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Influence of mineral matter content on static burning rate of Virginia tobacco from different production areas in Serbia

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ABSTRACT

The aim of this study was to determine the influence of particular element of the minerals complex in Virginia tobacco, from different production areas, on value of static burning rate (SBR). Large leaf tobacco, type Virginia from five production areas in Serbia during year 2013, was used as a research material. Mineral content was determined by the atomic absorption spectrophotometer. Static burning rate was determined by the device Free Burning Rate Meter.

Result: had confirmed that the most important factors for mineral matter content in tobacco leaves are soil pH, organic matter content in soil and vicinity of large industrial centers. A very strong positive correlation between the content of Ca and Pb, a positive correlation of Mg and Na, and a strong negative correlation of Cd and both SBR values has been found.

Virginia tobacco type grown at Senta area had the highest values for both speeds of combustion (4.99 mm/min for SBR_l and 69.97 mg/min for SBR_m). Virginia tobacco type grown at Sremska Mitrovica area had the lowest values for both speeds of combustion (3.95 mm/min for SBR_l and 49.11 mg/min for SBR_m).

1. Introduction

Tobacco is an industrial plant which occupies an important place of agriculture in the Republic of Serbia. The total production of tobacco amounted to 10,000 t, in 2013. Proportion of Virginia tobacco in total production is about 80%. Proportion of this tobacco is about 60% in cigarette blend (Radojičić, 2011). Given such a large share of this tobacco in the composition, it is important to analyze its chemical composition, especially the amount and content of the mineral complex and its influence on the burning, because of it depends the production elements of tobacco smoke inhaled by active and passive smokers.

Mineral matter is normally present in cultivated plants in quantities that vary depending of plant variety, climate, and other factors (Bell et al., 1988; King, 1989). Influence of fertilization and irrigation on morphological and chemical characteristics of tobacco plant has been well explored and documented (Sifola and Postiglione, 2002; Karaivazoglou et al., 2005; Sifola, 2005; Tsadilas et al., 2005; Bilalis et al., 2009; Çakir and Çebi, 2010). Mineral matter plays an important role in tobacco metabolism during its growth (Kastori, 1990; Veresoglou et al., 1987). They are particularly important for the combustion process of tobacco, because they affect temperature and combustion conditions and ash characteristics (Lazarević et al., 2012; Nikolić and Josić, 1997; Pyriki and Philipp, 1955). In addition, it is not important only the total content of minerals, but also their relationship (Radojicic et al., 2006). It should be noted that some of these elements are in the group of heavy metals that may be toxic and hazardous to health (Bell and Mulchi, 1990; Djukić and Radojičić, 1998; Kaličanin and Velimirović, 2012). Based on previous research it was found that tobacco contains the highest percentage of calcium, potassium and magnesium and less phosphorus, sodium, silicon, iron, chlorine and sulfur (Rodgman and Perffeti, 2009; Davis and Nielsen, 1999).

SBR is a technological characteristic of cigarettes. By definition, the SBR represents the average of the burning rate at the beginning, middle and end of a cigarette, and in the center and edge cigarettes, since cigarettes do not burn the same speed along the whole of its volume and length (Nikolić, 2004). SBR value depends on the applied method of drying, on physical and chemical properties of material, especially of the content of mineral matter, which indicating differences in the combustion of the major types of tobacco (Nikolić and Josić, 1997). Tobacco type, cut width, additives, and

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Table 1
The values of SBR of tobacco produced in Serbia

Type of tobacco	SBR_l (mm/min)	SBR_m (mg/min)
Sun cured	4.2	45
Flue cured	5.3	61
Air cured	6.8	69

SBR_l – the relationship of a unit of length of tobacco burned statically per unit of time.
SBR_m – the relationship of a unit of weight of tobacco burned statically per unit of time.

moisture content are important tobacco variables influencing SBR. The structure of the cigarette paper also affects the combustion mechanisms that occur during both smouldering and puffing. This, in turn, can significantly affect the smoke chemistry and other performance characteristics of the cigarette. (Branton and Baker, 2002).

Table 1 shows the burning rate of three basic types of tobacco, calculated on the data derived of the five-year research (Nikolić and Josić, 1997). Burley is relatively fast burning, while Virginia lies between the two. Many researchers have studied the effect of not only the total mineral complex, than effect of its certain elements to the static burning rate (Nikolić and Josić, 1997; Pyriki, Philipp, 1955; Radojicic et al., 2006). It has been shown that potassium has positive influence on tobacco burning process; calcium and phosphorus have no influence, while chlorine, sulfur, magnesium and nitrogen have negative influence on burning rates. Besides, for good and proper combustion, it is important to their relationship. Based on the results of previous research (Radojicic et al., 2006), it was found that with the increase of K/Mg, increasing SBR. In this way K/Mg ratio reduces the production of total particulate phase of tobacco smoke, and thus the nicotine.

Thus, it can be concluded, the special significance of SBR is in the fact that it directly affects the production on the production level of cigarette smoke. The production of total particulate phase and thus the harmful components of smoke are increased if the cigarette burns slowly and incompletely (Artho, 1965; Nikolić et al., 1993).

2. Materials and methods

Large leaf tobacco, Virginia type, cultivar Heveshi-9, from five production areas in Serbia during year 2013, was used as research material. Each sample represented an average sample of 10 hectares of a typical production area Senta, Čoka, Šabac, Bajina Bašta and Sremska Mitrovica. At tobacco seedling, transplanting was applied at 80 cm line distance and 50 cm stalk distance as the most suitable way for good furrow, good yield and quality of row material. The NPK fertilizer in quantity ratio 50:80:140 kg/ha was used at the experimental lots on all five production areas. 8 irrigation treatments were applied in the same period and with same water quantity. The total quantities of water were 400 mm. Topping is done in the earlier stage when around 30% of the plants were in full flower.

The samples of cured tobacco leaf, after redrying process were milled into a fine tobacco powder. Only the middle stalk position leaves were used as the leaves of the best quality. The whole leaf with the main stem was milled.

2.1. Climate conditions and characteristics of experimental soil

References of primary climate conditions have been obtained in local meteorological stations. Because of results clearness, the climatic parameters only for vegetation period are presented. Soil samples were collected at 30 cm-depths, at three different places within the experimental plots, air dried and sieved. They kept in plastic bag for further analysis. Soils were characterized for common chemical properties according to Sparks et al. (1996).

2.2. Determination of mineral matter content

Mineral content was determined by the atomic-absorption spectrophotometer AAS PerkinElmer 300 (Veličković and Vucelić-Radović, 1993).

The solutions for the metal content determination were prepared by a modified method applied for plant material destruction. Tobacco powder was dissolved in nitric acid and heated at 80° C. Heating was stopped after the separation of yellow dark steam was finished. Then, we added perchloric acid and heating was done up to 200° C. The process was finished after the color of the sample disappeared. A blind test was prepared in the same way. Amount of potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), iron (Fe), copper (Cu), zinc (Zn), lead (Pb), cadmium (Cd) i mercury (Hg) in samples of tobacco was determined. Analysis was carried out in triplicate. The values of different parameters were expressed as the mean value.

2.3. Determination of static burning rate

For the determination of SBR, Free Burning Rate Meter MK.II (Filtrona) was used. Free Burning Rate Meter measure a weight loss of material (ISO 3612) and provides already calculated data (ISO 3612, 1977). The printer list includes data for all three of these characteristic values. For preparation of cigarettes, whole leaf tobacco was cut (lamina and stem) by semi-automatic laboratory cutter "Comas", which was set to the width of cut of 0.8 mm. From each sample of tobacco seven cigarettes were made (a total of $5 \times 7 = 35$ cigarettes). All cigarettes are made from the same raw-materials. Paper tube length element was 6 cm, length of the filter was 2.5 cm and weighs of paper tube was 0.18 g. Cigarettes are made by hand and conditioned on Borgwaldt Automatic Feeder and Weighting Unit to 12.5% moisture (ISO 3402, 1999). Cigarettes weighing 1070 mg ± 0.5 were used in experiment.

2.4. Statistical analyses

Data obtained from the experiments were analyzed and the results were expressed as mean ± SD. Statistics were performed using SPSS 17.0 software ANOVA with post hoc test analyses based on Tukey was used to compare differences between samples (De Coster, 2004).

3. Results and discussion

More details about climatic parameters and properties of experimental soil are given in Tables 2 and 3, .

According to the data given in Table 2, the temperature conditions and air humidity during growth and ripening of tobacco, in the experimental production areas were within optimal range. However, amounts of precipitation were different, both the total and at the monthly level. The minimum amount of precipitation was in the area of Šabac (188.7 mm) and the maximum in the area of S. Mitrovica (242.5 mm) in the observed vegetation period. Considering that the same amount of NPK fertilizer, as the same amount of water for irrigation was used, their influence on the quantity of mineral matter was excluded in this investigation.

Results of investigations of mineral matter content in Virginia tobacco leaves are shown in Table 4.

According to results shown in Table 4, it can be concluded that there were differences in mineral content of tobacco leaves grown at different areas. Analysis of variance showed that the location has