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EFFECT OF PHOSPHORUS DEFICIENCY ON GROWTH AND TRASPORT OF K^+, NA^+, CL^-, NO_3^- IN LENTIL SEEDLING (*LENS CULINARIS* MEDIK. VAR. BARIMASUR-4)

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Abstract

Effects of phosphorus deficiency on accumulation of dry matter and transport of some monovalent ions *viz.*, Na^+, K^+, Cl^-, and NO_3^- in lentil showed that seedlings raised in culture solution with and without different amount of phosphorus decreased accumulation of K^+ and increased accumulation of Na^+ in both the root and shoot of lentil. Cl^- contents increased under P-deficiency. Concentration of NO_3^- was increased in the root and decreased in the shoot of P-deficient lentil. P-deficiency caused an increase in the root dry matter and a decrease in the shoot. P-deficiency resulted in a decrease in the shoot : root.

Introduction

Phosphorus is recognized as an important mineral element limiting crop growth and production.(1) It is generally considered as the second most limiting nutrient after N for plant growth.(2-3)

The acid-weathered soils of the tropics and subtropics are particularly prone to P-deficiency and Al toxicity.(4) The available P in Bangladesh soils could be considered to be between low and medium. About 20.7% area were reported to be predominantly low in available P and 21.2% were medium in available P(5) which is limiting crop production. Therefore, one of the adverse effects in agriculture practice in Bangladesh is phosphorus deficiency. Plants cannot live at phosphate concentration below two parts per ten million in soil solution.(6)

Plants suffering from P-deficiency showed retarded growth and low shoot/root dry matter ratio.(7) P-deficiency affected the development of reproductive organs and decreased number of flowers.(8) The formation of fruits and seeds is especially depressed in plants subjected to P- deficiency.

The reports on the effect of P-deficiency on growth and ion transport in lentil are rare. Moreover, the information on the effect of P-deficiency on transport of K^+, Na^+, Cl^- and NO_3^- may help to understand the mechanism of retarding growth and yield of plants. Hence, studies were carried out to investigate the effect of P-deficiency on growth and transport of K^+, Na^+,Cl^- and NO_3^- in lentil seedlings grown in culture solution.

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Materials and Methods

Lentil [*Lens culinaris* Medik. (Syn. *Lens esculenta* Moench., *Ervum lens* L., 2n=14) var. Barimasur-4] was used as plant material. The seeds were collected through the courtesy of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. The seeds were surface sterilized to avoid fungal infection by soaking the seeds in 4% sodium hypochlorite solution for one min, followed by washing repeatedly times in running tap water and three times in distilled water.

Plants were raised in culture solution for ion transport and dry matter accumulation. P-containing solution was used as control and P- free solution was used as treatment. Accumulation of ions was measured in roots and shoots of the seedlings at 7, 14, 21 and 28 days of P-deficiency treatments.

K^+ and Na^+ ions were measured by flame photometer (Jenway, PEP-7, UK) at wavelengths of 767 and 589 nm, respectively. The concentrations of K^+ and Na^+ were calculated using standard curves and expressed as m-equiv. K^+/g dry tissue and μ-equiv. Na^+/g dry tissue.

Amount of Cl^- was measured by the titrametric method. Sample solution containing Cl^- was titrated with 0.05N $AgNO_3$ using 5% $K_2Cr_2O_7$ as an indicator. Chloride content of the sample was expressed as m-equiv. Cl^-/g dry tissue. NO_3^- was determined following the method of Cataldo *et al.*[9] Absorbance was measured with a spectrophotometer (Campsec, M-202, UK) at 410 nm. The nitrate content was expressed as mg NO_3^-/g dry tissue. Three replicates were used for each measurement.

The root and shoot samples were dried in an oven at 80ºC for 72 hrs to a constant weight and kept in a desiccator to prevent absorption of moisture. Dry weights of the samples were recorded with an electronic balance for analysis of biomass production. Shoot : root dry weight was calculated.

Results and Discussion

Accumulation of K^+ in the root of lentil was inhibited by 11.5 to 21.9% from 7 to 28-day of P-deficiency treatment (Fig. 1a). Similarly, P-deficiency inhibited the accumulation of K^+ by 30% at 7-day of treatment in the shoot of lentil and the inhibitory effect was sustained up to 28-day of treatment (Fig. 1b).

P-deficiency slightly increased the accumulation of Na^+ from 7 to 21-day of treatment in the root and decreased at 28-day of treatment (Fig. 1c). Na^+ accumulation was increased in the shoot by 26.0 to 12.8% from 7 to 28-day of treatment (Fig. 1d).

Similar P-deficiency induced inhibition of K^+ accumulation was reported in strawberry[10] and maize.[11]

On the contrary, P-deficiency increased K^+ content in rape and radish. [12]

P-deficiency resulted in a decrease in K^+ accumulation with a concomitant increase in that of Na^+ in the root and shoot of lentil (Fig. 1a-d). This result shows that P-deficiency eliminates the K^+/Na^+ selectivity.

High levels of Na^+ or high Na^+/K^+ ratio can disrupt various enzymatic processes in the cytoplasm. Moreover, protein synthesis requires high concentration of K^+ for the binding of tRNA to ribosome.[13] The disruption of protein synthesis by elevated concentrations of Na^+ appears to be an important cause of damage by Na^+.

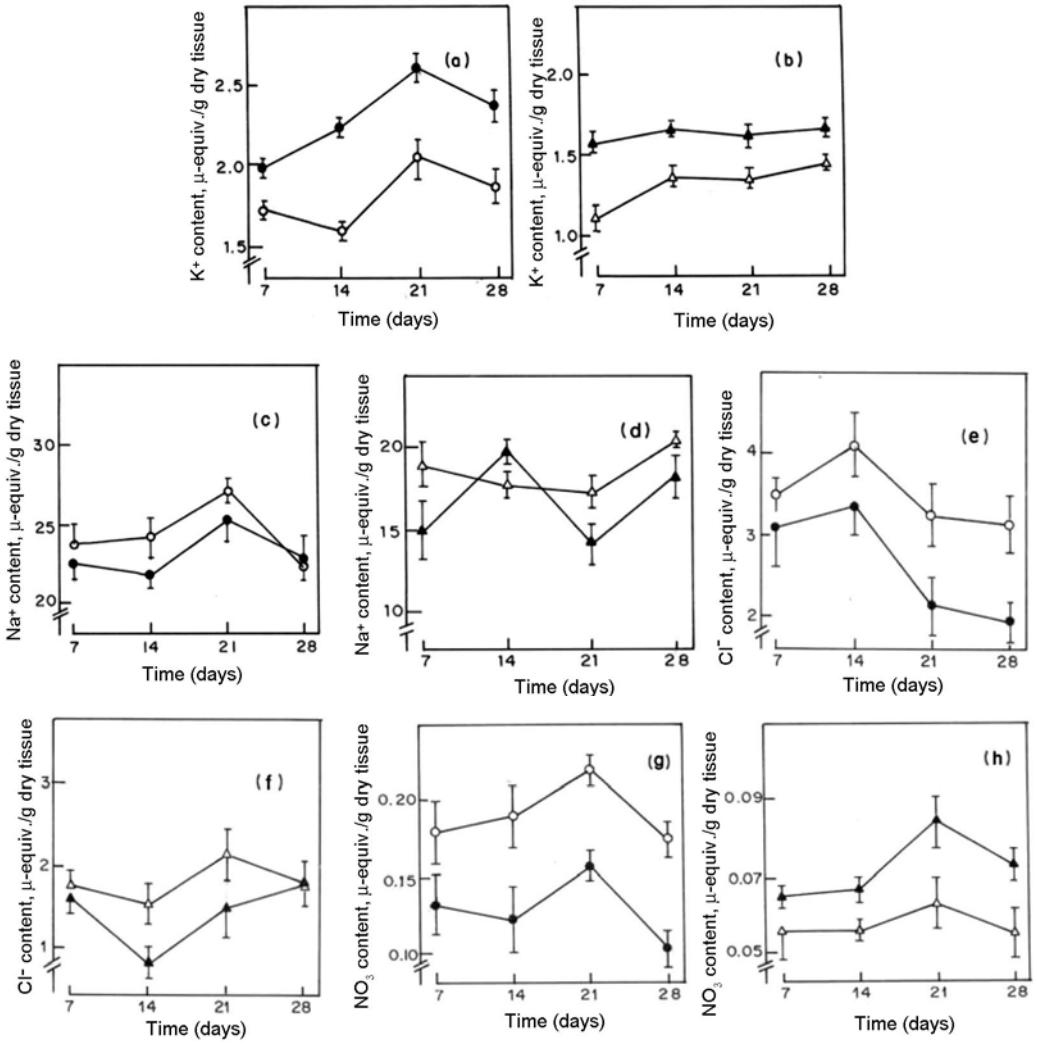

Fig. 1. Effect of P-deficiency on accumulation of K^+ in the (a) root and (b) shoot , Na^+ in the (c) root and (d) shoot , Cl^- in the (e) root and (f) shoot and NO_3^- in the (g) root and (h) shoot of lentil plants grown in culture solution. Solid symbols indicate + P and open symbols - P. o root, Δ stem. Each value is the mean of three replicates and bar represents ± standard error of mean.

Chloride accumulation in the root was increased by 12.9 to 24.0% from 7 to 14-day of treatment and this stimulatory effect was sustained up to 28-day of treatment. Similarly, in the shoot , accumulation of Cl^- was increased by 66% and 42% at 14 to 21-day of phosphorus deficiency treatment and the stimulatory effect was nullified at 28-day of treatment (Fig. 1e, f).

Cl^- accumulation increased in the root and shoot of P-deficient lentil at almost all the developmental stages (Fig. 1e-f). Similar P-deficiency induced stimulation of Cl^- accumulation was observed in *Populus maximowiczii*.[14]

Nitrate accumulation was increased in the root from 26.0 to 46.5% following 7 to 28-day of P-deficiency treatment. On the other hand, in the shoot, P-deficiency decreased nitrate accumulation by 14.0 to 23.5% from 7 to 28-day of treatment (Fig. 1g, 1h).

P-deficiency induced increase in the accumulation of NO_3^- in the root with concomitant decrease in that in the shoot may be due to the decreased transport of NO_3^- from the root to shoot (Fig. 1g-h). This view is supported by Jeschke *et al.*[15-16] who found that P-deficiency decreased transport of NO_3^- from the root to shoot of *Ricinus communis*. A similar restriction in NO_3^- translocation from the root to shoot was reported in nitrate-dependent soybean[17] and bean[18-19] deprived of external P.

P-deficiency increased NO_3^- accumulation in the root (Fig. 1g). It is suggested that phosphorus deficiency-induced NO_3^- accumulation may also be due to increased efflux.

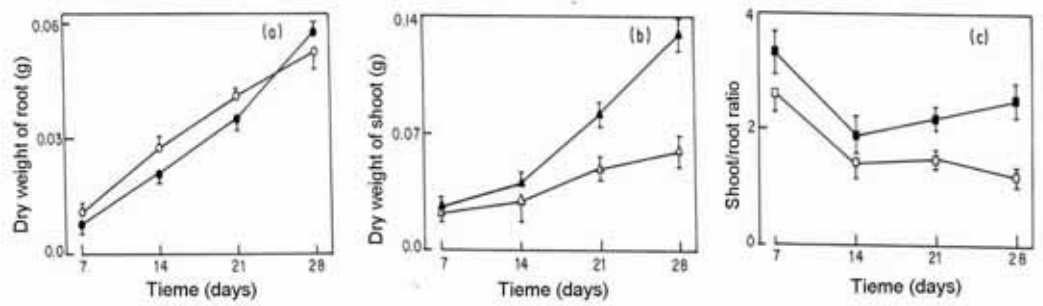

Fig. 2. Effect of P-deficiency on dry weight of the (a) root, (b) shoot and (c) shoot/root ratio of lentil plants at different developmental stages. Otherwise as Fig. 1.

P-deficiency caused a 25 to 14% increase in the dry matter content of the root of lentil at 7 to 21-day of treatment (Fig. 2a). Dry matter content of the shoot of this plant was inhibited from 3.5 to 53.8% at 7 to 28-day of P-deficiency treatment (Fig. 2b). P-deficiency caused a 20 to 54% decrease in the shoot/root ratio of lentil at 7 to 28-day of treatment (Fig. 2c). P-deficiency increased the root dry weight while it decreased the shoot dry weight leading to a decrease in the shoot/root ratio (Fig. 2c). These results were in agreement with the work of Luquct *et al.* who reported that P-deficiency decreased the shoot to root dry weight ratio in rice seedlings.[20] P-deficiency-induced decrease in the shoot : root ratio was also observed in maize.[21]

The P-deficiency caused in a decrease in an accumulation of K^+ and NO_3^- with concomitant increase of Na^+ and Cl^- which might cause to decrease in protein synthesis. The decrease of protein synthesis may lead to decrease in growth and development as well as yield of the lentil plants.

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