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MACRONUTRIENT AVALIABILITY OF DIFFERENT ORIENTAL TOBACCO VARIETIES GROWN UNDER THE SAME AGROTECHNICAL AND ECOLOGICAL CONDITIONS

Biljana Jordanoska Shishkoska[1*], Valentina Pelivanoska[1], Marija Srbinoska[1]
[1]St. Kliment Ohridski University – Bitola, Scientific Tobacco Institute - Prilep, Republic of North Macedonia
**Corresponding author: biljana.jordanoska@uklo.edu.mk*

Abstract

Macronutrients are essential for the growth and development of all plants, including oriental tobacco. Their availability determines the overall health and growth of tobacco plants and it is in the focus of sustainable tobacco production. Proper management of soil macronutrients is necessary for high and quality crop yield.

In order to evaluate the macronutrient content and factors influencing their availability, different varieties of oriental tobacco were selected for a field experiment. Plants were grown under the same agrotechnical conditions, on two locations, on a colluvial-delluvial and fluvisol soil type. Available forms and total content of nitrogen, phosphorus, potassium, magnesium and calcium as important macronutrients were determined in soil samples, while only total content was analyzed in leaf samples. Availability ratios were presented by available and total content as a direct measure of the potential effectiveness of the selected macronutrient in soil. Macronutrients Ca and P have greater availability as compared to N, K and Mg. Analyzation of the available and total content of macronutrients in soil and leaf samples gives helpful insight in application of certain cultivation practices for specific agricultural and environmental management purposes.

Key words: *tobacco, nutrients, macronutrients, growth factors*

INTRODUCTION

Macronutrients have a multilevel and vital role for plants with wide range of chemical activities within their cells. In order to reach optimal plant growth and overall plant health, it is important to understand macronutrients availability and to make certain that plants receive an adequate supply of them.

In agriculture, plants are usually supplied with nutrients from fertilizers. The impact of a certain nutrient varies depending on the plant type, and for oriental tobacco, it has direct reflection on the quality of the raw material (Adamu et al., 1989; Pelivanoska & Jordanoska, 2013, 2016, 2018). Nitrogen is essential element for tobacco plants and its availability determines the growth rate of the plant. The influence of nitrogen fertilizers is directly related to the content of nitrogen in the leaves; therefore, it highly effects the ripening, drying, yield and quality of oriental tobaccos (Pelivanoska, 2009; Gholizadeh et al., 2012). It was shown that tobacco constantly accumulates nitrogen and phosphorus during the vegetation period and their content in the leaves is constantly increasing (Hawks & Collins, 1987). Phosphorus is essential for the formation of strong roots and stems, flower development, and seed production. It contributes to the maturity and development of tobacco as prerequisite for quality dried leaves that have good chemical properties (Filiposki, 1990; Mitreski & Korubin-Aleksoska, 2005; Filiposki et al., 2010). Potassium significantly contributes to the storage of carbohydrates, plays an important role in maintaining the ionic status of the plant, shortens the growing season, improves tobacco burning qualities (Pelivanoska, 2009; Filiposki et al., 2010; Pelivanoska et al. 2012, 2017;

Zaprijanova & Hristova, 2018). Magnesium is an integral part of the chlorophyll molecule and has a catalytic role in protein synthesis within plants (Campbell, 2000). Calcium plays a major role in cell maintenance, growth and activation of numerous enzymes in the tobacco plant. Additionally, it acts as an antagonist to various toxic metals such as Cu, Zn, Mn, Fe and protects plants from the toxic reaction (Tiffin, 1977).

The main factors that affect availability and uptake of macronutrients are their content and form in the soil, soil characteristics, plant biology, fertilization and utilization of soil amendments (Tso,1990; Bell et al., 1992; Rodgman & Perfetti, 2009; Golia et al., 2009; Khan et al., 1992; Zaprijanova et al., 2010; Subhashini, 2016; Jordanoska et al., 2018; Kumaresan et al., 2019; Lisuma et al., 2020). This study provides an analysis on the relationships between factors that have a crucial role in the availability and uptake of P, N, K, Ca and Mg. The main purpose was to determine the availability of selected nutrients for four oriental tobacco varieties, considering soil characteristics and different fertilization rates.

MATERIAL AND METHODS

Methodology of the field experiment

For the purpose of the research, two experiments were set in two different locations. One experimental field was on a colluvial-diluvial soil type at the experimental field at Scientific Tobacco Institute – Prilep and the other field was on fluvisol soil type in locality Dobrushevo. The experimental fields were set up in complete randomized block design with three replications and with four oriental tobacco varieties (P-23, P-79-94, Dzhebel Basma 1 and Elenski 817) (Pelivanoska & Jordanoska Shishkoska, 2019). The same agrotechnical practices were applied for all varieties at both locations. Availability of studied macronutrients was examined though application of different nitrogen rates (0, 20, and 30 kg/ha) and application of phosphorus (60 kg/ha) and potassium (40 kg/ha) for both experimental fields (Pelivanoska & Jordanoska Shishkoska, 2019).

Soil and plant analyses

Pretreatment of soil samples for physico-chemical analysis was done in accordance to ISO 11464 (2006). Soil samples were collected before planting and after harvest from both locations and analyzed for soil texture, pH, total nitrogen content, organic matter content, carbon content, available phosphorus and available potassium content (Pelivanoska, 2012). The total macronutrient content in soil samples was determined according to ISO 14869-1 (2001), analyzed by the application of atomic emission spectrometry with inductively coupled plasma, ICP-AES (Varian, 715-ES). Available nitrogen, calcium and magnesium content was determined according to Kim (2005).

The harvest of the mature tobacco leafs was done manualy in 5 rounds. Leaves were washed carefully to remove any adhering soil particles and rinsed with redistilled water. The plant material was dried and homogenized to a constant weight after drying at 75 °C for 12 hours. Total nitrogen in leaves was analyzed by modified Kjeldahl method (Srbinoska, 2012). For the analyses of total P, K, Ca and Mg, plant samples (0.5000 g) were digested in Teflon vessels with HNO_3 and H_2O_2 using the Mars microwave system (CEM, USA) and analyzed by ICP-AES with ultrasonic nebulizer CETAC (ICP/U-5000 AT), (US-EPA Method 3050B, 2007).

The reference standard materials JSAC 0401 (soil) as well moss samples M-2 and M-3 (Steinnes et al., 1997) were used for quality control.

RESULTS AND DISCUSSION

Soil properties

According to the results from soil samples, it is obvious that soils from the two experimental locations have different properties (Table 1). According to agrochemical parameters, soil sample from experimental filed in Prilep has low humus content, poorly acidic soil pH and medium content of available phosphorus and potassium. Soil sample from Dobrushevo has an average humus content, low content of available phosphorus, optimal content of available potassium and neutral to poorly acidic pH reaction. The results from soil analysis after the harvest and at the end of the vegetation are presented in Table 2.

Table 1. Soil properties of experimental fields in Prilep and Dobrushevo before planting.

	Prilep	Dobrushevo
Clay (%)	24.50	25.70
pH (H_2O)	6.64	7.15
pH (KCl)	5.98	6.18
Humus (%)	0.81	1.77
Total N (%)	0.04	0.09
Total P (%)	0.05	0.03
Total K (%)	0.21	0.36
Total Ca (%)	0.24	0.18
Total Mg (%)	0.19	0.39
Available N (mg/kg)	6.10	7.10
Available P (mg/kg)	68.4	28.8
Available K (mg/kg)	110	180
Available Ca (mg/kg)	656	812
Available Mg (mg/kg)	114	190

Table 2. Soil properties of different experimental plots in Prilep and Dobrushevo.

Studied element	Prilep			Dobrushevo		
	Ø	$N_{20}P_{60}K_{40,}$	$N_{30}P_{60}K_{40}$	Ø	$N_{20}P_{60}K_{40,}$	$N_{30}P_{60}K_{40}$
pH (H_2O)	6.12	6.02	6.02	6.58	6.70	6.70
pH (KCl)	5.96	5.86	5.86	6.10	6.12	6.12
Humus, %	0.62	0.60	0.60	0.96	0.92	0.92
Total N (%)	0.02	0.03	0.03	0.07	0.08	0.08
Total P (%)	0.04	0.04	0.04	0.02	0.02	0.02
Total K (%)	0.20	0.19	0.20	0.32	0.31	0.31
Total Ca (%)	0.23	0.24	0.25	0.19	0.20	0.20
Total Mg (%)	0.18	0.17	0.17	0.40	0.41	0.41
Available N (mg/kg)	5.18	6.70	6.70	7.20	8.20	8.20
Available P (mg/kg)	58.12	62.13	62.13	30.12	40.15	40.15
Available K (mg/kg)	120	150	150	220	210	210
Available Ca (mg/kg)	750	700	700	950	895	895
Available Mg (mg/kg)	112	110	110	179	192	192

*Ø- unfertilized control, $N_{20}P_{60}K_{40}$, $N_{30}P_{60}K_{40}$ (the index indicates applied nitrogen, phosphorus and potassium doses in kg/ha).

Tobacco leaf samples

The content of the analyzed macronutrients in tobacco leaves from both locations are given in Table 3 and Table 4. As it can be seen, highest content of nitrogen is detected in the treatments with highest nitrogen dosage of 30 kg/ha for all tobacco varieties and on both locations. According to Pelivanoska (2009), Pelivanoska et al. (2012) and Pelivanoska & Jordanoska (2016, 2018), the influence of nitrogen fertilizers is directly related to the ripening, drying, yield and quality of oriental tobaccos. The nitrogen content in tobacco leaves (1.4 % - 3.6 %) are in the limits to those observed in the oriental tobacco samples (Jordanoska et al., 2018). Similar findings are observed in the same tobacco varieties by Zaprijanova & Hristozova, (2018).

Table 3. Macronutrient content in tobacco leaves from experimental field in Prilep.

Treatment	Tobacco variety	N (%)	K (%)	P (%)	Ca (%)	Mg (%)
Ø	P-23	1.60	2.80	0.36	6.72	0.72
$N_{20}P_{60}K_{40}$		2.10	3.20	0.36	7.33	0.78
$N_{30}P_{60}K_{40}$		2.23	2.60	0.32	7.69	0.70
Ø	P-79-94	1.71	2.99	0.38	6.82	0.67
$N_{20}P_{60}K_{40}$		2.46	2.92	0.32	9.32	0.82
$N_{30}P_{60}K_{40}$		2.57	2.74	0.35	8.49	0.70
Ø	Dzhebel Basma 1	1.45	2.27	0.31	6.96	0.54
$N_{20}P_{60}K_{40}$		1.89	2.25	0.27	8.32	0.58
$N_{30}P_{60}K_{40}$		2.02	2.40	0.32	8.84	0.69
Ø	Elenski 817	1.68	2.21	0.30	7.36	0.66
$N_{20}P_{60}K_{40}$		2.01	2.25	0.28	8.02	0.74
$N_{30}P_{60}K_{40}$		2.23	2.52	0.35	7.61	0.73

*Ø- unfertilized control, $N_{20}P_{60}K_{40}$, $N_{30}P_{60}K_{40}$ (the index indicates applied nitrogen, phosphorus and potassium doses in kg/ha).

According to Campbell (2000), potassium content in dry plant material ranges from 1.0 to 5.0% and the required amount for normal development of the leaf is from 1.5 to 3.0% potassium. In our study, potassium content in all tested tobacco varieties is within these limits. Oriental tobacco P-66 is the most cultivated variety in North Macedonia with average potassium content from 0.26% to 1.33% (Jordanoska et al., 2018). According to our findings, four tested oriental varieties (P-23, P-79-94, Dzhebel Basma 1 and Elenski 817), from both locations (Tabs. 3 and 4) have higher potassium content compared to variety P-66.

Table 4. Macronutrient content in tobacco leaves from experimental field in Dobrushevo.

Treatment	Tobacco variety	N (%)	K (%)	P (%)	Ca (%)	Mg (%)
Ø	P-23	1.78	3.24	0.33	5.19	1.41
$N_{20}P_{60}K_{40}$		1.94	3.10	0.37	5.07	1.36
$N_{30}P_{60}K_{40}$		2.19	3.53	0.35	5.36	1.42
Ø	P-79-94	1.8	2.91	0.35	4.79	1.16
$N_{20}P_{60}K_{40}$		2.03	3.55	0.36	5.96	1.44
$N_{30}P_{60}K_{40}$		2.39	3.79	0.36	5.91	1.51
Ø	Dzhebel Basma 1	1.46	2.79	0.31	5.23	1.36
$N_{20}P_{60}K_{40}$		1.65	3.10	0.33	6.05	1.36
$N_{30}P_{60}K_{40}$		1.9	2.68	0.29	5.44	1.22
Ø	Elenski 817	1.66	2.89	0.36	5.08	1.21
$N_{20}P_{60}K_{40}$		1.94	2.45	0.30	4.67	1.18
$N_{30}P_{60}K_{40}$		2.05	3.03	0.32	5.32	1.32

*Ø- unfertilized control, $N_{20}P_{60}K_{40}$, $N_{30}P_{60}K_{40}$ (the index indicates applied nitrogen, phosphorus and potassium doses in kg/ha).

Campbell (2000) found that phosphorus content in technically mature tobacco leaves from the upper, middle and lower harvest belt are 0.14-0.3 %, 0.13-0.3 %, 0.12-0.3 %, respectively. Similar content of phosphorus was found in the most of the tested samples. The results are higher as compared to oriental tobacco P-66, that has phosphorus content from 0.04% to 0.2 % (Jordanoska et al., 2018; Zaprijanova & Hristozova, 2018).

Calcium content for all varieties is higher than the average 1.5% found in oriental tobacco P-66 and the ranges from 1.0 to 2.1% (Jones et al., 1991; Campbell, 2000; Jordanoska et al., 2018; Zaprijanova & Hristozova, 2018). Several studies found that calcium content in tobacco leaves depends on the calcium content of the soil and soil pH (Mylonas, 1984; Apostolova, 1990).

All tested varieties from experimental field in Prilep have lower magnesium content compared from the samples from Dobrushevo (Table 3 and Table 4). A range of magnesium content from 0.07-0.18% was observed in oriental variety P-66 (Jordanoska et al., 2018). The magnesium content in our samples was higher as compared to findings of Zaprijanova & Hristozova (2018), who found magnesium content in narrow limit of 0.38-0.56%. Comparison of the results from both locations shows that tobacco leaf samples from location Dobrushevo are richer in macronutrients, which is accordingly macronutrients content in soil samples from same location.

Based on the available and total content of the studied elements in soil samples, we calculated the availability ratio (Figure 2). Availability ratios are presented as direct measure of the potential effectiveness of the examined macronutrient in soil. Based on the results from both locations, nutrients availability percentage sequence the following order: Ca>P>Mg>K>N.

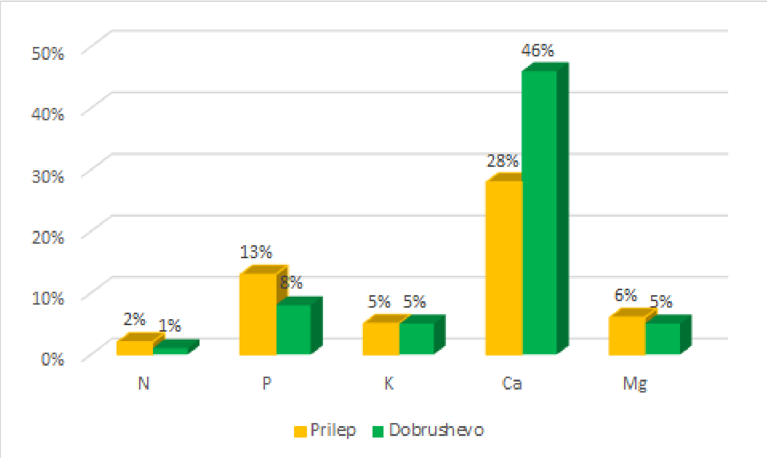

Figure 1. Availability of studied macronutrients calculated as a ratio of available content and total content of each macronutrient in soil before planting.

CONCLUDING REMARKS

According to our findings, there was no difference in the content of available and total nitrogen in the analyzed soil samples from the treatments with increased amounts of nitrogen (20 kg/ha and 30 kg/ha). The content of most of the studied elements in soil samples corresponds respectively with those from the oriental tobacco leaves from the particular location. Increasing doses of nitrogen fertilizer leads to increasing content of nitrogen in the leaves. For any tested tobacco variety, absorption capacity differs respectively for individual macronutrient. Calcium and magnesium content for all tested varieties from both locations were higher than most of the findings for oriental tobacco. It was found that Ca has greater availability compared to other observed nutrients.

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ДОСТАПНОСТ НА МАКРОНУТРИЕНТИТЕ ЗА РАЗЛИЧНИ ВИДОВИ ОРИЕНТАЛЕН ТУТУН ОДГЛЕДАН ВО ИСТИ АГРОТЕХНИЧКИ И ЕКОЛОШКИ УСЛОВИ

Билјана Јорданоска-Шишкоска [1*] Валентина Пеливаноска[1] Марија Србиноска[1]
[1]*Научен институт за тутун - Прилеп, Универзитет „Св. Климент Охридски" - Битола*

**Контакт автор: biljana.jordanoska@uklo.edu.mk*

Резиме

Макронутриентите се неопходни за растот и развојот на сите растенија, вклучувајќи го и ориенталниот тутун. Нивната достапност го одредува целокупното здравје и растот на тутунските растенија и е во фокусот на одржливото тутунско производство. Правилно управување со макронутриентите во почвата е неопходно за одржување на висок и квалитетен принос.

Со цел да се оцени содржината на макронутриенти и факторите кои влијаат на нивната достапност, направен е опит со четири различни сорти на ориентален тутун. Растенијата се одгледани со исти агротехнички услови, на две локации на колувијално-делувијален тип почва и на флувисол. Вкупната и достапна содржина на азот, фосфор, калиум, магнезиум и калциум, како најважни макронутриенти е одредена во примероците почва, додека вкупната содржина е одредена во примероците од растителен материјал. Достапноста на испитуваните елементи е претставена како соднос на одредената достапна и вкупна содржина во почвените примероци и служи како директна мерка за потенцијалната ефективност на избраниот макронутриент. Калциумот и фосфорот имаат поголема достапност во споредба со магнезиумот, калиумот и фосфорот. Анализирањето на соодносите меѓу својствата на почвата и достапноста на хранливите материи дава корисен увид за примената на одредени мерки за специфични цели во земјоделството и управување со животната средина.

Клучни зборови: *тутунски растенија, нутриенти, макронутриенти, фактори на раст.*