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Susceptibility of Several Insecticides on Three Aphids

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Abstract

Differences in susceptibility of several organophosphate, carbamate and pyrethroid insecticides to three aphids species were determined by leaf-dipping and spray methods. The insects tested were the apterous adults of the green peach aphid (*Myzus persicae*), cotton aphid (*Aphis gossypii*) and soybean aphid (*Aphis glycines*). The comparison of LC_{50} levels was indicated as follows: (1) The susceptibility to insecticides tested were greatly varied with the test methods. (2) The leaf-dipping method is more recommendable than the spray method for c insecticide screening with aphids. It was easier, more accurate and less variable than the latter. (3) The susceptibility to insecticides was greatly varied between the aphid species. Soybean aphid was more susceptible to the insecticides than green peach aphid and cotton aphid. Exceptionally, pirimicarb was not effective on the cotton aphid.

Introduction

Developing novel insecticides requires both synthesis or extraction of new chemicals and a screening system to test their activity. To screen insecticides, a proper test method for target insects and differences in susceptibility between the pest species must be considered.

It has been reported that susceptibility to insecticides varies according to test methods and insect species [6,7,13,16,19,21,22].

We conducted comparative studies with 3 aphid species (green peach aphids, cotton aphids, soybean aphids) and with 10 insecticides to obtain a basis for selecting test methods and insect

species.

Materials and Methods

Insects

Green peach aphids (*M. persicaea*) were obtained from the Department of Entomology, Seoul National University. Cotton aphids (*A. gossypii*) and soybean aphids (*A. glycines*) were collected in the fields around the Korean Research Institute of Chemical Technology in 1986. The test aphids were reared in a growth chamber at 23 ±2 °C: green peach aphids on tobacco, cotton aphids on cucumber, soybean aphids on soybean.

Insecticides

Six organophosphates, three synthetic pyrethroids and one carbamate were used in this study. Their chemical names and formulations are shown in table 1.

Bioassays

The insecticides were tested by leaf-dipping and spray methods. In the spray methods, the insecticides were sprayed onto leaves so as not to drip. In the leaf-dipping method, leaves were dipped in insecticide solutions diluted to the required concentration for 30 seconds and air-dried for 30-60 minutes. Three replicates, each with 20 apterous adult aphids were used at each treatment.

The treated leaves were placed on filter papers in petri dishes (ϕ9cm) then infested with aphids. Mortality was recorded after holding at 25±1 °C with a photoperiod of 16 hrs. Mortalities were corrected and LC_{50} values were calculated by probit analysis (Finney, 1963).

Results and Discussion

Differences in susceptibility between the test methods

Susceptibility of 3 aphid species (*M. persicae*, *A. gossypii*, *A. glycines*) to insecticides between the test methods was compared (Tables 2-4). Table 2 shows the LC_{50} values of 10 insecticides for green peach aphids with different test methods. The susceptibility to demeton-S-methyl and fenvalerate was 2.2 and 2 times higher respectively in the spray method than in the

leaf-dipping method. The spray method showed higher insecticidal activity than the leaf dipping.

Susceptibility was significantly different with the insecticides and the testing methods for cotton aphids (Table 3) and in soybean aphids (Table 4). For cotton aphids, the susceptibility to demeton-S-methyl, vamidothion, phosphamidon, phenthoate+dimethoate, deltamethrin and fenvalerate was different between the test methods. In particular, the susceptibility to vamidothion was significantly different. The susceptibility of soybean aphids to demeton-S-methyl, monocrotophos, phenthoate+dimethoate, fenvalerate and cypermethrin was different between the test methods. Notably, monocrotophos and fenvalerate showed significant differences. This result is possibly due to the penetration route of insecticides: stomach poison, contact poison, smoke generator or systemic insecticides. A stomach poison insecticide will show stronger insecticidal activity in leaf-dipping method than in spray method while a contact poison insecticide will show stronger activity in spray method. Also the mode of action (i.e. neurotoxin, dermal toxin, respiratory toxin, muscular toxin) will affect the insecticidal activity [(20)]. Therefore, an appropriate test method is an important consideration to screen insecticides against aphids.

Sugimoto [(21)] reported similar results of differences in the susceptibility of Adzuki bean weevils (*C. chinensis*) to insecticides between topical and feeding method. Tanaka and Asano [(13)] *[Note from editor: These names are inconsistent with citation number 13, attributed to Hosotsuji]* reported that the insecticidal activity of some insecticides against 3rd larvae of *Spodoptera litura* was higher in immersion method than in leaf-dipping method. In our study, the susceptibility of green peach aphids was higher in the spray method than the leaf-dipping method but the susceptibility of cotton aphids and soybean aphids varied with the insecticides and the test methods.

Lee [(16)] compared slide dip and leaf-dipping methods to determine resistance of two spotted mites (*Tetranychus urticae*) to insecticides, and found no significant difference between the two methods. However, he recommended the slide dip method to determine mite resistance because

it was more accurate.

Comparing leaf dipping and spray methods for aphids, the former is easy to use, insecticides can be spread on test plants evenly, and errors can be reduced. Also the escape of test insects can be prevented, and the leaf-dipping method can be used to test stomach and contact poison. The spray method is easy to use and can also be used to test stomach and contact poison. However, insecticide spray can formulate into drops, into which aphids might be drawn. Therefore the leaf-dipping method is preferred for screening insecticides against aphids.

Species-specific susceptibility to insecticides

Table 5 and 6 present species-specific susceptibility to insecticides by different test methods. The susceptibility of soybean aphids was higher than that of green peach aphids and cotton aphids. The susceptibility of cotton aphids to pirimicarb was extremely high compared with other species. Also species-specific susceptibility was shown in cypermethrin, fenvalerate, monocrotophos, phenthoate+dimethoate, phosphamidon and vamidothion.

Hozotsuzi [13] reported that the insecticidal activity of several insecticides to cotton aphids was lower than to green peach aphids (especially pirimicarb). A similar trend was shown in our results, with pirimicarb showing much lower insecticidal activity against cotton peach aphids than other aphid species. More specific studies will be needed to explain this trend.

Fukuda and Nagate [11], who compared susceptibilities of 3 planthopper species, reported that some organophosphates showed species-specific susceptibility. The species in order of susceptibility were: small brown planthoppers > white backed planthoppers > brown planthoppers. Miyahara and Fukuda [17] reported significant differences in susceptibility between green rice leafhoppers and small brown planthoppers to organophosphates like MEP and MPP using a topical application method.

This species-specific susceptibility of aphids to insecticides could be explained with the enzymatic detoxification (phosphatase, carboxyesterase, glutathion-S-transferase, mixed function oxidase) and difference in inhibition of Cholinesterase and AchE related to the

susceptibility in the site of action [12,14].

Generally, test method and insects showing high susceptibility are selected in order to screen insecticides. However, the advantages and disadvantages of test methods and insects should be considered.

Therefore, in our experiment the soybean aphid is preferred as a test insect because it is the most susceptible among the 3 species of aphids and it is easy to rear and treat. The leaf-dipping method is preferred to the spray method for testing aphids due to its accuracy and simplicity.

Summary

Susceptibility of 3 aphid species (green peach aphids, cotton aphids, soybean aphids) to 10 insecticides was compared by different test methods. The results are as follows.

1) The susceptibility of 3 species of aphids varied with the test insecticides and methods.
2) The susceptibility of green peach aphids was higher in spray methods than leaf-dipping methods. The cotton aphids and soybean aphids showed different susceptibilities with the test insecticides. In particular, the susceptibility of cotton aphids to phenthoate+dimethoate and that of soybean aphids to fenvalerate was significantly different.
3) Species-specific susceptibility was observed in this study. The soybean aphids were more susceptible than cotton aphids and green peach aphids. Especially the insecticidal activity of pirimicarb to cotton aphids was significantly lower than to soybean aphids and green peach aphids.
4) Among the 3 species of aphids, soybean aphids showing high susceptibility are desirable for screening insecticides. The leaf-dipping method is recommended for testing aphids because it is easy to use, less variable, and can provide more accurate results.

Table 1. Test insecticides and their formulations

Chemicals	Formulation	Chemical name
Organophosphate		
acephate	50 Wp	0, S-dimethyl N-acetyl phosphoroamidothioate
demeton-S-methyl	25 Ec	S-2-ethylsulfinylethyl 0, 0-dimethyl phosphorothioate
vamidothion	40 Lq	0, 0-dimethyl-S-[2(1-methyl carbamoyl ethyl thio)ethyl] phosphorothioate
monocrotophos	24 Ec	dimethyl(E)-1-methyl-2-(methylcarbamoyl)-vinyl phosphate
phosphamidon	50 Ec	2-chloro-2-diethylcarbamoyl-1-methylvinyl dimethyl phosphate
phenthoate+dimethoate	30 Ec+15 Ec	S-α-ethoxycarbonylbenzyl 0, 0-dimethyl phosphorodithioate +0, 0-dimethyl S-methyl carbamoylmethyl phosphorodithioate
Pyrethroid		
cypermethrin	5 Ec	α-cyano-3-phenoxybenzyl(1RS) cis, trans-3-(2, 2-dichlorovinyl)-2, 2-dimethyl-cyclopropanecarboxylate
deltamethrin	1 Ec	α-cyano-3-phenoxybenzyl(1RS) cis-3-(2, 2-dibromovinyl)-2, 2-dimethylcyclopropanecarboxylate
fenvalerate	5 Ec	α-cyano-3-phenoxybenzyl α-isopropyl-4-chlorophenylacetate
Carbamate		
pirimicarb	25 Wp	2-dimethylamino-5, 6-dimethylpyrimidin-4-yl dimethylcarbamate

Table 2. Susceptibility of insecticides by leaf-dipping and spray methods to green peach aphid (*M. persicae*)

Insecticide	LC_{50} (ppm)		Ratio[a]
	Leaf-dipping test	Spray test	
acephate	78	80	1.0
demeton-S-methyl	59	27	2.2
vamidothion	315	301	1.0
monocrotophos	125	75	1.7
phosphamidon	333	210	1.6
phenthoate+dimethoate	168	100	1.7
cypermethrin	119	73	1.6
deltamethrin	18	21	0.9
fenvalerate	67	33	2.0
pirimicarb	9	9	1.7

[a] Ratio = $\frac{LC_{50} \text{ of leaf-dipping method}}{LC_{50} \text{ of spray method}}$

Table 3. Susceptibility of insecticides by leaf-dipping and spray methods to *A. gossypii*

Insecticide	LC_{50} (ppm)		Ratio[a]
	Leaf-dipping test	Spray test	
acephate	39	51	0.9
demeton-S-methyl	68	30	2.1
vamidothion	1175	307	3.9
monocrotophos	42	48	0.9
phosphamidon	323	149	2.2
phenthoate+dimethoate	718	167	4.3
cypermethrin	8	12	0.7
deltamethrin	2	2	1.0
fenvalerate	315	161	2.0
pirimicarb	698	>1000	0.7

[a] Ratio = $\frac{LC_{50} \text{ of leaf-dipping method}}{LC_{50} \text{ of spray method}}$

Table 4. Susceptibility of insecticides by leaf-dipping and spray methods to *A. glycines*

Insecticide	LC_{50} (ppm)		Ratio[a]
	Leaf-dipping test	Spray test	
acephate	64	52	1.2
demeton-S-methyl	4	1	4.0
vamidothion	13	4	3.3
monocrotophos	0.3	2.9	0.2
phosphamidon	3.2	6	0.5
phenthoate+dimethoate	8	36	0.2
cypermethrin	95	28	3.3
deltamethrin	1.6	3	0.5
fenvalerate	41	7	5.8
pirimicarb	6	2.3	2.6

[a] Ratio = $\frac{LC_{50} \text{ of leaf-dipping method}}{LC_{50} \text{ of spray method}}$

Table 5. Susceptibility of several insecticides by leaf-dipping method to three kinds of aphids

Insecticide	LC_{50} (ppm)		
	M. persicae	*A. gossypii*	*A. glycines*
acephate	78	39	64
demeton-S-methyl	59	68	4
vamidothion	315	1175	13
monocrotophos	125	42	0.3
phosphamidon	333	323	3
phenthoate+dimethoate	168	718	8
cypermethrin	119	8	95
deltamethrin	21	2	3
fenvalerate	67	315	41
pirimicarb	9	598	6

Table 6. Susceptibility of several insecticides by spray method to three kinds of aphids

Insecticide	LC_{50} (ppm)		
	M. persicae	*A. gossypii*	*A. glycines*
acephate	80	51	52
demeton-S-methyl	21	32	3
vamidothion	301	307	4
monocrotophos	75	48	3
phosphamidon	210	144	6
phenthoate+dimethoate	100	167	36
cypermethrin	73	12	28
deltamethrin	27	31	1.1
fenvalerate	33	161	7
pirimicarb	9	>1000	2

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