Effect of Crop Straw Treatments on the Nutrient Uptake of Peach (*Prunus davidiana*) Seedlings

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Keywords: Nutrient Absorption, Peach (*Prunus davidiana*), Straw.

Abstract: The effects of crop straw treatments (rape straw, paddy straw, wheat straw, and corn straw) on the nutrient uptake of peach [*Prunus davidiana (Carr.) Franch*] seedlings were analyzed by conducting a pot experiment. Analysis showed that the nitrogen content in the roots and stems of peach seedlings decreased with wheat straw addition and that in the roots, stems, and leaves of peach seedlings significantly increased with rape straw addition compared with that of the control. Phosphorus, potassium, and sodium contents in the roots, stems, and leaves of peach seedlings with four different straw treatments were more than that of the control. Paddy straw addition increased the calcium content in roots, stems, and leaves of peach seedlings, while the other treatments reduced the calcium content in roots, stems, and leaves; magnesium content showed an opposite pattern. Based on these findings, rape straw addition is considered the most favourable practice for the nutrient uptake of peach seedlings.

1 INTRODUCTION

Straw is a natural soil conditioner, and straw return-to-field is a commonly used management practice to conserve the water and fertilizer. Straw returned into the soil is decomposed by soil microorganisms under suitable soil moisture and temperature conditions, which can release the nutrients and microelements, such as organic matter, nitrogen (N), phosphorus (P), and potassium (K), improve soil fertility and enhance the absorption and utilization of plant nutrients (Zhu et al., 2010, Gong et al., 2013, van Asten et al., 2005). Studies have shown significant positive effects of straw return-to-field in corn, rice, wheat, and other crops by promoting the growth and enhancing the yield of those crops (Zheng et al., 2014, Yao et al., 2019, Hu et al., 2013, Zhang, Wang, 2013). Straw is also widely used in vegetable cultivation; its addition increases the chlorophyll content and antioxidant capacity of cowpea leaves which resulting the fast growth of cowpea seedlings (Chen et al., 2019). Addition of wheat, corn, or *Jerusalem artichoke* straw promotes the growth of cucumber seedlings (Gong et al., 2015), and application of straw significantly increases sweet pepper yield (Feng, 2010). In this experiment, the effects of addition of different types of straw (wheat, paddy, rape and corn straw) on the nutrient uptake of peach [*Prunus davidiana* (Carr.) Franch were studied. The aim of this study was to select the most suitable straw for the nutrient uptake of peach seedlings.

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2 MATERIALS AND METHODS

2.1 Materials

Peach seeds were collected from a 10-year-old peach tree in Chengdu, Sichuan, China. The seeds were sown in a tray containing a moist substrate [perlite and vermiculite (V: V, 1:1)] and kept in an artificial climate chamber under the following conditions: 14-h day at 25°C, relative humidity 70%, 4000 Lux; and 10-h night at 20°C, relative humidity 90%, 0 Lux (Li et al., 2020). The Hoagland nutrient solution was added to the tray to cultivate seedlings. After 1

Liu, L., Lin, L., Huang, Y., Huang, K. and Wang, T.
Effect of Crop Straw Treatments on the Nutrient Uptake of Peach (Prunus davidiana) Seedlings.
DOI: 10.5220/0011236800003443
In *Proceedings of the 4th International Conference on Biomedical Engineering and Bioinformatics (ICBEB 2022)*, pages 569-573
ISBN: 978-989-758-595-1

month, when the seedlings reached about 10 cm in height, they were transplanted into pots.

2.2 Experimental Design

The experiment was conducted at the Chengdu Campus of Sichuan Agricultural University from April to October 2019. The soil was air-dried and passed through a 5 mm sieve, and each plastic pot (21 cm high, 20 cm in diameter) was filled with 3 kg air-dried soil. Then, the soil in each pot was mixed with the prepared straw of the studied plants completely. Thirty-gram straw were applied to each pot (10 g straw per kg soil), and the soil moisture was maintained at 80% of field capacity for 1 week. The five treatments were used in the experiment: no straw addition (control), addition of rape straw, addition of paddy straw, addition of wheat straw, and addition of corn straw. Each treatment was replicated four times using a completely randomized design with 10 cm spacing between pots. Four uniformly seedlings were transplanted into pots and then cultivated in a greenhouse under the following conditions: 14-h day (4000 Lux) at 25 °C and 70% relative humidity and 10-h night (0 Lux) at 20 °C and 90% relative humidity (Li et al., 2020). All pots were watered daily to keep the soil moisture content at 80% field capacity until the plants were harvested. Once the weed seedlings grew, they were pulled out immediately.

2.3 Measurement of Parameters

After 60 d cultivated, the whole plants were harvested, and divided into three parts (roots, stems, and leaves). These parts were washed with tap water followed by deionized water (3×). These were further dried at 80 ℃ to a constant weight. The plant samples were finely ground and sieved through a 0.149 mm nylon mesh sieve for chemical analysis. Dried plant samples (1.0 g) were digested in 6 mL H_2SO_4/H_2O_2 (5:1, v/v) solution with the electric heating plate at 200 °C until the solution was transparent, and the solution were used to determine the total N content by the Kjeldahl method, total P content by the Mo-Sb anti-colorimetry, total K and Na contents by the flame photometry, and total Ca and Mg contents by the atomic absorption spectrometry according to Bao (Bao 2000). The soil in each pot was air-dried and ground to particles with diameter < 0.25 mm for chemical analysis. The soil alkali-soluble N concentration was determined by alkali diffusion method, the soil available P concentration was determined by the Mo-Sb anti-colorimetry, soil available K and water-soluble Na concentrations were determined by flame photometry, and water-soluble Ca and Mg concentrations in soil were determined by EDTA titration (Bao, 2000).

2.4 Statistical Analysis

Statistical analyses were performed using SPSS 22.0 statistical software. Data were analysed using a one-way analysis of variance with the least significant difference test ($p \leq 0.05$).

3 RESULTS

3.1 Major Nutrients of Peach Seedlings

Compared to the control, N content in stems of peach seedlings with wheat straw addition decreased, while N, P, and K contents in roots, stems, and leaves of peach seedlings with other straw treatments increased or had no significant differences (Table 1). The N content in roots (5.03%), stems (19.63%), and leaves (9.87%), of peach seedlings with rape straw was significantly ($p < 0.05$) more than that of the control. The P contents in roots, stems, and leaves of peach seedlings with paddy straw were significantly ($p < 0.05$) more than that of the control, and P contents were the highest with straw addition, while K contents were rape straw.

Table 1: Major nutrients of peach seedlings.

Treatments	Root (mg g^{-1})	Stem (mg g^{-1})	Leaf (mg g^{-1})
N			
Control	1.59±0.03bc	2.14±0.02c	2.33±0.07c
Rape straw	1.67±0.03a	2.56±0.07a	2.56±0.06a
Paddy straw	1.64±0.05ab	2.25±0.05b	2.55±0.04a
Wheat straw	1.57±0.03c	1.78±0.03d	2.47±0.03b

Corn straw	1.65±0.01ab	2.18±0.04bc	2.50±0.02a
P			
Control	2.82 ±0.03c	2.70±0.04e	3.86±0.03d
Rape straw	2.94±0.07c	2.85±0.05d	4.07±0.08c
Paddy straw	5.06±0.11a	4.47±0.11a	5.32±0.06a
Wheat straw	3.30±0.12b	3.47±0.03c	4.37±0.10b
Corn straw	3.39±0.11b	3.62±0.05b	5.22±0.06a
K			
Control	0.65±0.04c	0.74±0.03d	1.14±0.02e
Rape straw	1.52±0.04a	1.61±0.06a	3.36±0.01a
Paddy straw	1.20±0.03b	1.28±0.04b	2.84±0.03c
Wheat straw	0.69±0.04c	1.20±0.03c	1.95±0.05d
Corn straw	1.46±0.03a	1.57±0.06a	3.10±0.09b

Different lowercase letters within a column indicate significant differences based on one-way analysis of variance and the least significant difference test ($p \leq 0.05$).

3.2 Secondary Macro of Peach Seedlings

The content of Ca in roots (17.34%), stems (9.45%), and leaves (35.87%) of peach seedlings with paddy straw addition increased significantly ($p < 0.05$) compared with that of the control (Table 2). The content of Ca in roots, stems, and leaves of peach seedlings decreased with other straw treatments. On the contrary, Mg content in roots and leaves of peach seedlings with paddy straw was significantly ($p < 0.05$) less than that of the control, and the Mg content in roots, stems and leaves of peach seedlings with other straw treatments was significantly ($p < 0.05$) more. The Mg content in roots, stems, and leaves of peach seedlings with wheat straw was the highest among the four straw treatments. The Na content in roots, stems, and leaves of peach seedlings treated with four different straws increased significantly compared with the control. The Na content in roots, stems, and leaves treated with rape straw increased by 67.16, 71.22, and 126.38% ($p < 0.05$), respectively, compared with the control.

3.3 Soil Available Nutrient Concentration

The addition of wheat straw decreased the concentration of soil alkali-soluble N, and the addition of rape and corn straw increased the soil alkali-soluble N concentration by 35.05 and 3.95% ($p < 0.05$) respectively, in which the concentration of soil alkali-soluble N with rape straw was the highest (Table 3). The concentrations of soil available P, available K, and water-soluble Na increased with all the four straw treatments compared with the control. Only with paddy straw addition, the concentration of water-soluble Ca was significantly ($p < 0.05$) more than that of the control (19.68%); however, with other treatments, the concentration of water-soluble Ca was lower than that of the control. Compared with the control, addition of rape, wheat and corn straw significantly increased the concentration of soil water-soluble Mg, while the addition of paddy straw significantly reduced the concentration of soil water-soluble Mg.

Table 2: Secondary macro of peach seedlings.

Treatments	Root (mg kg^{-1})	Stem (mg kg^{-1})	Leaf (mg kg^{-1})
Ca			
Control	14.76 ±0.34b	18.09±0.38b	18.23 ±0.63b
Rape straw	12.02±0.16d	15.64±0.09d	16.92±0.38b
Paddy straw	17.32±0.10a	19.80±0.70a	24.77±1.00a
Wheat straw	9.04±0.09e	14.74±0.12e	14.40 ±0.58c
Corn straw	13.96±0.27c	16.33±0.27c	17.27±0.90b

Mg			
Control	9.29 ±0.26d	7.15±0.18d	9.38±0.28d
Rape straw	12.49±0.46c	10.22±0.38c	10.81±0.17c
Paddy straw	6.45±0.39e	6.48±0.35d	6.30±0.23e
Wheat straw	19.15±0.17a	17.14±0.72a	13.67±0.38a
Corn straw	13.81±0.87b	11.88±0.21b	12.89±0.52b
Na			
Control	0.201±0.003d	0.139±0.008d	0.163±0.003e
Rape straw	0.336±0.018a	0.238±0.004a	0.369±0.011a
Paddy straw	0.228±0.010c	0.194±0.011c	0.323±0.002c
Wheat straw	0.214±0.009cd	0.147±0.005d	0.246±0.009d
Corn straw	0.258±0.011b	0.219±0.010b	0.344±0.012b

Different lowercase letters within a column indicate significant differences based on one-way analysis of variance and the least significant difference test (*p* ≤ 0.05).

Table 3: Soil available nutrient concentration.

Treatments	Alkali-soluble N (mg kg^{-1})	Available P (mg kg^{-1})	Available K (mg kg^{-1})	Water-soluble Ca (mg kg^{-1})	Water-soluble Mg (mg kg^{-1})	Water-soluble Na (mg kg^{-1})
Control	224.07±2.77bc	22.46±0.87d	18.47±2.47c	92.88±2.66b	8.52±1.01c	10.96±0.42c
Rape straw	302.60±9.83a	24.99±0.96c	70.36±0.52a	84.84±3.20cd	13.20±0.33b	17.27±1.07a
Paddy straw	227.19±3.99bc	32.37±1.13a	49.43±4.44b	111.16±4.70a	7.29±0.11d	11.86±0.52bc
Wheat straw	219.23±4.82c	29.96±1.30b	46.37±4.38b	79.72±1.16d	8.41 ±0.50a	11.49±0.55bc
Corn straw	232.92±5.72b	30.49±0.87ab	48.40±3.54b	89.86±3.13bc	13.59±0.23b	12.43±0.20b

Different lowercase letters within a column indicate significant differences based on one-way analysis of variance and the least significant difference test (p ≤ 0.05).

4 DISCUSSION

This other study shows that the concentrations of organic matter, total N, total P, available N, and available K in the soil increase significantly after straw return (Mu et al., 2012). In this study, the concentrations of soil organic matter, available P, available K, and water-soluble Na with four straw additions were more than those of the control. Moreover, nutrient absorption by peach seedlings was different with different straw treatments. This may be due to coexistence of multiple nutrient elements in the same soil environment, when plants absorb and utilize the nutrient elements, and there is a synergistic and antagonistic effect (Xu et al., 2006). The addition of wheat straw decreased the concentration of soil alkali-soluble N, whereas other treatments increased the concentration, which was similar to the N content of roots and stems of peach seedlings with wheat straw. The P, K, and Na contents in roots, stems, and leaves of peach seedlings in all treatments were consistent with the P, K, and Na concentrations in soil. Studies have confirmed the interaction among N, P, and K, and deficiency in any of these three nutrients will affect the absorption and utilization of the other two nutrients (Zhu et al., 2016). In this study, the N, P, and K contents in peach seedlings with wheat straw addition did not show any interaction. Among the four treatments, rape straw addition resulted in the lowest available P concentration in the soil; however, P content in the roots, stems, and leaves of peach seedlings was the highest, probably because the nutrients in the soil promoted the growth of peach seedlings. N promotes plant photosynthesis and increases plant nutrient accumulation, while its deficiency affects the formation, transport, and accumulation of photosynthetic products (Yang et al., 2017, Pettigrew, 2008). In this study, alkali-soluble N concentration of soil and N content in roots, stems, and leaves of peach seedlings were the highest with rape straw addition, and the photosynthetic pigment content of the peach seedlings with the same treatment was the highest. A previous study in tobacco showed that the Ca content of leaves increased significantly with increase in exchangeable Ca concentration in the soil, and the Mg concentration increased with increase in exchangeable Mg concentration in the soil (Xu et al., 2007). Here, the water-soluble Ca concentration in the soil and the Ca content in roots, stems, and leaves of peach seedlings were comparable. Rape and corn straw addition significantly increased the water-soluble Mg concentration in soil, while paddy and wheat straw addition significantly reduced the water-soluble Mg concentration. However, Mg content in roots, stems, and leaves of peach seedlings decreased significantly only with wheat straw addition. Combined with the previous study, rape straw addition was proven most conducive to the growth of peach seedlings.

ACKNOWLEDGMENTS

This work was financially supported by the Integrated Research and Application of New Varieties and Technologies of Horticultural Crops (2020-YF09-00055-SN).

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