

# Effects of Mulching with Accumulator Plants Straws on Nutrients Uptake of *Cyphomandra betacea* Seedlings under Cadmium Stress

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**Abstract:** A pot experiment was carried out to study the effects of mulching with four accumulator plants straws (*Trifolium repens*, *Eclipta prostrata*, *Conyza canadensis*, *Stellaria media*) on the total phosphorus and total potassium content in *Cyphomandra betacea* seedlings under cadmium stress. The results showed that all accumulator plants straws could improve the content of total phosphorus in *C. betacea* seedlings in varying degrees compared with the uncovered. And under cadmium stress, the total potassium content of roots in *C. betacea* seedlings was lower than uncovered by mulching with *T. repens* and *E. prostrata* straws. Other accumulator plants straws all increased the total potassium content of *C. betacea* seedlings compared with the uncovered. And in all parts of *C. betacea* seedlings, mulching with *S. media* straw maximized the total phosphorus and total potassium content in *C. betacea* seedlings. Therefore, mulching with *S. media* straw could significantly promote the nutrients uptake of *C. betacea* seedlings under cadmium stress.

## 1. Introduction

Due to the emission of industrial waste and the improper use of chemical fertilizers and pesticides, the orchards in the outskirts of the city have already faced the hazard of heavy metal pollution [1]. Cadmium (Cd) is a high-residue and hard-to-degrade heavy metal that can easily cause plants metabolic disorder and affect the yield and quality of crops [2]. It has been found that when the content of Cd in the soil exceeds a certain limit, it will inhibit the absorption of nutrients by plants [3]. Returning straw to field is a commonly used measure for crops cultivation, which can improve soil structure, promote soil nutrients cycling and effectively increase the soil fertility to promote plants growth [4]. And the return of straw could also improve the utilization of soil nutrients by plants, which in turn increases the amount of plants nitrogen, phosphorus and potassium [5]. Some scholars have found that applying different accumulator plants straws to the Cd-contaminated soil could significantly increase the shoots biomass and leaves SPAD of *Capsella bursa-pastoris*, providing a new theory for plants growth under Cd stress [6]. *Cyphomandra betacea* is a perennial evergreen shrub of the genus Solanaceae, which combines ornamental and edible values with rich vitamins and beneficial trace elements [7]. However, with the intensification of Cd pollution in orchard soil, the growth of *C. betacea* is potentially threatened. Study has reported that planted *C. betacea* seedlings after mulching with four Cd-tolerant plants straws in Cd-contaminated soil could effectively increase the photosynthetic pigment content and antioxidant enzyme activity of *C. betacea* [8]. But studies on the nutrients uptake of *C. betacea* seedlings by mulching with accumulator plants straws in Cd-contaminated soil have not been reported. Therefore, the purpose of this study was to seek out the accumulator plants (*Trifolium repens* [9], *Eclipta prostrata* [10], *Conyza canadensis* [11], *Stellaria media* [12]) straws which could promote the nutrients uptake of *C. betacea* seedlings.

## 2. Materials and Methods

**Materials Collection.** The shoots of four accumulator plants (*T. repens*, *E. prostrata*, *C. Canadensis*, *S. media*) 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<sub>2</sub>·2.5H<sub>2</sub>O 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 [13]. The total potassium content of *C. betacea* seedlings were determined by flame spectrophotometer [13].

**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.

## 3. Results and Discussion

**Total Phosphorus Content in *C. betacea* Seedlings.** For the roots, stems, leaves and shoots of *C. betacea* seedlings, mulching with accumulator plants straws could increase its total phosphorus content in varying degrees compared to the uncovered (Table 1). The order of roots total phosphorus content in *C. betacea* seedlings from large to small was ranked: *S. media*, *C. canadensis*, *E. prostrata*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total phosphorus content of the roots in *C. betacea* seedlings by 68.85% ( $P < 0.05$ ) compared with the uncovered. The order of stems total phosphorus content in *C. betacea* seedlings from large to small was ranked: *S. media*, *C. canadensis*, *E. prostrata*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total phosphorus content of the stems in *C. betacea* seedlings by 188.83% ( $P < 0.05$ ) compared with the uncovered. The order of leaves total phosphorus content in *C. betacea* seedlings from large to small was ranked: *S. media*, *C. canadensis*, *E. prostrata*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total phosphorus content of the leaves in *C. betacea* seedlings by 72.12% ( $P < 0.05$ ) compared with the uncovered. The order of shoots total phosphorus content in *C. betacea* seedlings from large to small was ranked: *S. media*, *C. canadensis*, *E. prostrata*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total phosphorus content of the shoots in *C. betacea* seedlings by 95.94% ( $P < 0.05$ ) compared with the uncovered.

**Total potassium content in *C. betacea* seedlings.** For the stems, leaves and shoots of *C. betacea* seedlings, mulching with accumulator plants straws could increase its total potassium content in varying degree compared with the uncovered (Table 2). The order of roots total potassium content in *C. betacea* seedlings from large to small was ranked: *S. media*, uncovered, *T. repens*, *E. prostrata*, *C. canadensis*. And mulching with *S. media* straw increased the total potassium content of the roots in *C. betacea* seedlings by 42.61% ( $P < 0.05$ ) compared with the uncovered. The order of stems total potassium content in *C. betacea* seedlings from large to small were all ranked: *S. media*, *E.*

*prostrata*, *T. repens*, *C. canadensis*, uncovered. And mulching with *S. media* straw increased the total potassium content of the stems in *C. betacea* seedlings by 144.23% ( $P < 0.05$ ) compared with the uncovered. The order of leaves total potassium content in *C. betacea* seedlings from large to small was ranked: *S. media*, *E. prostrata*, *C. canadensis*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total potassium content of the leaves in *C. betacea* seedlings by 109.64% ( $P < 0.05$ ) compared with the uncovered. The order of leaves total potassium content in *C. betacea* seedlings from large to small was ranked: *S. media*, *E. prostrata*, *C. canadensis*, *T. repens*, uncovered. And mulching with *S. media* straw increased the total potassium content of the shoots in *C. betacea* seedlings by 119.03% ( $P < 0.05$ ) compared with the uncovered.

Table 1 Total phosphorus content in *C. betacea* seedlings

Cd accumulate plant straw	Roots (g/kg)	Stems (g/kg)	Leaves (g/kg)	Shoots (g/kg)
Uncovered	0.244±0.004d	0.206±0.007d	0.373±0.017d	0.320±0.012d
<i>T. repens</i>	0.245±0.014d	0.256±0.012c	0.389±0.034d	0.344±0.023d
<i>E. prostrata</i>	0.291±0.022c	0.269±0.021b	0.449±0.028c	0.389±0.036c
<i>C. canadensis</i>	0.320±0.018b	0.270±0.016b	0.494±0.043b	0.418±0.041b
<i>S. media</i>	0.412±0.032a	0.595±0.043a	0.642±0.035a	0.627±0.052a

Values are means ± standard errors. Means with the same letter within each column are not significantly different at  $p < 0.05$ .

Table 2 Total potassium content in *C. betacea* seedlings

Cd accumulate plant straw	Roots (g/kg)	Stems (g/kg)	Leaves (g/kg)	Shoots (g/kg)
Uncovered	28.30±0.77b	18.56±0.64c	22.92±0.78d	21.54±0.45d
<i>T. repens</i>	27.76±0.45b	21.08±1.28b	30.54±0.75c	27.37±0.63c
<i>E. prostrata</i>	27.03±0.72b	21.88±0.55b	37.58±0.69b	32.34±1.22b
<i>C. canadensis</i>	21.94±0.41c	20.78±0.49bc	36.86±0.82b	31.41±0.65b
<i>S. media</i>	40.36±2.13a	45.33±2.61a	48.05±1.76a	47.18±1.26a

Values are means ± standard errors. Means with the same letter within each column are not significantly different at  $p < 0.05$ .

#### 4. Conclusions

In cadmium contaminated soil, planted *C. betacea* after mulching with *T. repens*, *Eclipta prostrate*, *C. canadensis*, *S. media* straws could affect the content of total phosphorus and total potassium in *C. betacea* seedlings. For the content of total phosphorus in all parts of *C. betacea* seedlings, all accumulator plants straws could improve the total phosphorus content in *C. betacea* seedlings. Among all treatments, mulching with *E. prostrate*, *C. Canadensis* and *S. media* straws could significantly increase the content of total phosphorus in roots, stems, leaves and shoots of *C. betacea* seedlings. And mulching with *S. media* straw maximized the total phosphorus content in all parts of *C. betacea* seedlings. For the content of total potassium in leaves and shoots of *C. betacea* seedlings, all accumulator plants straws could significantly increase the total potassium content in *C. betacea* seedlings. And the content of total potassium in leaves and shoots of *C. betacea* seedlings was significantly higher than other treatments by mulching with *S. media* straw. For the total

potassium content of the roots in *C. betacea* seedlings, only mulching with *S. media* straw significantly increased the content of total potassium in *C. betacea* seedlings. In addition, mulching with *T. repens*, *E. prostrate* and *S. media* straws all significantly increased the total potassium content of the stems in *C. betacea* seedlings. And the total potassium content of the stems in *C. betacea* seedlings was highest in all treatments by mulching with *S. media* straw. These results indicated that only mulching with *S. media* straw could significantly increase the total phosphorus and total potassium content in all parts of *C. betacea* seedlings in Cd-contaminated soil. Therefore, mulching with *S. media* straw could significantly promote the nutrients uptake of *C. betacea* seedlings under Cd stress.

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## References

- [1] Y.X. Su, S.J. Wang, L.W. Zhao and Q.B. Chen: Tianjin Agricultural Sciences Vol. 22(2016), p. 20.
- [2] P. Yu, F. Gao, J. Liu, Q. Liang, Y.Y. Han, J.X. Wang and Y.H. Jia: Chinese Agricultural Science Bulletin Vol. 33(2017), p. 89.
- [3] X.S. Han, C.Y. Cao, J.D. Yao and F.F. Gao: Chinese Journal of Ecology Vol. 28(2009), p. 2250.
- [4] J. Zhang, X.X. Wen, Y.C. Liao and Y. Liu: Plant Nutrition and Fertilizer Science Vol. 16(2010), p. 612.
- [5] G.W. Xu, L.N. Yang, Z.Q. Wang, L.J. Liu and J.C. Yang: Acta Agronomica Sinica Vol. 34(2008), p. 1424.
- [6] L.J. Lin, D.Y. Yang, F.Y. Tang, L. Luo, M. A. Liao and L. Yuan: Chinese Journal of Soil Science Vol. 46(2015), p. 483.
- [7] S. Zhi, Y.X. Wu, Y. J. Wang, H. Wang and Z.X. Huang: Hubei Agricultural Sciences Vol. 53(2014), p. 5880.
- [8] J. He, L.J. Lin, J. Shi, Y.M. Tan, Q.Q. Ma, C.Y. Liu, K. Wen, J.J. Huang, C.C. Zhong and M.A. Liao: Chinese Journal of Soil Science Vol. 47(2016), p. 1259.
- [9] G. Bidar, G. Garçon, C. Pruvot, D. Dewaele, F. Cazier, F. Douay and P. Shirali: Environmental Pollution Vol. 147(2007), p. 546.
- [10] L. Luo, L.J. Lin, M.A. Liao, X. Zhang and D.Y. Yang: Acta Agriculturae Boreali-Sinica Vol. 29(2014). p. 216.
- [11] S.H. Wei, Q. X. Zhou, U. K. Saha, H. Xiao, Y.H. Hu, L.P. Ren and G. Ping: Journal of Hazardous Materials Vol. 163(2009), p. 32.
- [12] L.J. Lin, B. Ning, M. A. Liao, H.J. Lan and H. Liang: Ecology and Environmental Sciences Vol. 23(2014), p. 673.
- [13] S.D. Bao: *Agrochemical Soil Analysis* (3rd edition, China Agriculture Press, Beijing, China 2000).