Effects of Biochar on Soil Water-Soluble Sodium, Calcium, Magnesium and Soil Enzyme Activity of Peach Seedlings

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Abstract. The effects of biochar (rape straw, paddy straw, wheat straw and corn straw) on soil water-soluble sodium (Na), calcium (Ca), magnesium (Mn) and soil enzyme activity of peach seedlings was studied by pot experiment. The experimental result indicated that the effect of paddy straw biochar on soil water-soluble Na content was not significant compared with control, but caused a significant increase in the content of soil water-soluble Ca and Mn. Corn straw biochar significantly increased the content of soil water-soluble Na, and the content of soil water-soluble Ca and Mg were little different from that of control. The soil water-soluble Ca content under wheat straw biochar treatments was significant lower than that of other treatments. Soil enzyme activity is a comprehensive index of soil fertility, and all the biochar treatments led to a significant increase in soil urease activity, which significantly decreased the soil invertase and acid phosphatase activities, and the soil catalase activity between biochar treatments and control had no obviously difference. In conclusion, paddy straw biochar and corn straw biochar have a better effect on soil water-soluble mineral elements such as Ca and Mg, and biochar can promote or inhibit soil enzyme activity under planting peach seedlings.

1. Introduction

Due to the characteristics of biochar of physical, chemical, and biological stability, the conversion of straw into biochar and treating soils with successive applications may be feasible choice to improve soil quality and crop yield, soil C storage, maintain the balance of the soil ecosystem and utilize straw resources[1-3]. Some scholars found that biochars increase the content of essential nutrients [4]. Rice-straw biochar improves the availability of soil phosphorus, potassium, calcium, and magnesium, promotes the uptake of nutrients by plants, and then increases the yield of crops [3]. Soil enzymes reflected the soil fertility level, biochar has influence to the soil enzyme activity, and application of biochar significantly improved the soil dehydrogenase and urease activity, but inhibited the activity of soil catalase and neutral phosphatase [5]. After adding biochar to the soil, the lower the soil fertility, the higher increase of soil enzyme activity, with high mineral ash biochars performing better than low mineral ash biochars derived from plant material [2, 6].

In this study, by applying different carbons (rape straw, paddy straw, wheat straw and corn straw) to the soil, studied the effects of different carbon on the soil of essential nutrients, such as soil watersoluble sodium (Na), calcium (Ca) and magnesium (Mn), as well as the activities of urease, invertase, acid phosphatase and catalase.
2. Materials and methods

2.1. Materials
Peach seeds were purchased from a market in Chengdu, Sichuan, China. The straws were collected in farmland around Sichuan Agricultural University (30°42′N, 103°51′E). The rape straw, paddy straw, wheat straw and corn straw was dried, cut and placed in a muffle furnace, separately, where it is charred at 500 degrees for 2 hours to produce biochar.

2.2. Experimental design
Experiment was carried out in the greenhouse of Chengdu campus of Sichuan Agricultural University from April to July 2019. In April 2019, sowing and raising seedlings of peach. The soil was air-dried through a 5mm sieve and each plastic pot (15cm high and 18cm in diameter) was filled with 3 kg soil. And rape straw, paddy straw, wheat straw and corn straw was added respectively to prepared plastic pots, and the soil and biochar were mixed sufficiently, with a ratio of biochar to soil of 10 g/kg. All pots are watered daily to keep the soil moist. In April 2019, three seedlings which germinated robustly in good trim, about 10 cm high (with about seven true leaves) were transplanted into the previously prepared plastic pots. The soil moisture content was maintained at 80% of field capacity. The experimental treatments included biochar treatment of rape straw, biochar treatment of paddy straw, biochar treatment of wheat straw, biochar treatment of corn straw and control. Each treatment was repeated three times. After a month, harvest the plants and collect soil samples, respectively. The contents of water-soluble Na, Ca and Mg in soil were determined as described by Hao et al. [7]. The soil enzyme activity (urease, invertase, acid phosphatase and catalase) were determined as described by Jin et al. [8].

2.3. Statistical analysis
Excel 2010 and DPS17.10 were used to analyze the data, data analysis by one-way ANOVA with least significant difference at 5% confidence level.

3. Results and discussion

3.1. The content of soil water-soluble Na, Ca and Mg
Rape straw biochar and corn straw biochar significantly increased the soil water-soluble Na content compared with control, and which between paddy straw biochar, wheat straw biochar and control had no significant difference. The water-soluble calcium content was elevated significantly in the soils treated with paddy straw biochar, apparently decreased under rape straw biochar and wheat straw biochar treatments, and there were no significant difference between corn straw biochar treatment and control. With the addition of paddy straw biochar, the content of water-soluble Mg content in soil increased significantly, and there was no significant difference between other biochar treatments and control.

Table 1. The content of soil water-soluble Na, Ca and Mg.

| Treatments       | Soil water-soluble Na (mg/kg) | Soil water-soluble Ca (mg/kg) | Soil water-soluble Mg (mg/kg) |
|------------------|-------------------------------|-------------------------------|-------------------------------|
| Control          | 11.67±1.461c                  | 149.6±6.734b                 | 12.98±1.161bc                |
| Rape straw biochar | 22.92±0.797a                 | 110.0±7.862c                 | 16.16±1.755b                 |
| Paddy straw biochar | 13.66±0.577c                | 175.3±5.554a                 | 21.51±1.354a                 |
| Wheat straw biochar | 13.55±0.850c                | 76.43±1.134d                 | 12.37±0.683c                 |
| Corn straw biochar | 18.45±1.794b                | 148.7±3.590b                 | 16.12±1.114b                 |

Note: The data were mean ± standard deviation. Lowercase letters of the two groups were completely different; the difference between the two groups was significant (p < 0.05).

3.2. The enzyme activity in soil
All the biochar treatments had a significant effect on the soil urease activity comparing with control, and according to the level of soil urease activity, the biochar treatments were arranged in order: paddy straw biochar > wheat straw biochar > rape straw biochar > corn straw biochar > control. Rape straw biochar, paddy straw biochar, wheat straw biochar and corn straw biochar significantly decreased soil invertase by 41.8%, 42.2%, 15.6% and 25.0% respectively, and significantly decreased soil acid phosphatase by 34.0%, 31.5%, 29.0% and 21.6%, respectively, compared with control. The effect of different biochar treatments on catalase activity in soil was not significant.

### Table 2. The enzyme activity in soil.

| Treatments             | Soil urease activity (mg/g) | Soil invertase activity (mg/g) | soil acid phosphatase (mg/g) | Soil catalase activity (ml/g) |
|------------------------|----------------------------|--------------------------------|-----------------------------|------------------------------|
| Control                | 0.124±0.004d               | 7.957±0.092a                   | 36.06±0.220a                | 0.413±0.010a                 |
| Rape straw biochar     | 0.146±0.004bc              | 4.628±0.070d                   | 23.81±1.567c                | 0.428±0.011a                 |
| Paddy straw biochar    | 0.160±0.001a               | 4.601±0.006d                   | 24.69±1.288c                | 0.419±0.008a                 |
| Wheat straw biochar    | 0.154±0.004ab              | 6.718±0.190b                   | 25.60±1.620bc               | 0.430±0.009a                 |
| Corn straw biochar     | 0.140±0.002c               | 5.967±0.115c                   | 28.28±1.530b                | 0.417±0.012a                 |

Note: The data were mean ± standard deviation. Lowercase letters of the two groups were completely different; the difference between the two groups was significant (p < 0.05).

### 4. Conclusions

Biochar to soils significantly changed the available soil concentrations of elements, the available concentrations of elements such as Na, Mg and Ca significantly increased in most biochar treatments [3, 9], biochar added impact on plant growth depends largely on the amount of applying biochar content and types, mainly related to its nutrient content [10]. Different kinds of biochar were added in soil, it was found that paddy straw biochar had no significant difference in the content of soil water-soluble Na compared with control, but caused a significant increase in the content of soil water-soluble Ca and Mn. Rape straw biochar and corn straw biochar significantly increased the content of soil water-soluble Na compared with control, however, the content of soil water-soluble Ca and Mg were little different from that of control, except that rape straw biochar apparently decreased the content of soil water-soluble Ca.

Soil enzyme activity is related to soil fertility, which is affected by soil chemical properties and other enzymes [11-12]. In this study, all biochar treatments significantly increased soil urease activity, and significantly decreased the soil invertase and acid phosphatase activity, and the soil catalase activity between biochar treatments and control had no obviously difference. Furthermore, wheat straw biochar treatment strengthen the activity of soil urease significantly higher than rape straw biochar and corn straw biochar, wheat straw biochar and corn straw biochar treatment inhibited soil invertase significantly lower than rape straw biochar and paddy straw biochar, corn straw biochar inhibited soil acid phosphatase significantly lower than rape straw biochar and paddy straw biochar.

In conclusion, paddy straw biochar and corn straw biochar have a better effect on soil water-soluble mineral elements such as Ca and Mg, and the biochar can promote or inhibit soil enzyme activity, wheat straw biochar and corn straw biochar are better than rape straw biochar and paddy straw biochar in general.

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