Article AR2026a DOI: HTTPS://DOI.ORG/10.23910/IJBSM/2019.10.5.2026a

International Journal of Bio-resource and Stress Management

October 2019

Crossref

Print ISSN 0976-3988

Online ISSN 0976-4038

IJBSM 2019, 10(5):481-490

Research Article Abiotic Stress

Evaluation of Climate Resilient Groundnut Genotypes for Thermo Tolerance under Climate Change

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Citation: John et al., 2019. Evaluation of Climate Resilient Groundnut Genotypes for Thermo Tolerance under Climate Change. International Journal of Bio-resource and Stress Management 2019, 10(5):481-490. HTTPS://DOI.ORG/10.23910/IJBSM/2019.10.5.2026a

Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

Conflict of interests: The authors have declared that no conflict of interest exists.

Acknowledgement: This research was supported under the DST-SERB to the first author by the Department of Science and Technology –Science and Engineering Research Board, New Delhi is gratefully acknowledged.

Abstract

A total of about one hundred groundnut *(Arachis hypogaea* L.) genotypes were evaluated for temperature tolerance. The *per se* performance under induced temperature, the mean root length ranged from 0.00 (ICGV-05155, ICGV-06424, ICGV-07247 and ICGV-07273) to 6.90 cm (TCGS-1837). The mean shoot length ranged from 0.00 (TCGS-1826, ICGV-05155, ICGV-06423, ICGV-06424, ICGV-07222, ICGV-07225, ICGV-07240, ICGV-07245, ICGV-07247, ICGV-07262, ICGV-07235, ICGV-07273, ICGV-07395, ICGV-07337, ICGV-07406, MLTG-03, MLTG-09, MLTG-11andNarayani) to 3.20cm (TCGS-1522). Under lethal temperature, the mean root length ranged from 0.00 (ICGV-05155, ICGV-06424, ICGV-07247 and ICGV-07273 to 6.9 cm (TCGS-1837). The mean shoot length ranged from 0.00 (TCGS-1826, TCGS-1843, TCGS-1859, TCGS-1861, ICGV-06423, ICGV-06424, ICGV-07219, ICGV-07220, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07268, ICGV-07235, ICGV-07270, ICGV-07273, ICGV-07286, ICGV-07390, ICGV-07392, ICGV-07395, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07403, ICGV-07404, ICGV-07405, ICGV-07406, ICGV-7408, MLTG-02, MLTG-03, MLTG-04, MLTG-06, MLTG-08, MLTG-09, MLTG-11, Narayani and K-6 to 3.00 cm (TCGS-1522 and TCGS-1824). The best performing groundnut genotypes *viz.,*TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1817, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1824, TCGS-1825, TCGS-1829, TCGS-1831,TCGS-1837, TCGS-1838, TCGS-1839, TCGS-1845, TCGS-1851, TCGS-1853, TCGS-1855, TCGS-1868, TCGS-1869, TCGS-1872, TCGS-1876 and ICGV-07262 were found promising climate resilient groundnut genotypes based on survival under lethal temperature.Some of the genotypes showed better performance under induced and lethal temperatures for root and shoot lengths such as TCGS-1511, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809 and TCGS-1810.These promising genotypes could be utilized in the breeding programme as donors to develop high yielding drought tolerant genotypes.

Keywords: Groundnut, temperature induction response, induced temperature, lethal temperature

1. Introduction

Drought is the single most factor limiting productivity under rainfed conditions. High temperatures associated with drought also affect many physiological processes in plant resulting poor yield. Further, heat tolerance will be necessary because of global climatic change (Schneider,

Article History

RECEIVED in 19th August 2019 RECEIVED in revised form 04th October 2019 ACCEPTED in final form 20th October 2019

1989), coupled with increase in CO_2 concentration. During *rabi* season, especially in the late sown crop, January and February, yield gets reduced due to high temperature in March and April months during flowering and pod development stages. Further, the variety must be acceptable to the producer, the processor and the consumer. The effect of high temperature can be seen at cellular level and at whole plant level affecting growth, reproduction and productivity of crop plants.Thetechnique of exposing young seedlings to sub lethal andlethal temperatures has been validated in other crop speciesviz. rice (Sudhakar et al., 2012, Harihar et al., 2014), sunflower (Senthil Kumar et al., 2003), cotton (Ehab et al., 2012) and pea (Venkatachalayya et al., 2001). The effects ofheat stress during the vegetative and reproductive growth stages using agronomic, phenological, morphological and physiological assessment has been studied in various cropssuch as wheat (Sharma et al., 2005), rice (Weerakoon et al., 2008) and cotton (Cottee et al., 2010).

Plant responses to high temperature vary with plant species and phenological stages (Wahid et al., 2007). Reproductive processes are markedly affected by high temperatures in most plants, which lead to reduced crop yield. For example, both grain weight and grain number appeared to be sensitive to high-temperature stress in wheat, as the number of grains per head at maturity declined with increasing temperature (Ferris et al., 1998). Vara Prasad et al. (2000) investigated the effects of daytime soil and air temperature of 28 and 38 °C, from start of flowering to maturity of groundnut, and reported 50% reduction in pod yield at high temperatures. These authors observed that day temperature above 34 °C decreased fruit-set and resulted in fewer numbers of pods. However, Greenberg et al. (1992) and Ndunguru et al. (1995) reported that varieties grown by farmers in the Sahel yielded well in the hot months prior to the onset of the rains, and this has been attributed to their ability to maintain partitioning to pods above that in normal temperatures. Heat tolerance results in improved photosynthesis, assimilate partitioning, water and nutrient use efficiency, and membrane stability (Camejo et al., 2005, Ahn and Zimmerman, 2006, Momcilovic and Ristic, 2007). There exists a strong relationship between the plant water status and temperature, thus making it very difficult to separate the contributions of heat and drought stress under field conditions (Vara Prasad and Staggenborg, 2008).

Moisture stress coupled high temperature is known to adversely affect the growth and development in groundnut, ultimately resulting in low pod yield. To increase the productivity and to stabilize production in the ever-changing environment, development of genotypes that are capable to survive better under abiotic stresses is essential. Identification of groundnut genotypes for high temperature stresses in natural conditions, which are highly variable, is very difficult. Drought stress coupled with high temperature isassociated with reduced water availability and cellulardehydration alters the cellular metabolism coupled with osmotic adjustment (Khanna et al., 2016). In the present study an attempt was made to identify groundnut genotypes for temperature tolerance based on temperature induction response technique.

2. Materials and Methods

Hundred groundnut genotypes were evaluated to identify the genotypes for temperature tolerance based on temperature induction response technique during *kharif*, 2017. The principle assumption behind this technique is that a genotype will withstand lethal temperature stress by maximum expression of stress-induced genes. Some of the studies conducted at the Department of Crop Physiology, GKVK campus, University of Agricultural Sciences, Bangalore and elsewhere have shown that the genetic variability and difference in the expression of stress responsive genes for stress tolerance is seen only upon prior induction at sub-lethal stress (Uma et al., 1995, Kumar et al., 1999, Gopalakrishna et al., 2001). The technique involved by exposing germinating seedlings to sub lethal gradual temperatures (36 ^{o}C– 52 ^{o}C) for 5 hours followed by challenging lethal temperatures (55 ^{o}C) for 2 hours and bringing back to incubated conditions for 6 days. The percent seedling survival with sustaining root and shoot growth reveals the thermo tolerance ability of the line. The principle assumptionbehind this technique is that a genotype will withstand lethal temperature stress by maximum expression ofstress-induced genes. A screening protocol for temperature induction response was developedwherein groundnut seedlings were exposed to gradual inductiontemperatures (sub lethal stress) and later they wereexposed to lethal temperature. About 5-10% of seedlings that survive at this level of stress areconsidered as highly tolerant because they recover afterbeing exposed to a very severe lethal stress. During the gradual induction of stress several stress responsiveproteins are expressed which in turn trigger severalphysiological and biochemical parameters, which confers stress tolerance (Gangappa et al., 2006).

The phenotypically uniform seedlings from eachgenotype were transferred to three different sets ofpetri plates for further studies on (i) induction temperature (ii) direct exposure to lethal temperature and (iii) control. Initial root and shoot length were recorded beforesubjecting the seedlings to different treatments. Theinduced and non-induced seedlings were thentransferred to a lethal temperature (55 ^{o}C for 3 hrs). After exposure to the lethal temperature the seedlingswere allowed for recovery at 30 ^{o}C for 72 hrs. One set of control seedling set was maintained at 30 ^{o}C all through the experiment to serve as thecontrol. The observations wererecorded on shoot length and root length in all thethree sets at the end of recovery period. Optimum induction response was assessed at the end of theinduction period (based on maximum recovery growthafter the seedlings were subjected to induction stress followed by lethal stress. As the rate of germination isgenotype specific, the seedling radical length wouldvary among the genotypes. Therefore, to arrive at induction response, the difference in growth before subjecting to induction and after the recovery growthperiod was determined in this system.

3. Results and Discussion

The p*er se* performance of root and shoot lengths under control temperature, induced temperature and lethal temperature are presented in Tables 1 and 2.

Table 1: *Per se* performance of groundnutgenotypes/germplasm for thermo tolerance

Sl. No.	Genotype	Control temperature		Induced temperature		Lethal Temperature	
		Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
1.	TCGS-1508	12.4	2.1	2.7	2.2	2.8	1.4
2.	TCGS-1511	4.4	2.6	3.5	2.4	3.2	2.3
3.	TCGS-1514	3.9	2.7	3.3	2.2	2.0	1.8
4.	TCGS-1516	3.6	2.6	2.7	2.4	2.3	1.5
5.	TCGS-1517	3.3	2.6	2.8	2.6	2.2	2.6
6.	TCGS-1518	4.8	2.3	3.0	1.7	2.9	1.7
7.	TCGS-1520	8.6	3.0	3.5	2.7	3.5	2.5
8.	TCGS-1521	7.0	2.9	3.5	2.8	3.0	2.5
9.	TCGS-1522	5.4	3.5	4.2	3.2	3.8	3.0
10.	TCGS-1523	5.3	3.1	2.8	2.9	2.3	2.7
11.	TCGS-1527	3.4	2.5	3.1	2.1	2.9	1.4
12.	TCGS-1528	6.8	2.6	3.5	2.5	3.2	1.7
13.	TCGS-1529	5.6	2.4	3.3	2.2	2.9	2.1
14.	TCGS-1804	6.0	3.1	4.4	2.7	3.2	2.2
15.	TCGS-1805	4.2	2.7	2.6	1.7	2.6	1.6
16.	TCGS-1807	7.4	3.6	3.6	2.8	3.6	2.1
17.	TCGS-1809	4.0	2.5	3.1	2.0	3.1	1.8
18.	TCGS-1810	6.5	2.2	3.6	1.8	3.5	1.5
19.	TCGS-1813	5.4	2.3	4.3	1.7	4.0	1.5
20.	TCGS-1814	6.2	3.0	4.0	2.4	3.9	1.1
21.	TCGS-1815	3.5	2.8	3.0	2.2	2.9	2.2
22.	TCGS-1816	4.2	3.0	3.3	2.8	3.2	1.2
23.	TCGS-1817	4.7	1.8	3.9	1.3	3.6	1.3
24.	TCGS-1818	4.5	2.7	3.2	2.3	3.1	2.1
25.	TCGS-1819	6.4	2.5	2.9	1.9	2.8	1.6
26.	TCGS-1820	5.6	3.1	5.0	2.6	3.4	2.2
27.	TCGS-1821	8.4	3.2	5.5	2.1	4.2	1.8
28.	TCGS-1822	9.5	2.0	4.9	2.6	4.6	2.0
29.	TCGS-1823	6.4	2.4	6.0	2.1	4.5	1.3
30.	TCGS-1824	4.0	3.7	3.5	2.3	3.2	3.0
31.	TCGS-1825	6.0	2.0	4.7	2.1	3.4	0.2
32.	TCGS-1826	2.6	0	2.2	0	2.1	0
33.	TCGS-1829	4.5	2.8	3.0	2.0	2.9	1.3
34.	TCGS-1830	3.8	1.4	2.5	1.0	2.4	0.8

Table 1: Continue...

Sl. No.	Genotype	Control temperature		Induced temperature		Lethal Temperature	
		Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
35.	TCGS-1831	5.0	2.6	4.0	2.4	3.5	2.2
36.	TCGS-1837	7.1	1.9	6.9	1.8	6.9	1.8
37.	TCGS-1838	4.4	2.5	3.2	2.3	3.2	1.8
38.	TCGS-1839	3.8	2.0	2.5	1.6	2.1	1.5
39.	TCGS-1843	2.5	1.0	2.0	0.6	1.7	0
40.	TCGS-1845	4.4	2.0	2.6	1.8	2.2	1.1
41.	TCGS-1849	3.6	1.6	3.0	1.4	2.6	1.2
42.	TCGS-1851	4.5	2.5	3.9	2.4	3.6	2.2
43.	TCGS-1853	5.8	2.8	5.0	2.7	4.2	2.6
44.	TCGS-1855	3.9	3.6	2.7	2.4	2.4	2.0
45.	TCGS-1859	2.6	1.0	1.8	0.8	1.6	0
46.	TCGS-1861	3.7	1.7	3.4	1.6	1.3	0
47.	TCGS-1862	6.5	2.0	3.5	1.6	3.0	0.4
48.	TCGS-1868	4.6	2.0	3.1	1.5	2.3	1.5
49.	TCGS-1869	3.6	2.4	2.5	2.3	2.4	2.3
50.	TCGS-1871	3.7	2.3	2.1	0.6	2.0	0.2
51.	TCGS-1872	3.3	2.0	2.3	1.8	2.3	1.2
52.	TCGS-1876	4.5	3.2	3.0	2.0	2.9	1.5
53.	TCGS-1877	5.6	2.4	2.6	2.2	2.4	0.6
54.	ICGV-05155	0	0	0	0	0	0
55.	ICGV-05158	5.5	2.5	3.6	2.0	3.5	1.0
56.	ICGV-06423	1.2	1.2	0.9	0	0.7	0
57.	ICGV-06424	0	0	0	0	0	0
58.	ICGV-07219	4.5	1.5	3.4	1.2	2.2	0
59.	ICGV-07220	1.8	0.6	1.8	0.6	1.0	0
60.	ICGV-07222	1.5	1.0	0.9	0	0.7	0
61.	ICGV-07225	1.0	0.5	0.9	0	0.5	0
62.	ICGV-07228	0.9	0	0.8	0	0.7	0
63.	ICGV-07240	1.5	0.9	0.6	0.8	1.0	0
64.	ICGV-07241	1.2	0	0.6	0	0.4	0
65.	ICGV-07245	1.4	0.6	0.9	0	0.8	0
66.	ICGV-07247	0.0	0	0	0	0	0
67.	ICGV-07262	3.9	2.0	3.5	1.5	3.2	1.0
68.	ICGV-07268	1.8	0.4	1.0	0	0.7	0
69.	ICGV-07235	2.3	1.8	1.6	1.5	1.5	0
70.	ICGV-07270	4.2	2.0	4.0	1.8	1.5	0
71.	ICGV-07273	0	0	0	0	0	0
72.	ICGV-07286	4.0	2.2	3.8	2.1	2.7	0
73.	ICGV-07390	5.5	3.2	5.2	3.0	4.2	0

Table 1: Continue...

Sl. No.	Genotype	Control temperature		Induced temperature		Lethal Temperature	
		Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
74.	ICGV-07392	4.4	2.0	4.0	1.8	3.5	0
75.	ICGV-07395	5.0	0.7	4.8	0	2.4	0
76.	ICGV-07396	7.0	2.6	3.9	0.4	3.8	0
77.	ICGV-07296	7.3	2.5	4.9	0.4	4.5	0
78.	ICGV-07337	5.7	2.8	4.9	0	4.6	0
79.	ICGV-07403	3.7	0.8	1.4	0.6	1.1	0
80.	ICGV-07404	6.1	2.4	4.3	2.0	4.3	0
81.	ICGV-07405	6.8	2.6	1.6	1.2	1.4	0
82.	ICGV-07406	4.5	0	3.9	0	3.7	0
83.	ICGV-07408	5.7	2.0	4.5	1.2	4.3	0
84.	MLTG-01	5.0	3.1	4.6	2.9	4.2	0.4
85.	MLTG-02	4.0	2.5	3.5	2.3	3.0	0
86.	MLTG-03	3.3	0	3.1	0	2.9	0
87.	MLTG-04	5.6	1.0	4.7	0.8	3.6	0
88.	MLTG-05	3.6	0.8	2.6	0.7	2.5	0.6
89.	MLTG-06	4.9	3.2	4.0	3.2	3.7	0
90.	MLTG-07	3.8	2.3	3.7	1.0	3.3	0.8
91.	MLTG-08	6.7	2.7	3.7	1.4	3.5	0
92.	MLTG-09	5.8	0.4	4.2	0	3.7	0
93.	MLTG-10	6.3	2.6	5.8	2.5	5.6	1.8
94.	MLTG-11	1.7	0	1.5	0	1.0	0
95.	MLTG-12	6.6	2.0	5.7	1.7	5.0	1.2
96.	MLTG-13	5.9	0.9	5.5	0.7	3.2	0.4
97.	Narayani	2.0	0	1.5	0	1.3	0
98.	Dharani	6.0	1.8	2.2	1.8	1.3	1.5
99.	Greeshma	5.8	3.1	2.0	1.5	1.9	1.5
100.	K-6	1.3	1.4	0.8	0.2	0.9	0
Mean		4.48	1.96	3.12	1.51	2.69	0.94
Variance		4.56	1.06	2.11	096	1.71	0.89
CV %		47.77	52.55	46.47	64.90	48.70	95.40
SE		0.21	0.10	0.15	0.09	0.13	0.09

3.1. Control temperature

*3.1.1. Root length (cm):*Among groundnut genotypes, the mean root length under control temperature ranged from 0.00 (ICGV-05155, ICGV-06424, ICGV-07247 and ICGV-07273) to 12.4 cm (TCGS-1508) with a general mean of 4.6cm. The genotypes *viz.,*TCGS-1508, TCGS-1518, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1817, TCGS-1819,TCGS-1820,TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1825, TCGS-1831, TCGS-1837, TCGS-1853, TCGS-1862, TCGS-1868, TCGS-1877, ICGV-05158, ICGV-07390, ICGV-07395, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07404, ICGV-07405, ICGV-07408, MLTG-01, MLTG-04, MLTG-06, MLTG-08, MLTG-09, MLTG-10, MLTG-12, MLTG-13, Dharani and Greeshma exceeded the general mean.

3.1.2. Shoot length (cm)

Among groundnut genotypes, the mean shoot length under control temperature ranged from 0.00 (TCGS-1826, ICGV-05155, ICGV-06424, ICGV-07228, ICGV-07241, ICGV-07247,

ICGV-07273, ICGV-0727307406, MLTG-03, MLTG-10 and MLTG-13) to 3.60 cm (TCGS-1807) with a general mean of 2.00 cm. The genotypes *viz.,*TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517, TCGS-1518, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1805, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1816, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821, TCGS-1823, TCGS-1824, TCGS-1829, TCGS-1831, TCGS-1838, TCGS-1851,TCGS-1853, TCGS-1855, TCGS-1869, TCGS-1871, TCGS-1876, TCGS-1877, ICGV-05158, ICGV-07286, ICGV-07390, ICGV-07396, ICGV-07296, ICGV-07337, ICGV- 07404, ICGV-07405, MLTG-01, MLTG-02, MLTG-06, MLTG-07, MLTG-08, MLTG-10 and Greeshma exceeded the general mean.

3.2. Induced temperature

3.2.1. Root length (cm)

Among groundnut genotypes, the mean root length under induced temperature ranged from 0.00 (ICGV-05155, ICGV-06424, ICGV-07247 and ICGV-07273) to 6.90 cm (TCGS-1837)

Table 2: Performance of groundnut genotypes under different temperature conditions for root and shoot lengths

Length (cm)	Induced Temperatures		Lethal Temperatures	
	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
0-2.0 cm	TCGS-1843, TCGS-1859, ICGV-05155, ICGV-06423, ICGV-06424, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07268, ICGV-07273, ICGV-07403, ICGV-07235, ICGV-07405, ICGV-07220, MLTG (SB)-K-2017-11, Narayani and Greeshma.	TCGS-1518, TCGS-1805, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1817, TCGS-1819, TCGS-1826, TCGS-1829, TCGS-1830, TCGS-1837, TCGS-1839, TCGS,1843, TCGS-1845, TCGS-1849, TCGS-1859, TCGS-1861, TCGS-1862, TCGS-1868, TCGS-1871, TCGS-1872, TCGS-1876, ICGV-05155, ICGV-05158, ICGV-06424, ICGV-06423, ICGV-07219, ICGV-07220, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07235, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07262, ICGV-07268, ICGV-07270, ICGV-07273, ICGV-07296, ICGV-07337, ICGV-07392, ICGV-07395, ICGV-07396, ICGV-07403, ICGV-07404, ICGV-07405, ICGV-07406, ICGV-07408, MLTG(SB)-K-2017-03, MLTG(SB)-K-2017-04, MLTG(SB)-K-2017-05, MLTG(SB)-K-2017-07, MLTG(SB)-K-2017-08, MLTG(SB)-K-2017-09, MLTG(SB)-K-2017-11, MLTG(SB)-K2017-12, MLTG(SB)-K2017-13, Narayani and Greeshma	TCGS-1514, TCGS-1843, TCGS-1859, TCGS-1861, TCGS-1871, ICGV-05155, ICGV-06423, ICGV-06424, ICGV-07220, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07235, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07268, ICGV-07270, ICGV-07273, ICGV-07403, ICGV-07405, MLTG-(SB)-K-2017-11, Narayani and Greeshma	TCGS-1508, TCGS-1514, TCGS-1516, TCGS-1518, TCGS-1527, TCGS-1528, TCGS-1805, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1816, TCGS-1817, TCGS-1819, TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1825, TCGS-1826, TCGS-1829, TCGS-1830, TCGS-1837, TCGS-1838, TCGS-1839, TCGS-1843, TCGS-1845, TCGS-1849, TCGS-1855, TCGS-1859, TCGS-1861, TCGS-1862, TCGS-1868, TCGS-1871, TCGS-1872, TCGS-1876, TCGS-1877, ICGV-05155, ICGV-05158, ICGV-6423, ICGV-06424, ICGV-07219, ICGV-07220, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07262, ICGV-07268, ICGV-07235, ICGV-07270, ICGV-07273, ICGV-07286, ICGV-07390, ICGV-07392, ICGV-07395, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07403, ICGV-07404, ICGV-07405, ICGV-07406, ICGV-7408, MLTG (SB)-K2017-01, MLTG (SB)-K2017-2, MLTG (SB)-K-2017-03, MLTG (SB)-K-2017-04, MLTG (SB)-K-2017-05, MLTG (SB)-K-2017-06, MLTG (SB)-K-2017-07, MLTG (SB)-K-2017-08, MLTG(SB)-K-2017-09, MLTG (SB)-K-2017-10, MLTG (SB)-K-2017-11, MLTG(SB)-K-2017-12, MLTG (SB)-K-2017-13, Narayani and Greeshma.

Table 2: Continue...

Length (cm)	Induced Temperatures		Lethal Temperatures	
	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
2.1-3.0 cm	TCGS-1508, TCGS-1516, TCGS-1517, TCGS-1518, TCGS-1523, TCGS-1805, TCGS-1815, TCGS-1819, TCGS-1826, TCGS-1829, TCGS-1830, TCGS-1839, TCGS-1845, TCGS-1849, TCGS-1855, TCGS-1869, TCGS-1871, TCGS-1872, TCGS-1876, TCGS-1877,MLTG(SB)-K-2017-05, K-6 and Dharani.	TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517, TCGS-1520, TCGS-1521, TCGS-1523, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1814, TCGS-1815, TCGS-1816, TCGS-1818, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1824, TCGS-1825, TCGS-1831, TCGS-1838, TCGS-1851, TCGS-1853, TCGS-1855,TCGS-1869, TCGS-1877, ICGV-07286, ICGV-07390, MLTG(SB)-K-2017-01, MLTG(SB)-K-2017-02, MLTG(SB)-K-2017-10, K-6 and Dharani.	TCGS-1508, TCGS-1516, TCGS-1517, TCGS-1518, TCGS-1521, TCGS-1523, TCGS-1527, TCGS-1529, TCGS 1805, TCGS-1815, TCGS-1819, TCGS-1826, TCGS-1829, TCGS-1830, TCGS-1839, TCGS-1845, TCGS-1849, TCGS-1855, TCGS-1862, TCGS-1868, TCGS-1869, TCGS-1872, TCGS-1876, TCGS-1877, ICGV-07219, ICGV-07286, ICGV-07395, MLTG(SB)-K-2017-02, MLTG(SB)-K-2017-03, K-6 MLTG(SB)-K-2017-05 and Dharani.	TCGS-1511, TCGS-1517, TCGS-1520,TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1529, TCGS-1804, TCGS-1807,TCGS-1815, TCGS-1818, TCGS-1820, TCGS-1824, TCGS-1831, CGS-1851,TCGS-1853, TCGS-1869, Dharani and K-6.
3.1-4.0 cm	TCGS-1511, TCGS-1514, TCGS-1520, TCGS-1521, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1814, TCGS-1816, TCGS-1817, TCGS-1818, TCGS-1824, TCGS-1831, TCGS-1838, TCGS-1851, TCGS-1861, TCGS-1862, TCGS-1868, ICGV-05158, ICGV-07219, ICGV-07262, ICGV-07270, ICGV-7286, ICGV-07392, ICGV-07396, ICGV-07406, MLTG(SB)-K-2017-02, MLTG(SB)-K-2017-03, MLTG(SB)-K-2017-06, MLTG(SB)-K-2017-07 and MLTG(SB)-K-2017-08.	TCGS-1522, MLTG(SB)-K2017-06	TCGS-1511, TCGS-1520, TCGS-1522, TCGS-1528, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1816, TCGS-1817, TCGS-1818, TCGS-1820, TCGS-1824, TCGS-1825, TCGS-1831, TCGS-1838, TCGS-1851, ICGV-05158, ICGV-07262, ICGV-07392, ICGV-07396, ICGV-07406, MLTG(SB)-K2017-04, MLTG(SB)-K2017-06, MLTG(SB)-K2017-07, MLTG(SB)-K2017-08, MLTG(SB)-K2017-09 and MLTG(SB)K2017-13,	-

Table 2: Continue...

Length (cm)	Induced Temperatures		Lethal Temperatures	
	Root length (cm)	Shoot length (cm)	Root length (cm)	Shoot length (cm)
4.1-5.0 cm	TCGS-1522, TCGS-1804, TCGS-1813, TCGS-1820, TCGS-1822, TCGS-1825, TCGS-1853, ICGV-07296, ICGV-07337, ICGV-07395, ICGV-07404,ICGV-07408, MLTG(SB)-K-2017-01,MLTG(SB)-K-2017-04 & MLTG(SB)-K-2017-09		TCGS-1821, TCGS-1822, TCGS-1823,TCGS-1853, ICGV-07296, ICGV-07337, ICGV-07390, ICGV-07404, ICGV-07408, MLTG(SB)-K-2017-01 and MLTG (SB)-K-2017-12	-
5.1-6.0 cm	TCGS-1821, TCGS-1823,ICGV-07390, MLTG (SB)-K-2017-10, MLTG (SB)-K-2017-12 and MLTG (SB)-K-2017-13.		MLTG (SB) – K-2017-10.	-
> 6.1 cm	TCGS-1837		TCGS-1837.	-

with a general mean of 3.10 cm. The genotypes *viz.,*TCGS-1511, TCGS-1514, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1816, TCGS-1817, TCGS-1818, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1824, TCGS-1825, TCGS-1831,TCGS-1837, TCGS-1838,TCGS-1839, TCGS-1851, TCGS-1853, TCGS-1861, TCGS-1862, ICGV-05158, ICGV-07219, ICGV-07262, ICGV-07270, ICGV-07273, ICGV-07286, ICGV-07390, ICGV-07392, ICGV-07395, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07404, ICGV-07406, ICGV-07408, MLTG-01, MLTG-02, MLTG-04, MLTG-06, MLTG-07, MLTG-08, MLTG-09, MLTG-10, MLTG-12 and MLTG-13 exceeded the general mean.

3.2.2. Shoot length (cm)

Among groundnut genotypes, the mean shoot length under induced temperature ranged from 0.00 (TCGS-1826, ICGV-05155, ICGV-06423, ICGV-06424, ICGV-07222, ICGV-07225, ICGV-07240, ICGV-07245, ICGV-07247, ICGV-07262, ICGV-07235, ICGV-07273, ICGV-07395, ICGV-07337, ICGV-07406, MLTG-03, MLTG-09, MLTG-11 and Narayani) to 3.20 cm (TCGS-1522) with a general mean of 1.5 cm. The genotypes *viz.,*TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517,TCGS-1518, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1805, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1816, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1824, TCGS-1825, TCGS-1829, TCGS-1831, TCGS-1837, TCGS-1838, TCGS-1839, TCGS-1845, TCGS-1851, TCGS-1853, TCGS-1855, TCGS-1861, TCGS-1862, TCGS-1869, TCGS-1872, TCGS-1876, TCGS-1877, ICGV-05158, ICGV-07270, ICGV-07286, ICGV-07390, ICGV-07392, ICGV-07404, MLTG-01, MLTG-02, MLTG-06, MLTG-10, MLTG-11, MLTG-12 and Dharani exceeded the general mean.

3.3. Lethal temperature

3.3.1. Root length (cm)

Among groundnut genotypes, the mean root length under lethal temperature ranged from 0.00 (ICGV-05155, ICGV-06424, ICGV-07247 and ICGV-07273 to 6.9 cm (TCGS-1837) with a general mean of 2.70 cm. The genotypes *viz.,*TCGS-1508,TCGS-1511,TCGS-1518, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1527, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1816, TCGS-1817, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1823, TCGS-1824, TCGS-1825, TCGS-1826, TCGS-1829, TCGS-1830, TCGS-1831,TCGS-1837, TCGS-1838, TCGS-1851, TCGS-1853, TCGS-1862, TCGS-1876, ICGV-05158, ICGV-07262, I CGV-07390, ICGV-07392, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07404, ICGV-07406, ICGV-07408, MLTG-01, MLTG-02, MLTG-03, MLTG-04, MLTG-06,MLTG-07, MLTG-08, MLTG-09, MLTG-10, MLTG-12 and MLTG-13 exceeded the general mean.

3.3.2. Shoot length (cm)

Among groundnut genotypes, the mean shoot length under lethal temperature ranged from 0.00 (TCGS-1826, TCGS-1843, TCGS-1859, TCGS-1861, ICGV-06423, ICGV-06424, ICGV-07219, ICGV-07220, ICGV-07222, ICGV-07225, ICGV-07228, ICGV-07240, ICGV-07241, ICGV-07245, ICGV-07247, ICGV-07268, ICGV-07235, ICGV-07270, ICGV-07273, ICGV-07286, ICGV-07390, ICGV-07392, ICGV-07395, ICGV-07396, ICGV-07296, ICGV-07337, ICGV-07403, ICGV-07404, ICGV-07405, ICGV-07406, ICGV-7408, MLTG-02, MLTG-03, MLTG-04, MLTG-06, MLTG-08, MLTG-09, MLTG-11, Narayani and K-6 to 3.00 cm (TCGS-1522 and TCGS-1824) with a general mean of 1.00 cm. The genotypes *viz.,* TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517, TCGS-1518, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1528, TCGS-1529,TCGS-1804, TCGS-1805, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1816, TCGS-1817, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821,TCGS-1822, TCGS-1823, TCGS-1824, TCGS-1829, TCGS-1831, TCGS-1837, TCGS-1838, TCGS-1839, TCGS-1845, TCGS-1849, TCGS-1851, TCGS-1853, TCGS-1855, TCGS-1868, TCGS-1869, TCGS-1872, TCGS-1876, MLTG-10, MLTG-12, MLTG-13, Dharani and Greeshma exceeded the general mean (Figure 3).Earlier studies revealed that at the molecular level, one of the most extensivelycharacterized stress responses in higher plants is the synthesis of stress shock proteins. These proteins are synthesized under a variety of stresses such as high temperature (Sachs and Ho, 1986 and Key et al., 1981). Many of these proteins are known to protect the cell against the adverse effect of stress. The relevance of these stress proteins has been well characterized in several studies (Lin et al., 1984 and Krishnan et al., 1989). These proteins are synthesized when the genotype is exposed to a mild-lethal level of stress often, referred to as an induction stress. The ability of induced systems to tolerate several levels of stress signifies the importance of stress proteins (Vierling, 1991).

Promising climate resilient groundnut genotypes were identified through temperature induction response.

A total of forty groundnut genotypes were selected based on survival under lethal temperature. The best performing groundnut genotypes *viz.,* TCGS-1508, TCGS-1511, TCGS-1514, TCGS-1516, TCGS-1517, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1523, TCGS-1527, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809, TCGS-1810, TCGS-1813, TCGS-1814, TCGS-1815, TCGS-1817, TCGS-1818, TCGS-1819, TCGS-1820, TCGS-1821, TCGS-1822, TCGS-1824, TCGS-1825, TCGS-1829, TCGS-1831,TCGS-1837, TCGS-1838, TCGS-1839, TCGS-1845, TCGS-1851, TCGS-1853, TCGS-1855, TCGS-1868, TCGS-1869, TCGS-1872, TCGS-1876 and ICGV-07262. These genotypes could be utilized in the breeding programme as donors.

4. Conclusion

TCGS-1511, TCGS-1520, TCGS-1521, TCGS-1522, TCGS-1528, TCGS-1529, TCGS-1804, TCGS-1807, TCGS-1809 and TCGS-1810 were identified as best performing genotypes for both root and shoot lengths under induced temperature and lethal temperature. Further, these promising genotypes could be utilized in the breeding programme as donors to develop high yielding drought tolerant genotypes or can be further utilized to increase the seed to test in farmers' field for different yield and its related components under drought stress conditions.

5. Acknowledgement

This research was supported under the DST-SERB to the first author by the Department of Science and Technology –Science and Engineering Research Board, New Delhi is gratefullyacknowledged.

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