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MICROELEMENT CONTENT OF ORIENTAL TOBACCO VARIETIES GROWN UNDER THE SAME AGRO-ECOLOGICAL CONDITIONS

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Abstract

The microelement content (essential elements and heavy metals) of Bulgarian oriental tobacco varieties (*Dzhebel basma* 1, *Elenski* 817) and introduced oriental tobacco varieties (*Prilep* 23*, Prilep*), were studied in field experiments under the same agro-ecological conditions. The soil on which the study was carried out was humus–carbonate (Rendzic Leptosols), with an alkaline soil reaction, medium humus content, and heavy sandy loam texture. Total content and mobile forms of the elements Fe, Mn, Cu, Zn, Pb, Cd in the soil were determined, as well as their concentration in mature leaves from the middle section of the plant (commercially known as seco leaves). The response of the studied varieties to the agro-ecological conditions was ascertained. For any tobacco variety, absorption capabilities differed for each microelement. The determined concentrations of iron, manganese, copper, and zinc corresponded with the data reported in other reference sources and fell within the range of optimal tobacco leaves concentrations. Lead and cadmium contents were lower than the critical concentrations valid for all tobacco varieties. It was observed that the studied varieties had similar absorption capabilities as referred to the microelements zinc and cadmium.

Keywords: microelements, soils, oriental tobacco varieties.

INTRODUCTION

The main constituents of the mineral composition of tobacco plants are the chemical elements. The macroelements calcium, potassium, magnesium, are phosphorus are present in larger quantities, and the microelements iron, manganese, copper, zinc, molybdenum, boron, and others are in smaller amounts.

A characteristic peculiarity in physiology is that, although micronutrients are vital for plant growth, at high concentrations they become toxic to the plant cells. The primary toxic effects include alteration of the cell membrane permeability, substitution of essential ions (mainly of macroelements) and blocking of vital functional groups (Peterson, 1971).

The main source of trace elements for all living organisms is soil. Trace element content varies within a wide range – from deficient levels to toxic. The main factors affecting microelement concentration in tobacco leaves are soil reaction, soil texture, and humus content (Adamu, 1987; Bell et al., 1992, Golia et al., 2009).

Zaprjanova et al. (2009, 2010, 2014) found a statistically significant correlation between the mobile forms of Mn, Cd, and Fe in soil and tobacco leaves. Zaprianova and Bozhinova (2004) ascertained that Burley varieties accumulate manganese and copper in higher amounts than Virginia varieties grown under the same soil and climatic conditions. Significant differences in trace element content were observed only between Berley varieties (Zapryanova and Dyulgerski, 2007) and between Virginia varieties (Zapryanova 2015). According to Stamatov et al. (2015), microelement contents of oriental tobacco leaves depend on the tobacco variety.

According to Tso (1990), trace element content varies greatly depending on the type and variety of the tobacco, and the place of cultivation. He ascertained that there are great differences in the microelement contents of Virginia tobacco plants grown in Canada, in the United States, and in Japan. Tsotsolis et al. (2001) found that zinc and manganese concentrations vary considerably in different oriental tobacco varieties, whereas lead and cadmium concentrations did not show significant differences.

In recent years, changes in the oriental tobacco varieties have been introduced. This necessitates further studies on the differentiation of variety groups, and the response of tobacco varieties to climatic and soil conditions about various indicators. Further detailed research on the influence of soil and climatic conditions to the uptake and accumulation of heavy metals in tobacco plants is required.

This would aid the selection of varieties with lower absorption capacities.

The aim of the study is to investigate the content of microelements (nutrients and heavy metals) in Bulgarian and imported oriental tobacco varieties grown under the same agro-ecological conditions.

MATERIALS AND METHODS

The study on oriental tobacco was carried out on humus–carbonate (Rendzic Leptosols) soil at the Institute of Tobacco and Tobacco Products, Markovo (Plovdiv), from 2011 through 2013. The soil reaction was alkaline, humus content was medium, and the soil texture was heavy sandy loam (Table 1).

The total content of the element iron, manganese, copper, zinc, cadmium, and the lead was determined after digestion with aqua regia, ISO 11466, and their mobile forms – after digestion with 0.005M DTPA + 0.1M TEA, pH 7.3, ISO 14870.

Bulgarian oriental tobacco varieties (Dzhebel Basma 1, Elenski 817) and introduced ones (Prilep 23, Prilep 79–94) were studied. The main agro-technical practices – planting distances, digging, watering, were carried out in the same way for all tobacco varieties. For plant analysis, mature leaves from the middle section of the plant were collected (commercially known as seco leaves).

Plant sample preparation for the determination of Fe, Mn, Cu, Zn, Cd и Pb involved dry ashing and dissolution in 3 M HCL. To measure the content of microelements in soil and tobacco samples, an absorption spectrometer (Spektra AA 220, Australia) was used at the following wavelengths: Fe – 248.3 nm, Mn – 279.5 nm, Cu – 324.8 nm, Zn – 213.9 nm, Pb – 217.0 nm, Cd – 228.8 nm.

Statistical treatment (ANOVA, Duncan) was performed using SPSS software for Windows.

RESULTS AND DISCUSSION

Soils

Data on iron, manganese, copper, zinc, cadmium and lead total content is shown in Table 2. Fe content is medium. The total content of manganese is lower than the average 1000–1200 mg/kg for Bulgaria (Brashnarova, 1981; Koynov et al., 1998).

The total content of copper, zinc, lead, and cadmium, is relatively high but does not exceed the Bulgarian standards for maximum permissible concentrations at the respective pH.

Mobile forms of iron extracted with DTPA, pH 7.3, are low, probably due to the alkaline soil reaction. According to DTPA classification (Jones, 2001), mobile manganese content is high.

The soil was characterized as very highly supplied with mobile forms of copper and zinc, which did not correspond to the alkaline reaction and could probably be a result of industrial pollution (KCM Plovdiv). The content of mobile lead was high as well.

Tobacco

Iron (Fe)

Iron is an essential element in plant nutrition, which, about its specific function in plans, is classified as a microelement; whereas in soils it is considered to be a macroelement (Gorbanov, 2010).

Tobacco is particularly sensitive to high iron content. Symptoms of toxicity occur at plant concentrations above 1000 mg.kg^{-1} and result in root growth inhibition, leaf damage and necrotic spots (Kabata–Pendias, 1984). Iron supply in plants is the highest at pH between 4 and 6. In soils with pH greater than 6, iron mobility is reduced. Iron deficiency causes interveinal chlorosis on the young organs, and the so-called "gray tobacco" in Virginia varieties, which is unfavourable.

Campbell (2000) indicates that the optimal range for iron concentration in seedlings, at early growth stages, in blossoming, and at full development is 50–300 mg.kg^{-1}, and in leaves in maturity stage – 40–200 mg.kg^{-1}. In all studied tobacco varieties, irrespective of the alkaline soil reaction and the low mobile content of iron in the soil, Fe concentrations measured in the leaves fell within the specified optimal range. The Bulgarian variety Dzhebel Basma 1 was determined to have the highest concentration of iron. It was distinguishable from the other varieties with a statistically significant difference, and it fell within a separate group (Table 3).

Table 1. Soil characteristics

Soil	pH	Humus, %	Silt+Clay (< 0.02mm), %
Humus–carbonate (Rendzic Leptosols)	8.00	2.88	47.3

Manganese (Mn)

Manganese deficiency In tobacco occurs at leaf content smaller than 20–30 $mg.kg^{-1}$ (Jones et al., 1991; Campbell, 2000), especially when grown on alkaline soils.

According to Stoilova and Zapryanova (2003), manganese concentration in the leaves of Bulgarian tobacco varieties grown in different regions of the country varies between 56 and 425 $mg.kg^{-1}$ for oriental tobacco, between 55 and 452 $mg.kg^{-1}$ in Virginia varieties, and from 70 to 747 $mg.kg^{-1}$ for Burley varieties.

Mn concentration increases very quickly in acidic soil and can reach up to 2400 $mg.kg^{-1}$ or more (Tso, 1990; Bell et al., 1992).

Mn concentrations measured in the leaves of the studied oriental tobacco varieties were 43. 933 to 55.567 $mg.kg^{-1}$. The values obtained were similar to those established by Gondola and Kadar (1993) for soils with neutral and weakly alkaline reactions.

Concerning manganese, the studied varieties were differentiated into 2 groups. The Bulgarian Varieties fell within the first group. The difference in Mn values between the introduced varieties and the Elenski 817 variety was not statistically significant. Therefore, this variety fell within the second group as well (Table 4).

Copper (Cu)

Physiological and biochemical functions of copper are associated with some of the most complex processes in plant cells: breathing, photosynthesis, protein and carbohydrate synthesis, nitrogen and phosphorus cycles, etc. (Gorbanov, 2010).

In all studied tobacco varieties, the results for copper were similar to those reported in some reference sources and ranged from 5 to 15 $mg.kg^{-1}$ (Bell et al., 1992; Adamu, 1987). Other reference sources indicate higher corresponding values. According to Collins et al. (1961), copper content in Virginia tobacco varieties ranges between 14.9 and 21.1 $mg.kg^{-1}$. Values established by Radojicic et al. (2003) fall within the range of 16.42–31.45 $mg.kg^{-1}$ and Zaprianova and Bozhinova (2004) reported the range 16.9–25.8 mg/kg.

Table 2. Microelement content in soils

Total content, mg/kg						
Fe	**Mn**	**Cu**	**Zn**	**Cd**	**Pb**	**Fe**
29 700	651.6	90.2	163.9	2.5	72.0	29 700
Mobile forms, mg/kg						
Fe	**Mn**	**Cu**	**Zn**	**Cd**	**Pb**	**Fe**
4.98	22.5	11.0	13.0	0.40	10.3	4.98

Zinc (Zn)

Zinc has direct or indirect effects on photosynthesis, respiration, biosynthesis of chlorophyll and growth regulators; and on phosphorus, nitrogen and carbohydrate cycles. This multifaceted role in plant organisms is determined predominantly by the fact that zinc is a component of some important enzymes (Gorbanov, 2010).

In general, all studied varieties were characterized by a relatively high zinc content, likely due to the high content of mobile zinc in the soil (Table 6). The results obtained were consistent with data reported in other reference sources (Fischer, 1992; Radojicic, 2003), and were lower than critical concentrations for plants – 100–400 $mg.kg^{-1}$ (Kabata–Pendias and Pendias, 1984). The difference between the varieties studied was not statistically significant, and they fell within one Duncan group.

Lead and cadmium do not belong to the group of essential elements vital for plants. It is well known (Toulupov, 1992; Bozjinova et al., 1994; Golia, 2003) that tobacco accumulates significant amounts of heavy metals, especially lead and cadmium, in its leaves.

Subsequently, these elements are present in tobacco smoke and easily enter smokers' organs. It has been shown that cadmium content is higher in the blood of smokers, and an association between cadmium exposure and cardiovascular disease was ascertained (Ozcellik et al., 2000).

Lead (Pb)

Background lead content in plants grown in uncontaminated areas is considered to range from 0.1 to 10 $mg.kg^{-1}$. According to Kabata–Pendias, and Pendias (1984), critical concentrations fall within the range from 30 to 300 $mg.kg^{-1}$.

In all tobacco varieties studied, the concentration of this element was relatively high, probably due to the high content of mobile lead in the soil. Nevertheless, the determined concentrations were lower than the adopted by Bozhinova et al. (1995), threshold limit concentration of 30 mg.kg^{-1}.

The Bulgarian variety Prilep 23 was determined to have the lowest Pb content. It was distinguishable from the other varieties with a statistically significant difference, and it fell within a separate group (Table 7).

Cadmium (Cd)

Cd concentrations in all studied varieties were relatively high (from 2.300 to 2.767 mg.kg^{-1}). As the difference between them was not statistically significant, they fell into one group (Table 8).

The values were consistent with the data reported by other authors (Adamu A., 1987; Bell et al., 1992), and were lower than the assumed by Bozhinova et al. (1995) critical concentrations of 5 mg.kg^{-1} in tobacco.

Table 3. Fe content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05	
	1	2
Prilep 23	177.433	
Elenski 817	186.233	
Prilep 79–94	193.433	
Dzhebel Basma 1		259.433
Significance	0.404	1.000

Table 4. Mn content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05	
	1	2
Dzhebel Basma 1	43.933	
Elenski 817	51.133	51.133
Prilep 23		54.200
Prilep 79–21		55.567
Significance	0.080	0.270

Table 5. Cu content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05	
	1	2
Elenski 817	9.400	
Dzhebel Basma 1	10.200	10.200
Prilep 23		11.900
Prilep 79–21		11.933
Significance	0.396	0.100

Table 6. Cd content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05
	1
Dzhebel Basma 1	67.967
Prilep 23	72.067
Prilep 79–94	77.300
Elenski 817	79.700
Significance	0.156

Table 7. Pb content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05	
	1	2
Prilep 23	8.333	
Elenski 817		11.333
Dzhebel Basma 1		12.000
Prilep 79–21		12.000
Significance	1.000	0.609

Table 8. Cd content in oriental tobacco leaves. Grouping of the varieties (Duncan's method)

Varieties	Homogenous groups Subset for α = 0.05
	1
Prilep 23	2.300
Dzhebel Basma 1	2.500
Prilep 79–94	2.600
Elenski 817	2.767
Significance	0.172

CONCLUSIONS

1. The response of the studied varieties to agro-ecological conditions was ascertained. It was determined that absorption capabilities in any of the studied tobacco varieties differed for each microelement.

2. Iron, manganese, copper, and zinc concentrations were consistent with data reported in other reference sources and values fell within the optimal range for concentrations in tobacco leaves.

3. The lead and cadmium content was lower than critical concentrations valid for all tobacco varieties. Regarding the microelements zinc and cadmium, the studied varieties had similar accumulation capabilities.

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