Korean J. Crop Sci. 46(5):387~394(2001)

Salinity Tolerance of Blackgram and Mungbean: II. Mineral Ions Accumulation in Different Plant Parts

P. K. Raptan*, A. Hamid*, Q. A. Khaliq*, A. R. M. Solaiman*, J. U. Ahmed* and M. A. Karim*†

**Department of Agronomy; Dr. A.R.M. Solaiman, Department of Soil Science and Department of Crop Botany, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur-1703, Bangladesh*

ABSTRACT : Blackgram (*Vigna mungo*) is more salt tolerant than mungbean (*Vigna radiata*). This study was initiated to know whether the accumulation pattern of mineral ions in different plant parts plays a significant role in the differences in salt tolerance between the two *Vigna* species. Different mineral ions, viz. N, Cl, Na, K, Mg and Ca in different organs of two varieties of each of blackgram- Barimash-1 (susceptible one) and Barimash-2 (tolerant one), and mungbean-Barimung-3 (tolerant one) and Barimung-4 (susceptible one), were analyzed after growing with 0, 50, 75 and 100 mM NaCl solutions. The two crops showed a decreased but similar pattern of total N accumulation under saline conditions. The tolerant variety of both the crops showed a less reduction in total N than the susceptible one. Leaves showed the maximum while stem the minimum N, irrespective of levels of salinity. Cl^- and Na^+ accumulation increased with the increasing salinity levels. Interestingly, similar to a halophyte, the salt tolerant blackgram exhibited conspicuously higher amount of Na^+ in the shoot than the salt-susceptible mungbean. However, the tolerant varieties showed less amount of Na^+ than the susceptible one, especially in blackgram. Seeds of both *Vigna* spp. accumulated the minimum amount of Na^+ than other plant parts. K^+ accumulation decreased by salinity in most of the plant parts, except seeds. Blackgram showed larger reduction in K than mungbean. The Mg^{++} increased in leaves, petioles and stem by salinity while decreased in the roots, podshells and seeds in both the crops. Salinity increased Ca^{++} accumulation in all plant-parts except roots of both *Vigna* spp. Apparently, the leaves of mungbean accumulated higher concentration of Ca^{++} than blackgram. Varietal differences in the accumulation pattern of K^+, Mg^{++} and Ca^{++} were not clear. It was concluded that blackgram, presumably, possesses a similar salt tolerance mechanism to halophyte, and the pattern of accumulation of mineral ions in blackgram and mungbean was not fully ascribed to the differences in salinity tolerance between the two *Vigna* species.

Keywords : mineral ions, salinity, blackgram, mungbean.

†Corresponding author: (Phone) +681-52020, 52566, 52572 (E-mail) akarim@citechco.net <Received September 24, 2001>

Crops differ widely in their ability to absorb mineral nutrients from a saline substrate. Salinity decreased the uptake of N, P, K, Ca, and Mg, while increased the uptake of Na in crop plants (Bernstein, 1975). Leguminous crops are generally sensitive to salinity though there is a considerable difference in salt tolerance between legume species (Maas and Hoffman, 1977). Tolerant species can exclude Na^+ and Cl^- from the leaves more efficiently than salt-susceptible ones (Sharma and Kumar, 1990). However, the mechanisms of salt exclusion and its significance to plant adaptation to saline environment are not fully understood (Lauchli, 1984). Salt resistance in soybean varieties was correlated with Cl^- exclusion ability from the shoot (Abel and Mackenzie, 1964). *Trifolium alexandrium*, an effective Na^+ and Cl^- excluder, was found more salt tolerant than *T. pratense* (Winter and Lauchli, 1982). In contrast, Alfocea *et al.* (1993) noticed that salinity tolerance in tomato was correlated with higher Cl^- and Na^+ and lower K^+ in root, a typical character of a halophyte, as well as their restricted translocation to shoot and maintenance of K selectivity. Experiment of Gill (1990) with greengram revealed that the adverse effects of salinity at germination and three-leaf stages were related with the disturbance in both osmotic (water stress) and ionic balance (specific ion effect), whereas at branching and pod formation stages were due to the disturbance with only ionic balance.

In the former experiment it was established that blackgram (*Vigna mungo*) is more salt tolerant than mungbean (*Vigna radiata*) though they belong to the same genus. These two crops also showed varietal differences in their salt tolerance. It is possible that the two crops as well as the varieties possess different pattern of uptake and distribution of mineral ions in various plant parts. Usually tolerant crop and/ or variety shows less ionic imbalance than susceptible ones (Blum, 1988). It was also observed in soybean (Laüchli and Wieneke, 1979) and triticale (Karim *et al.*, 1992) that tolerant cultivars maintain a higher concentration of Na^+ in the roots and less in the shoot compared to salt susceptible ones. The information on mineral ions distribution pattern in different pant parts of *Vigna spp.* is insufficient although that would be the basic to understand the salt tolerance mechanisms of the two popular *Vigna* crops. In this study the distribution pattern of different mineral ions in various plant parts of mungbean and blackgram varieties, differing in salt tolerance, was analyzed to understand the role of mineral ions in salt tolerance mechanisms of the two *Vigna* crops.

MATERIALS AND METHODS

Two varieties of each of blackgram- Barimash-1 and Barimash-2, and mungbean-Barimung-3 and Barimung-4, were employed in this study. The cultivation procedures of the plants used in this experiment have already been described in Part I. In the former experiment Barimash-2 showed higher salt tolerance than Barimash-1 in blackgram. In mungbean, Barimung-3 performed better than Barimung-4 under saline conditions.

For chemical analysis 100 mg dried samples of each plant part at maturity stage were powdered with a Wiley Mill grinder. Total nitrogen in different plant-parts was analyzed at flowering stage. Estimation of total nitrogen was done by colorimetric method following Linder (1944). Plant samples were digested in Kjeldahl digestion flask with Salicylic H_2SO_4 and digestion catalyst. After digestion, color of the solution was developed with four different reagents. Then absorbance of the solution was measured at 625 nm wavelength with Double Beam Spectrophotometer (Model 200-20). Chloride concentration was estimated at maturity, following the method described by Jackson (1973). The ground plant materials were dry-ashed in porcelain evaporating cup with calcium oxide in a muffle furnace at 550°C for 6h. Then the ash was extracted with hot water and the chloride was analyzed by titration with standard silver nitrate.

Sodium, potassium, magnesium and calcium were determined following Hitachi, Ltd. (1986). Dried plant samples were digested with nitric-perchloric acid solution. After digestion, the sample was diluted with distilled water. The absorbance of the respective ions was measured with Atomic Absorption Spectrophotometer (Model. 170-30 Hitachi). Each treatment was replicated three times and pair of means was compared with standard error (±SE).

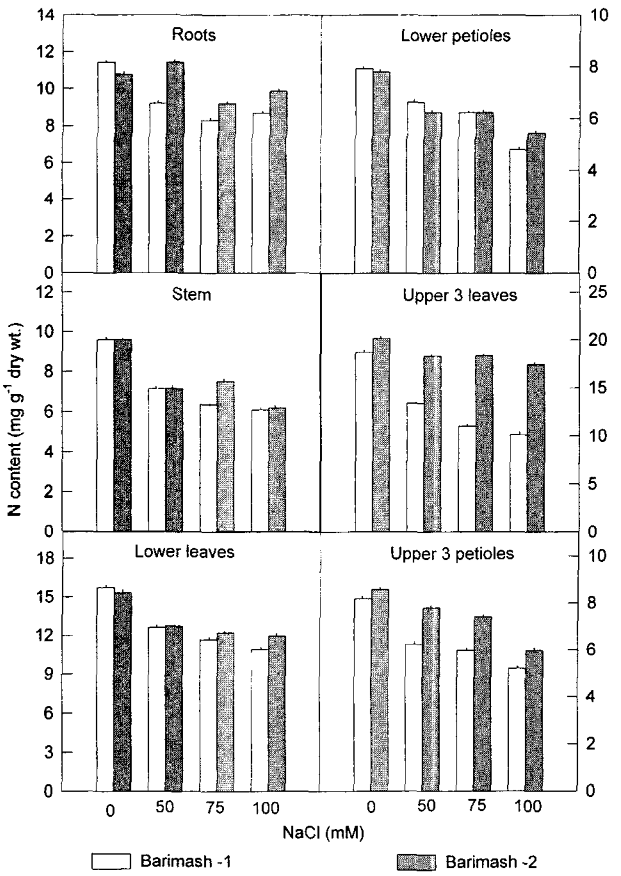

Fig. 1. Changes in N content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

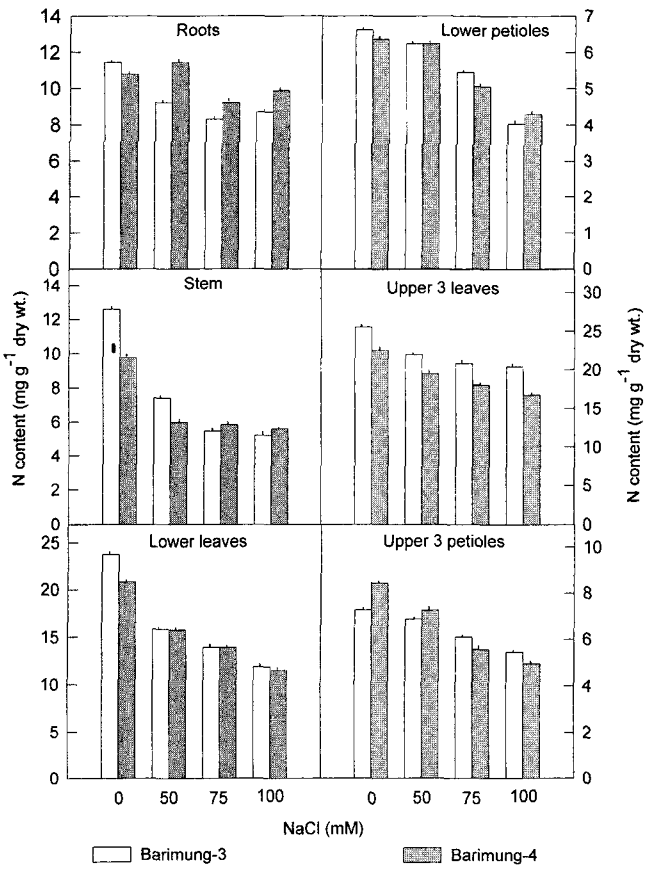

Fig. 2. Changes in N content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

RESULTS AND DISCUSSION

Total nitrogen

The changes in the concentrations of total nitrogen in different plant parts are shown in Fig. 1 and Fig. 2 for blackgram and mungbean, respectively. Under control conditions, most of the plant parts of mungbean had higher amount of N than in blackgram. Leaves accumulated greater amount of N while petioles the least. Salinity decreased total N concentrations in all the plant parts in both blackgram and mungbean. In blackgram, on an average, the reduction in N was less in Barimash-2 (tolerant) than that in Barimash-1 (sensitive). This trend was especially clear in upper three leaves, petioles and roots. In mungbean, the total N in Barimung-4 (sensitive one) decreased more than that in Barimung-3 (relatively tolerant one). Like blackgram the varietal differences in the reduction of total N was clear in upper three leaves and petioles, and also in roots of mungbean. Salinity induced reduction of total nitrogen was also reported earlier by a number of workers, eg. in chickpea (Ram *et al.*, 1989; Kumar and Promilla, 1983), in mungbean (Hafeez *et al.*, 1988; Patil *et al.*, 1995), in blackgram (Paliwal and Maliwal, 1980), in mungbean, cowpea and soybean (Egeh and Zamora, 1992). Nodulation and nitrogen fixation are highly sensitive to salinity (Hafeez *et al.*, 1988) although Lahiri *et al.* (1987) reported that N content in clusterbean decreased non-significantly with the increasing salinity up to 10 dS/m compared to control plants. Curtin *et al.* (1993) pointed out that Cl^- competes strongly with NO_3^- for the same binding sites on plasma membrane, and can suppress the transport of NO_3^- from external solution, which might also be the case in the present study.

Chloride

Chloride ion increased dramatically with the increasing salinity levels. Blackgram, in general, accumulated higher amount of Cl^- than mungbean. Varietal difference in Cl^- accumulation was noticed. Barimash-2 apparently accumulated higher amount of Cl^- in different plant parts, except roots and seeds. In mungbean, Barimung-3 accumulated rel-

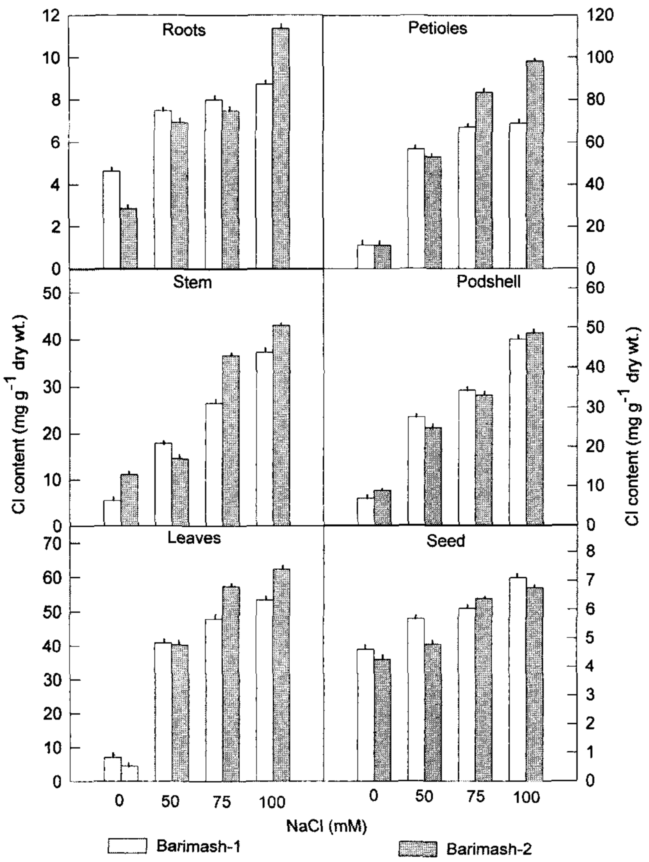

Fig. 3. Changes in Cl content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

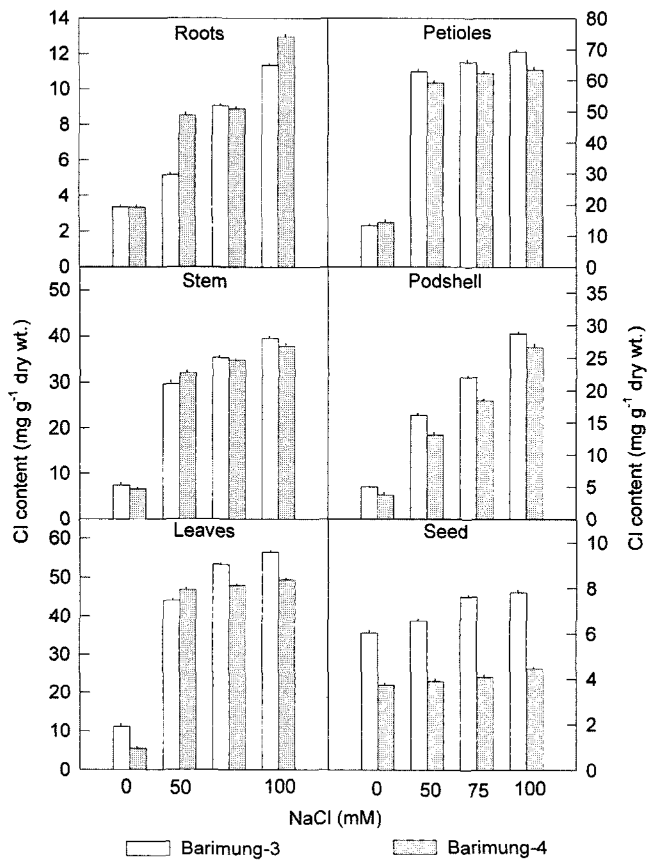

Fig. 4. Changes in Cl content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

atively higher content of Cl^- in most of the plant parts except roots. In the treated plants, petioles accumulated the greater quantity of Cl^- followed in decreasing order by leaves, podshells, stems, roots and seeds irrespective of crop species. It appears that different plant-parts, by retaining huge Cl^-, regulated Cl^- transportation to the seeds. Keating and Fisher (1985), Lauchli and Wieneke (1979), and Winter and Lauchli (1982) reported that chloride concentration in the shoot is closely correlated with the relative yield reduction in grain legumes. The greater uptake of Cl^- with the increased concentration of salinity eventually led to the specific ion effect or to osmotic effect on plant cell (Agastian and Vivekanandan, 1997).

Sodium

In general, Na^+ accumulation increased in plants with the increasing salinity levels. Fig. 5 and 6 clearly indicated that all the plant parts of blackgram (tolerant crop) accumulated higher amount of Na^+ than that of mungbean (susceptible crop). Generally it is found that a tolerant crop accumulates less amount of Na^+ than susceptible one (Blum, 1988; Maas and Hoffman, 1977). In this study, the two *Vigna* species, however, showed a different response. Blackgram, the tolerant *Vigna spp.*, accumulated higher amount of Na^+ than mungbean, the susceptible one. This finding indicates that the salt tolerance character of blackgram is partly similar to a halophyte, which can tolerate high concentration of salinity compartmenting Na^+ in the plant cell. Barimash-2, a relatively salt tolerant blackgram variety, accumulated less amount of Na^+ in most of the plant parts compared to Barimash-1, except roots. Similar results reported by Lauchli and Wieneke (1979) for soybean, and Karim *et al.* (1992) for triticale that tolerant cultivar maintained relatively larger Na^+ in the roots and a smaller amount in the shoot compared to the salt-susceptible one. The shoots of Barimung-3 accumulated maximum while podshells and seeds accumulated the minimum Na^+ than those of Barimung-4. It appeared

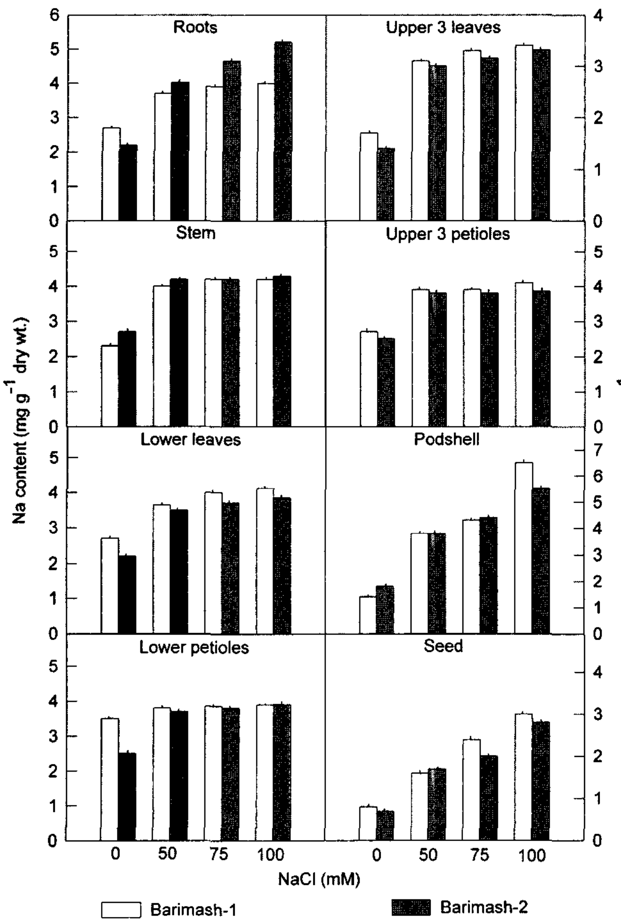

Fig. 5. Changes in Na content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

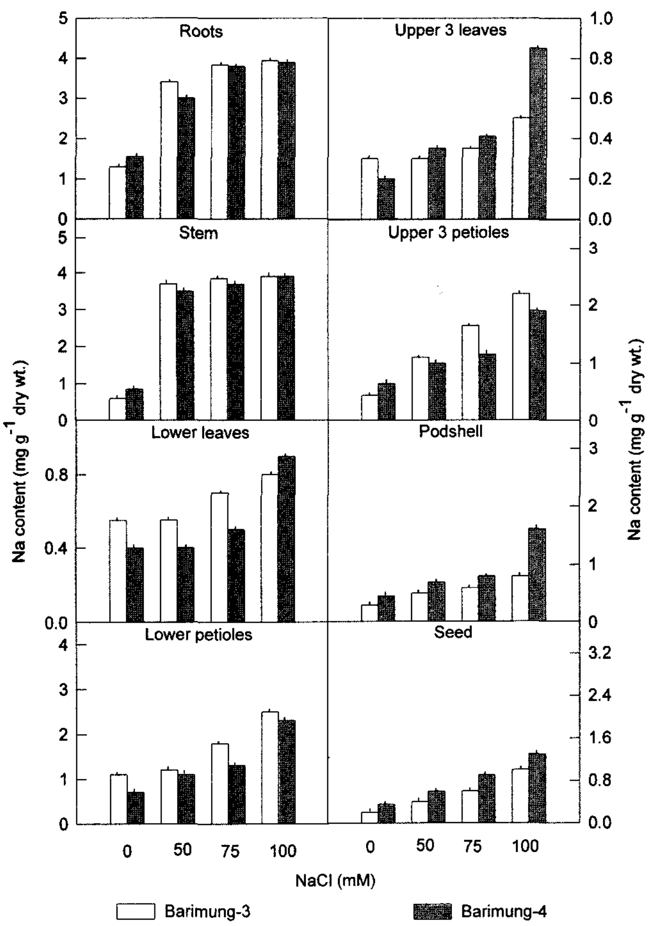

Fig. 6. Changes in Na content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

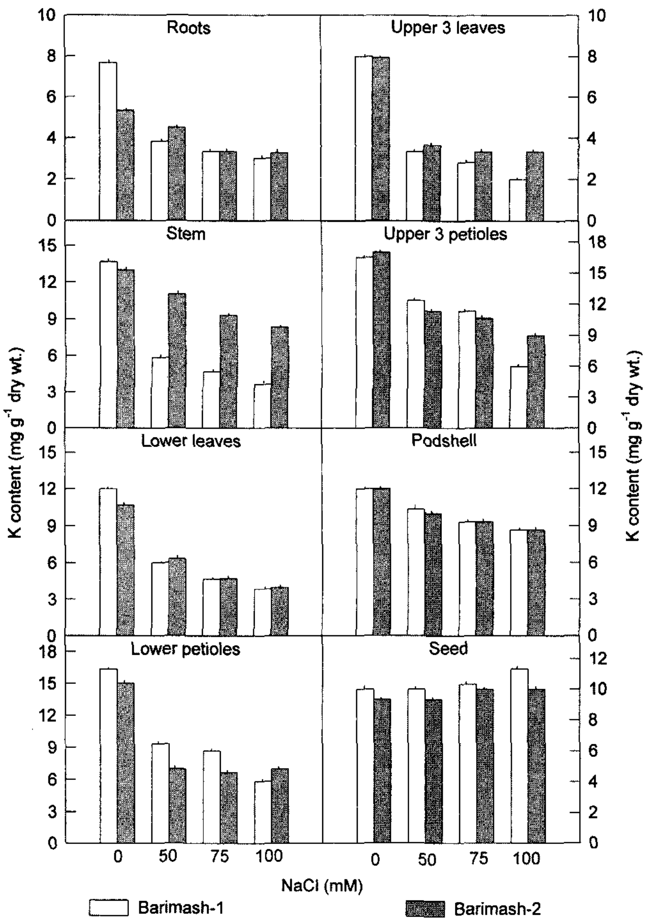

Fig. 7. Changes in K content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

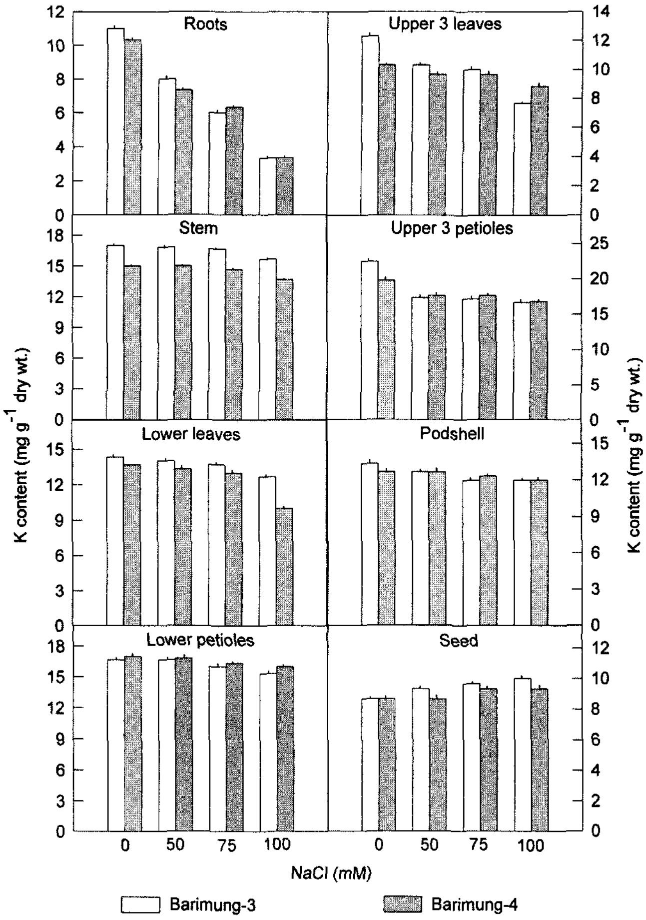

Fig. 8. Changes in K content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

that the different plant parts of the relatively tolerant variety (Barimung-3), by maintaining higher concentration of Na^+, controlled the transportation of Na^+ to the seeds. Excessive accumulation of Na^+ drastically reduced plant growth as the plant use available energy for the survival instead of cell elongation (Hug and Larher, 1983 a,b). Moreover, Na^+ competes with Ca^{++} for the same binding site in plasma membrane and thus creates physiological disorders in the cell metabolic processes.

Potassium

In general K^+ decreased by salinity in most of the plant parts in both blackgram and mungbean, except seeds. On an average, mungbean accumulated greater amount of K^+ than blackgram at all levels of salinity (Fig. 7 and 8). The reduction of K^+ due to salinity was larger in blackgram than in mungbean. Moreover, the traditional concept that tolerant crop maintains higher K:Na ratio than susceptible one was not observed in the two *Vigna spp.* differing in salinity tolerance. Apparently, the K^+ reduction with salinity was less in the shoot of relatively tolerant Barimash-2 than Barimash-1. However, the K^+ accumulation in response to salinity in two mungbean varieties was more or less similar (Fig. 8). Under saline conditions plant cells utilize K^+ as a metabolite to maintain turgor to escape from osmotic shock (Blum 1988; Greenway and Munns, 1980). Sudhakar *et al.* (1990) observed in horsegram and greengram that K^+ concentration in roots decreased while in shoot increased with salt stress. Absorption of Na^+, Ca^{2+} and Cl^- in large proportions upsets the accumulation of major nutrient like K (Lal and Bhardwaj, 1984).

Magnesium

Total amount of Mg^{2+} accumulation was little higher in mungbean than in blackgram, though the later is relatively salt tolerant than mungbean (Fig. 9 and 10). Both blackgram

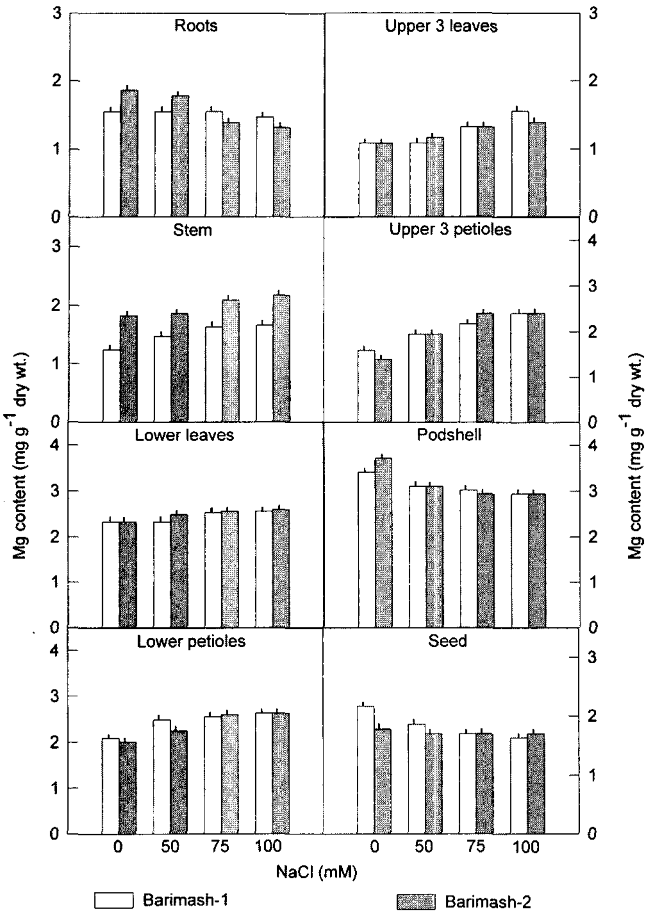

Fig. 9. Changes in Mg content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

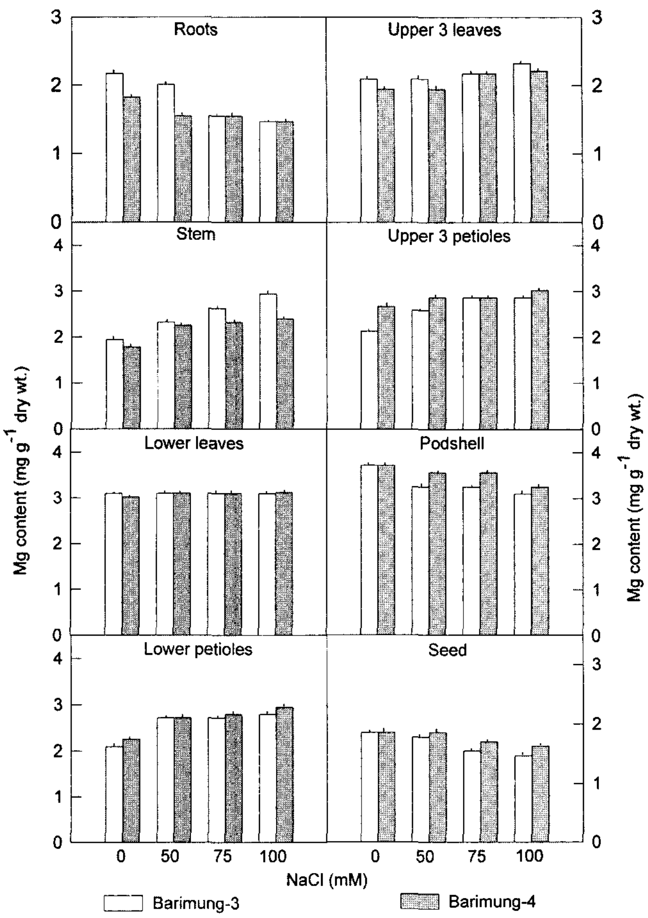

Fig. 10. Changes in Mg content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

and mungbean showed an interesting pattern of magnesium accumulation under saline conditions. The Mg^{2+} increased in all the organs of shoots, i.e. leaves, petioles and stem while decreased in the roots, podshells and seeds. The accumulated Mg^{2+} in the source of the plant presumably was helpful to maintain the osmoregulation, to protect the plant cells from osmotic shock created by salinity. In both blackgram and mungbean, the varietal differences in Mg^{2+} accumulation, under saline condition, was not clear. There are contradictory reports on the pattern of accumulation of Mg^{2+} under saline conditions. Lal and Bhardwaj (1984) and Paliwal and Maliwal (1980) reported that divalent cations (Ca and Mg) decreased with increasing salinity, though Patil *et al.* (1995) did not find any influence of salinity on Mg^{++} accumulation in greengram.

Calcium

Salinity increased the Ca $^{2+}$ accumulation in all the parts except roots of both the crops (Fig. 11 and 12). Apparently the leaves of mungbean, the susceptible crop, accumulated higher concentration of Ca^{++} than blackgram, and other organs of the two crops showed more or less similar quantity of Ca^{++}. Like some other elements Ca^{++} also act as metabolite to protect plant cells from osmotic shock (Blum, 1988). In blackgram both the varieties, even they are dissimilar in salt tolerance, showed a similar concentration of Ca^{++} in different plant parts, except roots. The roots of Barimash-2 (tolerant variety) accumulated greater amount of Ca^{++} than Barimash-1 (susceptible one) under both saline and non-saline conditions. In mungbean the varietal differences in Ca^{++} accumulation was obscure. The result of this experiment partly corroborate with the findings of Lal and Bhardwaj (1984) in pea, and Sudhakar *et al.* (1990) in horsegram and greengram that concentration of Ca^{++} in roots and shoots increased with salt stress. Contrary, Nakamura *et al.* (1990) in mungbean, Patil *et al.* (1992) and Patil *el al.* (1995) in greengram found that, in general, calcium uptake decreased with the increase in saline water irrigation. Nakamura *et al.* (1990) reported that addition of Ca to the exter-

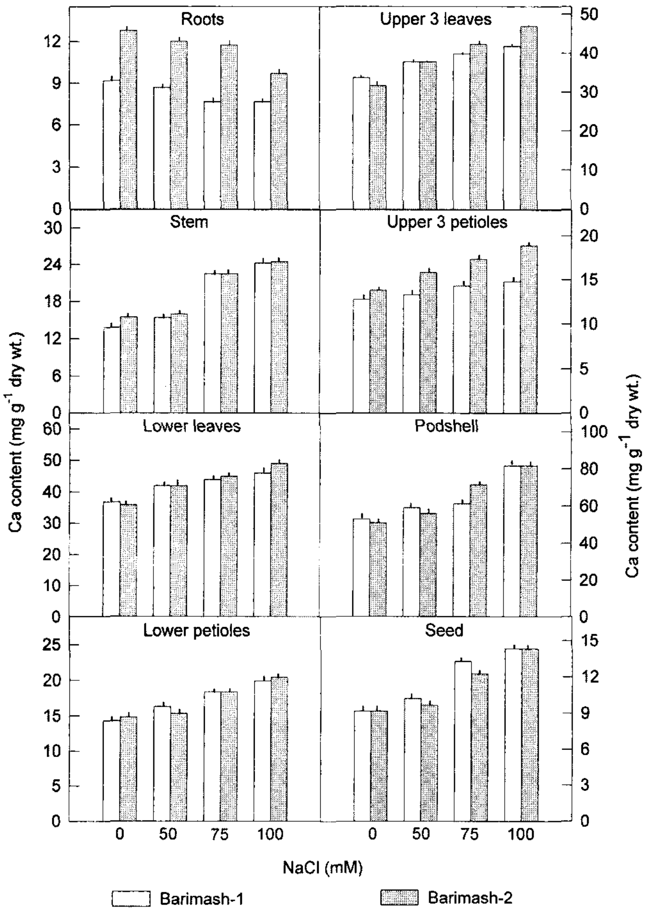

Fig. 11. Changes in Ca content in different plant parts of two blackgram varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

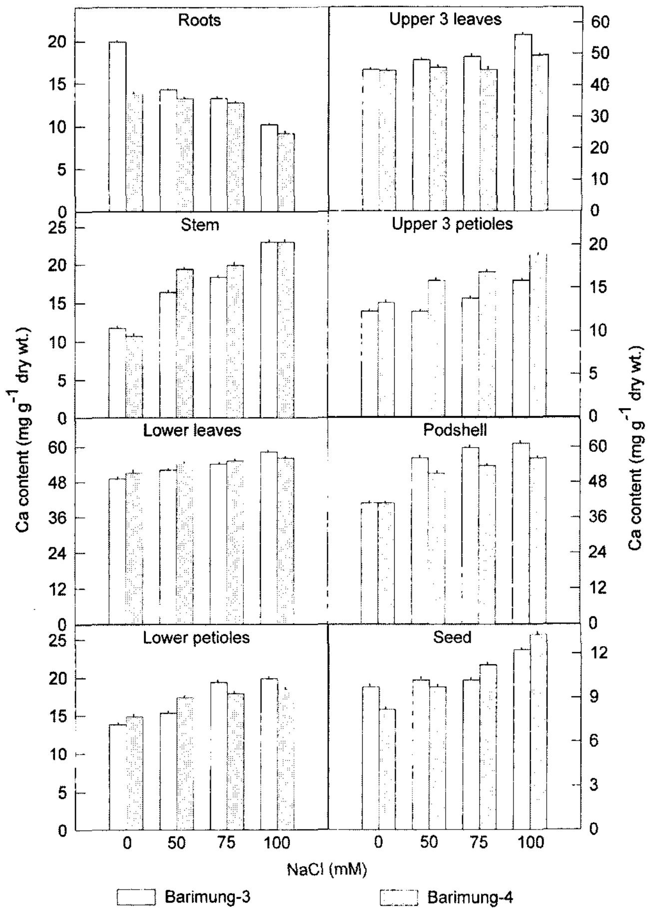

Fig. 12. Changes in Ca content in different plant parts of two mungbean varieties grown at different levels of NaCl salinity. Bars indicate ± SE (n=4).

nal medium alleviated the inhibition of root elongation by salt stress. Moreover, the plant under such condition maintained a high intracellular concentration of K in the elongation region of the roots by encountering NaCl stress. These findings indicate that Ca^{2+} prevents the leakage of intracellular K and thereby supports the elongation of roots under salt stress.

In conclusion, we have demonstrated that salinity decreased the total N concentration in the plants and the tolerant varieties showed less reduction in total N than the susceptible ones in both mungbean and blackgram. In contrast to the general concept that tolerant crop (glycophyte) accumulates less amount of Na^+ and/ or Cl^- than susceptible one, the tolerant blackgram accumulated larger quantity of Na^+ and Cl^- than the salt-susceptible mungbean. The calculated K:Na ratio was also lower in blackgram than that in mungbean. Perhaps the salt tolerance mechanism of blackgram is similar to a halophyte that maintains plant growth even by maintaining high concentration of Na^+ in the shoot. Mg^{++} and Ca^{++} accumulations in different plant parts were higher in mungbean than blackgram. Probably, in addition to the other metabolites, these two ions were needed for maintaining osmoregulation, and being a susceptible crop mungbean had to accumulate larger quantity of the ions than the tolerant blackgram.

REFERENCES

Abel, G. E., and A. J. Mackenzie. 1964. Salt tolerance of soybean varieties (*Glycine max* L. Morrill) during germination and later growth. *Crop Sci.* 4 : 157-161.

Agastian, S. T. P., and M. Vivekanandan. 1997. The effect of induced salt stress on growth and uptake of mineral nutrients in mulbery (*Morus alba*) genotypes. *Indian J. Agric. Sci.* 67 : 469-472.

Alfocea, F. P., M. T. Estan, M. Caro, and M. C. Bolarin. 1993. Response of tomato cultivars to salinity. *Plant and Soil.* 150 : 203-221.

Bernstein, L. 1975. Effect of salinity and sodicity on plant growth. *Ann. Rev. Phytopathol.* 13 : 295-312.

Blum, A. 1988. Salinity resistance. *In:* Plant Breeding for Stress

Environments. pp.163-179. CRC Press (Florida).

Curtin, D., H. Steppuhan, and F. Selles. 1993. Plant response to sulphate and chloride salinity, growth and ionic relations. *Amer. J. Soil Sci.* 57 : 1304-1310.

Egeh, A. O., and O. B. Zamora. 1992. Growth and nutrient content of mungbean (*Vigna radiata* L.), cowpea (*Vigna unguiculata* L.) and soybean (*Glycine max* L.) under different levels of salinity. *Philippine J Crop Sci.* 17 : 75-83.

Gill, K.S. 1990. Effect of saline irrigation at various growth stages on growth, yield attributes and ionic accumulation pattern in greengram (*Phaseolus radiatus*). *Indian J. Agric. Sci.* 58: 210-212.

Greenways, H., and R. Munns. 1980. Mechanisms of salt tolerance in non-halophytes. *Ann. Rev. Plant Physiol.* 31 : 149-190.

Hafeez, F. Y., Z. Aslam, and K. A. Malik. 1988. Effect of salinity and inoculation on growth, nitrogen fixation and nutrient uptake of *Vigna radiata* (L.) Wilczek. *Plant and Soil.* 106: 3-8.

Hitachi, Ltd. 1986. Instruction manual for Model 170-30 Atomic Absorption Flame Spectrophotometer. Tokyo, Japan.

Hug, S. M. I., and F. Larher. 1983a. Osmoregulation in higher plants: Effects of NaCl salinity on non-nodulated *Phaseolus aureus* L.I. Growth and mineral content. *New Phytologist.* 93 : 203-208.

Hug, S. M. I., and F. Larher. 1983b. Osmoregulation in higher plants: Effects of NaCl salinity on non-nodulated Phaseolus aureus L. 11. Changes in organic solutes. *New Phytologist.* 93 : 209-216.

Jacson, M. L. 1973. Soil chemical analysis. Prentice Hall of India Pvt. Lid. New Delhi.

Karim, M. A., E. Nawata, and S. Shigenaga. 1992. Dry matter production and distribution of mineral ions in different parts of the plant in hexaploid *Triticale* under salt stress conditions. *Jpn. J. Crop Sci.* 61 : 439-446.

Keating, B. A., and M. J. Fisher. 1985. Comparative tolerance of tropical grain legumes to salinity. *Aust. J. Agric. Res.* 36 : 373-383.

Kumar, S., and K. Promila. 1983. Effects of chloride and sulphates type of salination and desalination on nudulation and nitrogen fixation in chickpea. *Indian J. Plant Physiol.* 26 : 65-70.

Lahiri, A. N., B. K. Garg, S. Kajhju, S. P. Vyas, and P. C. Mali. 1987. Response of clusterbean to soil sodicity. *Ann. Arid Zone.* 26:33-42.

Lal, R. K., and S. N. Bhardwaj. 1984. Effect of salinity on mineral composition and ionic balance in field pea (*Pisum sativum* Linn.Var. Arvensis). *Indian J. Plant Physiol.* 27 : 351-354.

Lauchli, A. 1984. Salt exclution: An adaptation of legumes for crops and pastures under saline conditions. *In*: R. C. Staples and G. H. Toennissen, eds. "Salinity Tolerance in plants". Wiley Inter Science, New York. 171-188.

Lauchli, A., and J. Wieneke. 1979. Studies on growth and distribution of Na^+, K^+ and Cl^- in soybean varieties differing in salt tolerance. *Z. Pflan. Boden.* 142 : 3-13.

Linder, R. C. 1944. Rapid analytical method for some of the more common inorganic constituents of the plant tissues. *Plant Physiol.*, 19 : 76-89.

Mass, E. V., and G. J. Hoffman. 1977. Crop salt tolerance current assessment. *J. Irrig. Drain. Div.* 103 : 115-134.

Nakamura, Y., K. Tanaka, E. Ohta, and M. Sakata. 1990. Protective effect of external Ca^{2+} on elongation and intracellular concentration of K^+ in intact mungbean roots under high NaCl stress. *Plant and Cell Physiol.* 31: 815-821.

Paliwal, K. V., and G. L. Maliwal. 1980. Growth and nutrient uptake relationship of some crops in saline substrate. *Ann. Arid Zone.* 19 : 251-258.

Patil, S. L., C. S. Hunshal, D. P. Viswanath, V. P. Chimmad, V. S. Kubsad, S. B. Salimath, and R. M. Hosmani. 1992. Effects of saline water irrigation on soil properties, growth and yield of greengram during summer. *J. Maharastrra Agric. Univ.* 17 : 229-231.

Patil, S. L., C. S. Hunshal, D. P. Viswanath, V. P. Chimmad, V. S. Kubsad, S. B. Salimath, and R. M. Hosmani. 1995: Effect of use of saline water to supplement good water on the uptake of nutrients by greengram on black soil. *Indian J. Agric. Res.* 29 : 181-187.

Ram, P. C., O. P. Garg, B. B, Singh, and B. R. Maurya. 1989. The effect of salt on nodulation fixed nitrogen partitioning and yield attributes in chickpea. *Indian J. Plant Physiol.* 32 : 115-121.

Sharma, S. K., and S. Kumar. 1990. The effect of salinization on growth and distribution of Na^+ and Cl^- in two genotypes of chickpea. *Indian J. Plant Physiol.* 33 : 269-274.

Sudhakar, C., P. S. Reddy, and K. Veeranjaneyulu. 1990. Effects of salt stress on dry mattter production and mineral content during early seedling growth of horsegram (*Macrotyloma uniflorum* (Lam.) Verdc.). *Plant Physiol. Biochem.* 17 : 88-91.

Winter, E., and A. Lauchli. 1982. Salt tolerance of *Trifolium alexandrinum* and *T. pratense*. *Aust. J. Plant Physiol.* 9 : 221-266.