

## Traits imparting drought tolerance in some chickpea genotypes

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### ABSTRACT

Chickpea (*Cicer arietinum* L.) genotypes viz. RSG 143-1, CSJD 884, RSG 888, RSG 895, RG 896, RSG 945, RSG 957, RSG 974 and Phule G 5 were grown under moisture stress conditions in field for studying certain physiological traits related to drought tolerance. The study revealed that the genotype RSG 143-1 showed drought tolerance at par with Phule G 5 amongst the genotypes tested. These genotypes, RSG 143-1 and Phule G 5 showed drought tolerance due to higher level of osmolytes in leaf cell sap, better water relation indices, lower membrane injury, higher root biomass and higher photosynthetic rate as compared to other genotypes. All these physiological parameters resulted in lower drought susceptibility index (DSI) values of these genotypes.

**Key words:** Chickpea, Drought Susceptibility Index, Drought tolerance, Membrane injury, Osmolytes

Chickpea (*Cicer arietinum* L) is an important pulse crop, mostly grown as post rainy season crop under rainfed conditions and consequently faces stress at the time of pod formation resulting in drastic reduction of productivity by more than 20%. Because of this, its average productivity is limited to about 773 kg/ha (Ali and Kumar 2003). There is wide gap between the potential and realizable yield in chickpea. The traits for adaptation to stress conditions and associated with yield are distributed randomly among genotypes (Basu and Singh 2003). Thus, efforts to identify the genotypes having drought tolerance traits and pyramiding them in good agronomic background is important for finding a solution to fill the yield gap. With this view, an experiment was conducted to study certain physiological traits related to drought tolerance in selected chickpea genotypes.

### MATERIALS AND METHODS

Nine chickpea genotypes viz., RSG 143-1, CSJD 884, RSG 888, RSG 895, RG 896, RSG 945, RSG 957, RSG 974 and Phule G 5 were grown in randomized block design with three replications under moisture stress (pre-sowing irrigation only) and non-stress (Irrigated as and when required) conditions during *rabi* 2004–05 and 2005–06. The soil was loamy sand with field capacity 10.5% at -0.1 bar and wilting coefficient 2.49% at -15 bar at 0-15 cm soil depth. Grain yield was measured under moisture stress and non-stress conditions for computing drought susceptibility index, DSI (Fischer and Maurer 1978). All other parameters were measured under moisture stress conditions to assess the response of different

genotypes to drought. Fifth, sixth and seventh leaves from the top of the main shoot were sampled at pod formation stage for measuring relative water content (RWC), leaf moisture retention index, LMRI (Gupta and Sharma 2006), specific leaf area (SLA) and membrane injury (Sullivan 1972). Soluble sugars (Dubois *et al.* 1951), free amino acids (Moore and Stein 1948), proline (Bates *et al.* 1973) and osmotic potential (Osmometer, Wescor, USA) were measured to study the osmolytes concentration of the genotypes under the stress conditions. Photosynthetic rate was measured on fully expanded upper leaves between 10.00-11.00 AM using Infra Red Gas Analyzer (LCA-2, ADC). Water expense efficiency (WEE) was calculated following Sandhu *et al.* (1992). Seed nitrogen was measured by acid digestion method using Auto Nitrogen Analyzer (TICATOR, USA). The data were statistically analyzed.

### RESULTS AND DISCUSSION

The soil moisture reduced to 56% of the initial moisture at flowering stage and further reduced to 34% at pod formation stage (Table 1). The atmospheric drought was high as shown by the vapour pressure saturation deficit (VPSD, 37 mili bar) during initial crop growth period. It was high (33-39 mili bar) again after flowering. Thus, the crop faced soil as well as atmospheric drought, particularly after flowering and pod formation stages.

Drought susceptibility index at the drought intensity of 0.34 was significantly lower (0.52) in RSG 143-1, followed by RSG 888 and RSG 974 (Table 2). The low DSI value showed tolerance to drought in these genotypes (Gupta *et al.* 2000).

Leaf moisture retention index at pod formation stage was significantly higher in RSG 143-1 (0.89) followed by Phule G 5 (0.83) and RSG 945 (0.81) (Table 2). LMRI has been reported as one of the drought tolerance indices in chickpea (Gupta

Table 1. Vapour Pressure Saturation Deficit (VPSD) and soil moisture (0-100 cm depth) at different growth stages

Days after sowing	Stress condition		Non-stress conditions	VPSD (mili bar)
	Soil moisture (%)	% of initial	Soil moisture (%)	
Initial	10.53	-	10.61	37.00
40	8.22	78	11.53	18.89
80	5.92	56	6.28	19.53
120	3.57	34	8.34	33.11
130	2.97	28	3.38	39.21

Note: Irrigation at 35, 85 and 115 days after sowing.

**Table 2.** DSI, water relation indices and osmolytes in chickpea genotypes under water stress

Genotype	DSI	LMRI	RWC (%)	Osmotic potential (m mol/kg H <sub>2</sub> O)	Soluble sugars (mg/g)	Soluble amino acids (mg/g)	Proline (mg/g)
RSG 143-1	0.52	0.89	66	715	69.82	6.22	2.67
CSJD 884	1.43	0.73	64	670	62.35	4.00	2.00
RSG 888	0.75	0.63	59	671	61.00	3.68	2.08
RSG 895	1.00	0.79	64	646	62.00	3.58	1.85
RSG 896	1.63	0.54	65	655	55.37	3.45	1.89
RSG 945	1.08	0.81	62	650	59.15	3.70	1.90
RSG 957	0.94	0.67	60	660	58.40	3.70	1.93
RSG 974	0.75	0.70	64	680	64.00	4.10	2.00
Phule G 5	0.99	0.83	70	690	68.70	5.86	2.60
CD at 5%	0.16	0.05	3.9	11.2	3.49	0.33	0.08
CV (%)	9.38	3.58	3.8	6.3	5.9	5.5	6.2

and Sharma 2006). The higher values of LMRI in RSG 143-1, Phule G 5 and RSG 945 indicated greater tolerance of these genotypes to drought.

Relative water content in leaves under moisture stress conditions at pod formation stage was maximum in Phule G 5 (70%) followed by RSG 143-1 (66%) (Table 2). Thus, these genotypes have better mechanism to maintain moisture status to support normal metabolism.

Osmotic potential of leaf cell sap was significantly higher in RSG 143-1 (715 m mol/kg H<sub>2</sub>O) followed by Phule G 5 (690 m mol/kg H<sub>2</sub>O). This observation is supported by higher level of cellular osmolytes like soluble sugars, amino acids and proline in these genotypes (Table 2). The osmotic adjustment in plants plays an important role in drought tolerance (Morgan 1984). Higher level of osmolytes has been reported to maintain desired water status in plants (Gupta *et al.* 1994). Higher level of osmolytes in response to drought could be one of the causal mechanisms for imparting drought tolerance in these genotypes.

Per cent membrane injury under the stress was significantly lower in RSG 143-1 (53%) followed by Phule G 5 (57%) (Table 3). Membrane stability is important for normal plant metabolism (Sullivan 1972). Thus, the genotypes showing lesser injury under stress may sustain the normal metabolism and hence show tolerance to stress.

RSG 143-1 and RSG 974 showed maximum specific leaf area (120 cm<sup>2</sup>/g dry leaf) amongst the genotypes and were at par with RSG 896 (116 cm<sup>2</sup>/g dry leaf), RSG 957 and Phule G 5 (118 cm<sup>2</sup>/g dry leaf) (Table 3). Leaf area was higher in RSG 143-1 (5.26 cm<sup>2</sup>) followed by RSG 945 (4.77 cm<sup>2</sup>) and Phule G 5 (4.69 cm<sup>2</sup>) (Table 3). Leaf area is generally reduced under stress and lower SLA (or higher specific leaf weight) has been reported as a good indicator of higher photosynthesis (Gupta *et al.*

**Table 3.** Some leaf and seed based characters in chickpea genotypes in response to water stress

Genotype	Membrane injury (%)	SLA (cm <sup>2</sup> /g)	Area/leaf (cm <sup>2</sup> )	Photosynthetic rate (µmol/m <sup>2</sup> /s)	Seed nitrogen (%)	Water imbibition (g/seed)*
RSG 143-1	53	120	5.26	14.19	3.04	0.179
CSJD 884	62	113	3.31	08.80	2.80	0.140
RSG 888	69	099	3.71	08.83	2.85	0.141
RSG 895	68	105	3.81	08.75	2.81	0.131
RSG 896	70	116	3.64	08.77	2.83	0.130
RSG 945	71	108	4.77	08.90	2.77	0.143
RSG 957	69	118	3.50	08.69	2.76	0.145
RSG 974	60	120	3.75	09.00	2.70	0.155
Phule G 5	57	118	4.69	12.75	2.95	0.175
CD at 5%	2.03	5.2	0.47	3.77	0.16	0.018
CV (%)	10.5	2.8	7.7	7.60	5.2	5.3

\*In 48 h

1989) and grain yield (Katiyar and Katiyar 1994). At the same time, it is well known that leaves are important photosynthetic organs and physiologically active leaves are essential for development of fruits (Sinha 1986). Thus, higher SLA in RSG 143-1 and Phule G 5 may enhance harvesting of light and photosynthetic activity under stress. This is evident by higher photosynthetic rate and nitrogen level at pod formation stage in RSG 143-1 (Table 3). In addition, RSG 143-1 possessed higher water imbibition capacity (Table 3), higher root biomass, improved grain yield and higher water expense efficiency under stress (Table 4).

Thus, it is evident that RSG 143-1 behaves as most drought tolerant genotype under test. The drought tolerant

**Table 4.** Root dry matter, grain yield and water expense efficiency in chickpea genotypes under water stress

Genotype	Root dry wt. (g/plant)*	Grain yield (q/ha)		WEE (kg/ha cm)
		Non-stress	Stress	
RSG 143-1	1.58	11.11	9.15	63.2
CSJD 884	1.11	07.68	3.92	35.1
RSG 888	1.10	07.68	5.72	39.5
RSG 895	1.09	07.02	4.66	38.0
RSG 896	1.10	08.82	3.92	35.1
RSG 945	0.95	07.51	4.74	38.3
RSG 957	1.00	13.23	8.98	60.0
RSG 974	1.05	12.09	8.98	60.0
Phule G 5	1.45	08.66	5.72	39.5
CD at 5%	0.08	1.29	1.05	3.60
CV (%)	10.3	9.81	12.10	13.59

\*At flowering stage in pots.

behaviour of these genotypes appears to be due to higher osmolytes level in cell sap, better water relation indices (RWC, LMRI), lower membrane injury, higher root biomass and higher photosynthetic rate, all of which resulted in maintaining lower DSI value. Hence, RSG 143-1 appears to be a good genotype for use as a drought tolerant parent.

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