,* 59^{0}C for two hours and then transferred to the normal temperature for recovery. The temperature regimes and durations varied to arrive at optimum induction protocol (Table 3). The optimum sub lethal temperatures were arrived based on the per cent survival of seedlings. The sub lethal treatment which recovered least per cent seedlings survival reduction was considered as optimum range of temperatures *i.e.,* 38°C-58°C.

Thermo Induction Response (TIR)

Foxtail millet seeds were surface sterilized by treating with 2 per cent carbendazim solution for 30 minutes and washed with the distilled water for 4-5 times and kept for germination at 30°C and 60 per cent relative humidity in the incubator. After 24 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 temperatures increasing from 38°C-58°C for five hours in the environmental chamber (WGC-450 Programmable Plant Growth Chamber). Later these seedlings were exposed to lethal temperatures (59°C) for 2 hours (induced). Another set of seedlings were directly exposed to lethal temperatures (non induced).

Induced and non induced foxtail seedlings were allowed to recover at 30°C and 60 per cent relative humidity for 24 hours. The following parameters were recorded from the seedlings.

a) Per cent survival of seedlings =

$$\frac{\text{No. of seedlings survived at the end of recovery}}{\text{Total number of seedlings sown in the tray}} \times 100$$

b) Per cent reduction in root growth =

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

c) Per cent reduction in shoot growth

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

A lethal temperature of 59^{o}C for 2 hours and induction treatment from 38-58^{o}C for five hours was standardized using TIR (Thermo Induction Response) (Fig. 1) and considered as best lethal and induction temperatures for Phenotyping of foxtail millet seedlings for intrinsic heat tolerance at cellular level. (Table 2 and Table 3).

RESULTS AND DISCUSSION

The experimental data was recorded and the genotypes which showed contrast values for survival of seedlings, reduction in root and shoot growth were presented in the Table 4. Among the 60 genotypes screened, Prasad, SiA 3580, SiA 3604, SiA 3618, SiA 3623, SiA 3625 showed the highest thermo tolerance in terms of 70-100 per cent seedlings survival and only 2-15 reduction in root and 7-18 reduction in shoot growth. These varieties here shown the ability to survive even when they were exposed to lethal temperatures. In spite of exposing to 59^{o}C, germination and seedling growth were not affected in the genotypes, Prasad, SiA 3580, SiA 3618 and SiA 3623 probably due to acquired thermo tolerance. In the genotypes *viz.,* SiA 3555, SiA 3563, SiA 3569 and SiA 3572 the seedling survival, shoot and root growth were completely affected despite of the recovery conditions maintained after exposing to sub lethal to lethal temperature. The technique of exposing young seedlings to sub lethal and lethal temperatures has been validated in many crop species by several scientists in different crop species, Sudhakar *et al.* (2012) and Renukha *et al.* (2013) in rice, Senthil kumar *et al.* (2003) in sunflower, Ehab Abou Kheir *et al.* (2012) in cotton, Gangappa *et al.* (2006), in groundnut, Venkatachalayya *et al.* (2001) in pea and they concluded that TIR technique is one of the best screening techniques to screen the genotypes for thermo-tolerance.

CONCLUSION

The present study releaved that the TIR technique be used in foxtail millet crop for identifying thermo tolerant genotypes. In the present study, six genotypes *viz.*, Prasad, SiA 3580, SiA 3618, SiA 3604, SiA 3625

Table 1. Details of the respective 60 foxtail millet genotypes

S. No.	Genotype	S. No.	Genotype
1	Suryanandi (Check)	31	Sri Lakshmi (Check)
2	SiA 3539	32	SiA 3589
3	SiA 3542	33	SiA 3591
4	SiA 3543	34	SiA 3595
5	SiA 3545	35	SiA 3596
6	SiA 3546	36	SiA-3598
7	SiA 3550	37	SiA 3600
8	SiA 3551	38	SiA 3604
9	SiA 3554	39	SiA 3605
10	SiA 3555	40	SiA 3607
11	Narasimharaya (Check)	41	Krishnadevaraya (Check)
12	SiA 3558	42	SiA 3608
13	SiA 3559	43	SiA 3610
14	SiA 3560	44	SiA 3611
15	SiA 3562	45	SiA 3613
16	SiA 3563	46	SiA 3615
17	SiA 3569	47	SiA 3618
18	SiA 3570	48	SiA 3619
19	SiA 3572	49	SiA 3622
20	SiA-3574	50	SiA 3623
21	Prasad (Check)	51	SiA 3085 (Check)
22	SiA 3575	52	SiA 3625
23	SiA 3578	53	SiA 3626
24	SiA 3580	54	SiA 3628
25	SiA 3581	55	SiA 3631
26	SiA 3582	56	SiA 3632
27	SiA 3583	57	SiA 3634
28	SiA 3584	58	SiA 3636
29	SiA 3585	59	SiA 3637
30	SiA 3586	60	SiA 3156 (Check)

Table 2. Per cent mortality of foxtail millet seedlings at different lethal temperatures

S. No.	Temperature °C	Per cent mortality of foxtail seedlings after recovery		
		Duration of temperature		
		1 hour	2 hour	3 hour
1	55	0	0	7
2	56	0	21	33
3	57	0	50	59
4	58	51	81	86
5	59	62	100	100

Table 3. Per cent survival of foxtail seedlings at different induction (sub lethal) temperature range

S. No.	Temperature Range (Induction treatment for 5 hrs)°C	Per cent survival of seedling
1	34-53	80
2	34-55	86
3	36-56	86
4	36-57	88
5	38-58	95
6	38-59	84

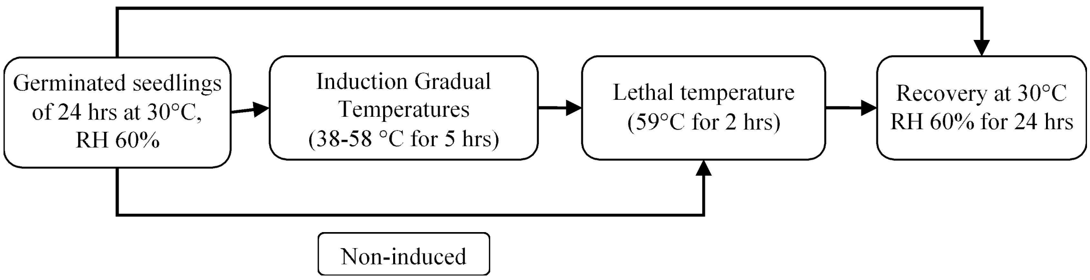

Fig. 1. Protocol of the technique: Temperature Induction Response (TIR)

Table 4. List of promising thermo tolerant and sensitive foxtail genotypes identified through TIR technique

Tolerance range	Genotype	Per cent reduction in root growth (%)	Per cent reduction in shoot growth (%)	Per cent survival of seedlings (%)
Highly Tolerant Germplasm Lines	Prasad	3	18	100
	SiA 3580	8	7	95
	SiA 3604	15	11	95
	SiA 3618	2	13	95
	SiA 3623	2	17	70
	SiA 3625	9	16	100
Highly Sensitive Germplasm lines	SiA 3555	72	69	60
	SiA 3563	68	67	60
	SiA 3569	64	70	55
	SiA 3572	62	58	55

and SiA 3623 showed high level of thermo tolerance. These genotypes can be used as potent donar sources in breeding programmes aimed for development of genotypes against high temperatures.

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