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# Effects of Mulching Tolerance Plant Straw on Phosphorus and Potassium Uptakes of *Cyphomandra betacea* Seedlings under Cadmium Stress

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**Keywords:** *Cyphomandra betacea*; Tolerant plant straw; Phosphorus; Potassium; Cadmium stress
**Abstract:** A pot experiments were conducted to study the effect of mulching tolerance plant straw on phosphorus and potassium uptakes of *Cyphomandra betacea* seedlings under cadmium (Cd) stress, four tolerance plants (*Digitaria sanguinalis, Clinopodium confine, Plantago asiatica, Ranunculus sieboldii*) straw were used as materials to mulch on the surface of Cd-contaminated soil and planted *C. betacea* seedlings. Cd-contaminated soil-mulched tolerant plant straw had effect on the contents of phosphorus and potassium in *C. betacea* seedling plants. Except for the *P. asiatica* straw mulching treatment, the contents in phosphorus and potassium in the roots of *C. betacea* seedlings treated with *D. sanguinalis* straw, *R. sieboldii*, and *C. confine* straw were significantly higher than those without soil-resistant straw. The contents of phosphorus and potassium in shoots of *C. betacea* seedlings were higher than those of control after mulching four tolerant plant straw, indicating that mulching tolerant plant straw promoted the translocation of phosphorus and potassium to the shoots of *C. betacea* seedlings. This experiment showed that compared with the *P. asiatica* straw, the straw mulched with *D. sanguinalis* straw, the *C. confine* straw, and the *R. sieboldii* straw were more beneficial to the uptake of tolerant in Cd-contaminated soil by *C. betacea* seedlings.

## Introduction

Cadmium (Cd) is one of the heavy metal elements harmful to plant growth and human health [1]. In recent years, the current status of cadmium pollution in China has become increasingly serious [2-3]. The *Cyphomandra betacea* is a fruit tree with commercial exploitation value of Solanaceae, and it is a fruit tree integrating flower, fruit and food, mainly in Southwest China [4]. Phosphorus and potassium are among the various nutrients needed in plants [5]. Straw mulching is a commonly used method of water retention and fertilization in agricultural practices [6]. It mainly releases organic matter, trace elements and other substances during the process of straw decomposing, improves soil physical and chemical properties, increases soil organic matter content, and then improves soil fertility and soil texture, which increases the yield and quality of crop [7]. This experiment used four tolerance plants (*Digitaria sanguinalis* [8], *Clinopodium confine*, *Plantago asiatica* and *Ranunculus sieboldii* [9]) straw mulch on the surface of Cd-contaminated soil and planted *C. betacea* seedlings, and the effect of mulching tolerance plant straw on phosphorus and potassium uptakes of *C. betacea* seedlings under cadmium (Cd) stress.

## Materials and Methods

**Materials Collection.** The shoots of four tolerance plants (*D. sanguinalis*, *C. confine*, *P. asiatica* and *R. sieboldii*) and soil were collected from the farmland of Ya'an Campus of Sichuan Agricultural University (not polluted by Cd) in June, 2014. And fixed all plants at 110°C for 15 minutes and dried at 80°C until they were weighed after washing them with deionized water. Then cut into small pieces of less than 1 cm by scissors and stored. The seeds of *C. betacea* were collected from three-years of fruitful *C. betacea* from the Ya'an Campus of Sichuan Agricultural

University in October 2013. And the seeds of *C. betacea* were sowed in the sand plate in June 2014.

**Experimental Design.** The experiment was conducted in farm of Ya'an Campus of Sichuan Agricultural University. In June 2014, the unpolluted soil was air-dried and passed through a 5-mm sieve. 3 kg air-dried soil was weighed into each plastic pot (15 cm high, 18 cm in diameter), soaking uniformly $CdCl_2 \cdot 2.5H_2O$ by 10 mg/kg and balanced for 4 weeks. In July 2014, the straws of four accumulator plants were separately mulched in Cd-contaminated soil surface. Coverage was 6g per pot and the water was kept moist and equilibrated for one week. Then, the same growth *C. betacea* with the four real leaves were transplanted into the pots. Two plants were planted in each pot. Five replicates per treatment and all pots were watered each day to keep the soil moisture about 80%. The distance between pots was 15 cm, and the pot position exchanged aperiodically to weaken the impact of the marginal effects. After 40 days, all *C. betacea* seedlings were harvested and divided, fixed all plants at 110°C for 15 minutes and dried at 80°C until they were weighed after washing them with deionized water. The total phosphorus content of *C. betacea* seedlings were determined by molybdenum antimony colorimetric method [10]. The total potassium content of *C. betacea* seedlings were determined by flame spectrophotometer [10].

**Statistical Analyses.** Statistical analyses were conducted using statistical software of SPSS 17.0. Data were analyzed by one-way ANOVA with least significant difference at 5% confidence level.

## Results and Discussion

**Phosphorus Contents in *C. betacea* Seedlings.** The total phosphorus content in *C. betacea* seedling plants is shown in Table 1. After mulching tolerant plant straw, the total phosphorus content in the roots of *C. betacea* seedlings was in the following order: *D. sanguinalis* straw > *R. sieboldii* straw > *C. confine* straw > control > *P. asiatica* straw, where the soil mulched *D. sanguinalis* straw treatment, *R. sieboldii* straw treatment and *C. confine* straw treatment The content of total phosphorus in the roots of the treatment and adjacent to the cabbage and straw was increased by 132.70% ($P < 0.05$), 96.58% ($P < 0.05$) and 11.03% ($P > 0.05$), respectively. The total phosphorus content in the roots was not significantly different from the control. Excluding the *P. asiatica* straw and *R. sieboldii* straw, the content of total phosphorus in the stems of *C. betacea* seedlings was significantly lower than that of control. The rest of the treatments were significantly higher than the control. The order of the total phosphorus content was: *C. confine* straw > *D. sanguinalis* straw > control > *P. asiatica* straw > *R. sieboldii* straw. The order of total phosphorus content in leaves and shoots of plant *C. betacea* seedlings were as follows: *D. sanguinalis* straw > *C. confine* straw > *R. sieboldii* straw > *P. asiatica* straw > control, the total phosphorus content in shoots of *C. betacea* seedlings that were mulched with *D. sanguinalis* straw, *C. confine* straw, *R. sieboldii* and straw and *P. asiatica* straw increased by 121.01% ($P < 0.05$), 100.00% ($P < 0.05$), 40.62% ($P < 0.05$), and 3.08% ($P > 0.05$), respectively, compared with the control.

Table 1 Effects of mulching tolerant plant straw on total phosphorus content in *C. beracea* seedlings

| Tolerant plant straw | Root (g/kg) | Stem (g/kg) | Leaf (g/kg) | Shoot (g/kg) |
|---|---|---|---|---|
| Control | 0.263±0.001 cd | 0.273±0.002 c | 0.396±0.009 de | 0.357±0.002 c |
| *D. sanguinalis* | 0.612±0.011 a | 0.394±0.007 b | 0.988±0.044 a | 0.789±0.044 a |
| *C. confine* | 0.292±0.002 c | 0.649±0.012 a | 0.747±0.025 b | 0.714±0.031 a |
| *P. asiatica* | 0.233±0.001 d | 0.238±0.002 d | 0.435±0.013 d | 0.368±0.001 c |
| *R. sieboldii* | 0.517±0.002 b | 0.173±0.001 e | 0.656±0.035 c | 0.502±0.012 b |

Note: Different letters indicate significant difference at 5% level among different treatments.

**Potassium Contents in *C. betacea* Seedlings.** The effects of tolerance plant straw-mulched *C. betacea* seedlings on their total potassium content were shown in Table 2. After the soil mulched the resistant plant straw, the total potassium content were not significantly different except for the *P. asiatica* straw treatment compared with the control. The rest of the treatments were significantly higher than the the control. The order of their size was as follows: *D. sanguinalis* straw > *R. sieboldii* straw > *C. confine*s straw > control > *P. asiatica* straw. The total potassium content in roots of *C. betacea* seedlings mulched by straw of *D. sanguinalis*, *R. sieboldii* and *C. confine*s was increased by 122.70% ($P < 0.05$), 106.57% ($P < 0.05$), and 33.45% ($P < 0.05$) compared with the control. After the soil was mulched with tolerant plant straw, the total potassium content in stems, leaves and shoots of *C. betacea* seedlings was higher than that of control. The order of the total potassium content was as follows: *D. sanguinalis* straw > *R. sieboldii* straw > *C. confine*s straw > *P. asiatica* straw > control. These results showed that mulching tolerant plant straw promoted the transfer of potassium to the shoot of *C. betacea* seedlings. The total potassium content in shoots of *C. betacea* seedlings with *D. sanguinalis* straw, *C. confine* straw, *P. asiatica* straw and *R. sieboldii* straw were 5.37 times ($P < 0.05$) and 2.60 times ($P < 0.05$), 2.59 times ($P < 0.05$) and 2.07 times ($P < 0.05$) than control. These results showed that mulching tolerant plant straw promoted the transfer of potassium to the shoot of *C. betacea* seedlings.

Table 2 Effects of mulching tolerant plant straw on total potassium content in *C. beracea* seedlings

| Tolerant plant straw | Root (g/kg) | Stem (g/kg) | Leaf (g/kg) | Shoot (g/kg) |
|---|---|---|---|---|
| Control | 27.71±0.82 d | 20.83±1.14 d | 13.56±0.64 d | 15.85±0.92 d |
| *D. sanguinalis* | 61.71±3.32 a | 71.52±3.68 a | 91.95±4.65 a | 85.10±2.64 a |
| *C. confine* | 36.98±1.33 c | 39.95±1.45 b | 41.62±2.99 b | 41.07±1.17 b |
| *P. asiatica* | 27.06±1.01 d | 30.05±1.79 c | 34.18±0.51 c | 32.78±1.76 c |
| *R. sieboldii* | 57.24±2.93 b | 40.49±2.11 b | 41.63±1.82 b | 41.26±1.35 b |

Note: Different letters indicate significant difference at 5% level among different treatments.

## Conclusions

Cd-contaminated soil-mulched tolerant plant straw had effect on the contents of phosphorus and potassium in *C. betacea* seedling plants. Except for the *P. asiatica* straw mulching treatment, the contents in phosphorus and potassium in the roots of *C. betacea* seedlings treated with *D. sanguinalis* straw, *R. sieboldii*, and *C. confine* straw were significantly higher than those without soil-resistant straw. The contents of phosphorus and potassium in shoots of *C. betacea* seedlings were higher than those of control after mulching four tolerant plant straw, indicating that mulching tolerant plant straw promoted the translocation of phosphorus and potassium to the shoots of *C. betacea* seedlings. This experiment showed that compared with the *P. asiatica* straw, the straw mulched with *D. sanguinalis* straw, the *C. confine* straw, and the *R. sieboldii* straw were more beneficial to the uptake of tolerant in Cd-contaminated soil by *C. betacea* seedlings.

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