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Nodulation and nitrogen fixation in chickpea (*Cicer arietinum* L.) under salt stress

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SUMMARY

The effects of salt stress on the growth, nodulation and N accumulation during the vegetative phase was studied in chickpea (*Cicer arietinum*). Growth and N accumulation were adversely affected by salinity. The larger control plants produced new nodules but the existing nodules on stressed plants grew larger than those of control plants. All plants had similar % N contents but the total plant N was less in stressed plants due to the reduced growth of these plants. Reduced plant vigour was the primary effect of salt stress and was mediated through processes other than symbiotic N fixation.

INTRODUCTION

The adaptability of grain legumes to saline environment, which depresses growth and yield of most crop plants, depends upon the establishment of symbolic nitrogen fixation. The nitrogen metabolism is affected by salt stress (Ben-Zioni, Itai & Vaadia, 1967). There are a few studies (Hamissa, 1972; Imbamba, 1973) on salt injury on growth of grain legumes but information regarding their symbiotic nitrogen fixation under saline conditions is lacking. Balasubramanian & Sinha (1976) observed a considerable decrease in nitrogen fixation efficiency of mung beans under a saline environment but not in cowpea. Obviously, variations in the response to the stress exist amongst legumes. The present study reports the effect of salt stress on growth, nodulation and nitrogen fixation in chickpea, an important grain legume crop.

MATERIALS AND METHODS

Chickpea (*Cicer arietinum* cv. G62-404) seeds were inoculated with an effective *Rhizobium* strain obtained from the Division of Microbiology, Indian Agricultural Research Institute, and sown in the winter season in acid-washed sand watered with nitrogen-deficient half-strength Hoagland solution (Hoagland & Arnon, 1950). The seedlings were thinned to three in each pot after germination. The salinity treatments were started 15 days after thinning and continued until 12 weeks after sowing by adding nutrient solutions of defined salt concentrations to give a variable salt stress (Richards, 1954). The concentrations used were 0, 0·15, 0·32 and 0·84 % sodium chloride. The treatments have been designated S_0, S_1, S_2 and S_3 in Tables and the electrical conductivity of the solutions were 0·5, 3·0, 6·0 and 15·0 mmhos/cm respectively. Drainage of excess solution was not impeded and the concentration in the sand was not determined.

The dry weights of plants and nodules of five replicate pots were determined fortnightly until flowering. After flowering nodule weight declined and the experiment was discontinued. Duplicate samples of oven-dried plants were analysed for total nitrogen on a Technicon Auto Analyser using the method based on the reaction of ammonia with alkaline hypochlorite and phenol.

RESULTS AND DISCUSSION

The accumulation of dry matter was progressively less with increasing salt stress (Table 1). The number of nodules per plant as well as their weight decreased. Salinity has been found to be inhibitory to growth and nodulation in soya beans (Bernstein & Ogata, 1966). In the present experiments, the decrease in nodulation was proportionately due more to number of nodules than to their weight. In fact the nodules in salt-stressed plants were bigger than those in the control plants (Table 1), probably because relatively fewer nodules were competing for photosynthates. A similar effect was observed in cowpea and mung beans by Balasubramanian & Sinha (1976). Wilson (1970) reported that, in *Glycine wightii*, nodules developed before salt treatment appeared remarkably resistant to stress but the development of new nodules was inhibited.

Although all plants had similar N concentrations,

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Table 1. *Effects of salt stress on dry-matter production and nodulation during vegetative growth (up to 12 weeks) of chickpea plants*

Plant age (weeks)	Treatments S_0	S_1	S_2	S_3
	Total dry wt./plant (mg)			
4	128	126	127	89
6	194	222	208	147
8	332	334	314	274
10	465	398	398	278
12*	555	497	392	374
	* L.S.D. ($P = 0{\cdot}05$) = 85·0.			
	Nodule dry wt./plant (mg)			
4	1·5	—	—	—
6	4·8	3·8	4·4	1·6
8	19·7	11·3	15·7	10·1
10	33·7	29·6	34·7	18·1
12*	44·7	46·3	36·6	32·4
	* L.S.D. ($P = 0{\cdot}05$) = 11·58.			
	Maximum number of nodules/plant			
12*	24	8	5	7
	* L.S.D. ($P = 0{\cdot}01$) = 8·8.			
	Nodule size (dry wt. (mg)/nodule)			
12	1·6	5·8	7·2	4·6

the total nitrogen content in stressed plants decreased due to their reduced growth (Table 2). The nitrogen-fixing efficiency of plants also declined under saline conditions, probably because the demand for N was less due to the poorer growth rate of these plants. As a result of reduction in dry matter, the total potential nitrogen harvest would be low from plants grown under saline conditions. The data also lead to the conclusion that the reduced plant vigour was the primary effect of salt stress and was mediated through processes other than symbiotic nitrogen fixation.

Table 2. *Effects of salt stress on nitrogen content and nitrogen fixation efficiency of chickpea plants*

Plant age (weeks)	Treatments S_0	S_1	S_2	S_3
	Total N content/plant (mg)			
4	3·3	3·0	3·0	2·3
6	4·1	4·2	4·0	3·1
8	6·3	5·5	7·2	5·5
10	10·9	8·3	9·3	7·4
12	12·8	12·7	9·6	8·4
	Nitrogen fixation efficiency (mg N fixed/100 mg nodules/week)			
6–12	3·6	3·3	2·9	2·8

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