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Growth disturbance of extracts from several crops straw (residue) on *Ageratina adenophora* and biological-control implications in hazardous weed invasion for eco-restoration

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ABSTRACT

Laboratory biological simulation experiment was conducted to investigate growth disturbance of high, moderate, low concentration of aqueous extracts (i.e. the original extracts with a solid–liquid ratio of 1:40 g mL^{-1} and its 5 times diluents and 25 times diluents) from several crops straw (residue) on *Ageratina adenophora*, a worldwide notorious invasive weed. The results showed: (a) aqueous extracts from several crops straw (residue) brought about different impacts on the single index for germination and growth of *A. adenophora*, e.g., high concentration of aqueous extracts from *Brassica oleracea* waste leaves showed a strong inhibition against the germination rate (*GR*) and germination index (*GI*) of *A. adenophora*, while high concentration of aqueous extracts from *Vicia cracca* straw showed a strong inhibition against radicle length (*RL*) and hypocotyl length (*HL*) of *A. adenophora*; (b) high concentration of aqueous extracts from *B. oleracea* waste leaves and high, moderate and low concentration of aqueous extracts from *Oryza sativa* straw and *Triticum aestivum* straw showed rather strong synthetic effects (inhibition) on *GR* and *GI* of *A. adenophora*, which could be chosen for the control over the seeds germination of *A. adenophora*; (c) high and moderate concentrations of aqueous extracts from *V. cracca* straw, high concentration of aqueous extracts from *B. campestris* waste leaves, and moderate and low concentrations of aqueous extracts from *O. sativa* straw and *T. aestivum* straw showed rather strong synthetic effects (inhibition) on *RL* and *HL* of *A. adenophora*, which could be selected as ideal materials for the control over the seedlings growth of *A. adenophora*; and (d) high concentrations of aqueous extracts from *V. cracca* straw, *B. oleracea* waste leaves and *B. campestris* waste leaves, and high, moderate and low concentrations of aqueous extracts from *O. sativa* straw and *T. aestivum* straw showed rather strong synthetic effects (inhibition) on *GR*, *GI*, *RL* and *HL* of *A. adenophora*, which could be selected as ideal materials for the control over the seeds germination and seedlings growth of *A. adenophora*. Thus, this study would provide a theoretic guidance and technical support for the resources utilization of crops straw (residue) and the prevention and control over invasive weeds as well.

1. Introduction

Ageratina adenophora, a worldwide notorious invasive weed, spreads over agro-ecosystem, which has greatly threatened regional bio-diversity, ecological safety and environment health (Wan et al., 2010; Wang and Wang, 2006; Xie et al., 2001), featured with great hidden danger; meanwhile, crops straw (residue) was abandoned or burned in the agro-ecosystem as waste and thus brings about potential pollution afterwards, which could possibly have a direct impact or potential damage on regional agriculture development and ecological sustainable development (Liu et al., 2008; Cao et al., 2008; Duan et al., 2004). Thus, it would be a good way to turn the waste into wealth if the abandoned crops straw (residue) could be used as a way for the prevention and control over invasive weeds. In this paper, based on lab biological

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simulation experiment, the growth disturbance of several crops straw (residue) on the invasive *A. adenophora* was investigated, aimed at the exploration on an ideal material and technique for the effective prevention and control over the seeds germination and seedlings growth of *A. adenophora*, which would be of great importance in guiding the resources utilization of crops straw (residue) and the prevention and control over *A. adenophora* as well.

2. Materials and methods

2.1. Materials collection and pre-treatment

Seven commonly seen crops straw (residue), i.e., the straw of *Oryza sativa, Zea mays*, *Triticum aestivum*, *Pisum sativum*, and *Vicia cracca*, and waste leaves of *Brassica campestris* and *Brassica oleracea*, were selected as the experiment donors, which were all collected in October, 2011 in the crop field at Duanqi village, Shangsuan, Jinning County, Kunming, where *A. adenophora* was characterized with serious invasion. The materials collected were dried with the wind power in the shade place and grinded as powder for further use.

A. adenophora seeds were selected as the experiment receptors, which were collected at Huma Hill bordering the 3rd Ring Road East of Kunming city in April, 2012. Before experiment, the full seeds of *A. adenophora* with almost the same size and rather dark in color were selected and sterilized with 0.1% sodium hypochlorite solution for 10 min, and watered 3 times with distilled water for further use.

2.2. Experiment design and observation

2.2.1. The preparation of aqueous extracts

1.5 g of powder sample of one single crop straw (residue) was selected to be put into a 150 ml conical flask, filled with distilled water with a solid–liquid ratio of 1:40 g mL^{-1}, and put into the oscillator to process for 30 min after seal, then filtered with qualitative filter paper after placing for 2 h, thus the filtered liquid, namely, the original liquid of the aqueous extract (1×), was obtained, and then part of 1× was selected to make 5 times diluents (5×) and 25 times diluents (25×).

2.2.2. Experiment design and observation

In this paper, lab biological simulation was conducted, with Petri dish method for both the seeds germination simulation experiment and seedlings growth simulation experiment.

Design and observation of seeds germination simulation experiment: 56 glass Petri dishes with 10 cm in diameter (washed with distilled water and dried in the dryer at a temperature of 80 °C) were selected and divided into 7 groups, with 8 dishes for each group; 2 pieces of qualitative filter paper with 9 cm in diameter were place in the bottom of each Petri dish; 7 groups of Petri dishes with filter paper inside were filled with aqueous extracts of crops straw (residue) with different concentrations respectively (each group of Petri dish was filled with a certain crops straw (residue)). Specifically speaking, there were 2 Petri dishes for 1×, 5× and 25×, respectively, and another 2 Petri dishes filled with distilled water as CK; in each Petri dish, 3 ml of liquid was added and 30 seeds of *A. adenophora* were evenly placed in each Petri dish (3 even sectors, with 10 seeds in each sector); the Petri dishes with seeds well placed were put into the incubator with constant temperature (the temperature of 25 °C, humidity of 80%) for a 7 d dark culture. During the culture period, the number of germinated seeds was observed and recorded every 1 d (with radicle breaking through seed coat as the standard for germination); meanwhile, distilled water was added into the Petri dishes to keep humidity. The whole experiment was repeated 3 times.

Design and observation of seedlings growth simulation experiment: this experiment was a little different from the seeds germination simulation experiment mentioned above. The difference lied in seeds presprouting, namely, a number of the seeds of *A. adenophora* were placed in the Petri dish with qualitative filter paper as the germinating bed for presprouting. The germinated seeds were selected as samples for seedlings growth simulation experiment while the design, culture media and added material were the same to the seeds germination simulation experiment. At the 7th day of seedlings growth simulation experiment, radicle length (*RL*) and hypocotyl length (*HL*) of receptors' seedlings were measured. The whole experiment was repeated 3 times.

2.3. Tested indexes and calculation methods

2.3.1. Indexes for seeds germination and seedlings growth

As for the seeds germination, germination rate (*GR*) and germination index (*GI*) were adopted as the tested indexes, with the calculation formula as below respectively:

$$GR = \frac{\text{total germinated seeds}}{\text{total seeds for experiment}} \times 100\%$$

$$GI = \sum \frac{Gt}{Dt}$$

where *Gt* is the germination number in the day of *t*; *Dt* is the accordingly germination days.

Seedling growth indexes would be directly gained through measuring the *RL* and *HL* of receptors' seedlings.

SPSS 11.5 was adopted for the calculation of the mean and standard error, and the analysis of significant difference for the tested indexes for seeds germination and seedlings growth under different experiments.

2.3.2. Allelopathic effect indexes

Allelopathic effect indexes include response index (*RI*) for single index and synthetic effect index (*SEI*) for multiple indexes.

RI is calculated according to the following formula:

$$RI = 1 - \frac{C}{T} \quad (\text{when } T \geq C) \quad \text{or} \quad RI = \frac{T}{C} - 1 \quad (\text{when } T < C)$$

where *C* is the check value, *T* is the treatment value. When $RI > 0$, it is described as promoting effect, while when $RI < 0$, it is described as inhibitory effect, the bigger the absolute value of *RI*, the greater the potential of allelopathic effects (promotion or inhibition) is.

SEI is the arithmetic mean of *RI* for the same donor on multiple (two) testing items of receptors. *SEI* can be positive and negative, the positive value means promotion, while negative value inhibition, with 0 as CK value.

3. Results

3.1. The impact of water-soluble materials of donors on the single index for seeds germination and seedlings growth of A. adenophora

3.1.1. The impact of water-soluble materials of donors on the single index for seeds germination of A. adenophora

The statistics results of single tested index for the seeds germination simulation experiment were shown in Table 1. It showed that aqueous extracts from 7 crops straw (residue) were characterized with universal impacts on the single index for seeds germination of *A. adenophora* as shown in Table 1.