Effects of mulching with hyperaccumulator straw on soluble sugar content of accumulator *Perilla frutescens*

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**Abstract.** The effects of mulching with four hyperaccumulator plants *Youngia erythrocarpa*, *Galinsoga parviflora*, *Gnaphalium affine* and *Crassocephalum crepidioides* straws on the soluble sugar content of *P. frutescens* under cadmium stress were studied by a pot experiment. The results showed that the straw-mulch *C. crepidioides* and *G. affine* increased the soluble sugar content of *P. frutescens*. But, the straw-mulch *Y. erythrocarpa* and *G. parviflora* decreased the soluble sugar content of *P. frutescens*. The soluble sugar content in shoot of *P. frutescens* for the treatments of mulching with straw of *C. crepidioides* and *G. affine* were 5.18% and 25.83% higher than control. In conclusion, the treatment of *G. affine* is the best, followed by *C. crepidioides*.

**1. Introduction**

Straw mulching is an effective way to use the straw resource. Straw mulching can have various effects on soil. For example, it can improve soil physical properties, reduce soil bulk density, increase porosity, increase the number of soil microorganism, and enhance the activity of biology and most enzymes. It also can increase soil organic matter accumulation and nutrient content and change the composition and characteristics of soil humus. In short, straw mulching has a good ecological effect on farmland [1]. Soluble sugar content is one of the most important regulators of plant growth, development and gene expression. It is not only a source of energy and a structural substance, but also a primary messenger similar to hormone in signal transduction. Sugar can exist as a signal molecule in a hormone-like manner and play a regulatory role in many processes of plant growth, development, maturation and senescence [2-3]. The straw mulching will affect the soluble sugar content of plants. The content of soluble sugar in stems and leaves of *Galinsoga parviflora* was reduced by soil application of *Conyza canadensis*, *Nasturtium officinale*, *Cardamine hirsuta* and *Eclipta prostrata* straws [4]. However, the soluble sugar content in leaves of *Galinsoga parviflora* was increased by soil application of *Clinopodium confine* and *Mazus japonicus* straws [5]. Therefore, it can be inferred that mulching with straw will affect the soluble sugar content of other plants. In the study, four kinds of Cd hyperaccumulators (*Youngia erythrocarpa* [6], *Galinsoga parviflora* [7], *Gnaphalium affine* [8] and *Crassocephalum crepidioides* [9]) straws were mulched on the surface of cadmium contaminated soil, then cultivated *Perilla frutescens*, and studied the effects of mulching with straw of different cadmium hyperaccumulators on the soluble sugar content of Cd accumulator of *Perilla frutescens* [10] under cadmium stress.
2. Materials and Methods

2.1. Materials
Seeds of *P. frutescens* were collected from uncontaminated soil on a farm at the Chengdu Campus of Sichuan Agricultural University (30°71ʹN, 103°87ʹE) in October 2017, air dried and stored at 4°C. Shoots of *Y. erythrocarpa*, *G. parviflora*, *G. affine*, and *C. crepidioides* were collected from the same site at the same time. The collected shoots were dried to constant weight at 80°C, finely ground and sieved through a 5-mm-mesh nylon sieve. Paddy soil was also collected at the same site. The basic physico-chemical properties of the soil were as follows: pH, 7.42; organic matter, 31.73 g/kg; total nitrogen, 1.05 g/kg; total phosphorus, 0.37 g/kg; total potassium, 25.71 g/kg; alkali nitrogen, 56.13 mg/kg; available phosphorus, 17.15 mg/kg; available potassium, 56.65 mg/kg; and total Cd, 0.025 g/kg [11].

2.2. Experimental design
The experiment was conducted in the greenhouse of Chengdu campus farm from March to July 2018. In March 2018, after the soil was air dried, crushed, mixed and sieved (6.72 mm), 3.0 kg soil was accurately weighed into each plastic pot (23 cm height × 30 cm diameter). A CdCl₂·2.5H₂O solution was added into the soil, the final concentration of Cd was 10 mg/kg [12-13], and the soil moisture was maintained at 80% of field capacity for 8 weeks, then crushed and mixed the soil thoroughly. Four uniform *P. frutescens* seedlings (with three pairs of expanded true leaves) were transplanted into each pot in May 2018, and each pot of soil was covered with 6 g shoots of four hyperaccumulator plant species. We applied five treatments: not mulched with straw (control), mulched with *Y. erythrocarpa* straw, mulched with *G. parviflora* straw, mulched with *G. affine* straw, and mulched with *C. crepidioides* straw. Repeated each treatment four times, and watered every day to keep soil moisture at 80% of field capacity until the plants are harvested. Two months after the plants were transplanted (July 2018), harvested the whole plant, separated its roots, stems and leaves, washed with tap water, repeatedly rinsed with deionised water and then dried at 80°C to determine its soluble sugar content [14].

2.3. Statistical Analyses
SPSS 20.0 statistical software was used for statistical analysis. Data were analyzed with one-way analysis of variance with least significant difference at the 5% significance level.

3. Results and Discussion

3.1. Soluble sugar content in roots of *P. frutescens*
The effects of straw mulching of Cd hyperaccumulators on the soluble sugar content in root of *P. frutescens* had two types (Figure 1). Compared to control, straw mulching of *C. crepidioides* and *G. affine* increasing the soluble sugar content in root of *P. frutescens*, the soluble sugar content in root of *P. frutescens* for the treatment of straw mulching of *C. crepidioides* and *G. affine* were 4.38% (P > 0.05) and 23.76% (P < 0.05) which were higher than control. The soluble sugar content in roots for the treatments of straw mulching of *Y. erythrocarpa* and *G. parviflora* decreased, which were 12.55% (P < 0.05) and 26.03% (P < 0.05) and lower than control.

3.2. Soluble sugar content in stems of *P. frutescens*
Compared with the control, the straw-mulch *C. crepidioides* and *G. affine* treatments increased the soluble sugar content in stems of *P. frutescens*, but the straw-mulch *C. crepidioides* and *G. parviflora* decreased the soluble sugar content in stems of *P. frutescens* (Figure 2). Straw mulching of *G. affine* treatment was the highest, followed by the straw of *C. crepidioides* followed, which increased by 40.00% (P < 0.05) and 6.95% (P > 0.05) respectively, showing a significant difference from control. Straw mulching of *Y. erythrocarpa* and *G. parviflora* was not significantly different from control.
3.3. Soluble sugar content in leaves of *P. frutescens*

The soluble sugar content in stems of *P. frutescens* was similar with the soluble sugar content in stems (Figure 3). The soluble sugar content in stems of *P. frutescens* was ranked in the following order: straw mulching of *G. affine* > straw mulching of *C. crepidioides* > control > straw mulching of *G. parviflora* > straw mulching of *Y. erythrocarpa*. Straw mulching of *G. affine* treatment was the highest, followed by the straw of *C. crepidioides* followed, which increased by 13.81% (*P* < 0.05) and 3.78% (*P* > 0.05) respectively.
3.4. Soluble sugar content in shoots of *P. frutescens*

The soluble sugar content in shoots of *P. frutescens* was similar with the soluble sugar content in roots, stems and leaves (Figure 4). The soluble sugar content in stems of *P. frutescens* was ranked in the following order: straw mulching of *G. affine* > straw mulching of *C. crepidioides* > control > straw mulching of *G. parviflora* > straw mulching of *Y. erythrocarpa*. Straw mulching of *Y. erythrocarpa* treatment was the lowest, followed by the straw of *G. parviflora*, which decreased by 37.68% (*P* < 0.05) and 10.19% (*P* > 0.05) respectively.

4. Conclusions

The experiment showed that different kinds of Cd hyperaccumulators straws mulching had different effects on the soluble sugar content of *P. frutescens*. After four kinds of hyperaccumulators straws mulching, the the soluble sugar content in roots, stems, leaves and shoots were divided into two types. The straw-mulch *C. crepidioides* and *G. affine* increased the soluble sugar content of *P. frutescens*. But, the straw-mulch *Y. erythrocarpa* and *G. parviflora* decreased the soluble sugar content of *P. frutescens*. In conclusion, straw-mulch treatments had different effects on the soluble sugar content of *P. frutescens* and the treatment of *G. affine* is the best.

Acknowledgments

This work was funded by the Project of Education Department of Sichuan Province (17ZB0342).

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