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POTENTIAL USE OF ATPOLAN 80 EC FOR PROTECTING SOME SPECIES OF ORNAMENTAL PLANTS AGAINST DISEASES

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Abstract

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The study was an evaluation of the efficacy of Atpolan 80 EC (76% mineral oil SN) in the protection of ornamental plants against some pathogens – the causal agents of powdery mildew, leaf spot and rust. Depending on the target pathogen, Atpolan 80 EC was used at concentrations from 0.5 to 2% in spray treatments carried out 4 to 9 times at 7-day intervals.

At each of the test concentrations, Atpolan 80 EC, used as a curative treatment of roses, significantly inhibited the development of the pathogens responsible for powdery mildew and black spot. In the control of powdery mildew (*Sphaerotheca pannosa* var. *rosae*), Atpolan 80 EC sprayed on some rose varieties 4 times at 0.5 and 0.75% showed an efficacy of 96% and 98%, respectively, while at higher concentrations completely inhibited the development of disease symptoms. Its efficacy was from 74.4 to 100%, depending on the concentration, in the protection of *Rosa canina* 'Fenders', a rootstock for roses. When used as a remedy to control black spot (*Diplocarpon rosae*), its efficacy after 6 spray treatments was from 31.5% to 85.1%, depending on the concentration used and the susceptibility of the rose variety to the pathogen. However, after 9 treatments its effectiveness was found to decrease. When used curatively on chrysanthemums, Atpolan 80 EC significantly inhibited the development of symptoms of white rust caused by *Puccinia horiana*. After spraying chrysanthemum plants 4 times with the oil at a concentration of 2% there was a 2.5 times reduction in the number of telia forming per leaf, and, depending on the concentration, it caused 16.6 to 100% of telia to disintegrate. There was no evidence of phytotoxicity of Atpolan 80 EC towards the plant species and varieties tested.

Key words: Sphaerotheca pannosa var. *rosae*, *Diplocarpon rosae*, *Puccinia horiana*, mineral oils, control, Atpolan 80 EC

Introduction

Atpolan 80 EC (76% mineral oil SN), produced by Agromix Niepołomice Poland, is recommended as an adjuvant (a substance enhancing the action of another) in liquid form for use in conjunction with the working liquid of some plant protection products. Studies on rose plants to date have shown that Atpolan 80 EC at a concentration of 0.3% can be used as an additive that helps reduce, by as much as 30-50%, the dose of the emulsion fungicides recommended for controlling powdery mildew and black spot (Orlikowski and Wojdyła, 1995; Wojdyła, 1998; Zdonek et al., 1986). Similar literature data indicate high efficacy of oils used on their own (without mixing them with fungicides) in the control of many plant pathogens (Dell et al., 1998; Fernandez et al., 2006; Hummer and Picton, 2001; Ko et al., 2003; McGrath and Shishkoff, 2000; Picton and Hummer, 2003) and pests (Najar-Rodríguez et al., 2008). The author's own research conducted over many years has shown high efficacy of mineral and vegetable oils used at concentrations from 0.25 to 4% in the control of powdery mildew (*Sphaerotheca pannosa* (Wallr. ex Fr.) Lev. var. *rosae* Wor.) on rose (Wojdyła, 2002, 2013, 2015), black spot (*Diplocarpon rosae* Wolf) on rose (Wojdyła, 2012a), rust (*Melampsora epitea* Thüm.) on willow (Wojdyła and Jankiewicz, 2004), and grey mould (*Botrytis cinerea* Pers.) on rose (Wojdyła, 2003). Also in the control of apple scab (*Venturia inaequalis* Cooke/Winter),

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a significant increase in the fungicidal activity of potassium bicarbonate was observed when the fertilizer was mixed with a mineral oil (Jamar et al., 2007).

In an experiment done by Horst et al. (1992), powdery mildew, caused by *Sphaerotheca pannosa* var. *rosae*, and black spot, caused by *Diplocarpon rosae*, were significantly controlled by weekly spray treatments with a 0.063 M aqueous solution of sodium bicarbonate plus 1.0% (v/v) SunSpray Ultra-Fine Oil on *Rose* spp. Petroleum spray oils are currently regarded as more environmentally friendly than synthetic pesticides and are again becoming an essential part of many integrated pest management (IPM) programmes for agricultural crops worldwide, mainly because they are effectively non-toxic to vertebrates, degrade relatively quickly in the environment and have never been associated with resistance (Najar-Rodríguez et al., 2008). Oils might be used as alternatives to conventional fungicides and integrated into programmes that already include other necessary materials, thereby reducing the frequency of use of all the fungicide groups in the programme and the risk of developing resistance to them (Northover and Schneider, 1996). However, long-term use of fungicides can contribute to significant environmental pollution as well as to the development of resistance among the target pathogens (Rongai et al., 2009). A possible way to prevent pathogens from becoming resistant to fungicides is to use them alternately, remembering to employ rotation of substances from different chemical groups, and especially with different mechanisms of action. Therefore, including oils in the range of products recommended for controlling pathogens may contribute to a significant increase in plant health by combating the races of pathogens resistant to the existing remedies and by preventing resistance.

The aim of this study was to determine the efficacy and the optimum concentration of Atpolan 80 EC in the control of the pathogens causing powdery mildew, leaf spot and rust.

Materials and Methods

Table 1

Environmental conditions in Skierniewice during application of plant protection products against *Sphaerotheca pannosa var. rosae* and *Diplocarpon rosae*

Term of plant protection product application	Temperature (ºC)	Air humidity (%)	Fall in the day of application (mm)	Total fall between application (mm)	Wind speed (m/s)
25.06.2003	16.3	66	0	38.0	2.9
02.07.2003	17.6	87	0	12.0	2.9
09.07.2003	19.4	77	0	22.6	1.8
16.07.2003	25.0	63	0	13.0	0.9
23.07.2003	21.8	85	0	22.4	0.6
30.07.2003	19.8	94	0	1.4	0.2
06.08.2003	21.1	60	0	0.2	0.4
13.08.2003	24.2	57	0	28.0	0.0
20.08.2003	18.5	97	0	7.6	0.5

Table 2

Environmental conditions in Młynki during application of plant protection products against *Sphaerotheca pannosa var. rosae* and *Diplocarpon rosae*

Term of plant protection product application	Temperature (ºC)	Air humidity (%)	Fall in the day of application (mm)	Total fall between application (mm)	Wind speed (m/s)
25.06.2003	17.7	60	1.6	1.6	1.0
02.07.2003	15.3	88	0.1	15.2	5.0
09.07.2003	15.4	77	0	9.4	3.0
16.07.2003	19.0	88	0	17.3	1.0
23.07.2003	20.3	92	0	16.3	1.0
30.07.2003	19.0	92	0	16.9	0.0
06.08.2003	17.6	74	0	7.5	1.0
13.08.2003	19.6	76	0	0.6	0.0
20.08.2003	18.2	84	0	8.2	3.0

The study involved the use of a mineral oil – Atpolan 80 EC (76% oil SN), produced by Agromix Niepołomice, and a standard fungicide Saprol 190 EC (190 g triforine in 1 dm^3) from American Cyanamid Company, USA.

Control of powdery mildew

Rose plants cv. 'Madelon' and rootstocks of *Rosa canina* 'Fenders' were grown in soil in an experimental field of the Institute of Horticulture in Skierniewice, and those of cv. 'Mercedes' on a nursery farm in Młynki. After the onset of symptoms of powdery mildew (*Sphaerotheca pannosa* var. *rosae*), the plants were sprayed with the test product 4 times at 7-day intervals. During the experiments, when watering, the water jet was aimed directly at the substrate. The effectiveness of the oil was determined on a rating scale before the experiment and 3 days after spraying the rose plants 2 and 4 times (Table 5).

Table 3

Environmental conditions in greenhouse during application of plant protection products against *Puccinia horiana* (Experiment 1)

Term of plant protection product application	Temperature (ºC)	Air humidity (%)
28.05 2003	17.0	90
04.06.2003	18.0	86
11.06.2003	19.0	75
18.06.2003	21.0	80

Table 4

Environmental conditions in greenhouse during application of plant protection products against *Puccinia horiana* (Experiment 2)

Term of plant protection product application	Temperature (ºC)	Air humidity (%)
01.08 2003	21.0	80
08.08.2003	22.0	85
15.08.2003	19.0	80
22.08.2003	18.5	76

Control of black spot on rose

Rose plants cv. 'Red Berlin' were grown in soil in an experimental field of the Institute of Horticulture in Skierniewice, and those of cv. 'Sandra' on a nursery farm in Młynki. The experiments were performed on rose plants on which black spot appeared every year. During the growing season, if necessary, the shrubs were watered by means of a capillary system to prevent the agents from being washed off from the surface of the plants when sprinkling. After finding symptoms of black spot (*Diplocarpon rosae*), the shrubs were sprayed 9 times, every 7 days, with Atpolan 80 EC at a concentration from 0.5 to 2%. The effectiveness of the oil was determined on a rating scale before the experiment and 3 days after spraying the rose plants 3, 6, and 9 times (Table 8).

Protection against rust

Seedlings of chrysanthemum cv. 'Fiji Yellow', sensitive to *Puccinia horiana*, were planted in 1 dm^3 pots filled with a peat substrate. The plants were placed in a greenhouse on window sills lined with capillary mats. A chrysanthemum with symptoms of rust sporulation was placed among the healthy plants. In order to ensure a relative humidity above 90%, which favours the development of the pathogen, the sills were covered with a tunnel made of thin polyethylene film. After finding the first symptoms of leaf spot, but before the formation of telia, spraying of the plants began. The chrysanthemum plants were sprayed 4 times, at 7-day intervals. Before spraying began, and then 3 days after the completion of the treatments, an assessment was conducted to determine the percentage of infected leaves, and the average number and percentage of dried-up telia.

The experiments on controlling powdery mildew and black

Table 5

Effectiveness of Atpolan 80 EC in the control of *Sphaerotheca pannosa* var. *rosae* on rose cv. Madelon (Beginning of experiment and initial infection level: 2003.07.16 = 1.3. Place: Skierniewice)

Treatments	Concentration (%)	Frequency of spraying in days	Mean degree of shoots infection after sprayings	
			2	4
Control	-	-	3.60 e	5.00 d
Triforine	0.03	7	1.85 d	1.75 c
Atpolan 80 EC	0.5	7	0.40 c	0.10 b
Atpolan 80 EC	0.75	7	0.25 b	0.00 a
Atpolan 80 EC	1.0	7	0.10 a	0.00 a
Atpolan 80 EC	1.5	7	0.00 a	0.00 a
Atpolan 80 EC	2.0	7	0.00 a	0.00 a

Note: Means in columns, followed by the same letter, do not differ with 5% of significance (Duncan's multiple range test)
Disease index: 0 – no symptoms, 1 – up to 1% of shoot area covered with mycelium, 2 – 1.1 up to 5%, 3 – 5.1 up to 10%, 4 – 10.1 up to 20%, 5 – over 20% of shoot area covered with mycelium

spot of roses were conducted in different climate and soil conditions on plantations about 150 km away from each other. Spraying of the plants was carried out using an Apor laboratory pneumatic sprayer, with a tank capacity of 1.5 dm^3 and a liquid pressure of 0.2 MPa adapted for spraying plots of that size. During spraying, the spray tip was held at a height of 30 cm above the plants. For each treatment, the spraying of plants started at 8 o'clock in the morning; some meteorological data at that hour were also recorded. In all the experiments, the plants were sprayed in the morning using 1 dm^3 of working solution per 10 m^2, by covering well the upper and lower side of the leaf blade. In a period of up to 7 days from the time of spraying, daily observations were carried out to check for possible phytotoxicity of the oil. During the observations it was checked whether there were signs of yellowing/browning of plant tissues or inhibition in growth. An automatic weather station recorded the weather conditions during the experiments (Tables 1, 2, 3, 4). When analysing the results using a simplified Abbott's formula, the percentage efficacy of the oils relative to the control was calculated (Abbott, 1925).

The experiments were carried out in a randomized block design in 4 replicates, each with five rose shrubs or chrysanthemum plants.

Results

Control of powdery mildew

In the experiment conducted in Skierniewice, after spraying rose shrubs twice with Atpolan 80 EC, at each of the concentrations used there was a significantly lower percentage of infected shoots compared with the control plants (Table 5). The percentage efficacy of the oil, depending on its concentration, ranged from 88.9% (conc. of 0.5%) to 97.2% (conc. of 1%). The shrubs sprayed with higher concentrations of Atpolan 80 EC showed no disease symptoms. After 4 spray treatments, Atpolan 80 EC significantly inhibited the development of symptoms at each of the test concentrations. No disease symptoms were found on the plants sprayed with Atpolan 80 EC at a conc. of 0.75% and higher.

In the second experiment conducted on *Rosa canina* 'Fenders', after spraying the shrubs twice with Atpolan 80 EC, at each of the concentrations used there was a significantly lower percentage of infected shoots compared with the control plants (Table 6). Depending on the working concentration of Atpolan

Table 6

Effectiveness of Atpolan 80 EC in the control of *Sphaerotheca pannosa* var. *rosae* on rose *Rosa canina* Fenders (Beginning of experiment and initial infection level: 2003.07.16 = 1.25. Place: Skierniewice)

Treatments	Concentration (%)	Frequency of spraying in days	Mean degree of shoots infection after sprayings	
			2	4
Control	-	-	4.45 e	4.68 e
Triforine	0.03	7	2.25 d	2.05 d
Atpolan 80 EC	0.5	7	1.80 c	1.20 c
Atpolan 80 EC	0.75	7	1.50 b	1.15 c
Atpolan 80 EC	1.0	7	1.45 ab	0.20 b
Atpolan 80 EC	1.5	7	1.35 ab	0.10 ab
Atpolan 80 EC	2.0	7	1.30 a	0.00 a

Note: see Table 5

Table 7

Effectiveness of Atpolan 80 EC in the control of *Sphaerotheca pannosa* var. *rosae* on rose cv. Mercedes (Beginning of experiment and initial infection level: 2003.07.16 = 2.45. Place: Młynki)

Treatments	Concentration Stężenie (%)	Frequency of spraying in days	Mean degree of shoots infection after sprayings	
			2	4
Control	-	-	3.60 f	5.00 d
Triforine	0.03	7	2.00 e	1.60 c
Atpolan 80 EC	0.5	7	1.00 d	0.20 b
Atpolan 80 EC	0.75	7	0.75 c	0.15 b
Atpolan 80 EC	1.0	7	0.55 b	0.00 a
Atpolan 80 EC	1.5	7	0.30 a	0.00 a
Atpolan 80 EC	2.0	7	0.20 a	0.00 a

Note: see Table 5

EC 80, its percentage effectiveness in reducing disease symptoms ranged from 59.6 to 70.8%. Similarly, after 4 spray treatments with Atpolan 80 EC, its effectiveness ranged from 74.4 to 97.9%. The plants sprayed with the oil at 2.0% showed no disease symptoms.

In the experiment in Młynki, after spraying the shrubs twice with Atpolan 80 EC, at each of the test concentrations there was a significantly lower percentage of infected shoots compared with the control shrubs, and the percentage efficacy of the oil ranged from 72.2 to 94.4% (Table 7). Also after 4 spray treatments, Atpolan 80 EC significantly inhibited the development of disease symptoms, and its efficacy ranged from 68 to 97%. No disease symptoms were found on the plants sprayed with Atpolan 80 EC at a conc. of 1.0% or higher. In each observation, an increase in the concentration of Atpolan 80 EC was associated with an increase in its effectiveness. Saprol 190 EC, in each observation, was significantly less effective than the oil tested.

Control of black spot of rose

In the experiment conducted in Skierniewice, after spraying the rose shrubs 3 times, Atpolan 80 EC significantly inhibited the development of disease symptoms in comparison with the control shrubs, and its effectiveness ranged from 24.8% to 80%. The efficacy of the oil at a concentration of 1.0% or higher was similar or better than the efficacy of the standard product Saprol 190 EC (Table 8). Similarly, after 6 weeks of protection, Atpolan 80 EC significantly inhibited the development of disease symptoms, and its effectiveness, depending on the concentration used, was from 31.9% to 85.1%. Also after 9 treatments, Atpolan 80 EC at each of the test concentrations significantly inhibited the development of disease symptoms, and its effectiveness ranged from 26.2% to 40.5%.

In the experiment conducted in Młynki, after spraying the rose shrubs three times, Atpolan 80 EC significantly inhibited the development of disease symptoms, and its effectiveness ranged from 41.4% to 75.8%. (Table 9). Atpolan 80 EC used at 1.5 and 2.0% showed similar effectiveness to that of the standard fungicide. Similarly, after 6 treatments, the efficacy of the oil ranged from 51.5 to 75.8%. Also after spraying the plants 9 times, Atpolan 80 EC significantly inhibited the development of disease symptoms, and its efficacy ranged from 44.5% to 56.9%. In each observation, an increase in the concentration of the oil was associated with an increase in its effectiveness. In both experiments, in the observations carried out after 6 and 9

Table 8

Effectiveness of Atpolan 80 EC in the control of *Diplocarpon rosae* on rose cv. Red Berlin (Beginning of experiment and initial infection level: 2003.06.25 = 0.6. Place: Skierniewice)

Treatments	Concentration (%)	Frequency of spraying in days	Mean degree of shoots infection after sprayings		
			3	6	9
Control	-	-	1.25 e	2.35 g	4.20 e
Triforine	0.03	7	0.50 b	0.20 a	0.30 a
Atpolan 80 EC	0.5	7	0.94 d	1.60 f	3.10 d
Atpolan 80 EC	0.75	7	0.75 c	1.45 e	3.00 d
Atpolan 80 EC	1.0	7	0.44 b	1.20 d	2.65 c
Atpolan 80 EC	1.5	7	0.38 ab	0.60 c	2.55 bc
Atpolan 80 EC	2.0	7	0.25 a	0.35 b	2.50 b

Note: see Table 5

Disease index: 0 – no symptoms, 1 – 0.1 up to 25% of plant leaves with disease symptoms, 2 – over 25% leaves with disease symptoms, 3 – up to 25% of fallen leaves and rest of the leaves with disease symptoms, 4 - up to 50% of fallen leaves and rest of the leaves with disease symptoms, 5 – from 50,1 up to 90% of fallen leaves, 6 – over 90% of fallen leaves

Table 9

Effectiveness of Atpolan 80 EC in the control of *Diplocarpon rosae* on rose cv. Sandra Beginning of experiment and initial infection level: 2003.06.25 = 0.23. Place: Młynki

Treatments	Concentration (%)	Frequency of spraying in days	Mean degree of shoots infection after sprayings		
			3	6	9
Control	-	-	1.28 d	3.30 g	5.68 f
Triforine	0.03	7	0.25 a	0.25 a	1.00 a
Atpolan 80 EC	0.5	7	0.75 c	1.60 f	3.15 e
Atpolan 80 EC	0.75	7	0.69 c	1.45 e	2.95 d
Atpolan 80 EC	1.0	7	0.44 b	1.20 d	2.70 c
Atpolan 80 EC	1.5	7	0.31 a	1.00 c	2.45 b
Atpolan 80 EC	2.0	7	0.31 a	0.80 b	2.45 b

Note: see Table 5

Table 10
Effectiveness of Atpolan 80 EC in the control of white rust (*Puccinia horiana*) on chrysanthemum cv. Fiji Yelow (Beginning of experiment and initial infection level: 2003.08.01)

Treatments	Concentration (%)	Frequency of spraying in days	Mean percentage diseased leaves	Mean number of telia per leaf	Average percentage of dried telia
Control	–	–	40.5 de	3.05 c	0.6 a
Triforine	0.03	7	31.2 b	2.15 b	3.4 b
Atpolan 80 EC	0.5	7	28.1 a	1.40 a	16.6 c
Atpolan 80 EC	0.75	7	31.7 b	2.30 b	17.3 c
Atpolan 80 EC	1.0	7	41.7 e	3.50 d	24.4 d
Atpolan 80 EC	1.5	7	35.6 c	2.15 b	56.4 e
Atpolan 80 EC	2.0	7	38.3 d	1.20 a	100.0 f

Note: see Table 5
Mean percentage diseased leaves – 60, Number telia per leaf – 3.0

Table 11
Effectiveness of Atpolan 80 EC in the control of white rust (*Puccinia horiana*) on chrysanthemum cv. Fiji Yelow (Beginning of experiment and initial infection level: 2003.08.26)

Treatments	Concentration (%)	Frequency of spraying in days	Mean percentage diseased leaves	Mean number of telia per leaf	Average percentage of dried telia
Control	–	–	65.9 b	24.2 d	0.0 a
Triforine	0.03	7	61.7 a	18.3 c	7.3 b
Atpolan 80 EC	0.5	7	61.8 a	14.5 b	20.6 c
Atpolan 80 EC	0.75	7	70.0 c	15.4 b	29.6 d
Atpolan 80 EC	1.0	7	60.5 a	12.8 a	60.4 f
Atpolan 80 EC	1.5	7	69.2 c	12.0 a	42.4 e
Atpolan 80 EC	2.0	7	61.9 a	12.0 a	69.4 g

Note: see Table 5
Mean percentage diseased leaves – 64, Number telia per leaf – 18.1

spray treatments, Atpolan 80 EC showed a significantly lower effectiveness than the standard fungicide. The study showed that an increase in the working concentration of Atpolan 80 EC was associated with an increase in its effectiveness. Generally, it can be stated that in the observations carried out after 3 and 6 treatments the effectiveness of the oil was higher than after 9 treatments (Tables 8, 9).

Control of chrysanthemum white rust

In the first experiment, after 4 spray treatments, Atpolan 80 EC at the concentrations of 0.5, 0.75 and 1.5% significantly reduced the percentage of diseased leaves in comparison with the control plants (Table 10). On the other hand, the plants sprayed with the oil at 1.0 and 2.0% had a similar or even higher percentage of diseased leaves in relation to the control plants. The average number of telia per leaf on the plants sprayed with the oil at 0.5, 0.75, 1.5, and 2.0% was significantly lower than on the control plants. The chrysanthemums sprayed with the oil were found to have from 16.6 to 100% dried telia, depending on the oil's concentration. An increase in the working concentration of the oil was associated with an increase of its effectiveness in the drying of the clusters of sporulation.

In the second experiment, after 4 spray treatments, Atpolan 80 EC at the concentrations of 0.5, 1, and 2% significantly decreased the percentage of infected leaves (Table 11). However, the plants sprayed with the oil at the concentrations of 0.75% and 1.5% had an even higher percentage of diseased leaves than the control plants. The absence of a difference in the percentage of diseased leaves between the control plants and those sprayed with the tested fungicides could have been caused by a very high initial severity of disease symptoms. On the other hand, the average number of telia on the leaves of plants sprayed with Atpolan 80 EC was significantly lower in relation to the control. The percentage of dried telia on the chrysanthemum plants sprayed with the oil was from 20.6 to 69.4%, depending on the oil's concentration. An increase in the concentration of the oil was associated with an increase in its effectiveness. Atpolan 80 EC showed a significantly greater efficacy in reducing the number of telia forming and in their disintegration after spraying compared with the fungicide Saprol 190 EC.

Discussion

The study showed that the effectiveness of Atpolan 80 EC depended on the target pathogen, concentration, time of observation and experiment. The highest efficacy of up to 100% was achieved using Atpolan 80 EC for controlling powdery mildew caused by *Sphaerotheca pannosa* var. *rosae*. The findings confirmed the results of previous studies that had shown a very high efficacy of Atpolan 80 EC in controlling this pathogen (Wojdyła, 2002). On the other hand, examinations conducted with a scanning electron microscope had shown that Atpolan 80 EC at a concentration of 0.2% used to spray shrubs with symptoms of powdery mildew caused severe deformation and disintegration of cellular walls of the mycelium and spores (Wojdyła, 2000). Similarly, Hummer and Pikton, (2001) had recorded a very high efficacy of a mineral oil called JMS Stylet-Oil in inhibiting the development of symptoms of powdery mildew caused by *Sphaerotheca mors-uvae* (Schwein) Berk. Et Curt. on different varieties of blackcurrant. In a series of greenhouse experiments, the petroleum oils used against powdery mildew on grapevines provided moderate protection, excellent pre-lesion and post-lesion curative action, and were antisporulative. The plant oils showed significant action only in pre-lesion treatments and as antisporulants in treatments applied to established lesions (Northover and Schneider, 1996).

The weather conditions during the experiments described here were favourable to the protection products used (Tables 1, 2). When the plants were being sprayed, the prevailing temperature of about 20°C and a relative humidity above 60% did not cause rapid evaporation of the liquid from the treated plants, and it was also possible for the preparations to penetrate into plant tissues. Also, lack of rainfall during the 24 hours after treatment did not cause the fungicides to be washed off from the surface of the plants (Tables 1, 2). A slight breeze at the time of spraying contributed to a better coverage of the treated plants with the liquid.

High effectiveness of Atpolan 80 EC in controlling *Diplocarpon rosae* on rose had been found in the author's previous studies (Wojdyła, 2012b, 2013). The author's research had shown that Atpolan 80 EC sprayed on rose shrubs against *D. rosae* significantly inhibited the germination of spores while causing them to deform severely and shrink (Wojdyła, 2012a). In the present study, the weather conditions during spraying and in the first hours after treatment was conducive to a high effectiveness of the fungicides used (Tables 1, 2). The prevailing temperature of 15.3 to 25°C (occasionally) and air humidity of 57 to 97% did not cause rapid evaporation of the liquid from the treated plants, and thus did not hinder the penetration of the preparations into plant tissues. The absence of rainfall during the 24 hours after spraying (Skierniewice), or up to 1.6 mm of rainfall (Młynki) did not cause the oil and Saprol 190 EC to wash off from the plants (Tables 1, 2). A slight wind during spraying contributed to a better coverage of the treated plants with the liquid.

The present study demonstrated a high efficacy of Atpolan 80 EC in controlling rust (*Puccinia horiana* P. Henn.) on chrysanthemum. The results confirm those of previous studies, which had shown a high efficacy of the oil in the control of rust on different plant species. The author's study on willow had also shown a high efficacy of Atpolan 80 EC in controlling rust caused by *Melampsora epitea* (Wojdyła and Jankiewicz, 2004). Atpolan 80 EC, depending on the concentration, caused from a 7 to 17-times reduction in the formation of uredinia clusters, of which 9-62% were browned and disintegrating. Similarly, studies on geranium confirmed the high efficacy of Atpolan 80 EC in the control of *Puccinia pelargonii-zonalis* Doidge (Wojdyła, 2005). The author had shown that the product, used at a concentration of 1%, after spraying geraniums 4 times, every 7 days, caused an almost 1.5-times reduction in the number of uredinia compared with the control plants, and 51.4% of them drying out. Also, Picton and Hummer, (2003) had demonstrated high effectiveness of mineral oils in inhibiting the development of symptoms of rust caused by *Cronatrium ribicola* Fisch. on blackcurrant. During the spraying of plants, the prevailing temperature of 17 to 22°C and a relative air humidity of 75 to 90% did not cause rapid evaporation of the liquid from the treated plants, and thus allowed it to penetrate into the plant tissues.

Studies on different plant species have shown an increase in the effectiveness of the oil being tested with increasing concentration used for spraying. Vawdrey et al. (2004) has found the similar relationships between the effect of the working concentration of oils and their effectiveness. However, because of the cost of the oils used per unit area, environmental pollution in the case of mineral oils, and possible phytotoxicity, the optimum concentration seems to be 1% (Wojdyła, 2012b).

In Poland, it is currently allowed to use paraffinic oils for pest control, such as Promanal 60 EC at a concentration of 2% and Treol 770 EC at 1.5%. It can thus be assumed that the use of Atpolan 80 EC for controlling pathogens will also contribute to a reduction in the populations of pests occurring on plantations, including aphids and spider mites. Because of the wide range of foliar pathogens to be controlled, Atpolan 80 EC and other oils should be included in the protection of rose varieties and other plant species against diseases.

Conclusions

Atpolan 80 EC used curatively for spraying rose shrubs at a concentration of 0.5 to 2% significantly inhibited the development of powdery mildew. After applying it 4 times at the concentrations of 0.5 and 0.75%, the oil showed 96 and 98% efficacy, respectively, while at higher concentrations it caused complete inhibition in the development of *Sphaerotheca pannosa* var. *rosae*. In the protection of *Rosa canina* 'Fenders' a rootstock for roses, its efficacy was from 74.4 to 100%. The product applied curatively for spraying rose shrubs at a concentration from 0.5 to 2% significantly inhibited the development of leaf black spot. After 6 treatments, its efficacy was between 31.5% and 85.1%, depending on the concentration used and the susceptibility of the rose variety to *Diplocarpon rosae*. Atpolan 80 EC used curatively for spraying chrysanthemum plants significantly inhibited the development of rust. After spraying the plants 4 times, the oil at a concentration of 2% caused a 2.5-times reduction in the number of *Puccinia horiana* telia forming, and, depending on the concentration, caused 16.6 to 100% of them to disintegrate. There was no evidence of phytotoxicity of Atpolan 80 EC towards the studied species and varieties of plants.

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