Effect of Intercropping of *Solanum nigrum* L., Tomato and Eggplant on Potassium Content under Cadmium Stress

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Abstract: A pot experiment was conducted to study the effect of intercropping *S. nigrum*, tomato and eggplant on the potassium content under cadmium stress. The results showed that compared with the control, the intercropping of *S. nigrum* and tomato has reduced potassium content in *S. nigrum* stems, leaves and aerial parts by 9.19%, 16.10% and 14.44%, and the content of potassium in tomato roots, stems, leaves and aerial parts was increased by 17.27%, 108.04%, 11.92% and 42.61%, respectively. Compared with the control, the intercropping of *S. nigrum* and eggplant increased the potassium content of *S. nigrum* roots, stems, leaves and aerial parts by 5.00%, 2.01%, 8.73% and 3.85%, respectively, and the potassium content of stems, leaves and aerial parts of eggplant decreased by 3.54%, 8.37% and 6.71%. Therefore, the intercropping of *S. nigrum* and tomato can increase the potassium content of tomato, which is helpful to improve the resistance of tomato to heavy metal.

1. Introduction

Intercropping can increase the yield of the plant complex population [1], reduce the occurrence of diseases and pests, and improve the productivity of unit land area [2]. Under the condition of heavy metal pollution, different plant hybrids will produce a "rhizosphere dialogue" in the rhizosphere environment, which affects the uptake of metals by plants, thus affects plant growth [3]. A reasonable intercrop can significantly improve crop under the condition of heavy metal pollution of soil nutrient absorption and improve soil biological diversity and productivity. The intercrop of corn and hummus promoted the absorption of organophosphorus from corn [4]. The phosphorus and potassium content of the plants increased significantly after the intercropped planting of cherries and *C. canadensis*, while the phosphorus and potassium content changed little or even decreased after intercropped planting with *S. nigrum* and *D. sanguinalis*. In contrast to cherries, the levels of phosphorus and potassium in roots and aerial parts were increased to varying degrees after intercropping [5]. After intercropped planting, the total phosphorus and total potassium content of root and aerial parts of rootstock cherry were higher than that of monoculture to different degrees, and the root and aerial parts and total potassium content of rootstock cherries of intercropped *C. canadensis* (Farmland ecotype) were lower than that of intercropped *C. canadensis* (Mine ecotype). The content of total phosphorus and total potassium in the roots and the aerial parts of the two ecotype *C. canadensis* were also higher than the after the monoculture stock [6]. In this experiment, the cadmium hyperaccumulator plant *S. nigrum* intercropped with tomato and eggplant, respectively, and the
absorption of potassium by three plants was studied, which provided a basis for rational intercropping under cadmium stress.

2. Materials and methods

2.1. Materials.
*S. nigrum* is collected from farmland around Sichuan Agricultural Chengdu Campus, tomato and eggplant was purchased from the surrounding market of Sichuan Agricultural University Chengdu Campus.

2.2. Experimental design.
The dried and crushed soil was placed into a plastic basin of 21 cm × 20 cm (diameter × height), each of which was 3.0 kg. The analytically pure CdCl$_2$·2.5H$_2$O solution was added to make the cadmium concentration of 10 mg/kg. The soil was kept moist and placed around. In November 2017, tomato, *S. nigrum* and eggplant seeds were planted in pots while waiting for second true leaves. The treatments were as follows: monoculture of *S. nigrum*, monoculture of tomato, monoculture of eggplant, intercrop of *S. nigrum* and tomato, and intercrop of *S. nigrum* and eggplant. For monoculture, four plants were planted in each pot, two plants were planted in each pot of intercrop. Each treatment was replicated for three times with a completely randomized design with 10 cm spacing between pots. During the growth period, the location of pots and basins was changed irregularly to weaken the effect of marginal effect, and the soil water capacity was kept at about 80% in the field by watering, weeding and pest control. After 60 days of harvest, the *S. nigrum*, tomato and eggplant seedling root, stem, leaf separation were washed with tap water, then rinse with deionized water three times, in 110°C after filming for 15 min, 75°C drying to weighing, crushing, 0.149 mm sieve set aside, according to each part of the total potassium content is determined samples from drying.

2.3. Statistical Analyses.
Statistical analysis was carried out by using SPSS 20.0 statistical software. The data were analyzed by one-way ANOVA, with the least significant difference at the 5% confidence level.

3. Results and discussion

3.1. Potassium content in roots.
After the intercropped of *S. nigrum* and eggplant, the potassium content of root was significantly higher than that of *S. nigrum* monoculture, with an increase of 5.00% (*p*<0.05) (Figure. 1). After intercropped of tomato and *S. nigrum*, the content of potassium in root was also significantly higher than that of tomato monoculture, which increased by 17.27% (*p*<0.05). The potassium content of tomato root was increased after intercropped with *S. nigrum* and tomato. The potassium content in the root of *S. nigrum* was increased after it was intercropped with eggplant.

3.2. Potassium content in stems.
Compared with monoculture the content of potassium in the stems of *S. nigrum* (intercropping with eggplant) and *S. nigrum* (intercropping with tomato) is significantly different, which is increased by 2.01% (*p*<0.05) and decreased by 9.19% (*p*<0.05) (Figure. 2). Compared with the monoculture of tomato, the combination of tomato and *S. nigrum* increased by 108.04% (*p*<0.05). After intercropping the eggplant with the *S. nigrum* the potassium content in the stem was reduced by 3.54% (*p*<0.05) compared to the monoculture of eggplant. After the intercropped of *S. nigrum* and tomato, the potassium content in the stem of *S. nigrum* was decreased and the potassium content in the stem of tomato was increased. After the intercropped of *S. nigrum* and eggplant, the potassium content in the stem of *S. nigrum* increased and the potassium content in the stem of the eggplant decreased.
3.3. Potassium content in leaves.
After intercropped with tomato, the potassium content of the leaves of *S. nigrum* decreased by 16.10% \((p<0.05)\) compared with that of the monoculture, after intercropped with eggplant, *S. nigrum* increased by 8.73% \((p<0.05)\) (Figure 3). After intercropped with *S. nigrum*, the potassium content of the leaves of tomato increased by 11.92% \((p<0.05)\) compared with that of the monoculture, the potassium content of the leaves of eggplant increased by 8.37% \((p<0.05)\). After the intercropped of *S. nigrum* and tomato, the potassium content in the leaves of *S. nigrum* decreased and the potassium content in the stem of tomato increased, after the intercropped of *S. nigrum* and eggplant, the potassium content in the leaves of *S. nigrum* increased and the potassium content in the stem of eggplant decreased.

3.4. Potassium content in aerial parts.
The content of potassium in the aerial part of *S. nigrum* intercroped with eggplant increased significantly compared with the monoculture, with increase of 3.85% \((p<0.05)\), and the content of potassium in the aerial part decreased by 14.44% \((p<0.05)\) after intercropped with tomato (figure 3). After intercropped with tomato and *S. nigrum*, the potassium content in the aerial part increased by 42.61% \((p<0.05)\) compared with the monoculture. The potassium content in the aerial part of the intercropped of eggplant and *S. nigrum* was 6.71% \((p<0.05)\) lower than that of the monoculture. After intercropped with tomato, the potassium content of the aerial part of the *S. nigrum* was decreased and the potassium content of the tomato stem was increased. After intercropped with eggplant, the potassium content of the aerial part of the *S. nigrum* was increased and the potassium content of the eggplant was decreased.

Figure 1 Effect of intercropping on potassium content in roots under cadmium stress. *Mon-Sn* means the monoculture of *S. nigrum; Sn-T means *S. nigrum* (intercropping with tomato); Sn-E means *S. nigrum* (intercropping with eggplant); Mon-T means the monoculture of tomato; T-Sn means tomato (intercropping with *S. nigrum*); Mon-E means the monoculture of eggplant; E-Sn means eggplant (intercropping with *S. nigrum*).

The same as follow.

Figure 2 Effect of intercropping on potassium content in stems under cadmium stress.
Figure. 3 Effect of intercropping on potassium content in leaves under cadmium stress.

Figure. 4 Effect of intercropping on potassium content in aerial parts under cadmium stress.

4. Conclusion
The results showed that under cadmium stress, different plants had different effects on their potassium content. The intercrop of *S. nigrum* and tomato reduced the potassium content of the stem, leaf and aerial part of the *S. nigrum*, and increased the potassium content of tomato root, stem, leaf and aerial part. The intercrop of *S. nigrum* and eggplant increased the potassium content of the root, stem, leaf and aerial part of the *S. nigrum*, while decreased the potassium content of the stem, leaf and aerial part of the eggplant, which indicated that the content of nutrient elements in the plant could be increased by suitable plant intercrop, thus enhancing the plant resistance to cadmium stress.

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