RESEARCH ON LITHIUM-PHYTOLOGICAL METABOLISM AND RECOVERY OF HYPO-LITHIUM[1]

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ABSTRACT - Vegetables are a rich mineral source in human diet. It was demonstrated that lithium, a nonessential mineral in plants, has an important role on the psychosomatic normality of man, with its use related to human health problems such as hypertension, depressive state, hormonal balance, leukemia, diabetes, dental cavities, immunological functions, and others. To determine Li uptake by plants, a greenhouse study was carried out in solution culture with radish, lettuce and watercress at lithium levels of 0.1, 1.0 and 2.0 mM. Thirty days after transplanting, plants were collected, had their fresh and dry weights measured and nutrient contents were analyzed. In general, lithium increased iron uptake but did not affect uptake of other nutrients by lettuce. Growth of watercress was depressed at 2 mM Li but radish and lettuce growth was not significantly affected. Lithium content of watercress increased from 37 ppm with 0.1 mM Li to 1216 ppm with 2 mM Li in a quadratic response relationship to Li rate. The other plants responded similarly.

Index terms: watercress, lettuce, radish, trace element.

PESQUISA SOBRE A METABOLIZAÇÃO LITIOFITOLÓGICA NA RECUPERAÇÃO DA HIPOLITMIA

RESUMO - Os vegetais são rica fonte de minerais na dieta humana. Foi demonstrado que o lítio, mineral não essencial em plantas, tem importante papel na normalidade psicossomática do homem, com seu uso relacionado a problemas de saúde, tais como hipertensão, depressão, balanço hormonal, leucemia, diabetes, cáries e funções imunológicas, entre outros. Para determinar a absorção de lítio em plantas, conduziu-se um experimento em casa de vegetação, em solução nutritiva, com rabanete, alface e agrião, usando-se 0,1; 1,0 e 2,0 mM de lítio. Trinta dias após o transplante, as plantas foram coletadas e seus pesos frescos e de matéria seca bem como concentração de nutrientes foram analisados. Em geral, o lítio aumentou a absorção de ferro, mas não afetou a absorção de outros nutrientes em alface. O crescimento do agrião diminui ao nível de 2 mM de lítio, mas o do rabanete e alface não foram significativamente afetados. O teor de lítio em agrião aumentou de 37 ppm com 0,1 mM de lítio para 1.216 ppm com 2 mM de lítio, numa curva de resposta quadrática; as demais plantas tiveram comportamento similar.

Termos para indexação: agrião, alface, rabanete, elementos traçadores.

INTRODUCTION

Vegetables are rich mineral source in the human diet and can be forced to supply larger amounts of a specific mineral, to supply adequate levels in human food. It is known that vegetable metabolism can transform toxic organic and mineral complexed forms into

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nontoxic forms in the anabolic and catabolic processes by animals. An example is the reduction of the toxic $N\text{-}NO_3^-$ to NH_4 and its incorporation in essential amino acids for human diet (Magalhães & Wilcox 1984a, b).

Due to the relative selectivity on iron uptake, mineral accumulation at plant tissues, under certain limits, is a function of the ionic concentration of the element at the growing medium. So, uptake can be induced with hydroponic culture, to increase the level of a determined mineral in a very efficient process (Hara et al. 1977).

Lithium is a nonessential element to plants, though there are some evidences of its effects on photosynthesis, synthesis and sugar translocation, and a great number of enzymatical processes and nitrogen metabolism (Shkolnik 1984). On the other hand, hundreds of scientific papers showed the important role of lithium upon the psychosomatic normality of man with a lot of different manifestatitons. Effects of lithium are related to hypertension (Levy et al. 1983), depressive state (Williams & Jones Júnior 1984), hipothyroidism (Teshima et al. 1983), headache (Split & Durko 1983) and cyclic fevers (Igara et al. 1983), hormonal balance (Amsterdam et al. 1986), rythmia (Schneider & Goovaerts 1983), stomach acidity (Goode et al. 1984), bone marrow cell activity (Besa et al. 1983), ovarian carcinoma (Richman et al. 1983), leukemia (Horns Júnior et al. 1984) diabetes (Saran 1982), maternal milk quality (Hurgoin et al. 1982), transport and metabolism of other minerals especially calcium (Suva et al. 1986), dental cavities (Eisenberg et al. 1986), adrenaline (Ebstein et al. 1976) and melanine (Arnaud & Bore 1981) activity, functional properties of hemoglobin (Amiconi et al. 1986) and sperm fertility (Anke et al. 1986), immunologic function (Weetman et al. 1982), alcoholism (Anton et al. 1986), leucocyte activity in hepatic cirrhosis (Humberto et al. 1981), weight disturbances (Sampath et al. 1981), *anorexia nervosa* (Stein et al. 1982), glucose metabolism in brain (Plenge 1982), respiratory resistance (Weiner et al. 1983) phosphorylation of peptidic chains in eyes (Sredy & Spector 1986), the tear being a good fluid for measuring lithium concentration (Jefferson et al. 1984), coline carrier in erythrocytes (Uney et al. 1986), inhibition of virus Herpes activity (Lieb 1981), intelligence coefficient (Breuning & Davidson 1981), activation of several enzimatic processes (Knapp & Mandell 1983). On the other hand, it is important to give prominence to the fact that an excess of lithium can lead to toxicity thus causing nausea, diarrhea, callus on bones, possible interference with type 2 diabetes, light sensitivity, increase of some epileptic cases, temor and effect on kidney activities, thus its use is not recommended at as high as 30 mg/day for a long period, specially with other drugs or in cases of a salt diet (Trevisan et al. 1981). Lithium can substitute for 50% of the potassium in plants (Codina et al. 1983). Due to this fact, and to the great range of its content in different soils, 0.002 to 63 ppm (Vergara-Edwards et al. 1986) lithium concentration in plants has been reported to vary from 0.01 to 6000 ppm (Wallace et al. 1986). So based on its physico-chemical similarities with potassium, the lithium content can increase hundreds of time its concentration in plants depending on its concentration in the growing medium. Lithium is found mainly in its ionic state, in plants (Shkolnik 1984), thus can be easily assimilated by the animals.

The intent of this study is to demonstrate the induction of increase lithium content in plants so as to serve as a source of this mineral in the human diet.

MATERIALS AND METHODS

A study was carried out under greenhouse conditions, in solution culture, with three vegetable crops (radish, lettuce and watercress). The seedlings were transferred to a Hoagland's modified nutrient solution, seven days after germination in vermiculite. Plants were grown in plastic pots with aerated solution. The nutrient solution was made as follows:

5 mM NH_4NO_3, 1 mM KH_2PO_4, 2 mM K_2SO_4 2 mM $MgSO_47H_2O$, 4 mM $CaCl_2$, 50 mM Fe-EDTA, 2.86 mg/1 H_3BO_3, 1.81 mg/1 $MnCl_2 4H_2O$, 0.22 mg/l $ZnSO_4$'H_2O, 0.08 mg/l $CuSO_45H_2O$ and 0.025 mg/l Na_2MoO_4. The pH of the nutrient solution was set to 5.8 being adjusted every day with 0.1N H_2SO_4 or 0.1N NaOH. The nutrient solution was replaced every week. The experimental design was a complete randomized block, with three lithium levels in solution (0.1, 1.0 and 2.0 mM) applied as lithium nitrate, with six replications per treatment. Thirty days after transplanting, the plants were harvested, shoots and roots separately, and their fresh weight determined. They were oven-dried at 70°C for 72 hours, weighted, ground in a Wiley mill and analyzed for N, P, K, Ca, Mg, Fe and Li contents after digestion in H_2SO_4 and H_2O_2. N was determined by Nesslerization, P by an ammonium molybdate-amino naphthol sulfonic acid reduction method (Murphy & Riley 1962), K and Li by flame emissior and Ca, Mg and Fe by atomic absorption (Sarruge & Haag 1974).

RESULTS AND DISCUSSION

Results obtained show that the plant growth had a quadratic response to lithium levels (Table 1). Radish growth was not affected by lithium levels. Less growth was obtained for lettuce and watercress plants at the lowest lithium level. Lithium accumulation in plant tissue was an exponential function of the lithium levels applied for the three species studied.

Potassium content in both aerial and root parts of radish was affected by lithium levels as well as Ca in the aerial part of the plant (Table 2). Other mineral contents were not affected. In watercress, only N and Ca contents were affected by Li levels applied (Table 3).

In general, lithium application did not significantly affect other iron uptake but increased iron uptake by lettuce (Tables 3 and 5). Lithium contents in plants increased with increasing lithium levels in solution (Table 4). Lithium content in watercress increased from 37 to 1216 ppm when lithium in solution increased from 0.1 to 2.0 mM, whereas in radish (aerial part) Li increased from 17 to 1008 ppm and in lettuce from 11 to 508 ppm.

TABLE 1. Radish, lettuce and watercress growth as affected by lithium levels applied in solution culture.

Plant specie	Plant part	Plant dry weight (g/pot) Li solution concn (mM) 0.1	1	2
Radish				
	Leaves	41.5 a*	49.6 a	34.5 a
	Bulb	63.2 a	64.2 a	56.7 a
Lettuce	Leaves	28.5 b	37.7 a	35.3 a
Watercress	Leaves	10.6 b	13.3 a	10.7 b

* Means with same letter are not significantly different at the 0.05 level, by Duncan's test. Statistical analysis for each crop and plant part were done separately.

TABLE 2. Mineral contents in radish plants as affected by lithium levels in solution culture.

Nutrient element	Plant part	Composition (% DW) Li solution concn (mM) 0.1	1	2
N	leaves	2.50 a*	2.60 a	2.60 a
	bulb	1.80 a	1.80 a	1.80 a
P	leaves	0.70 a	0.68 a	0.70 a
	bulb	0.90 a	0.90 a	0.80 a
K	leaves	3.00 a	2.70 a	2.20 b
	bulb	3.96 a	3.60 b	3.30 b
Ca	leaves	3.50 a	3.40 a	2.85 b
	bulb	0.50 a	0.47 a	0.40 a
Mg	leaves	0.83 a	0.73 a	0.71 a
	bulb	0.29 a	0.30 a	0.28 a

* Means with same letter are not significantly different at the 0.05 level, by Duncan's test. Statistical analysis for each crop and plant part were done separately.

TABLE 3. Mineral contents in lettuce and watercress as affected by lithium levels in nutritive solution.

Nutrient element	Composition (% DW)					
	Li solution conc (mM)					
	0.1	1	2	0.1	1	2
	Lettuce			Watercress		
N	2.60 a*	2.30 a	2.30 a	4.50 b	4.90 b	6.00 a
P	0.60 a	0.70 a	0.78 a	1.00 a	1.00 a	1.20 a
K	2.30 a	2.30 a	2.30 a	3.60 a	3.60 a	3.40 a
Ca	0.85 a	0.92 a	1.02 a	1.84 a	1.82 a	1.67 b
Mg	0.39 a	0.43 a	0.52 a	0.49 a	0.48 a	0.46 a

* Means with same letter are not significantly different at the 0.05 level by Duncan's test.
Statistical analysis for each crop were done separately.

TABLE 4. Lithium content in radish, lettuce and watercress plants as affected by lithium applied levels in nutritive solution.

Plant specie	Plant part	Li composition (ppm Dw)		
		Li solution concn (mM)		
		0.1	1	2
Radish				
	Leaves	17 c*	840 b	1008 a
	Bulb	11 b	283 a	289 a
Lettuce	Leaves	11 c	277 a	508 a
Watercress	Leaves	37 c	775 b	1216 b

* Means with same letter are not significantly different at the 0.05 level, by Duncan's test. Statistical analysis for each crop were done separately.

In Table 6 a summary of lithium content in some food sources is presented. As demonstrated in this study, the lithium levels in plants can be increased to become a good lithium source. Plants had different responses to lithium applications, thus suggesting that other species could be studied. The mean concentration of Li in plants of the same specie collected at different points in the Brazilian "cerrado" markets was less than 6 ppm (Table 7). The requirement of Li in human diet is estimated in 70 μg/day. Based on this data, in order to attend the Li necessity, a man would intake, for example, about 2 g of watercress per day in fresh weight base, in case of plants supplied with lithium, but the amount of this vegetable would need to be greater than 400 grams per day, if not fertilized with the mentioned element.

TABLE 5. Iron content in radish, lettuce and watercress plants as affected by lithium applied levels in nutritive solution.

Plant specie	Plant part	Fe composition (ppm Dw)		
		Li solution concn (mM)		
		0.1	1	2
Radish				
	Leaves	125 a*	126 a	123 b
	Bulb	142 a	135 a	108 b
Lettuce	Leaves	104 b	116 b	163 a
Watercress	Leaves	107 a	89 a	81 a

* Means with same letter are not significantly different at the 0.05 level, by Duncan's test. Statistical analysis for each crop were done separately. done separately.

TABLE 6. Lithium content in some food sources (FW).

Source	Lithium content ug/g	Source	Lithium content ug/g
Wheat	0.02	fish	0.04
Tamarine	1.71	sugar	0.04
Pepper	0.13	cows milk	1.50
Mango fruit	0.07	human milk	0.15
Orange	0.02	beans	0.65

TABLE 7. Lithium content of produce from Brazilian "cerrado" markets.

Li composition (ppm DW)			
Watercress	Lettuce	Radish	
		Leaves	Bulb
6.64 a*	4.15 b	4.74 b	4.56 b

* Means of six replications Means with same letter are not significantly different at the 0.05 level by Duncan's test.

CONCLUSION

Vegetable crops supplied with 1 mM Li would become a good lithium source in human food, along with good plant growth.

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