Activity of Environmentally Friendly Plant-derived Agents with Pollution Control Effect

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Abstract. In agricultural production, a large number of chemical pesticides are used, causing environmental pollution. The development of plant-derived pesticides has attracted worldwide attention. 10 plant extracts were selected to study the insecticidal activity of an aphid. The results showed that Acorus tatarinowii had the strongest insecticidal activity on aphid when the concentration was 50mg/mL, and the corrected mortality was 94.73%, followed by Conidium monnieri. Acorus tatarinowii and Cnidium monnieri are worthy of exploitation and utilization.

Keywords: Plant Extract, Aphis gossypii Glover, Insecticidal Activity.

1. Introduction

Chemical pesticides are the main means of preventing and controlling all kinds of pests in agricultural production. They are important measures to improve the yield and quality of various crops and play a positive role in ensuring the stable growth of agriculture. However, in the process of using pesticides, the air, water, soil and other environmental pollution. For many years, the uncontrolled and frequent use of chemical pesticides in agricultural production has not only caused pollution to the environment, but also posed a threat to human health. The long-term use of chemical pesticides has destroyed the ecosystem, made the control objects resistant to drugs, killed beneficial organisms, and made them lose their due control effect [1]. It is urgent to develop new pesticide which has good compatibility with environment and is not easy to induce drug resistance [2].

As an important biological pesticide, plant-derived pesticides have natural active components rather than synthetic chemicals [3]. After being applied, they have a smooth way of degradation in nature with little environmental pollution [4]. Plant-derived pesticides have many insecticidal components and unique action modes, which make it difficult for pests to develop resistance. Low toxicity to humans, animals and natural enemies, and relatively low development and use costs [5]. China is rich in plant resources and has a long history of using plants to kill pests. There is a solid foundation for the development of plant-derived pesticides. In recent years, reports on plant extracts have been increasing year by year, and the research on effective components used to control pests has also been more and more in-depth [6].
The purpose of this study is to screen out plant extracts with good insecticidal activity and good environmental compatibility, so as to provide theoretical basis for the development of new pesticides, thus reducing the use of chemical pesticides and environmental pollution caused by chemical pesticides.

2. Materials and methods

2.1. Experimental insects

Aphids belonging to Insecta and Hemiptera. There are more than 4000 kinds of aphids known in the world, which are widely distributed all over the world and harm various cash crops and are important agricultural pests [7]. In this study, *Aphis gossypii* Glover was selected as the experimental insect. After identification, aphids continued to proliferate in the laboratory. After breeding for 2 generations, the same size wingless aphids were selected for experiment.

2.2. Experimental plants

In this study, 10 kinds of plants with insecticidal activity were selected for the experiment. The family, species name and test parts used by the plants are shown in Table 1.

| Family         | Plant’s species                  | Tested parts         |
|----------------|----------------------------------|----------------------|
| Rosaceae       | *Agrimonia pilosa* Ldb.          | Overground part      |
| Asclepiadaceae | *Cynanchum glaucescens* (Decne.) Hand. -Mazz. | Root stalk          |
| Zingiberaceae  | *Kaempferia galanga* Linn.       | Root stalk           |
| Simaroubaceae  | *Brucea javanica* (Linn.) Merr.  | Seed                 |
| Zingiberaceae  | *Curcuma longa* L.               | Dried root           |
| Caprifoliaceae | *Lonicera japonica* Thunb        | Stalk                |
| Celastraceae   | *Tripterygium wilfordii* Hook. f. | Root                 |
| Umbelliferae   | *Cnidium monnieri* (L.) Cuss.    | Seed                 |
| Menispermaceae | *Sinomenium acutum* (Thunb.) Rehd. et Wils. | Stalk               |
| Araceae        | *Acorus tatarinowii* Schott.     | Root stalk           |

The genus name and species name are used in plant scientific name mentioned below.

2.3. Extraction of plant active components

The effective components of plants were extracted by decocting method. Firstly, 10 kinds of test plants were dried thoroughly, and then ground with high-speed pulverizer respectively to make coarse powder. Weigh 30g powder, add 300mL distilled water, heat it to boil, and then gently heat it for 30min. Filter it with gauze, and keep the volume constant to 300mL [8]. At this time, the concentration of the prepared plant extract was 100mg/mL, and it was used as mother liquor. The mother liquor of each plant extract was diluted into 50mg/mL, 25mg/mL, 12.5mg/mL, 6.25mg/mL and 3.125mg/mL by two-fold dilution with distilled water, respectively. Five different concentration gradients were used for standby application [9].

2.4. Determination of insecticidal activity

50 aphids were selected under the dissecting microscope. Soak the leaves in the pre-prepared liquid for 5s, take out the leaves and absorb the excess liquid at the leaf edge with absorbent paper. Together with 50 aphids, they were placed in a 9cm petri dish and sealed with plastic wrap to prevent aphids from escaping. Then use insect needle to tie several air holes on the plastic wrap. Set 3 groups for repetition and control with clean water (CK). Death was observed 24 hours later under the dissecting microscope. During the examination, the insect body was gently plucked with tweezers. If the insect body fell and...
could not crawl, it would be considered dead. The death situation was recorded, and the corrected mortality and toxicity regression equation were calculated [10].

3. Results and analysis

3.1. Insecticidal activities of 10 plant extracts on *Aphis gossypii* Glover

After 24h treatment of *Aphis gossypii* Glover with 10 plant extracts of different concentrations, the death rate and corrected death rate of aphids were obtained, as shown in Table 2. The results showed that 10 kinds of plant extracts with different concentrations had certain insecticidal effect on *Aphis gossypii* Glover, and the insecticidal effect was improved with the increase of concentration. When the concentration of the extract was 50mg/mL, the insecticidal effect was the best.

| Plant’s species                  | Corrective mortality (%) |
|----------------------------------|--------------------------|
|                                  | 50mg/mL | 25mg/mL | 12.5mg/mL | 6.25mg/mL | 3.125mg/mL |
| *Agrimonia pilosa*              | 57.84a  | 47.30ab | 44.67ab   | 23.58     | 10.41b      |
| *Cynanchum glaucescens*         | 68.38a  | 65.74a  | 49.93ab   | 42.03     | 44.66b      |
| *Kaempferia galanga*            | 71.01a  | 65.74a  | 36.76b    | 31.49     | 15.68c      |
| *Bupleurum japonicum*           | 57.84a  | 47.30a  | 42.03a    | 39.39     | 36.76a      |
| *Curcuma longa*                 | 55.20a  | 47.30a  | 44.66a    | 39.39     | 34.12a      |
| *Lonicera japonica*             | 84.19a  | 52.57b  | 49.93bc   | 36.76bc   | 31.49c      |
| *Tripterygium wilfordii*        | 73.65a  | 71.01a  | 49.93b    | 36.76b    | 34.12b      |
| *Cnidium monnieri*              | 84.19a  | 78.92ab | 65.74b    | 60.47b    | 57.84b      |
| *Sinomenium acutum*             | 78.92a  | 73.65a  | 68.38a    | 57.84a    | 44.66a      |
| *Acorus tatarinowii*            | 94.73a  | 92.09a  | 86.82a    | 84.19a    | 47.30b      |

Note: the lowercase letter represents the significance of the difference when P≤0.05, the same as below.

Among the 10 plant extracts, *Acorus tatarinowii* had the best insecticidal effect, which was much higher than that of other plant extracts. When the concentration of extracts was 50mg/mL, the insecticidal effects of extracts *Acorus tatarinowii*, *Lonicera japonica* and *Cnidium monnieri* of the three plants with better insecticidal activities were shown in Figure 1.

![Figure 1. Insecticidal activity of extracts of *Acorus tatarinowii*, *Lonicera japonica* and *Cnidium monnieri* on aphids](image-url)
When the concentration of Acorus tatarinowii extract was 50mg/mL, the corrected mortality of aphids was 94.73% with the highest insecticidal activity. Secondly, the corrected mortality was 92.09% at 25mg/mL. At these two concentrations, the corrected mortality of Acorus tatarinowii extract was higher than 90%, showing better insecticidal activity. Again, when the concentration of Acorus tatarinowii extract was 12.5mg/mL, the corrected mortality was 86.82%. Even at a lower concentration of 6.25mg/mL, the corrected mortality was 84.19%, the same as that of Cnidium monnieri and Lonicera japonica at a higher concentration of 50mg/mL. However, when the concentration of extraction solution was 3.125 mg/mL, the corrected mortality was only 47.30%, the prevention and control effect of aphids was relatively low, indicating that the crude extract of Acorus tatarinowii with a low concentration would significantly reduce the prevention and control effect of aphids, while the solvent with a high concentration would maintain a relatively high prevention and control effect. On the whole, among the 10 plant extracts, Acorus tatarinowii has the best insecticidal effect, which is worthy of further research and development.

![Figure 2. Insecticidal activity of extracts of Lonicera japonica and Kaempferia galanga on aphids](image)

The insecticidal activity of Lonicera japonica and Kaempferia galanga are shown in Figure 2. Among the extracts of 10 kinds of plants, the insecticidal effect of Lonicera japonica and Kaempferia galanga was significantly improved with the increase of the concentration. The corrected mortality was 31.49% at the concentration of 3.125mg/mL and 84.19% at the concentration of 50mg/mL. The corrected mortality was 15.68% when the extract concentration was 3.125mg/mL, and 71.01% when the extract concentration was 50mg/mL. Lonicera japonica and Kaempferia galanga could increase the concentration for further study.

The corrected mortality of Agrimonia pilosa, Brucea javanica and Curcuma longa at 50 mg/mL were 57.84%, 57.84% and 55.20% respectively, all lower than 60%. This indicates that the insecticidal activities of Agrimonia pilosa, Brucea javanica and Curcuma longa on aphids are weak, and it is not recommended to study further.

3.2. Toxicity of 10 plant extracts to Aphis gossypii Glover

The toxicity regression equation of 10 plant extracts on Aphis gossypii Glover are shown in Table 3. And the median lethal concentration of 10 plant extracts on Aphis gossypii Glover are shown in Figure 3. All 10 plant extracts had different degrees of toxicity on aphids, according to the principle that the smaller LC$_{50}$ was, the better the toxicity effect was. The extract of Acorus tatarinowii was the most toxic.
to *Aphis gossypii* Glover, with LC₅₀ of 0.07mg/mL. The LC₅₀ of *Cnidium monnieri* extract was 0.55mg/mL.

| Plant’s species       | Toxicity regression equation |
|-----------------------|------------------------------|
| Agrimonia pilosa      | \( Y=4.1831+0.3718X \)        |
| Cynanchum glaucescens | \( Y=4.3001+0.4211X \)        |
| Kaempferia galanga    | \( Y=4.3877+0.3995X \)        |
| Brucea javanica       | \( Y=4.5029+0.3291X \)        |
| Curcuma longa         | \( Y=4.4913+0.3281X \)        |
| Lonicera japonica     | \( Y=4.6091+0.4010X \)        |
| Tripterygium wilfordii| \( Y=4.6610+0.3886X \)        |
| Cnidium monnieri      | \( Y=5.1028+0.3937X \)        |
| Sinomenium acutum     | \( Y=4.9728+0.3865X \)        |
| Acorus tatarinowii    | \( Y=5.5116+0.4599X \)        |

The order of toxicity of 10 plant extracts to *Aphis gossypii* Glover was as follows: Acorus tatarinowii > Cnidium monnieri > Sinomenium acutum > Tripterygium wilfordii > Lonicera japonica > Brucea javanica, Kaempferia galanga > Curcuma longa > Cynanchum glaucescens > Agrimonia pilosa.

**Figure 3.** The median lethal concentration of 10 plant extracts on *Aphis gossypii* Glover

**4. Conclusion**

The insecticidal activity of 10 plant extracts selected in this study on aphids showed that *Acorus tatarinowii* had the best insecticidal activity, followed by *Cnidium monnieri*, which was worth developing and utilizing as a plant source. In the experiment, the mass concentration of the sample was crude extract, while the content of effective insecticidal active components in the plant was very low. If further purified, the insecticidal activity of the sample might be further improved.

The insecticidal activities of plant extracts and their components are not well studied and have great development and utilization value. Quite a number of plant secondary metabolites of pests may have strong biological activity, the factors that make up the plant insect resistance in occupies an important position, is the study of botanical pesticide based on chemistry, ecology, from rich plant resources enable people to research and develop environmentally friendly pesticide, and thus to minimize the use of chemical pesticides and reduce the environmental pollution caused by chemical pesticides.
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References
[1] Li Xiaofei, Xu Zheng. Progress in studies on plant derived fungicides. Southern Agriculture, 2018, 12 (13): 40 - 42.
[2] Zhou Zhidie, Li Xiaogang, Li Guiyin. Status and development trend of plant-derived pesticides. Guangdong Chemical Industry, 2013, 19 (40): 68 - 69.
[3] Namu Han, Li Caifeng, Tang Jian, Zhang Chunhong, Yang Zhiguo. Research progress of plant pesticide resources in Inner Mongolia. Chinese Modern Traditional Medicine, 2017, 19 (7): 907 - 933.
[4] Wang Junhao. Exploring the status quo, problems and suggestions of scientific and technological development of plant extract industry [J]. Friends of farmers. 2018 (12): 17.
[5] Cai Puying, Mao Shaoming, Sun Hanzhou. Progress in studies on plant derived insecticides. Pesticides, 2014, 53 (8): 547 - 551.
[6] Ge Yang, Sun Jiahui, Wang Tielin, Shi Wangpeng, Yuan Qingjun, Guo Lanping. Advances in the application of medicinal plants in the prevention and control of Noctuid moth in grassland. Journal of plant protection.2020, 4: 706 - 718.
[7] Tang Pinghua, Chen Guoping, Zhu Mingku. Advances in aphid control technology. Plant protection, 2013, 39 (2): 5 - 12.
[8] Song Shanshan, Wang Hui, Wang Zhangxun, Wang Xin. Effects of extracts of Several Traditional Chinese medicines on the biological activity of Mites and its main detoxifying metabolic enzymes. Plant protection, 2017, 43 (05): 79 - 86.
[9] Su Xiu, Ma Liangjin. Insecticidal Activity of Extracts from Husk of Carya cathayensis. Journal of northeast forestry university, 2010, 11: 128 - 129.
[10] Zhang Jianying, Yang Guijun, Yu Youzhi, Yang Le. Antifeeding and insecticidal activity of ethanol extracts from 11 plants against Aphis sp. of Lycium barbarum. Journal of Agricultural Sciences, 2007, 3: 21 - 23.