Effects of pepper tissue extracts on allelopathic effects of different vegetables and soil enzyme activities

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Abstract. Cucumber, cabbage (Brassica oleracea L.), and cowpea as acceptor materials, the effects of four concentrations of (0.01 g/ml, 0.02g/ml, 0.03 g/ml and 0.04g/ml) root, stem and leaf aqueous extracts of pepper on the allelopathy of recipient vegetable and the enzyme activity in rhizosphere soil were studied. The results showed that the allelopathic effect of different tissue extracts of pepper was leaf > root > stem, and the greater the concentration of treatment solution, the stronger the inhibitory effect on the recipient vegetables. According to the value of the comprehensive membership function, the order of the allelopathic effect of different tissue extracts of capsicum on the recipient vegetables is cucumber > cabbage > cowpea. The concentration of the pepper extract, the extraction site, and the difference of the acceptor materials can affect the soil enzyme activity. The urease activity increases with the increase of the concentration, and the catalase and sucrase activities increase first and then decrease.

1. Introduction
Capsicum annuum L. is a plant of the genus Capsicum, which is widely grown all over the world. However, there is a serious continuous cropping disorder in the production of pepper; one of the reasons is the allelopathic effect of pepper [1]. Allelopathy is a direct or indirect, beneficial or unfavorable interaction of plants (including microorganisms) with other plants or microorganisms in the environment [2]. One of the ways of allelopathic effects is to directly or indirectly affect soil enzyme activity through plant-derived allelochemicals. Lin RY [3] studied the rhizosphere soil enzymes of different allelopathic potential rice, and found that allelopathic rice inhibited the activities of dehydrogenase, peroxidase, polyphenol oxidase, urease and cellulolytic enzymes in rhizosphere soil.

In this experiment, the enzyme activities of rhizosphere soil of various vegetable receptors were studied by different concentrations of tissue extracts from pepper. The aim of this study is to reveal the changes of the enzyme activities in the rhizosphere soil of the recipient crops, and to provide a theoretical basis for the analysis of the allelopathic mechanism and rational formulation of rotation, intercropping and intercropping of pepper and other vegetables.

2. Materials and methods

2.1 Plant materials
The donor material is pepper (spicy long, early maturing, hybrid generation), and the acceptor materials are cucumber (Jinyan No. 4), cowpea (Chengjiang No. 7), and cabbage (Brassica oleracea L.).
2.2 Experiment design

2.2.1 Preparation of the extract. The pepper plants grown for about 60 days were collected, washed with water, separated by roots, stems and leaves, and air-dried, cut into 2 cm sections, and pulverized for use. The pulverized pepper roots, stems and leaves samples were weighed 20 g each, placed in 4 beakers, 500 mL distilled water was added, the sealed bottle mouth was stored for 2 d, double filtered, the supernatant was taken as mother liquor, sealed and stored in stand by at 4 °C. At the time of the test, each mother liquid was diluted with distilled water to a treatment liquid having a concentration of 0.01, 0.02, 0.03, and 0.04 g/mL.

2.2.2 Experiment design. Cowpea, cabbage and cucumber seeds were planted in 13×13cm pots, one per pot, and the soil was pasted without vegetables and pests. Treating different pepper extracts when the seedlings were 45 days. 6 pots of each vegetable were treated with a concentration of 0.01, 0.02, 0.03, 0.04 g/mL, and the same amount of water was used as a control. Watering every 7 days, each time pouring 100 mL of different concentrations of pepper extract, and measuring the plant height and stem diameter of different treated plants, 4 times in succession, taking soil sample after one month of treatment. Determination of soil catalase [4], sucrose [5], urease activity [6].

2.3 Statistical methods

The allelopathic effect of the extract on the receptor is expressed by the allelopathy effect index (RI). The RI values were calculated for plant height and stem diameter, respectively, using the method of Williamson [7]:

\[
RI = \frac{T}{C} - 1
\]

Where: C is the control value, T is the treatment value, and RI is the allelopathy effect index.

Inductive membership function value \(X(\text{ij})\) [8]: Calculated by the method of fuzzy math membership function, the formula is:

\[
X(\text{ij}) = \frac{X_{ij} - X_{\text{min}}}{X_{\text{max}} - X_{\text{min}}}
\]

\(X_{\text{ij}}\)-represents the allelic membership value of the i-type j indicator,

\(X_{ij}\)-represents the measured value of the i-type j indicator,

\(X_{\text{max}}\) and \(X_{\text{min}}\) are the maximum and minimum values of the indicator.

All data were analyzed with statistical software SPSS version 22.0 (IBM Corporation). Comparisons of the means used the least significant difference (LSD) at \(P \leq 0.05\).

3. Results

3.1 Allelopathic effects of extracts from different tissues of pepper on recipient vegetables

It can be seen from Table 1 that the allelopathic effects of the extracts of pepper roots, stems and leaves on the same vegetable are different, and the allelopathic responses of different vegetables to the same tissue extract are also different. The greater the concentration of the treatment liquid, the more the vegetables are the stronger the allelopathic effect. From the value of the comprehensive membership function, compared with the control, the root and stem 0.01g/mL treatment value is higher than the control, which has a certain promoting effect on the growth of the recipient vegetable, leaf treatment inhibited all three vegetables; The different allelopathic effects of pepper extracts on cucumber were the strongest, and the comprehensive membership function was the smallest, followed by cabbage, and again the cowpea. The allelopathic effects of different tissue extracts of pepper were leaf > root > stem.
Table 1. Integrated allelopathic effects of extracts from different tissues of pepper on allelopathic effects of recipient vegetables

| Different tissues | Extract concentration (g/mL) | Comprehensive evaluation value | Cabbage | Cowpea | Cucumber |
|-------------------|------------------------------|--------------------------------|---------|--------|----------|
| Root              | CK                           | 3.00                           | 2.99    | 2.74   |
|                   | 0.01                         | 3.89                           | 4.02    | 3.75   |
|                   | 0.02                         | 3.43                           | 3.71    | 2.96   |
|                   | 0.03                         | 2.99                           | 3.69    | 2.09   |
|                   | 0.04                         | 2.61                           | 3.47    | 1.86   |
|                   | Total                        | 12.92                          | 14.89   | 10.66  |
| Stem              | 0.01                         | 3.49                           | 3.86    | 3.27   |
|                   | 0.02                         | 3.27                           | 3.69    | 3.26   |
|                   | 0.03                         | 2.73                           | 3.59    | 2.88   |
|                   | 0.04                         | 2.47                           | 3.52    | 2.56   |
|                   | Total                        | 11.96                          | 14.66   | 11.97  |
| Leaf              | 0.01                         | 2.76                           | 3.75    | 2.38   |
|                   | 0.02                         | 2.51                           | 3.14    | 1.79   |
|                   | 0.03                         | 2.06                           | 1.97    | 0.43   |
|                   | 0.04                         | 0.28                           | 0.12    | 0.01   |
|                   | Total                        | 7.6                            | 8.98    | 4.61   |
|                   | Total                        | 35.5                           | 41.52   | 29.98  |

3.2 Effect of Capsicum Extract on Urease Activity of Rhizosphere of Different Vegetables

Urease activity can reflect the conversion of soil organic nitrogen. It can be seen from Table 2 that with the increase of the concentration of pepper extract, the urease activity in the rhizosphere of the three vegetable soils increased compared with the control, and it was significantly different from the control, but the concentration effects of different vegetables were different. Among them, the treatment of pepper leaves at 0.04 g/ml concentration had the greatest effect on cabbage, cowpea and cucumber, and increased by 149%, 247.7% and 61.2%, respectively, compared with the control urease activity.

Table 2. Effect of Capsicum Extract on Urease Activity of Different Vegetables

| Different tissues | Extract concentration (g/mL) | Cabbage | Cowpea | Cucumber |
|-------------------|------------------------------|---------|--------|----------|
| Root              | CK                           | 0.5422<sup>bA</sup> | 0.0287<sup>dD</sup> | 0.968<sup>cC</sup> |
|                   | 0.01                         | 0.6643<sup>bB</sup> | 0.0343<sup>cC</sup> | 1.3179<sup>hB</sup> |
|                   | 0.02                         | 0.7644<sup>aA</sup> | 0.0391<sup>bB</sup> | 1.4354<sup>aA</sup> |
|                   | 0.03                         | 0.7873<sup>aA</sup> | 0.0388<sup>bB</sup> | 1.4588<sup>aA</sup> |
|                   | 0.04                         | 0.7993<sup>aA</sup> | 0.0442<sup>aA</sup> | 1.4687<sup>aA</sup> |
| Stem              | CK                           | 0.5422<sup>bA</sup> | 0.0287<sup>hC</sup> | 0.968<sup>bB</sup> |
|                   | 0.01                         | 0.5517<sup>bA</sup> | 0.0312<sup>abC</sup> | 1.0344<sup>hB</sup> |
|                   | 0.02                         | 0.5669<sup>abA</sup> | 0.0341<sup>bBC</sup> | 1.3235<sup>aA</sup> |
|                   | 0.03                         | 0.5769<sup>abA</sup> | 0.0385<sup>abA</sup> | 1.4381<sup>aA</sup> |
|                   | 0.04                         | 0.5993<sup>aA</sup> | 0.0417<sup>aA</sup> | 1.4501<sup>aA</sup> |
| Leaf              | CK                           | 0.5422<sup>bC</sup> | 0.0287<sup>bcC</sup> | 0.968<sup>bB</sup> |
|                   | 0.01                         | 0.7459<sup>bDBC</sup> | 0.0823<sup>bB</sup> | 1.4666<sup>aA</sup> |
|                   | 0.02                         | 0.8582<sup>bBC</sup> | 0.0891<sup>bABC</sup> | 1.5418<sup>abA</sup> |
|                   | 0.03                         | 1.0644<sup>abAB</sup> | 0.093<sup>abAB</sup> | 1.5511<sup>bAB</sup> |
|                   | 0.04                         | 1.3537<sup>aA</sup> | 0.0988<sup>aA</sup> | 1.5609<sup>aA</sup> |

Note: Little letters indicate significant differences at $P<0.01$ and $P<0.05$ level respectively. The same below.
### 3.3 Effect of Capsicum Extract on Catalase Activity of Different Vegetables

Catalase activity is closely related to the rate of transformation of soil organic matter. It can be seen from Table 3 that as the concentration of the extract increases, the activity of catalase increases first and then decreases, and the effect varies depending on the recipient crop. Among them, the effects on cabbage and cucumber did not reach significant difference, while cowpea reached the difference significantly under the four concentrations of leaf extract, reaching the maximum at 0.02g/ml, which was 9.59% higher than the control.

| Different tissues | Extract concentration (g/mL) | Cabbage | Cowpea | Cucumber |
|-------------------|-------------------------------|---------|--------|---------|
| Root              | CK                            | 1.0211A | 1.1051B | 1.3521A |
|                   | 0.01                          | 1.0358A | 1.1175abA | 1.3647A |
|                   | 0.02                          | 1.0398A | 1.1245abA | 1.3673A |
|                   | 0.03                          | 1.0351A | 1.1285A  | 1.3421A |
|                   | 0.04                          | 1.0231A | 1.1068abA | 1.3533A |
| Stem              | CK                            | 1.0211A | 1.1051B  | 1.3521A |
|                   | 0.01                          | 1.0215A | 1.115abAb | 1.3531A |
|                   | 0.02                          | 1.1338A | 1.1221aA  | 1.3542A |
|                   | 0.03                          | 1.1232A | 1.1152abAB | 1.3524A |
|                   | 0.04                          | 1.1202A | 1.117aAb  | 1.3505A |
| Leaf              | CK                            | 1.0211A | 1.1051bBC | 1.3521A |
|                   | 0.01                          | 1.0344A | 1.2012bA  | 1.3567A |
|                   | 0.02                          | 1.0392A | 1.2112aA  | 1.3584A |
|                   | 0.03                          | 1.0228A | 1.1064abBC | 1.3497A |
|                   | 0.04                          | 1.0218A | 1.0944cA  | 1.3432aA |

### 3.4 Effect of Capsicum Extract on Sucrose Activity of Different Vegetables

Sucrase can promote the hydrolysis of sucrose to produce glucose and fructose, which plays an important role in increasing the soluble nutrients in the soil. It can be seen from Table 4 that as the concentration of the extract increases, the activity of the sucrase decreases, and the receptors are different. The effect of the pepper extract on the sucrase is different. Cabbage was significantly different from the control in the extract of pepper roots and stems, especially the 0.04 g/ml pepper root extract, the enzyme activity decreased by 3.9% compared with the control; Under the treatment of leaf extract, the difference is not significant. In contrast, cowpea is not significantly different under the treatment of rhizome extracts. On the contrary, under the treatment of leaves, the activity of sucrase increased first and then decreased, at the concentration of 0.02 g/ml, the maximum increase was 2.9%. There was no significant difference in the treatment of cucumber with stalk extract; in the treatment of roots and leaves, the activity of sucrase decreased with increasing concentration.

| Different tissues | Extract concentration (g/mL) | Cabbage | Cowpea | Cucumber |
|-------------------|-------------------------------|---------|--------|---------|
| Root              | CK                            | 3.4776AB | 5.4762A | 8.4776A |
|                   | 0.01                          | 3.5121B | 5.7589A | 8.7786abA |
|                   | 0.02                          | 3.5265A | 5.5941A | 8.8213B |
|                   | 0.03                          | 3.4963AB | 5.5894A | 8.7327abA |
|                   | 0.04                          | 3.3769C | 5.4654A | 8.3681cA |
| Stem              | CK                            | 3.4776AB | 5.476A  | 8.4772A |
|                   | 0.01                          | 3.4971A | 5.5291A | 8.4964A |
|                   | 0.02                          | 3.4978A | 5.5211A | 8.4811A |
4. Conclusions
Different pepper tissue extracts have concentration effects on cucumber, cowpea and cabbage. The greater the concentration, the stronger the inhibition, but the different sensitivity of the recipient crop. The effect of the extracts from the three parts on the recipient vegetables was leaf > root > stem.

Urease activity increases with increasing concentration of pepper extract. It indicates that the pepper extract contains certain chemicals, which can affect the activity of urease, and the concentration of the extract is larger, the more the substance content, the greater the influence. The activity of catalase and sucrase increased first and then decreased, indicating that the low concentration of the extract is beneficial to the rhizosphere of the plant. Catalase can decompose the peroxide which is toxic to the organism, thus avoiding Peroxide accumulation in the soil and damage to the plant body. The high activity of sucrase indicates that the soil has good biological activity and the soil fertility is high. High concentrations of extract may affect the activity of the enzyme and affect the normal decomposition of soil nutrients.

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