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Development of Methods for the Use of Aphid Alarm and Mite Aggregation Pheromones

Irina Sergeevna Agasyeva (Corresponding Author)
Federal Research Centre of Biological Plant Protection, Krasnodar, Russia
Email: irina-agasyeva@mail.ru

Vladimir Yakovlevich Ismailov
Federal Research Centre of Biological Plant Protection, Krasnodar, Russia

Mariya Vladimirovna Nefedova
Federal Research Centre of Biological Plant Protection, Krasnodar, Russia

Anton Sergeevich Nastasiy
Federal Research Centre of Biological Plant Protection, Krasnodar, Russia

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Abstract

The purpose of this work was to develop effective methods of protecting fruit crops based on the use of aphid alarm and mite aggregation pheromones. The study was conducted in 2020-2021 on a private farm in the Krasnodar Territory. Laboratory studies were carried out on two types of aphids: *Aphis pomi* Deg. and *Myzus cerasi* F. with the use of trans-beta-farnesene where crushed aphids of the tested species served as the source of the alarm pheromone, and insects without treatment were used as a control group. Field tests were carried out on registered trees with aphid colonies up to 10% of shoots in the crown, and mite colonies of 15-23 specimens/ leaf. Significant differences in the types of ethological reactions of apple and cherry aphids to trans-beta-farnesene were observed. In *A. pomi*, the predominant type was the twitching of the body during the initial period of exposure to the semiochemical. In cherry aphids, only one type of behavioral reaction to the alarm pheromone was noted, namely leaving the feeding site. The results of testing trans-beta-farnesene compositions with preparations based on biorational active substances, Phytoverm CE (2 g/l), and experimental insecticides based on coriander essential oil indicate the prospects of using the aphid alarm pheromone (trans-beta-farnesene) to increase the effectiveness of anti-aphid insecticides. Similar results were obtained in tests of trans-nerolidol, the pheromone used for aggregation of red spider mites in a composition with the Apollo, SC acaricide (500 g/l).

Keywords: Mite aggregation pheromone; Aphid alarm pheromone; Apple aphid Aphis *pomi* Deg; Cherry aphid *Myzus cerasi* F.; Red spider mites.

1. Introduction

Pheromones are biologically active substances (BAS) that are secreted by some specimens and perceived by others within the same species, with the help of which chemical communication is carried out in the population. This approach lacks the disadvantages inherent in the use of traditional pesticides, including eliminating the risks of the formation of resistant insect populations [1, 2].

Low toxicity of pheromone materials, extremely low consumption, and a wide range provide an advantage of their use in comparison with chemical methods of pest control [3]. In this regard, the priority area of research is the search for new [4] and improvement of known methods of using pheromones to regulate the number of harmful species of insects and mites [5-7].

To date, several methods of using sexual pheromones to protect plants from pests are known, among them, the use of pheromones and traps for monitoring or mass trapping of the pests [8-11] the method of disorientation, which allows disrupting the natural processes of mating by oversaturation of the protected area with the pheromone of the pest, which leads to the disorientation of males and the inability to detect a female and mate with her [12, 13] the "attract and kill" method, implying the use of a pheromone with a combination of insecticide, which should lead to the death of the target object attracted by a specific pheromone [14].

In addition to sexual pheromones, arthropods produce some other substances that have various functions and play an important role in the vital activity of insects and mites, in particular, alarm pheromones, aggregation pheromones [15], egg-laying marking pheromones, trace pheromones, and others [16-18].

The complex use of BAS (juvenoid, insegar, and the sexual pheromone dienol) in the fruitery allows protecting the fruitage from damage to the dominant species of apple moth, reduce the frequency of treatments in the fruitery by 5 times while preserving the complex of acariphages, the regulating activity of which allows canceling chemical treatments against red spider mites [8].

1.1. The Purpose of the Study

The purpose of this work was to develop effective methods of protecting fruit crops based on the use of aphid alarm and mite aggregation pheromones.

2. Methods

The study was conducted in 2020-2021 in Krasnodar Region of Russia on the apples of the Goldrazh variety and cherries of the Valery Chkalov variety.

The experiment zone (45°05′ N 38°28′ E) was the Abinsk district, which belongs to the South-Western zone of the Krasnodar Territory and is characterized by a variety of soil and climatic conditions. The climate of the experiment region is moderately continental, with long hot summers and relatively mild-warm spring. Transitional seasons are not always clearly expressed. The following conditions are typical for the region: the average annual temperature is 10.6-10.8°C, the sum of effective temperatures is 3,000-3,500°C, a frost-free period of more than 200 days, with annual precipitation of 600 mm, and a moisture coefficient of 0.4.

During ethological experiments in laboratory conditions, trans-beta-farnesene was dissolved in pentane, then applied to filter paper (size 5*5 mm), which was placed over a colony of aphids at a height of 1 cm. As a comparison option (a natural source of the alarm pheromone), a similar piece of paper was used with twenty aphids of the test species crushed on it, while aphid colonies without treatment served as a control. Two types of aphids were involved in the tests for comparison: the apple aphid *Aphis pomi* Deg (economically significant pest of apple trees, especially young plantings) and cherry aphid *Myzus cerasi* F. Aphids reacting to chemical stimuli were taken into account for 5 minutes (t + 26°C, relative humidity 80%).

In our field experiments, we used trees with aphid colonies up to 10% of shoots in the crown, and mite colonies reaching 5-7 specimens/leaf. All experiments were carried out in a fourfold repetition. Aphid accounting was carried out by counting imagos and larvae per 10 cm of the shoot (one branch from 4 sides of the crown of each model tree, the branches were marked with labels). To account for mites, larvae, and imagos were counted using a 7-10 fold magnifying glass on 20-40 leaves (5-10 leaves on 4 sides of the crown, depending on the degree of colonization) on each accounting tree. The indicator of the biological effectiveness of the tested substances was the magnitude of the decrease in the number of pests relative to the initial one.

3. Results and Discussion

In connection with the possible prospects of practical use, a primary assessment of trans-beta-farnesene, the main component of aphid alarm pheromone, and trans-nerolidol, the aggregation pheromone of red spider mites, was carried out.

The experiment results of trans-beta-farnesene for the apple aphid indicate that the maximum effect of exposure for it was registered at a pheromone concentration of 0.01%, and for cherry aphid, this number equaled 0.1% (Table 1).

Table-1. Results of the laboratory tests of aphid alarm pheromone

Variant of the experiment	Pheromone concentration, %	Number of aphids reacting to the semiochemical (leaving the feeding site)	
		apple aphids	cherry aphids
trans-beta-farnesene	0.001	32.9±2.0	2.8±1.0
trans-beta-farnesene	0.01	84.4±3.0	16.7±2.0
trans-beta-farnesene	0.1	81.2±2.0	73.3±1.0
natural alarm pheromone	-	17.7±2.0	26.2±1.0
control	-	0±0	0±0

Significant differences were found in the types of ethological reactions of apple and cherry aphids to trans-beta-farnesene. In *A.pomi*, the predominant ethological response was twitching of the body during the initial period of exposure to the semiochemical, and at its maximum concentration, this reaction was observed in 100% of aphids. Subsequently, the main part of the aphids released their oral organs (stilettos) and left the feeding site. It was also noted that the larvae of younger ages responded to the effects of pheromones by fleeing to a lesser extent than adults. Cherry aphids had only one type of behavioral reaction to the alarm pheromone, namely leaving the feeding site.

The ethological reactions of aphids revealed as a result of laboratory experiments, consisting in a significant increase in their mobility and the release of stilettos, which are the most vulnerable parts of the body to toxic effects, suggested that the compositions of insecticides, especially the biorational ones containing trans-beta-farnesene, should lead to an increase in the effectiveness of protective measures.

To confirm this assumption, field experiments were conducted for apple aphids, compositions with trans-beta-farnesene with preparations based on biorational active substances, Phytoverm CE (2 g/l), and experimental insecticides based on coriander essential oil. Aphid colonies treated with distilled water served as a control variant. The test results are shown in Table 2.

Table-2. Biological effectiveness of the composition of aphidicides and trans-beta-farnesene against the apple aphid *A. pomi* Deg

Variant of the experiment	**Dose of the preparation, l/ha**	**Amount of the pest, specimens**		**Biological effectiveness, %**
		Before treatment	**After treatment**	
Alpha-terpineol	0.25	57±2.0	23±1.0	59.7
Alpha-terpineol+ trans-beta-farnesene	0.25 (0.001 % application rate (ar))	63±3.0	3±2.0	95.3
Coriander essential oil	0.5	59±3.0	17±3.0	71.2
Coriander essential oil + trans-beta-farnesene	0.5 (0.001 % ar)	58±1.0	5±2.0	91.4
Fitoverm CE	1.0	47±2.0	21±4.0	55.4
Fitoverm CE + trans-beta-farnesene	1.0 (0.001 % ar)	42±3.0	7±2.0	83.4
Control (distilled water treatment)	-	53±2.0	64±3.0	-
Least significant difference (LSD)05				11.2

The experiment results indicate that the aphid alarm pheromone (trans-beta-farnesene) could be successfully used to increase the effectiveness of anti-aphid insecticides. On average, the biological effectiveness increases by 25%. Thus, the use of the pheromone will significantly increase the effectiveness of protective measures, especially in biocontrol systems, and primarily to increase the effectiveness of biopesticides, as well as to reduce the pesticide load by reducing the consumption rates of insecticides and the frequency of their use.

Similar results were obtained in tests of trans-nerolidol, the red spider mite aggregation pheromone together with the Apollo, SC acaricide (500 g/l).

Table-3. Results of the use of trans-nerolidol against red spider mites

Variant of the experiment	**Dose of the preparation, l/ha**	**Number of mites, specimens/leaf**		**Biological effectiveness, %**
		Before treatment	**After treatment**	
Apollo, SC (500 g/l)	0.4	-30±1.0	7±2.0	76.7
Apollo, SC +trans-nerolidol +A	0.2+0.02	34±3.0	2.0±1.0	94.2
Control (distilled water treatment)	-	29±2.0	64±3.0	-
LSD05				8.4

A significant increase in the biological effectiveness of the acaricide used was established, with a 2-fold reduced consumption rate. In the future, extensive production testing of new semiochemicals will be carried out, including the aphid alarm and mite aggregation pheromones.

4. Conclusion

The experiments carried out showed that the use of biorational pesticides in conjunction with semiochemics contributes to an increase in the effectiveness of protective measures: the use of the aphid alarm pheromone trans-beta-farnesene in combination with preparations (Fitoverm CE, coriander essential oil) increased the biological effectiveness by an average of 25%; The use of the tetranych mite aggregation pheromone trans-nerolidol in combination with the acaricide Appolo, KS increased the biological efficiency by 17.5%. These results indicate the possibility of developing effective techniques for protecting fruit crops using aphid alarm pheromones and mite aggregation. Thus, the high biological activity of biologically active substances of natural origin creates real prerequisites and opportunities for expanding the range of biorational pesticides with a high degree of efficiency and a wide spectrum of action. And such semiochemists as various arthropod pheromones (sex pheromones, alarm pheromones, aggregation pheromones, etc.) can be successfully used in the formulation of new environmentally friendly insecticides.

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