Effects of Intercropping with Different Varieties of Radish on Potassium Absorption under Selenium Stress

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Abstract: An experiment was conducted to study the effects of intercropping with three varieties radish (White, Red and Green radish) on potassium absorption, soil organic matter content and the content of soil available potassium under selenium (Se) stress. The result showed that the potassium content in roots, stems and leaves of red or white radish seedlings and soil available potassium content significantly increased by intercropping compared to monoculture. Also, the content of soil organic matter decreased. However, the potassium content and the soil available potassium reduced but the soil organic matter increased, because the green radish intercropped with white radish. In conclusion, intercropping increased the potassium content and improved the resistance to Se stress of radish.

Introduction

Potassium is one of essential minerals that contributes to plant growth and development [1]. Different plant species show various K\textsuperscript{+} utilization efficiency [2]. Intercropping can not only improve the balanced absorption of soil nutrients, but also improve the soil environment and increase soil enzyme activity and microbial population [3-4]. There is a research showing that the contents of soil organic matter and available K are obviously improved by intercropping with green manure and sod culture [5]. Therefore, in this study, we used three varieties of radishes (White, Red and Green radish) to intercrop with each other under Se stress by a pot experiment to study the effects on potassium absorption.

Materials and Methods

Materials. In August 2017, the seeds of three radish varieties white radish, green radish and red radish were collected from the surrounding farmland at Chengdu campus of Sichuan Agricultural University. Then, the seeds were put in the climate chamber to germination and further cultivation and transplanting. The soil for the experiment was collected from the surrounding farmland at Chengdu campus of Sichuan Agricultural University in August 2017.

Experimental Design. The experiment was conducted in Chengdu Campus of Sichuan Agricultural University from August to December 2017. In August 2017, the 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 by 10 mg/kg Se (in the form of Na\textsubscript{2}SeO\textsubscript{3}) solution for 4 weeks [6-8]. All pots were watered every day to keep the soil moisture about 80%. In September 2017, cultivating the seeds of the three varieties of radishes, when the second leaf expanded, uniform seedlings were transplanted into the previously prepared polyethylene pots. In this experiment, there are 7 treatments: white radish monoculture (MW), green radish monoculture (MG), red radish monoculture (MR), white radish intercropping with green radish (WG), white radish intercropping with red radish (WR), red radish intercropping with green radish (RG), three varieties radish intercropping (RGW). Four uniform-sized seedlings (two true leaves expanded) of radish were
transplanted into each pot for intercropping. For each treatment with three replicates and the pots placed completely random. The distance between pots was 10 cm, and the pot position exchanged aperiodically to weaken the impact of the marginal effects. The soil moisture content was maintained at 80% of field capacity until the plants were harvested.

In November 2017, radish seedlings were dug up and divided into three parts of root, stem and leaf, then washed with tap water firstly, followed by deionized water for three times. Finally, weighed the fresh weight and then simmered for 15 min at 110 °C. After that, the tissues of all plants were dried at 75 °C until constant weight, weighed, ground to < 0.149 mm to determine the potassium content of different parts of the radish seedlings, the organic matter and available potassium content in soil [9].

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

**Results and Discussion**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Roots (mg/g)</th>
<th>Stems (mg/g)</th>
<th>Leaves (mg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW</td>
<td>2.392±0.041hi</td>
<td>2.521±0.014gh</td>
<td>1.345±0.033h</td>
</tr>
<tr>
<td>WR</td>
<td>5.024±0.051a</td>
<td>3.747±0.001a</td>
<td>2.718±0.016de</td>
</tr>
<tr>
<td>WG</td>
<td>3.000±0.071cd</td>
<td>3.335±0.033b</td>
<td>2.776±0.025d</td>
</tr>
<tr>
<td>WRG</td>
<td>2.914±0.044de</td>
<td>3.241±0.027c</td>
<td>1.917±0.008g</td>
</tr>
<tr>
<td>MG</td>
<td>3.104±0.046c</td>
<td>3.166±0.021d</td>
<td>2.970±0.022c</td>
</tr>
<tr>
<td>GW</td>
<td>2.482±0.054gh</td>
<td>2.568±0.030g</td>
<td>2.508±0.058f</td>
</tr>
<tr>
<td>GR</td>
<td>3.667±0.051b</td>
<td>3.372±0.014b</td>
<td>3.771±0.014a</td>
</tr>
<tr>
<td>GWR</td>
<td>3.030±0.051cd</td>
<td>2.984±0.012e</td>
<td>2.630±0.080e</td>
</tr>
<tr>
<td>MR</td>
<td>2.275±0.048i</td>
<td>2.128±0.006i</td>
<td>1.859±0.098g</td>
</tr>
<tr>
<td>RW</td>
<td>2.633±0.046f</td>
<td>2.577±0.057g</td>
<td>3.289±0.075b</td>
</tr>
<tr>
<td>RG</td>
<td>2.786±0.087e</td>
<td>2.832±0.012f</td>
<td>3.379±0.058b</td>
</tr>
<tr>
<td>RGW</td>
<td>2.560±0.095fg</td>
<td>2.496±0.021h</td>
<td>3.019±0.007c</td>
</tr>
</tbody>
</table>

Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 17.0 followed by the least significant difference test (p < 0.05). MW=white radish monoculture, WR=white radish intercropping with red radish, WG=white radish intercropping with green radish, WRG=white radish intercropping with red radish and green radish, MG=green radish monoculture, GW=green radish intercropping with white radish, GR=green radish intercropping with red radish, GWR=green radish intercropping with white radish and red radish, MR=red radish monoculture, RW=red radish intercropping with white radish, RG=red radish intercropping with green radish, RGW=red radish intercropping with green radish and white radish. The same as below.

**Potassium Content.** Compared with the white radish monoculture, the potassium content in roots, stems and leaves increased by intercropping under selenium stress (Table 1, p < 0.05). The potassium content in seedlings’ roots and stems of white radish by intercropping with red radish, increased by 110.03% and 48.63% respectively compared to white radish monoculture. The potassium content of leaves intercropping with green radish increased by 106.39% compared to white radish monoculture. Similarly, compared to the red radish monoculture, the potassium content in roots, stems and leaves increased by intercropping. The potassium content in the seedlings’ roots, stems and leaves of red radish by intercropping with green radish, increased by 22.46%, 33.08% and 81.76% respectively compared to red radish monoculture. Also, the potassium content in the seedlings’ roots, stems and leaves of green radish by intercropping with red radish, increased by
18.14%, 6.51% and 26.97% respectively compared to green radish monoculture. However, green radish intercropping with white radish, green radish intercropping with white radish and red radish all made the potassium content decrease.

**Organic Matter Content in Soil** Intercropping significantly decreased the organic matter content in soil compared to monoculture of white radish (Fig. 1, P < 0.05). The organic matter content was ranked as: white radish monoculture > intercropping with green radish > intercropping with red radish > intercropping with green and red radish, which decreased the organic matter content by 4.46%, 25.35% and 32.31% compared to white radish monoculture, respectively. Compared to red radish monoculture, intercropping reduced the soil organic matter content. The order was red radish monoculture > intercropping with green radish > intercropping with white radish > intercropping with green and white radish. And intercropping with green radish, white radish, green and white radish decreased by 1.86%, 17.03% and 24.77% compared to red radish monoculture. But the organic matter content was increased by intercropping with red or white radish compared to green radish monoculture. Intercropping with the three varieties radish made soil organic matter content lower than other treatments.

Fig. 1 Organic matter content in soil. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 17.0 followed by the least significant difference test (p < 0.05).

**Available Potassium Content in Soil** Intercropping significantly increased the available potassium content in soil under Se stress compared to white radish monoculture (Fig. 2, P < 0.05). The soil available potassium content was ranked as: intercropping with red radish > intercropping with red and green radish > intercropping with green radish > white radish monoculture, which increased the available potassium content by 122.70%, 64.14% and 44.76% compared to white radish monoculture, respectively. Similarly, compared to red radish monoculture, the soil available potassium content increased by intercropping. The available potassium content in soil was ranked as: intercropping with white radish > intercropping with green radish > intercropping with white and green radish > red radish monoculture, which increased the soil available potassium content by 177.44%, 153.07% and 104.48% compared to red radish monoculture. The soil available potassium content increased by intercropping with red radish compared to green radish monoculture. On the contrary, intercropping with white radish or white and red radish all made the soil available potassium content reduce. They were reduced by 25.06% and 15.03%, respectively.

Fig. 2 Available potassium content in soil. Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 17.0 followed by the least significant difference test (p < 0.05).
Conclusions

In this study, intercropping increased the potassium content in roots, stems and leaves of radish seedlings and the available potassium content in soil under Se stress compared to white or red radish monoculture. Also, the soil organic matter content decreased by intercropping. But for the green radish, intercropping with white radish decreased soil available potassium content and the potassium content but increased the organic matter content in soil.

Acknowledgements

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References