

GENOTYPIC VARIATION OF CHICKPEA (*CICER ARIETINUM* L.) GROWN UNDER ADEQUATE AND K DEFICIENT STRESS IN HYDROPONICS CULTURE

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We evaluated growth response and potassium utilization efficiency of 10 chickpea cultivars grown under adequate (3.0 mM) and deficient (0.3 mM) K supply in hydroponics. Cultivars were grown for one month to study growth and physiological parameters relating tolerance against K deficiency. Cultivars differed significantly in biomass production, shoot K concentration, uptake and use efficiency at both levels of K supply. Shoot and root biomass production was significantly decreased due to K deficiency stress. Reduction in shoot dry matter varied significantly among cultivars and efficient cultivars showed minimum reduction in shoot dry matter due to K deficiency. Efficient K utilized cultivars (C-612, C-44, 93081) produced higher biomass as indicated by significant positive correlation ($r = 0.84$, $P < 0.01$) between SDM and K use efficiency. Positive and significant correlation ($r = 0.92$, $P < 0.01$) between SDM and Na uptake suggested dependence of SDM production on Na uptake at adequate as well as deficient levels of K supply. The results indicated significant genetic differences in K utilization efficiency among chickpea cultivars which can be exploited for breeding efficient cultivars to be grown under low K soils especially in low input sustainable agriculture.

Key words: Chickpea, potassium, genetic variations, nutrient use efficiency

INTRODUCTION

Chick pea (*Cicer arietinum* L.) is grown as a winter crop in the Indo-Pak subcontinent, which accounts for nearly 85 % of the area sown to the crop world wide. It is an important dry land pulse crop of arid and semi arid tropics, low yield of chickpea are often due to soil water and nutrient stresses. Identification and selection of nutrient efficient cultivars as a low cost, low input technology, is considered one of the most effective approaches for improving crop production in resource poor environment.

However, very little or no use of K fertilizer along with slow release of mineral-K to soil solution, impels for K fertilization especially of high K requiring crops. Non-availability at time and sporadic responses of crop are major factors responsible for low fertilization by farmers. Hence strategies should be aimed to increase its use efficiency in agriculture.

Plant species differ extensively in the uptake, translocation, and use of mineral elements (Clark, 1983). Remarkable genetic differences in K uptake and utilization efficiency in field crop have been reported earlier by several scientists (Siddiqui & Glass, 1981; Gill *et al.*, 1997). Although most of these differences are under genetic control, yet their expression may be altered dramatically when plants are grown under different environments e.g. nutrient deficiency stress. Selection and use of germplasm with the ability to grow under low K condition will enhance productivity in K deficient soils. Hence, the experiment was conducted to evaluate the chickpea genotypes for their relative tolerance against K deficiency stress.

MATERIALS AND METHODS

The experiment was conducted in a wire house. Mean temperature during growth period at 2:00 pm was between 27 and 35° C. Seeds of chickpea cultivars (a) C727, b) C 612, c) C 447, d) CM 88, e) CM 72, f) 90313, g) 90122, h) Paidar 91 and i) Punjab 91) were collected from Ayub Agricultural Research Institute, Faisalabad. Seeds were germinated in polyethylene-lined iron trays, containing pre-washed riverbed sand. Trays were kept moist with distilled water till transplanting. Two weeks old uniform sized seedlings were transplanted in foam plugged holes of thermopal sheets, floating on Johnson's nutrient solution (Johnson's *et al.*, 1957) with out K, in two polyethylene lined iron tubs. The solution, in tubs, was modified according to K treatments by adding potassium sulfate to maintain 0.3 (deficient) and 3.0 mM K (adequate), respectively. The pH of the solution was monitored and maintained at 5.5 ± 0.5 with HCl or NaOH as required. Completely randomized factorial design was (Steel and Torrie, 1980) with 8 repeats of each cultivar. Plants were harvested four weeks after transplanting and washed with distilled water. Harvested plants were separated into shoots and roots and were dried at 70°C for 48 hours to record dry matter production. Dried plant samples were ground to 40-mesh before digesting their 0.5 g portion with 10 ml of di-acid mixture (perchloric acid and nitric acids) (Miller, 1998). Potassium concentration in plant digest was estimated by Flame photometer (Jenway PFP-7). Potassium uptake was calculated by multiplying shoot K

concentration with shoot dry matter, while utilization efficiency was calculated by dividing K concentration with dry matter. Data recorded was analyzed statistically and Duncan Multiple Range Test (DMR) was employed to compare treatment means.

RESULTS AND DISCUSSION

Biomass production

Statistical analysis of data revealed significant effects of K levels (K), cultivars (C) and K X C interaction on shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), root shoot ratio (RSR) and potassium stress factor (PSF) (Table 2 and Fig. 1). General plant health can be guessed on the basis of a number of growth parameters. Amongst different parameters, SDM is considered to be the most

Potassium stress factor (KSF) is calculated as percent reduction in SDM production due to K deficiency in growth medium, and is considered a useful parameter in evaluating relative tolerance of crop cultivars against nutrient deficiency (Ahmad, 1998, Ahmad et al., 2001). Cultivars with higher values of KSF are considered unsuitable for growing under K limiting conditions while cultivars with low KSF values are considered most suitable for low input sustainable agricultural systems. In this study, KSF of cultivars varied from 10 % (C-612) to 60% (90313) (Fig. 1). Although KSF is good indicator of relative tolerance of cultivars against nutrient deficiency stresses, yet it is not considered a good selection criterion for breeding nutrient efficient cultivars. In this experiment, for example, cultivar 90313 showed maximum reduction in SDM due to K deficiency; however its efficiency for biomass

Table 2. Growth performance of ten chickpea cultivars grown at adequate and deficient levels of K supply

Cultivars	Shoot Dry Matter (g/plant)		Root Dry Matter (g/plant)		Root Shoot Ratio		Shoot K concentration (mg g ⁻¹)		Shoot K uptake (mg plant ⁻¹)	
	K Levels		K Levels		K Levels		K Levels		K Levels	
	0.3 mM K	3.0 mM K	0.3 mM K	3.0 mM K	0.3 mM K	3.0 mM K	0.3 mM K	3.0 mM K	0.3 mM K	3.0 mM K
C 727	0.72 c	1.33 b	0.30 a-c	0.48 bc	0.41 b	0.36 bc	17.95 bc	36.94 bc	12.89 bc	49.14 b
C 612	1.00 a	1.07 c	0.36 a	0.41 cd	0.38 bc	0.39 bc	20.85 b	39.44 a	19.99 ab	42.01 b
C 44	0.96 a	1.45 b	0.36 ab	0.54 b	0.37 bc	0.37 bc	22.23 a	36.28 bc	21.25 a	52.64 b
CM 88	0.44 d	0.75 d	0.18 d	0.22 e	0.41 b	0.29 d	21.14 ab	29.67 d	9.39 d	23.54 d
CM 72	0.65 c	0.95 c	0.27 c	0.34 d	0.41 b	0.35 b-d	18.14 bc	39.71 a	11.84 c	37.84 bc
90313	0.77 bc	1.90 a	0.28 bc	0.78 a	0.37 bc	0.41 b	16.28 b-e	36.46 bc	12.45 bc	69.13 a
93081	0.91 ab	1.42 b	0.32 a-c	0.36 d	0.35 c	0.25 e	16.76 b-d	36.44 bc	15.17 ae	51.78 b
90122	0.74 bc	0.96 c	0.26 c	0.26 e	0.34 cd	0.27 d-f	18.60 bc	35.56 c	13.84 b	34.13 c
Paidar 91	0.72 c	1.07 c	0.34 ab	0.37 d	0.48 a	0.35 c	17.24 b-d	38.04 ab	12.48 bc	40.51 b
Punjab 91	0.72 c	1.07 c	0.25 c	0.34 d	0.35 c	0.32 c-e	16.02 b-e	35.80 c	11.55 c	38.45 bc
K mean	0.96 B	1.20 A	0.29 B	0.41 A	0.39 A	0.34 B	18.52 B	35.13 A	14.09 B	42.81 A

Means with different letter (s) differ significantly according to Duncan's multiple range test (P=0.05)

sensitive plant response parameter to nutrient deficiency and is given a pivotal place in screening experiment (Fageria *et al.*, 2001, Römer and Schenk, 1998). This study described a considerable variation in SDM production among chickpea cultivars at both K levels (Table 2 and Fig. 1) indicated by significant K X C interaction (Table 2). Cultivar 90313 proved to be most responsive to K application in term of SDM production. Genetic differences for SDM under K stress were also reported by Figdore *et al.*, (1989) in tomato strains and Gill *et al.*, (1997) in wheat cultivars.

production at both levels of K supply makes it most suitable for low K conditions and suitable choice for farmers. Root dry matter production by chickpea cultivars decreased 1.4 folds as K level decreased 10 times. However, reduction in RDM is quite lower compared to reduction in SDM indicated by an increase in RSR (Table 2). Root: shoot ratio measures the partitioning of biomass between root and shoot. Gill *et al.*, (1997) was also reported variations in RSR among wheat genotypes at deficient K level.

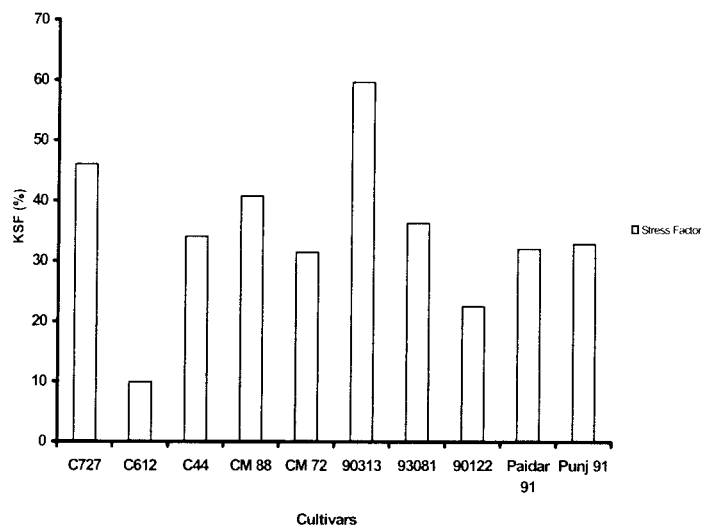


Fig 1. Potassium stres factor (Percent reduction in SDM) of chickpea cultivars

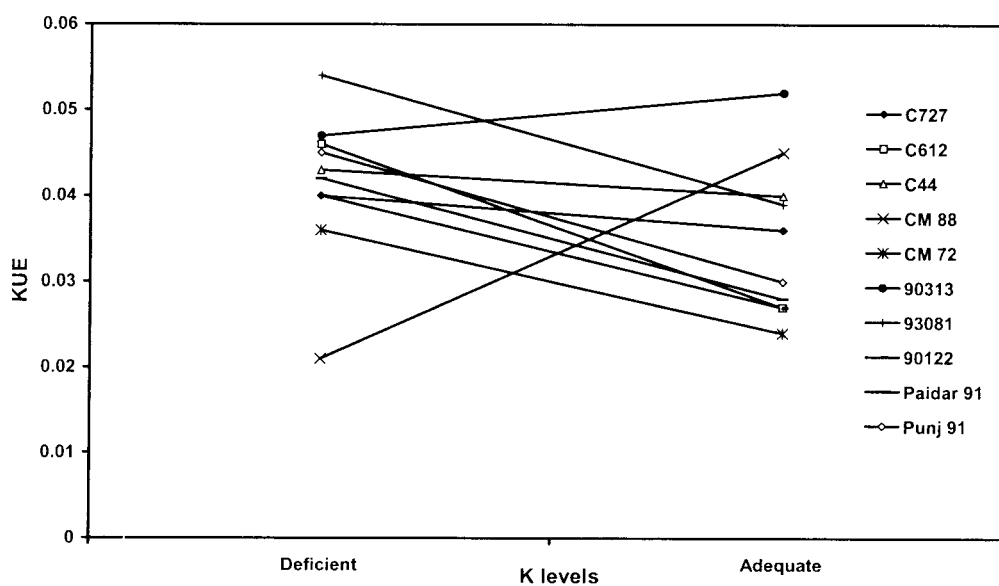


Fig. 2. Potassium use efficiency of chickpea cultivars grown at adequate and deficient levels of K supply

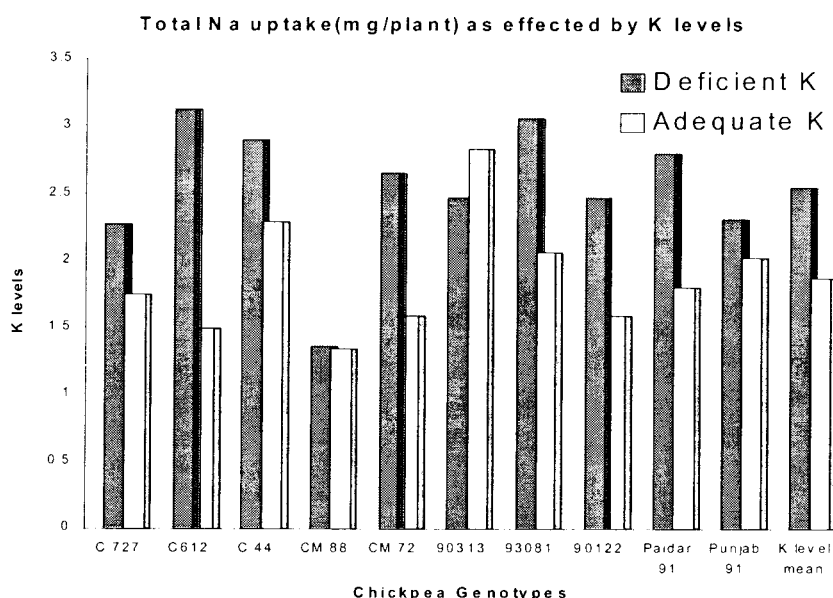


Fig. 3. Total (shoot + root) Na⁺ uptake in Chick Pea Genotypes

The correlation values (r) values between SDM and other various growth parameters, at both levels of K supply, is presented in (Table 1). Root dry matter, K uptake and K use efficiency showed positive and significant effect on SDM at both treatments. Sodium uptake also correlated positively with SDM production at both levels of K supply showing its role in biomass production and possible substitution for K as reported by Mengel and Kirby (2001).

Table 1. Correlation of SDM production with different parameters at adequate and deficient K supply

Parameters	Correlation values (r)	
	Deficient K	Adequate K
Root dry matter	0.87 **	0.93**
Root shoot ratio	-0.37	0.48
K concentration	0.1	0.7*
K uptake	0.89**	0.95**
K utilization efficiency	0.83**	0.62*
Na uptake	0.90**	0.92**

Potassium Concentration, Uptake and Utilization Efficiency

There were significant main and interactive effects of cultivars and K levels on K concentration, uptake and use efficiency (Table 2 and Fig. 2). Shoot concentration of plant indicates the efficiency of a plant to absorb nutrient from deficient growth medium Ashraf *et al.*, (1997). Increasing K concentration ten fold in the growth medium resulted in a 2 fold increase in shoot K

concentration. Potassium concentration in shoots of low K level genotypes had poor relation with their root dry matter ($r = 0.87$) which is contrary to many observations that plant species and genotypes with larger root biomass can accumulate higher nutrients in their shoots. Genotypes with small concentration of certain mineral nutrients and a high rate of organic matter synthesis are the ones that are considered highly nutrient efficient Saurbeck *et al.*, (1990). Varietal mean across both K levels indicated that cultivar 90313 had the largest uptake (40.74 mg/plant). Genetic differences for K uptake under differential k levels were also reported by Cassman *et al.*, (1989) in cotton, Gill *et al.*, (1997) in wheat and Guoquan *et al.*, (2003) in sweet potatoes.

Nutrient use efficiency is generally considered to be resulted from either a better ability in uptake of nutrients or better efficiency in using nutrients already available in the tissue (Blume, 1988). In this experiment, both i.e. uptake and use efficiency had positive correlation ($r=0.83$) with SDM as well as for each other ($r=0.75$). This suggests possibility of combining these two parameters to improve growth response of chickpea cultivars to applied K Sattelmacher *et al.*, (1994). Since both these parameters showed considerable genetic influence, it may be possible to increase chickpea yield by breeding for high KUE. Data revealed non significant differences in cultivars for KUE however, KUE differed significantly due to K X C interaction (Fig. 3). These cultivar X environment interactions are very important in

developing crop cultivars (Kang, 1998). These interactions are broadly grouped into two categories; qualitative and quantitative interactions. Comparisons such as CM-88 versus CM-72 or C-612 versus C-727 are qualitative or cross over interactions, while comparisons such as cultivar 90313 versus CM-72 or 90313 versus CM 88, where lines do not intersect, are quantitative or non crossover interactions (Fig. 2). These crossover interactions are considered more important than non crossover interactions due to their non additive and non separable nature.

Sodium Uptake

Data regarding Na was given in (Fig. 3). Total uptake of sodium was significantly affected by K treatments and genotypes. Mean total Na uptake was higher at deficient K level ($2.54 \text{ mg plant}^{-1}$) compared to adequate level ($1.87 \text{ mg plant}^{-1}$). The varieties mean across the two K level showed that genotype 90313 had the highest Na uptake as compared to all other genotypes. The similar results for genetic differences in terms of Na uptake had also been reported by Figdore *et al.*, (1989) in tomato strains.

CONCLUSIONS

Chickpea cultivars differed considerably in their growth response, K uptake and utilization efficiency under both K treatments. Potassium uptake, use efficiency significantly correlated with SDM indicating important role in biomass production. Cultivars efficient in K uptake and use efficiency such as C-612, C-44 and 90313, accumulated higher biomass at both K levels as indicated by significant positive correlation ($r>0.78$). However, verification of solution culture results is warranted under field situation.

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