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EFFECTS OF SULPHUR DEFICIENCY ON ACCUMULATION OF K^+, Na^+, NO_3^-, PO_4^{3-} AND TRANSPORT OF K^+, Na^+ IN MUNGBEAN (*VIGNA RADIATA* L. VAR. BARI MUNG-6)

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Key words: Sulphur deficiency, Ion transport, Mungbean

Abstract

Sulphur deficiency caused a decrease in accumulation of Na^+ but increased the accumulation of K^+ in the root, stem and leaf of mungbean seedlings grown in solution culture under light bank. It also decreased K^+ and Na^+ accumulation in the root, stem and leaf of mungbean plants grown in sand culture under natural environmental conditions. However, sulphur deficiency increased the accumulation of NO_3^- in the root and stem but decreased that in leaf of mungbean seedlings grown in solution culture. It decreased accumulation of PO_4^{3-} in the root, stem and leaf except an initial increase in the leaf. It increased net influx, long distance transport and transport index of K^+ but decreased those of Na^+ in mungbean seedlings. This result indicates that K^+ is more mobile in plants than Na^+.

Introduction

Sulphur is a secondary nutrient which is involved in the formation of nitrogenase enzyme known to promote nitrogen fixation in legumes[1][2]. The role of sulphur in pulses growth is important from the point of view that the deficiency of the sulphur containing amino acids cysteine, cystine and methionine may limit the nutritional value of food and feed[3]. Plant species vary largely in sulphur requirements and balanced sulphur nutrition is crucial for their production and quality[4]. Sulphur deficiency decreased accumulation of K^+ in *Hordeum vulgare*[5], *Mentha arvensis* var. piperascens[6] and bean plants[7]. It increased the accumulation of Na^+ in the root and shoot of tobacco suspension[8]. Sulphur deficiency decreased accumulation of NO_3^- in maize[9]. Phosphate accumulation was increased in soybean[10] and barley[11] following sulphur deficiency treatment. Sulphate deprivation decreased Fe and Cu concentrations but increased Mn concentrations in tissue of mulberry plants[12].

Mungbean is an important summer pulse crop of many South Asian countries including India, Pakistan, Bangladesh, Thailand and Korea[13]. There is no report on the

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effect of sulphur deficiency on the accumulation of Na^+, K^+, NO_3^-, PO_4^{3-}in mungbean (*Vigna radiata* L.). In this paper, the effect of sulphur deficiency on the accumulation of Na^+, K^+, NO_3^-, PO_4^{3-} is reported.

Materials and Methods

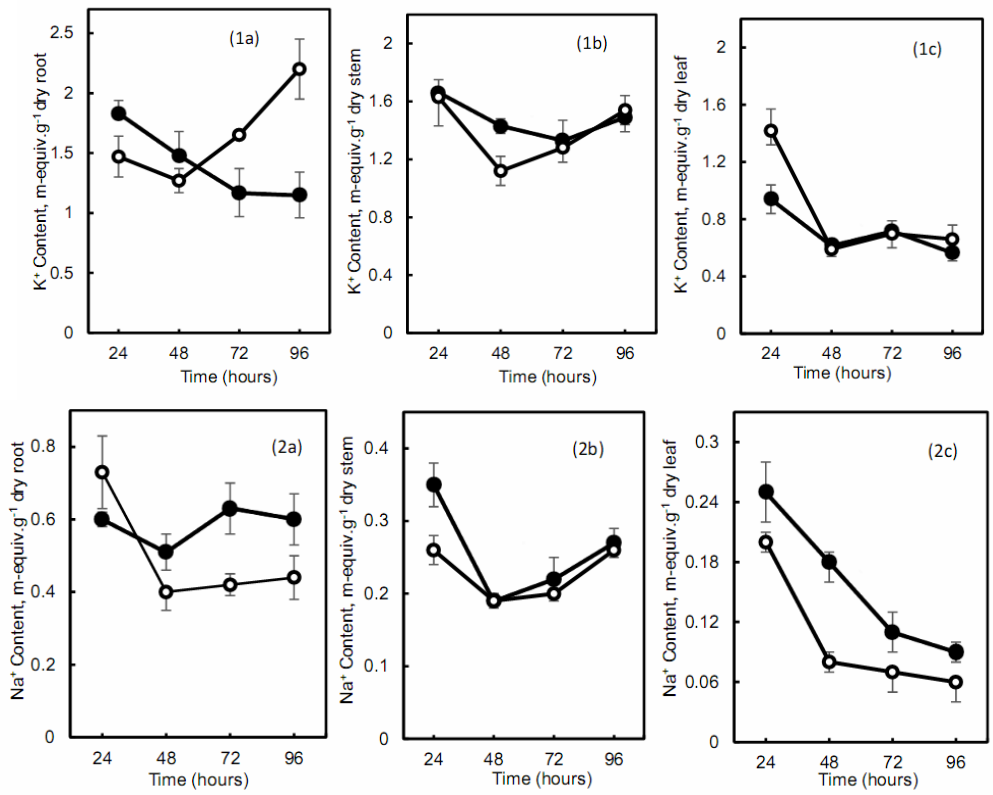
Mungbean (*Vigna radiata* L. var. BARI MUNG-6) was used as plant material. The seeds were obtained from Bangladesh Agricultural Research Institute (BARI), Gazipur. Plants were grown in solution culture following the method described by Hewitt[14] to study the accumulation of Na^+, K^+, NO_3^-, PO_4^{3-}. Plants were also grown in sand culture in natural environmental condition to study the effect of sulhur deficiency on Na^+, K^+ accumulation under light bank and natural environmental conditions. Seeds were surface sterilized by 5.25% sodium hypochlorite solution according to Samad and Karmoker[15]. Then the seeds were spread over a cotton gauge placed in a lid having holes (3 cm dia.) and the lid with seeds was placed on a beaker containing 500 ml of half-strength Long Ashton solution. The beaker was painted black to avoid the exposure of light to the roots. The beakers were kept in dark for 48 hrs to facilitate the germination of seeds. After germination, the beakers with the seedlings were placed in light bank at 22/18°C day/night temperature, 13/11 hrs day/night length and light intensity was 160 $\mu Em^{-2}s^{-1}$. The relative humidity was 65 - 80%. Sulphur-containing half-strength Long Ashton solution (+ S-solution) was used as control. Sulphur-free half-strength Long Ashton solution (– S-solution) was used as sulphur-deficiency treatment. Solutions of control and tratments were aerated continuously by an air compressor. In case of sand culture, sterilized seeds were sown in pots filled with purified sand at natural environmental conditions. Accumulation of Na^+, K^+, NO_3^-, PO_4^{3-} was measured in the root, stem and leaves of the seedlings grown in solution culture at 24, 48, 72 and 96 hrs of sulphur deficiency treatment. Three replicates were used in each treatment. The tissue were dried in an oven at 80ºC for 72 hrs to attain constant weight. K^+ and Na^+ were measured in mungbean plants grown in sand culture at 7, 14 and 21 days of sulphur deficiency treatment.

Na^+ and K^+ were extracted from dry tissue by boiling in water bath with two changes of 10 ml distilled water contained in test tubes. Phosphate was extracted by boiling dry tissue in HNO_3 : $HClO_4$ acid mixture (4 : 1) in a sand bath[16]. Na^+ and K^+ contents were measured according to Begum[17] and NO_3^-- by Cataldo *et al.*[18]. PO_4^{3-} contents was measured following Jackson[19].

Results and Discussion

Sulphur deficiency decreased accumulation of K^+ in the root by 20 to 14% from 24 to 48 hrs and increased by 41 to 91.3% from 72 to 96 hrs of treatment (Fig. 1a). It decreased K^+ accumulation in the stem by 22% at 48 hrs and was nullified at 72 hrs of treatment (Fig.

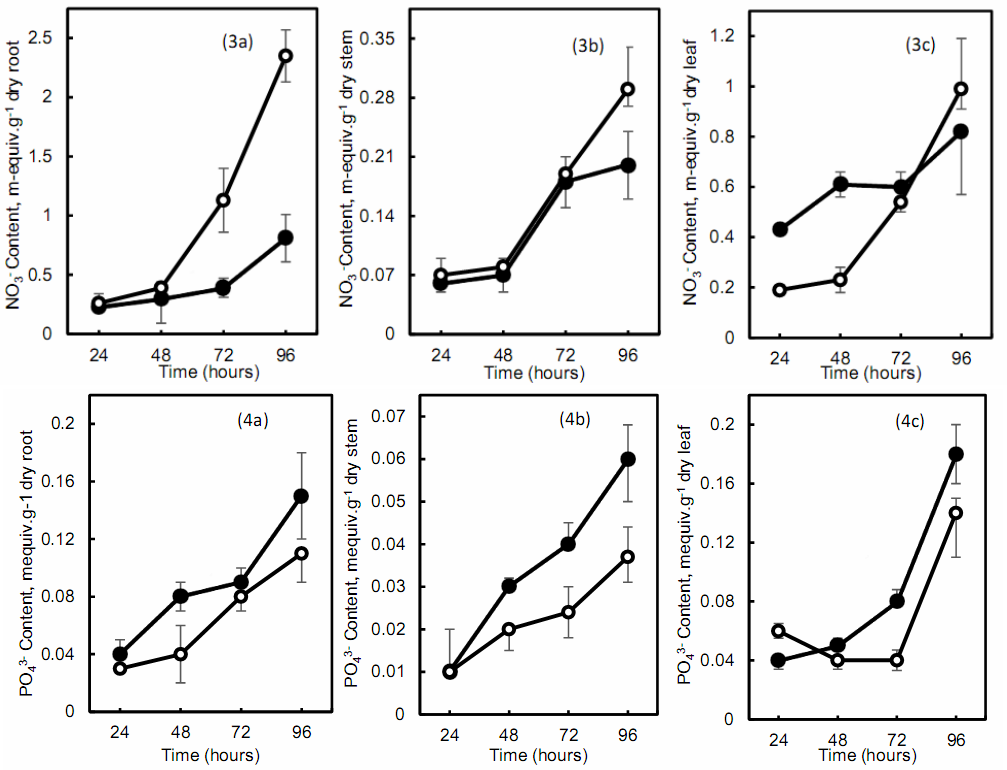
1b). K^+ accumulation was increased in leaf by 51 and 16% at 24 and 96 hrs of treatment, respectively (Fig. 1c). Andonova[20] found that sulphur deficiency decreased the accumulation of K^+ in maize. On the contrary, Ivanic[11] reported that sulphur deficiency increased K^+ accumulation in barley.



Figs 1-2: 1. Effects of sulphur deficiency on the accumulation of K^+ in the (a) root, (b) stem and (c) leaf of intact mungbean seedlings grown in solution culture. Solid symbols represent +S and open symbols represent –S. Each value is the mean of three replicates; Bars represents ± stamdard error of the mean value. e. Effects of sulphur deficiency on the accumulation of Na^+ in the (a) root, (b) stem and (c) leaf of intact mungbean seedlings grown in solution culture. Otherwise as Fig. 1.

Sulphur deficiency decreased Na^+ accumulation in the root from 48 to 96 hrs of treatment except an initial increase (Fig. 2a). It decreased Na^+ accumulation in the stem by 25.7% at 24 hrs which remain low up to 96 hrs of treatment (Fig. 2b). It caused a decrease in Na^+ accumulation in the leaf by 20 to 64% at 24 to 48 hrs and the inhibitory effect was sustained up to 96 hrs of treatment (Fig. 2c). On the contrary, Osman and Rady[21] reported that sulphur deficiency increased the accumulation of Na^+ in *Pisum sativum* L.

Sulphur deficiency caused an increase in NO_3^- accumulation in the root by 2.8- to 2.9-fold at 72 to 96 hrs of treatment (Fig. 3a). It also increased NO_3^- accumulation in the stem (Fig. 3b). S-deficiency decreased NO_3^- accumulation in the leaf but increased at 96 hrs (Fig. 3c). This result is in agreement with the work of Badruddin and Karmoker [22] who found that nitrate accumulation in the root and shoot of chickpea increased by sulphur stress. The increase of nitrate accumulation may be due to the reduction of nitrogen metabolism.



Figs 3-4: 1. Effects of sulphur deficiency on the accumulation of NO_3^- in the (a) root, (b) stem and (c) leaf of intact mungbean seedlings grown in solution culture. Solid symbols represent +S and open symbols represent –S. Each value is the mean of three replicates; Bars represents ± standard error of the mean value. 4. Effects of sulphur deficiency on the accumulation of PO_4^{3-} in the (a) root, (b) stem and (c) leaf of intact mungbean seedlings grown in solution culture. Otherwise as Fig. 3.

In the root, sulphur deficiency caused a decrease in accumulation of PO_4^{3-} by 25 to 50% from 24 to 48 hrs and the inhibitory effect was maintained up to 96 hrs of treatment (Fig. 4a). It also decreased accumulation of PO_4^{3-} in the stem (Fig. 4b) and in the leaf (Fig. 4c). Similarly, Singh and co-workers[6] reported that sulphur deficiency reduced accumulation of phosphate in *Mentha arvensis* var. piperascens.

Sulphur deficiency decreased net influx of K^+ at 48 hrs of treatment which was nullified at 72 and 96 hrs of treatment grown in solution culture. It increased long distance transport of K^+ by 16.9% and the stimulatory effect was sustained up to 96 hrs of treatment. Sulphur deficiency increased transport index of K^+ by 20.4 to 8.6% from 24 to 48 hrs followed by a decrease of that (Table 1).

Table 1. The effect of sulphur deficiency on net influx, long distance transport and transport index of K^+. Each value is the mean of the three replicates; ± standard error.

Duration of treatment	Net influx (Ψoc), mequiv./plant		Long distance transport (Ψcx), mequiv./shoot		Transport index (Ψcx/ Ψoc × 100)	
Treatment (hrs)	+ S	– S	+ S	– S	+ S	– S
0 - 24	4.44 ± 0.51	4.51 ± 0.41	2.61 ± 0.16	3.05 ± 0.32	58.39 ± 3.03	70.30 ± 1.94
0 - 48	3.13 ± 0.08	2.98 ± 0.22	1.65 ± 0.05	1.71 ± 0.06	53.11 ± 2.84	57.67 ± 3.08
0 - 72	3.22 ± 0.06	3.44 ± 0.21	2.06 ± 0.03	1.79 ± 0.09	64.24 ± 0.22	51.99 ± 4.47
0 - 96	3.22 ± 0.45	4.40 ± 0.08	2.07 ± 0.02	2.20 ± 0.11	64.40 ± 5.03	51.07 ± 5.10

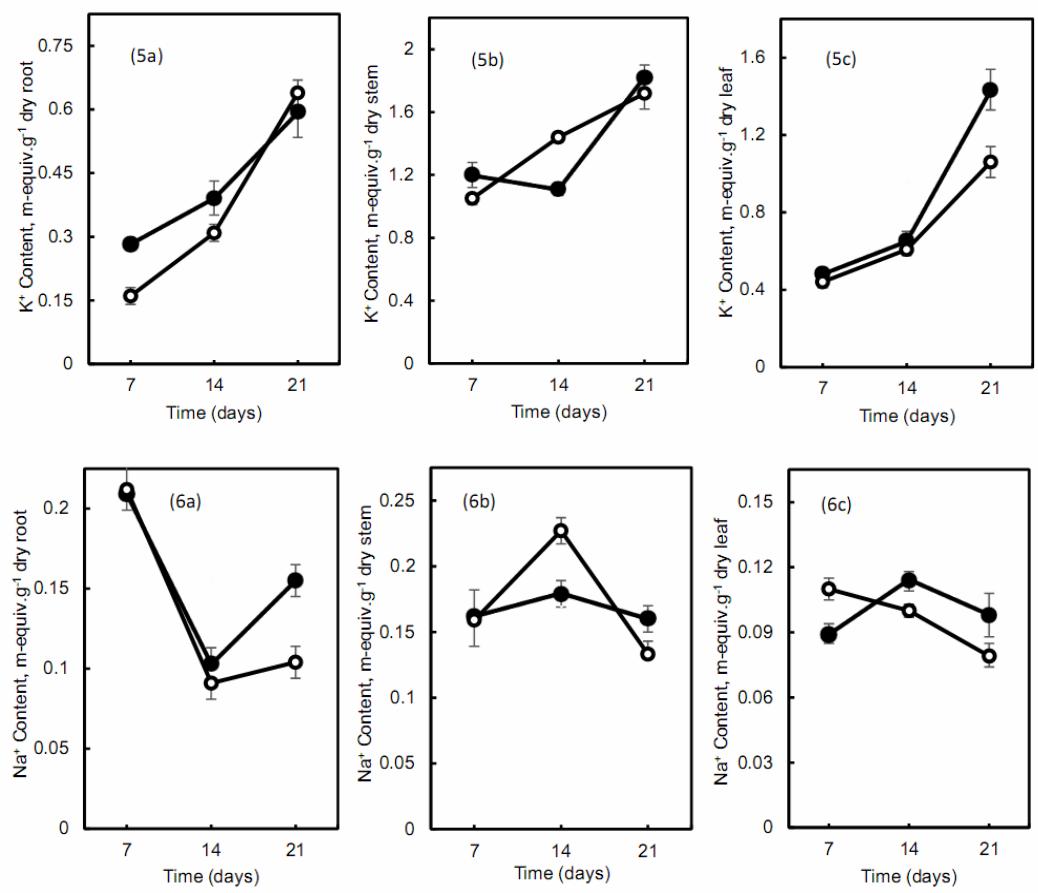
Table 2. The effect of sulphur deficiency on net influx, long distance transport and transport index of Na^+. Each value is the mean of the three replicates; ± standard error.

Duration of treatment	Net influx (Ψoc), mequiv./plant		Long distance transport (Ψcx), mequiv./shoot		Transport index (Ψcx/ Ψoc × 100)	
(hrs)	+ S	– S	+ S	– S	+ S	– S
0 - 24	1.20 ± 0.22	1.19 ± 0.10	0.597 ± 0.03	0.457 ± 0.08	49.47 ± 0.22	40.70 ± 2.96
0 - 48	0.780 ± 0.06	0.660 ± 0.06	0.269 ± 0.02	0.273 ± 0.02	34.61 ± 2.43	41.76 ± 0.84
0 - 72	0.964 ± 0.03	0.712 ± 0.11	0.333 ± 0.01	0.291 ± 0.02	35.48 ± 2.25	41.01 ± 2.03
0 - 96	0.749 ± 0.07	1.06 ± 0.10	0.352 ± 0.01	0.341 ± 0.03	48.38 ± 0.10	32.56 ± 1.49

Sulphur deficiency decreased net influx of Na^+ by 15.4 to 26.1% from 48 to 96 hrs of treatment and the inhibitory effect was nullified at 96 hrs of treatment grown in solution culture. It also decreased long distance transport of Na^+ by 23.5, 12.6 and 3.1% at 24, 72 and 96 hrs of treatment, respectively. Sulphur deficiency inhibited transport index of Na^+

by 18 to 32.7% from 24 to 96 hrs of treatment (Table 2). These results indicate that K^+ is more mobile in plants than Na^+.

In the root of mungbean plants grown in sand culture, accumulation of K^+ in the root was decreased by 44 to 21% from 7 to 14 days and inhibitory effect was nullified at 21 days of sulphur deficiency treatment (Fig. 5a). It decreased K^+ accumulation in the stem by 12% at 7 days but increased 30% at 14 days of sulphur deficiency treatment (Fig. 5b). It decreased K^+ accumulation in leaf by 26% at 21 days of treatment (Fig. 5c).



Figs 5-6: 5. Effects of sulphur deficiency on the accumulation of K+ in the (a) root, (b) stem and (c) leaf of intact mungbean plants grown in sand culture. Solid symbols represent +S and open symbols represent –S. Each value is the mean of three replicates; Bars represents ± standard error of the mean value. 6. Effects of sulphur deficiency on the accumulation of Na+ in the (a) root, (b) stem and (c) leaf of intact mungbean plant grown in sand culture. Otherwise as Fig. 5.

S-deficiency decreased Na^+ accumulation in the root by 33% at 21 days of treatment (Fig. 6a). It caused a decrease in Na^+ accumulation in the stem by 16.9% at 21 days of

treatment (Fig. 6b). It decreased Na^+ accumulation in the leaf by 13 to 20% from 14 to 21 days of treatment (Fig. 6c).

Sulphur deficiency-induced increase in nitrate accumulation might be due to the reduction of nitrogen metabolism. Transport index of Na^+ and K^+ shows that K^+ is more mobile in plants than Na^+.

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