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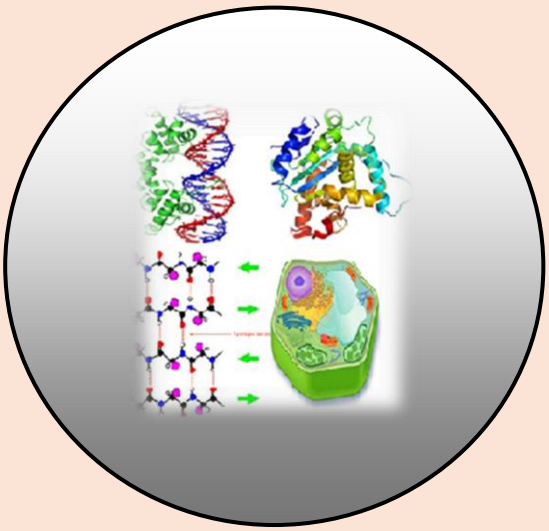

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Biochar Improve Plant Growth and Development of Soybean under Arid Soil Condition

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ABSTRACT

A positive effect of biochar was reported in many studies. In this study, pot experiments in glasshouse were carried out to understand the effect of biochar amendment on the soybean growth, and development. The results indicate that, plant dry biomass of soybean grown in soil amended with biochar, were increased significantly compared to the control plants. We have also observed a changes in nodule number in root system of soybean grown in biochar applied soil. Nodule number increased significantly in soil amended with biochar produced from chickpea manure, household waste in both 0.5 and 1% concentrations. But no significant differences found under biochar produced from wheat straw. The results showed that biochar produced from chickpea manure and hpousehold waste at 1% stimulated plant height by 20% compared to plant inoculated with B. japonicum. Taken together, these findings provide new insights into the potential of microbial inoculant induced by biochar for the improvement of soybean production.
Keywords: Soybean, Plant Biomass, Plant Height, Biochar, Chicken Manure and Wheat Straw.

INTRODUCTION

Biochar can be obtained from any organic matter, including waste, through various pyrolysis processes (Lehmann et al., 2011). It is based on the fact that pyrolysis with the addition of several raw materials in the production of biochar is more effective than biochar obtained from the pyrolysis of one raw material, in which ash is reduced, and the adsorption property of biochar for pollutants increases (Ahmed and Hameed 2020). Biochar showed several positive effect on soil and plant health, such as enhanced soil organic matter content (Chan et al., 2007), soil enzyme activity (Ma et al. 2019), soil cation exchange and water holding capacity (Yu et al., 2013), microbial diversity (Egamberdieva et al. 2016, 2020), and plant nutrient acquisition (Cao et al., 2017).

The production of biochar depends on the temperature index, composition of raw materials, pyrolysis time, duration and other parameters, which also affect the composition of biochar. The use of biochar in agriculture provides benefits for soil productivity. The biochar provide plants with nutrients directly or indirectly by improving soil properties, resulting in increased plant nutrient utilization efficiency (Frenkel et al. 2017). There were many reports on the beneficial effect of biochar application on plant growth, soil fertility, plant protection and plant stress tolerance (Postma and Nijhuis 2019). The biochar application are considered as environmental friendly approach and allows lower inputs through reduced agrochemicals and pesticides that cause potential risks to ecosystem (Wang et al. 2020).

The plant beneficial effect of biochar, and rhizobia on plant growth and soil fertility has been well documented (Mia et al., 2014). These application methods are considered environmentally friendly and allow lower inputs through reduced agrochemicals that cause potential risks to the ecosystem (Wang et al., 2020). Several studies reported plant growth development by organic fertilizers, e.g., the plant growth of chickpea, and lupin (Egamberdieva et al., 2020) was increased by biochar application. However, a synergistic effect of biochar combined with plant beneficial bacteria in plant growth stimulation has been described in a few reports. Zafar-ul-Hye (2020) observed an improved plant growth of spinach by *Bacillus amyloliquefaciens* combined with biochar produced from compost. The biochar produced from wood combined with *Paenibacillus polymyxa* improved switchgrass growth and development (Shanta et al., 2016).

In this study, we aim to evaluate the combined effect of three type of biochar produced from chicken manure, wheat straw and household waste with *Bradyrhizobium japonicum* on plant growth of soybean, under arid soil condition. The outcome of the research work will facilitate the development of strategies to enhance biochar effectiveness for soybean.

MATERIALS AND METHODS

Soil, Plant, Bacteria and Biochar

The serozem soils from Tashkent province were collected for pot experiments. The biochar was produced from chicken manure (CB, wheat straw (WB), and household waste (HB) by heating at 400^{o}C for 40 min. The soybean seeds were obtained from Tashkent State University of Agriculture. *Bradyrhizobium japonicum* was obtained from National University of Uzbekistan.

Plant Growth Experiment

The biochar were used as a soil amendment at 0.5 and 1 % concentrations. A sterilised soybean seeds (10% v/v NaOCl and 70% ethanol) were germinated in petri plates in a dark room at 25°C for 2 days. The treatments were as follow: a) plants inoculated with *B. japonicum* and grown in soil without biochar; c) plants inoculated with with *B. japonicum* and grown in soil amended with biochar. Four pots were arranged in a randomized complete block design and plants were grown in greenhouse at a temperature of 24°C/16°C (day/night). After 30 days, dry biomass of root and shoot of plants were determined.

Statistical Analysis

The obtained data were analyzed for statistical significance using the analysis of variance package (Microsoft Excel 2007). Mean comparisons were conducted using a least significant difference (LSD) test (P=0.05).

RESULTS AND DISCUSSIONS

The present study demonstrated that biochar has an important effect on the plant microbe interactions, and plant growth. The effect of biochar combined with *B. japonicum* on root and shoot dry weight of soybean were investigated. The results indicate that, Nodule number, dry weight of root and shoot of soybean grown in soil amended with biochar, and biochar combined with *B. japonicum* were increased significantly compared to the control plants. Nodule number increased significantly in soil amended with biochar produced from chickpea manure, household waste in both 0.5 and 1% concentrations. But no significant differences found under biochar produced from wheat straw (Figure 1).

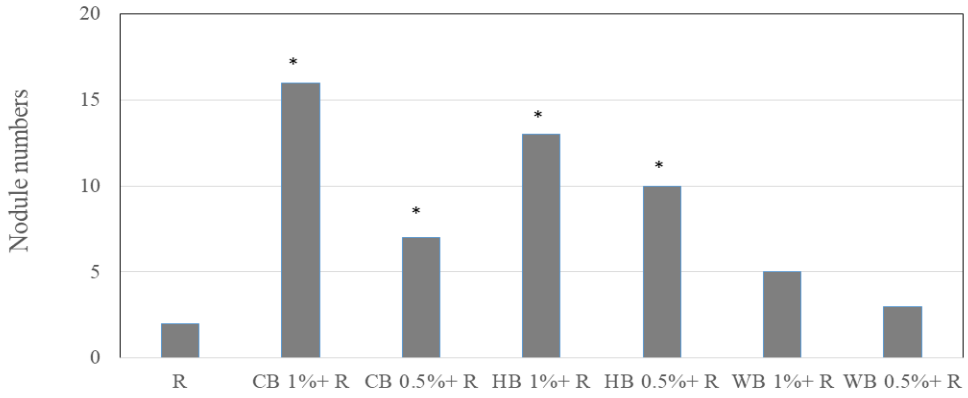

Figure 1. The nodule numbers of soybean grown in soil amended with biochar produced from chicken manure, wheat straw and household waste.

Several studies explained this positive effect as facilitation of favorable condition for bacterial proliferation, protection from abiotic stresses, and availability of nutrients by biochar (Iijima et al., 2015, Pietikainen et al., 2000). The improvement of plant microbe interactions under biochar application was reported in several studies (Egamberdieva et al., 2020a; Wang et al., 2018). Shoot dry weights were 12 and 24%, higher in plants grown in soil amended with biochar produced from chicken manure and household waste at 1% combined with *B. japonicum* compared control plants (Figure 2). Other treatments did not show any increase in shoot growth.

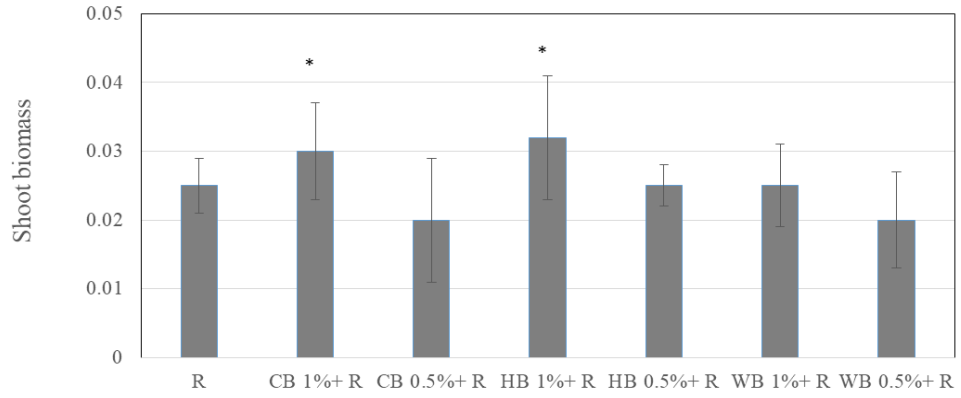

Figure 2. The shoot dry weight of soybean grown in soil amended with biochar produced from chicken manure, wheat straw and household waste.

The shoot height of soybean was also increased by biochar application. The results showed that biochar produced from chickpea manure and hpousehold waste at 1% stimulated plant height by 20% compared to plant inoculated with *B. japonicum* (Figure 3). This finding indicate that biochar improve potential effect of plant beneficial bacteria on plant growth, through possible stimulation of root system (Egamberdieva et al. 2020).

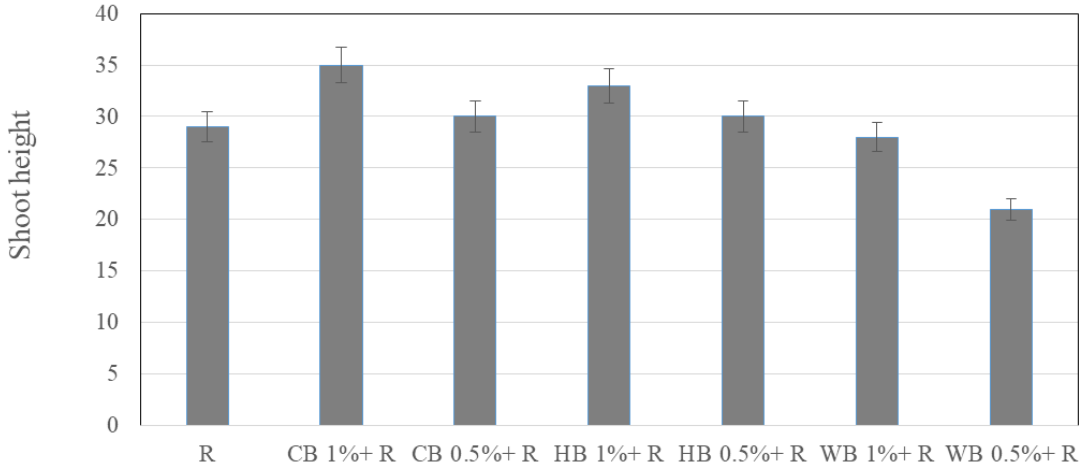

Figure 3. The shoot height of soybean grown in soil amended with biochar produced from chicken manure, wheat straw and household waste.

The positive effect of biochar on plant growth was explained by the increased availability of essential nutrients for plant growth and development (Amini et al. 2016). Biochar is rich in organic carbon and minerals and supplies additional nutrients to the soil available for plant acquisition, improving plant nutritional status and plant development (Qayyum et al. 2012). The improvement of soybean growth by combined application of biochar with rhizobia inoculants under arid soil conditions suggests that biochar plays an important role for rhizobial efficiency. In general, biochar addition in soil combined with bacterial inoculation showed a more profound effect on soybean growth. Taken together, these findings provide new insights into the potential of microbial inoculant induced by biochar for the improvement of soybean production.

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