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Morpho-Chemical Responses of Gram (*Cicer arietinum* L.) to Salinity and Nitrogen

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Abstract: The research work reported here was carried out to evaluate the effect of salinity and nitrogen on two gram varieties (Punjab-91 and C-44 in pots with three salinity levels 3.5 (control), 7.5 and 11.5 dS m^{-1} and four nitrogen levels i.e., 60, 75 and 90kg N ha^{-1} as urea It was observed that plant height increased as the amount of urea increased under 3.5 dS m^{-1}. At higher salinity levels plant height showed retrogressive effect. Number of pod/plant were the maximum when 60 and 75 kg ha^{-1} urea was applied. But pod plant decreased at higher salinity levels sharply. Biomass of plant also increased with the addition of urea. Number of seeds/ pod were maximum at 3.5 dS m^{-1} with 60 and 75 kg N ha^{-1} urea. Number of seeds pod, yield/ plant and 100 seed weight were the maximum when 60 kg N ha^{-1} urea was added in saline soils. As for as amount of K^+ and Na^+ are concerned the maximum amount of K^+ was observed in leaves while it was minimum in shoots. Urea decreased K^+ and Na^+ ion uptake in saline soils. Nitrogen percentage in seeds also increased with the addition of urea. But it decreased when 90 kg N ha^{-1} urea was added in each salinity level.

Key words: Salinity, *Cicer arietinum*, morpho-chemical responses

Introduction

Agricultural production is the back bone of the economy of Pakistan, but unfortunately it could not cope with the challenging need of the country. There are so many factors which are responsible for the low production of the crops. Besides the others, one is the soil salinity. According to the latest figure of 1998 salt affected soil in Pakistan was 6.67 mha (Qureshi, 1998) and is increasing day by day. The climate of Pakistan is semi rid to arid where high rate of evaporation was observed as a consequence of which natural soil salinization. Soil salinity is also a serious problem in areas where under ground brackish water of high salt content is the only source of water available for irrigation (Rashid, 1996). Soil salinity has rendered many fertile areas in Pakistan unfit for cultivation. The magnitude of damage and gravity of situation is very alarming and salinity is constantly corroding the land at a formidable rate. Due to lack of proper drainage system and low rainfall, non saline soils are gradually becoming salinized to varying degrees. Sodium salts commonly found in saline soils are the most harmful for majority of plants. Saline soils contain excessive amount of soluble salts such as chlorides and sulphates of sodium, potassium, calcium and magnesium (Flowers *et al.* (1977). Salts are usually most damaging to young plant but not necessarily at the time of germination, although high salt concentration can slow seed germination by several days or completely inhibit it. Salinity level decreased chlorophyll content and stomatal conductance (Ashraf and Bhatti, 2000). Salinity affects photosynthesis, not only due to its effect on stomatal closure but also due to other non-stomatal effects like ultra structural damage and decrease in chlorophyll content (Malesse and Caesar, 1992 and Ashraf and Naqui, 1996).With the increase in population, effective utilization of saline soils has become necessary, either by reclamation or growing some salt tolerant crops.

A number of institutions has been attempting to develop and apply new methods and techniques for the management and reclamation of salt affected soils. The objective is to minimize the salinity to which plant roots are exposed. However, cost in terms of money, energy and water is very high. Therefore, an alternative method was considered that is to grow such crops which show resistant to salinity. Keeping in view the above facts present work was conducted to assess the effect of salinity and nitrogen on the two chick pea (*Cicer arietnium* L.) varieties.

Materials and Methods

The seeds of two gram varieties i.e., Punjab-91 and C-44 were obtained from Ayub Agriculture Research Institute Faisalabad, Pakistan. The experiment was carried out in pot lined with polythene bags. Before filling the pots with soil, it was analyzed for pH and electrical conductivity (EC) which were 7.1 and 3.5 dS m^{-1} respectively with the saturation Percentage 20.9%. Three treatments of salinity levels i.e., 3.5, 7.5 and 11.5 dS m^{-1} were developed by using NaCl and were applied before sowing. Four nitrogen levels were maintained by adding urea @ 0, 60, 75 and 90 kg N ha^{-1}. Plant height, number of branches per plant, number of pods per plant, number of seeds per pod, 100 seeds weight and Biomass of plants were recorded. Chemical analysis were carried out at the time of final harvest for seeds nitrogen Na^+ and K^+ in root, stem and leaf of plants.

Results

The effect of salinity and nitrogen on plant height in two gram varieties is evident from Fig. 1. Salinity showed gradual decrease in plant height at 3.5, 7.5 and 11.5 dS m^{-1}. The maximum plant height 47.7, 42.15 cm was observed in C-44 and Punjab-91 respectively under 3.5 dS m^{-1}. However, when urea as a nitrogen source was applied the plant height was 50.16, 45.76 cm recorded in the (Punjab-91 and C-44) at the same salinity level. The results indicated that salinity gradually decreases the number of branches in Punjab-91 and C-44 but 18.03 % increase was observed in C-44 when 90kg N ha^{-1} urea was applied to plants growing in 3.5 dS m^{-1} level of salinity. But at 0, 60 and 75 kg N ha^{-1} at 3.5 dS m^{-1} level of salinity plant have similar values for number of branches in Punjab-91 but 90 kg N ha^{-1} urea, decreased number of branches/ plant in Punjab-91. Same was true for the plants growing under 11.5 dS m^{-1} salinity and 0, 60, 75 and 90 kg Nha^{-1} urea. The maximum number of branches were counted in C-44 under 3.5 dS m^{-1} salinity level at 90 Kg N ha^{-1} urea was added. The minimum number of branches were counted in C-44 in that plant which was growing under 11.5 dS m^{-1} salt stress even with 75 kg Nha^{-1} urea. It was further investigated that under 11.5 dS m^{-1} salt stress, plants were died at flowering stage in under 0 and 90 kg N ha^{-1} urea. Biomass of plants decreased with the increase of salinity level. Under 7.5 and 11.5 dS m^{-1} levels of salinity biomass decreased, but in C-44 at 7.5 dS m^{-1} 2.43% increase was observed at 90 kg N ha^{-1} urea. The maximum biomass (1.93 g) was observed in Punjab-91 under 3.5 dS m^{-1} when 90 kg N ha^{-1} urea was added. The minimum biomass 0.13 g was noted in C-44 at 11.5 dS m^{-1} salinity and 75 kg N ha^{-1} urea. Treatments showed that salinity reduced 61.83 and 86.66% biomass in Punjab-91 and C-44, respectively.

The data showed the trend of decrease both in the salinity levels and the application of urea when the number of pods per plant were counted. It is obvious from the data (Fig. 3) that the maximum number of seeds pod (1.40) were counted in Punjab-91 under 3.5 dS m^{-1} with 60 kg Nha^{-1} urea. The minimum (0.66) number of seeds/pod was observed in same variety under 11.5 dS m^{-1} with 60 kg ha^{-1} urea. No seeds were observed in any other treatment in both varieties at 11.5 dS m^{-1}. Maximum 100 seed weight was recorded under 3.5 dS m^{-1} level when 60 kg Nha^{-1} urea was added while when 70 and 90 kg N ha^{-1} urea was applied 100 seed weight reduced in both varieties. The maximum weight (40.66 g) was measured under 3.5 dS m^{-1}, N ha^{-1} urea in C-44. The minimum weight (13.76 g) was measured in Punjab 91 at 11.5 dS m^{-1} level salinity with 60 kg Nha^{-1} urea. It was observed that the maximum (3.3 g) yield was recorded under 3.5 dS m^{-1} level of salinity with 60 kg N ha^{-1} urea in Punjab-91 (Fig. 2). While the minimum (0.13 g) yield was produced in the same variety at 11.5 dS m^{-1} in which 60 kg N ha^{-1} urea was added. Variety C-44 showed the maximum

Table 1: Influence of different levels of N (Urea) fertilizer on Na^+ and K^+ (%) uptake in different parts of two gram varieties

	Different Nitrogen levels (Kg Nha^{-1})			
Genotype	O	60	75	90
Leaves (Na^+)				
Punjab -91	0.47±0.30	0.37±0.17	0.32±0.13	0.28±0.10
C-44	0.26±0.12	0.45±0.32	0.28±0.17	0.15±0.03
Stem				
Punjab -91	0.78±0.38	0.74±0.34	0.60±0.26	0.34±0.09
C-44	0.37±0.11	0.03±0.09	0.29±0.11	0.15±0.03
Root				
Punjab -91	0.73±0.24	0.57±0.20	0.38±0.16	0.21±0.07
C-44	1034±0.19	0.28±0.24	0.69±0.13	0.40±0.23
Leaves (K^+)				
Punjab-91	0.51±0.03	0.46±0.05	0.42±0.08	0.37±0.02
C-44	0.42±0.06	0.31±0.11	0.36±0.06	0.39±0.07
Stem				
Punjab -91	0.56±0.08	0.48±0.06	0.45±0.06	0.54±0.10
C -44	0.46±0.05	0.44±0.04	0.36±0.01	0.36±0.01
Root				
Punjab-91	0.22±0.03	0.27±0.02	0.16±0.04	0.09±0.03
C-44	0.32±0.11	0.35±0.10	0.27±0.09	0.24±0.06

Table 2: Effect of salinity and nitrogen on K^+ uptake by root, stem, and leaves of two varieties of gram cultivars

	Salinity levels		
Genotype	3.5 dS m^{-1}	7.5 dS m^{-1}	11.5 dS m^{-1}
Leaves (Na^+)			
Punjab -91	0.21±0.01	0.27±0.04	0.60±0.17
C-44	0.13±0.01	0.27±0.08	0.69±0.19
Stem			
Punjab -91	0.35±0.07	0.58±0.07	0.92±0.40
C-44	0.19±0.05	0.34±0.11	0.36±0.06
Root			
Punjab -91	0.43±0.20	0.68±0.28	0.31±0.13
C-44	0.75±0.37	0.02±0.36	0.56±0.05
Leaves (K^+)			
Punjab-91	0.41±0.15	0.0.36±0.09	0.43±0.04
C-44	0.37±0.08	0.40±0.04	0.25±0.012
Stem			
Punjab -91	0.44±0.02	0.61±0.06	0.48±0.06
C-44	0.38±0.03	0.43±0.07	0.39±0.03
Root			
Punjab-91	0.19±0.05	0.19±0.05	0.18±0.11
C-44	0.22±0.04	0.40±0.06	0.25±0.02

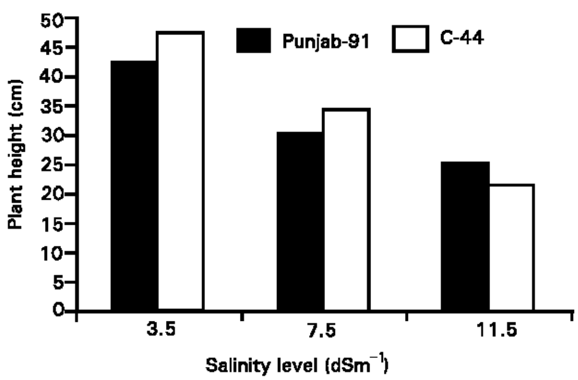

Fig. 1: Effect of salinity in plant height of two gram varieties

2.96 g yield at 3.5 dS m^{-1} level of salinity with 60 kg N ha^{-1} urea. The minimum 0.5 g yield was observed in 11.5 dS m^{-1} level of salinity with 60 kg N ha^{-1} data reflect the interactive effect of salinity and nitrogen on K^+ up take in roots of two gram varieties. K^+ concentration was higher in 3.5 dS m^{-1} salinity level when 60 kg Nha^{-1} urea was added. In the other levels of salinity (7.5 and 11.5 dS m^{-1}) amount of urea added decreases the K ion accumulation in both varieties. Treatment means of salinity showed that there was 4.21% decrease in K^+ in root in Punjab-91 while in C-44 12% increase was observed (Table1 and 2). However, in stem K ions concentration was high in each salinity level which was provided by 0, 60, and 90 kg N ha^{-1} urea. Treatment means showed that salinity increased the K^+ uptake in stem.

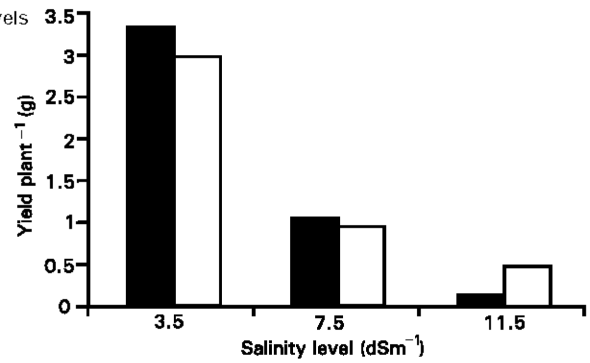

Fig. 2: Effect of salinity on yield / plant in two gram varieties

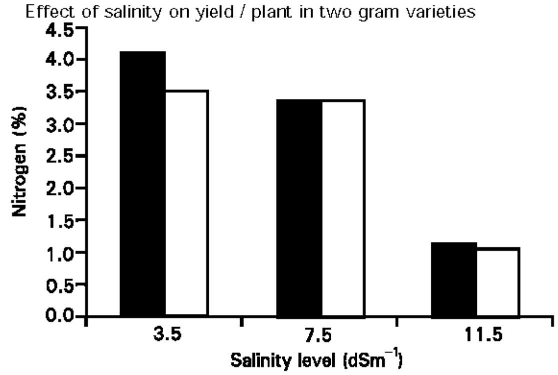

Fig. 3: Effect of salinity on nitrogen (%) in seeds of gram varieties

The 2.56% increase in K^+ uptake was observed in Punjab-91 and C-44, respectively. Comparison between varieties for leaves reflect that the Punjab-91 under 3.5 dS m^{-1} NaCl stress with out the addition of urea performed better. In contrast the minimum value (0.17 mmol/g) was observed in C-44 under 11.5 dS m^{-1} salinity with 60 kg N ha^{-1} urea performed. Treatment means of salinity levels showed that in

Punjab-91, 4.6 %K^+ ion increases while in C-44 36.25% decrease was noted (Table 1 and 2). Na^+ accumulation decreases with the increasing level of salinity and urea in both varieties. The maximum (1.52 mmol g^{-1}) amount of Na^+ ion was recorded under 7.5 dS m^{-1} level of salinity with out the addition of urea in C-44. The minimum value (0.12 mmol/ g) was noted in Punjab-91 under 11.5 dS m^{-1} with 90 kg Nha^{-1} urea. Salinity increases the amount of Na^+ accumulation in stem. The maximum amount (1.29 mmol g^{-1})was observed at 11.5 dS m^{-1} with out the addition of urea in Punjab-91. The minimum value (0.12) was noted at 3.5 dS m^{-1} with 90 kg Nha^{-1} urea in C-44. Treatment means showed salinity increases the amount of Na^+ in stem. Increase of 61.95 and 47.22% was observed in Punjab-91 and C-44, respectively. Salinity increases the amount of Na^+ in the leaves. The maximum (0.87 mmol g^{-1}) was observed under 11.5 dS m^{-1} without urea in Punjab-91. The minimum value (0.12 mmol g^{-1}) was observed in C44 at 3.5 dS m^{-1} with 75 and 90 kg Nha^{-1} urea. Treatment means showed that salinity decreases 65 and 81.15% Na^+ uptake in leaves in Punjab 91 and C-44, respectively.The maximum N %age (4.02 %) was observed in Punjab-91 under 3.5 dS m^{-1} level of salinity, where as the minimum (0.98 %) N was observed in C-44 under 11.5 dS m^{-1}. Treatment means showed that salinity decreases as 75.62% N contents in Punjab-91, while this decrease was 25.4 % in C-44 under 7.5 dS m^{-1} level of salinity as compare to control (3.5 dS m^{-1}). There were only two entries which exhibited 4% of protein content having a slight edge under the check. Though the range of protein content is rather wide, in fact the individualistic behavior sharply categorizes them into two groups. However, the highest group shows some genetic advancement over the other.

Discussion

Plant height is an important character in determining the competitive ability of plant. It depends on genetic and environmental factors. Plant height increases under 3.5ds m^{-1} level of salinity as the amount of urea increases. Maximum height was observed under 3.5 dS m^{-1} when 60 kg Nha^{-1} urea was added in Punjab-91. Under 7.5 and 11.5 dS m^{-1} salinity there was gradual decrease in the plant height. In C-44 some plants were died under 11.5 dS m^{-1} EC level of soil which was provided with 0 and 90 kg Nha^{-1} urea. Osmotic stress results from lowering of soil water potential as salt content of soil rises. This leads to a water deficit or a state of dehydration in plants. Specific ion toxicities results due to penetration of injurious concentrations of Na^+ or Cl^- in the protoplast, which may lead to an inactivation of enzymes, inhibition of protein synthesis, change in membrane permeability and damage to cell organelles ionic or nutritional imbalance results in plants growing under saline conditions due to competition of salt ions with nutrient (Dubey, 1997; Khan *et al.*, 1992).

All these changes affect the growth of plant which leads to decreased plant height. The salt tolerant varieties develop an osmotic adjustment mechanism which allows cell enlargement and plant growth at low water violability caused by the presence of ions especially Na^+ and Cl^- (Pugnaire *et al.* 1994). Our results are in accord with the observations of Khan *et al.* (1990) and Zaiter and Mahfouz (1993) who noted a decrease in shoot length under high salinity stress. Salts in soil causes an imbalance in the biotic and abiotic components of the soil which are necessary for luxury plant growth (Wahid *et al.*, 1998). Number of branches decreases under salt stress conditions. Nitrogen application had almost non significant effect in increasing the number of branches. Tolerant varieties develop osmotic adjustment mechanism which is most important physiological adaptation for survival and growth in maximum K^+ ion accumulation (0.56 mmol g^{-1}) was noted in saline environment. Gorham *et al.* (1985) pointed out that by intracellular ompartmentisation, cells are able to increase salt levels in the cytoplasm. Number of green leaves played an vital role in growth and yield of plant. Green leaves supply photosynthates to developing seeds and contribute about 41-43 % of seed weight. The reproductive yield of plant depend on the number of green leaves, particularly during ripening stage (Osaki *et al.* (1991).

In the present study the relationship of green leaves with the total weight per plant and yield remains uncertain because this is difficult to establish any concrete relationship between these characters. Salinity caused a significant decrease in number of pods/plant. There was no pod formation under 11.5 dS m^{-1} level of salinity in both varieties. These results are closely related to the observations of Salim and Pitman (1987). Yield/plant also increases with the increase of urea under 3.5 dS m^{-1} level of salinity. Over all salinity reduced the yield/plant. Our results of reduction in yield with salinity are in line with the observations of Maas and Ross (1989). Osmoregulation is an important process which confess salt tolerance to plants. It reduces the cell osmotic potential to a level which provides high turgor potential for the maintenance of growth. Minimum K ion concentration was observed in the root while the maximum amount of K ion was accumulated in the stem. Potassium ion decreased with increasing salinity. Our observations are in line with the findings of Abbas *et al.* (1991), Ashraf *et al.* (1999) Sharma (1991) and Reddy *et al.*, 1992. Na ion concentration was the maximum in stem and the minimum accumulation of Na^+ was noted in the leaves of the both varieties. While Na ion uptake increases with the increase levels of salinity. Amount of Na^+ was greater in stem as compare to roots. Results are almost in line with the observations of Ashraf and Naqvi (1996), Sudhakar *et al.* (1991) and Reddy *et al.* 1992. Salinity and nitrogen had a very significant effect on the nitrogen percentage of seeds. N content declined with increasing levels of NaCl salinity. Increase in nitrogen contents was observed with the addition of urea in soils having low level of salinity. These results are near to the results of Singleton and Bohlool (1984) and Reddy *et al.*, 1992. It can be summarized from the experimental observations that over all growth parameter decrease with the increase in salinity. Though the nitrogen application in the form of urea is a good practice for the improvement of plant growth but in chick pea it showed an adverse effect by effecting the development and functioning of nodules. However, it was observed in the experiment that there was some improvement in the growth of chick pea, when urea was applied under 3.5 dS m^{-1} level of salinity.

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