Effect of Compost Application on Uptake and Allocation of Heavy Metals and Plant Nutrients and Quality of Oriental Tobacco Krumovgrad 90

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***Abstract*—**A comparative research on the impact of compost on uptake and allocation of nutrients and heavy metals and quality of Oriental tobacco Krumovgrad 90 has been carried out. The experiment was performed on an agricultural field contaminated by the lead zinc smelter near the town of Kardzali, Bulgaria, after closing the lead production. The compost treatments had significant effects on the uptake and allocation of plant nutrients and heavy metals. The incorporation of compost leads to decrease in the amount of heavy metals present in the tobacco leaves, with Cd, Pb and Zn having values of 36%, 12% and 6%, respectively. Application of the compost leads to increased content of potassium, calcium and magnesium in the leaves of tobacco, and therefore, may favorably affect the burning properties of tobacco. The incorporation of compost in the soil has a negative impact on the quality and typicality of the oriental tobacco variety of Krumovgrad 90. The incorporation of compost leads to an increase in the size of the tobacco plant leaves, the leaves become darker in colour, less fleshy and undergo a change in form, becoming (much) broader in the second, third and fourth stalk position. This is accompanied by a decrease in the quality of the tobacco. The incorporation of compost also results in an increase in the mineral substances (pure ash), total nicotine and nitrogen, and a reduction in the amount of reducing sugars, which causes the quality of the tobacco leaves to deteriorate (particularly in the third and fourth harvests).

***Keywords*—**Chemical composition, compost, oriental tobacco, quality.

I. Introduction

TOBACCO is a major agricultural crop for many countries, including Bulgaria. Appropriate climatic conditions in the country determine the cultivation of high-quality oriental tobaccos that are distinguished by their specific smoking and technological properties. Among the Bulgarian oriental tobaccos, Krumovgrad origin is most common in the production and best realizing in international markets. The quality of the tobacco is largely determined by its chemical composition. The study of the chemical composition of the tobacco is primarily associated with its technological qualities, mainly with the combustibility, but tobacco consumption makes them significant also in terms of their biological effects on human health. This issue is particularly important given the ability of the tobacco to accumulate heavy metals, and the ability of part of them to be emitted in the main and side tobacco smoke stream [1]. The chemical properties of tobacco depend on many factors, among which the following should be noted: variety, habitat (soil and climate), as well as the impact of agro-technical practices on the physical, chemical and biological properties of the soil. Soil conditions and nutrient content are crucial for the growth and development of plants. Yield and quality of tobacco is strongly influenced by fertilization, and especially, by the introduction of nitrogen and potassium fertilizers [2]. The use of organic fertilizers can affect the physicochemical properties of the soil and can improve the conditions for crop development. Also, the organic fertilizer can neutralize or reduce the acidity of the soil and can increase the content of certain trace elements such as zinc and copper. Organic fertilizers can increase the weight of tobacco leaves and yield. The efficiency of organic fertilization is manifested in rapid growth, earlier senescence of leaves, and improvement of the combustibility of the leaves [3]. The increasing application of organic fertilizers leads to improvement of the soil's ability to deliver nutrients, in this way providing enough quantities of N, P, and K for the development of tobacco [4].

The purpose of this study was to conduct a comparative study that would allow us to determine the influence of compost on chemical composition and quality of Oriental tobacco variety Krumovgrad 90.

II. Material and Methods

The study included oriental tobacco (variety Krumovgrad 90) grown near Lead-Zink Complex /LZC/ - Kardzhali, after closing the lead production. Field trials were set in two variants under the block method in four repetitions.

The treatments included control (without addition of amendments) and the treatment with the introduction of compost (added to the amount of 40 t/daa to the soil). Characteristics of soil and compost are shown in Tables I-III. Soil samples from the area of LZC - Kardzhali are slightly polluted with Pb and Cd and are characterized by acidic reaction (pH 6.3) and average content of organic matter (2.18%). Soil characteristics are a prerequisite for medium mobility of metals, which is confirmed by the results of the amounts of Pb, Cd and Zn extracted with DTPA.

Technically senescenced leaves of various stem positions were taken for analysis. As the leaves of oriental tobacco ripen sequentially, harvesting is done in stages /harvests/ by following the sequence of senescence of leaves. Harvesting of

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leaves is carried out for five harvests (1-bottom leaves, 2-lower middle leaves, 3- middle leaves, 4-upper middle leaves, 5- lower top leaves and top leaves) (Fig. 1). The collected technically senescenced leaves were strung on a single needle and dried in natural conditions, observing the technology of solar drying of oriental tobacco.

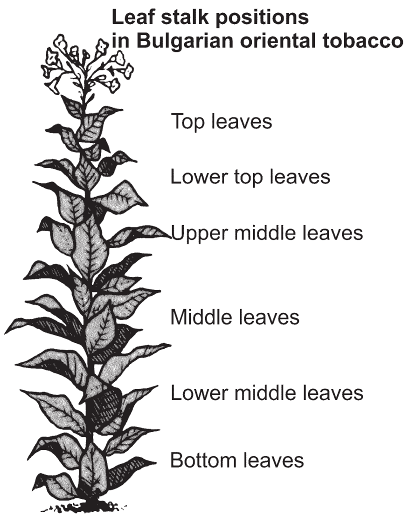

Fig. 1 Leaf stalk positions in Bulgarian Oriental tobacco

The content of heavy metals, micro and macronutrients in tobacco leaves was determined by the method of dry mineralization. The total content of metals in the soil was determined in accordance with [5]. The mobile forms were extracted by a solution of DTPA (1 M NH_4HCO_3 and 0.005 M DTPA, pH 7.8) [6]. The quantitative measurements were carried out with inductively coupled plasma emission spectrometry (ICP) (Jobin Yvon Emission - JY 38 S, France).

TABLE I
CHARACTERIZATION OF THE SOIL AND THE ORGANIC AMENDMENTS USED IN THE EXPERIMENT

	pH	EC	Organic matter, %	N, %
Soil	6.3	0.3	2.18	0.22
Compost	6.8	0.2	72.0	1.49

TABLE II
CONTENT OF HEAVY METALS AND MICROELEMENTS (MG/KG) IN SOIL AND THE ORGANIC AMENDMENT USED IN THE EXPERIMENT

	Pb	Cd	Zn	Cu	Fe	Mn
Total, mg/kg	130.4	3,3	267	34.4	33400	864.5
DTPA, mg/kg	30.9	0.68	66.8	6.3	41.3	70.3
DTPA/Total,%	23.7	20.6	25.0	18.3	0.12	8.1
Compost, mg/kg	12.0	0.19	170.8	14.2	3177.3	360.5

MPC (pH 6.0-7.4) – Pb -100 mg/kg, Cd-2.0 mg.kg, Zn-320 mg/kg

In the dried leaves, the content of substances was determined, directly related to the quality and the smoking properties of tobacco - total nitrogen, protein, reducing substances, mineral substances, and nicotine. Analyzes were carried out according to conventional methods [7], [8], as they are expressed in percentage by dry matter. The assessment of the smoking and taste properties was conducted by a three-member tasting committee, under the method of profile description of mono cigarettes of the five harvests. A blend of five harvests, compiled on the basis of their natural ratio in variety Krumovgrad 90, also underwent taste assessment.

TABLE III
CONTENT OF MACROELEMENTS (MG/KG) IN SOIL AND THE ORGANIC AMENDMENT USED IN THE EXPERIMENT

	K	Ca	Mg	P
Total, mg/kg	6300	12937.5	8310	1223.5
DTPA, mg/kg	570.1	323	559	32.5
DTPA/Total, %	9.0	2.5	6.7	2.7
Compost, mg/kg	6081.7	32158.7	2086.5	12653.9

III. RESULTS AND DISCUSSION

A. Content of Heavy Metals, Micro and Macronutrients in Oriental Tobacco Krumovgrad 90

The distribution of heavy metals, micro and macroelements in the organs of Oriental tobacco has selective character specific for individual elements. The main part of heavy metals, micro and macroelements are accumulated in leaves. A very small amount is contained in roots and stems. Roots contained only 1-2% of the total content of heavy metals and macroelements. Significantly higher is the content of Fe and Mn in the roots (15% and 8 %) (Fig. 2).

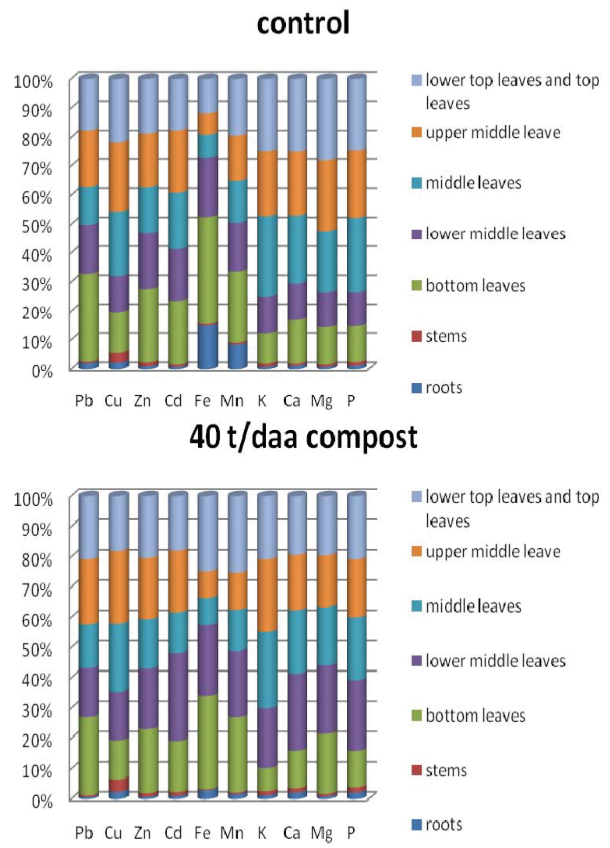

Fig. 2 Distribution of heavy metals, micro and macroelements in Oriental tobacco Krumovgrad 90

The distribution of heavy metals, micro and macroelements in the organs of the tobacco, with the addition of compost, follows the same relation observed in the control sample (Fig. 2). The highest content of heavy metals was found in the leaves followed by the roots and stems. These results are contrary to the results obtained by [9], who found that Pb accumulated mainly in the roots of tobacco. The lead content in tobacco leaves varies from 25.8 mg/kg to 60.1 mg/kg in the control, and from 24.7 mg/kg to 45.0 mg/kg in variants with incorporation of compost. Visible symptoms, caused by high levels of Pb, which occur in tobacco - dark green leaves, leafroll of old leaves, dark brown and short roots, were not observed in our experiments. According [10], the content of Pb in tobacco leaves varies widely - from 0 mg/kg to 200 mg/kg, and depends largely on the soil characteristics, the type and variety of tobacco, as well as the place of cultivation [11]. The significantly higher results, received by us before closing the lead production (135.6 mg/kg to 272.5 mg/kg, unpublished data), are probably due to soil and aerosol pollution. The incorporation of compost leads to a decrease of the lead content in tobacco leaves from the lower middle and middle leaves (Fig. 3).

The cadmium content in tobacco leaves varies from 5.52 mg/kg to 6.8 mg/kg in the control, and from 3.4 mg/kg to 5.9 mg/kg in variants with incorporation of compost. Visible symptoms caused by the increased content of Cd in plants, such as growth arrest, damage to the root system, chlorosis on leaves, reddish to dark brown colour on their edges, were not observed. According [12] the content of Cd in tobacco ranges from 0.5 mg/kg to 3.5 mg/kg, while [10] reports values reaching up to 11.6 mg/kg. The significantly higher results, received by us before closing the lead production (6.4 mg/kg to 9.0 mg/kg Cd, unpublished data), are probably due to soil and aerosol pollution.

The content of lead and cadmium is the highest in the leaves from the first harvest. Our results confirm the results of [13], according to whom the highest values of Cd are found in the leaves from the lower zone of tobacco and significantly lower in the leaves of top zone, assuming gradual accumulation over time. Incorporation of compost leads to a reduction of cadmium in tobacco leaves.

The zinc content in tobacco leaves varies from 188.7 mg/kg to 299.0 mg/kg in the control, and from 179.2 mg/kg to 234.2 mg/kg in variants with incorporation of compost. Symptoms of zinc toxicity which manifest themselves as chlorosis and necrosis at the edges of the leaves, interveinal chlorosis in young leaves, plant growth arrest as a whole, damage to the roots, were not observed as well. According to [14], [15], the optimum amount of Zn in the tobacco is in the range from 20 mg/kg to 60 (80) mg/kg and excess were observed in values above 80 mg/kg to 100 mg/kg.

According to [15], the optimum values of copper for tobacco are 5 mg/kg to 10 mg/kg, whereas [16] found that level of Cu in tobacco is in the range of 11.9 mg/kg to 13.3 mg/kg. The values identified by us for Cu in the leaves from untreated tobacco plants are in the range of 8.4 mg/kg to 16.22 mg/kg.

The content of zinc is higher in the bottom leaves (first harvests), in comparison with the leaves of the lower middle and middle leaves (second and third harvests). Possible reason for this is the poor mobility of these elements in tobacco plant [10]. The incorporation of compost decreases the content of zinc and copper in tobacco leaves (Fig. 3).

The iron content in tobacco leaves varies from 255.7 mg/kg to 1283.9 mg/kg (before 215.2 mg/kg to 584.4 mg/kg) in the control, and from 336.9 mg/kg to 1170.8 mg/kg in variants with incorporation of compost. In scientific literature the optimal iron content in tobacco leaves is 50 mg/kg to 300 mg/kg [14], whereas 40 mg/kg to 50 mg/kg is considered a low concentration depending on the stage of plant development [13]. The iron content established by us in the technically senescenced leaves is above the indicated critical value for tobacco. The incorporation of compost leads to increase of the iron content in the tobacco leaves from the upper zone (top leaves).

The manganese content in tobacco leaves varies from 34.5 mg/kg to 59.1 mg/kg in the control, and from 30.5 mg/kg to 63.2 mg/kg in variants with incorporation of compost. Although the content of mobile manganese in the soil is not high, tobacco leaves contain manganese above the lower limit of 20 ppm indicated by [15]. The incorporation of compost results in increased manganese content in leaves of the tobacco from the lower and upper zone (bottom and top leaves) (Fig. 3).

Mineral substances have a direct impact on tobacco combustibility. If there is a favourable ratio between the elements, tobacco has a good combustibility, which is characterized by uniform and sufficiently intense smoldering.

Phosphorus content in tobacco leaves, depending on the stage of development, ranges from 0.1% to 1% [14]. Observed concentrations in technically senescenced leaves of oriental tobacco are around the lower limit, despite the good preservation of the soil by mobile phosphorus (Table III). Most rich in phosphorus are technically senescenced leaves from the upper harvesting zone (upper middle and top leaves). This zone is enriched directly from the soil and by the re-utilization of phosphorus from the lower leaves that become poorer. The influence of compost on the phosphorus content in leaves is relatively weak. A trend for reduction of phosphorus in leaves is observed in the leaves of the upper harvesting zone.

The content of K in the leaves of tobacco plants varies depending on the stem position (Fig. 3). These values are similar to those reported by [17], according to which the content of N in the leaves of 2.5% to 4.2% has a positive influence on tobacco combustibility. The content of potassium in leaves is the highest in the middle harvesting zone. Despite the good soil preservation with assimilable potassium, the concentration of potassium in leaf tissues decreases. This may be due to the high content of calcium, and therefore of antagonism between potassium and calcium, where the intensity of the absorption of potassium is greatly reduced [18]. Similar are the results obtained following the incorporation of compost in soil. There is a notable trend of reduction of K at the above-situated leaves.

The calcium content in tobacco leaves varies from 2.5% to 4.9% in the control (Fig. 3) and from 1.5% to 3.0 % in the variants with the incorporation of compost. These values are similar to those reported by [19]. The concentration of Ca in tobacco leaves depends on the stem position. Most Ca is accumulated in senescenced leaves from the middle and upper harvesting zone (Fig. 3). The incorporation of compost in the soil results in a decrease of the calcium content in tobacco leaves (up to 1.5% in the leaves of the lower zone and 2.2% in the leaves of the upper zone).

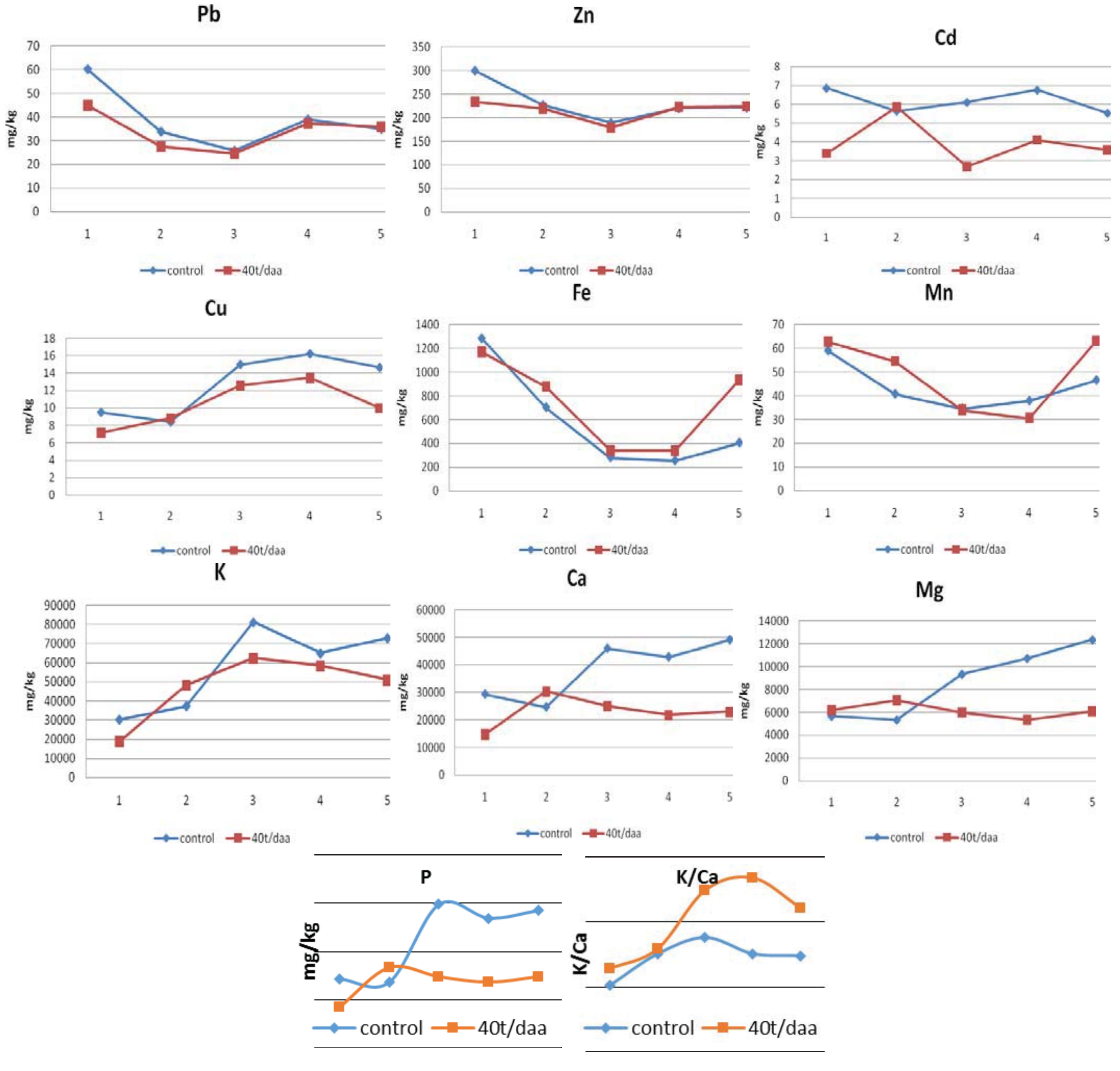

Fig. 3 Effect of compost on uptake of heavy metals, micro and macronutrients in Oriental tobacco leaves

The minimum magnesium content in tobacco leaves, where symptoms of insufficiency do not appear, is about 0.25% [10]. According to [19] the content of magnesium in technically senescenced leaves of oriental tobacco is changed in a narrow range from 0.33% to 0.69% and depends mainly on the location of the leaves to the stem. According [20] plant in Mg deficiency have a lower content of the element in the lower leaves in comparison to the upper ones, while in normal supply, the highest concentration of Mg in the lower leaves. The magnesium content established by us in technically senescenced leaves is above the critical value for tobacco. The highest concentration of magnesium is in the leaves of the upper harvesting zone. Apparently, the good preservation of the soil with Mg provides enough direct intake of magnesium in the above organs, which reduces the need for reuse, of which this element is subject to [2]. The organic additives lead to decrease in the magnesium content in tobacco leaves from the middle and upper zone (Fig. 3). The K/Ca ratio is important for the quality of tobacco raw material and mainly associated with it is the structure of tobacco leaf and combustibility. When calcium prevails over potassium, raw material is obtained with poor elastic properties and volume. Our results show that K content in tobacco leaves from control plants prevails over the content of Ca. The incorporation of compost in the soil leads to decreased contents of potassium and calcium, the K/Ca ratio in the leaves from all harvesting zone is increased (Fig. 3).

B. Effect of Compost on Quality of Tobacco

Table IV presents the results of the impact of compost on chemical parameters (content of mineral substances, soluble carbohydrates, proteins, total nitrogen and nicotine).

The content of mineral substances (ash) has well-expressed correlation with the fleshiness of tobacco leaves, and from there with their quality. According to [21] ash content in dried leaves of oriental tobacco ranges from 12% to 15%. The ash content in tobacco leaves varies from 14.37% to 17.55% in the control (Table IV) and from 18.21% to 20.80% in variants with incorporation of compost. The increase in the ash content compared to the control sample is evident in the incorporation of compost in the soil. The increase in the amount of macro elements leads to the increase of ash content.

TABLE IV
CHEMICAL COMPOSITION (%) OF DRIED TOBACCO LEAVES, VARIETY KRUMOVGRAD 90

Harvests	Treatment	Parameter				
		1	2	3	4	5
1	Control	17.55	13.81	10.67	1.71	1.52
	40 t/daa	20.80	7.54	12.21	1.96	1.79
2	Control	16.51	16.02	10.40	1.64	1.67
	40 t/daa	18.94	8.43	13.43	2.15	2.26
3	Control	17.27	10.06	13.00	2.08	1.96
	40 t/daa	18.95	3.68	16.15	2.59	2.52
4	Control	14.37	13.46	13.75	2.20	1.79
	40 t/daa	17.27	5.22	19.30	3.09	2.81
5	Control	16.23	7.32	17.55	2.81	1.22
	40 t/daa	18.21	3.99	22.62	3.62	1.92

1- Mineral substances, %, 2- Soluble carbohydrates, %, 3- Proteins, %, 4- Total nitrogen, %, 5- Nicotine, %

The influence of protein substances on consumer qualities of tobacco is generally negative, since pyrolysis of proteins produces nitrogenous substances in tobacco smoke with unpleasant odour and irritating taste. The content of proteins in tobacco leaves varies from 4% to 16%, while in the oriental tobaccos it reaches up to 8.5%. Our results indicate that oriental tobacco accumulates more proteins. The protein content varies from 10.40% to 17.55% in the control and from 12.21% mg/kg to 22.62% mg/kg in variants with incorporation of compost. The increase in protein in leaves from the five harvests compared to the control sample is strongly expressed in the incorporation of compost.

The supply of nitrogen is the most important factor influencing the quality of tobacco [22], [23]. The use of organic fertilizers leads to increase the content of nitrogen and nicotine in the leaves of oriental tobacco and Virginia [2], [16]. Controlled release of nitrogen from organic fertilizers can be useful practice for increasing the content of nicotine in tobacco. The availability of nitrogen in the later stages of development of tobacco is a critical factor influencing the content of nicotine in the leaves. Reference [22] reported that the mineralization of nitrogen itiner-late stages is an important factor influencing the accumulation of nitrogen and hence the content of nicotine in the leaves. Reference [3] reported that the content of nicotine in the leaves of tobacco increases in the later stages of development, especially after the crushing of the blossoms. Nicotine is the most important alkaloid contained in tobacco and an indicator of its quality. The nicotine content in the tobacco leaves varies between 0.05% (Virginia tobacco) through 3% - 4% ("Burley") to 7.5% (*Nicotiana rustica* "Machorka", Russia) [21]. Oriental tobacco Kroumovgrad 90 is characterized by an average content of nicotine (approximately 1.3%). The nicotine content established by us in the technically senescenced leaves is above the indicated value for Oriental tobacco. The nicotine content varies from 1.22% to 1.96% in the control and from 1.79% to 2.52 % in variants with incorporation of compost. The results show that the nicotine level of tobacco leaves increases from bottom leaves to lower top leaves and decreases in top leaves. The increase in nicotine content in leaves from the five harvests compared to the control sample is strongly expressed in the incorporation of compost.

TABLE V
INDEXES, DETERMINING THE QUALITY OF ORIENTAL TOBACCO

Harvests	Treatments	Index			
		1	2	3	4
1	Control	9.06	0.79	1.13	8.08
	40 t/daa	4.21	0.36	1.09	3.85
2	Control	9.59	0.97	0.98	9.77
	40 t/daa	3.73	0.45	0.95	3.92
3	Control	5.13	0.58	1.06	4.84
	40 t/daa	1.46	0.19	1.03	1.42
4	Control	7.52	0.94	1.23	6.12
	40 t/daa	1.86	0.30	1.10	1.69
5	Control	6.00	0.45	2.30	2.60
	40 t/daa	2.08	0.22	1.89	1.10

1- Total reducing substances/nicotine index, 2- Total reducing substances/ ash index, 3- Total nitrogen/nicotine index, 4- Total reducing substances/ proteins (Schmuck's number)

Oriental tobaccos contain significant amounts of reducing sugars and small amounts of protein. According to [21] the average content of soluble carbohydrates in oriental tobaccos ranges from 10% to 18%. At very high content of soluble carbohydrates - over 16% for oriental tobaccos and low content of nitrogen compounds, a lopsided taste with insufficient completeness is obtained, and the burning sensation is enhanced. The soluble carbohydrates content established by us in the technically senescenced leaves is lower than the indicated value for Oriental tobacco. The soluble carbohydrates content varies from 7.32% to 16.02% in the control and from 3.68% to 8.43% in variants with incorporation of compost. The incorporation of compost in soil leads to lower content of soluble carbohydrates in tobacco leaves.

TABLE VI
CHARACTERISTICS OF TOBACCO SAMPLES (ACCORDING TO EXPERT EVALUATION)

Harvests	Treatments	
	Control	40 t/daa compost
1 Includes leaves from the lower part of the plant – bottom leaves (in Bulgarian – commonly known as *dib* and *dib bashi*)	Light material with light yellow to light brown colour (lighter than sample with incorporation of 40 t/daa compost). Leaves, poor in content, damaged in low to medium level by *sharilka* dominate. About 3-5% is a successful volado material - light yellow with greenish hue. Relatively more rigid, thick and non-elastic leaves from the treated tobacco. Leaves sizes - 9-13 cm (about 70%) and 6-9 cm (25-30 %).	Light yellow to light brown and brown colour. Moderate damage of *sharilka*. Without greenish hues and fading. Less fleshy (about 5% are impeccable - yellow with greenish hue). Sizes - from 8 to 18 cm. (Prevailing 12-15 cm (about 50%); 6-11 cm (~ 30%) and 15-18 cm (~ 20%)).
2 Includes leaves from the lower middle part of the plant - lower middle leaves	Light yellow to light brown colour. Damaged by burns, to a medium degree, from disease - to a medium degree; separate leaves - damage from *sharilka* to a lesser degree. Average flesh. Pleasant smell of the leaves. Sizes - from13 to 20 cm (10%), 16-18 cm (~90%)	A deep yellow to brown and red-brown colour (darker than sample without compost). The leaves are much larger than sample without compost. Typical broad elliptic shape form (different from sample without compost). Damaged by *sharilka* and blight; damage from disease to a medium degree. Medium fleshy. A fainter aroma than that of leaves from sample without compost. Sizes – from 12 to 25 cm ((Prevailing 20 – 23 cm (~80 %); 12 – 15 cm (~10 %); 16-18 cm (~10 %))
3 Includes middle and upper middle leaves	Bright, with yellow, yellow-brown to light brown colour (About ¼ of the sample are red and red-brown colour, about ¼ - with yellow and yellow-brown colour). Burnt. Low level of damage by diseases. Average quality. Pleasant aroma of the leaves. Sizes - from 16 to 22 cm. (Prevailing 19-20 cm (~70%); 17-18 cm (~ 25-30%)).	The leaves are very wide (different from the control; with width of 18-19 to 30 cm (in significant proportion of the middle leaves the length/width ratio reaches ~ 1/1). Pleasant aroma of the leaves. Middle leaves are yellow-brown to bright red; upper middle leaves - orange-red. Medium fleshy. Low level of damage from diseases. Sizes - from 15 to 30 cm. (Prevailing 24-27 cm (~70 %); 18-19 cm (~20 %)).
4 Includes mainly upper middle leaves (~ 90%) and lower top leaves (in Bulgarian - *kovalama*) (~ 10%).	The upper middle leaves are of medium quality, yellow to brown; blight. Lower top leaves are of good quality, orange-red with greenish hues. In general - light material, yellow-brown. Sticky, elastic, with pleasant smell of the leaves. Sizes from 12-14 to 20-21 cm (Prevailing 18-20 cm (~ 80%); 13-14 cm (~ 10%)).	The upper middle leaves are thinner and less elastic than sample without compost; predominantly red-brown. Lower top leaves are thick, sticky, red-brown and green. Material of average quality; darker and inferior in quality compared to sample without compost, with less pleasant aroma. The leaves are large, wide in shape. Sizes – for the leaves of the middle part of the plant from 17-18 to 23-24 cm (prevailing 20-22 cm (~ 70%)); for the lower top leaves - from 11 to 18 cm, (prevailing 14-15 cm).
5 Includes top leaves (~ 10%), lower top leaves (~ 70%) and some upper middle leaves (~ 10%).	Sticky, thick and fleshy material. Colour - from yellow-orange (few leaves) to brown and red; with oil stains (generally brownish). Sizes - from 9-10 to 12-13 cm (for top leaves), and up to 18-19 cm (for upper middle leaves and lower top leaves). Prevailing sizes - for top leaves 11-12 cm; for lower top leaves and upper middle leaves - 16-17 cm.	Red, olive green in colour. Dense, very sticky, fleshy material (in general – red with oil stains). Sizes - from 6-7 cm to 12-13 cm (top leaves) and 20-21 cm (lower top leaves). In top leaves prevailing are 10-11 cm; in lower top leaves - 13-15 cm (over 65-70%).

* *Sharilka* - a specific dot-like necrosis formation on Oriental type tobacco

Determining the quality of tobacco by its chemical composition is more widely used in practice. It was found that chemical substances contained in tobacco and its smoke, its effects can be divided into two main groups - substances that cause pleasurable sensations – i.e. positively affecting substances and substances that cause unpleasant sensations – i.e. negatively affecting substances. Schmuk [24] allocated to the first group of soluble carbohydrates and nicotine content at levels up to 1.5%, and the second to the protein. Different chemical factors have been developed and are offered on the quality of tobacco, representing a proportion between favourable and unfavourable affecting substances.

For the objective determination of the quality of light tobaccos, especially important is the balance between the main components of the chemical composition expressed in various ratios. The incorporation of compost leads to a slight change in these indicators. The total reducing substances/ash index, providing information for the fleshiness of the tobacco, varies from 0.45 to 0.9 in the untreared tobacco plants and from 0.19 to 0.58 in tobacco with incorporation of compost. The reducing substances/nicotine index is in the range from 5.13 to 9.59 in control plants and from 1.46 to 4.21 in treated plants. The total nitrogen/nicotine index is in the range from 0.98 to 2.30 in control plants and from 0.95 to 1.89 in treated plants (Table V).

With the help of the Schmuck's number (ratio of soluble carbohydrates and proteins) the main quality categories of oriental tobaccos can be objectively characterized. Quality tobacco has value over 1.0, average quality - between 0.5 and 1.0, and low-quality - below 0.5. Schmuck's number ranges from 2.6 to 9.77 in the control sample, and from 1.1 to 3.92 in the variant with compost.

The indicators of the chemical composition characterize the material from the five harvests as quality and of average quality, which correlates very well with the results of the expert evaluation of the tobacco samples (Table VI). The results obtained show that soil pollution with heavy metals does not affect the performance of the chemical composition, determining the quality of tobacco. The normal course of amendment of the chemical indicators is expressed by harvests, characteristic of the oriental tobacco. The resulting values are typical for tobacco of Krumovgrad origin (variety Krumovgrad 90) grown in field conditions, with the exception of the content of nicotine, which is significantly less than the typical for this variety and origin.

Tasting evaluation found the compost to the manifestation of the smoking properties characteristic of the oriental tobacco by harvest, is shown in Table VII.

TABLE VII
TASTING EVALUATION OF SMOKING PROPERTIES OF ORIENTAL TOBACCO

Harvests	Treatments	
	Control	40 t/daa compost
1	regular tobacco aroma; weak bitterness and coating; below-average physiological strength;	neutral to slightly unpleasant odour; slight irritation, below-average bitterness; average physiological strength;
2	neutral to slightly pleasant aroma; slight sweetness, slight irritation; average physiological strength	ordinary tobacco aroma, with low intensity; average severity and irritation, low mouth coating; strong physiological effect
3	pleasant aroma, medium intensity; smooth, non-defective taste; above-average to strong physiological effect;	intense aroma, but with notes (of dark tobacco) non-typical of oriental tobacco; pronounced sharpness, irritation and mouth coating; physiological effect in a strong degree;
4	intense pleasant aroma; smoothness, fullness, above-average physiological effect;	intense but simple aroma, with dark notes; strong bitterness, sharpness, irritation and mouth coating; physiological effect in a strong degree;
5	intense pleasant aroma, typical; dense, full, smooth taste, below-average physiological strength;	pleasant aroma, intense, dark, with a hint of ammonia; strong bitterness and sharpness, mouth coating; above-average to strong physiological effect.

In all mono cigarettes the weaker physiological effect was marked. The tasting of blend of four harvests did not reveal any significant differences from the typical taste and aroma of Krumovgrad origin.

The leaves from treatment tobacco plants (with incorporation of compost) are generally with larger leaves, a darker colour, less fleshy, in the second, third and fourth stalk position – with a modified form (much broader than the corresponding tobacco leaves without compost). The chemical composition in tobacco with amendment shows higher content of mineral substances, total nitrogen and nicotine and lower - of reducing substances, i.e. quality deterioration (particularly in the third and fourth harvest). This is also confirmed by the following indices: (1) reducing substances/clean ash that characterizes fleshiness - in tobacco without amendment it is 0.45 - 0.97; in those with amendment – 0.19 – 0.58, (2) reducing substances/nicotine - without amendment 5.13 - 9.59, with amendment 1.46 - 4.21.

With regard to the smoking properties, in the first and second harvests there is almost no difference between the tobacco samples with amendments and those without (but these are harvests with mediocre quality of oriental tobacco), but in the third, fourth and fifth harvests the samples with amendments fall far short of those without amendment.

IV. CONCLUSION

1. The distribution of the heavy metals in the organs of the Oriental tobacco has a selective character and depended above all on the parts of the plants and the element that was examined. Pb, Fe, Mn and Ca distribution in tobacco decreases in the following order: leaves > roots> stems, and for Cu, Zn, Cd, K, Mg and P - leaves >stems> roots.
2. The incorporation of compost leads to decrease in the content of Cd, Pb and Zn in the tobacco leaves with 36%, 12% and 6%, respectively.
3. The introduction of compost resulting in increased uptake of macro elements potassium, calcium and magnesium, and leads to improvement of the life status of the tobacco plant, and has a beneficial effect on burning properties of tobacco.
4. Incorporation of compost leads to an increase in the size of leaves (larger leaves, a darker colour, less fleshy, with a modified form (much broader) in the second, third and fourth stalk position and a decrease in the quality of tobacco.
5. Compost affects the indicators defining the quality of tobacco (ash content, total protein, and nicotine and reducing sugars). The introduction of the compost to the soil leads to an increase of the mineral substances (pure ash), total nitrogen and nicotine, and reduces the amount of reducing sugars, i.e. quality deterioration (particularly in the third and fourth harvest) in tobacco leaves.
6. The application of compost to the soil affects more negatively, as regards to the quality and typicality of the Oriental tobacco variety of Krumovgrad 90.

REFERENCES

[1] A. Stoilova, and K. Markova, “Exploring the contents of major macro and micro elements in tobacco smoke”, *Scientific Works University of Food Technology*, vol.51 (3), pp. 137-142, 2004.
[2] P. Bozhiova, and V. Bozhinov, “Exploring the influence of some soil parameters on growth and yield of Oriental tobacco Ustina origin”, *Scientific works Agricultural University Plovdiv*, vol.51, pp.41-46, 2006.
[3] X. Z. Wang, G. S. Liu, H. C. Hu, Z.H. Wang, G. H. Liu, X. F.Liu, W.H. Hao, and Y. T. Li, “Determination of management zones for a tobacco field based on soil fertility”, *Computers and Electronics in Agriculture*, vol.65, pp.168-175, 2009.
[4] P. Y. Cao, S. J. Lu, and W. S. Zhang, “Advances in soil organic matter contents and vermicomposts application in tobacco growing areas”, *Acta Tabacaria Sinica*, vol.10(6), pp.40-42, 2004.
[5] Soil quality - Extraction of trace elements soluble in aqua regia. ISO 11466, 1995.
[6] P. N. Soltanpour, and A. P. Schwab, “A new soil test of macro- and micro- nutrients in alkaline soils”, *Commun. Soil Sci. Plant Analysis*, vol.8, pp.195-207, 1977.
[7] Tobacco - Determination of the content of reducing carbohydrates. Continuous-flow analysis method. ISO 15154, 2003.
[8] Tobacco - Determination of the content of proteins – method of Moore. BDS 9142,1988.
[9] L del Piano, M. Abet, C. Sorrentino, L. Barbato, M. Sicignano, E.

Cozzolino, and A. Cuciniello, “Uptake and distribution of lead in tobacco (Nicotiana tabacum L.)”, *Journal of Applied Botany and Food Quality*, vol.82, pp.21 – 25, 2008.

[10] T. C. Tso, *Production, physiology and biochemistry of tobacco plant*. Beltsville, MD, Ideals,1991.

[11] N. Lugon-Moulin, M.Zhang, F. Gadani, L. Rossi, D. Koller, M. Krauss, and G. J. Wagner, „Critical review of the science and options for reducing cadmium in tobacco (*Nicotiana tabacum* L.) and other plants”, *Adv. Agron*.,vol. 83, pp.111-180, 2004.

[12] E. E. Golia, A. Dimirkou, and I. K. Mitsios, “Accumulation of metals on tobacco leaves (primings) grown in an agricultural area in relation to soil”, *Bull Environ Contam Toxicol*., vol.79 (2), pp. 158-162, 2007.

[13] G. J. Wagner, “Accumulation of cadmium in crop plants and its consequences to human health”, *Adv. Agronomy*, vol.51, pp.173-212, 1994.

[14] J. Jones, B. Wolf, and H.A.Mills, *Plant Analysis Handbook*. Micro-Macro Publishing Inc., 1991.

[15] C. R. Campbell, “Tobacco, Flue-cured”, in *Reference sufficiency ranges for plant analysis in the southern region of the United States*, C. R. Campbell, Ed. Southern Cooperative Series Bulletin 394, 2000, pp. 39-45.www.ncagr.gov/agronomi/saaesd/scsb394.pdf

[16] P. Zaprjanova, and R. Bozhinova, “Fe, Mn, Cu and Zn content in plant organs of the oriental and Virginia tobacco”, *Tobacco*, vol.58, 7-8, 179-185, 2008**.**

[17] N. I. Volodarskiy, “Mineral nutrition of tobacco”, in *Physiology of agricultural plants*, B. A. Rubin, Ed. Moskow University, Moskow, 1971, pp. 196-243.

[18] K. Enikov, and M. Benevski, *Guide on fertilization*. Sofia, 1984.

[19] D.Yancheva, “Mineral composition of the oriental tobacco leaves depending on the nitrogen vermicompost rate”, *in Proc. The Second Balkan Scientific Conference Quality and efficiency of the tobacco production, treatment and processing*, Plovdiv, pp.162-166, 2002.

[20] C. B. McCants, and W. G. Woltz, “Growth and Mineral Nutrition of Tobacco”, *Advances in Agronomy,* vol.19, pp. 211-265, 1967.

[21] L.Gyuselev, *Science of tobacco commodity*. Hristo G. Danov, Plovdiv, 1983.

[22] X. T. Ju, F. C. Chao, C. J. Li, R. F. Jiang, P. Christie, and F. S. Zhang, “Yield and nicotine content of flue-cured tobacco as affected by soil nitrogen mineralization”, *Pedosphere*, vol. 18, pp.227-235, 2008.

[23] D. Bilalis, A. Karkanis, A. Efthimiadou, A. R. Konstantas, and V. Triantafyllidis, “Effects of irrigation system and green manure on yield and nicotine content of Virginia (Flue-cured) organic tobacco (Nicotiana tabacum), under Mediterranean conditions”, *Ind. Crops Prod*., vol. 29, pp.388-394, 2009.

[24] A. Schmuk, and I. A. Nauk, “The taste, quality and chemical composition of tobacco”, in *The Chemistry and Technology of Tobacco*”, N.I. Gavrilov, Ed. Pishchepromizdat, Moscow, 1953, pp. 5-22.