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# A study on the interactions among several plant secondary compounds and aphids

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**Abstract**—The research, focused on the specific interactions among seven plant secondary compounds and aphids, was carried out and the preliminary results showed: (1) "T-typed tube method" was regarded as the best method compared with others designed to observe the interactions. (2) Cabbage aphid was able to be attracted by laurolene while it was not susceptible to $\alpha$-pinene, $\beta$-pinene and diamylene. (3) Gossypol, a major secondary substance in cotton, was able to be implicated as feeding attractant to cotton aphid. (4) Rutin might be implicated repellent to cotton aphid.

**Keywords:** plant secondary compound; aphid; chemical ecology.

## INTRODUCTION

Cotton is an important economic agricultural crop. During its growth period, cotton is infested by many insect pests, especially by cotton aphid. In China, cotton aphid depredates large amount of cotton seedlings especially in the area of Yellow River, which worsen fusarium wilt. Meanwhile, the probability of leaf formation and the growth of root may decrease. In the case of seriously devastated, cotton sapling may die off so that cotton buds and bolls shed ahead of time. This damage results in decrease of cotton production. So how to prevent the cotton aphid devastation has become a urgent problem to study and discuss.

In the long history of co-evolution, insect pests gradually get the habit of eating relevant plant. In order to repel insect feeding, a plant may not necessarily have to produce a substance that is highly toxic to the insect. It may be sufficient to produce a compound that is unpleasant or distasteful (Harborne, 1982). It can be done either by reducing the edibility or nutritive status of the leaves or more positively by introducing a toxin, an unpleasant taste or an offensive odor into the leaf tissue. Some compounds such as tannins were studied on the interaction with insect pests. C. S. Wang and S. W. Dong (1986) reported that the more a cotton contained tannins, the strongly it repelled two-spotted spider mite. But so far, at least in China, there is

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no real anti-aphid cotton species. Cotton aphid is usually killed by pesticides. It must give rise to pollution and other negative influence.

If the interactions between special compound and insect is discovered and the synthesis mechanism of this compound is elucidated, we will be able to find out the anti-insect gene in plant. With the application of biotechnique, cell engineering and plant gene engineering (recombinant DNA technology), the new variety of anti-aphid and high-production cotton will be got. We believe this expectation will become true and its repercussion will extend far beyond the new species itself.

The authors have made a preliminary study on the interactions between plant secondary compound and aphid in view of theory of chemical ecology, a new interdisciplinary subject, in order to find out some chemical compounds that deter or attract insect pests. According to this specific relationship, some successful methods of reduction in insect feeding or killing insect may be obtained. The research proved the fact that: the interactions among same substance and different insects were different; the interactions among same insect and different substances were different as well.

## MATERIALS AND METHODS

*Materials*

Plant secondary compounds (A. R. ): laurolene (70%), diamylene (50%), α-pinene (90%), β-pinene (90%), gossypol, rutin, quercetin

Aphids: cabbage aphid (*Myzus persicae Sulzer*), cotton aphid (*Aphis gossypii Glover*)

Plants: cabbage (*Brassica chinensis L.* ), cotton (*Gosspium sp. L.*) (DAI-15)

*Methods*

A T-typed glass tube was designed as shown on the Fig. 1. In the darkness, aphids were put on end of 0 while a block of cotton containing chemical substance was put on end of A. After a period of time, the data of aphids in end of B and A was obtained. On the Fig. 1, we can see most of the cabbage aphids were attracted to end of A where a piece of cabbage leaf was put.

## RESULTS AND DISCUSSION

*Interactions of volatile secondary compounds and cabbage aphid*

The concentrations of laurolene were 120 ppm (C1), 200 ppm (C2), 400 ppm (C3), 800 ppm (C4) and 1600 ppm (C5) respectively. Total number of aphids was 35. Results showed that laurolene attracted cabbage aphid, especially in concentration of 800 ppm (Fig. 2). The interactions among cabbage aphid and other three monoterpenes, α-pinene, β-pinene and diamylene remained unclear.

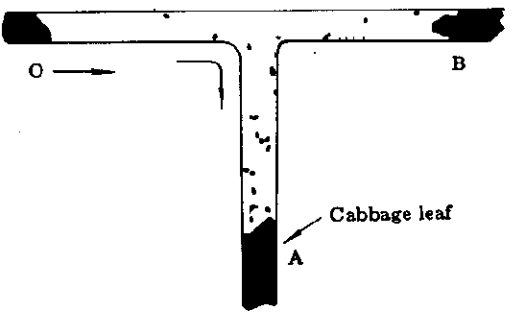


**Fig. 1** T-typed tube method

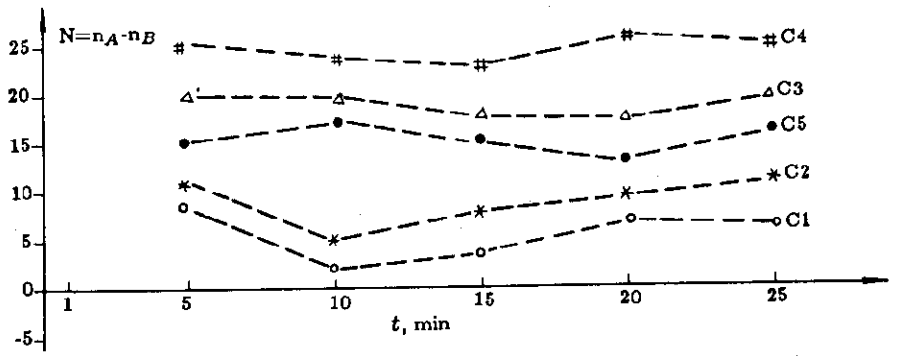


**Fig. 2** Attraction of laurolene to cabbage aphid

*Interactions among gossypol and cotton aphid, cabbage aphid*

The concentrations of gossypol were 500 ppm, 200 ppm, 100 ppm, 50 ppm and 5 ppm respectively. Total number of cotton aphids or cabbage aphids was equal to 25. Results showed that gossypol attracted cotton aphid, especially in concentration of 100 ppm. The interaction between gossypol and cabbage aphid was not obvious (Fig. 3). Gossypol played different role in interacting with cotton aphid and cabbage aphid. This result can be proved by Table 1 and followed calculation.

**Table 1** Data of aphids after 10 minutes ($N_i=n_A-n_D$)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $N_{1i}$ ($n_1=10$) | 15 | 11 | 17 | 11 | 13 | 9 | 15 | 13 | 13 | 15 |
| $N_{2i}$ ($n_2=10$) | 9 | 7 | 11 | 11 | 7 | 5 | 9 | 7 | 11 | 9 |

$$S^2 = \frac{1}{n}\left[\sum_{i=1}^{n} N_i^2 - \frac{(\sum_{i=1}^{n} N_i)^2}{n}\right]$$

$$t = \frac{\bar{N}_1 - \bar{N}_2}{\sqrt{\frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = 4.60$$

$$|t| > t_{0.01}\ (f = 18) = 2.88$$

So there is a significance difference between $N_{1i}$ and $N_{2i}$.

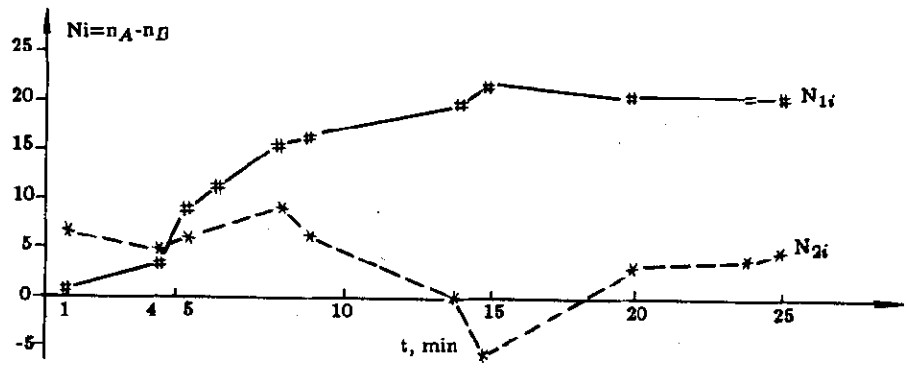


**Fig. 3** Interactions among gossypol and cotton aphid, cabbage aphid (c=100 ppm)

#—# Attraction of gossypol to cotton aphid

*—* No attraction of gossypol to cabbage aphid

*Interactions among cotton aphid and quercetin, rutin*

The concentrations of quercetin are 1000 ppm, 500 ppm, 200 ppm, 50 ppm, 10 ppm and rutin are 1000 ppm, 500 ppm, 50 ppm, 10 ppm, 5 ppm, respectively. Total number of cotton aphids is 20. Results showed that rutin repel cotton aphid especially in concentration of 10 ppm while cotton aphid was not susceptible to quercetin. This difference can be verified from Table 2 and the followed calculation.

**Table 2** Data of aphids after 10 hours ($N_i = n_B - n_A$)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| $N_{1i}$ ($n_1$=10) | 12 | 6 | 14 | 10 | 8 | 12 | 4 | 10 | 8 | 10 |
| $N_{2i}$ ($n_2$=10) | 4 | 6 | 6 | -2 | 8 | 6 | 4 | 6 | 4 | 4 |

$$S^2 = \frac{1}{n}\left[\sum_{i=1}^{n} N_i^2 - \frac{N_i^2(\sum_{i=1}^{n} N_i)^2}{n}\right]$$

$$t = \frac{\bar{N}_1 - \bar{N}_2}{\sqrt{\frac{n_1 s_1^2 + n_2 s_2^2}{n_1 + n_2 - 2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}} = 3.78$$

$$|t| > t_{0.01}\ (f = 18) = 2.88$$

So there is a significance difference between $N_{1i}$ and $N_{2i}$

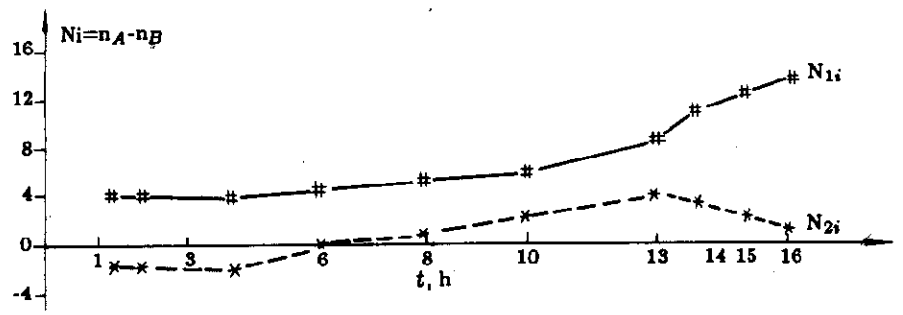


**Fig. 4** Interactions among cotton aphid and rutin, quercetin (c=10 ppm)
#—# Rutin as repelling factor to cotton aphid
*—* Quercetin without affection to cotton aphid

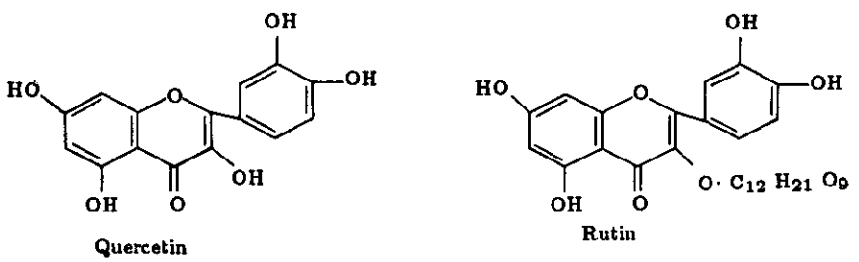


**Fig. 5** The similar structures of quercetin and rutin

Quercetin and rutin are two structurally related compounds. Quercetin has a hydroxyl group in the 3-position of the aromatic A-ring while rutin has a 3-rutinoside in the same position (Fig. 5). Quercetin is not a repelling factor to cotton aphid only because the rutin 3-rutinoside is replaced by 3-H. It can be elucidated that a receptor site sensitive to repellent chemicals is triggered and the aphid is detered. This result is a good match to that of Dr. Y. Hamamura, who had studied the silkworm–mulberry interactions. It is noteworthy that simple substitution of one group for another group in the flavonoid molecule can have a dramatic effect on insect attraction.

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