EVALUATION THE IMPACT OF BIOCHAR APPLICATION ON MAIZE VEGETATION

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Abstract The requirements of modern agriculture include besides obtaining maximum yields of crops of each ecological region through appropriate agrotechnics also maintaining and improving soil fertility and environmental protection. Traditionally, post-harvest residues of cereals crops in past was used for feed. Nowadays, under the conditions of greatly reduced livestock and lack of market, they have to be exported from the field or burned. This practice leads to deterioration of soil fertility, loss of fresh organic matter, disrupting soil structure and its properties, as well as release of large amounts of CO_2. Biomass is a sustainable source of organic carbon. There are many ways of its processing and use. Transformation of biomass into biochar (BC) as a result of pyrolysis has various everyday life applications - heating and barbecues, as well as a soil improver and the composting.
In recent years, interest of usage solid phase (charcoal or biochar) obtained by pyrolysis as soil improver increases. The number research concerning biochar applications in order to mimic the effect of fertile soils in the Amazon Terra Petra (Gunarathne, V., 2017) were carrying out in last ten years.
The biochar structure, porosity, chemical composition, influence of external factors on the BC properties and its application, distribution and movement in the soil profile is necessary to be studied. In Bulgaria are made research only to determining the influence of systematic plowing of crop residues on the soil fertility and crop productivity on gray forest soil (Medina, J., 2015). The studies of BC influence on the soil properties and plant growth are less.
The aim of study is to testing of biochar agronomic impact on the water physical, agrochemical properties of soil and on the growth, plant development and some of their quality indicators.
Keywords: Biochar, pot experiment, fertilizer, maize

1. INTRODUCTION

The requirement of the now day agricultural practice is related to obtain of highest crop in all ecological area with suitable for agrotechnics. Preserving and enhancing soil fertility and protecting the environment. Traditionally, plant residues used for feed, in conditions of severely reduced livestock production and lack of market, have to be removed from the field or burned. This practice leads to deterioration of soil fertility, loss of fresh organic matter and disturbance of soil structure. Biomass is a sustainable source of organic carbon. There are many methods for its recycling and use. The conversion of biomass to biochar (BC) as a result of pyrolysis has many uses in households - heating and grilling, as well as soil improver and composting.
In recent years, interest in use of solid phase obtained by process of pyrolysis - biochar (BC) as a soil improver has been intensifying. A number of studies have been conducted on its use in order to mimic the effect of Terra Preta's fertile soils in the Amazon (Gunarathne, V., 2017; Thomas B., 2004; Głodowska, 2016).
It is necessary to study the structure and porosity of biochar formed from plant materials and their chemical composition. Few studies have been done in Bulgaria to influence the systematic plowing of plant residues on soil fertility and crop productivity (Petrova, V., et al. 2018).
Purpose of the experiment:
The aim of the study is to determine the agronomic impact of biochar on certain water-physical and agrochemical properties of the soil, as well as on the growth, development of plants and some of their qualitative indices.

2. MATERIAL AND METHODS

A pot experiment has been carried out to test the agronomic impact of biochar application on some of the water's physical and agrochemical properties of the soil. Plants development and quality indicators were tested. The biochar used in the experiment was obtained by pyrolysis of apple and cherry wood.
The experiment is based on two soil types of alluvial-meadow from Tsalapitsa village and leached cinnamon forest soil from the Sekirovo village. Based on preliminary studies the rate of imported biochar by variants has been recalculated for the rate of 200 kg /da and 400 kg / da.

The following variants have been set out:

1. Control 1 / clean soil /
2. Control + BC 1/6 g per vessel /

3. Control + BC 2/12 g per vessel /
4. Control 2 - (soil + NPK)
5. NPK +BC 1/6 g per vessel /
6. NPK + BC 2/12 g per vessel

The pot experience is conducted in vessels with a capacity of 2 kg soil, in three replications of two soil types.
The fertilization rates are: nitrogen fertilizer - ammonium nitrate - 150 mg nitrogen per 1 kg of soil; triple superphosphate - 120 mg P_2O_5 per 1 kg soil; potassium sulfate - 100 mg K_2O per 1 kg soil. The testing crop was maize variety Kn 209. After emergence, 3 plants are left in each pot. Maize plants are harvested in 6-7 leaf development stage.
The irrigation regimes during the growing season are close to optimal.
Phonological observations and biometric measurements were made during the vegetation. The content of plastid pigments and total sugars has been determined. Both soil types used in the experiment were analyzed.

3. RESULTS AND DISCUSSION

The two soil type's alluvial-meadow from Tsalapitsa and the leached cinnamon-forest soil from Sekirovo, used for conducting the vegetation experiments, were analyzed.
The soil from the Tsalapitsa village is leached meadow-cinnamon, with a light mechanical composition, thanks to which the processes in it proceed faster. According to the chemical analysis of the soil (Stoycheva, 2007) the soil in Tsalapitsa is characterized by a low content of total N (0.052%) and humus (0.70%), with a slightly acidic reaction throughout the profile and a sorption capacity of 22.5 meq / 100g soil. In regard to the exchange bases, the soil has a low buffer capacity against the acidifying anthropogenic impacts.
Soil from the experimental field Sekirovo (Cinnamon Podzolic) is characterized by low humus content, which gradually decreases in depth. The soil has medium acidity in the surface horizon and low acidity in the By horizon. Total nitrogen reserves are very low. It has very low sorption capacity. The distribution of cations is diffuse. There is an exchangeable acidity. The chemical composition – pH in KHL varies between 5.5 for the surface horizon and 6.8 for the By horizon with a depth of 22–40 cm; Total Nitrogen 0.060 and 0.061, Humus 0.90-0.89.

Table 1. Chemical analysis of soil from Tsalapitsa and Sekirovo village used for pot experience

Soil Type	KCl	NH_4+NO_3 mg/kg	P_2O_3 mg/100g	K2O mg/100g	Humus %
Alluvial-Meadow	7,3	23,6	25,2	43.7	2,98
Cinnamon Podzolic	5,5	19	22,7	33,3	2,15

The effect of BC on soil pH is shown in Table 2. An increase in pH values is observed when BC is applied inn rate - 12 g/ per pot on both soil types.

Table 2. Chemical analysis of soil samples after harvesting of maize growing experiment

Soil types and locations	Vriants		pH	Σ N- NH_4+NO_3	P_2O_5	K_2O	Humus %	Ca	Mg
			KCL	mg/kg	mg/100g		%	mg/100g	
Secirovo-Cinnamon Podzolic	without fertilizer	0 mg BC	5,50	10,9	18,7	20,3	1,55	190,5	7
		6 mg BC	5,90	11,5	25,3	39,6	1,68	176	11
		12 mg BC	6,00	10,6	35,5	86,6	1,78	134	12,5
	NPK	0 mg BC	4,9	77,7	46,4	26,4	1,51	155,5	6
		6 mg BC	5,1	38	51,6	38,7	1,64	143,5	9,5
		12 mg BC	5,3	51,8	55,5	73	1,68	141	13
Tsalapitsa - Alluvial-Meadow	without fertilizer	0 mg BC	6,5	5	21,9	23,8	1,59	109	15,5
		6 mg BC	7,2	5,8	22,7	37,5	2,03	97	17
		12 mg BC	7,5	10,9	31	67,8	2,28	93	18,5

	NPK	0 mg BC	5,7	75,5	31,7	28,3	1,58	104	13,5
		6 mg BC	6,7	71,1	45,8	44,9	1,53	100	17,5
		12 mg BC	6,9	54,7	45,6	67,5	1,50	99,5	18

The poor soil acidification observed is probably due to the acidifying ability of the root system of the plants, as well as the inability of light soils to retain the phases. The lowest values were reported in the control variants. The addition of NPK has a slight acidifying effect on both soil types.

Similar results have been obtained by many other authors Nigussie et al. 2012 reported a statistically proven (P <0.01) increase in pH after biochar application at a ratio of 10 t / ha. The increase in soil pH resulting from the use of organic coal is usually attributed to the accumulation of ash residues, which are usually dominated by carbonates of alkali and alkaline earth metals, varying amounts of silica, heavy metals, phosphates and small amounts of organic and inorganic N (Raison, 1979). Accordingly, Tammeorg, P. (2014) also reported the capacity of ash to neutralize soil acidity.

Another reason for the increase in soil pH resulting from the use of organic BC may be due to the large surface area and porous nature of organic BC, which increases the capacity of soil cation exchange.

The residual content of NH_4 + NO_3 in the variants of the experiment ranges between 10.6-77.7 mg / kg soil for Sekirovo and between 5.00-75.00 mg / kg soil for Tsalapitsa.

The residual nitrogen content for the mineral fertilizer variants is much higher than for the imported biochar. From the residual content of NH_4 + NO_3 in both soil types, it can be assumed that, given the low humus content of the two soil types, the baseline rates of 6 and 12 mg biochar per kg / soil are insufficient.

The NH_4 + NO_3 content is closely related to the fresh and air-dried biomass produced. In the case of higher yield of fresh biomass, the variant of nitrogen export is higher and the residual content of mobile nitrogen is lower.

During the vegetation experiment with maize, results were obtained for the amount of plastid pigments in the leaves of each variant. The content of plastid pigments in the plants depends on the type, variety, development stages, temperature, light, feeding conditions, etc. For this reason, chlorophyll content can serve as an indirect indicator of plant development, with chlorophyll "a" being more sensitive to external effects than chlorophyll "b" (Petrova, 2010).

Figure 1 shows the chlorophyll content of a 6-7 leaf maize leaf. There is a similar tendency for the increase of chlorophyll 'a' from the control variant to the variant with imported 12 g of biochar per kilogram of soil. Chlorophyll 'a' ranges from 0.39 to 1.35 mg / g fresh weight. The highest values of both soil types for both fertilization variants were reported for the variants with imported 12 g biochar per kilogram of soil. Chlorophyll " b " ranges from 0.19 to 0.65 mg / g fresh weight. The ratio of Ch "a" to Ch "b" is 2 (3): 1, which is within normal range.

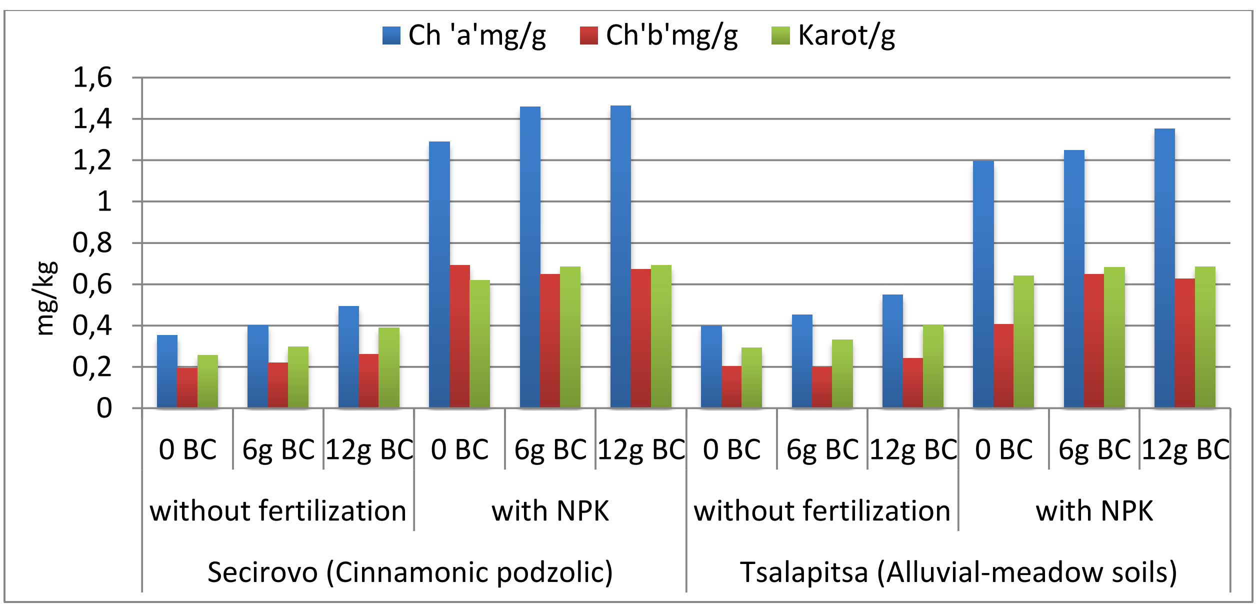

Figure 1. Content of plastid pigments in pot experiment with maize phase 6-7 leaf

In accordance with the lower N content in the variant BV in the soil test from Tsalapitsa compared to the soil in Sekirovo village, a lower content of plastid pigments was obtained probably the nitrogen content in these soils did not ensure the optimal regime of a nitrogen diet that stains with chlorophyll. In both soil types, the content of plastid pigments increases with the fertilizer rate.
The molecules of sugar produced in the process of photosynthesis are an essential building block for everything we see growing above and below ground in the form of leaves, stems, tree trunks, branches, fruits, bulbs, grain, roots and even algae.

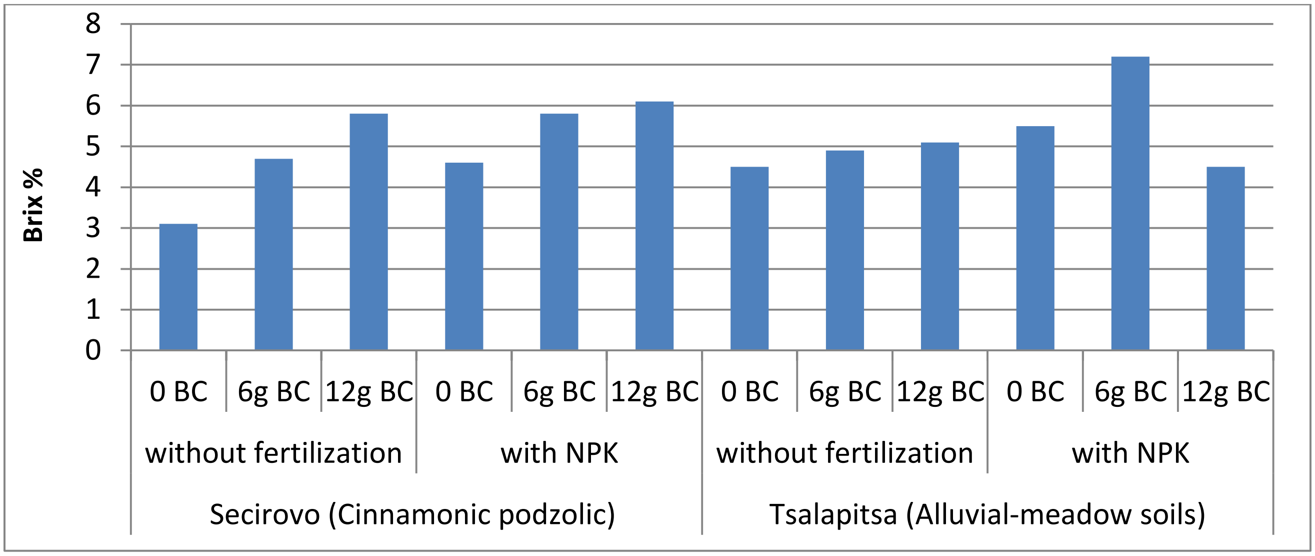

Figure 2. Total sugar content in maize 6-7 leaves.

The reported total sugars content of the two soil types ranges between 3.15 and 7.15 Brix%. There is an increase in the sugar content of the two soil types with an increase in the BC content in the no fertilizer variants. For NPK variants, the highest values were reported for the 6 g BC + NPK variant.
The yield of fresh biomass from the vegetation experience with maize varies between 12.08 and 48.4.

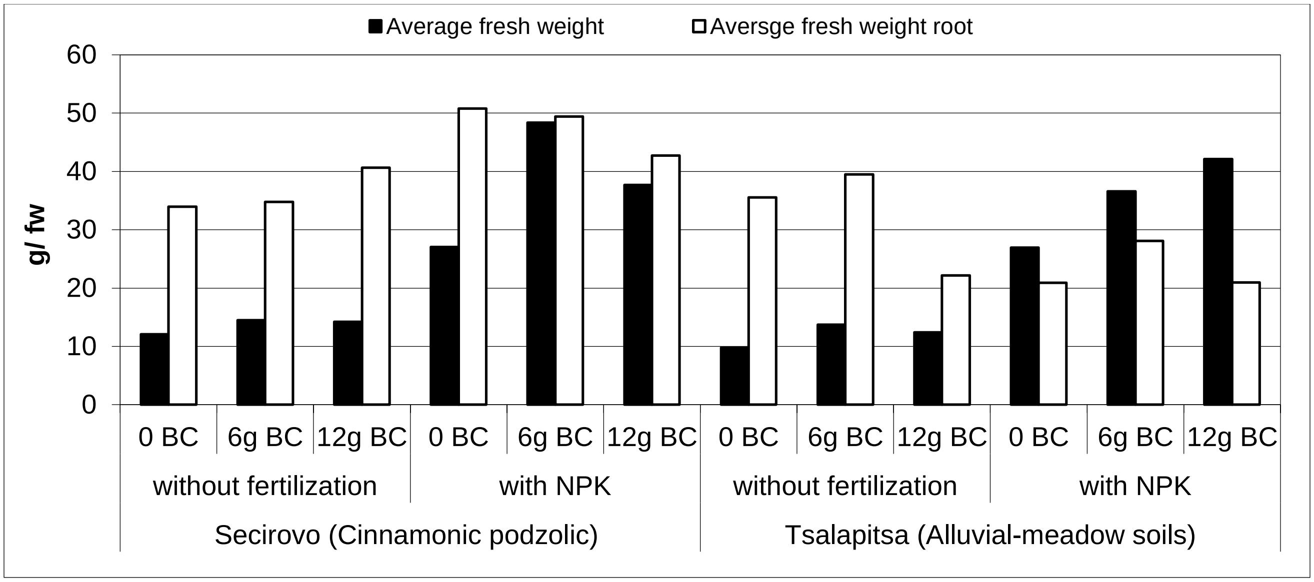

Figure 3. Average weight of the fresh biomass and root of maize grown on two soil types

The obtained fresh biomass in the organic fertilizer variants shows that for both soil types the differences between the control and the two variants with increasing biochar norm are minimal, which once again supports the idea that the selected norm and the step between them is small. The similar result was obtained by Mannan, Md. (2019).
In the variants with mineral fertilization + Biochar in the experiment performed on Sekirovo soil, the highest yield of fresh biomass was reported at 6 g. Biochar + NPK - 48,4 g. Whereas, when tested on soil from Tsalapitsa, which has a lower initial content of nitrogen, the results are regular and the yield increases from the control to the variant with 12 g of biochar + NPK, therefore from 26.9 to 42.13 g.
With the fresh weight of the maize roots on the Cinnamon Podzolic soil, the variants without the addition of NPK show an increase in their mass with an increase in the rate of imported bio-coal. This dependency is the opposite of the NPK variants. On Alluvial Meadow soil, the highest values of root mass were reported in the variants with imported 6 g of biochar.

4. CONCLUSIONS

The introduction of BC increases the humus content slightly in both soils. Mineral fertilizer variants do not show a change in humus content.
An increase in pH is observed upon the introduction of BC.
The introduction of BC in combination with NPK has a positive effect on the crop yield.
In pot trials, chlorophyll and sugar have better values for BC variants.

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