

Decreased sensitivity of *Sphaerotheca fuliginea* to fungicides which inhibit ergosterol biosynthesis

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Fungicides which inhibit ergosterol biosynthesis (EBI's) are widely used for disease control in a variety of crops. Most of them are regarded as fungicides with a specific mechanism of action (cf. Ragsdale, 1977). This implies the risk of development of resistance. Indeed, *in vitro* EBI-resistant strains can be readily isolated (cf. Fuchs and De Waard, 1982). In practice no disease control failure due to EBI resistance has been reported. However monitoring of EBI-treated cereals revealed a decreased sensitivity of powdery mildew to these fungicides (Fletcher and Wolfe, 1981; Hollomon, 1982; Laws et al., 1982; Buchenauer, 1983).

In the Netherlands, EBI's (fenarimol, imazalil, triforine and recently bitertanol) are used for control of cucumber powdery mildew (*Sphaerotheca fuliginea*). Many growers treat their crop almost exclusively with these fungicides; application of ten sprays during one growing season is not exceptional. This spray program gives rise to a high selection pressure which favours build-up of an EBI-resistant pathogen population. Development of resistance of *S. fuliginea* under similar conditions has been described earlier for dimethirimol, benomyl and pyrazophos (Bent et al., 1971; Kooistra et al., 1972; Dekker and Gielink, 1979). For this reason the sensitivities to EBI's of two *S. fuliginea* isolates from EBI-treated crops and a reference isolate were compared.

The reference isolate used has been maintained at the Laboratory of Phytopathology for more than 10 years. It has never been in contact with any fungicide, and is regarded to have a wild-type sensitivity. One test isolate was collected in 1982 in a glasshouse in the Netherlands, where imazalil was the only fungicide used for the previous 2 years. The other isolate was sampled in 1982 from a fenarimol-treated cucumber field in Israel.

Fungitoxicity of the EBI's was determined in a foliar spray test. In this test 3 to 4 week-old cucumber plants were sprayed in duplicate to run-off with formulated fungicide solutions at various concentrations. The leaves were allowed to dry and conidia of the isolate to be tested were rubbed on the leaves. The percentage of leaf area infected with cucumber powdery mildew was assessed after 7 days of incubation under greenhouse conditions (60-80% r.h., 17-23 °C).

The EC₅₀ and EC₉₀ values of the EBI's tested for the isolates from the Netherlands

Table 1. Sensitivity of *Sphaerotheca fuliginea* isolates from the Netherlands and Israel to ergosterol biosynthesis inhibitors in foliar spray tests with cucumber plants.

Fungicide	Isolate					
	wild-type ¹		D-17 ²		Isr-1 ³	
	EC ₅₀	EC ₉₀	EC ₅₀	EC ₉₀	EC ₅₀	EC ₉₀
Bitertanol (300.0) ⁴	1.5 ⁵	30.0	7.0	70.0	9.0	60.0
Fenarimol (24.0)	0.2	0.5	3.0	5.0	2.5	6.0
Imazalil (50.0)	0.5	4.0	3.5	30.0	15.0	45.0
Triforine (200.0)	6.0	60.0	> 600.0	—	> 600.0	—

¹ Maintained at the Laboratory of Phytopathology, Wageningen.

² Collected in a glasshouse in the Netherlands.

³ Sampled from a cucumber field in Israel.

⁴ Between brackets: dosage (mg a.i. l⁻¹) recommended in practice.

⁵ Fungicide concentration in mg a.i. l⁻¹.

Tabel 1. Gevoeligheid van isolaten van Sphaerotheca fuliginea uit Nederland en Israel voor ergosterolbiosynthese remmers in spuitproeven met komkommerplanten.

and Israel were higher than those of the wild-type isolate (Table 1). The recommended dosages of bitertanol and fenarimol were still high enough to achieve a proper control of the EBI-resistant isolates. Control of the resistant isolates by imazalil was marginal only and could just barely be obtained at the recommended dosage. The resistance level to triforine was high and above the recommended dosage. This is in accordance with the experience of growers who apply triforine only at the beginning of the growing season, and later switch to fenarimol and imazalil, because of poor mildew control by triforine.

From 1972 to 1977, when triforine was the only EBI available, it was successfully used during the whole growing season. This may be due to the fact that triforine exerts a low selection pressure: a result of its short half-life in aqueous suspensions (Fuchs and Ost, 1976). The continuous selection pressure of more persistent EBI's (fenarimol, imazalil) may have increased the level of EBI resistance to such an extent that the weakest EBI, triforine, lost much of its efficacy. In discussing resistance to triforine, Fuchs et al. (1977) already mentioned the introduction of more powerful EBI's as a potential hazard to triforine.

The decreased sensitivities to EBI's of the Dutch and the Israeli isolates were almost similar. In the Netherlands a change to shorter spray intervals was sufficient to again achieve proper control by fenarimol and imazalil, contrary, to what has been found in Israel where control provided by EBI's including fenarimol has been impaired in some cases (M. Faulkner, personal communication). This discrepancy may be related to different rates of breakdown of the fungicides in the two countries, due to different climatic conditions (temperature, UV-light intensity). In addition, infection pressure in Israel is relatively high because of rapid spread of conidia by winds in outdoor cucumber crops.

It is concluded that use of EBI's results in selection of *S. fuliginea* isolates with decreased sensitivity to EBI's which may lead to partial or complete loss of the EBI's' ability to control this pathogen. Additional problems of resistance to EBI's of *S. fuliginea* have to be expected when the selection pressure is not drastically reduced. Strategies to reduce selection pressure of EBI's should thus be strongly recommended.

Samenvatting

Verminderde gevoeligheid van Sphaerotheca fuliginea voor fungiciden die de ergosterolbiosynthese remmen

Isolaten van *Sphaerotheca fuliginea* uit Nederland en Israel vertoonden een verminderde gevoeligheid voor de ergosterolbiosynthese remmers bitertanol, fenarimol, imazalil en triforine. In enkele gevallen heeft dit reeds geleid tot het falen van de bestrijding.

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