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Effect of Selenium on quality and Nitrogen, Potassium concentration of Brussels sprouts grown in hydroponics

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ABSTRACT
Effect of Selenium (Se) concentration in the nutrient solution on quality and Nitrogen, Potassium concentration of Brussels sprout plants (*Brassica oleracea*, var Gemmifera) was evaluated. The Brussels sprout plants were treated with six concentration of Se as selenate sodium ($Na_2 SeO_4$., 0, 2, 4, 8, 16 and 32 mg L^{-1}). Treatments were arranged in a completely randomize design with four replicates. The total soluble solid, vitamin C increased by increasing Se concentration from 0 to 8 mg L^{-1}. Also, results showed the effect of Se application (0, 2, 4, 8, 16 and 32 mg/l Se as Na_2SeO_4) increased nitrogen and potassium content of young and old leaves plants as compared with the control treatments in floating system. However they were reduced in 16 and 32 mg L^{-1} Se concentration. It can be concluded that Se supplements (8 mg L^{-1}) improve yield, quality and Se concentration in the bud.

Introduction

Selenium is a trace element that can function as an essential nutrient for humans and animals or as an environmental toxicant; the boundary between the two is narrow and depends on its chemical form, concentration, and other environmentally regulating variables (Fan et al., 2002; Shardendu et al., 2003). It is an important microelement, exists in small amounts in microorganisms, plants, animals and humans. Although selenium is an essential trace nutrient important to humans and most other animals as an antioxidant, toxicity occurs at high concentrations due to replacement of sulphur with selenium in amino acids resulting in incorrect folding of the protein and consequently nonfunctional proteins and enzymes. The essentiality of selenium to higher plants is still under debate (Terry et al., 2000).

Selenium can increase the tolerance of plants to UV-induced oxidative stress, delay senescence, and promote the growth of ageing seedlings (Xue et al., 2001; Pennanen et al., 2002). Recently it has been shown that selenium has the ability to regulate the water status of plants under conditions of drought (Kuznetsov et al., 2003). Hartikainen et al. (2000) reported about growth promoting effect of selenium in ryegrass. Senescence stress is partly counteracted with enhanced antioxidation which is associated with an increase glutathione peroxidase (GSH-Px) activity. Although some studies have evaluated the effect of hardness, temperature, pH and other parameters on selenium toxicity, sulphate has perhaps been most widely studied in relation to selenium uptake and toxicity in aquatic and terrestrial organisms (Sappington, 2002). Selenium and sulphur are nutrients with very similar chemical properties and their uptake and assimilation proceed through common pathways (Eapen in D'Souza, 2005).

Brussels sprouts contain sulforaphane, a chemical believed to have potent anticancer properties. Based on the literature this investigation aimed to study the response of Brussels sprouts (*Brassica oleracea* var. Jade cross E) are grown in a floating system with application Selenium on the yield, quality and nitrogen, potassium status.

Material and method

The experiments were conducted in a greenhouse located in Tabriz, Iran, to study the effect of selenium on the yield, quality and Se status on Brussels sprouts (B*rassica oleracea* var. Jade cross E*)* grown in hydroponic cultures. After 72 h, germinated seeds (with 1 cm radicles) were transferred to plastic cup and the four-leaf stage into the larger plastic pots perlite both containing. After good growth of the plants, they were transferred to the floating system. The main medium experiment, the water medium in pots of 12 liter only nutrient solution is poured. Aeration was provided to the solution in each pot. The nutrient solution contained 300KNO_3, 455Ca $(NO_3)_2.4H_2O$, 10 NH_4NO_3, 50 KH_2PO_4, 250 $MgSO_4.7H_2O$, 1.3 H_3BO_3, 1.81$MnSO_4.4H_2O$, 0.22$ZnSO_4.5H_2O$, 0.08 $CuSO_4.5H_2O$, 0.02 $H_2MoO_4.H_2O$, 4 Fe EDTA (concentrations are expressed in mg L^{-1}). After 10 week of grow plants to the nutrient solution was added with 0 (control), 2, 4, 8, 16 and 32 mg Se L^{-1} as sodium selenate (Na_2SeO_4). Experiments consisted of 6 treatment and 4 replications. After 14 weeks, when sprouts reached commercial maturity, i.e. 1-2 inches in diameter, plants of each replicate were harvested.

In the fresh leaf and sprouts weight the concentration of TSS (Total Soluble Solid) and vitamin C was determined by the Refractometer) Atago, Pall, Japan((Tabatabaie, 2009), and the content of vitamin C by Skinner's technique (Skinner, 1997) (Table2).

In the dry weight the concentration of nitrogen was determined by the Kjeldahl method and Potassium, by the Flame Photometer (410), (Tabatabaie, 2009) (Table3).

Analysis was performed with the Software Statistical Package for the Social Science (SPSS) v. 16.0. Individual treatment means were compared with a Duncan's test to determine whether they were significantly different at the 0.05 probability.

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Results And Discussion

Sprout Quality Parameters

The effects of selenium addition on the most important quality parameters such as TSS were significant and cause of improving in quality. Data in table (2) indicated that application of Se at rates of (0, 2, 4, 8, 16 and 32 mg/l) significantly promoted TSS of young and old leaves as compared with the control which was in agreement with obtained results by Sharma *et al*., 2009, Pennanen *et al*., 2002 and Mazzafera., 1998. Over-application of Se may result in a decrease in TSS which was in agreement with obtained results by Abbas,. *et al*., 2012. Low selenium concentrations increases plant resistance to stress (Peng, 2002), and increased anthocyanin content and soluble sugar.

Table 2. Effect Se supplementation on the leaf TSS and vitamin C in Brussels sprouts (*Brassica oleracea* var. Jade cross E) plants grown for 14 weeks in greenhouse

Se (mg/l)	TSS young leaf (%)	TSS old leaf (%)	vitamin C (mg/100gFWt)
0	8/2b	6/1bc	92b
2	7/5c	5/7c	72/5c
4	7/6c	6/6b	86/7b
8	9/6a	7/7a	99/5a
16	7/1c	5/6c	78c
32	7/5c	6/4b	64/5d

Data of each parameter followed by the same letter are not significantly different ($P<0.05$).

The important antioxidant Brussels sprouts such as vitamin C was affected by selenium treatment. So increasing of selenium concentration to 8 mg/L improved vitamin C content of sprouts (Table 2). The highest vitamin C content was recorded with application 8 mg/l se and the lowest vitamin C content with application 32 mg/l Se (figure 2).

These results are in a good harmony with (Zhang et al, 1998, Lee et al, 1999, sago et al, 2004, Huang et al, 2005, Hu et al., 2003, and Kweon et al, 2004) who mentioned that Selenium treatment on vitamin C content in was significantly increased as compared with control.

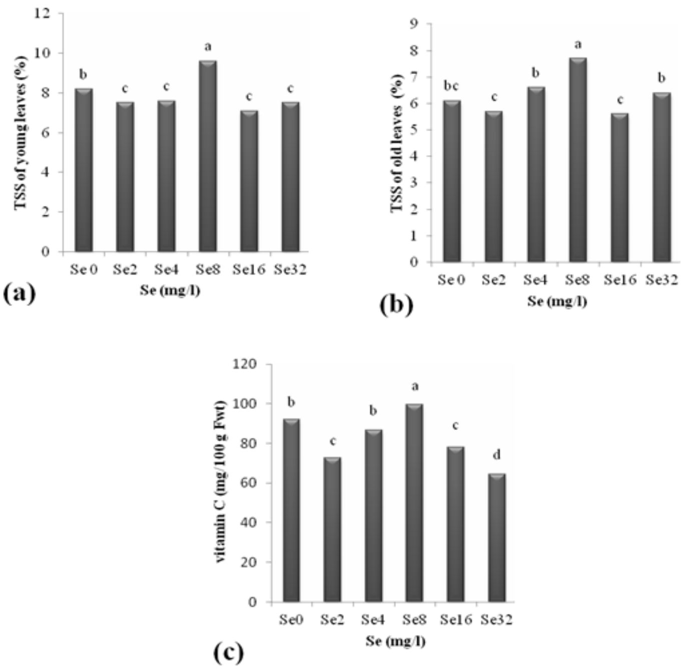


Fig. 2. Effect of Se supplementation (0, 2, 4, 8, 16 and 32 mg/l Se as Na_2SeO_4) on the TSS of young leaves (a), TSS of old leaves (b), vitamin C (c) in Brussels sprout (*Brassica oleracea* var. Jade cross E) plants grown in floating system

Chemical Composition

Results in Table (3) showed the effect of Se application (0, 2, 4, 8, 16 and 32 mg/l Se as Na_2SeO_4) on nitrogen and potassium content of young and old leaves and Se content of all part plants in floating system. Data indicated that all treatments tended to increase nitrogen and potassium content in leaves young and old as compared with the control treatments. Our results cooperate with the findings of Yassen, et al. 2011, Ježek,, et al. 2011, Azza, et al. 2010 and Alam, et al. 2007. From the data recorded in Table (3), it can be seen that application of selenium gave high significant decrease in N content of young leaves. These results are in agreement with Mahendra Singh (1979) who found that N concentration was decreased with increasing Se application. Also data showed that Se content in root, stem, young and old leaves and sprouts with increase Se concentration on nutrient solution increased (Table 3). These results are in agreement with Ducsay and lozek (2006).

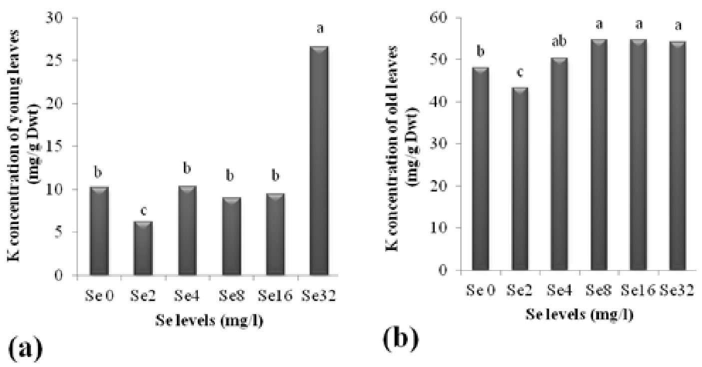
Table 3. Effect Se supplementation on the nitrogen and potassium (mg/gDWt) in Brussels sprouts (Brassica oleracea var. Jade cross E) plants grown for 14 weeks in greenhouse.

	N		K	
Se (mg/l)	**young leavs**	**old leavs**	**young leavs**	**old leavs**
0	2.4bcd	2.6a	10/2b	48b
2	2.9a	2.7a	6/2c	43/2c
4	2.7ab	2.4b	10/3b	50/4ab
8	2.3cd	2.3b	9b	54/6a
16	2.6bc	2.6a	9/4b	54/7a
32	2.2d	2.5ab	26/6a	54/2a

Data of each parameter followed by the same letter are not significantly different ($P<0.05$).

The highest level of K of young leaves was recorded at 32 mg/l Se and of old leaves at 8, 16 and 32 mg/l Se. It is evident from the obtained data in Table (3) that potassium content was slightly increased with increased Se applied .Data also indicate that selenium of young leaves at rate of 32 mg/l more effective on K content and of old leaves at rate 8, 16 and 32 mg/l Se. Positive effects of selenium on potassium accumulation were also observed by Pazurkiewicz-Kocot et al. (2003), who found that the content of potassium in maize leaves significantly increased when introducing 10 μmol Se dm into the medium, but a contrary dependence was recorded in roots Kopsell et al. (2000) revealed that potassium level in cabbage leaves was linearly increased along with the increase in selenium concentration in the medium rose (figure 3).

In experiment, the highest Se content in the roots and stems at the 16 and 32 mg/l and in young leaves at the 32 mg/l and in old leaves at the 8, 16, 32 mg/l and in the sprouts at the 32 mg/l Se concentration was observed. The lower Se content in all parts plants was observed at control (figure 3).



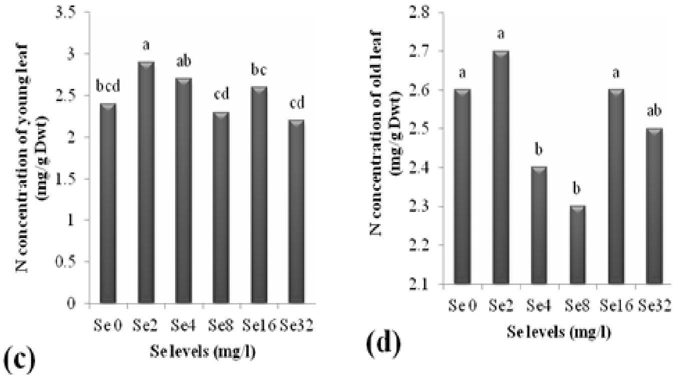


Fig. 3. **Effect of Se supplementation (0, 2, 4, 8, 16 and 32 mg/l Se as Na_2SeO_4) on the K concentration of young leaves (a), K concentration of old leaves (b), N concentration of young leaves (c), N concentration of old leaves (d), in Brussels sprout (*Brassica oleracea* var. gemmifera. C.v. Jade cross E) plants grown in floating system**

Conclusion

The aim of this research was to examine the Effect of Selenium on quality and Nitrogen, Potassium concentration of Brussels sprout plants. The findings of this study showed that the addition of selenium on quality of important parameters, such as TSS sprout was significantly and improve sprout quality and the important antioxidant Brussels sprouts such as vitamin C was affected by selenium treatment, so increasing of selenium concentration to 8 mg/L improved vitamin C content of sprouts. Also, results showed the effect of Se application (0, 2, 4, 8, 16 and 32 mg/l Se as Na_2SeO_4) increased nitrogen and potassium content of young and old leaves plants as compared with the control treatments in floating system. The total soluble solid, vitamin C increased by increasing Se concentration from 0 to 8 mg L^{-1}. However they were reduced in 16 and 32 mg L^{-1} Se concentration. It can be concluded that Se supplements (8 mg L^{-1}) improve quality in the bud. In conclusion, our results suggest that the addition of Se in a nutrient solution can be a useful system for providing enriched leafy vegetables. In particular, a floating system can be used to modulate Se content in the nutrient solution and to grow vegetables with the optimal Se content for human health.

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