

Decrease of *Venturia inaequalis* (Cook) Aderh. Sensitivity to Dodine and Sterol Demethylation Inhibitor Fungicides

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Abstract

The effectiveness of fenarimol and difenoconazole, DMIs fungicides, and dodine was tested in two experimental orchards and in greenhouse in two seasons. In 2001 monitoring of resistance to dodine was conducted also in some commercial orchards located in main apple production. In both experimental orchards fenarimol gave significantly poorer control of apple scab than difenoconazole when curative treatments were applied. The same results were obtained in greenhouse tests using for inoculation the suspension of conidia of *V. inaequalis* from these orchards. In many monitored orchards, in each region, a high level of dodine resistant isolates in population of *V. inaequalis* (even more than 40%) was noted. Only in six from 65 tested orchards there was less than 1% resistant isolates in population of the fungus.

Keywords: *Venturia inaequalis*; fungicides resistance; dodine; sterol demethylation inhibitors

INTRODUCTION

Apple scab (*Venturia inaequalis* (Cook) Aderh.) is the most serious disease of apple in Poland. Fungicides as sterol demethylation inhibitors and dodine are widely used to control apple scab (KÖLLER 1994; SCHWABE *et al.* 1984; SZKOLNIK 1981). DMIs and dodine fungicides had and in some orchards still have excellent postinfection activity (DAVIS *et al.* 1985; ELLIS *et al.* 1984; KELLEY & JONES 1981; O'LEARY & SUTTON 1986). In Poland the first *V. inaequalis* strains resistant to dodine and less sensitive to fenarimol were noted in 1990 (NOWACKA 1991).

The purpose of our study was to investigate the postinfection activities of two (the oldest and the best) DMIs fungicides and dodine against apple scab in field and greenhouse conditions. Also the monitoring of the occurrence in population of low sensitive to dodine *V. inaequalis* isolates was carried out in some commercial orchards located in main apple production regions.

MATERIAL AND METHODS

Fungicides. In the field and greenhouse experiments the effectiveness of two DMIs fungicides, fenarimol (Rubigan 12 EC – 0.6 l/ha) and difenoconazole (Score 250 EC – 0.2 l/ha), and dodine (Syllit 65 WP – 2 kg/ha) were compared.

The field experiments. The field experiments were conducted on 'McIntosh' apple trees in Experimental Orchards at Skierniewice and Dąbrowice (Central Poland) in 2000 and 2001. Preventive fungicides, captan (Captan 50 WP – 3.0 kg/ha) and dithianon (Delan 700 WG – 0.5 kg/ha), were used three or four times from the beginning of the season until blooming. Tested fungicides were applied after infection according to Mills' criteria, 3 and 5 times in 2000 and 2001, respectively. The degree of apple scab infection was determined on 200 leaves and 100 fruits samples per replication (in four replicates).

Greenhouse experiments. One year old 'Lobo' trees growing in pots (20 cm diameter), three per treatment, were inoculated with *V. inaequalis* conidium suspension derived from scabbed leaves collected from two experimental orchards. Inoculum was prepared by rinsing conidia from sporulating lesions and conidial densities were adjusted to 10⁵ conidia per ml. After inoculation trees were placed for 48 h in a mist chamber at 20°C and 100% relative humidity. Then trees were moved to a greenhouse. Tested fungicides were applied by handgun sprayer after the longest recommended time for each product after inoculation (dodine – 72, fenarimol – 96 and difenoconazole – 120 h). Severity of scab symptoms on leaves was evaluated 3 weeks after inoculation using 5-degree scale (0 – no scab lesion, 4 – more than 50% of leaf surface covered by scab lesions).

Monitoring of *V. inaequalis* resistance to dodine. The monitoring of resistance to dodine in population of *V. inaequalis* was conducted in 2001. It covered 65 orchards located in the most important apple production regions, in central and southern Poland. Scabbed leaves (50 per each orchard) were collected from orchards, where chemical control of scab was unsuccessful. Conidia from a single scab lesion from each leaf were transferred directly onto PDA plates supplemented with 1 ppm (mg/l) dodine and on unamended media as control and incubated at 20°C. After 24 h incubation germination of conidia was checked. From each orchard 5 000 conidia (100 from lesion per leaf) were screened.

RESULTS

The curative activity of DMIs and dodine fungicides in the field experiments. Severity of scab infection differed in seasons 2000 and 2001. On untreated trees it was noted 17–24% infected leaves and 17% infected fruits in 2000 while in 2001 severity of scab was significantly higher and percent of infected leaves was 46–65% and fruits – 100%. In both orchards decrease of efficacy of fenarimol and dodine was noted. The

poorest control of scab gave fenarimol (7–35% affected leaves at Skierniewice and 12–14% at Dąbrowice). In the most cases the effectiveness of dodine was also low. The control of fruit scab by both products was not good enough. However, difenoconazole still provided good protection of leaves and fruits in tested orchards (Table 1).

Greenhouse experiments. Greenhouse experiments showed that effectiveness of fenarimol and dodine was significantly lower than difenoconazole. In some cases they did not control scab at all (Table 2).

Monitoring of *V. inaequalis* resistance to dodine. The conidial germination tests showed that in most of the 65 monitored orchards a high level of dodine resistant isolates (5 to 20%) in population of *V. inaequalis* exists. In some orchards even more than 40% resistant isolates were noted. Only in 6 orchards it was found less than 1% resistant strains (Table 3).

DISCUSSION

Fungicide resistance often causes a serious problem in disease management with chemical control agents. PRINCE *et al.* (1989) proved that isolates with a reduced sensitivity were generally associated with

Table 1. Effectiveness of tested fungicides in apple scab control in field experiments McIntosh cv. (percent of infected leaves or fruits)

Fungicide and rate per 1 ha	Active ingredient	Skierniewice		Dąbrowice			
		leaves		2000		2001	
		2000	2001	leaves	fruits	leaves	fruits
Control		17.0 c*	46.1 c	24.5 c	16.8 c	64.8 c	100.0 c
Score 250 EC 0.2 l	difenoconazole	2.3 a	18.9 a	6.4 a	0.6 a	7.7 a	4.4 a
Rubigan 12 EC 0.6 l	fenarimol	7.1 b	34.8 b	12.0 b	3.2 b	14.1 b	8.2 b
Syllit 65 WP 2.0 kg	dodine	5.0 b	24.4 a	7.7 a	2.5 b	11.0 ab	9.9 b

Table 2. Curative activity of fungicides in apple scab control in greenhouse McIntosh cv. (severity of leaf infection in 5-degree scale: 0 – no scab lesion, 4 – more than 50% surface of leaves covered by scab lesions)

Fungicide and rate per 1 ha	Active ingredient/time of treatment (hrs after inoculation)	Source of inoculum			
		Skierniewice		Dąbrowice	
		1999	2000	1999	2001
Control		3.0 c*	1.7 b	3.1 c	3.3 b
Score 250 EC 0.2 l	difenoconazole/120 h	0.3 a	0.1 a	0.2 a	0.7 a
Rubigan 12 EC 0.6 l	fenarimol/96 h	2.4 c	0.8 ab	1.6 b	1.3 a
Syllit 65 WP 2.0 kg	dodine/72 h	1.6 b	X	1.9 bc	X

X – not tested

*Mean followed by the same letter are not significantly different at $P \leq 0.05$

Table 3. The occurrence of resistant isolates to dodine in population of *V. inaequalis*

% of resistant isolates in population of <i>V. inaequalis</i>	Number of orchards			
	Warka (26)	Błędów (12)	Grójec (11)	Sandomierz (16)
< 1	5	1	0	0
1–5	3	8	1	3
5–20	9	2	9	8
20–40	6	0	1	4
>40	3	1	0	1

regularly applied DMIs fungicides, six to nine sprays per year. However, field resistance to DMIs has not been reported frequently (DELP 1980; KÖLLER & SCHEINPFLUG 1987). In Poland a low effectiveness of fenarimol and dodine was observed in orchards, where these fungicides had been used for more than 10 years. The control of *V. inaequalis* with DMIs is presently recommended only in mixtures with protectant fungicides (SCHEINPFLUG 1988). Fungi often show cross resistance to DMIs fungicides (KÖLLER 1988). Therefore sensitivity to one DMI fungicide should indicate the same reaction to other DMIs. In our experiments, however, both in field and greenhouse, difenoconazole gave a good control of apple scab, although fenarimol showed poor effectiveness. Resistance to dodine is associated with uncontrolled use of this chemical. SHOLBERG *et al.* (1989) reported that some conidia from a half of 173 orchards were resistant to dodine. Also in Poland in the most of monitoring orchards a high level of resistant isolates in population of *V. inaequalis* was noted.

References

- DAVIS A.E., FORT T.M., DENIS S.J., HENRY M.J. (1985): A broad spectrum fungicide for the control of tree fruit diseases. (Abstr.) *Phytopathology*, **75**: 1307.
- DELP C.J. (1980): Coping with resistance to plant disease control agents. *Plant Dis.*, **64**: 652–658.
- ELLIS M.A., MADDEN L.V., WILSON L.L. (1984): Evaluation of an electronic apple predictor for scheduling fungicides with curative activity. *Plant Dis.*, **68**: 1055–1057.
- KELLEY R.D., JONES A.L. (1981): Evaluation of two triazole fungicides for postinfection control of apple scab. *Phytopathology*, **71**: 737–742.
- KÖLLER W. (1988): Sterol demethylation inhibitors: Mechanism of action and resistance. In: DELP C.J. (ed.): *Fungicide Resistance in North America*. Am. Phytopath. Soc., St. Paul, MN: 79–88.
- KÖLLER W. (1994): Chemical control of apple scab – Status quo and future. *Norw. J. Agric. Sci.*, **17**: 149–170.
- KÖLLER W., SCHEINPFLUG H. (1987): Fungal resistance to sterol biosynthesis inhibitors: A new challenge. *Plant Dis.*, **71**: 1066–1074.
- NOWACKA H. (1991): A decrease of *Venturia inaequalis* (Cke.) Aderh. sensitivity to fenarimol. *Fruit Sci. Rep.*, **18**: 139–142.
- O'LEARY A.L., SUTTON T.B. (1986): Effects of postinfection applications of ergosterol biosynthesis inhibiting fungicides on lesion formation and pseudothecial development of *Venturia inaequalis*. *Phytopathology*, **76**: 119–124.
- PRINCE R.W., MOORE M.S., WEARING C.H. (1989): The New Zealand Committee on Pesticide Resistance, 1989 Summary. In: *Proc. 42nd N.Z. Weed and Pest Control Conf.*: 278–292.
- SCHEINPFLUG H. (1988): History of DMI fungicides and monitoring for resistance. In: DELP C.J. (ed.): *Fungicide Resistance in North America*. Am. Phytopath. Soc., St. Paul, MN: 77–78.
- SCHWABE W.F.S., JONES A.L., JONKER J.P. (1984): Greenhouse evaluation of the curative and protective action of sterol-inhibiting fungicides against apple scab. *Phytopathology*, **74**: 249–252.
- SHOLBERG P.L., YORSTON J.M., WARNOCK D. (1989): Resistance of *Venturia inaequalis* to benomyl and dodine in British Columbia, Canada. *Plant Dis.*, **73**: 667–669.
- SZKOLNIK M. (1981): Physical modes of action of sterol-inhibiting fungicides against apple diseases. *Plant Dis.*, **65**: 981–985.