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Wood Biochar as an Amendment for Enhanced Growth of *Phacelia tanacetifolia*

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Abstract. The paper presents the results of evaluating the effect of different concentrations (2.5, 5.0, 7.5, and 10.0%) of biochar from birch wood on the growth parameters of *Phacelia tanacetifolia* Benth. in model pots. The addition of biochar to the soil in most cases had a positive effect on growth parameters (root and shoot length and biomass, leaf area) of *P. tanacetifolia*. The best results were observed when biochar was added in concentrations of 7.5% whereas least effect – at 2.5%.

INTRODUCTION

Change in climate and deterioration in physico-chemical characteristics of soil cause severe loss in vegetation which is of prime concern for today's world. Addition of chemical fertilizers showed good response in improving plant growth however they remain persistent in the soil for long time and cause environmental problems [1, 2]. Biochar (BC) is carbonaceous material produced by pyrolysis of carbon-enrich materials in the absence of oxygen [3, 4]. BC showed good results in carbon sequestration, improvement in physical properties and microbiological activity of soil and meager improvement in chemical characteristics [5–9]. Moreover, BC produced from waste biomass is very useful with many environmental and agricultural benefits, including waste reduction, energy production, water resource protection [4, 10–13]. Thus, BC acts as an alternative to many other amendments, which create secondary contamination and could help in sustainable agricultural practices.

Phacelia tanacetifolia L. is a very important annual plant from Hydrophyllaceae family. It grows up to 120 cm in height with an extensive root system and capable to tolerate winter stress. This plant species has a very colorful purple flower, which attract bees and insects, and promotes cross-pollination. Moreover, they also bind the soil and help to retain or improve the phosphorous content in soil.

Present study was aimed to understand the effect of different concentrations (2.5, 5.0, 7.5, and 10.0%) of wood biochar on the biometric growth parameters (length and biomass of root and shoot as well as leaf area) of *P. tanacetifolia*.

MATERIALS AND METHODS

The experiments were carried out using a biochar made by a domestic manufacturer (OOO "DianAgro", Novosibirsk, Russia) from birch wood. Homogenization of BC was done using mortar-pestle and then it was analyzed

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for physico-chemical parameters. The pH and electric conductivity (EC) of BC were determined using a pH meter/conductometer ("Hanna Instruments", Germany). A sterile soil substrate based on peat garden soil was added to pots (a volume of 400 mL) with the addition of BC in concentrations of 2.5, 5.0, 7.5, and 10.0% (by volume). The control was the substrate without the addition of BC (Table 1).

TABLE 1. Treatments showing amendments and rates.

Treatment	Composition
C (control)	Garden soil (100%)
T1	Garden soil 97.5% + Biochar 2.5%
T2	Garden soil 95.0% + Biochar 5.0%
T3	Garden soil 92.5% + Biochar 7.5%
T4	Garden soil 90.0% + Biochar 10.0%

The seeds of *P. tanacetifolia* similar in size and shape were selected to conduct the experiment. Seeds were cleaned by multiple washing using sterile double distilled Millipore water (Millipore, USA). For providing good aeration, the bottom 2 cm of the pots was filled with clay stones. In each pot 15 seeds were sown and allowed to face a day-night regime of 14:10 h, watered on every alternate day with distilled water. The growth of shoot was recorded twice at mid of the plant growth experiment and at 56th day. At harvest, plants were removed carefully, washed in running tap water and separated into root and shoot. The biometric growth parameters i.e. number of leaves, root and shoot length as well as fresh and dry biomass were measured. To determine the area of leaves in dynamics, they were photographed next to graph paper using a Panasonic Lumix DMC-TZ20 camera. The resulting leaf photographs were processed using JMicroVision 1.2.7 program.

The data on Fig. 2 and 3 are presented as the Mean ± standard error (SE) from six replicates. Significance of differences between treatments was determined with one-way ANOVA followed by Tukey's test at $p < 0.05$.

RESULTS AND DISCUSSION

The pH of the BC used for conducting the experiment was 7.3 whereas the EC was 271. BC was found low in nutrient content however its high water holding capacity (>210%) helps to hold the water for longer duration. Presence of high internal surface area not only improves the physical characteristics of the substrate but also helps in absorption/adsorption of nutrients and minerals from the soil [6, 14, 15]. The moisture content after cooking was <4%. The carbon, hydrogen and oxygen contents were 84.0%, 4.3% and 8.1%, respectively. The C/H and C/O ratios were 19.5 and 10.4, respectively.

The pot-scale experiment was conducted by using wood biochar as an amendment to see its effect on the growth of *P. tanacetifolia*. Results of study showed that the application of BC improved the growth of *P. tanacetifolia* plant (Fig. 1).

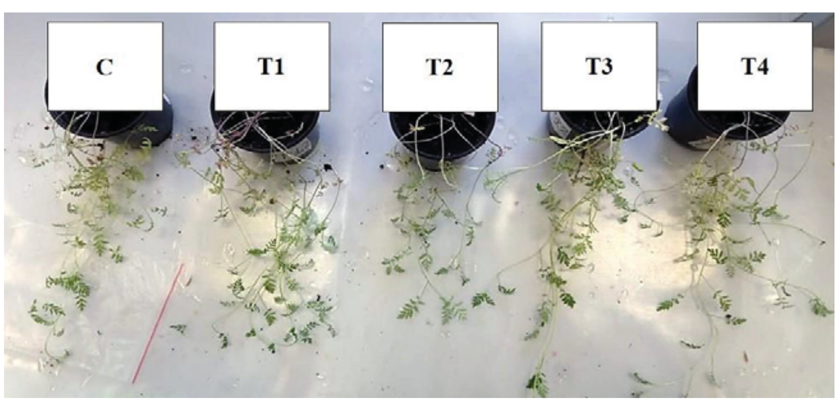


FIGURE 1. The shoots of *P. tanacetifolia* after 56 days of growing in pots under various biochar treatments

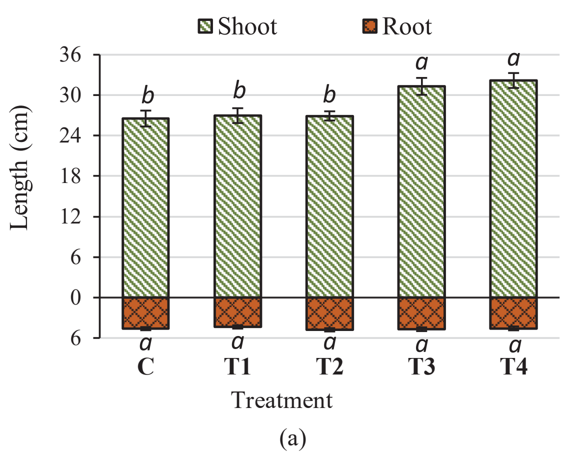
The addition of BC to the soil accelerated seed germination as compared to the control. This was especially pronounced at a BC concentration of 10.0%.

The maximum shoot length was found in 7.5% and 10.0% BC treatments where *P. tanacetifolia* showed shoot length above 30 cm. At the same time, no significant differences were observed between the different BC concentrations based treatments in root length (Fig. 2a). Thus the result suggests that application of higher percentage of BC had majorly affected the *P. tanacetifolia* shoot length whereas, minor or no effect was observed for increase in length of its primary roots.

The number of leaves per plant was found in the order of 10.0% BC > 7.5% BC > 5.0% BC > Control > 2.5% BC and was non-significantly different. However, the leaf area at BC ≥ 5.0% was 1.3 times higher than in the control. The plants in the 7.5% BC treatment had the largest leaf area (Fig. 2b). Similar results were also observed at 27th day of plant growth experiment.

It was also observed that application of higher percentage of BC up to 7.5% increased the growth parameters concentration and further increase in its concentration doesn't make any significant effect on its growth parameters (Fig. 2a, b). The overall fresh biomass of roots and shoots was significantly higher in 7.5% BC-treatment followed by 10.0% BC > 5.0% BC > Control > 2.5% BC (Fig. 3a). The fresh biomass of *P. tanacetifolia* shoots in the 7.5% and 10.0% BC treatments was 1.3 times higher compared to the control. A similar trend was noted for dry biomass of shoots, while the variations in root biomass differed to a lesser extent (Fig. 3b). Some authors [4, 14–16] also noted an increase in the cultivated plants biomass after BC application. Moreover, Jones et al. [17] reported that at higher percentage of BC application the growth of the sunflower plant increased.

The results suggest that BC application improved the physical and chemical properties and helped plants in its biometric growth parameters by retaining higher water content and nutrients from the soil. In general, it was shown that an increase in the concentration of BC from 2.5% to 7.5% increased the growth parameters of *P. tanacetifolia*, and beyond this, they did not change significantly. Probably, the use of BC in a concentration of ≥5% improved the physicochemical properties of the soil and promoted plant growth, providing a favorable water-air and nutrient regime [7, 12, 15].



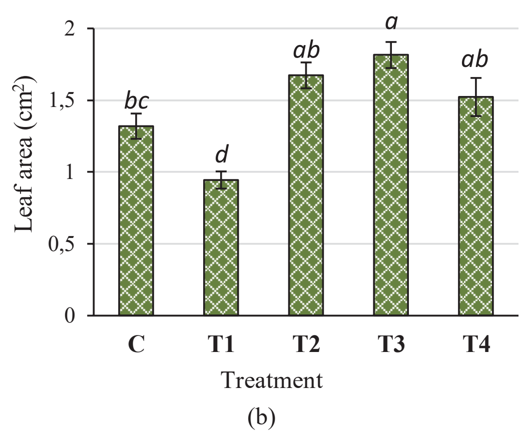


FIGURE 2. Length of shoot and root (a), and leaf area (b) of *P. tanacetifolia* after 56 days of growing under various biochar treatments. Data presented Mean ± SE. Different alphabetical letters indicate significant differences at $p < 0.05$

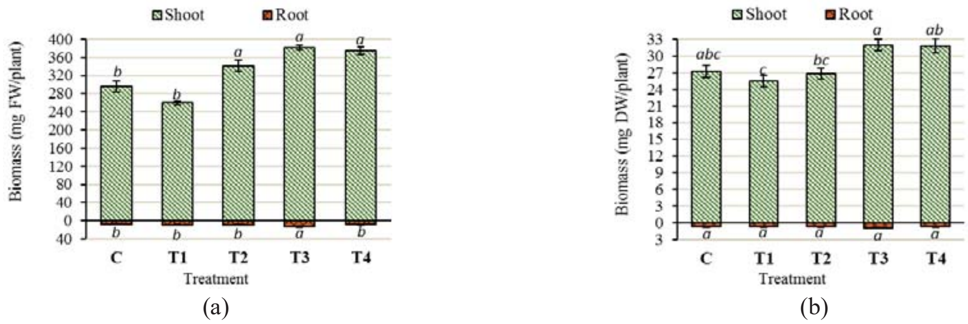


FIGURE 3. Fresh (a) and dry (b) biomass of shoot and root of *P. tanacetifolia* after 56 days of growing under various biochar treatments. Data presented Mean ± SE. Different alphabetical letters indicate significant differences at $p < 0.05$

CONCLUSION

The addition of biochar to the soil in most cases had a positive effect on growth parameters (root and shoot length and biomass, as well as leaf area) of *P. tanacetifolia*. The best results were observed when biochar was added in concentrations of 7.5% whereas least effect – at 2.5%. Further research is required to better understand the mechanisms of action of biochar on the physiological and biochemical parameters of plants.

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