ACTA Acta Sci. Pol., Hortorum Cultus 11(4) 2012, 143-156

EFFECT OF VEGETABLE AND MINERAL OILS ON THE GERMINATION OF SPORES OF *Diplocarpon rosae* Wolf

Adam T. Wojdyła
Research Institute of Horticulture in Skierniewice

Abstract: Black spot caused by *Diplocarpon rosae* Wolf is one of the most common and dangerous disease of roses grown in the field, but recently also under covering. During the vegetation season conidia are the major source of the pathogen spread, therefore the studies aimed at finding the most efficient method to reduce spores germination were undertaken. Experiments were carried out to determine the effect of vegetable oils: corn, olive, rapeseed (canola), sunflower, soybean, and grape; vegetable oils recommended as adjuvants: Dedal 90 EC (90% vegetable oil) and Olejan 80 EC (85% rapeseed oil); and mineral oils: Atpolan 80 EC (76% mineral oil SN), Ikar 95 EC (95% SAE mineral oil), Olemix 84 EC (84% DSA mineral oil), Promanal 60 EC (60% mineral oil), and Sunspray 850 EC (85% mineral oil) used at a concentration of 1% for a one-off spray treatment of rose bushes to control the germination of *D. rosae* spores. Observations of the number of germinating spores were conducted 1, 7 and 14 days after the treatment. In addition, 24 hours after spraying the bushes, an assessment of the effect of the tested oils on the spores of the fungus was carried out under a scanning electron microscope. The effectiveness of the tested oils in comparison with the control depended on the oil being tested, the time of observation and the experiment. After 1 day, the effectiveness of the tested oils ranged from 6.2% (olive oil) to 90.9% (Olemix 84 EC); after 7 days, from 4.2% (Promanal 60 EC) to 99% (Olemix 84 EC and Sunspray 850 EC); and after 14 days, from 0% (Atpolan 80 EC and Olemix 84 EC) to 94.1% (Ikar 95 EC).

Key words: black spot, rose, oils, control, scanning electron microscopy

INTRODUCTION

The black spot disease caused by *Diplocarpon rosae* Wolf is, besides powdery mildew *Sphaerotheca pannosa* (Wallr. ex Fr.) Lév.var. *rosae* Wor., one of the most serious and most common diseases of roses [Wojdyła et al. 2007]. Studies carried out previ-

Corresponding author – Adres do korespondencji: Adam T. Wojdyła, Department of Ornamental Plant Protection, Research Institute of Horticulture, Konstytucji 3 Maja 1/3, 96-100 Skierniewice, e-mail: adam.wojdyla@inhort.pl

ously *in vivo* showed that fungicides and biotechnical preparations (garlic juice, grapefruit extract, chitosan) can be highly effective in reducing disease symptoms of black spot [Wojdyła and Orlikowski 1999, Wojdyła and Łyś 2000, Wojdyła 2001a, b, Wojdyła 2003b, Wojdyła 2009b].

Literature data shows that various oils have been used to control insect and mite pests for hundreds of years [Lewis 1999]. The author's own studies, as well as those of others, have also shown high effectiveness of oils in controlling the pathogens responsible for causing powdery mildew, leaf spot, rust and grey mould diseases [Northover and Schneider 1996, Wojdyła 2002, 2003a, 2005, 2009a, 2010a,b, Wojdyła and Jankiewicz 2004]. Oils can be used as adjuvants with fungicides or herbicides in order to increase their effectiveness and help reduce the dose of the agent per unit surface area [Dobrzański et al. 1995, Matysiak et al. 1995]. On the other hand, used as an additive to the working solution of foliar fertilizers they have been found to significantly increase the yield of greenhouse tomato [Roszyk et al. 2006].

During the vegetation period the main source of the spreading of *D. rosae* are spores released during wetting of the leaves. The spores are carried to neighbouring plants by the drops of water splashing about during rain or irrigation with sprinklers, and by insects and air currents, thus contributing to an increase in the severity of disease symptoms [Horst 1983, Wojdyła et al. 2007]. Inclusion in the programme for the protection of roses against *D. rosae* of oil compounds with a different mechanism of action against pathogens, as compared with previously used agents, could significantly contribute to the inhibition of spore germination and thus improve the health of rose bushes. The author's previous studies on the effect of fungicides on the germination of *D. rosae* spores showed an 86–100% efficacy rate of dichlofluanid, kresoxim-methyl and triforine [Wojdyła and Łyś 2000]. Vegetable oils and their ready-made forms available commercially as adjuvants, because of their rapid biodegradability in the environment and safety to people and animals, can be particularly useful for protecting plants against disease. Literature data concerning the mechanism of action of oils show that oils have a fungistatic rather than fungicidal effect, possibly indicating a temporary effect on host physiology [Northover and Schneider 1996]. Calpouzos [1959] and Whiteside [1973] considered it also likely that oil exerts a therapeutic action not directly on the pathogen, but rather through an alteration in the physiology of the host.

The author's own tests conducted on *Sphaerotheca pannosa* var. *rosae* on rose have shown that oils may have a very strong direct effect on plant pathogens [Wojdyła 2000]. In the case of vegetable oils, some researchers also mention the possibility of indirect action through the induction of systemic resistance. Among the many elicitors of induced systemic resistance (ISR) mentioned in the literature there is also oleic acid, linoleic acid, and linolenic acid – the main components of the vegetable oils used in the present experiments (tab. 1). So far, studies have shown that ISR is most effective against fungi, less effective against bacteria and least effective against systemic viruses [Kuć 2001]. Studies by Cohen et al. [1990] also demonstrated a high efficacy of the above-mentioned components of vegetable oils in inducing systemic resistance in potato plants to the late blight fungus *Phytophthora infestans*.

The aim of the experiments was to determine the effect of certain vegetable and mineral oils on the germination of spores of *Diplocarpon rosae* Wolf. and the morpho-

Table 1. The studied oil composition – percent by weight of total fatty acids
Tabela 1. Skład badanych olejów roślinnych – ogółem procent wagowy kwasów tłuszczowych

Oil – Olej	Unsat. ± sat. ratio Stosunek kwasów Nienasycone ± nasycone	Saturated – Kwasy nasyscone		Mono Unsaturated Mono nienasycone	Poly unsaturated – Kwasy wielo nienasycone	
		palmitic acid C16:0 kwas palmitynowy	stearic acid C18:0 kwas stearynowy	oleic acid C18:0 kwas oleinowy	linoleic acid (ω 6) C18:2 kwas linolowy	alpha linolenic acid (ω3) C18:3 kwas alfa linolenowy
Canola Oil (Rape oil) Olej rzepakowy	15.7	4	2	62	22	10
Corn Oil (Maize Oil) Olej kukurydziany	6.7	11	2	28	58	1
Grape seed Oil Olej winogronowy	7.3	8	4	15	73	-
Olive Oil Olej z oliwek	4.6	13	3	71	10	1
Soybean Oil Olej sojowy	5.7	11	4	24	54	7
Sunflower Oil* Olej słonecznikowy	7.3	11	5	28	51	5

Source: http: ± ± www.scientificpsychic.com ± fitness ± fattyacidsl.html logical changes visible under the scanning electron microscope resulting from the application of those oils.

MATERIALS AND METHODS

The following compounds were used in the experiments:

Vegetable oils (cooking oils) used as food: corn seed oil, olive (fruit) oil, rapeseed oil (canola oil), soya seed oil, and sunflower seed oil (tab. 1).

Vegetable oils recommended for plant protection: Dedal 90 EC (90% vegetable oil) – produced by Danmark Łódź Poland, Olejan 80 EC (85% rapeseed oil) – produced by Danmark Łódź Poland.

Mineral oils: Atpolan 80 EC (76% SN mineral oil) – produced by Agromix Niepołomice Poland, Ikar 95 EC (95% SAE mineral oil) – produced by Danmark Łódź Poland, Olemix 84 EC (84% DSA mineral oil) – produced by Danmark Łódź Poland, Promanal 60 EC (60% mineral oil) – produced by Neudorff GmbH KG Germany, Sunspray 850 EC (85% mineral oil) – produced by Sun Oil Company (Belgium).

Fungicides: Saprol 190 EC (190 g triforine per dm^3) produced by American Cyanamid Company USA, and Score 250 EC (250 g difenoconazole per dm^3) produced by Syngenta Crop Protection AG, Switzerland.

Surfactant: Tergitol™ 15 – S-9 (surfactant) – produced by DOW Chemical Co.

The experiments were carried out on roses cv. 'Kardinal' and cv. 'Red Berlin', grown in an open and susceptible to black spot. During the course of the experiments the roses were watered using a capillary system to prevent the applied agents from being washed off the surface of the plants during sprinkling. In all the experiments, shrubs were sprayed in the morning using 1 dm^3 of working solution per 10 m^2 of surface area. Both the upper and lower surface of the leaf blade was thoroughly covered. Tergitol™, at a concentration of 0.3%, was added to the spray mixtures of the vegetable oils used. One, 7 and 14 days after spraying, the leaves with visible disease symptoms were sampled. In the laboratory, a droplet of sterilized water was put on the leaf surface and spores were scraped with a razor onto potato-dextrose agar. A second droplet of water was added to the suspension of spores, which was then spread over the medium's surface. To reduce development of bacteria, rose bengal at 0.5 $mg \cdot dm^{-3}$ and 80,000 units of penicillin per dm^3 were added to the mycelium. After 44–48 hrs of incubation at 18–20°C the total number of spores and the number of germinating spores in the observation field were counted under a light microscope (Jenaval Carl Zeiss Jena) at a magnification of 125×. Five counting places with 30–60 spores in the observation field were selected. In the case of a high number of spores they were counted only from one half or ¼ of the observation field. Next, using a formula, the percentage rate of the oils' effectiveness in inhibiting the germination of spores was calculated [Borecki 1981].

Microscopic observations. In the experiment conducted in 2006, 12 hours after spraying 'Berlin Red' rose bushes, leaf samples were collected from each combination and placed in sealed plastic containers, ensuring the relative humidity was above 90%. After another 12 hours from the time of the treatment, the effects of the applied compounds on the mycelium and spores of *Diplocarpon rosae* were assessed. The specimens were examined and photographed with a scanning electron microscope (FEI Quanta 200, Analytical Centre, Warsaw Agricultural University). The material to be photographed was coated with carbon and silver, in a high vacuum mode, using an ETD decoder (Everhart Thornley Decoder), as in earlier experiments on the effects of various compounds on the mycelium and spores of *Microsphaera alphitoides* [Mazur et al. 2010].

The experiment was set up in a randomised block design with 4 replications, each replication consisting of 5 plants or 4 plates of PDA.

RESULTS AND DISCUSSION

In 2003, in the first assessment a day after the spray treatment, the percentage effectiveness of the tested oils relative to the control ranged from 8.4% (Olejan 85 EC) to nearly 91% (Olemix 84 EC). Seven days after the treatment, the effectiveness in inhibiting spore germination was found to be from 14.9% (corn oil) to almost 99% (Sunspray 850 EC). In the case of the treatments with Atpolan 80 EC and Promanal 60 EC, even more spores were found germinating than in the control. After 14 days, the rate of inhibition of spore germination was found to range from 2.2% (olive oil) to 59.9% (Sunspray 850 EC) compared to the control. Atpolan 80 EC and Olemix 84 EC stimulated the germination of *D. rosae* spores (tab. 2).

Table 2. Influence of oils used for rose shrubs 'Kardinal' protection on spore *Diplocarpon rosae* germination (in %). Beginning of experiment: 16.10.2003

Tabela 2. Wpływ olejów użytych do opryskania krzewów róż 'Kardinal' na procent kiełkujących zarodników *Diplocarpon rosae.* Początek doświadczenia: 16.10.2003

	Treatment Środek	Concentration % Stężenie%	Days after spraying – Po dniach od opryskania 1	7	14
	Control – Kontrola	-	79.1 g	79.0 e	75.0 ef
	Saprol 190 EC	0.15	50.2 de	0.6 a	18.0 a
Plant oils used as a food (Cooking oils) Oleje roślinne	Corn oil	1.0	59.3 e	67.3 d	38.4 bc
	Olive oil	1.0	26.8 c	3.1 a	73.4 ef
	Rape oil	1.0	8.2 a	0.8 a	62.1 de
	Soybean oil	1.0	14.5 ab	31.6 c	42.4 bc
	Sunflower oil	1.0	40.8 d	9.1 b	51.9 cd
Plant oils recommended in plant protection Oleje roślinne używane jako adjuwanty	Dedal 90 EC	1.0	18.8 bc	3.0 a	53.9 cd
	Olejan 85 EC	1.0	72.5 fg	1.7 a	61.4 de
Mineral oils Oleje mineralne	Atpolan 80 EC	1.0	13.3 ab	83.5 ef	86.2 fg
	Ikar 95 EC	1.0	14.6 ab	1.7 a	54.2 cd
	Olemix 84 EC	1.0	7.2 a	1.1 a	90.9 g
	Promanal 60 EC	1.0	26.6 c	89.5 f	62.3 de
	Sunspray 850 EC	1.0	61.7 ef	0.9 a	30.1 ab

Mean values marked with the same letter do not differ at the significance level p = 0.05 according to the Duncan's test

Średnie oznaczone tą samą literą w obrębie kolumn nie różnią się istotnie (5%) według testu Duncana

In the experiments conducted in 2004, in the first assessment a day after spraying the plants, the percentage effectiveness of the tested oils relative to the control ranged from 21.1% (corn oil) to 60.7% (Dedal 90 EC). With the passing of time after the spray treatment, the effectiveness of the tested oils was found to decrease. Seven days after spraying the roses, the effectiveness in inhibiting spore germination was from 14.9% (corn oil) to nearly 42.2% (Olemix 84 EC). After 14 days, the rate of inhibition of spore germination was found to be from 9.1% (soybean oil) to 21.5% (corn oil) compared with the control (tab. 3).

Table 3. Influence of oils used for rose shrubs 'Kardinal' protection on spore *Diplocarpon rosae* germination (in %) – Synthesis from 3 experiment. Beginning of experiment: 25.08.2004, 26.08.2004, 31.08.2004

Tabela 3. Wpływ olejów użytych do opryskania krzewów róż 'Kardinal' na procent kiełkujących zarodników *Diplocarpon rosae* – Synteza z 3 serii. Początek doświadczenia: 25.08.2004, 26.08.2004, 31.08.2004

	Treatment Środek	Concentration % Stężenie%	Days after sparying – Po dniach od opryskania		
			1	7	14
	Control – Kontrola	-	84.0 e	91.6 f	99.5 e
	Score 250 EC	0.05	37.6 ab	68.0 a-e	73.3 a
Plant oils used as a food (Cooking oils) Oleje roślinne	Corn oil (maize oil)	1.0	66.3 de	77.9 de	78.0 ab
	Grape seed oil	1.0	65.4 c-e	67.9 a-e	84.9 a-d
	Olive oil	1.0	46.1 a-c	69.4 a-e	83.3 a-d
	Rape oil (canola oil)	1.0	65.3 b-e	76.0 c-e	84.3 a-d
	Soybean oil	1.0	46.3 a-d	58.1 a-d	90.4 de
	Sunflower oil	1.0	62.9 a-e	68.7 a-e	81.8 a-d
Plant oils recommended in plant protection Oleje roślinne używane jako adjuwanty	Dedal 90 EC	1.0	33.0 a	56.7 a-c	80.9 a-c
	Olejan 85 EC	1.0	63.4 a-e	69.7 a-e	87.5 c-e
Mineral oils Oleje mineralne	Atpolan 80 EC	1.0	62.6 a-e	71.2 b-e	83.8 a-d
	Ikar 95 EC	1.0	53.5 a-e	61.2 a-e	84.9 a-d
	Olemix 84 EC	1,0	58.3 a-e	53.0 a	87.1 b-e
	Promanal 60 EC	1.0	59.1 a-e	53.2ab	81.9 a-d

Note: see Table 2

In the experiments conducted in May 2006, in the first assessment a day after the spraying, the percentage effectiveness of the tested oils relative to the control ranged from 6.2% (olive oil) to nearly 86.9% (soybean oil). After 7 days, the effectiveness in inhibiting spore germination was found to be from 34.8% (canola oil) to 92.1% (Sunspray 850 EC). And after 14 days, the rate of inhibition of spore germination was found to be from 3.8% (olive oil) to 94.1% (Ikar 94 EC) in comparison with the control. The sunflower oil used for spraying the roses stimulated the germination of *D. rosae* spores (tab. 4).

Table 4. Influence of oils used for rose shrubs 'Red Berlin' protection on spore *Diplocarpon rosae* germination (in %). Beginning of experiment: 30.05.2006

Tabela 4. Wpływ olejów użytych do opryskania krzewów róż 'Red Berlin' na procent kiełkujących zarodników *Diplocarpon rosae*. Początek doświadczenia: 30.05.2006

	Treatment Środek	Concentration % Stężenie %	Days after spraying – Po dniach od opryskania 1	7	14
	Control – Kontrola	-	63.1 h	47.0 f	63.1 g
	Control + water	-	61.1 h	56.0 f	65.8 g
	Score 250 EC	0.05	15.3 bc	10.1 bc	9.3 b
Plant oils used as a food (Cooking oils) Oleje roślinne	Corn oil	1.0	32.0 de	14.7 b-d	35.4 f
	Olive oil	1.0	59.2 h	30.0 e	60.7 g
	Rape oil	1.0	46.2 fg	30.64 e	35.7 f
	Soybean oil	1.0	8.3 a	17.3 cd	19.0 de
	Sunflower oil	1.0	53.4 gh	18.8 d	69.3 g
Plant oils recommended in plant protection Oleje roślinne używane jako adjuwanty	Dedal 90 EC	1.0	21.4 c	7.8 ab	10.8 bc
	Olejan 85 EC	1.0	39.6 ef	13.5 b-d	14.5 b-d
Mineral oils Oleje mineralne	Atpolan 80 EC	1.0	35.8 e	19.4 d	24.1 e
	Ikar 95 EC	1.0	15.0 bc	17.3 cd	3.7 a
	Olemix 84 EC	1.0	23.4 cd	8.2 ab	16.9 c-e
	Promanal 60 EC	1.0	19.3 bc	29.8 e	14.9 b-d
	Sunspray 850 EC	1.0	13.0 ab	3.7 a	14.7 b-d

Note: see Table 2

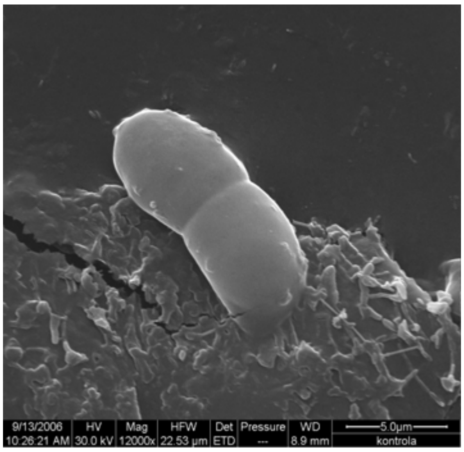
Table 5. Influence of oils used for rose shrubs 'Red Berlin' protection on spore *Diplocarpon rosae* germination (in %). Beginning of experiment: 11.09.2006

Tabela 5. Wpływ olejów użytych do opryskania krzewów róż 'Red Berlin' na procent kiełkujących zarodników *Diplocarpon rosae*. Początek doświadczenia: 11.09.2006

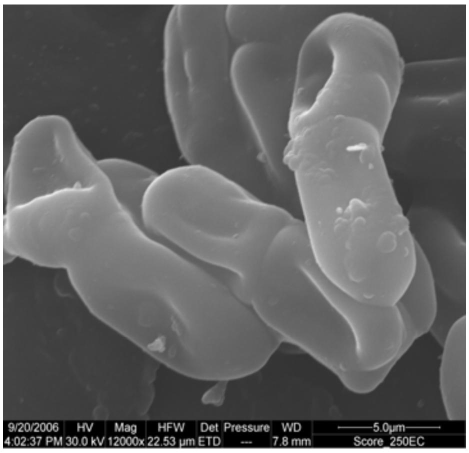
	Treatment Środek	Concentration % Stężenie %	Day after spraying – Po dniach od opryskania 1	7	14
	Control – Kontrola	-	66.7 f	67.7 j	78.7 g
	Score 250 EC	0.05	3.4 a	12.4 a	11.7 a
Plant oils used as a food (Cooking oils) Oleje roślinne	Corn oil	1.0	34.5 bc	48.3 f-h	48.7 de
	Olive oil	1.0	52.8 e	56.8 hi	48.6 de
	Rape oil	1.0	38.6 b-d	44.9 e-g	47.4 c-e
	Soybean oil	1.0	46.7 de	46.0 e-g	42.6 cd
	Sunflower oil	1.0	51.0 e	32.8 cd	36.2 c
Plant oils recommended in plant protection Oleje roślinne używane jako adjuwanty	Dedal 90 EC	1.0	45.9 de	29.9 bc	45.5 c-e
	Olejan 85 EC	1.0	33.9 bc	22.4 b	17.4 ab
Mineral oils Oleje mineralne	Atpolan 80 EC	1.0	46.8 de	54.3 gh	64.3 f
	Ikar 95 EC	1.0	35.9 bc	39.7 d-f	24.7 b
	Olemix 84 EC	1.0	35.4 bc	43.2 ef	38.0 cd
	Promanal 60 EC	1.0	40.9 b	64.8 ij	56.2 ef
	Sunspray 850 EC	1.0	31.1 b	36.3 c-e	40.1 cd

Note: see Table 2

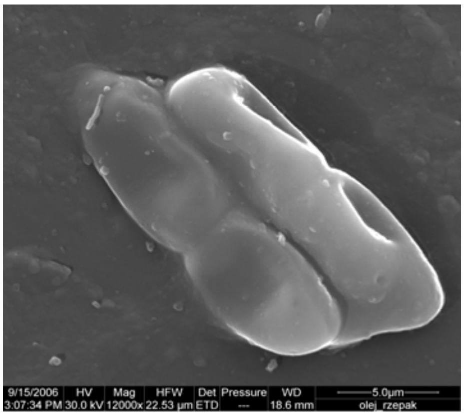
In the experiments conducted in the autumn of 2006, in the first assessment a day after spraying the plants, the percentage effectiveness of the tested oils relative to the control ranged from 20.9% (olive oil) to over 53% (Sunspray 840 EC). Seven days after the spraying, the effectiveness in inhibiting spore germination was found to be from 4.2% (Promanal 60 EC) to nearly 66.9% (Olejan 85 EC). And after 14 days, the rate of inhibition of spore germination was found to be from 18.3% (Atpolan 80 EC) to 77.8% (Olejan 85 EC) in comparison with the control (tab. 5).



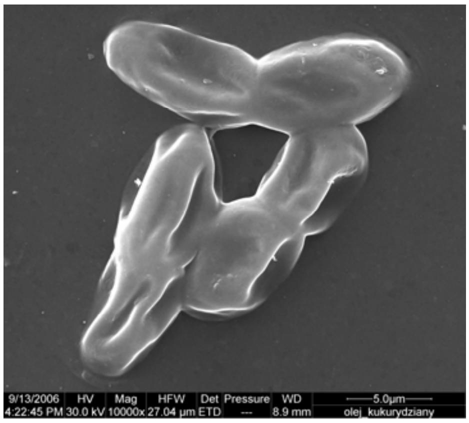
Phot. 1. Spores of *Diplocarpon rosae* on the surface of control plants
Fot. 1. Zarodniki konidialne D*iplocarpon rosae* na powierzchni roślin kontrolnych



Phot. 2. Strongly deformed spores after Score 250 EC application
Fot. 2. Silnie zdeformowane zarodniki po zastosowaniu środka Score 250 EC

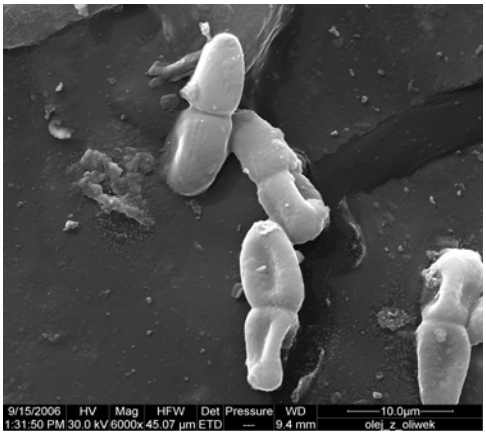


Phot. 3. Strongly deformed spores after canola oil application
Fot. 3. Zdeformowane zarodniki po zastosowaniu oleju rzepakowego

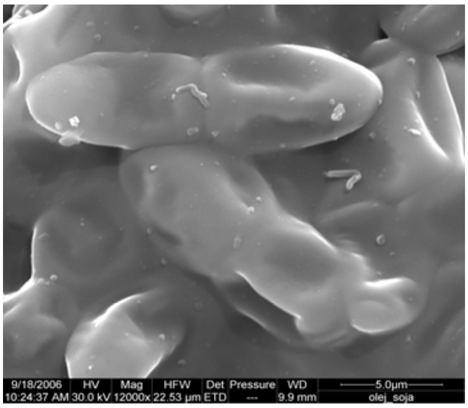


Phot. 4. Very strongly deformed spores after corn oil application
Fot. 4. Bardzo duża deformacja zarodników po zastosowaniu oleju kukurydzianego

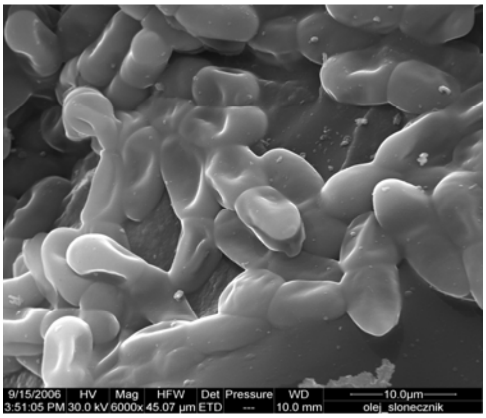
In spite of conducting 6 series of experiments, the obtained results do not allow the drawing of a clear conclusion as to which of the tested vegetable or mineral oils showed the highest effectiveness in inhibiting germination of *D. rosae* spores. The percentage effectiveness of the tested oils relative to the control depended on the oil being tested, the time of observation and the experiment. Overall, in the assessments that were conducted after 1 and 7 days from the time of treatment, the effectiveness of the tested oils was higher than after 14 days (tab. 2, 3). However, the results obtained in 2006 do not



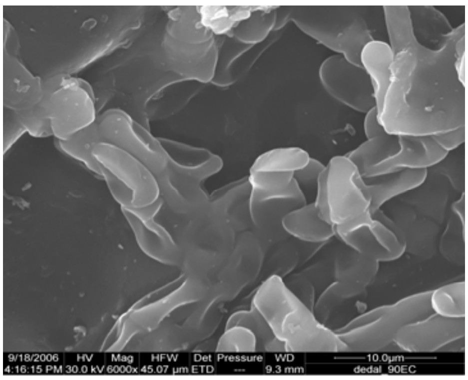
Phot. 5. Damage of spores after olive oil application
Fot. 5. Uszkodzenie zarodników po zastosowaniu oleju z oliwek



Phot. 6. Strongly deformed spores after soybean oil application
Fot. 6. Silna deformacja zarodników po zastosowaniu oleju sojowego

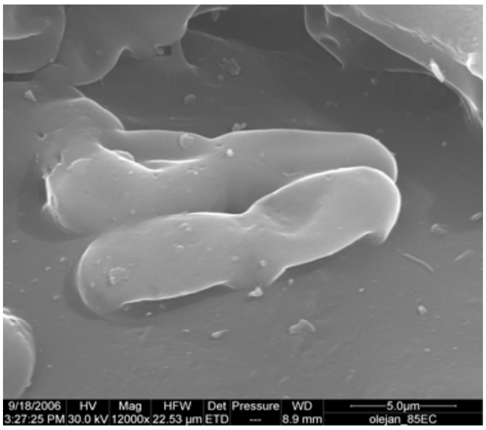


Phot. 7. Very strongly deformed spores after sunflower oil application
Fot. 7. Bardzo silna deformacja zarodników po zastosowaniu oleju słonecznikowego



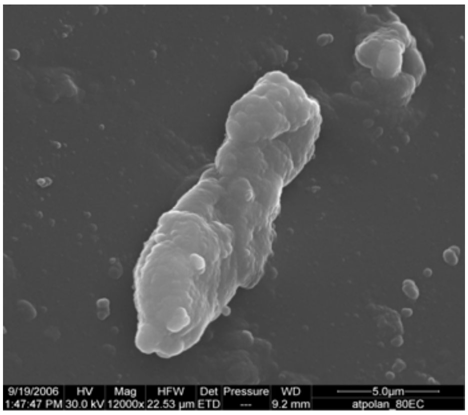
Phot. 8. Strongly deformed spores after Dedal 90 EC application
Fot. 8. Silnie zdeformowane zarodniki po zastosowaniu oleju Dedal 90 EC

confirm this (tab. 4, 5). Also, the deformation of spores visible under the scanning electron microscope resulting from the application of the oils did not explicitly translate into the inhibition of spore germination (phot. 3–12). Similarly, McGrath and Shishkoff [2000], in their experiments on cucumber, showed that although oil appeared to cause abnormalities of conidiophores and *Sphaerotheca fusca* spores immediately after application, the effect was temporary. Studies have shown that even after treatment with a fungicide there was no disintegration of *D. rosae* spores, but only their deformation



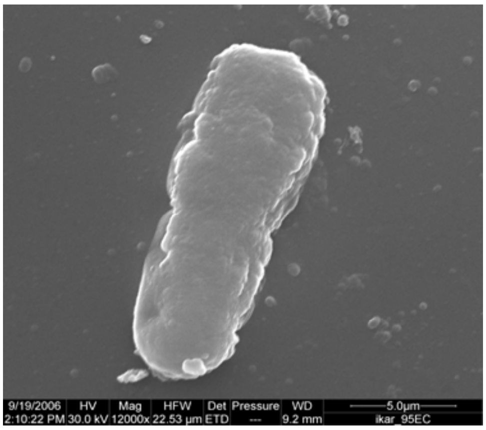
Phot. 9. Strongly collapsed spores after Olejan 85 EC application

Fot. 9. Silnie odwodnione zarodniki po zastosowaniu oleju Olejan 85 EC



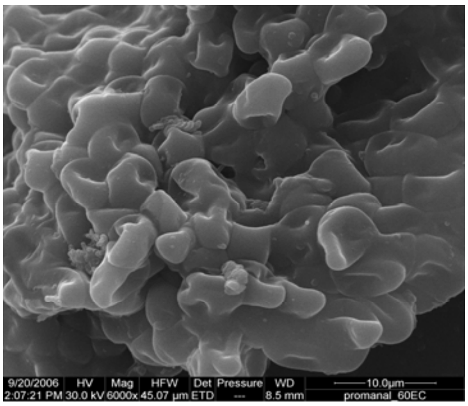
Phot. 10. Very strongly deformed spores after Atpolan 80 EC application

Fot. 10. Bardzo silnie zdeformowane zarodniki po zastosowaniu oleju Atpolan 80EC



Phot. 11. Strongly deformed spores after Ikar 95 EC application

Fot. 11. Silnie zdeformowne zarodniki po zastosowaniu oleju Ikar 95 EC



Phot. 12. Strongly collapsed spores after Promanal 60 EC application

Fot. 12. Silnie odwodnione zarodniki po zastosowaniu oleju Promanal 60 EC (phot. 2). The author's earlier studies on the effects of various compounds on the mycelium and spores of *Sphaerotheca pannosa* var. *rosae*, which causes powdery mildew, showed that Atpolan 80 EC and the fungicide Saprol 190 EC were able to almost completely destroy conidia and hyphae [Wojdyła 2000]. Likewise, Hafez [2008] showed that the protective effect of oils against powdery mildew resulted mainly from the inhibition of conidia germination and the suppression of the mycelial growth of the pathogens and that there was slight activation of the host's defence mechanisms. In another publications, Aaqbool et al. [2010] found that *in vitro* experiments on potato dextrose agar (PDA) plates amended with 0.4% cinnamon oil showed promising results among all the treatments in suppressing the mycelial growth of *Colletotrichum musae* and in inhibiting the germination of conidia (83.2%). The results concerning good effectiveness of oils in inhibiting the germination of fungal spores are not always confirmed by the author's own studies and those of others. The tested oils used for spraying rose petals and PDA media only slightly inhibited the germination of *Botrytis cinerea* spores and the length of the germ tube [Wojdyła 2003a]. Whiteside [1973], too, showed in his experiments that a spray treatment with 1% oil-water emulsion applied to the leaves of sweet orange (*Citrus sinensis*) did not reduce germination and germ tube growth by ascospores of *Mycosphaerella citri* deposited 4 hrs later on the treated lower leaf surface. However, oil sprays applied even as early as 56 days before inoculation reduced appressoria formation and the number of subsequent hyphal penetrations into the mesophyll. Hyphal penetration was also reduced by oil sprays applied 14 days after inoculation. This suggests that the main action of oil in controlling greasy spot is by inducing greater host resistance. Also Calpouzos et al. [1959] showed that petroleum oil did not inhibit mycelial growth of *Mycosphaerella musicola*, or impair ascospores discharge or conidial production on diseased leaves.

The author's own experiments and those of other researchers have shown that the inhibition of the germination of pathogen spores by oils depends mainly on the pathogen (disease causing agent) involved in the tests. The highest effectiveness in reducing the germination of spores has been found in the case of the causal agents of powdery mildew. To sum up, the effect of the tested oils on reducing the germination of *D. rosae* spores was not stable in the individual experiments. However, because of the safety of vegetable oils to the environment, and an effectiveness rate of close to 100% in controlling *S. pannosa* var. *rosae* – the main disease of roses, the possibility of restricting the development of *Botrytis cinerea* – the causal agent of grey mould, and of *Phragmidium mucronatum*, vegetable oils should certainly be included in the protection programme of this ornamental plant species [Wojdyła 2000, 2003a].

CONCLUSIONS

The results of the experiments do not allow the drawing of a clear conclusion as to which of the tested vegetable or mineral oils had the highest effectiveness in reducing the germination of *D. rosae* spores. Depending on the experiment and the time of observation, the percentage inhibition of spore germination was found to vary. After 1 day, the effectiveness of the tested oils ranged from 6.2% (olive oil) to 90.9% (Olemix

84 EC); after 7 days, from 14.9% (corn oil) to 99% (Olemix 84 EC and Sunspray 850 EC); and after 14 days, from 0% (Atpolan 80 EC and Olemix 84 EC) to 94.1% (Ikar 95 EC). The deformation of spores visible under the scanning electron microscope resulting from the treatment with the oils did not explicitly translate into the inhibition of the germination of spores.

REFERENCES

Aaqbool M., Ali A., Alderson P.G., 2010. Effect of cinnamon oil on incidence of anthracnose diseases and postharvest quality of bananas during storage. Int. J. Agric. Biol. 12, 516–520.

Borecki Z., 1981. Materiały do zajęć specjalizacyjnych z fitopatologii. Cz. IV Fungicydy stosowane w ochronie roślin. Skrypt SGGW AR Warszawa, 139.

Calpouzos L., Theis T., Rivera C.M., Colberg C., 1959. Studies on the action of oil in the control of *Mycosphaerella musicola* on banana leaves. Phytopathology 27, 119–122.

Cohen Y., Gisi U., Mosinger E., 1990. Germination and infection of *Phytophthora infestans* in the presence of fatty acid (Abstr.) Phytopathology 80, 1067.

Dobrzański A., Pałczyński J., Anyszka Z., 1995. Wpływ niektórych adiuwantów na skuteczność herbicydów w uprawie warzyw. Materiały XXXV Sesji Nauk. Inst. Ochr. Rośli, cz. I – Referaty, 73–79.

Hafez Y.M., 2008. Effectiveness of the antifungal black seed oil against powdery mildews of cucumber (*Podosphaera xanthii*) and barley (*Blumeria graminis* f. sp. *hordei*). Acta Biologica Szegediensis 52 (1), 17–25.

Horst R.K., 1983. Compendium of rose diseases. APS St. Paul USA, 7–11.

http://www.scientificpsychic.com/fitness/fattyacidsl.html

Kuć J., 2001. Concepts and direction of induced systemic resistance in plants and its application. Eur. J. Plant Pathol. 107, 7–12.

Lewis D., 1999. Using horticultural oil sprays for pest control. Horticulture and Home Pest news: February 16. www.ipm.iastste.edu/ipm/hortnews/1999/2-19-1999/oilsprays.html

Matysiak R., Woźnica Z., Pudełko J., Skrzypczak G., 1995. Adiuwanty do herbicydów – mechanizm działania. Materiały XXXV Sesji Nauk. Inst. Ochr. Rośli, cz. I – Referaty, 67–72.

McGrath M.T., Shishkoff N., 2000. Control of cucurbit powdery mildew with JMS Stylet-Oil. Plant Disease 84, 989–993.

Mazur S., Wojdyła A.T., Królak E., 2010 Wpływ wybranych fungicydów syntetycznych i biotechnicznych na *Microsphaeria alphitoides* Griffon & Maubl., sprawcę mączniaka prawdziwego dębu. Zesz. Probl. Post. Nauk Rol. 551, 211–218.

Northover J., Schneider K.E., 1996. Physical modes of action of petroleum and plant oils on powdery and downy mildews of grapevines. Plant Dis. 80, 544–550.

Roszyk J., Nowosielski O., Komosa A., 2006. Wpływ adjuwantów na skuteczność dokarmiania dolistnego pomidora szklarniowego. Acta Agrophysica 7 (3), 709–720.

Whiteside J.O., 1973. Action of oil in the control of citrus greasy spot. Phytopathology 63, 262–266.

Wojdyła A.T., 2000. Influence of some compounds on the development of *Sphaerotheca pannosa* var. *rosae*. J. Plant Protection Res. 40, no.2, 106–121.

Wojdyła A.T., 2001a. Garlic juice in the control of some rose diseases. Bull. of the Polish Academy of Science – Biological Sci. 49 (3), 253–263.

Wojdyła A.T., 2001b. Grapefruit extract activity in the control of rose powdery mildew and black spot. Med. Fac. Landbouww. Univ. Gent, 66/2a, 167–177.

Wojdyła A.T., 2002. Oils activity in the control of rose powdery mildew. Med. Fac. Landbouww. Univ. Gent, 67/2, 369–376.
Wojdyła A., 2003a. Biological activity of plant and mineral oils in the control of *Botrytis cinerea* on roses. Bull. of the Polish Academy of Science – Biological Sci. 51 (2), 153–158.
Wojdyła A., 2003b. Chitosan as the biocontrol agent of fungal pathogens: activity and mode of action. Bull. of the Polish Academy of Science – Biological Sci. 51 (2), 159–165.
Wojdyła A.T., 2005. Activity of plant and mineral oils in the control of *Puccinia pelargonii-zonalis*. Comm. App. Biol. Sci. Ghent University, 70/3, 193–198.
Wojdyła A.T., 2009a. Effectiveness of Olejan 85 EC against chrysanthemum and willow rust. Scientific Work Of The Lithuanian Institute Of Horticulture and Lithuanian University of Agriculture. Sodininkystė Ir Daržininkystė. Mokslo darbai 28 (3), 243–248.
Wojdyła A.T., 2009b. Wpływ związków strobilurynowych na rozwój *Diplocarpon rosae*. Prog. Plant Protection/Post. Ochr. Roślin 49 (1), 301–304
Wojdyła A.T., 2010a. Olejan 85 EC – Potential use of Olejan 85 EC for protecting some species of ornamental plants against diseases. J. Plant Protection Res. 50 (2), 164–171.
Wojdyła A.T., 2010b. Ocena skutecznośći środka Olejan 85 EC w ochronie róż przed *Sphaerotheca pannosa* var. *rosae* i *Diplocarpon rosae.* Zesz. Probl. Post. Nauk Rol. 554, 295–303.
Wojdyła A.T, Jankiewicz D., 2004. Oils activity against *Melampsora epitea* on willow. Comm. App. Biol. Sci. Ghent University, 69 (4), 697–703.
Wojdyła A., Kamińska M., Łabanowski G., Orlikowski L., 2007. Ochrona róż. Plantpress Kraków Wydanie IV, 112.
Wojdyła A.T., Łyś J., 2000. Influence of chemical compounds on germination and development of *Diplocarpon rosae.* J. Plant Protection Res. 40, 2, 168–172.
Wojdyła A.T., Orlikowski L.B., 1999. Strobilurin compounds in the control of rust, powdery mildew and black spot on ornamental plants. Med. Fac. Landbouww. Univ. Gent, 64/3b, 539–545.

WPŁYW OLEJÓW ROŚLINNYCH I MINERALNYCH NA KIEŁKOWANIE ZARODNIKÓW *Diplocarpon rosae* Wolf.

Streszczenie. Czarna plamistość powodowana przez *Diplocarpon rosae* należy do jednej z najczęściej występujących i najgroźniejszych chorób róż w uprawie polowej, a ostatnimi laty również pod osłonami. W okresie wegetacji zarodniki konidialne są głównym źródłem rozprzestrzeniania się patogenu, dlatego też podjęto badania mające na celu poszukiwania metody ograniczenia ich kiełkowania. W przeprowadzonych badaniach określano wpływ olejów roślinnych (kukurydziany, olej z oliwek, rzepakowy, słonecznikowy, sojowy, winogronowy), olejów roślinnych polecanych jako adjuwanty Dedal 90 EC (90% oleju roślinnego), Olejan 80 EC (85% oleju rzepakowego) oraz olejów mineralnych Atpolan 80 EC (76% oleju parafinowego 11–13), Ikar 95 EC (95% oleju mineralnego SAE 10/95), Olemix 84 EC (84% oleju mineralnego DSA), Promanal 60 EC (60% oleju parafinowego) oraz SunSpray 850 EC (85% oleju mineralnego) stosowanych w stężeniu 1% do jednokrotnego opryskiwania krzewów róż na kiełkowanie zarodników *D. rosae* po 1, 7 oraz 14 dniach od zastosowania. Również 24 godz. po opryskiwaniu krzewów pod mikroskopem skaningowym określano wpływ badanych olejów na zarodniki grzyba. Skuteczność badanych olejów w porównaniu z kontrolą była uzależniona od badanego oleju, terminu obserwacji oraz doświadczenia. Po 1 dniu skuteczność badanych olejów wahała się pomiędzy 6,2% (olive oil) – 90,9% (Olemix 84 EC), po 7 dniach 4,2% (Promanal 60 EC) – 99% (Olemix 84 EC and Sunspray 850 EC) oraz po 14 dniach 0% (Atpolan 80 EC i Olemix 84EC) – 94,1% (Ikar 95 EC).

Słowa kluczowe: czarna plamistość, róże, oleje, zwalczanie, mikroskop skaningowy

Accepted for print – Zaakceptowano do druku: 13.04.2012