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Research Article

Genetic variability for induced thermo tolerance in groundnut (*Arachis hypogaea* L.) germplasm

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Abstract

High temperature is a major constraint to crop adaptation and productivity in groundnut especially when coincides with moisture stress. In the present study, thirty nine groundnut germplasm comprising of interspecific derivatives, advanced breeding lines, mutants and released cultivars were evaluated for their thermo tolerance at seedling stage in the laboratory under induced temperature treatment. Highly significant differences were observed among temperature treatments, genotypes and genotype x temperature interactions indicating differential response of genotypes to temperature treatment. High heritability coupled with high genetic advance over mean under induced temperature treatment revealed better scope for selection in the germplasm under induced temperature. Foliar disease resistant mutant (Mutant 110) and several advanced breeding lines (R 9214, ICGV 96266, ICGV 96262, ICGV 93020, ICGV 91177, ICGV 87264 and NC Ac 343) and three released cultivars (K 134, TMV 2 and Dh 40) have shown very less reduction (<30%) under induced temperature treatment indicating their seedling thermo-tolerance. These genotypes need to be assessed for their temperature tolerance under field conditions at different stages of crop growth.
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Key words

Groundnut, induced temperature, thermo tolerance, interspecific derivatives

Introduction

Groundnut (*Arachis hypogaea* L.) is an economically important oilseed crop and is a major source of protein (25 to 28 %) and vegetable oil (45 to 50 %) for human nutrition. The groundnut production in India and China accounts for about two thirds of the world's groundnut and USA contributes about 6 % (Guo *et al.,* 2012). In India, it is grown mainly under rainfed situation which reduces groundnut productivity drastically. The main factors under rainfed cultivation are biotic and abiotic stresses. Among the abiotic stresses, drought, salinity, high temperature are having greater effect on groundnut yield. High temperature is a major constraint to crop adaptation and productivity, especially when coincides with drought at critical stages of plant development (McWilliam, 1980). Groundnut is often exposed to temperatures of more than 40^o C for short periods during the growing season in semi-arid tropics (ICRISAT, 1994). Furthermore, with the present trends of global warming (Schneidar, 1989), temperature are likely to become hotter, and an increase in mean air temperature of 2-3^o C is predicted to reduce groundnut yields in India by 23-36 per cent (Hundal and Laur, 1996). Therefore, to sustain the economic yield, breeding temperature tolerant varieties is essential. The major constraint in breeding for temperature tolerance is lack of efficient techniques for screening germplasm. An efficient technique would be screening genotypes based on temperature induction response.

Under natural environment, plants are exposed to a sub-lethal stress before being subjected to lethal stress. Plants are known to withstand lethal temperatures upon exposure to sub-lethal temperatures due to induced response (Lin *et al.,* 1984). Seed germination is the most critical stage in crop growth cycle and it is very much sensitive to temperature stress. Poor germination leads to poor crop stand and ultimately low productivity. Present study envisages to assess the level of seedling tolerance to temperature stress in groundnut germplasm under diverse genetic background.

Materials and methods

The genetic material comprised of thirty nine diverse groundnut germplasm consisting of interspecific derivatives, advanced breeding lines, induced mutants and released cultivars, and its pedigree details are given in Table 1. Hundred seeds were germinated in each genotype on moist filter paper at 30^o C for 48 hours and uniform seedlings (30 each) were transferred to 3 petri plates. One set was subjected to induction temperatures of 36^o C for 1 hour, 40^o C for 1 hour and 45^o C for 2 hours (Savita, 1995). Then control (directly stressed) and induced sets were subjected to lethal temperature (55^o C) for three hours. The treated seedlings were allowed to recover at 30^o C for 3 days. One set was maintained at ambient temperature as absolute control. All the treatments were replicated thrice. Seedling length was measured before lethal treatment and after 72 hours of recuperation and percent reduction in induced and stressed treatments over absolute control was measured as given below.

A. Growth during recovery (GDR) = Growth at the end of recovery-growth before inducing lethal stress.

B. 1. In case of induced stress (IT)

% R (IT) = GDR of control-GDR of induced/GDR of control

2. In case of stressed (CT)

% R (CT) = GDR of control-GDR of directly stressed/GDR of control

The data obtained was subject to factorial ANOVA wherein temperature was the first factor and genotype was the second factor.

Results and discussion

Highly significant differences were observed between treatments (T), genotypes (G) and T x G interactions (Table 2) indicating differential response of genotypes to temperature treatments. In case of direct stress, the variation was less (54.4 to 100) as compared to induced (0 to 86.7) temperature treatment (Table 3). There was no difference between phenotypic and genotypic coefficient of variance indicating the total variability is due to genetic differences among the germplasm under study. Though heritability in both directly stressed and induced temperature treatment was higher, genetic advance over mean was less in case of direct stress as compared to induced treatment which recorded higher GAM (106.8). The high heritability coupled with high genetic advance over mean under induced temperature treatment revealed better scope for selection in the germplasm under induced temperature. Earlier reports also indicated genetic variability for stress tolerance only when plants are subjected to sub-lethal stress (Uma *et al.*, 1995, Gangappa *et al.*, 2006).

Foliar disease resistant mutant (Mutant 110) and several advanced breeding lines (R 9214, ICGV 96266, ICGV 96262, ICGV 93020, ICGV 91177, ICGV 87264 and NC Ac 343) and three released cultivars (K 134, TMV 2 and Dh 40) have shown very less reduction (< 30%) under induced treatment indicating their seedling thermo-tolerance (Table 4). Earlier, K 134 was reported to have only 8 % reduction in recovery growth under induced temperature (Gangappa *et al.*, 2006). Cursory analysis of many advanced breeding lines exhibiting thermo tolerance had NC Ac 2214 or NC Ac 2232 as a parent in their pedigree (Table 1). The morphological or physiological adaptation of any genotype is a result of gene expression and the product of the gene brings about the required metabolic changes for adaptation. In the present study, in spite of the exposure of different groundnut genotypes to induction temperatures, the recovery in terms of seedling growth differed amongst the genotypes. Variation in the stress adaptive mechanisms among the genotypes could be the possible reason for observed variation for induced temperature tolerance. However, it is well known that, the stress responsive genes are many and diverse. One of the possible mechanisms for the enhanced recovery growth of the induced seedlings is through synthesis of heat shock proteins, which impart thermo-tolerance (Vierling, 1991). In a study on evaluation of selected accessions of groundnut minicore germplasm at seedling stage for acquired thermo tolerance has shown more chlorophyll accumulation in tolerant genotypes upon exposure to light (Selvaraj *et al.*, 2011). In the present study, the identified thermo tolerant lines need to be assessed for their thermo tolerance under field conditions at different stages of plant growth for future use in breeding. They could also serve as ideal material for understanding biochemical/molecular mechanism of thermo-tolerance.

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Table 1. Pedigree of groundnut germplasm used for induced thermo tolerance in the study

SI. No.	Genotypes	Botanical Group	Pedigree	Source
Interspecific derivatives				
1	ICGV 86699	VB	[(*A. batizocoi* x *A. duranensis*) x *A. hypogaea* (Cv.NC 2]	ICRISAT, India
2	ICGV 87165	VB	[*A. hypogaea var.fastigiata* (PI 261942) x *A. cardenasii*]	ICRISAT, India
3	ICGV 88256	VB	(ICGV 87165 x (Robut 33-1x NC Ac 316)	ICRISAT, India
4	ICGV 93023	VB	[(Robut 33-1 x NC Ac 2214) x Cyto 213-2]	ICRISAT, India
5	A 30b	VB	KRG 1 x ICGV 87165	Karnataka, India
6	B 37c	SB	JL 24 x ICGV 87165	Karnataka, India
7	GPBD 4	SB	KRG 1 x ICGV 8655(*A. hypogaea* x *A cardenasii*)	Karnataka, India
Advanced breeding lines				
8	ICGV 86031	SB	F 334 A-B-14 x NC Ac 2214	ICRISAT, India
9	ICGV 87264	SB	Manfredi x NC Ac 17133RF	ICRISAT, India
10	ICGV 87807	VL	[(MK 374 x Robut 33-1) x FESR 2]	ICRISAT, India
11	ICGV 90266	VB	[((J11x(M 13 x NC Ac 2232) x (TMV 7 x FSB 7-2) x NC Ac 2214]	ICRISAT, India
12	ICGV 91173	VB	[(NC Ac 343 x NC Ac 2214) x ICG 5240]	ICRISAT, India
13	ICGV 91177	VB	(F 334 A-B-14xNC Ac 2232) x ((TMV 7xFSB 7-2) x NC Ac 2214)	ICRISAT, India
14	ICGV 91180	VB	(TMV 2x FSB 7-2)xNC Ac 2232)x((F 334 A-B-14x NC Ac 2214)	ICRISAT, India
15	ICGV 92188	VB	Robut 33-1 x (M 13 x Nc Ac 2214)] x JL 24	ICRISAT, India
16	ICGV 93008	VB	Mani Pintar x (Robut 33-1 x (M 13 x Nc Ac 2232)] x ICG 2320	ICRISAT, India
17	ICGV 93020	SB	[(Manfredi 68x NC Ac 343)x Mani Pintar x (Robut 33-1 x Nc Ac 2232)))]	ICRISAT, India
18	ICGV 93021	VB	[(F 334 A-B-14 x NC Ac 2214) x 9/136]	ICRISAT, India
19	ICG 2271	VB	NC Ac 343 ((NC Bunch x PI 121067)	North Carolina
20	ICG 1697	VL	NC Ac 17090	North Carolina
21	ICGV 96262	VB	89 R/52-8 x PI 270806	ICRISA, India
22	ICGV 96266	VB	ICGV 91177 x . ICGV 86594	ICRISA, India
23	Dh 73	SB	Dh 3-30 x . ICGV 87264	Karnataka, India
24	R 8972	SB	ICGS 59 x NC Ac 2240	Karnataka, India
25	R 9214	SB	(ICGS 7 X NC Ac 2214) x ICGV 86031	Karnataka, India
26	R 9227	SB	(ICGS 7 X NC Ac 2214)x ICGV 86031	Karnataka, India
Induced Mutants				
27	VL 1	VL	EMS mutant of Dharwad Early Runner (DER)	Karnataka, India
28	Mutant 28-2	SB	EMS mutant of Valencia 1(VL1)	Karnataka, India
29	Mutant 45	SB	EMS mutant of Valencia 1(VL1)	Karnataka, India
30	Mutant 110	SB	EMS mutant of Valencia 1(VL1)	Karnataka, India
Released cultivars				
31	ICGV 86590	VL	X 14-4-B-19Bx PI 259747	ICRISA, India
32	K 134	SB	Kadiri 3 x JL 24	Kadiri, India
33	KRG 1	SB	Selection from Argentina	Karnataka, India
34	JL 24	SB	Selection from EC 94943	Maharashtra, India
35	TMV 2	SB	Mass selection from “Gudhiatham bunch”	Tamilnadu, India
36	Dh 8	SB	Selection from RS 144	Karnataka, India
37	Dh 40	SB	Dh-3-30 x TGE 2	Karnataka, India
38	R 8808	SB	ICGS 11 x Chico	Karnataka, India
39	TAG 24	SB	TGS 2 x TGE 1	BARC, India

SB- Spanish bunch, VB –Virginia bunch, VL -Valencia

Table 2. Analysis of variance for temperature stress in groundnut germplasm

Source of variation	df	Mean sum of squares
Replication	2	0.058
Factor A (Temperature treatment)	1	91948.362 **
Error	2	0.566
Factor B (Genotypes)	38	658.729**
Temperature x Genotype interaction	38	644.289**
Error	76	0.827

** - Significant at 1 % level of probability

Table 3. Genetic components of variation for temperature stress in groundnut germplasm

Components	Induced temperature	Directly Stressed
Maximum	86.7	100.0
Minimum	0.0	54.4
Mean	44.9	93.5
PCV	51.9	11.1
GCV	51.9	11.1
H	99.8	99.5
GAM	106.8	22.7

Table 4: Mean performance of groundnut germplasm for temperature stress

SI. No.	Genotypes	% reduction in seedling length	
		Induced temperature	Directly Stressed
Interspecific derivatives			
1	ICGV 86699	68.12	100.00
2	ICGV 87165	76.58	95.48
3	ICGV 88256	61.46	98.84
4	ICGV 93023	35.17	98.85
5	A 30b	70.18	61.47
6	B 37c	86.71	81.56
7	GPBD 4	75.60	99.20
Advanced breeding lines			
8	ICGV 86031	57.88	96.85
9	ICGV 87264	0.87	99.58

10	ICGV 87807	84.50	98.03
11	ICGV 90266	51.57	88.35
12	ICGV 91173	38.28	95.14
13	ICGV 91177	17.64	98.84
14	ICGV 91180	50.97	97.15
15	ICGV 92188	36.99	89.02
16	ICGV 93008	54.58	98.66
17	ICGV 93020	7.98	100.00
18	ICGV 93021	48.56	97.65
19	ICG 2271	28.13	100.00
20	ICG 1697	70.84	99.40
21	ICGV 96262	25.93	95.59
22	ICGV 96266	22.74	54.38
23	Dh 73	59.91	8.37
24	R 8972	35.74	89.81
25	R 9214	0.00	94.79
26	R 9227	37.79	99.67
Induced Mutants			
27	VL 1	59.06	96.81
28	Mutant 28-2	60.48	95.90
29	Mutant 45	33.01	84.97
30	Mutant 110	28.68	91.89
Released cultivars			
31	ICGV 86590	39.19	97.62
32	K 134	20.06	100.00
33	KRG 1	73.45	98.45
34	JL 24	32.86	100.00
35	TMV 2	21.08	85.30
36	Dh 8	38.61	71.98
37	Dh 40	14.38	98.08
38	R 8808	48.01	99.49
39	TAG 24	79.19	99.24
Mean		44.94	93.50
CV (%)		2.35	0.73
CD (5%)		2.99	0.78