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# GROWTH AND MINERAL NUTRITION OF MOTH BEAN (*PHASEOLUS ACONITIFOLIUS* JACQ.) UNDER SALINE CONDITIONS

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## SUMMARY

The influence of NaCl salinity on growth and mineral nutrition of moth bean (*Phaseous aconitifolius* Jacq.), one of the most neglected but promising legumes, has been investigated. The studies on growth parameters such as biomass production, relative growth rate (RGR) net assimilation rate (NAR) leaf area ratio (LAR) and reproductive growth revealed that the plant performs well upto 50 mM NaCl salinity level indicating its salt tolerant nature. Eventhough Na and Cl accumulated in both the plant parts, root and shoot, under saline conditions, the shoot was relatively kept away from toxic accumulation of Na. K content did not fall below the optimum under saline conditions, except at 100 mM NaCl during later stages of development. It appeared that Ca suppressed Na uptake and probably contributed to the ionic balance under stress conditions. Uptake and distribution of P and Mg under NaCl salinity, were favourable for plant growth upto 50 mM NaCl. Fe and Mn were accumulated to the toxic level at 100 mM NaCl.

## INTRODUCTION

Soil salinity is an ever alarming problem in Indian agriculture. Saline habitats are characterized by an excess of inorganic salts and salts accumulation in the upper soil layer. This soil anomaly profoundly influences negatively, the growth, yield and even very existance of crop plants. According to Epstein *et al* (1980), besides an engineering approach, development of crops, tolerant to salinity, is a better strategy for meeting the challange of this problem. To achieve this, a better understanding of physiology of mechanism of salt tolerance in plants is highly essential. Moth bean (*Phaseolus aconitifolius* Jacq.) is one of the important minor grain legume crops of arid and semiarid regions. In India, it is grown as a hot season crop. It is the most drought resistant of the Kharif pulses and is largely grown on dry, light, sandy soils in the arid and semiarid regions of the country. It is certain, therefore, that moth bean can be an ideal material for the study to understand the mechanism(s) of drought resistance and salt tolerance in plants. It was thought worthwhile, therefore, to investigate the effect of NaCl salinity on growth, uptake and distribution of inorganic ions in moth bean in order to understand the mechanism of salt tolerance in this legume.

## MATERIALS AND METHODS

Plants of moth bean (*Phaseolus aconitifolius*, local variety) were grown in pot soil culture. About 10 plants were grown in each pot. Plants were irrigated twice a week with two litres of tap water every time. One month after stabilization of plants, salt treatments were given. The concentrations of NaCl used in the experiment were 0 (Control), 10, 25, 50 and 100 mM. The treatments were given twice a week, in alternate with equal amount of water to avoid excess of salt accumulation and loss of water due to evaporation in the soil. After an interval of every ten days (I-40, II-50, III-60, IV-70, V-80 and VI-90 days growth), plants were analysed for growth parameters, and inorganic constituents. The experiment was done in triplicate.

Growth parameters on twenty plants were recorded on average shoot length, average plant height, root to shoot ratio, number of leaves and number of internodes plant$^{-1}$. Dry matter of root, stem, leaves and pods, leaf area, and number of pods plant$^{-1}$ were also determined. From the data Relative Growth Rate (RGR), Net Assimilation Rate (NAR) and Leaf Area Ratio (LAR) were computed.

For estimation of inorganic constituents an acid digest from oven dried plant material was used (Toth *et al.*, 1948). Na, K and Ca were estimated flame photometrically following the procedure standardised in our laboratory. Cl was estimated following the method by Volhard (1956) while phosphorus was determined following the method by Sekine *et al.* (1965). The method described by Drausdoff and Nearpass (1948) was adopted for estimation of Mg. Fe and Mn were determined following the methods by Durie *et al.*, (1965).

## RESULTS AND DISCUSSION

Height of *P. aconitifolius* plants increased continuously till the last stage of maturity (90 days) and was very rapid only after I stage or vegetative phase (after 40 days) (Table I). However, the root : shoot ratio was maximum during the last stage of growth indicating continuation of root growth rather at the faster rate. The number of leaves produced per plant was maximum during the early phases of

Table I. Effect of NaCl salinity on growth of *P. aconitifolius*

| Growth parameter | NaCl treatment, mM | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 (Control) | | | 10 | | | 25 | | | 50 | | | 100 | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| Plant height (cm) | 23.77 ±1.37 | 26.05 ±2.01 | 28.75 ±1.47 | 21.75 ±2.21 | 24.30 ±1.92 | 32.25 ±2.67 | 22.85 ±2.55 | 25.15 ±2.60 | 33.35 ±3.12 | 22.50 ±2.41 | 29.75 ±2.43 | 40.05 ±3.13 | — — | 30.5 ±3.11 | 32.2 ±3.11 |
| Root : Shoot ratio | 0.53 ±0.06 | 0.57 ±0.03 | 0.58 ±0.04 | 0.51 ±0.05 | 0.56 ±0.06 | 0.72 ±0.10 | 0.64 ±0.03 | 0.60 ±0.02 | 0.64 ±0.04 | 0.57 ±0.06 | 0.57 ±0.05 | 0.57 ±0.07 | — — | 0.62 ±0.04 | 0.72 ±0.08 |
| No. of leaves $plant^{-1}$ | 7 | 6 | 4 | 5 | 6 | 7 | 6 | 6 | 8 | 6 | 7 | 9 | — | 6 | 4 |
| No. of internodes $plant^{-1}$ | 4 | 5 | 6 | 4 | 4 | 6 | 4 | 5 | 6 | 4 | 5 | 6 | — | 5 | 6 |

*Plant developmental stages. I—Initial vegetative, II—Flowering, III—Maturity. The values for number of leaves and internodes have been rounded to the next or first whole number.

growth, later it was decreased. This may be due to fall of senescent leaves towards maturity.

Dry matter production was increased with the advancement in growth (Fig. 1). However, the rate of increase was higher during the third and fourth stages of development. At maturity (VI stage) it was markedly declined, probably due to loss of dried and senescent leaves. This was also evident from the growth rate values (Table II). RGR was highest during flowering stage which was kept higher even during the later stages of growth. NAR was higher during the third and final phase of development. However, LAR was affected remarkably during later stages of growth. It appears that NAR may be the main contributing factor for increased RGR during later stages of growth.

Salinity stress caused a considerable decrease in growth of *P. aconitifolius* in terms of average plant height, number of leaves, leaf area, biomass (dry matter), number and dry wt of pods per plant produced only at the highest salinity

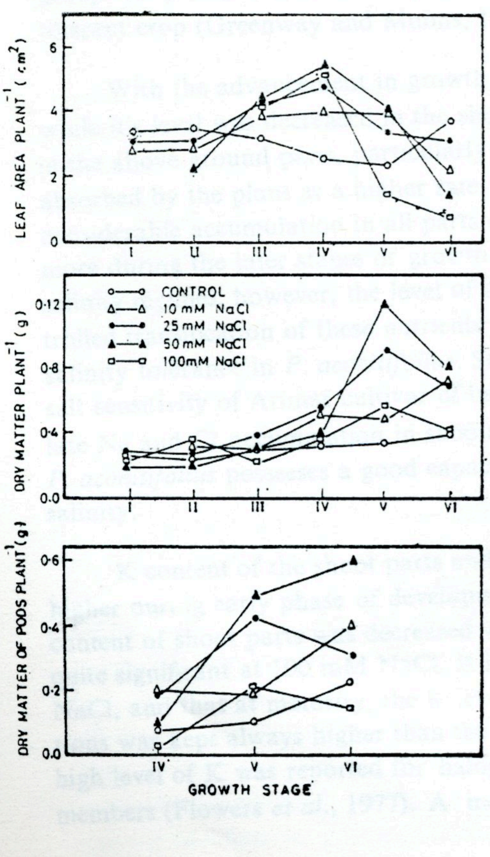


Fig. 1. Effect of NaCl salinity on leaf area, dry matter and pod formation in *Phaseolus aconitifolius* (Jacq.) at various developmental stages.

Table II. Effect of NaCl salinity on relative growth rate (RGR), net assimilation rate (NAR) and leaf area ratio (LAR) in *P. aconitifolius*.

| Growth parameter | NaCl treatment, mM | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 (Control) | | | 10 | | | 25 | | | 50 | | | 100 | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| RGR (mg. $g^{-1}$ dry matter $day^{-1}$) | 0.29 | 0.35 | 0.29 | 0.39 | 0.45 | 0.41 | 0.53 | 0.37 | 0.47 | 0.45 | 0.46 | 0.67 | — | 0.47 | 0.59 |
| NAR (mg. $cm^{-2}$ $day^{-1}$ dry matter) | 0,29 | 0.47 | 0.61 | 1.4 | 0.82 | 4.6 | 0.92 | 1.3 | 3.4 | 0.21 | 0.50 | 0.92 | — | 0.67 | 0.82 |
| LAR ($cm^2$. $g^{-1}$ dry matter) | 1.00 | 0.73 | 0.11 | 0.28 | 0.56 | 0.09 | (.58 | 0.28 | 0.14 | 2.14 | 0.92 | 0.73 | — | 0.70 | 0.72 |

For developmental stages refer to Table 1.

level, 100 mM NaCl (Table I and Fig. 1). Root : Shoot ratio was increased at all stages of growth in the plants grown in 100 mM NaCl medium. This reflected more inhibitory effect of salt on shoot growth. Low leaf area in plants subjected to highest salinity level, alongwith decreased number of leaves per plant probably led to the development of less number of pods. 50 mM NaCl treated plants produced maximum dry matter. RGR was also maximum in these plants (Table II). However, NAR and LAR were higher in the plants grown in 10 and 25 mM NaCl medium. All these observations lead us to suggest that growth and development of *P. aconitifolius* is stimulated by NaCl salinity upto 50 mM salt concentration.

Hamid and Talibuddeen (1976) have shown that greater sodium uptake promotes dry matter yield in barley and sugarbeet. Matar *et al.* (1975) have found that with increasing Na supply, dry matter production was decreased in lettuce, while increased in spinach. From the present studies, it can be said that *P. aconitifolius* behaves like barley, sugarbeet or spinach. Thus the species can be included in a group of plants between halophytes and non-halophytes as a moderately salt tolerant crop (Greenway and Munns, 1980).

With the advancement in growth, Na was slightly accumulated in the roots, while it's level was decreased in the shoot (Tables III and IV). Cl was accumulated in the above ground parts, particularly towards maturity. Both these nutrients were absorbed by the plant at a higher rate under saline conditions resulting into their considerable accumulation in all parts of the plant. However, Na was accumulated more during the later stages of growth at 50 and 100 mM NaCl levels. At lower salinity regimes, however, the level of Na was kept lower than Cl. Thus the controlled translocation of these nutrients seems to be an adaptive feature towards salinity tolerance in *P. aconitifolius*. Storey and Wyn-Jones (1978) have correlated salt sensitivity of Arimar cultivar of barley with a poor ability of the plant to regulate Na and Cl accumulation in shoots. Present observation, however, suggests that *P. aconitifolius* possesses a good capacity for regulation of Na upto 50 mM NaCl salinity.

K content of the shoot parts and the roots of *P. aconitifolius* was relatively higher during early phase of development and decreased towards maturity. The K content of shoot parts was decreased with increase in the salinity level, which was quite significant at 100 mM NaCl. It is interesting to note that except at 100 mM NaCl, and that at maturity, the K level in all parts of the plant under saline conditions was kept always higher than the optimum (1.0% dry wt, Epstein, 1972). Such a high level of K was reported for halophytes and in particular for chenopodiaceae members (Flowers *et al.*, 1977). A mechanism of preferential uptake of K under

Table III. Effect of NaCl salinity on inorganic constituents of the roots of *P. aconitifolius*

| Inorganic constituents | NaCl treatment mM | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 (Control) | | | 10 | | | 25 | | | 50 | | | 100 | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| Na | 0.23 | 0.28 | 0.25 | 0.24 | 0.24 | 0.32 | 0.42 | 0.21 | 0.55 | 0.31 | 0.31 | 0.96 | — | 0.35 | 1.60 |
| K | 1.32 | 1.60 | 1.20 | 1.60 | 1.20 | 0.73 | 1.50 | 1.14 | 1.40 | 1.30 | 1.20 | 1.43 | — | 1.10 | 1.70 |
| K : Na | 5.73 | 5.71 | 4.80 | 6.70 | 5.00 | 2.30 | 3.60 | 5.40 | 2.60 | 4.20 | 3.90 | 1.50 | — | 3.10 | 1.10 |
| Cl | — | — | 2.90 | — | 2.90 | 0.96 | — | 4.80 | 1.00 | — | — | 0.96 | — | 0.32 | 1.59 |
| Na : Cl | — | — | 0.09 | — | 0.08 | 0.33 | — | 0.04 | 0.55 | — | — | 1.00 | — | 1.10 | 1.01 |
| Ca | 2.53 | 1.54 | 1.80 | 2.53 | 1.21 | 1.10 | 2.20 | 2.20 | 1.80 | 2.80 | 2.31 | 1.21 | — | 1.43 | 2.80 |
| P | 0.70 | 0.40 | 0.20 | 0.52 | 0.13 | 1.40 | 0.35 | 0.32 | 0.20 | 0.18 | 0.36 | 0.19 | — | 0.14 | 0.41 |
| Mg | 0.41 | 0.44 | 0.28 | 0.56 | 0.38 | 0.31 | 0.41 | 0.46 | 0.47 | 0.51 | 0.35 | 0.37 | — | 0.31 | 0.72 |
| Fe | 0.36 | 0.37 | 0.72 | 0.43 | 0.43 | 0.34 | 0.73 | 0.24 | 0.41 | 0.06 | 0.31 | 0.68 | — | 0.33 | 0.09 |
| Mn | 0.24 | 0.35 | 0.04 | 0.29 | 0.19 | 0.06 | 0.39 | 0.12 | 0.07 | 0.03 | 0.05 | 0.40 | — | 0.01 | 0.09 |

* Values are expressed as g 100 $g^{-1}$ dry tissue.

—not determined.

Table IV. Effect of NaCl salinity on inorganic constituents* of the shoot of *P. aconitifolius*

| Inorganic constituent | NaCl treatment, mM | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 00 (Control) | | | 10 | | | 25 | | | 50 | | | 100 | | |
| | I | II | III | I | II | III | I | II | III | I | II | III | I | II | III |
| Na | 0.24 | 0.23 | 0.19 | 0.34 | 0.35 | 0.49 | 0.42 | 0.34 | 0.35 | 0.67 | 0.76 | 1.60 | — | 0.96 | 1.25 |
| K | 2.55 | 1.65 | 1.60 | 2.75 | 1.55 | 1.65 | 2.25 | 1.22 | 1.55 | 1.97 | 1.65 | 1.29 | — | 1.50 | 0.85 |
| K : Na | 10.62 | 7.17 | 8.42 | 8.09 | 4.45 | 3.37 | 5.36 | 3.59 | 4.45 | 2.94 | 2.17 | 0.80 | — | 1.56 | 0.68 |
| Cl | 1.60 | 1.61 | 1.93 | 0.96 | 3.50 | 3.80 | 1.28 | 5.35 | 2.21 | — | 2.10 | 2.88 | — | 7.9 | 4.15 |
| Na : Cl | 0.15 | 0.14 | 0.10 | 0.35 | 0.10 | 0.13 | 0.33 | 0.33 | 0.06 | — | 0.36 | 0.56 | — | 0.12 | 0.30 |
| Ca | 5.10 | 4.95 | 4.95 | 5.17 | 4.37 | 5.07 | 4.72 | 6.62 | 4.40 | 5.50 | 5.70 | 3.85 | — | 5.39 | 3.51 |
| P | 0.45 | 0.26 | 0.22 | 0.64 | 0.17 | 00.91 | 0.26 | 0.32 | 0.14 | 0.15 | 0.46 | 0 35 | — | 0.15 | 0.27 |
| Mg | 0.67 | 0.48 | 0.57 | 0.65 | 0.50 | 0.47 | 0.49 | 0.82 | 0.50 | 0.59 | 0.77 | 0.45 | — | 0.68 | 0.50 |
| Fe | 0.17 | 0.20 | 0.10 | 0.25 | 0.24 | 0.14 | 0.11 | 0.11 | 0.12 | 0.14 | 0.04 | 0.09 | — | 0.10 | 0.80 |
| Mn | 0.10 | 0.14 | 0.03 | 0.05 | 0.20 | 0.09 | 0.08 | 0.02 | 0.06 | 0.06 | 0.09 | 0.04 | — | 0.04 | 0.44 |

* Values are expressed as g 100 $g^{-1}$ dry tissue.

—Not determined.

The Fe and Mn contents of the roots were almost three times more than those of the shoot parts. Both the nutrients were accumulated further in the roots during flowering. This trend was continued by Fe till maturity while, the concentration of Mn was declined notably in the roots towards maturity. NaCl salinity caused a slight increase in the concentration of both these nutrients in all parts of the plants at 10 mM NaCl salinity only, otherwise their level was kept low at all other salinity levels upto 50 mM NaCl. However, toxic salt concentration caused a dramatic increase in the level of these nutrients in the shoot parts at maturity.

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# SOURCE-SINK RELATIONSHIP DURING AGEING AND SENESCENCE OF SOLANUM TUBEROSUM L.

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## SUMMARY

During the post reproductive period of potato plant (65 days onwards) the levels of chlorophyll in the leaves as well as harvest index (tuber weight : whole plant weight) decreased but aerial plant weight increased as compared to plants of corresponding age, which remained in vegetative condition. Plants separately treated with kinetin and urea remained vegetative throughout and showed increased chlorophyll levels in the leaves and in aerial plant weight but decreased harvest index as compared to untreated control. Detuberization increased chlorophyll level and aerial plant weight. Evidently nutrient exhaustion causes whole plant senescence of potato in normal vegetative state and the term "Monocarpic senescence" is not applicable to the age induced senescence of such plant.

## INTRODUCTION

Most of the crop plants are annual but in strict sense not all fruit bearing annuals show monocarpic senescence (Woolhouse 1981). Potato plants seems to provide useful evidences for determination of whole plant senescence in annuals, since most of the plants, in normal condition, die vegetatively after completion of tuberization. A few plants produce flowers and fruits which also die in a way similar to the plants which do not proceed to reproductive stage, Therefore, this particular annual plant is not always monocarpic for the induction of senescence. Present paper deals with source sink relationship during whole plant senescence of potato plants which die in vegetative as well as in reproductive condition.

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