Effect of Crop Straw Treatments on the Growth and Physiology of Peach (*Prunus davidiana*) Seedlings

Kewen Huang[1][a], Ting Wang[1][b], Lei Liu[1][c], Lijin Lin[2][d] and Yan Huang[1][e*]
[1]*Research Institute of Horticulture, Chengdu Academy of Agriculture and Forestry Sciences, Chengdu, Sichuan, China*
[2]*College of Horticulture, Sichuan Agricultural University, Chengdu, Sichuan, China*

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Abstract: The effects of crop straw treatments (rape, paddy, wheat, and corn straw) on the growth and physiology of peach [*Prunus davidiana (Carr.) Franch*] seedlings were studied by experiment. It can be observed that the addition of rape straw markedly enhanced the dry weight and photosynthetic pigment content of peach seedlings, while the addition of other straw had the opposite effect. Soluble protein content increased with the addition of all four straw. The addition of rape straw increased the superoxide dismutase and catalase activities and decreased the peroxidase activity and malondialdehyde content, while the addition of paddy, wheat, and corn straw resulted in an opposite response. Based on these findings, rape straw addition is considered the most favourable practice for the growth of peach seedlings.

1 INTRODUCTION

Straw application in orchard improves soil structure and the soil water, gas and heat regulating ability, accelerates soil material circulation, improves soil nutrient utilization rate, and reduces agriculture input costs. This soil management practice has demonstrated remarkable effect (Oelbermann et al., 2004) and it improves fruit yield and quality (Sommer et al., 2004). Straw application in apple, plum, and pear changes the fertility and structure of soil, reduces the organic fertilizer and chemical manure use, while it increases the single fruit weight and improves the appearance and nutritional qualities of fruits (Zhou et al., 2019, Luo et al., 2019, Yi et al., 2019).

Peach is considered to be the sixth largest fruit in the world and is popular all over the world, especially China's peach production ranks first in the world (Jin et al., 2019). However, there are a few studies about applications the straw in peach. In this experiment, the effects of addition of different types of straw (wheat, paddy, rape and corn straw) on the growth and physiology of peach [*Prunus davidiana* (Carr.) Franch], which is often used for grafted rootstock in production and breeding were investigated. And the purpose of this study was to select the most appropriate straw for the growth of peach seedlings.

[a] https://orcid.org/0000-0002-4977-0853
[b] https://orcid.org/0000-0001-6424-5742
[c] https://orcid.org/0000-0001-5606-0035
[d] https://orcid.org/0000-0002-3650-8557
[e] https://orcid.org/0000-0003-2889-5806

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 seeded in a mixture of perlite and vermiculite and stored in an artificial climate chamber under conditions of 14 hours at 25°C during day, 70% relative humidity, 4000 Lux; and 10 hours with 20°C at night, 90% relative humidity, 0 Lux (Li et al., 2020). The Hoagland nutrient solution was added to the tray to cultivate seedlings. And the seedlings were then transplanted into pots when they were about 10 cm tall.

The old aerial parts (after the harvest mature grains) of rape, paddy, wheat, and corn collected from the farmlands around the Chengdu Campus of Sichuan Agricultural University (30°71' N, 103°87' E) and were dried at 80℃ to constant weight,

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shredded to 1-2cm. The contents of nitrogen, phosphorus, and potassium in rape straw were 2.69, 3.12, and 31.54 mg g^{-1}, respectively; in paddy straw were 0.83, 2.32, and 15.78 mg g^{-1}, respectively; in wheat straw were 0.19, 0.61, and 12.49 mg g^{-1}, respectively; in corn straw were 1.65, 1.25, and 23.52 mg g^{-1}, respectively.

Fluvo-aquic soil collected from the farmlands around the Chengdu Campus of Sichuan Agricultural University. And the properties of the soil were determined according to the method of Bao (2000) as: pH 7.71, total N 1.85 g kg^{-1}, total P 11.88 g kg^{-1}, total K 15.38 g kg^{-1}, alkali-soluble N 87.99 mg kg^{-1}, available P 55.78 mg kg^{-1}, available K 41.96 mg kg^{-1}, water-soluble calcium (Ca) 0.21 mg g^{-1}, water-soluble magnesium (Mg) 0.03 mg g^{-1}, and water-soluble sodium (Na) 0.03 mg g^{-1}.

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. Each pot of soil was then thoroughly mixed with the prepared straw. 1 kg of soil mixed with 10 g of straw, that is, 30 g of straw per pot. Then watered to keep soil moisture at 80% of field capacity and equilibrated for 1 week. The five treatments were used in the experiment: no straw (control), rape straw was added, paddy straw was added, wheat straw was added, and corn straw was added. Each treatment was repeated four times and placed at random, with the interval between pots maintained at 10 cm. 4 consistent seedlings of peach were transplanted in each pot, and grown in a greenhouse under conditions of 14 hours at 25°C during day, 70% relative humidity, 4000 Lux; and 10 hours with 20°C at night, 90% relative humidity, 0 Lux (Li et al., 2020). During cultivation, watered all pots irregularly to keep the soil moisture content at 80% field capacity. In addition, as soon as the weed seedlings appeared, they were pulled out immediately.

2.3 Measurement of Parameters

After transplanting for 60 days, the mature leaves were selected to analyze the contents of chlorophyll *a*, chlorophyll *b*, total chlorophyll, and carotenoid by acetone-ethanol mixture extraction method (Hao, 2004). Furthermore, fresh leaves were collected and homogenized in potassium phosphate buffer at 4°C, followed by centrifugation at 11,000 × *g* for 20 minutes, and the supernatant was collected for testing. Then the superoxide dismutase (SOD) activity was analyzed by nitrogen blue tetrazolium method; peroxidase (POD) activity was analyzed by guaiacol method; catalase (CAT) activity was analyzed by potassium permanganate titration method; soluble protein content was analyzed by coomassie brilliant blue colorimetric method; malondialdehyde (MDA) content was analyzed by thiobarbituric acid colorimetric method (Hao, 2004). After that, the whole plants were harvested and divided into roots, stems and leaves, which were then cleaned repeatedly with tap water and rinsed three times with deionized water. And the dry weight of roots, stems and leaves was measured by electronic balance after the different parts were dried in an oven at 80 °C to a constant weight.

2.4 Statistical Analysis

All the data in this experiment were analyzed by one-way ANOVA with the least significant difference test ($p \leq 0.05$) with SPSS 25.0 statistical software.

The shoot dry weight = stem dry weight + leaf dry weight. The root/shoot ratio = root dry weight/ shoot dry weight.

3 RESULTS

3.1 Dry Weight of Peach Seedlings

Different straw treatments had the different effects on the root, stem, leaf, and shoot dry weight of peach seedlings (Table 1). Leaf and shoot dry weight of peach seedlings with rape straw addition respectively increased by 10.28 and 6.71% compared with the control. On the contrary, the paddy, wheat, and corn straw addition decreased the dry weight of peach seedlings compared with the control, and the lowest dry weight of various organs was the wheat straw treatment. The root-shoot ratio of peach seedlings with rape straw addition had no significant difference and with other treatments was more than that of the control.

Table 1: Dry weight of peach seedlings.

Treatments	Root dry weight (g plant^{-1})	Stem dry weight (g plant^{-1})	Leaf dry weight (g plant^{-1})	Shoot dry weight (g plant^{-1})	Root/shoot ratio
Control	0.532±0.025ab	0.362±0.012a	0.652±0.020b	1.014±0.032b	0.525±0.017d
Rape straw	0.550±0.029a	0.363±0.017a	0.719±0.012a	1.082±0.030a	0.508±0.025d
Paddy straw	0.515±0.014ab	0.237±0.016c	0.413±0.011d	0.650±0.027d	0.793±0.047b
Wheat straw	0.493±0.023b	0.205±0.010d	0.333±0.014e	0.538±0.024e	0.917±0.004a
Corn straw	0.524±0.017ab	0.273±0.011b	0.513±0.006c	0.786±0.017c	0.667±0.036c

Different lowercase letters in the same column represent significant differences ($p \leq 0.05$).

3.2 Photosynthetic Pigment Content in Peach Seedlings

The effects of different straw treatments on the photosynthetic pigment content of peach seedling were similar to the biomass of peach seedlings (Table 2). The contents of chlorophyll a, total chlorophyll, and carotenoid in peach seedlings with rape straw addition increased by 10.81, 7.75, and 17.65% ($p < 0.05$), respectively, compared with the control. The paddy, wheat, and corn straw treatments decreased the contents of chlorophyll a, chlorophyll b, total chlorophyll, and carotenoid of peach seedlings compared with the control, and the wheat straw treatment had lowest photosynthetic pigments content of peach seedlings. The rape straw enhanced the chlorophyll a/b of peach seedlings, while wheat straw reduced that, compared with the control.

Table 2: Photosynthetic pigment content in peach seedlings.

Treatments	Chlorophyll *a* (mg g^{-1})	Chlorophyll *b* (mg g^{-1})	Total chlorophyll (mg g^{-1})	Carotenoid (mg g^{-1})	Chlorophyll *a/b*
Control	1.85±0.02b	0.72±0.02a	2.58±0.04b	0.34±0.01b	2.57±0.04b
Rape straw	2.05±0.06a	0.73±0.03a	2.78±0.06a	0.40±0.01a	2.80±0.14a
Paddy straw	1.77±0.02c	0.67±0.02b	2.45±0.04c	0.33±0.01b	2.65±0.05ab
Wheat straw	1.40±0.03d	0.61±0.03c	2.01±0.04d	0.23±0.01c	2.29±0.14c
Corn straw	1.78±0.02c	0.68±0.01b	2.46±0.03c	0.33±0.01b	2.64±0.03ab

Different lowercase letters in the same column represent significant differences ($p \leq 0.05$).

3.3 Physiological Indicators of Peach Seedlings

Rape straw treatment enhanced the SOD and CAT activities of peach seedlings compared with that of the control, while paddy, wheat and corn straw treatments had no significant or inhibited effects on that (Table 3). Paddy and wheat straw enhanced the POD activity of peach seedlings compared with the control, while rape and corn straw had no significant or inhibited effects on that. Compared with the control, rape straw had no significant effect on the contents of soluble protein and MDA in peach seedlings, and paddy, wheat and corn straw increased that.

Table 3 Physiological indicators of peach seedlings

Treatments	SOD activity (U g^{-1})	CAT activity (mg g^{-1} min^{-1})	POD activity (U g^{-1} min^{-1})	Soluble protein content (mg g^{-1})	MDA content (mg g^{-1})
Control	354.97±14.49b	0.55±0.02b	326.32±13.94c	4.72±0.13c	53.82±1.27d
Rape straw	398.04±18.19a	0.67±0.02a	283.64±14.89d	4.74±0.13c	49.66±0.82d
Paddy straw	347.65±11.04b	0.35±0.01c	370.44±17.99b	5.41±0.07b	82.27±3.57b
Wheat straw	282.50±11.41c	0.15±0.01d	405.17±15.92a	7.63±0.27a	98.41±7.63a
Corn straw	353.09±12.85b	0.32±0.02c	333.66±11.91c	5.25±0.02b	67.66 ±4.72c

Different lowercase letters in the same column represent significant differences ($p \leq 0.05$). .

4 DISCUSSION

After returning, straw gets decayed and releases organic matter, which improves soil structure, fertility, and nutrient cycling, and also influences various plant metabolic activities (van Asten et al., 2005). Addition the rice straw could markedly enhanced the biomass at maturity (18.95%) and spike biomass (15.3%) of rice (Wang et al., 2020). Winter wheat with maize straw return had higher kernels no. ear^{-1}, thousand-kernel weight, grain yields, and nitrogen efficiency than that without straw (Chen et al., 2017). And the study by Mierzwa-Hersztek et al., (2017) showed that the addition wheat straw biochar and *Miscanthus giganteus* straw biochar enhanced the dry weight of plants by 2% and 14%, respectively, compared to the conventional cultivation. In this study, rape straw addition increased the dry weight, while the addition of other kinds of straw reduced the biomass. Therefore, different straw had different effects on the growth of peach seedlings.

Several studies have demonstrated increase in plant photosynthesis with straw mulching (Shi et al., 2015, Chen et al., 2012, He et al., 2016). In this study, the photosynthetic pigment content showed a similar chanege with the biomass; the addition of rape straw increased the photosynthetic pigment content, while the addition of other kinds of straw reduced the content. The photosynthetic pigments play an important role in the photosynthetic metabolism of plants and is closely related to the accumulation of plant dry matter (Xiong, 2003). Therefore, the promoting effect of rape straw on peach seedlings dry weight may be related to its favorable effect on photosynthetic pigment synthesis.

SOD is the key enzyme of the plant defense system, which clears the reactive oxygen species and plays a role in protecting cells (Zheng et al., 2009). POD removes the active oxygen components in plants and plays a synergistic role with SOD, and these two enzymes maintain the redox balance in plants (Yin et al., 2009). The function CAT is to catalyze the decomposition of H_2O_2 into H_2O and O_2, so that H_2O_2 can not react with O_2 under iron chelation to produce very harmful -OH (Li and Guo, 2008). MDA content reflects the degree of cell membrane damage and membrane peroxidation (Ushimaru et al., 1999). Straw addition significantly enhanced antioxidant enzyme activity and decreased MDA content of cowpea leaves (Chen et al., 2019). In this study, the addition of rape straw increased SOD and CAT activities of peach seedlings and decreased POD activity and MDA content. However, the addition of paddy, wheat, and corn straw resulted in an opposite response, which may be indicated that the soil fertility was better, the protective enzymes were at a higher activity, and membrane damage reduced with rape straw addition. Soluble proteins are important osmotic adjustment substances (Fan et al., 2019). The soluble proteins in tomato (Wang et al., 2018) and cucumber (Qi et al., 2007) significantly increased with straw addition. In this study, all four kinds of straw treatments increased soluble protein content in peach seedlings, which helps enhance the resistance of *P. davidiana* seedlings.

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