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RESISTANCE OF SPIDER MITES TO ACARICIDES

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Ever since the increasing use of acaricides, resistance of mites to these compounds has become a serious problem. This is not astonishing if one looks at the biology of mites. Their life-cycle is short, especially at high temperatures, resulting in many generations per year. As different stages of development (egg, resting and active stages) are present at the same moment, exposure to sublethal dosages occurs very frequently. Furthermore the isolation is strong, as mites can't fly and consequently the chance of decrease of resistance by crossing with non-resistant mites is very small. It is evident that in glasshouses the built-up of resistance takes place even more rapidly, as under these conditions the life-cycle is still shorter and the isolation stronger.

Already more than 10 years ago resistance of mites to the then newly introduced group of organic phosphorous compounds was first reported from America. It concerned resistance to parathion of the mite Tetranychus urticae on roses grown in glasshouses (Garman, 1950). Since that time resistance of different species of mites has been detected in many countries, whilst resistance to other groups of acaricides has been found too. It is therefore conceivable that some people wonder whether chemical control alone will always be possible in the future.

As we were faced with the problem of resistance of mites in glasshousecrops in Holland several years ago already, much research in this field has been carried out during the last 8 years. Although many interesting items as to biology, genetics etc. arise around the problem of resistance, this article will be restricted to the phenomenon itself and a survey will be given of the work done at the Experimental Station for Fruit and Vegetable Growing under Glass at Naaldwijk.

Methods.

In all experiments mortality was determined under laboratory conditions by direct spraying of females or eggs.

By applying several concentrations LD50 and LD95 were calculated on log-probit paper, thus enabeling to compare the susceptibility of different strains of T. urticae to acaricides. The methods used have been published extensively elsewhere (Bravenboer, 1959). The results of one experiment with a parathion resistant and a non-resistant strain of T. urticae are given in fig. 1. In this case the LD50 of the resistant strain is 70 times higher than that of the non-resistant one. For the LD95 this is about 100, demonstrating that the slope of the non-resistant strain is steeper than that of the resistant one.

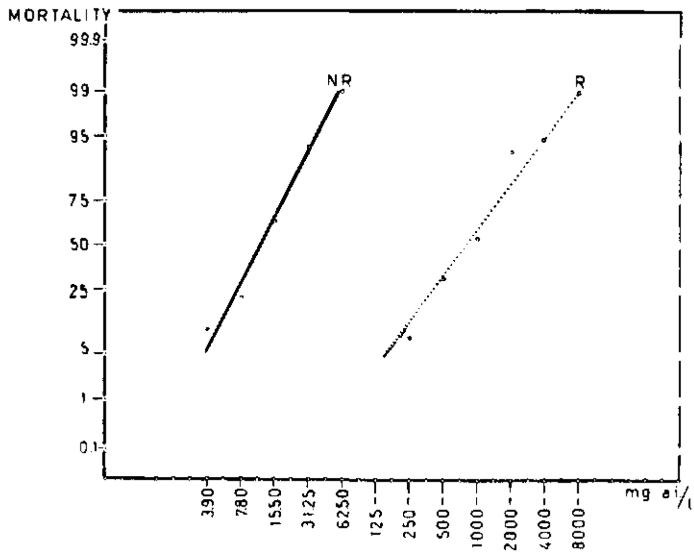

Fig. 1. Comparison of the susceptibility to parathion of a resistant and a non-resistant strain of T. urticae.

Resistance to organic phosphorous compounds.

Parathion was the first of this group to be applied for the control of red spider in Holland and it has been used very frequently under glass. Some years after its introduction, we found the first cases of resistance. Since that time we tested nearly all the organic phosphorous compounds as well on a parathion-resistant strain as on a non-resistant one. For the resistant one we always used mites with the same high degree of resistance. As nearly all the organic phosphorous compounds kill active stages only, we used females for these experiments. In fig. 2 the ratio of the LD50 of resistant and non-resistant strains and the ratio of the LD95 are given. From this it is evident that the resistant strains of T. urticae used in this experiments are more or less resistant to all the organic phosphorous compounds, expecially if one looks at the ratio of the LD95. On the origin of the big difference in the degree of resistance between these compounds very little is known up to now. It is clear, however, that cross-resistance occurs in the organic phosphorous compounds, indicating the same mode of action of this group.

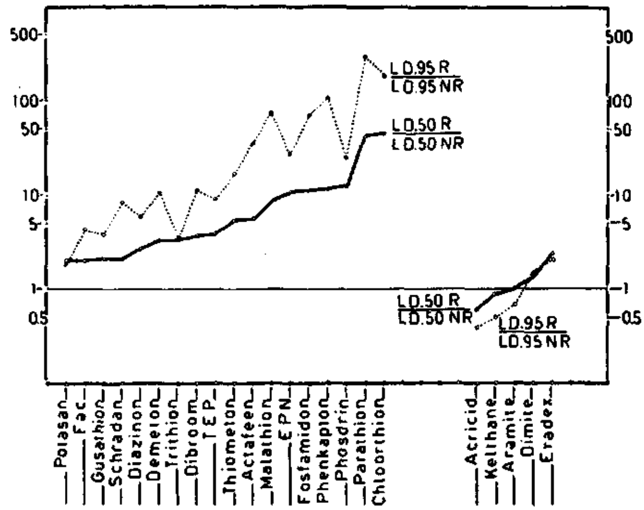

Fig. 2. Ratio of the LD50 and of the LD95 of a parathion resistant and a non-resistant strain of T. urticae with respect to different acaricides.

Mites resistant to organic phosphorous compounds have the same susceptibility to acaricides of other groups (Acricid, Aramite, Kelthane etc.) as non-resistant ones, as is clearly demonstrated on the right side of fig. 2. The ratio of the LD50 and of the LD95 of the parathion-resistant strain and the non-resistant one is in all cases about 1.

Resistance to ovocides.

Some years after the introduction of organic phosphorous compounds a new group of specific acaricides came into use, the so-called ovocides or ovolarvicides.

Most of these chemicals act in three different ways, namely a direct killing of eggs, a direct killing of larvae and young nympfs and an indirect killing of eggs. In the last case treated females deposit eggs that do not hatch during some days after the application of the ovocide.

In glasshouse crops only the ovocide tedion has generally been used. As recently resistance to this chemical was found in some cases, we carried out experiments to confirm this. We tested the susceptibility of the three above mentioned stages of both a resistant and a non-resistant strain to several acaricides. The results of some of these experiments are given in table 1, 2 and 3. From this it is evident that T. urticae may develop a high degree of resistance to ovocides. This especially holds for the direct and indirect effect on the eggs, the larvae seem to be somewhat less resistant. The tedion-resistant mites prove to have the same level of resistance to the sulfide-homologue of tedion (Animert). On the other hand this strain is not resistant to other ovocides such as chlorobenside. In other experiments not mentioned here, the tedion-resistant strain of T. urticae proved to be not resistant to fenson and chloro-fenson. From table 1 and 3 it is evident that tedion-resistant mites are not resistant to acaricides like Kelthane and Acricid.

It is interesting to note that in fruitgrowing in the open the reverse phenomenon seems to occur with regard to Metatetranychus ulmi. In several cases in practice the observation was made that populations of the fruittree red spider resistant to chlorobenside or (chloro)-fenson could easily be killed with tedion. These facts combined with our experiments indicate that in contrast to the organic phosphorous compounds cross-resistance does not necessarily occur in the group of ovolarvicides. Consequently the mode of action of all the ovolarvicides does not seem to be based on the same principle.

Resistance to other acaricides.

Although we have not yet traced resistance to other acaricides ourselves, in literature several cases are mentioned e.g. resistance to Aramite (Taylor c.s. 1959) and resistance to Kelthane (Helle c.s. 1961). It is however not very likely that cross-resistance exists within the other acaricides as they probably differ greatly in their mode of action.

Conclusion.

As has been demonstrated above the built-up of resistance of spider mites to acaricides may take place rapidly. It may therefore be sensible to look for supplementary possibilities to the chemical control. On the other hand the look-out for the near future is not too bad as at least seven different modes of action of acaricides are known at the moment. These seven are represented by the following chemicals or groups of chemicals : organic phosphorous compounds, at least two types of ovolarvicides, Aramite, Kelthane, Eradex and Acricid. Still more are to be expected as the chemical industries have not yet stopped looking for new acaricides.

TABLE 1

Percentage of dead eggs of a tedion-resistant and a non-resistant strain of T. urticae after direct spraying with different acaricides

	Percentage of dead eggs									
	Tedion		Animert		Chloro-benside		Kelthane		Acricid	
	NR	R	NR	R	NR	R	NR	R	NR	R
mg a.i/l.										
4000		32		7	100	100				
2000		18		12	100	100				
1000		17		7	82	77		98		95
500	93	21	83	7	79	73	89	89	92	59
250	93	17	26				38	58	59	44
125	64	13	7				6	21		
62.5	45	18	4							
Control	1	5	2	4	2	3	10	6	3	6

TABLE 2

Percentage of dead eggs of a tedion-resistant and a non-resistant strain of T. urticae deposited by females treated with different acaricides

	Percentage of dead eggs					
	Tedion		Animert		Chlorobenside	
	NR	R	NR	R	NR	R
mg a.i/l.						
4000		92		29	49	84
2000		63		20	39	57
1000		19		15	33	57
500	91	19	98	8	18	47
250	96	10	99			
125	97	7	89			
62.5	91	6	87			
Control	12	14	1	4	2	4

TABLE 3

Percentage of dead larvae of a tedion-resistant and a non-resistant strain of T. urticae after application of different acaricides

	Percentage of dead larvae									
	Tedion		Animert		Chloro-benside		Sulphenone		Kelthane	
	NR	R	NR	R	NR	R	NR	R	NR	R
mg a.i/l.										
4000		100		100			100	100		
2000		100		97			98	100		
1000		100		78	71	96	51	97		
500	94	97	99	53	78	90	13	55	100	100
250	97	25	98						100	99
125	100	9	97						45	57
62.5	97	6	94							
Control	1	6	1	4	1	1	1	1	2	2

LITERATURE

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CHEMICALS MENTIONED IN THIS ARTICLE

Potasan :	0, 0, diaethyl - 0-(4-methyl-7-oxycumarine) thiophosphate.
Fac :	0, 0, diaethyl - S - (N-isopropyl-carboxymethyl-amido) dithiophosphate.
Gusathion :	0, 0, dimethyl - S - (4-oxobenzotriazine-3-methyl) dithiophosphate.
Schradan :	octamethylpyrofosforamide.
Diazinon :	0, 0, diaethyl - 0 - {2-isopropyl-4-methylpyrimidyl (6)} thiophosphate.
Demeton :	0, 0, diaethyl - 0 - (2-aethylmercaptoaethyl) thiophosphate.
Trithion :	0, 0, diaethyl - S - (4-chlorophenylthiomethyl) dithiophosphate.
Dibroom :	0, 0, dimethyl - 0 - (1,2-dibromo-2,2-dichloroaethyl) phosphate.
TEP :	tetra-aethyldithiopyrophosphate.
Thiometon :	0, 0, dimethyl - S - (2-aethylmercaptoaethyl) dithiophosphate.
Actafeen :	bis {0, 0, diaethyl - S -} (2,3-p-dioxanedithiol) dithiophosphate.
Malathion :	0, 0, dimethyl - S - (1,2-dicarbethoxyaethyl) dithiophosphate.
EPN :	0, 0, aethyl - 0 - (4-nitrophenylthiobenzene) phosphate.
Fosfamidon :	0, 0, dimethyl - 0 - {diaethylamino-1-chlorocrotonyl (2)} phosphate.
Phenkapton :	0, 0, diaethyl - S - (2,5-dichlorophenylmercaptomethyl) dithiophosphate.
Phosdrin :	0, 0, dimethyl - 0 - (2-carbomethoxy-1-methylvinyl) phosphate.
Parathion :	0, 0, diaethyl - 0 - (4-nitrophenyl) thiophosphate.
Chloorthion :	0, 0, dimethyl - 0 - (3-chloro-4-nitrophenyl) thiophosphate.
Acricid :	dinitro-alkyl-phenylacrylate.
Kelthane :	1,1-di (4-dichlorophenyl) - 2,2,2-trichloroaethanol.
Aramite :	2-chloroaethyl - 2 - (4-tert. butylphenoxy)-1-methylaethylsulfite.
Dimite :	1,1-di (4-chlorophenyl) aethanol.
Eradex :	chinoxaline - 2,3-trithiocarbonate.
Tedion :	2,4,5,4' - tetrachlorodiphenylsulfon.
Animert :	2,4,5,4' - tetrachlorodiphenylsulfide.
Sulphenone :	4-chlorophenylphenylsulfon.
Chlorobenside :	4-chlorobenzyl - 4 - chlorophenylsulfide.
Fenson :	4-chlorophenylbenzenesulfonate.
Chlorofenson :	4-chlorophenyl - 4 - chlorobenzenesulfonate.

SAMENVATTING

Resistentie van spintmijten tegen acariciden

Hoewel resistentie van spintmijten tegen bestrijdingsmiddelen ook in het vrije veld in vele gevallen belangrijk is geworden, speelt dit probleem vooral bij glascultures een zeer belangrijke rol. Het betreft hier dan voornamelijk de soort Tetranychus urticae. Gezien de ontwikkeling van de acariciden is het begrijpelijk dat aanvankelijk alleen resistentie tegen organische fosforverbindingen optrad. Er is hier duidelijk sprake van een groepsresistentie : indien resistentie optreedt tegen een bepaald middel uit deze groep, is de betreffende stam van de spintmijt ook in meerdere of mindere mate resistent tegen alle andere middelen uit deze groep. Dit zou erop wijzen dat de werking van deze middelen op eenzelfde mechanisme berust. In een aantal gevallen is ook resistentie tegen oviciden bekend geworden. In tegenstelling tot de resistentie tegen organische fosforverbindingen is de resistentie tegen oviciden niet gekoppeld : resistentie tegen een bepaald ovicide impliceert niet dat de betreffende stam van de spintmijt ook resistent is tegen de overige oviciden. Dit zou er op wijzen dat het werkingsmechanisme van de verschillende oviciden niet hetzelfde is. Stammen van spint die resistent zijn tegen organische fosforverbindingen of oviciden, zijn niet resistent tegen de overige acariciden. Dat na herhaald gebruik van deze overige acariciden ook resistentie kan optreden, is reeds enkele malen aangetoond o.a. bij Aramite en Kelthane.

SUMMARY

Resistance of spider mites to acaricides

Although resistance of spider mites to acaricides may occur in the open, the problem is more serious in glasshouses, especially with regard to Tetranychus urticae.

It is evident that at first resistance to organic phosphorous compounds was found, as only chemicals from this group were used. If a strain of spider mites is resistent to one chemical of this group, it is also resistant to all the other organic phosphorous compounds (cross-resistance).

In a number of cases resistance to ovocides has been found. In contrast to resistance to organic phosphorous compounds, there is no cross-resistance in this case.

Strains of spider mites resistant to organic phosphorous compounds or ovocides are not resistant to other specific acaricides. After repeated application of these chemicals resistance may occurs too as has been found in some cases already (e.g. Aramite and Kelthane).

ZUSAMMENFASSUNG

Resistenz von Spinnmilben gegen Akariziden

Obwohl Resistenz von Spinnmilben gegen Akariziden auch auf freiem Feld häufig auftritt, ist es besonders in Gewächshäuser ein grosses Problem. Anfangs trat nur resistenz gegen Phosphorsäureester auf, weil keine anderen Mittel verwendet wurden. Wenn Spinnmilben resistent geworden sind gegen ein Mittel aus dieser Gruppe, sind sie auch resistent gegen alle anderen Mittel der Phosphorsäureester.

In enigen Fälle ist auch Resistenz gegen Oviziden festgestellt. Wenn ein Stamm der Spinnmilben resistent ist gegen ein Mittel dieser Gruppe, ist er im Gegensatz zu den Phosphorsäureestern nicht resistent gegen alle anderen Mittel der Oviziden.

Stämme von Spinnmilben die resistent sind gegen Phosphorsäureester oder Oviziden, sind nicht resistent gegen die übrigen Akariziden. Wenn Mittel dieser Gruppe häufig appliziert werden, kann aber auch Resistenz gegen diese Mittel entstehen, wie schon festgestellt worden ist bei z.B. Aramite und Kelthane.