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Physiological Responses of Chickpea Genotypes under Varying Salinity Levels

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A B S T R A C T

A pot experiment was conducted under natural conditions of screen house to evaluate the effect of saline irrigation given at flowering stage on plant water status functioning and their tolerance in two chickpea (*Cicer arietinum*) genotypes viz. HC-3 and CSG-8962. The pots containing dune sand were saturated with Cl^- dominated saline irrigation at (40-45 DAS) to maintain EC_{iw} of 2.0, 4.0 and 6.0dS m^{-1} as compared to control. The control plants were irrigated with distilled water. The water potential (Ψ_w) of leaves, osmotic potential (Ψ_s) of leaves and roots and RWC of leaves and roots decreased significantly with increase in saline irrigation level from control to 6.0 dS m^{-1} at flowering stage.HC-3 showed more decline in water potential of leaves and osmotic potential of leaves and roots and RWC of leaves and rootsas compared to CSG-8962. Hence, the mechanism of salt tolerance was comparatively better in the HC-3 than in CSG-8962 as found from the physiological traits studied.

Introduction

Salt stress in soil or water is one of the major abiotic stresses limiting crop productivity and affecting about 95 million hectares of land worldwide. Whereas, in India, salt affected soil is about 6.73 Mha consisting of nearly 2.96 mha saline and 3.77 mha sodic soil. Salinity limited the growth and development of plant by altering their morphological and physiological attributes and production in most of the arid and semi-arid regions of the world (Kandil *et al.,* 2012). Crops growing in arid and semi-arid regions suffer tremendously due to insufficient and regular distribution of precipitation as a result of which the crop plants relies extensively on irrigation water and a considerable proportion of underground water in most of these regions is of poor quality hence, immensely affecting the growth and yield of different agricultural crops in such areas.

Chickpea is an important pulse crop growing in arid and semi-arid regions of the country but owing to poor quality of water/ soil, the productivity of this crop is not optimal under such conditions. Chickpea (*Cicer arietinum*), belonging to family Fabaceae, is an ancient self-pollinated leguminous crop growing since

7000 BC, in different area of the world (Tekeoglu *et al.,* 2000) but its cultivation is mainly concentrated in arid and semi-arid environments such South Asia, West Asia, North Africa, East Africa, Southern Europe, North and South America, and Australia (Arefian *et al.,* 2014; Flowers *et al.,* 2010). Chickpea acquires its importance as source of food for both humans as well as for livestock. Chickpea plays an important role in nitrogen fixation and hence, helps in maintaining soil fertility, particularly in the arid and low rainfall area (Roy *et al.,* 2010).

In recent decades considerable improvements with respect to morphological and physiological traits have been made in different agricultural crops for salinity tolerance. However, not much findings have been reported for salinity tolerance in chickpea. Hence, the present investigation was conducted to study the physiological responses of different chickpea varieties under varying levels of salinity.

Materials and Methods

The study was conducted in the screen house at the Department of Plant, Physiology, CCS Haryana Agricultural University, Hisar. The study consisted of two chickpea genotypes *i.e.* CSG-8962 (salt tolerant) and HC-3 grown in pots filled with the dune sand (93.3% sand + 3.0 % slit + 3.7 % clay, saturation capacity 25 %, pH 8.2, ECe_2 0.8 dS m^{-1} at 25 ºC, 10.3 mg (N) kg^{-1}, 2.5 mg (P) kg^{-1}, 180 mg (K) kg^{-1}). The seeds before sowing were surface sterilized and were inoculated with effective *Rhizobium culture* (Ca 181).

Each pot was supplied with equal quantity of N_2 free nutrient solution at a regular interval of 15 days. The chloride dominated Hoagland solutions were prepared by using chloride salts of Na^+, Ca^{2+}, Mg^{2+} and sulfate salt of Mg. Four salinity levels (control, 2.0, 4.0 and 6.0 dS m^{-1}) were applied at 40-45 days after sowing (DAS) with Na (Ca^{2+} + Mg^{2+}) and Ca^{2+}: Mg^{2+} ratio at 1:1 and 1:3, respectively, whereas $Cl:SO_4^{2-}$ was maintained at 7:3 ratio. While, the sampling was done at 80-85 days after sowing (DAS).

Water potential of leaves was measured with the help of pressure chamber (Model 3005, Soil Moisture Equipment Corporation, Santa Barbara, CA, USA), between 8 AM to 10 AM during sunny days and the osmotic potential (Ψs) of leaves and roots was determined using vapour pressure osmometer (Model 5100-B, Wescor, Logan, USA). Whereas, the relative water content (RWC) of leaves and roots was measured according to Weatherley (1950) method.

Results and Discussion

The water potential (Ψ_w) of leaves and osmotic potential of leaves and roots decreased significantly in both the genotypes. Whereas, chickpea variety HC-3 showed more negative values Ψ_w of leaves *i.e.* from -0.42 to -0.49 MPa as compared to -0.44 to -0.54MPa in CSG-8962, respectively (Table 1).

The osmotic potential (Ψ_s) of leaves decreased from -0.58 to -1.12 and -0.72 to -1.28 MPa in HC-3 and CSG-8962, respectively (Table 2). Similarly, osmotic potential (Ψ_s) of roots also decreased from -0.56 to -0.81 in HC-3 and -0.58 to -0.88MPa in CSG-8962, respectively with an increase in salinity levels over control to 6.0 dS m^{-1} (Table 3). Relative water content (RWC) of leaves also decreased significantly from 9.2 to 28.8 % and 8.5 to 24.5 % in CSG-8962 and HC-3 genotypes respectively (Figure 1). Similarly, significant decrease from 5.5 to 29.5 % and 4.3 to 23.2 % in relative water content in roots was also observed in both the chickpea varieties *i.e.* CSG-8962 and HC-3, respectively with increasing saline irrigation levels (Figure 2).

Table.1 Effect of saline irrigation on water potential in leaves of chickpea genotypes

EC_{iw}	Control	2	4	6	Mean
HC-3	0.42	0.44	0.45	0.49	0.45
CSG-8962	0.44	0.45	0.46	0.54	0.48
Mean	0.43	0.44	0.46	0.51	
CD at 5%	Genotype = 0.01, Salinity = 0.02, Genotype x Salinity = NS				

Table.2 Effect of saline irrigation on osmotic potential in leaves of chickpea genotypes

EC_{iw}	Control	2	4	6	Mean
HC-3	0.58	0.87	0.98	1.12	0.89
CSG-8962	0.72	0.97	1.09	1.28	1.01
Mean B	0.65	0.92	1.03	1.20	
CD at 5%	Genotype = 0.01, Salinity = 0.02, Genotype x Salinity = 0.03				

Table.3 Effect of saline irrigation on osmotic potential in roots of chickpea genotypes

EC_{iw}	Control	2	4	6	Mean
HC-3	0.56	0.58	0.75	0.81	0.67
CSG-8962	0.58	0.68	0.8	0.88	0.73
Mean	0.57	0.63	0.77	0.84	
CD at 5%	Genotype = 0.01, Salinity = 0.02, Genotype x Salinity = 0.03				

Fig.1 Effect of saline irrigation on relative water content (RWC %) in leaves of chickpea genotypes

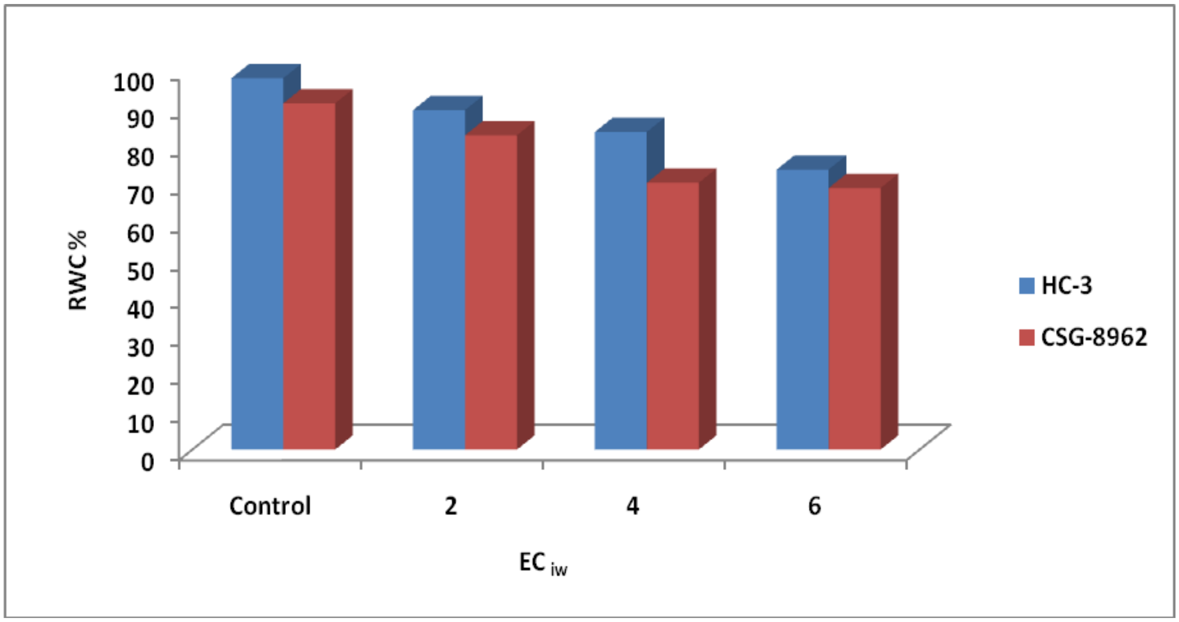
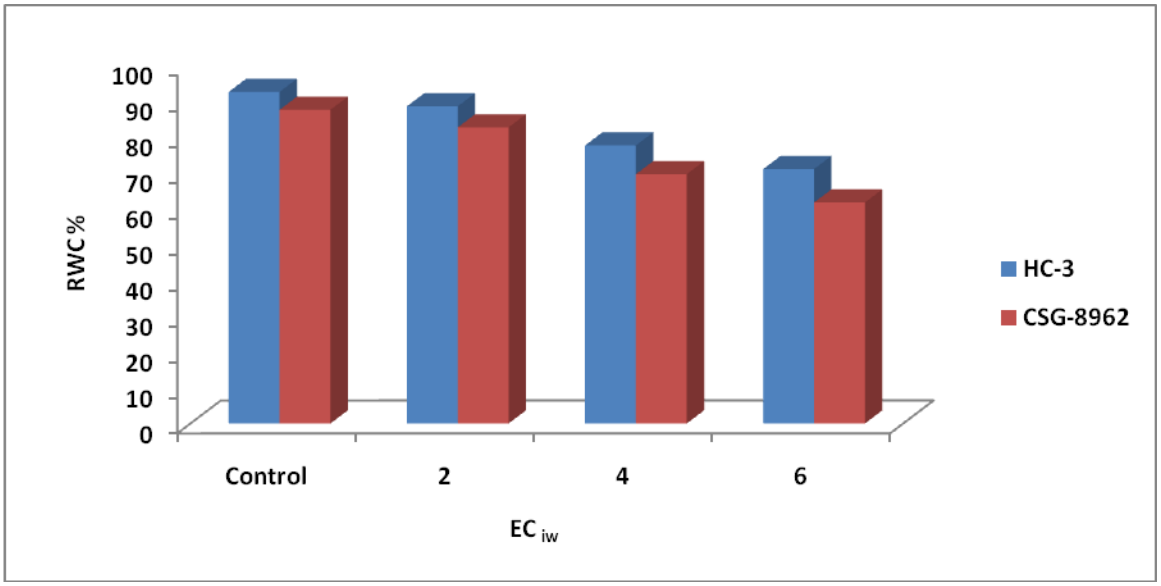


Fig.2 Effect of saline irrigation on relative water content (RWC %) in roots of chickpea genotypes



The possible reason for decreasing water and osmotic potential may be that the availability of water to the growing tissue becomes a limiting factor under saline conditions even in the presence of moisture in the soil resulting in what is termed as "Physiological drought". Water uptake by plants hence, attains importance under saline conditions. Plants cope up salinity by lowering their osmotic potential through accumulation of ions and compatible organic solutes. This is accompanied by a decline in water potential. Degree of decline in ψ_w and ψ_s depends upon the salinity resistance status of crop genotypes and accordingly these are able to absorb water from the rhizosphere (Singh, 2010). Salinity is one of the major stress which adversely affect many physiological and biochemical processes like ionic imbalance, water status, carbon allocation and its utilization (Zhu, 2001), lipid peroxidation and enzyme levels (Nandwal *et al.*, 2000) which culminate in yield reduction. Salt stress causes increase in osmotic potential of rooting medium as result of high solute content (Geetanjali and Neera, 2008), subsequently the water potential and osmotic potential decreased and cell turgor pressure increased with increased salinity (Parida and Das, 2005). Hence, it can be concluded that there was more reduction in water potential and osmotic potential in CSG-8962 as compared to HC-3. Therefore, HC-3 showed comparatively better performance than CSG-8962 on the basis of various physiological traits related to plant water relations under saline irrigation conditions. Hence, it can be recommended that the variety HC-3 could be further used in crop improvement programmes of salinity tolerance of chickpea.

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