J. Asiat. Soc. Bangladesh, Sci. 38(1): 1-6, June 2012

ION TRANSPORT AND ACCUMULATION OF TOTAL SUGAR, SOLUBLE PROTEIN AND AMINO ACID IN *LENS CULINARIS* MEDIK VAR. BARIMASUR-4 (LENTIL) UNDER PHOSPHORUS DEFICIENCY

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Abstract

Some ionic and biochemical responses of lentil (*Lens culinaris* Medik.) under phosphorus deficient condition were studied. Seedlings were raised in solution culture containing phosphorus and without phosphorus (P-deficiency). Phosphorus deficiency decreased Ca^{2+} and Fe^{2+} accumulation and slightly decreased Mg^{2+} accumulation in root and shoot of lentil. Phosphorus deficiency caused a decrease in accumulation of total sugars in leaf and stem but increased in root. Accumulation of total soluble proteins was depressed in lentil following P-deficiency treatment. Phosphorus deficiency increased total amino acid contents in both root and shoot.

Key words: Phosphorus deficiency, Sugar, Amino acid, Protein, Lentil , Ca^{2+}, Mg^{2+} , Fe^{2+}, SO_4^{2-} .

Introduction

Phosphorus (P) is one of the major elements required by all living species for growth and development (Hammond *et al.* 2004). Phosphate is intimately involved with cellular bioenergetics and metabolic regulation. Phosphorylated compounds like ATP are involved in the transfer and storage of energy within plant. Despite its ubiquitous importance to plant metabolism, Pi is one of the least available nutrients in many natural ecosystem (Barber 1980).

Availability of phosphorus to plant roots is limited both in acidic and alkaline soils, mainly due to formation of sparingly soluble phosphate compounds with Al and Fe in acidic and Ca in alkaline soil (Marschner 1995). The highly mobile P in sodic soils is thought to be associated with sodium. Thus, soils become deficient in phosphorus. Low phosphorus availability strongly limits plant productivity.

The relationship between P, Ca^{2+}, Mg^{2+} and Fe^{2+} concentration in plants grown in P-deficient soil is noteworthy. An optimum P nutrition was found to increase the leaf concentration of both Ca^{2+} and Mg^{2+} in wheat seedlings (Reinbott and Blevins 1991). Phosphorus deficiency in soil markedly reduced the grain Mg^{2+} content in rice (Saleque *et al.* 2001). When phosphorus supply in the growth medium was limited, accumulation of Fe^{2+} increased in the tolerant cultivar of rice but decreased in the sensitive cultivar (Li *et al.* 2004).

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As major nutrient ions, S and P are intimately involved in plant metabolism and growth having various interactions with S- and P- dependent metabolic processes. It would, therefore, be expected that in plants deprived of optimal P supply, assimilation of S may be altered significantly.

Tissue carbohydrate was found to increase in *Gracilaria cornopifolia* after 8-day of phosphorus deficiency (Lee 2004). Rufty *et al.* (1993) reported that phosphorus deficiency increased accumulation of asparagines in the root and stem of nitrate-fed soybean plants. Usuda (1995) reported that in maize, soluble and insoluble protein contents decreased as compared to that of control plants in low phosphorus condition.

The information on the effect of phosphorus deficiency on transport of some ion and biochemical changes may help to understand the mechanism of retarding growth and development of plants. Therefore, the present research was undertaken to study on transport of Ca^{2+}, Mg^{2+} , Fe^{2+}, SO_4^{2-} and accumulation of total sugar, amino acid and soluble protein in *Lens culinaris* Medik. var. Barimasur-4 (Lentil) under phosphorus deficiency.

Materials and Methods

Lens culinaris Medik (2n=14) var. Barimasur-4 was used as plant material. The seeds were surface sterilized by soaking the seeds in 4% sodium hypochlorite solution for one minute, followed by washing 7 to 8 times in tap water running and three times in distilled water.

Plants were grown in solution culture for ion transport and biochemical changes study. Phosphorus–containing solution (+P) was used as control and phosphorus free solution was used as treatment (-P). Plants were subjected to phosphorus deficiency treatment for 7, 14, 21 and 24 days prior to collection of samples and three replicates were taken for each treatment. Iron (Fe^{2+}), Ca^{2+}, Mg^{2+} were extracted in a mixture of nitric acid and perchloric acid (HCl_3O_4) at 4: 1 ratio. The amount of Fe^{2+} Ca^{2+}, Mg^{2+} in the extract was measured by an Atomic Absorption Spectrophotometer following ASI method. Sulphate (SO_4^{2-}) in plant material was determined through turbidimetric method as described by Hunt (1980).Total sugar was determined by phenol-H_2SO_4 method of Dubois *et al.* (1956). Soluble protein estimation was done by Lowry *et al.* (1951) and total amino acid was measured by the method of Lee and Takahasi (1966)

Results and Discussion

The Effect of phosphorus deficiency on transport of divalent cation: In the root of lentil, Ca^{2+} accumulation was decreased by 19.0 to 45% during the treatment period (Fig.1a). Similarly, Ca^{2+} content decreased from 6.7 to 42.7% in shoot (Fig.1b). A decrease in Ca^{2+} level may have impaired the cell membrane permeability of the root which in turn may alter its uptake properties of P-deficient triticale (Quartin *et al*. 2001).

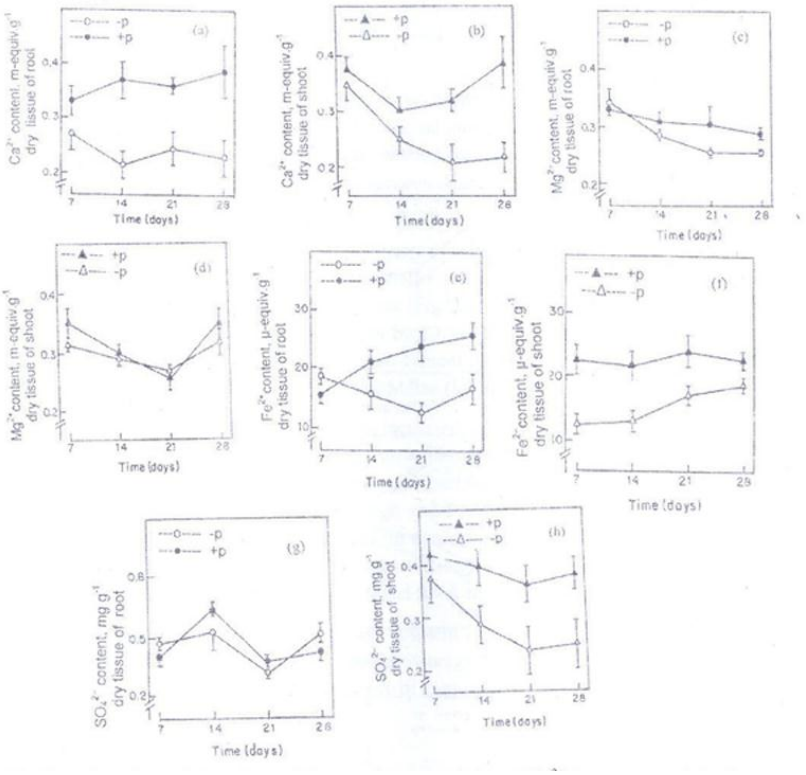

Fig. 1. The effect of phosphorus deficiency on accumulation of Ca^{2+} in (a) root and (b) shoot; Mg^{2+} in (c) root and (d) shoot; Fe^{2+} in (e) root and (f) shoot; SO_4^{2-} in (g) root and (h) shoot of lentil plants grown in solution culture. Solid symbols..... + P and Open symbols ... - P. O root, Δ shoot. Each value is the mean of three replicates and vertical bar represents ± standard error of mean.

Phosphorus deficiency caused A 5.9 and 12.0% decrease in accumulation of Mg^{2+} in root at 14 and 28-day of phosphorus deficiency treatment (Fig. 1c) and slightly decreased in shoot of lentil (Fig. 1d). Phosphorus deficiency-induced decrease in Mg^{2+} accumulation was found in the leaves of triticale (Quartin *et al.* 2001), and tolerant and sensitive cultivars of rice (Li *et al.* 2004).

Accumulation of Fe^{2+} in root decreased by 27.7 to 35.0% during the treatment period except an initial increase of 10% at the 7-day of treatment (Fig.1e). Similarly, Fe^{2+} accumulation in shoot was decreased by 44.5% at the 7-day of treatment and this

inhibitory effect was continued up to 28-day of phosphorus deficiency treatment (Fig.1f). Similar results were found due to phosphorus-stress in Fe^{2+} accumulation in phosphorus sensitive rice cultivars (Li *et al.* 2004).

The Effect of phosphorus deficiency on transport of divalent anion: Phosphorus deficiency had no effect in the accumulation of SO_4^{2-} in root (Fig. 1g) but decreased in shoot (Fig.1h). Jayalalitha and Naryanan (1996) also reported similar result in cotton.

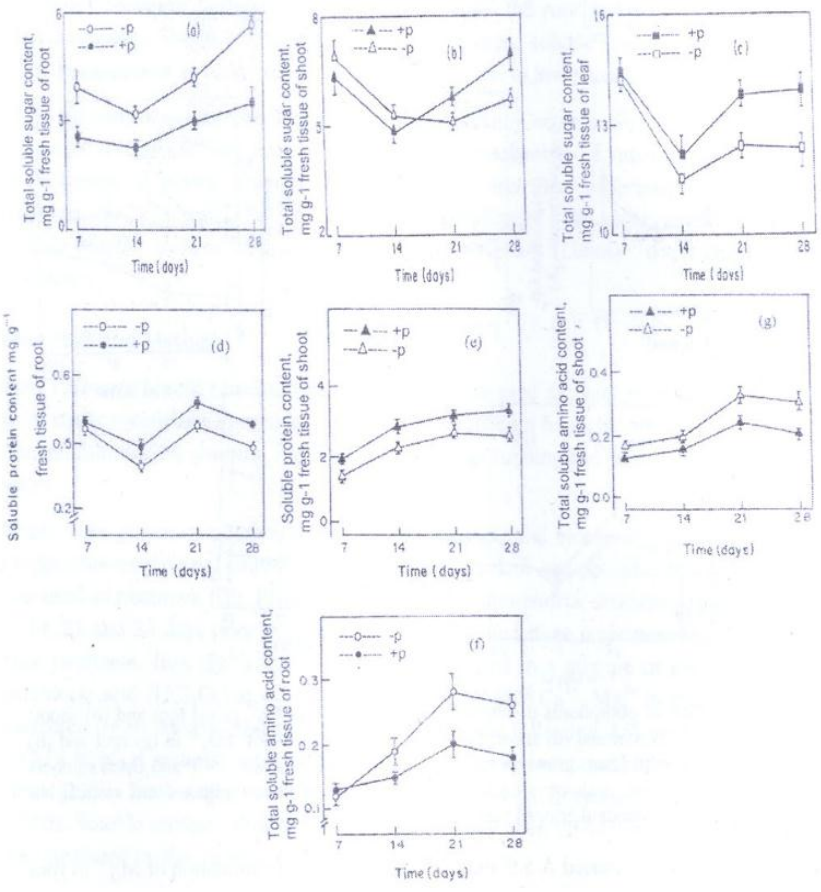

Fig. 2. The effect of phosphorus deficiency on accumulation of total soluble sugar in (a) root , (b) shoot and (c) leaf ; protein in (d) root and (e) shoot , amino acid in (f) root and (g) shoot of lentil plants at different developmental stages.

The Effect of phosphorus deficiency on transport of total sugar: Phosphorus deficiency increased accumulation of total sugar from 55.3 to 70.1% in root of lentil during the treatment period (Fig. 2a). Phosphorus deficiency increased total sugar content in the stem by 9.35 and 7.07% at 7 and 14-day of treatment respectively followed by an

inhibition of that by 9.9 and 17.5% at 21 and 28-day of treatment respectively (Fig. 2b). On the other hand, total sugar accumulation in leaf was decreased by 5.5 to 11.0% from 14 to 28-day during phosphorus deficiency treatment (Fig. 2c).In lentil, phosphorus deficiency increased total sugar accumulation in root whereas it decreased that in leaves (Fig. 2). The increase in total sugar in root might also be due to translocation of that from the leaves to root. This result was concomitant with Li *et al.* (2001) who found that soluble sugar content increased under phosphorus deficient conditions in root of rice due to its translocation from the shoot to root.

The Effect of phosphorus deficiency on transport of soluble protein and total amino acid: Phosphorus deficiency inhibited the accumulation of soluble protein in root by 20.5 to 14.0% from 14 to 28-day of treatment period (Fig. 2d). Phosphorus deficiency caused a decrease in soluble protein content of shoot by 23 to 18.3% during the treatment period (Fig. 2e).Similar inhibition of soluble protein content under phosphorus deficiency stress was reported in Larch (Guo *et al.* 2005) and Maize (Usuda and Shimogwara 1992).

Accumulation of total soluble amino acids increased from 26.4 to 44.6% in root of lentil from 14 to 28-day of treatment except an initial decrease at 7-day of phosphorus deficiency treatment (Fig. 2f) and the same increased from 21 to 47.6% in shoot (Fig.2g). Results obtained are similar to that of Singh and Pandey (2003) and Rabe and Lovatt. (1984, 1986). An increase in amino acid with concomitant decrease in protein synthesis may be due to inhibition of amino acid incorporation into protein, because phosphorus is an important structural component in DNA and RNA needed for protein synthesis.

Phosphorus deficiency-induced decrease protein synthesis as well as decrease carbohydrate synthesis might lead to decrease energy supply in plant which may affect transport of ions. The decrease of transport of ions may lead to decrease in growth of lentil plants.

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(Received revised manuscript on 27 May 2012)