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# The Effect of Biochar, Inoculated Biochar and Compost Biological Component of the Soil

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***Abstract*****—**Biochar can be produced from the waste matter and its application has been associated with returning of carbon in large amounts into the soil. The impacts of this material on physical and chemical properties of soil have been described. The biggest part of the research work is dedicated to the hypothesis of this material's toxic effects on the soil life regarding its effect on the soil biological component. At present, it has been worked on methods which could eliminate these undesirable properties of biochar. One of the possibilities is to mix biochar with organic material, such as compost, or focusing on the natural processes acceleration in the soil. In the experiment has been used as the addition of compost as well as the elimination of toxic substances by promoting microbial activity in aerated water environment. Biochar was aerated for 7 days in a container with a volume of 20 l. This way modified biochar had six times higher biomass production and reduce mineral nitrogen leaching. Better results have been achieved by mixing biochar with compost.

***Keywords*****—**Leaching of nitrogen, soil, biochar, compost.

## I. Introduction

TOTAL of over 2 trillion tons of waste are produced every year across the globe [1] From this, 40–85% is composed of organic waste, depending on the standard of living in the given country [2]. Placing this waste on dumps or disposing of it is ineffective and costly. Today, there is a number of methods of not only disposing of organic waste economically, but also of using it to support or renew components of the environment [3], [4]. The methods can be based on the living processes of microorganisms – composting and anaerobic digestion [5] or on physical processes – pyrolysis, drying [6].

Pyrolysis can lead to the creation of biochar, a dark substance similar to charcoal. The major advantage of biochar is the wide range of input raw materials. Biochar can be produced from wooden waste, sewage treatment sludge and depreciated compost [7]-[10]. Many authors confirm that the resulting product promotes the physical and chemical properties of the soil [11]-[15]. On the other hand, pyrolysis is a complex process, where a number of toxic substances can form. These substances can inhibit the function of soil biota and thus negatively affect yield [16]-[21].

Compost is an organic fertiliser rich in nutrients and microorganisms; its application to the soil promotes microbial activity and improves the soil parameters. Its positive effect, however, is short-term only when compared to biochar [22].

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Currently, methods of adjusting the properties of biochar are being developed. The goal is to reduce the amount of toxic substances in the biochar used. This can be done for example by mixing biochar with organic matter rich in nutrients [23]. The present study focuses on the method of activating biochar using native microflora in aerated water environment.

## II. Methods

The experiment was performed in a growth chamber (phytotron) over the course of 90 days. The daily temperature was 23°C, nightly was 20 °C. Humidity in the chamber was 75%.

### A. Experiment Design

Soil was placed in plastic containers with a diameter of 10 cm and height of 12 cm. An ionex disc was placed at the bottom of each of the containers. The containers each held 700 g of soil. Fertiliser was applied to the soil according to Table I. The VK variant was the control variant. For the VC variant, an amount of compost corresponding to 50 kg/ha was added. The VB variant contained biochar in a concentration of 50 t/ha. VBi also contained biochar; however, this one was inoculated with active microflora ahead of time. VC+B was prepared by mixing compost (50 kg/ha) and biochar (50 t/ha) in a ratio of 1:1. The VC+Bi variant was prepared in the same way, only with inoculated biochar.

Fig. 1 Variants of experiment

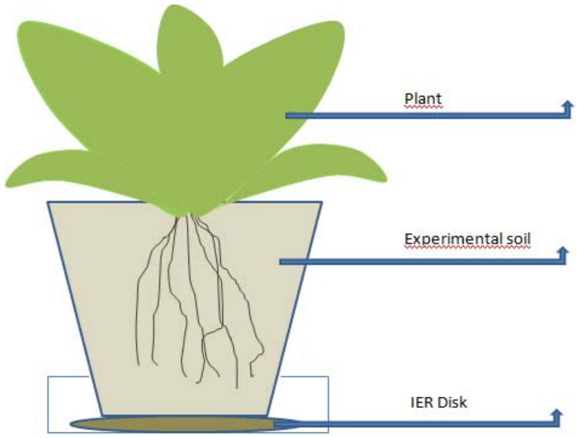


Fig. 2 Scheme of flowerpots

TABLE I
CHARACTERIZATION OF VARIANTS

| Variants | Fertiliser | Repetition |
|---|---|---|
| C | Compost (50kg/ha) | 4 |
| B | Biochar (50t/ha), magnetic induction | 4 |
| Bi | Activated biochar (50t/ha) | 4 |
| K | Control | 4 |
| C+Bi | Compost (50kg/ha) + Activated Biochar (50t/ha) 1:1 | 4 |
| C+B | Compost (50kg/ha) Biochar (50t/ha) 1:1 | 4 |

### B. Biochar Inoculation

The biochar was inoculated over the course of 7 days in water. The inoculation was performed using the native soil population in the area of Březová nad Svitavou. The site is located in a 2nd degree protective zone of water resources. 300 g of native soil was inoculated with 1 kg of biochar. The biochar was placed into fabric and immersed in a 20 l vessel with water. The vessel was continuously aerated. The inoculated biochar was left in laboratory conditions for 24 hours and was then used to set up the experiment.

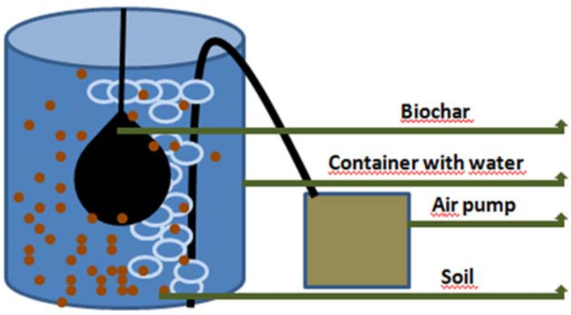


Fig. 3 Scheme biochar inoculated

### C. Experimental Soil

The experimental soil was collected in the Julin area in the Chinese province X. The experiment involved taking disturbed soil samples from the surface (0 – 25 cm depth) in accordance with ČSN ISO 10 381-6 (ČSN – Czech Technical Standard). Soil samples were sieved through a 2-mm mesh sieve.

### D. Production of Aboveground and Underground Biomass

After the experiment was completed, the aboveground and underground biomass was removed and dried over the course of 24 hours at a temperature of 105°C.

### E. Leaching of Mineral Nitrogen

Leaching of nitrate and ammonium nitrogen was measured using ionex discs. One ionex disc was placed at the bottom of each experimental container; after the experiment was completed, the discs were removed, dried and measured using a distillation titration method according to [24].

Fig. 4 IER disk

## III. Results

### A. Aboveground Biomass

One of the indicators chosen to measure the effect of fertilisers was the production of aboveground biomass. The highest aboveground biomass production was detected in variant VC, which contained a dose of compost. Variant VC+Bi showed the second highest biomass increase. On the other hand, the lowest values were achieved by variant VB, which contained only biochar. The biomass production in the container fertilised by inoculated biochar exceeded the production in the container with conventional biochar more than sixfold.

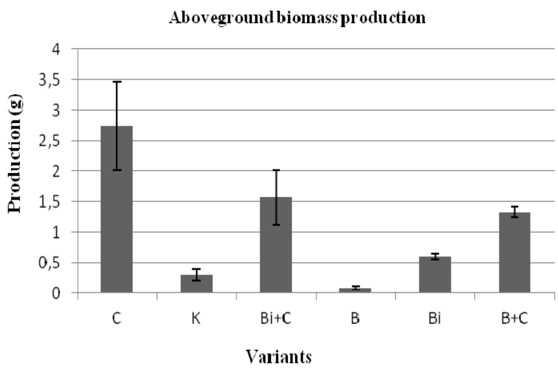


Fig. 5 Aboveground biomass

According to the results, compost is the most suitable substrate for plants, as its addition represents a rich source of organic substance and microflora. Mixing compost with inoculated biochar may reduce biomass production, but the graph shows that this substrate is more suitable than the one mixing compost and conventional biochar. Attention should also be paid to the comparison of the production in the control variant with the variants with conventional and inoculated biochar. In the case of inoculated biochar, the production exceeded the control variant. Inoculating biochar can thus eliminate the toxic properties of biochar and increase biomass production.

### B. Underground Biomass

In the case of underground biomass, the situation is very similar. The highest values were achieved by the variant with compost (VC). The lowest production of underground biomass was measured in the conventional biochar variant.

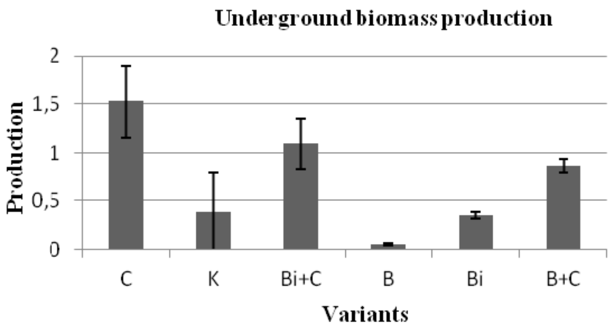


Fig. 6 Underground biomass

### C. Leaching of Mineral Nitrogen

The greatest amount of leaching of mineral nitrogen occurred in the control variant. No statistically significant differences between the variants were detected. The only exceptions were containers to which inoculated biochar was applied, where there was almost no leaching. Extensive leaching occurred also in variants containing compost, despite the large increase in biomass. Low leaching in the variant with inoculated biomass can be explained as an effect caused by the removal of substances inhibiting the activities of soil biota.

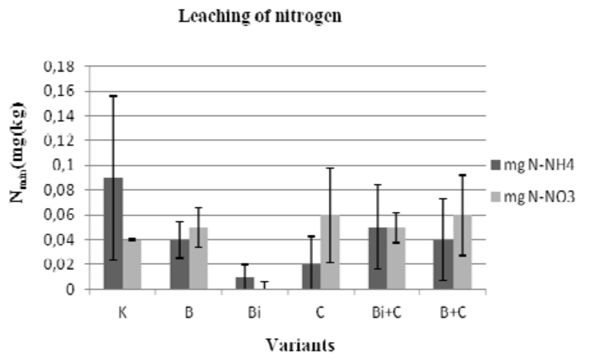


Fig. 7 Leaching of mineral nitrogen

## IV. Conclusion

According to our results, the aboveground biomass production as well as the reduction in the leaching of mineral nitrogen from the soil was stimulated more by activated biochar than by the conventional one. Activated biochar exceeded conventional biochar in both production of aboveground biomass and the ability to prevent mineral nitrogen leaching from the soil.

Biochar is a material which has large active surface when compared to other fertilisers such as compost [25]. Authors state [16]-[21] that the larger reactive surface leads to more effective binding of nutrients, which results in a reduction in nitrogen leaching. At the same time, however, biochar also contains substances that alter the biotic processes in the soil, so that the land is not able to bind nitrogen in the appropriate amount [26]. Aeration in the water environment lead to partial elimination of the toxicity of the material, yet allowed the biochar to maintain its large active surface, which may be the cause for the decrease in mineral nitrogen leaching. Similar to [27], we observed a reduction in the toxic properties of biochar after mixing with compost.

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