Effects of wood biochar addition on growth of cherry radish
(*Raphanus sativus L. var. radculus pers*)

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Abstract. Extensive cultivation and unreasonable management of the farmland result in severe soil degradation such as compaction, acidification, and salinization. Our results showed that the biochar amendment increased the cherry radish germination rate, while barely influenced the fresh biomass of shoot and root. Moreover, both 1.5% and 3% biochar addition showed no significant difference in the fruit shape index of cherry radish compared to the control treatment. These results suggested that the biochar application alone could not improve the cherry radish growth in this tested soil. Thus, application of biochar combined with fertilizer or composted with organic wastes should be taken into account for this soil.

1. Introduction

Soils have being suffered many degradation problems (e.g., soil compaction, acidification, and salinization) due to excessive development and inappropriate management [1]. Massah and Azadegan indicated that use of fertilizers more than the recommended amounts causes formation, accumulation and concentration of mineral salts of fertilizers which leads to compaction layer and soil degradation [2]. Biochar, a stable carbon-rich material obtained from charring biomass under relatively low temperature (< 700 ºC) and limiting oxygen or anaerobic completely, has been widely used in soil improvement and pollution control [3]. Numerous studies have shown that biochars commonly contain abundant mineral elements (e.g., K, Ca, and Mg) indicated their application to croplands for increasing crop yield and soil fertility [4]. However, Gul and Whalen suggested that N and P biochemical cycling in biochar-amended soils are strongly affected by the interactions of soil and biochar [5]. Spokas et al. also reviewed that the results about crop growth in biochar-amended soils in recent years, 50% of which promoted crop growth, 20% inhibited the growth of crops, while 30% had no significant effect on the growth of crops [6]. Thus, pot experiments were carried out to investigate the effects of biochar input on the growth of cherry radish, which will provide some useful information for improvement and proper utilization of the degraded farmland soil.

2. Materials and Methods

2.1 The preparation of samples

The tested soil was collected from 0-20 cm of topsoil in Qingdao, Shandong province, China then air-dried and passed through a 2 mm sieve. Cherry radish (*Raphanus sativus L. var. radculus pers*) was
chosen as the tested plant. Biochar was prepared from forest branch at 450 °C for 4 h and was ground to pass 2 mm sieve for further application.

2.2 Pot experiment

The pot experiment was conducted at a greenhouse (a day time temperature no more than 30°C and not less than 15°C and a lighting cycle of 8/16 h (light/dark)) with three treatments: no amendment (0%), 1.5% and 3% (w/w) biochar application, hereafter referred to as CK, 1.5%BC, and 3%BC, respectively. Each treatment was set up in quadruplicate. The soil sample (3 kg) was placed into a plastic pot (15 cm diameter and 20 cm height), watered and maintained 60-70% of maximum water holding capacity. The pots were pre-incubated for two weeks, then 5 cherry radish seeds were planted in soil randomly. After seeding, we count the germination rate and two plants were reserved finally. After 45 days, the shoot and root of cherry radish were harvested separately, then weighed and count. The fruit shape indexes (length, width, and height) of cherry radish were also measured and recorded.

2.3 Statistical analysis

All results in this study were expressed as the mean values. Error bars presented in the results represent the standard deviation. Significant differences between the treatments were analyzed using one-way analysis of variance (ANOVA) with Duncan’s multiple range test ($P = 0.05$) using SPSS 20.0.

3. Results and Discussion

3.1 The effects of biochar on cherry radish germination

As shown in Figure 1, biochar addition improved the germination rate of cherry radish compared with that of CK. Solaiman et al. showed that Oil Mallee- and Old Jarrah-derived biochars generally increased germination of wheat at low application rates (10-50 t ha$^{-1}$), whereas higher application rate of 100 t ha$^{-1}$ had no or adverse effect on the germination rate [7]. Moreover, Novak et al. explained that biochars may contain nutrients (e.g., Ca, K, Mn, and P) that could affect seed germination [8]. Chidumayo et al. also suggested that wood biochar increased soil pH and the content of exchangeable P and K, so seed germination was improved in biochar-amended soils compared with control soil [9]. In our study, the possible explain for the beneficial germination of cherry radish is that the content of available P in the tested soil was highly increased after the biochar addition from $3.86 \pm 0.78$ mg kg$^{-1}$ to $6.28 \pm 0.59$ mg kg$^{-1}$.

![Figure 1](image.png)

Figure 1. The effects of biochar addition on cherry radish dynamic variation of germination rate.

3.2 The effects of biochar on cherry radish fresh weight

No significant difference was observed in the fresh weight (Figure 2a) and the ratio of root to shoot (Figure 2b) before and after the biochar application. Solaiman et al. reported that the root/shoot ratio decreased at a high rate of biochar application, which is consistent with our results [7]. Moreover, Gul
and Whalen also indicated that poultry litter biochar addition increased soil pH from 4.9 to 8.4 may be ascribe to base cations in biochar, which affected the solubility and uptake of essential plant nutrients [5]. The possible explain for the unchanged growth of cherry radish in our study is that the biochar addition greatly increased the pH of the tested soil, leading to reducing the contents of available mineral elements (e.g., Fe, Zn, B, and Mo) in the biochar amended soils.

![Figure 2. The effects of biochar addition on the fresh biomass of shoots and roots (a) and the ratio of root to shoot (b) of cherry radish. The different lowercase letters represent significant difference between the treatments (P < 0.05).](image)

### 3.3 The effects of biochar on fruit shape of cherry radish

The biochar amendment had no significant effects on the length and width index of cherry radish fruit (Table 1). Similarly, the biochar addition did not alter the values of W/L, W/H and L/H, while application of 1.5%BC increased the fruit shape index slightly. However, the mechanism for the phenomenon in this pot experiment is still unknown. One possible point is that biochar addition could improve the soil physicochemical properties (e.g., water holding capacity, bulk density, and porosity) [10], which provides a better habitat for the development of cherry radish fruit.

| Treatments | Length(cm) | Width (cm) | Height (cm) | W/L | W/H | L/H |
|------------|------------|------------|-------------|-----|-----|-----|
| CK         | 4.22±0.19a | 3.68±0.12a | 4.72±0.20b  | 0.87±0.03a | 0.89±0.05a | 0.80±0.04a |
| 1.5%BC     | 3.98±0.21a | 3.55±0.18a | 4.02±0.24a  | 0.90±0.02a | 0.97±0.03a | 0.88±0.03a |
| 3%BC       | 4.12±0.15a | 4.12±0.15a | 4.37±0.39ab | 0.85±0.01a | 0.95±0.04a | 0.82±0.02a |

*W/L: Width / Length; W/H: Width / Height; L/H: Length / Height.
*The different lowercase letters represent significant difference between the treatments (n = 8, P < 0.05).

### 4. Conclusions

The results from the pot experiments revealed that the biochar improved the germination while had little influence on the growth of cherry radish. Moreover, the cherry radish fruit shape index were promoted slightly by the 1.5% biochar application, although it wasn't statistically significant (P > 0.05). Our results indicated that the biochar application alone did not improve the cherry radish growth
in the tested soil. Thus, the application of biochar combined with fertilizer or composted with organic wastes should be taken into account for this soil.

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