

## AZOLES IN THE CONTROL OF *Puccinia horiana* ON CHRYSANTHEMUM

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**Abstract:** The effectiveness of 10 azole fungicides (Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Magnate 50 EC, Mirage 450 EC, Opus 125 SC, Saprool 190 EC, Score 250 EC, Sportak 450 EC and Systhane 125 EC) in the control of *Puccinia horiana* was tested on chrysanthemum cv. Fiji Yellow. Additionally, their influence on plant growth, size of pustules and eventual phytotoxicity was assessed. Plants were sprayed 4 times at weekly intervals. On shrubs treated with Bayfidan 250 EC, Domark 100 EC, Magnate 50 EC, Mirage 450 EC, Opus 125 SC, Saprool 190 EC, Score 250 EC, and Systhane 125 EC only sporadic disease symptoms were observed. Mirage 450 EC and Sportak 450 EC were slightly less effective than the other tested fungicides. When most of the tested fungicides were applied curatively, except Mirage 450 EC and Sportak 450 EC, only sporadic pustules on leaves were noticed and over than 95% of pustules were destroyed.

**Key words:** chrysanthemum, white rust, *Puccinia horiana*, azole, control, plant growth

### INTRODUCTION

White rust caused by fungus *Puccinia horiana* is one of the most serious diseases on cultivated chrysanthemums. First symptoms appear on the upper surface of leaves, forming round, pale-green or yellow spots in diameter 2–5 mm. After few days, the telia consisted of teliospores (pustules), are forming mostly on the lower side of leaves. Infected leaves are being deformed, tissues around the telia become brown and with time the leaves die (Firman and Martin 1968). Chemical control is necessary if disease appears in time of chrysanthemum's production. So far carried out experiments showed a possibility of usage the following azole compounds: bitertanol (Dickens and Potter 1983; Orlikowski and Wojdyła 1981; Zamorski 1982), cyproconazole (Krebs 1997), diclobutrazol (Zamorski 1982), diniconazole (Aragon 1997), hexaconazole (Lam and Lim 1993), myclobutanil (Bonde et al. 1995; O'Neill and Pye 1997), propiconazole (Dickens and Potter 1983; Krebs 1985; Yang et al. 1992), triadimefon

(Orlikowski and Wojdyła 1981; Zamorski 1982), triadimenol (Aragon 1997; Krebs 1985); triforine (Gullino et al. 1979; Orlikowski and Wojdyła 1981; Zamorski 1982).

The aim of the conducted investigations was to evaluate an effectiveness of 10 azole fungicides in the control of *P. horiana* and their influence on chrysanthemum growth, diameter of pustules and eventual phytotoxic effect.

## MATERIAL AND METHODS

Chrysanthemum cultivar Fiji Yellow was used. Plants, about 5 cm high, were planted into 1 dm<sup>3</sup> pots filled with peat + composted pine bark and sand in ratio 1:1:0.5 and pH 6.5 with addition of 2 g/l of "Azofoska". The pots were put on greenhouse benches cushioned with fiber mat. In the course of the experiment air temperature ranged from 23 to 26°C and relative air humidity was kept at over 90%. At 7-day-intervals fertiliser "Novokont" 0.25% was applied in amount of 50 ml/pot. Water was given directly to the pots or on fiber mat. In the experiment with protective action of fungicides, the infected plants with pustules of *P. horiana* were placed among healthy chrysanthemums.

The efficacy of the following fungicides in pathogen control was evaluated: Bayfidan 250 EC (triadimenol), Bumper 250 EC (propiconazole), Domark 100 EC (tetraconazole), Magnate 50 EC (imazalil), Mirage 450 EC (prochloraz), Opus 125 SC (epoxiconazole), Saprol 190 EC (triforine – except Tab. 2), Score 250 EC (difenoconazole), Sportak 450 EC (prochloraz) and Systhane 12 EC (myclobutanil). First plant treatment was made before (Tab. 1) or after first disease symptoms appearance (Tab. 2) or after visible of pustules on leaves (Tab. 3). Next, the plants were sprayed 3 times at 7-day-intervals with an attention to thorough coverage of both sides of leaves. Sandovit 0.01% was added to spraying liquids. Number of pustules per leaf was estimated before treatment then 2 and 4 weeks after the treatment. After 4 weeks a diameter of spots, height of plants, percent of diseased leaves and phytotoxicity were evaluated. Also after 4 weeks on 100 randomized chosen leaves within combinations, it was counted a number of active pustules, and browned and destroyed.

The experiment was set in randomized block with 4 replications and each replication included 10 plants. The results were calculated statistically with analysis of variance. Means differences were evaluated with Duncan's test at 5% significance.

## RESULTS

### 1. Preventive effect of fungicides

After 2 weeks of treatment, disease symptoms didn't appear on chrysanthemums protected by fungicides: Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Magnate 50 EC, Opus 125 SC, Saprol 190 EC and Systhane 125 EC (Tab. 1). The number of pustules per diseased leaf on control plants was about 1.9. More pustules were recorded on plants in treatment with fungicides Mirage 450 EC and Sportak 450 EC than on leaves of control plants.

After 4 weeks of treatment, the number of spots increased over 15 times on the leaves of control plants. All tested fungicides significantly inhibited the development of

Table 1. Effectiveness of fungicides applied preventively in the control of *Puccinia horiana* on chrysanthemum cv. Fiji Yellow: 2(a) and 4(b) weeks after first spraying (1998.04.21)

Fungicides	Conc. in %	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves		Diam of spots (mm)	Height of plants (mm)
		a	b	a	b	a	b		b
Check	–	0.5 b	8.2 e	1.9 c	16.6 e	29.6 e	51.7 f	3.2 d	217 e
Bayfidan 250 EC	0.05	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	162 b
Bumper 250 EC	0.05	0.0 a	0.0 a	1.2 b	0.0 a	1.4 b	0.0 a	0.0 a	166 b
Domark 100 EC	0.05	0.0 a	0.1 b	0.0 a	2.7 c	0.0 a	2.4 b	1.4 b	190 cd
Magnate 50 EC	0.05	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	171 b
Mirage 450 EC	0.05	0.4 b	1.9 d	2.4 d	3.9 d	19.1 d	47.7 e	3.2 d	195 cd
Opus 125 SC	0.05	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	163 b
Saprol 190 EC	0.15	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	218 e
Score 250 EC	0.05	0.5 b	1.1 b	1.2 b	1.5 b	10.1 c	8.9 c	2.7 c	200 d
Sportak 450 EC	0.05	0.7 b	0.8 c	2.5 d	2.1 c	28.3 e	34.4 d	3.8 e	184 c
Systhane 125 EC	0.03	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	151 a

Note: means for each columns followed by the same letter do not differ at 5% level of significance ( Duncan's multiple range test)

Table 2. Effectiveness of fungicides applied curatively after first visible spots on leaf in the control of *Puccinia horiana* on chrysanthemum cv. Fiji Yellow: 2(a) and 4(b) weeks after first spraying (1998.03.20)

Fungicides	Conc. in %	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves		Diam of spots (mm)	Height of plants (mm)
		a	b	a	b	a	b		b
Check	–	12.7 d	18.2 d	19.3 c	24.4 d	63.9 d	63.2 e	4.3 g	405 ef
Bayfidan 250 EC	0.05	0.2 b	0.2 a	1.6 a	1.6 ab	13.5 c	9.1 bc	2.3 e	353 b–c
Bumper 250 EC	0.05	0.1 ab	0.1 a	1.6 a	1.1 a	7.1 b	7.4 b	1.6 c	346 b
Domark 100 EC	0.05	0.2 b	0.1 a	1.7 a	1.6 ab	14.5 c	10.9 c	1.4 ab	409 f
Magnate 50 EC	0.05	0.2 b	0.1 a	1.5 a	1.4 a	11.3 c	9.6 bc	1.5 bc	385 c–f
Mirage 450 EC	0.05	4.9 c	5.4 b	8.3 b	10.3 c	58.3 d	53.0 d	3.0 f	376 b–f
Opus 125 S.C.	0.05	0.3 b	0.2 a	2.1 a	2.2 b	12.3 c	8.5 bc	1.5 bc	401 d–f
Score 250 EC	0.05	0.2 b	0.1 a	1.5 a	1.5 a	12.6 c	9.6 bc	1.2 a	372 b–e
Sportak 450 EC	0.05	15.7 e	14.9 c	19.9 c	22.4 d	74.3 e	65.5 e	4.2g	312 a
Systhane 125 EC	0.03	0.0 a	0.0 a	1.9 a	1.3 a	2.4 a	2.8 a	1.9 d	376 b–f

Note: see table 1

disease symptoms. On leaves of control plants the number of pustules increased almost 2 times. In treatments with fungicides the number of spots per leaf was lower. Mirage 450 EC, Sportak 450 EC and Domark 100 EC showed the lowest effectiveness in controlling *P. horiana*.

On control plants about 29% of leaves was infected and similar results were obtained in the treatment with Sportak 450 EC. After 2 more weeks of performing the experiments the results showed that percent of diseased leaves increased to about 1.8-times on the control plants (Tab. 1). The fungicides Sportak 450 EC and Mirage 450 EC showed the lowest effectiveness (34.4% and 47.7% of infected leaves, respectively).

## 2. Curative effect of fungicides used after first visible spots

The results collected after 2 weeks revealed an average of about 13 spots per leaf on control plants (Tab. 2). In treatment with Sportak 450 EC the number of spots was even higher, what points at some stimulation effect of Sportak 450 EC on forming new spores on the leaves. Usage of other plant protection products, except Mirage 450 EC, showed as an average less number of spots than one spot per leaf. However, on the infected leaves of control plants an appearance of about 19 pustules was observed, like in usage of fungicide Sportak 450 EC (Tab. 2). Also proportional low effectiveness was recorded for Mirage 450 EC (about 8 pustules). In case of other investigated plant protection products the results showed an occasional appearance of pustules on single leaves.

After 4 weeks of the experiments 1.5 time increase of average number of spots on the leaf on control plants was recorded (Tab. 2). Results from fungicide treatments showed significantly lower average number of spots per leaf, which was below unit. On the leaves of plants sprayed with fungicides Mirage 450 EC and Sportak 450 EC 5.4 or 14.9 pustules per leaf were noted.

On infected leaves of control plants the results showed an appearance over 24 pustules, like on the plants sprayed with Sportak 450 EC (Tab. 2). Also Mirage 450 EC showed the lowest effectiveness (about 10.3 pustules per infected leaf). In case of other investigated fungicides, sporadic pustules on single leaves were noticed.

After 4 weeks of the experiments, percent of diseased leaves stayed unchanged (Tab. 2). Fungicides containing prochloraz (Mirage 450 EC and Sportak 450 EC) showed low effectiveness. In the case of using them, the percent of infected leaves was similar to the results obtained for the control or even higher. In case of other investigated plant protection products less than 15% of leaves with disease symptoms was recorded, what meant as average 2 leaves per plant with disease symptoms. Similar dependence was found after 2 succeeding weeks of performing the experiments.

## 3. Curative effect of fungicides used after first visible pustules

After 2 weeks of conducting the experiments there was observed an appearance of about 33 pustules on leaves of control plants (Tab. 3). Considerably fewer pustules were found on the leaves of chrysanthemums protected with plant protection products except fungicide Score 250 EC than on the leaves of control plants. Whereas on the infected leaves of control plants about 39.5 pustules were noted, like in treatments

Tabela 3. Effectiveness of fungicides applied curatively after pustules formed in the control of *Puccinia horiana* on *chrysanthemum* cv. Fiji Yellow: 2 (a) and 4 (b) weeks after first spraying (1998.07.27)

Fungicides	Conc. in %	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves	
		a	b	a	b	a	b
Check	–	32.6 f	42.0 g	39.5 c	43.9 d	82.7 h	95.9 f
Bayfidan 250 EC	0.05	6.6 ab	13.8 b	33.2 b	26.9 a	19.5 ab	51.3 b
Bumper 250 EC	0.05	6.0 a	16.2 c	29.8 a	36.6 b	20.3 ab	45.1 b
Domark 100 EC	0.05	20.0 d	41.4 g	44.8 d	46.2 d	44.6 d	89.8 de
Magnate 50 EC	0.05	21.6 d	32.3 f	42.6 cd	36.9 b	50.8 e	87.9 d
Mirage 450 EC	0.05	28.5 e	44.6 h	42.6 cd	45.3 d	68.8 f	99.3 g
Opus 125 S.C.	0.05	10.6 c	19.6 d	40.7 c	40.4 c	26.0 c	48.6 b
Saprol 190 EC	0.15	7.7 b	18.3 d	34.5 b	38.0 bc	21.9 b	48.4 b
Score 250 EC	0.05	38.7 g	25.4 e	45.1 d	37.2 bc	85.7 i	68.7 c
Sportak 450 EC	0.05	29.8 e	41.5 g	39.6 c	44.7 d	74.9 g	93.2 ef
Systhane 125 EC	0.03	6.0 a	9.1 a	31.4 ab	26.4 a	18.3 a	34.8 a

Note: see table 1

with fungicides Magnate 50 EC, Mirage 450 EC, Opus 125 SC Sportak 450 EC (Tab. 3). In case of using fungicides Domark 100 EC and Score 250 EC there was recorded even higher number of pustules on diseased leaves than on control plants. Other investigated fungicides considerably limited a number of pustules per leaf.

After 4 weeks of experiments an increase of number of pustules to about 42 was calculated on the leaves of control plants. Similar or higher number of pustules was found on plants sprayed with fungicides: Domark 100 EC, Mirage 450 EC and Sportak 450 EC. However, on diseased leaves of control plants an appearance of 43.9 pustules was recorded, similar like on the plants protected with fungicides Domark 100 EC, Mirage 450 EC and Sportak 450 EC. In the treatments with fungicides Bayfidan 250 EC and Systhane 125 EC less than 27 pustules per leaf were recorded. Other investigated fungicides considerably limited a number of pustules on the leaves.

After 2 weeks of experiments a percent of infected leaves on control plants was almost 83 (Tab. 3). The results obtained for the treatments with fungicides Score 250 EC and Sportak 450 EC were similar. The percent of infected leaves was lower for plants protected with other plant protection products. After 2 more weeks, on control plants the percent of infected leaves increased almost to 96 (Tab.3) and was similar to treatments with Mirage 450 EC and Sportak 450 EC. Less than 50% of infected leaves on plants sprayed with fungicides Bumper 250 EC, Opus 125 SC, Saprol 190 EC and Systhane 125 EC were recorded.

#### 4. Influence of fungicides on diameter of spots

While using fungicides preventively, a diameter of pustules on control plants was about 3.2 mm and was the same as on the leaves of plants sprayed with Mirage 450 EC. Sportak 450 EC stimulated development of pustules. On plants protected with fungicides: Domark 100 EC and Score 250 EC, the diameter of pustules oscillated between 1.4 and 2.8. In case of other investigated fungicides, no pustules on the leaves were found.

On the leaves of plants, sprayed curatively, the diameter of pustules was about 4.3 mm (Fig. 1) and was similar as on the plants protected with Sportak 450 EC. In case of fungicides Bayfidan 250 EC, Mirage 250 EC the diameter of spots oscillated between 2.3 and 3.0 mm. In case of other investigated plant protection products, the diameter of pustules was below 2 mm. After 3–4-time fungicide applications it was observed that on chrysanthemums protected with fungicides Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Opus 125 SC, Saprol 190 EC (Fig. 2), Score 250 EC and Systhane 125 EC (Fig. 3) over 90% of pustules were browned, dried and crumbled. In case of control plants or sprayed with fungicides Magnate 50 EC, Mirage 450 EC and Sportak 450 EC (Fig. 4) over 90% of pustules were active without visible changes of damages.

### 5. Influence of fungicides on chrysanthemum growth

While using plant protection products preventively after 4 weeks of experiments, a measured height of control plants was about 217 mm and was similar to a height of plants protected with fungicide Saprol 190 EC (Tab. 1). In case of other investigated fungicides a significant limitation of plants height was noted. Out of investigated products the strongest limitation of plants height caused Systhane 125 EC.

Applying fungicides with curative mode of action started when height of plants was about 250 mm. After 4 weeks of experiments height of plants was about 405 mm. Statistically similar height showed chrysanthemums protected with Domark 100 EC, Magnate 50 EC, Mirage 450 EC, Opus 125 SC and Systhane 125 EC. Bumper 250 EC

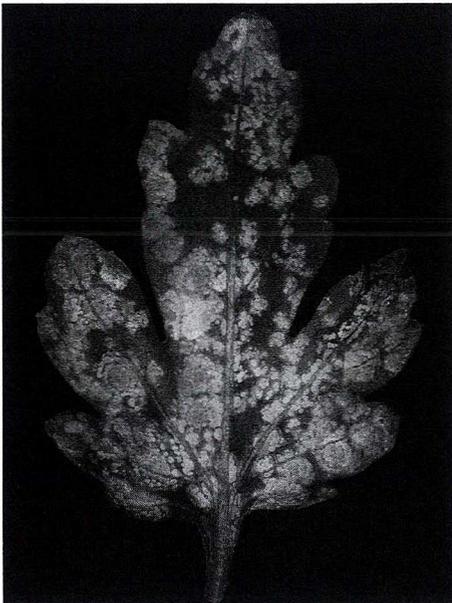


Fig. 1. Numerous pustules of teliospores on the leaves of unprotected plants



Fig. 2. Sporadic pustules on the leaves sprayed by Saprol 190 EC

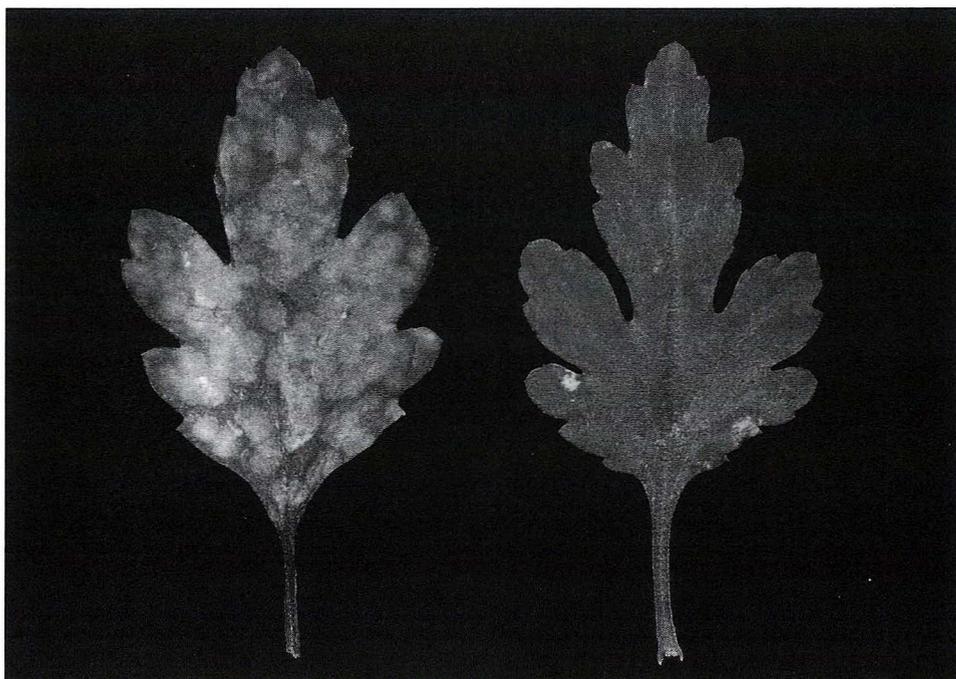


Fig. 3. Sporadic destroyed pustules on the leaves treated by Systhane 125 EC (right) compared to control plants (left)

(propiconazole) applied preventively and curatively limited height of investigated variety of chrysanthemums.

#### 6. Phytotoxic effect of tested fungicides

Tested fungicides Opus 125 SC and Score 250 EC showed their phytotoxicity to chrysanthemums. In case of fungicide Opus 125 SC, after 2–3-time spraying there was noticed an appearance of brown, dry, single spots on the margins of leaves. On these parts of the leaf surface spray liquid usually stays for a long time (Fig. 5). Probably usage different type of spraying equipment could help to avoid an appearance of this kind of damages. On some leaves sprayed with Score 250 EC an appearance of bright-yellow, elongated spots about 1–5 mm in diameter with limited margins was noticed (Fig. 6).

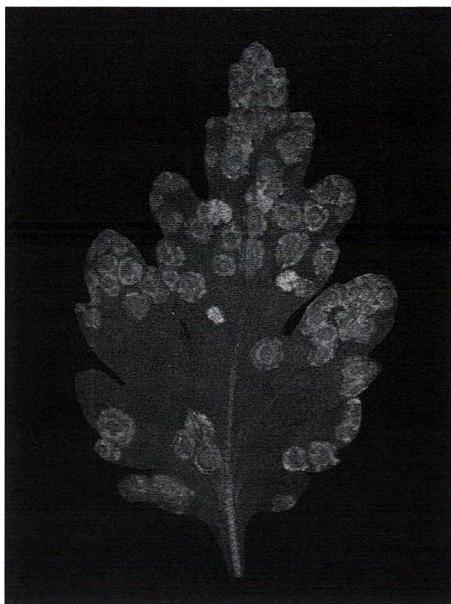


Fig. 4. Numerous pustules of teliospores on the leaves sprayed by Sportak 450 EC



Fig. 5. Brown, dry spots on the margins of leaves treated by Opus 125 SC

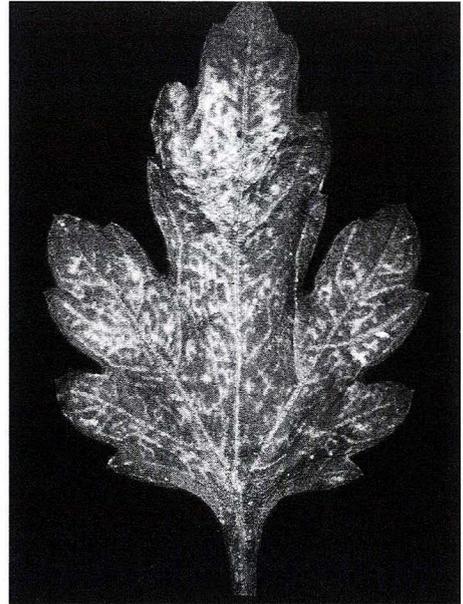


Fig. 6. Pale-yellow, elongated spots in diameter at about 1–5 mm on some leaves treated by Score 250 EC

## DISCUSSION

The experiments proved high effectiveness of myclobutanil, propiconazole and triadimenol applied preventively and also curatively against *P. horiana*. Obtained data confirms high effectiveness of myclobutanil (Bonde et al. 1995), propiconazole (Dickens and Potter (1983), Dickens (1990), Krebs (1985) and triadimenol (Krebs 1985) against *P. horiana*. The results of the experiments also proved that propiconazole is not phytotoxic to protected cultivar, what Rattink and Zamorski suggested (1985). That is why fungicide's phytotoxicity depends on cultivar of a plant. In conducted experiments propiconazole limited height of chrysanthemum what also confirmed Dickens (1990). Probably an influence of the fungicide on height depends on investigated variety of chrysanthemum. This hypothesis is based on the results from the experiments performed on 10 cultivars of roses, where an influence of fungicide on height, in dependence on the cultivar was observed (Wojdyła 2000). The preventive usage of fungicides inhibited growth of chrysanthemums to a larger extent than their curative usage. In case of preventive program, spraying of plants began directly after planting, when height of plants was about 6 cm what was the stronger phase of lengthening the internodes. Next curative program began 2–3 weeks later where height of plants was about 16–18 cm, when process of lengthening shoots was not that much intensive. Inhibiting lengthening of internodes is the strongest when retardants (or other compounds) are used in the most intensive phase of lengthening the internodes.

Subsequent usage of retardants is connected with reduction of their effectiveness (Nowak and Grzesik 1997). Also very high effectiveness against studied fungus

showed difenoconazole, epoxiconazole, imazalil, and tetraconazoles. However, epoxiconazole was phytotoxic causing appearance of brown spots on leaves. The experiment showed also high effectiveness of triforine what is confirmed by earlier obtained results of Orlikowski et al. (1985) and also other authors (Dickens 1990; Dickens and Potter 1983; Gullino et al. 1979; Zamorski 1982). Of tested azoles, relative lower effectiveness showed products containing prochloraz (Mirage 450 EC, Sportak 450 EC). In case of their application on chrysanthemum's leaves diameter of pustules was similar to the one noted on the leaves of control plants. All investigated fungicides except prochloraz (Mirage 450 EC and Sportak 450 EC) caused over 95% drying, getting brown and disintegration of a formed pustules after their 2–3 time spraying.

Analysis of a number of spots on leaves, proved that investigated fungicides showed particularly high effectiveness, when products were used for protecting the plants against infection and also after an appearance of a first spot symptoms or appearance of a first sporadic telia. The beginning of fungicide applications when there were a lot of formed pustules significantly reduced their effectiveness.

## CONCLUSIONS

1. The effectiveness of investigated plant protection products against *P. horiana* was different in spite that all of them belong to the same chemical group of azoles.
2. Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Magnate 50 EC, Opus 125 SC, Saprol 190 EC, Score 250 EC and Systhane 125 EC, used preventively, almost completely protected chrysanthemum leaves against *P. horiana*, and applied curatively limited development of disease symptoms very much.
3. Over 95% of dried pustules and their disintegration were found while using Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Magnate 50 EC, Opus 125 SC, Saprol 190 EC, Score 250 EC and Systhane 125 EC. Diameter of pustules was almost 3 times lower than on the leaves of control plants.
4. Among 10 tested azole fungicides, prochloraz (Mirage 450 EC and Sportak 450 EC) was less effective as compared to the others.
5. Opus 125 SC showed strong phytotoxicity toward tested chrysanthemum cultivar.

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## POLISH SUMMARY

### FUNGICYDY AZOLOWE W ZWALCZANIU *Puccinia horiana* NA CHRYSZANTEMACH

W prowadzonych badaniach oceniano skuteczność działania 10 fungicydów azolowych Bayfidan 250 EC, Bumper 250 EC, Domark 100 EC, Magnate 50 EC, Mirage 450 EC, Opus 125 SC, Sapol 190 EC, Score 250 EC, Sportak 450 EC oraz Systhane 125 EC w zwalczaniu *Puccinia horiana* na chryzantemach odm. Fiji Yellow. Preparaty stosowano profilaktycznie oraz interwencyjnie po wystąpieniu objawów chorobowych w formie 4-krotnego opryskiwania co 7 dni. Przed przystąpieniem do stosowania fungicydów oraz po 2 i 4 tygodniach ochrony oceniano liczbę plam/telii na liściach, procent porażonych roślin, wysokość oraz ewentualną fitotoksyczność.

Na roślinach opryskiwanych fungicydami Bayfidan 250 EC, Domark 100 EC, Bumper 250 EC, Magnate 50 EC, Opus 125 SC, Sapol 190 EC oraz Systhane 125 EC stwierdzono tylko pojedyncze telia na niektórych liściach. Stosowane profilaktycznie jak również interwencyjnie fungicydy Mirage 450 EC oraz Sportak 450 EC wykazywały stosunkowo niską skuteczność w porównaniu do pozostałych badanych azoli. Średnica telii na liściach roślin chronionych fungicydami Mirage 450 EC oraz Sportak 450 EC była podobna jak na liściach roślin nie opryskiwanych. Badane fungicydy stosowane profilaktycznie nieznacznie hamowały wzrost roślin, a stosowane interwencyjnie jedynie Bayfidan 250 EC, Bumper 250 EC i Sportak 450 EC ograniczały wzrost chryzantem. Opus 125 SC okazał się fitotoksyczny w stosunku do badanej odmiany.