ASPECTS OF SELENIUM CONTENT IN WHEAT CROPS

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Abstract. The organic compounds of selenium and selenates are the most available for uptake by plants. Their presence in soil over a certain level (seleniferous soil) can lead to increase of selenium content in plants who grow on respective soils, and in conclusion if we are to consume these plants, toxicological phenomena can appear – acute or chronic at human body and animals (selenosis). This paper is focused on the South-Eastern part of the Romanian Plain, Central and South Dobrogea, where a study was done regarding low level of selenium in plants, these areas being characterized by a natural handicap - selenium deficiency. For this purpose, data regarding selenium total content in plant (wheat), determined through investigations, chemical methods and analytic techniques, are presented. Analytical data were statistically analyzed, determining the parameters of the clustering center (xmed, x_g, Me, Mo) and the scattering parameter values (x_{min}, x_{max}, cv, σ).

Introduction

Interest in selenium (Se) has escalated in the past two decades. In trace amounts, Se is an essential micronutrient and has important benefits for animal and human nutrition. At high dosages, however, it may be toxic to animals (Lemly AD. 1997, Wilber CG. 1980, Nigam SN, Tu J-I, McConnell WB. 1969) and to humans (von Vleet JF, Ferrans VJ, 1992). The concentration range from trace element requirement to lethality is quite narrow; the minimal nutritional level for animals is about 0.05 to 0.10 mg Se kg^{-1} dry forage feed, while exposure to levels of 2 to 5 mg Se kg^{-1} dry forage causes toxicity (Wilber CG. 1980, Wu L, Mantgem PJV, Guo X. 1996). The first report of the nutritional benefit of Se was published in 1957 (Schwarz K., Foltz CM, 1957). In 1973, Se was shown to form part of the important antioxidant enzyme, glutathione (GSH) peroxidase (Rotruck JT, Pope AL, Ganther HE, Swanson AB, Hafeman DG, et al. 1973).

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Other health benefits include carcinoma suppression (Jansson B. 1980) and the relief of certain symptoms associated with AIDS (Hori K, Hatfield D,Maldarelli F, Lee BJ, Clause KA. 1997).

Se has not been classified as an essential element for plants, although its role has been considered to be beneficial in plants capable of accumulating large amounts of the determined by the chemical form and concentration, soil factors such as pH, salinity and CaCO3 content, the identity and concentration of competing ions, and the ability of the plant to absorb and metabolize selenium (Kabata Pendias, 2001). Actively growing tissues usually contain the largest amounts of selenium (Kahakachchi et al., 2004). Plants usually accumulate more selenium in shoot and leaf than in root tissues (Zayed et al., 1998).

Since Se was recognized as an essential nutrient (Schwarz & Foltz, 1957), a voluminous literature has accumulated that describes the profound effect of this element on human health. Given the high global incidences of HIV, hepatitis B and C, and other RNA viruses, including measles and influenza, the public health implications of selenium deficiency (estimated by Combs (2001) to affect more than a billion individuals) and suboptimality are enormous.

Several comprehensive reviews have examined Se and human health, including those of Reilly (1996), Rayman (2000, 2002) and Combs (2001). Combs discusses Se in humans within a food systems context and makes the distinction between Se's normal metabolic roles and its anti-carcinogenic activity at supra-nutritional levels. Selenate is transported more easily from root to shoot than is selenite or organic Se (Terry et al. 2000).

Selenium intake in humans is determined mainly by the level of available Se in the soil on which their food is grown, and by dietary composition. Se levels in major food classes usually occur within the following ranges: 0.10 – 0.60 mg/kg (fish), 0.05 – 0.60 (cereals), 0.05 – 0.30 (red meats), and 0.002 – 0.08 (fruit and vegetables) (Combs, 2001).

The absolute range of global daily Se intake by adults is around 7 (in Chinese Keshan disease areas) – 5,000 µg/d (in Chinese selenosis areas). Estimates provided by Combs (2001) of Se intake for several countries include England (12-43), Belgium (45), Canada (98-224), USA (60-220), Croatia (27), New Zealand (19-80), Japan (104-127) and Venezuela (200-350). In Australia few comprehensive studies have been conducted, but estimates of 63 and 96 µg/d have been provided, with a range of 23-204 (Fardy et al. 1989; Reilly, 1996).

It is obvious that many people do not consume enough Se to support maximum expression of selenoenzymes, let alone the level required for optimum prevention of cancer. Combs (2001) estimates the number of Se-deficient people in the world to be in the range of 500-1,000 million. In addition, he considers that the vast majority of the world's population have suboptimal Se intakes, and hence are at increased risk of cancer, heart disease, viral diseases, and indeed any conditions that involve increased levels of oxidative stress.

1. Material and methods

To collect samples of wheat plants, were carried out field surveys in Central and Southern Dobrogea and in the South-Eastern part of the Romanian Plain (especially Baragan). From various fields cropped with wheat in the years 2007/2008 and 2008/2009, plant samples were collected. The latter were collected when the plant height was 20-30 cm, i.e. at the start of training of the first node (stage 5 and 6 on Feekes scale), when all the plant was collected, and at maturity when only grain was harvested.

In the laboratory was determined the content of selenium in samples of wheat, both in the whole plant and grain. Plant samples were calcined at a temperature of 450ºC, and the ash obtained was dissolved in a solution of hydrochloric acid, selenium content was dosed by flame atomic absorption spectrometry. Analytical data were statistically analyzed, determining the parameters of the clustering center (Xmed, x_g, *Me*, *Mo*) and the scattering parameter values (x_{min}, x_{max}, *cv*, σ).

2. Results and discussion

The analytical data of the total selenium contents in the analyzed wheat plants are presented in table 1.

Tab.1 - Statistical parameters of the total selenium contents in wheat plants on 5-6 phase on Feeks scale from south - eastern Romanian Plain and central and south Dobrogea

Statistical parameters	South-Eastern Romanian 1 (2007-2008)	Dobrogea (2007-2008)	South-Eastern Romanian Plain 2 (2008-2009)	South-Eastern Romanian total
n	23	26	34	57
xmin	0.010	0.006	0.037	0.010
Xmax	0.065	0.055	0.080	0.080
$\bar{x}$	0.023	0.022	0.050	0.039
σ	0.012	0.014	0.011	0.018
xg	0.020	0.018	0.048	0.034
cv (%)	52	64	22	46
Me	0.018	0.018	0.046	0.040
Mo	0.017	0.013	0.041	0.017; 0.045

1 Slobozia – Călăraşi – Feteşti – Ţăndărei area
2 Slobozia – Orezu – Lehliu – Mănăstirea – Călăraşi area

In figure 1 is showed a tendency map of selenium content distribution from wheat plant, map based on coordinates points, for these two studied areas, South-Eastern Romanian Plain (Bărăgan Plain) and Central and South Dobrogea, map made in accordance with selenium content values. Points from colored part of map, those from left side, represents selenium content values in wheat plant from Bărăgan Plain, and the less colored, right side of map, is represented by selenium content values in wheat plant from Central and South Dobrogea.

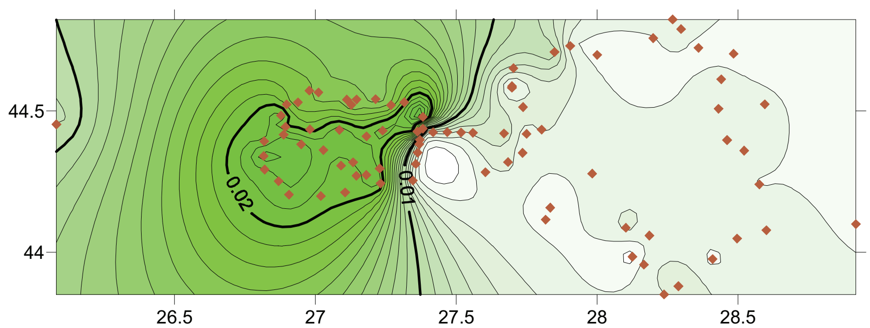

Fig. 1 - Tendency map of selenium distribution from green plant (stage Feeks 5-6 scale) in the South-Easten Romanian Plain and South and Central Dobrogea

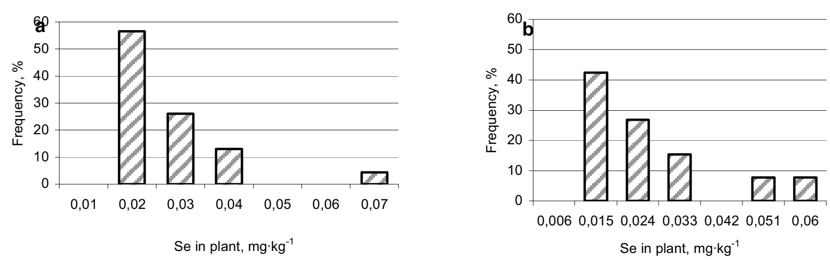

Fig. 2 - Frequency histograms of selenium content in wheat plants at the beginning and the formation of the first node grown on soils of South-Eastern Baragan (left) and Central and South Dobrogea (right)

At collection time of wheat plants samples, they had a height varying between 10 and 40 cm, with an average of 20-30 cm. This height corresponds to 5-6 stages of plant development (after Feeks, in Bergmann, 1976).

In the dry material representing the aerial plant, selenium content was determined. From their analysis, results a wider range of variation and a straight boundary value higher plants grown on Bărăgan, compared with those grown in

Dobrogea. The center grouping parameter values, except median (Me), are slightly higher in Baragan plants. Class frequency distribution of values is superior to plants grown in Baragan (25.75%) compared with those grown in Dobrogea (19%). In both cases the frequency distribution is unimodal (Fig. 2). If we compare our data with the analytical mean selenium content of wheat plants grown in the Czech Republic, 0.011 to 0.049 mg·kg^{-1} (Turek and Kopicowa, 1988), we find that our average values ($\bar{x}$ = 0.023; x_g = 0.020 mg·kg^{-1}; Me = 0.018 mg·kg^{-1}; Mo = 0.017 mg·kg^{-1}) are in the first half of the range of values prevailing in the Czech Republic.

Conclusions

The average content of selenium in wheat plants, in stages 5 and 6 (after Feeks scale) development is close in the two areas (0.023 mg·kg^{-1} in Bărăgan and 0.022 mg·kg^{-1} in Dobrogea).

Frequency histograms of content selenium in wheat plants lead us to a highlight trend of greater accumulation of selenium in wheat plants grown in the South-Eastern part of Baragan, compared with Dobrogea.

With the SURFER software, a tendency map of the selenium distribution was drawn in the green plant from the two areas studied.

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