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Seedling growth study of chickpea (*Cicer arietinum* L.) under phytotronic conditions

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Abstract
An experiment was conducted out under phytotronic conditions in a growth chamber using a factorial completely randomized design (FCRD). For this investigation, 20 genotypes of chickpea were chosen. After 21 days, the effects of several temperature regimes (15/15 °C, 20/20 °C, 25/15 °C, 25/20 °C and 25/25 °C) on seedling growth were examined by noting numerous observations, including shoot and root length, seedling length, dry weight, and calculation of various stress indices. The genotypes PG 719 and PG 96006 and Digvijay performed better for seedling growth and had the maximum shoot length, root length, total length, and Dry matter stress tolerance index. Among all of the temperature regimes, seedling growth was found to be optimal at 15/15 °C followed by 20/20 °C.

Keywords: Chickpea, gram, temperature, seedling growth, indices

Introduction
The chickpea is a resilient, deeply rooted, dry land crop that can be grown to maturity in situations that would be unsuitable for most crops. Due to the deep-tap root structure of the chickpea, it can tolerate drought conditions. But, in current scenario, productivity of chickpea decreases due to several abiotic stresses. In a variety of such stress conditions, temperature is one of the key factors influencing crop growth, and it may reduce chickpea yield.

According to climate study and current production trends, the growing area for chickpeas is threatened by rising temperatures, and production may move to cooler places. In contrast, climate change may benefit crops in cooler locations in the short term before the optimum (20-26 °C) thresholds temperature stated by Devasirvatham *et al*. 2012 [5]. Up until temperature thresholds are achieved, temperature rises are anticipated to sustain the beneficial effects of elevated CO_2. Beyond these limits, even with increased CO_2, crop yields will decline. According to Shivprasad and Sundara (2005) [15], the ideal temperature for chickpea seedling growth characteristics is between 20 and 24 °C. Temperature stress is another most important factor for reducing dry weight of crop. There have been fewer attempts to extend these findings across the world's chickpea production areas, despite the classification of chickpea heat responses having been established (Krishnamurthy *et al*. 2011; Upadhyaya *et al*. 2011) [7, 17]. The sowing of chickpeas in the Rabi season will be postponed if the rainy season i.e. Kharif is prolonged as reported by Ali, 2004 [1]. There is a positive and substantial link between GSI and the shoot length, root length, and dry weight of chickpea seedlings and germination rate index of chickpea decreased at high temperature was also reported by Salehi (2012) [13]. For a crop to succeed, improved seed germination and seedling emergence are crucial requirements. Meena *et al*. (2014) [9] reported that relative saturation deficit is lower at 25°C due to optimum growth in chickpea. According to Essemine *et al*. (2010) [6], temperature reduced the growth of wheat seedlings. Effects of a plant's entire metabolic activity on seedling growth and development ultimately result in a decrease in growth indices.

In light of these factors, the objective of this research was to investigate the impact of increased temperature on the genotype-specific growth indices of chickpea seedlings.

Materials and Methods
At the Phytotron facility, PGI, MPKV, Rahuri, Maharashtra, India, the experiment was carried out in year 2015. Twenty chickpea genotypes, including PG 12110, Virat, PG 405, PG 12107, PG 625, Vijay, PG 9758, PG 96006, PG 0625-9, PG 717, PG 08108, PG 11117, Digvijay, PG 0906-1, PG 719, Vihar, PG 611, Vishal, PG 609-15-2, and ICC 4958, were chosen for seedling study were exposed to different temperature regimes viz; 15/15 °C, 20/20 °C, 25/15 °C, 25/20

°C and 25/25 °C in growing chambers 1, 2, 3, 4, and 5 under phytotronic conditions, respectively with two replications arranged in FCRD. As previously noted, independent applications of the thermo-treatments were made in various growth chambers and seed surface was cleaned three times with distilled water after being sterilized for five minutes with a 10% sodium hypochloride solution.

In a root trainer block type 150cc, 20/25 cell containing a mixture of cocopit, bhusa, and perlite with no nutritional value; five seeds of every variety were consistently sown. Every day, 5 ml of the Hoagland solution was added to each cavity with excellent drains and exposed to the temperature regimes mentioned as above upto twenty one days and light of 10000 foot candle was provided. The growth was continued for twenty one days and then seedlings were uprooted and observations on shoot length, root length, seedling length, dry matter of shoot and root, saturated weight and fresh weight of leaves were recorded and by using this information in below given formulas indices for seedling growth were estimated.

1. Plant Height Stress Index (PHSI)

$$\text{PHSI (\%)} = \frac{\text{Plant height of stressed plants}}{\text{Plant height of control plant}} \times 100$$

2. Root Length Stress Tolerance Index (RLSI):- (Sammar Raza *et al*., 2012) [14]

$$\text{RLSI (\%)} = \frac{\text{Root length of stressed plants}}{\text{Root length of control plants}} \times 100$$

3. Shoot Length Stress Tolerance Index (SLSI)

$$\text{SLSI (\%)} = \frac{\text{Shoot length of stressed plants}}{\text{Shoot length of control plants}} \times 100$$

4. Dry Matter Stress Tolerance Index (DMSI): (Sammar Raza *et al*., 2012) [14]

$$\text{DMSI (\%)} = \frac{\text{Dry matter of stressed plant}}{\text{Dry matter of control plant}} \times 100$$

5. Relative Saturation Deficit (RSD)

$$\text{RSD (\%)} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Turgid weight} - \text{dry weight}} \times 100$$

Critical differences were estimated following the standard statistical analysis of the data. Critical differences (C.D.) at 5% of significance were calculated whenever the results were significant. The Factorial Completely Randomized Block Design (FCRD) recommended by Panse and Sukhatme (1985) [11] was used to analyze recorded data.

Results and Discussion

Although seedling growth is primarily a genetically determined trait, it is also influenced by genotype and environmental factors. For the seedling, the environment of young plants is different from germination and accordingly environmental requirement or tolerance shows adaptations to juvenile life. Seedlings are often sensitive to light exposer, temperature regimes and desiccation during their juvenile stage. It often shows a rapid growth rate to give them a competitive advantage. In addition to the correlation of other metrics, such as dry matter accumulation, plant height, and root length, seedling growth also determines consistency and productivity of various varieties.

According to the results of the current study, plant dry matter, shoot length, root length, seedling length, and other measurements all gradually dropped from the non-stressed state to the stressed condition.

Significant differences between genotypes, temperature and their interaction impact were revealed by the data on shoot length and plant height stress tolerance index (Table 1). The shoot length was higher at 15/15 °C (14.90 cm) and lower at 25/25 °C (12.87 cm). The mean shoot length decreased with increasing the temperature. Considering mean of all temperature treatments, genotype PG 719 was recorded significantly higher shoot length (16.11 cm) followed by genotypes PG 625 (15.89 cm) and Digvijay (15.59 cm) while Vishal recorded significantly lower mean shoot length (11.25 cm).

Based on the shoot length of stressed and controlled seedlings (15/15 °C), the shoot length stress tolerance index is calculated. The plant height stress tolerance index (PHSI) also decrease with increasing the temperature. Considering mean of all temperature treatments, Genotype PG 719 (94.87) had a considerably higher mean plant height stress tolerance index (PHSI) than other genotypes while, Vishal (88.87) recorded significantly lower mean plant height stress tolerance index (PHSI). Same results were reported by Saensee *et al*. (2012) [12] and Tripathi *et al*. (2009) [16] that shoot length and shoot dry weight of wheat seedlings in eight varieties were considerably reduced by a high temperature of 35°C.

Temperature and genotypes interacted significantly, as evidenced by the results on root length and root length stress tolerance index (RLSI) (Table 2). As the temperature rose, the length of the roots shortened. The mean root length was higher at 15/15 °C (9.78 cm) and lower at 25/25 °C (8.09 cm). Considering mean of all temperature treatments, genotype PG 719 was recorded significantly higher mean root length (10.03 cm) followed by genotype PG 625 (9.90 cm) while, PG 12107 recorded significantly lower mean root length (7.32 cm).

The root length of stressed and controlled seedlings at (15/15 °C) is used to calculate the root length stress tolerance index. The root length stress tolerance index (RLSI) also decreases with increasing the temperature. Considering mean of all temperature treatments, the mean root length stress tolerance index (RLSI) was significantly higher in genotype PG 405 (93.18) over other genotypes while, genotype PG 12107 (86.21) recorded significantly lower mean root length stress tolerance index (RLSI). These outcomes are similar with the outcomes of Saensee *et al*. (2012) [12], Cohen and Tadmor (1968) [4] reported in wheat, the temperature range of 10–20 °C resulted in a two- to three-fold increase in the rate of root elongation and root length stress tolerance index (RLSI) was drastically dropped with rise in temperature.

Among the genotypes, temperature, and its interaction effect, the data on total seedling length and the seedling length stress tolerance index (SLSI) revealed significant variations (Table 3). With rising temperatures, the mean seedling length decreases. In comparison to 25/25 °C (20.96 cm) mean seedling length was greater at 15/15 °C (24.68 cm). Considering mean of all temperature treatments, genotype PG 719 was recorded significantly higher mean seedling length (26.14 cm) followed by genotype PG 625 (25.79 cm) while genotype PG 12107 recorded significantly lower seedling length (18.64 cm).

The total length of regulated (15/15 °C) and stressed seedlings is used to calculate the seedling length stress tolerance index. The seedling length stress tolerance index (SLSI) also decreased with increasing the temperature. Considering mean of all temperature treatments, the mean seedling length stress tolerance index (SLSI) was significantly higher in genotype PG 719 (93.60) followed by genotypes PG 625 (92.66) and PG 08108 (92.63) while, genotype PG 11117 (85.16) recorded significantly lower mean Seedling length stress tolerance index (SLSI). Findings of Tripathi *et al*. (2009) [16], Salehi (2012) [13], and Saensee *et al*. (2012) [12] are in agreement with these results as dry matter stress index, plant height stress index, root length stress index and germination stress index were significantly decreased with increase in water stress levels in all sunflower genotypes. Additionally, Mohoney (1991) [10] stated that peas grow best at temperatures between 15 °C – 20 °C. Except for DMSI for interaction, the data on total dry matter and dry matter stress tolerance index (DMSI) revealed significant differences across genotypes, temperature, and its interaction effect (Table 4). Mean dry matter content decreased as temperature increased. At 15/15 °C, the mean dry matter content was higher (0.72 g), while at 25/25 °C, it was lower (0.55 g). Considering mean of all temperature treatments, genotype PG 719 was recorded significantly higher total dry matter content (0.80 g) followed by genotypes Digvijay (0.79 g) and PG 08108 (0.78 g) while Vishal recorded significantly lower total dry matter (0.46 g) followed by genotype PG 12107 (0.48 g).

Dry matter stress tolerance index (DMSI) is based on total dry matter of controlled seedling (15/15 °C) and stressed seedling. With rising temperatures, the mean Dry matter stress tolerance index (DMSI) also went down. Considering mean of all temperature treatments, dry matter stress tolerance index (DMSI) was considerably greater in genotype Vijay (96.52) followed by genotypes PG 96006 (95.82) and PG 08108 (92.63) while genotype PG 12107 (73.90) recorded significantly lower dry matter stress tolerance index (DMSI). These findings concur with those of Tripathi *et al*. (2009) [16], Salehi (2012) [13], and Saensee *et al*. (2012) [12], who found that sunflower genotypes significantly decreased their dry matter stress index, plant height stress index, root length stress index, and germination stress index as water stress levels increased. Shivprasad and Sundara (2005) [15], Tripathi *et al*. (2009) [16] and Saensee *et al*. (2012) [12] additionally stated that temperature stress is most important factor for reducing dry weight of crop. McDonald and Paulsen (1997) [8] also reported that plant dry matter is optimum at 20/15°C. While comparing the yield loss of genotypes in stressed conditions to non-stressed conditions, Bruckner and Frohberg (1987) [2] and Clarke and McCaig (1982) [3] reported that DSI was actually the best technique for measuring the yield stability of genotypes.

The information shown in Table 5 revealed significant variations in temperature and genotypes but not in the interaction effect for relative saturation deficit (RSD). The mean relative saturation deficit (RSD) decreases with increasing the temperature. The mean relative saturation deficit (RSD) was higher at 15/15 °C (84.86) and lower at 25/25 °C (79.32) treatment. Considering mean of all temperature treatments, genotype ICC 4958 recorded the highest relative saturation deficit (87.55) over other genotypes which was at par with PG 96006 (87.02) and PG 611 (86.99) while, PG 9758 recorded significantly lower (74.04) mean relative saturation deficit (RSD). These results support those of Meena *et al*. (2014) [9], who found that relative saturation deficit is reduced at 25°C due to chickpea growth at its peak.

Table 1: Shoot length (cm) and plant height stress tolerance index (PHSI) of chickpea genotypes influenced by various temperatures regimes.

Sr. No.	Genotypes	Shoot Length (cm)						PHSI				
		Temperature Treatment (°C)					Mean	Temperature Treatment (°C)				Mean
		15/15	20/20	25/15	25/20	25/25		20/20	25/15	25/20	25/25	
1	PG 12110	14.25	13.95	13.30	12.95	12.60	13.41	97.90	93.33	90.87	88.42	92.63
2	Virat	12.40	11.80	11.40	11.00	10.65	11.45	95.17	91.95	88.72	85.90	90.43
3	PG 405	13.65	13.05	12.65	12.15	11.65	12.63	95.62	92.68	89.05	85.38	90.68
4	PG 12107	12.30	11.75	11.25	10.85	10.45	11.32	95.53	91.47	88.21	84.97	90.05
5	PG 625	16.75	16.25	15.85	15.45	15.15	15.89	97.02	94.63	92.24	90.45	93.58
6	Vijay	16.80	15.85	15.15	14.80	14.45	15.41	94.35	90.18	88.09	86.01	89.66
7	PG 9758	15.05	14.50	14.05	13.15	12.00	13.75	96.34	93.35	87.38	79.72	89.20
8	PG 96006	15.95	15.30	15.15	14.85	14.25	15.10	95.93	94.99	93.11	89.35	93.34
9	PG 0625-9	15.25	14.75	14.30	13.75	13.45	14.30	96.81	93.85	90.29	88.30	92.31
10	PG 717	12.55	12.00	11.65	10.95	10.65	11.56	95.64	92.84	87.26	84.88	90.15
11	PG 08108	16.20	15.85	15.25	15.05	14.65	15.40	97.84	94.14	92.91	90.43	93.83
12	PG 11117	17.00	14.65	14.20	13.80	13.60	14.65	86.19	83.54	81.18	80.00	82.73
13	Digvijay	16.45	16.15	15.70	15.00	14.65	15.59	98.18	95.44	91.19	89.06	93.47
14	PG 0906-1	15.40	15.15	14.65	14.15	13.85	14.64	98.39	95.15	91.90	89.95	93.85
15	PG 719	16.80	16.60	16.15	15.75	15.25	16.11	98.81	96.13	93.75	90.77	94.87
16	Vihar	12.85	12.25	11.65	11.15	10.75	11.73	95.34	90.66	86.77	83.66	89.11
17	PG 611	16.05	15.65	14.75	14.55	14.00	15.00	97.51	91.91	90.67	87.23	91.83
18	Vishal	12.35	11.85	11.15	10.65	10.25	11.25	95.95	90.28	86.24	83.00	88.87
19	PG 609-15-2	15.00	14.60	14.05	13.60	12.30	13.91	97.32	93.67	90.69	82.00	90.92
20	ICC 4958	15.00	14.55	13.65	13.15	12.80	13.83	97.01	90.98	87.66	85.34	90.25
	Mean	14.90	14.33	13.80	13.34	12.87	13.85	96.14	92.56	89.41	86.24	91.09
		Variety		Treatment		Interaction		Variety	Treatment		Interaction	
	SEm(±)	0.060		0.030		0.133		0.55	0.24		1.09	
	CD (1%)	0.222		0.111		0.494		2.06	0.91		NS	

Table 2: Root length (cm) and root length stress tolerance index (RLSI) of chickpea genotypes influenced by various temperatures regimes.

Sr. No.	Genotypes	Root Length (cm)						RLSI				
		Temperature Treatment (°C)					Mean	Temperature Treatment (°C)				Mean
		15/15	20/20	25/15	25/20	25/25		20/20	25/15	25/20	25/25	
1	PG 12110	9.60	9.25	8.90	8.60	8.45	8.96	96.36	92.71	89.58	88.02	91.67
2	Virat	8.85	8.30	8.05	7.45	7.00	7.93	93.79	90.98	84.20	79.14	87.03
3	PG 405	9.50	9.35	9.10	8.70	8.25	8.98	98.44	95.81	91.60	86.87	93.18
4	PG 12107	8.25	7.70	7.35	6.85	6.45	7.32	93.48	89.46	83.31	78.58	86.21
5	PG 625	10.65	10.30	10.05	9.45	9.05	9.90	96.72	94.38	88.74	84.99	91.21
6	Vijay	10.50	10.00	9.70	9.15	8.65	9.60	95.26	92.40	87.15	82.38	89.30
7	PG 9758	10.00	9.40	8.95	7.90	7.45	8.74	93.98	89.45	79.07	74.54	84.26
8	PG 96006	10.55	10.05	9.55	9.00	8.65	9.56	95.29	90.52	85.31	82.00	88.28
9	PG 0625-9	10.30	9.70	9.15	8.90	8.55	9.32	94.17	88.88	86.46	83.05	88.14
10	PG 717	8.40	8.05	7.75	7.45	7.05	7.74	95.84	92.27	88.71	83.95	90.19
11	PG 08108	10.25	9.75	9.55	9.25	8.65	9.49	95.12	93.18	90.24	84.39	90.73
12	PG 11117	10.05	9.65	9.10	8.80	8.35	9.19	96.02	90.55	87.57	83.15	89.32
13	Digvijay	10.35	10.05	9.40	9.05	8.75	9.52	97.10	90.82	87.44	84.55	89.98
14	PG 0906-1	10.30	9.80	9.55	9.15	8.75	9.51	95.14	92.75	88.90	85.01	90.45
15	PG 719	10.75	10.45	10.00	9.60	9.35	10.03	97.21	93.02	89.31	86.98	91.63
16	Vihar	8.35	8.05	7.85	7.25	6.95	7.69	96.43	94.05	86.87	83.27	90.15
17	PG 611	10.45	10.05	9.55	9.25	9.00	9.66	96.17	91.38	88.52	86.12	90.55
18	Vishal	8.40	8.15	7.95	7.55	7.15	7.84	97.03	94.66	89.90	85.14	91.68
19	PG 609-15-2	10.10	9.75	9.15	8.30	7.65	8.99	96.56	90.64	82.19	75.76	86.29
20	ICC 4958	10.00	9.55	8.65	8.05	7.65	8.78	95.53	86.50	80.54	76.56	84.78
	Mean	9.78	9.37	8.97	8.49	8.09	8.94	95.78	91.72	86.78	82.72	89.25
		Variety		Treatment		Interaction		Variety	Treatment		Interaction	
	SEm (±)	0.060		0.030		0.135		0.95	0.43		1.91	
	CD (1%)	0.226		0.112		0.502		3.60	1.59		NS	

Table 3: Total seedling length (cm) and seedling length stress tolerance index (SLSI) of chickpea genotypes influenced by various temperatures regimes.

Sr. No.	Genotypes	Seedling Length (cm)						SLSI				
		Temperature Treatment (°C)					Mean	Temperature Treatment (°C)				Mean
		15/15	20/20	25/15	25/20	25/25		20/20	25/15	25/20	25/25	
1	PG 12110	23.85	23.20	22.20	21.55	21.05	22.37	97.28	93.08	90.35	88.26	92.24
2	Virat	21.25	20.10	19.45	18.45	17.65	19.38	94.59	91.53	86.82	83.06	89.00
3	PG 405	23.15	22.40	21.75	20.85	19.90	21.61	96.78	93.97	90.10	85.99	91.71
4	PG 12107	20.55	19.45	18.60	17.70	16.90	18.64	94.66	90.55	86.16	82.28	88.41
5	PG 625	27.40	26.55	25.90	24.90	24.20	25.79	96.90	94.53	90.88	88.32	92.66
6	Vijay	27.30	25.85	24.85	23.95	23.10	25.01	94.70	91.03	87.73	84.62	89.52
7	PG 9758	25.05	23.90	23.00	21.05	19.45	22.49	95.40	91.80	84.06	77.65	87.23
8	PG 96006	26.50	25.35	24.70	23.85	22.90	24.66	95.66	93.21	90.00	86.42	91.32
9	PG 0625-9	25.55	24.45	23.45	22.65	22.00	23.62	95.74	91.84	88.74	86.18	90.63
10	PG 717	20.95	20.05	19.40	18.40	17.70	19.30	95.71	92.60	87.83	84.49	90.16
11	PG 08108	26.45	25.60	24.80	24.30	23.30	24.89	96.79	93.76	91.87	88.09	92.63
12	PG 11117	27.05	24.30	23.30	22.60	21.95	23.84	89.83	86.13	83.55	81.15	85.16
13	Digvijay	26.80	26.20	25.10	24.05	23.40	25.11	97.76	93.66	89.74	87.31	92.12
14	PG 0906-1	25.70	24.95	24.20	23.30	22.60	24.15	97.08	94.16	90.66	87.94	92.46
15	PG 719	27.55	27.05	26.15	25.35	24.60	26.14	98.19	94.92	92.02	89.29	93.60
16	Vihar	21.20	20.30	19.50	18.40	17.70	19.42	95.75	91.99	86.80	83.49	89.51
17	PG 611	26.50	25.70	24.30	23.80	23.00	24.66	96.98	91.70	89.82	86.79	91.32
18	Vishal	20.75	20.00	19.10	18.20	17.40	19.09	96.39	92.05	87.72	83.86	90.01
19	PG 609-15-2	25.10	24.35	23.20	21.90	19.95	22.90	97.01	92.45	87.27	79.49	89.06
20	ICC 4958	25.00	24.10	22.30	21.20	20.45	22.61	96.42	89.18	84.81	81.82	88.06
	Mean	24.68	23.69	22.76	21.82	20.96	22.78	95.98	92.21	88.35	84.83	90.34
		Variety		Treatment		Interaction		Variety	Treatment		Interaction	
	SEm (±)	0.094		0.047		0.210		0.50	0.23		1.01	
	CD (1%)	0.350		0.174		0.778		1.90	0.84		3.76	

Table 4: Total dry matter (g) and dry matter stress tolerance index (DMSI) of chickpea genotypes influenced by various temperature regimes.

Sr. No.	Genotypes	Dry matter (g)						DMSI				
		Temperature Treatment (°C)					Mean	Temperature Treatment (°C)				Mean
		15/15	20/20	25/15	25/20	25/25		20/20	25/15	25/20	25/25	
1	PG 12110	0.78	0.73	0.68	0.60	0.55	0.67	94.30	87.54	77.27	70.75	82.46
2	Virat	0.62	0.55	0.49	0.44	0.40	0.50	89.40	78.50	71.20	65.21	76.08
3	PG 405	0.71	0.65	0.61	0.59	0.54	0.62	92.46	86.74	83.25	76.80	84.81
4	PG 12107	0.61	0.55	0.45	0.40	0.38	0.48	91.49	74.68	66.88	62.55	73.90
5	PG 625	0.75	0.72	0.68	0.64	0.62	0.68	97.07	91.56	85.99	83.03	89.41
6	Vijay	0.75	0.74	0.72	0.75	0.70	0.73	97.91	95.52	99.47	93.16	96.52
7	PG 9758	0.64	0.57	0.52	0.49	0.43	0.53	88.65	80.61	76.19	66.68	78.03
8	PG 96006	0.76	0.75	0.72	0.75	0.71	0.74	98.07	94.36	98.20	92.66	95.82
9	PG 0625-9	0.73	0.67	0.64	0.61	0.57	0.64	92.35	87.70	83.55	78.65	85.56
10	PG 717	0.75	0.70	0.66	0.63	0.50	0.65	93.27	87.73	83.18	67.04	82.81
11	PG 08108	0.82	0.80	0.78	0.76	0.72	0.78	98.00	95.55	92.38	87.85	93.45
12	PG 11117	0.71	0.67	0.65	0.62	0.58	0.65	94.55	92.25	87.58	81.24	88.90
13	Digvijay	0.84	0.81	0.79	0.75	0.73	0.79	97.16	94.45	90.03	86.77	92.10
14	PG 0906-1	0.75	0.64	0.57	0.55	0.46	0.59	86.19	76.93	73.45	61.55	74.53
15	PG 719	0.85	0.82	0.80	0.78	0.75	0.80	96.73	95.02	92.56	88.42	93.18
16	Vihar	0.58	0.53	0.48	0.45	0.41	0.49	92.30	83.87	78.70	70.48	81.34
17	PG 611	0.70	0.68	0.65	0.62	0.57	0.65	96.60	92.95	88.26	81.07	89.72
18	Vishal	0.58	0.51	0.43	0.41	0.35	0.46	89.76	74.58	71.85	61.28	74.37
19	PG 609-15-2	0.81	0.78	0.63	0.62	0.59	0.68	96.73	78.13	76.17	72.93	80.99
20	ICC 4958	0.67	0.60	0.55	0.54	0.51	0.57	90.04	82.62	80.73	75.93	82.33
	Mean	0.72	0.67	0.63	0.60	0.55	0.63	93.65	86.57	82.84	76.20	84.82
		Variety		Treatment		Interaction		Variety	Treatment		Interaction	
	SEm (±)	0.008		0.004		0.018		1.54	0.69		3.09	
	CD (1%)	0.031		0.015		0.068		5.82	2.58		NS	

Table 5: Relative saturation deficit (RSD) of chickpea genotypes influenced by various temperature regimes.

Sr. No.	Genotypes	Temperature Treatment (°C)					Mean
		15/15	20/20	25/15	25/20	25/25	
1	PG 12110	84.94	89.70	85.77	86.64	84.19	86.25
2	Virat	86.95	85.24	81.09	75.01	73.72	80.40
3	PG 405	84.81	76.87	67.89	79.64	83.92	78.63
4	PG 12107	77.00	82.68	80.95	78.36	69.86	77.77
5	PG 625	86.99	86.48	86.75	81.01	77.46	83.74
6	Vijay	87.77	87.00	85.94	84.59	79.73	85.01
7	PG 9758	81.11	78.09	72.27	67.47	71.25	74.04
8	PG 96006	83.97	89.23	88.28	87.60	86.00	87.02
9	PG 0625-9	84.14	78.90	77.28	79.00	80.07	79.88
10	PG 717	88.45	83.24	82.93	91.19	76.69	84.50
11	PG 08108	85.59	86.66	86.12	81.62	80.90	84.18
12	PG 11117	85.34	84.84	84.84	80.72	83.88	83.93
13	Digvijay	85.83	87.30	86.52	84.61	83.27	85.50
14	PG 0906-1	83.94	84.20	84.24	81.14	79.81	82.67
15	PG 719	85.61	85.22	87.19	84.27	80.43	84.54
16	Vihar	81.26	73.72	78.63	79.43	73.75	77.36
17	PG 611	87.57	87.19	89.25	85.99	84.96	86.99
18	Vishal	80.43	81.95	82.60	74.26	70.48	77.95
19	PG 609-15-2	86.18	83.41	84.50	81.31	79.61	83.00
20	ICC 4958	89.38	89.17	86.12	86.59	86.52	87.55
	Mean	84.86	84.05	82.96	81.52	79.32	82.54
		Variety		Treatment		Interaction	
	SEm (±)	1.420		0.710		3.175	
	CD (1%)	5.306		2.637		NS	

15/15 ºC

20/20 ºC

25/15 ºC

25/20 ºC

25/25 ºC

Plate 1: Growth of different genotypes of chickpea seedlings under various temperature regimes in growth chambers

Conclusion

The exposure of 15/15 °C temperature followed by 20/20 °C was found better in seedling growth studies of chickpea than other temperature regimes. In this experiment, genotype PG 719 showed better performance for seedling growth followed by PG 96006 and Digvijay whereas Vishal and PG 12107 showed poor performance. Dry matter content was also recorded highest in genotype PG 719 and Vijay recorded highest Dry matter stress tolerance index. Outcomes of this trial also showed that various growth indices were excellent tools for early screening of heat-tolerant and susceptible genotypes of chickpea. Genotypes PG 719, PG 96006, and Digvijay are demonstrated to be promising temperature stress tolerant genotypes at seedling growth stage of the crop based on seedling growth performance; consequently, they might be employed in breeding initiatives to develop improved varieties of chickpea.

References

1. Ali M. Role of pulses in crop diversification in India. In: 'Role of legumes in crop diversification and poverty reduction in Asia. Proc. of the Joint CLAN Steering Committee Meeting.10–12, ICRISAT, India, 2004, 42–56.
2. Bruckner PL, Frohberg RC. Stress tolerance and adaptation in spring wheat 1. Crop Science. 1987 Jan;27(1):31-6.
3. Clarke JM, McCaig TN. Evaluation of techniques for screening for drought resistance in wheat 1. Crop science. 1982 May;22(3):503-6.
4. Cohen Y, Tadmor NH. Effects of Temperature on the Elongation of Seedling Roots of Some Grasses and Legume 1. Crop Science. 1969 Mar;9(2):189-92.
5. Devasirvatham V, Tan DK, Gaur PM, Raju TN, Trethowan RM. High temperature tolerance in chickpea and its implications for plant improvement. Crop and Pasture Science. 2012 Jul 9;63(5):419-28.
6. Essemine J, Ammar S, Bouzid S. Effect of temperature on root and shoot development in wheat seedlings during early growth stage. Asian Journal of Plant Sciences. 2010;9(6):375.
7. Krishnamurthy L, Gaur PM, Basu PS, Chaturvedi SK, Tripathi S, Vadez V, *et al*. Large genetic variation for heat tolerance in the reference collection of chickpea (*Cicer arietinum* L.) germplasm. Plant Genet. Resour. 2011;9(1):59–69.
8. McDonald GK, Paulsen GM. High temperature effects on photosynthesis and water relations of grain Legumes. Pl. and Soil. 1997;196:47-58.
9. Meena NL, Kishwar A, Dehmukh PS, Aruna T. Effect of heat stress on physio-biochemical characteristics of chickpea (*Cicer arietinum*) genotypes. Indian Journal of Agricultural Sciences. 2014;84(3):401-6.
10. Mohoney J. Response of temperate crop legumes. South eastern Australian J Agril. Res. 1991;42:31-43.
11. Panse VC, Sukhatme PV. Statistical methods for Agriculture Workers. ICAR, New Delhi, 4th Edition; c1985.
12. Saensee K, Machikowa T, Muangsan N. Comparative performance of sunflower synthetic varieties under drought stress. Int. J. Agric. Biol. 2012;14:929-934.
13. Salehi M. The study of drought tolerance of lentil (Lens culinaris Medik) in seedling growth stages. Int J Agron Plant Prod. 2012;3(1):38-41.
14. Sammar Raza, M.A., Jamil, M., Ijaz, M., Khan, M.A., Evaluating drought stress tolerance cultivars in Wheat (*Triticum aestivum*). Russian Journal of Agricultural and Socio-Economic Sciences. 2012;12(12):41-46.
15. Shivprasad B, Sundara KS. Effect of temperature on seedling growth under impeding conditions: Thesis submitted to Indian Agricultural Research Institute, New Delhi; c2005.
16. Tripathi N, Verma RS, Verma O. Effect of heat and moisture stress treatments on seedling growth of wheat (*Triticum aestivum* L.) varieties. Indian Journal of Agricultural Research. 2009;43(4):257-62.
17. Upadhyaya HD, Dronavalli N, Gowda CL, Singh S. Identification and evaluation of chickpea germplasm for tolerance to heat stress. Crop Science. 2011 Sep;51(5):2079-94.