

Leaf moisture retention index (LMRI): an easily measurable physiological characteristic for drought tolerance in chickpea

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ABSTRACT

Studies were conducted to identify physiological traits related to drought tolerance in chickpea (*Cicer arietinum* L.). Eleven genotypes were grown in the field under moisture stress conditions, particularly at the pod formation stage by withholding irrigation. The genotypes like RSG 143-1 retaining higher relative water content (64%) and lower membrane injury (35.5%) under stress also showed higher leaf moisture retention index (0.85) and lower drought susceptibility index (0.95%). However, grain yield did not correlate with these traits. The LMRI is an easily measurable physiological trait reflecting leaf turgor maintenance under stress and, hence, may be related to drought tolerance of the genotype.

Key words: Chickpea, *Cicer arietinum*, Drought tolerance, Leaf moisture retention index, Membrane injury, Relative water content

Chickpea (*Cicer arietinum* L.) is the most important pulse crop in India. The average productivity of the crop is quite less than its potential yield. Among several yield constraints, abiotic stress factors are the most limiting ones. It has been reported that about 26% of the world's total arable land suffers from the problem of drought (1). Direct selection for higher grain yield under drought prone environments has not been successful and, hence, a need is felt to study the physiology of drought tolerance and its application in crop improvement programmes under limited water conditions. A wide range of morphological, physiological and biochemical traits have been identified that contribute to yield improvement in drought prone environments (10). However, their use in breeding programme has been limited due to laborious, time consuming and costly screening techniques. The present study was undertaken to identify simple physiological traits for identification of drought tolerant genotypes.

MATERIALS AND METHODS

Eleven chickpea genotypes (IPC 97-67, RSG 143-1, Phule G 9425-25, Phule G 96006, CSJ 302, CSJ 12, CSJ 73, Phule G 5, C 235, CSJD 884 and RSG 888) were grown in a randomized block design with three replications in loamy sand during Rabi 2003-04 in plots of 4 x 1.8 m size under moisture stress conditions. The field capacity of the soil was 8.62% at -1 bar and the wilting coefficient was 2.49% at -15 bars. The stressed plots were irrigated to field capacity prior to sowing and thereafter,

no irrigation was given as against non-stress plots where irrigation was given as and when required. Soil moisture was measured gravimetrically. Non-stressed plots were used to measure grain yield only for computation of drought susceptibility index (DSI) (2). The observations were recorded at podding stage on the 5th, 6th and 7th leaves from the top of the main shoot on relative water content (RWC), per cent membrane injury (9), leaf moisture retention index (LMRI) and specific leaf area (SLA). Seed filling rate, as seed yield per day seed fill (kg/ha) was measured by dividing the grain yield with seed filling period. LMRI was measured by weighing freshly sampled leaves (six leaves per sample, Fr). The sample leaves were left in open, allowing them to loose moisture at ambient temperature and humidity for 5 hrs and then weighed (Sr). Finally, the leaves were dried to their constant weight (Dr) by keeping in an oven at 80°C for 48 hours. The LMRI was

$$LMRI = \frac{Sr - Dr}{Fr - Dr}$$

calculated as under:

The data were statistically analyzed for variance

RESULTS AND DISCUSSIONS

The soil moisture in the stressed plots gradually reduced to 74% of the field capacity at flowering stage and further to about 40% at the podding stage (3.43% soil moisture) showing that there was an effective soil drought. The atmosphere was also dry at the podding stage as shown by relatively higher vapour pressure saturation deficit (19.9 mbars) resulting in high drought intensity (0.61).

Leaf moisture retention index (LMRI) at the podding stage varied in different genotypes ranging from a very low value (0.49) in RSG 888 to a very high value (0.86) in IPC 97-67, which was at par with RSG 143-1 (0.85) and Phule G 9425-25 (0.84). Variations in LMRI may be a reflection of the genotypic capability for retaining sufficient leaf moisture due to their inherent cuticular protection and osmotic status. High water content and water retention capacity have been reported to be useful traits in screening drought tolerant chickpea genotypes (6).

The genotypes with higher LMRI under stress also

Table 1. Physiological variations in different chickpea genotypes under moisture stressed conditions

Genotype	LMRI	DSI	Membrane Injury (%)	RWC (%)	SLA (cm ² g ⁻¹)	Seed fill rate (kg ha ⁻¹)	Grain yield (q ha ⁻¹)
IPC 97-67	0.86	0.95	42.8	63	112	11.2	6.5
RSG 143-1	0.85	0.95	35.8	64	120	15.3	9.2
Phule G 9425-25	0.84	0.97	42.5	64	107	6.9	5.2
Phule G 96006	0.77	0.97	33.8	65	117	8.7	5.4
CSJ 302	0.77	0.90	37.2	66	120	17.1	10.1
CSJ 12	0.74	0.92	40.1	63	121	14.7	8.4
CSJ 73	0.72	0.96	41.5	66	121	19.1	10.9
Phule G 5	0.72	1.03	30.7	62	122	12.4	7.3
C 235	0.70	1.11	53.9	62	124	10.3	6.2
CSJD 884	0.64	0.99	48.0	56	133	15.0	9.0
RSG 888	0.49	1.12	50.3	21	131	12.2	7.9
CD at 5%	0.05	0.05	3.8	4.1	7.3	2.2	1.4
CV (%)	3.4	2.7	5.4	3.9	3.5	4.3	3.1

maintained lower drought susceptibility index and higher relative water content (Table 1), which may be due to higher concentration of osmotic solutes in leaf tissues as reported in earlier studies (4). Variability in accumulation of organic solutes has been reported to be associated with drought tolerance through osmotic adjustment under water limited environment (5). Also, the tolerant genotypes have been reported to show lesser reduction in RWC in moth bean (3).

The membrane injury under stress was lower in the genotypes having higher LMRI values (Table 1). Higher membrane stability under stress may support metabolic stability to sustain the growth and development under water limited conditions. Lower membrane injury in drought tolerant genotypes under stress has been reported in chickpea (4) and other crops as well (7, 8).

The genotypes varied in their grain yield and seed filling rate. The seed fill rate was more or less a reflection of the yield potential of the genotype. Higher LMRI along with higher RWC and lower membrane injury under stress appeared to impart drought tolerance in chickpea genotypes which probably resulted in better survival of these genotypes under water stress conditions. However, none of these physiological parameters was found to be significantly associated with grain yield under the limited moisture environment (Table 2). Hence, for the sustainability of yield under moisture stress, it is necessary that drought tolerance traits are transferred in the cultivars with higher grain yield potential.

The LMRI appeared to be an important characteristic to identify the genotypic ability for drought tolerance. This is also easily measurable in short time in large number of genotypes involving simple equipments like electronic balance and an oven. However, the study needs further confirmation

Table 2. Correlation of DSI with some physiological characters under moisture stress conditions in chickpea

	LMRI	RWC	SLA	Membrane injury	Grain yield	DSI
LMRI	1.0000	0.8239*	-0.6717*	-0.3567*	0.3086	-0.6432*
RWC		1.0000	-0.5299*	-0.3803*	0.3044	-0.7474*
SLA			1.0000	0.2953	-0.3064	0.3499*
Membrane Injury				1.0000	-0.3695*	0.4518*
Grain Yield					1.0000	-0.3400
DSI						1.0000

* Significant at 5% level

involving larger number of genotypes and environments before this trait is recommended for screening drought tolerant genotypes.

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