

DEVELOPMENT OF *PUCCINIA HORIANA* ON CHRYSANTHEMUM LEAVES IN RELATION TO CHEMICAL COMPOUNDS AND TIME OF THEIR APPLICATION

Adam T. Wojdyła

Research Institute of Pomology and Floriculture
Pomologiczna 18, 96-100 Skierniewice, Poland
e-mail: awojdyła@insad.pl

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Abstract: The effectiveness of 12 chemical compounds (azoxystrobin, carbendazim, chlorothalonil, fenarimol, folpet, mancozeb, myclobutanil + mancozeb, prochloraz + carbendazim, tebuconazole + triadimefon, tetraconazole + chlorothalonil, tiophanate-methyl, tridemorph + epoxiconazole) 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 were assessed. Plants were sprayed 4 times at weekly intervals. Chrysanthemum sprayed with azoxystrobin, myclobutanil + mancozeb, tebuconazole + triadimefon and tridemorph + epoxiconazole did not show disease symptoms. Curatively application of these fungicides destroyed over 95% of pustules. Carbendazim, fenarimol and folpet were slightly less effective than the other tested fungicides. Mixture of tebuconazole + triadimefon caused some growth retardant effect but did not result in phytotoxicity problems. Tridemorph + epoxiconazole showed strong phytotoxicity to tested chrysanthemum cultivar.

Key words: chrysanthemum, white rust, *Puccinia horiana*, chemical compounds, control, phytotoxicity, plant growth

INTRODUCTION

White rust caused by *Puccinia horiana* (Henn) is one of the most serious diseases occurring on upper parts of plants in cultivated chrysanthemums. Over 20-year-observations in Poland showed that the fungus appears on chrysanthemum every year with different incidence (Wojdyła unpublished). Intensity of disease symptoms depends on susceptibility of cultivars (Wojdyła 1999a) but temperature and air humidity are also very important factors affecting disease incidence (Firman and Martin 1968). The pathogen finds especially well conditions for its development when air humidity rises over 90%. High air humidity usually occurs during chrysanthemum's cultivation in

plastic tunnels. Also high air humidity appears during controlled cultivation of chrysanthemums, when day length is controlled by plant shading with black polyethylene foil. Fungicide treatments are a basic method of pathogen's control however, integrated protection program includes also cultivation of resistant or less susceptible cultivars (Wojdyła 1999a) and maintaining air humidity below 90 during cultivation. In so far carried out investigations on the control of *P. horiana* high effectiveness showed fungicides containing among other: azoxystrobin (O'Neill and Pye 1997; Wojdyła 1999b), benodanil (Dickens and Potter 1983; Gullino et al. 1979; Vis 1981), chlorothalonil (O'Neill and Pye 1997), fenpropimorf (O'Neill and Pye 1997), kresoxim-methyl (Wojdyła and Orlikowski 1999), mancozeb (O'Neill and Pye 1997), maneb (Pei and Sun 1981), myclobutanil (Bonde et al. 1995; Strider 1995), oxycarboxin (Dickens and Potter 1983; Gullino et al. 1979; Orlikowski and Wojdyła 1981), tridemorph (Pein and Sun 1981). High effectiveness of azole fungicides against this pathogen was proved in assay (Wojdyła 2002). However, considering possible rise of resistance to azole and strobilurin fungicides there is necessity of including to this programme compounds which belong to other chemical groups or mixtures of them.

The aim of the conducted investigation was to evaluate development of *P. horiana* on chrysanthemum leaves in relation to 12 chemical compounds and time of their application and their influence on plant growth, diameter of pustules and eventual phytotoxic effect.

MATERIAL AND METHODS

Chrysanthemum cuttings cv. Fiji Yellow were used. Plants, about 5 cm high, were planted into 1 dm³ pots filled with peat + composted pine bark and sand in ratio 1:1:0.5 and pH 6.5 with addition 2 g/dm³ of "Azofoska". The pots were put on greenhouse bench cushioned with fibre mat, at air temperature ranged from 23 to 26°C and relative air humidity over 90%. At 7-day-intervals fertilizes "Novokont" 0.25% was applied in amount of 0.05 dm³/pot. Water was given directly to the pots or on fibre mat. In the experiment with protective action of fungicides, the infected plants with pustules of *P. horiana* were placed among health chrysanthemums.

The efficacy of the following fungicides in pathogen control was evaluated: Amistar 250 SC (250 g/dm³ azoxystrobin), Bravo 500 SC (500 g/dm³ chlorothalonil), Dithane M-45 80 WP (80% mancozeb), Eminent Star 312 SL (62.5 g/dm³ tetraconazole + 250 g/dm³ chlorothalonil), Folicur BT 225 EC (125 g/dm³ tebuconazole + 100 g/dm³ triadimefon), Folpan 80 WP (80% folpet), Rubigan 12 EC (12% fenarimol), Sarfun 500 SC (500 g/dm³ carbendazim), Sportak Alpha 380 EC (300 g/dm³ prochloraz + 80 g/dm³ carbendazim), Systhane MZ 61 WP (1.25% myclobutanil + 59.75% mancozeb), Tango 500 SC (375 g/dm³ tridemorph + 125 g/dm³ epoxiconazole) and Topsin M 70 WP (70% tiophanate-methyl). First plant spraying was made before (Tab. 1) or after first disease symptoms appearance (Tab. 2) or after visible 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 observed before treatment, then 2 and 4 weeks after treatment. After 4 weeks diameter of spots, height of plants, percent diseased leaves and phytotoxicity were

evaluated. Also after 4 weeks on 100 chosen fated leaves within combination, a number of active pustules, browned and destroyed were recorded.

The experiment was set in randomised block with 4 replicates (10 plants were a replication). 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 investigations, average less than 1 spot per leaf was recorded on control plants. On chrysanthemum leaves treated with mixture prochloraz + carbendazim even more spots than on control plants were observed. Also carbendazim, fenarimol, folpet, mancozeb and thiophanate-methyl turned out to be hardly effective and after their application 0.3 to 0.8 spots were registered on leaves. Other investigated fungicides really reduced development of disease symptoms. After 2 weeks on control plants the number of spots was 1.9 counting per infected leaf. On leaves treated with fungicides carbendazim, fenarimol, folpet, mancozeb, prochloraz + carbendazim and thiophanate-methyl the number of spots per leaf was similar or even bigger than on untreated chrysanthemums.

After 4 weeks of tests, leaves of control plants had 8.2 spots per leaf (Tab. 1). On leaves sprayed with fungicides fenarimol and folpet there were 3.2 and 6.3-time

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

Fungicides	Conc. in mg/dm ³	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves		Diam. of spots (mm)	Height of plants (mm)
		2 weeks	4 weeks	2 weeks	4 weeks	2 weeks	4 weeks	4 weeks	
Check	–	0.6 d	8.2 h	1.9 de	16.6 f	29.6 f	51.7 h	3.2 d	217 f
Azoxystrobin	250	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	197 ef
Carbendazim	500	0.4 cd	0.4 cd	2.1 e	2.1 bc	16.3 d	22.7 d	4.1 e	213 f
Chlorothalonil	1000	0.1bc	0.2 bc	1.4 c	2.2 bc	9.5 c	13.7 c	4.4 e	184 de
Fenarimol	36	0.4 cd	1.3 f	2.0 e	3.1 d	21.3 e	40.5 f	3.2 d	211 f
Folpet	800	0.8 de	2.6 g	2.6 f	5.9 e	28.5 f	47.0 g	3.3 d	189 de
Mancozeb	1600	0.5 cd	1.0 ef	2.1 e	3.4 d	29.1 f	27.5 e	3.1 d	185 de
Myclobutanil	25								
+ mancozeb	+1195	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	175 d
Prochloraz	150								
+ carbendazim	+40	1.3 e	0.7 de	2.7 f	2.7 cd	31.6 f	25.4 de	4.6 e	187 de
Tebuconazole	125								
+ triadimefon	+100	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	110 b
Tetraconazole	31.25								
+ chlorothalonil	+125	0.0 ab	0.1 b	1.0 b	1.9 b	2.2 b	5.8 b	1.2 b	153 c
Thiophanate-methyl	700	0.3 cd	0.5 cd	1.5 cd	1.8 b	19.8 e	27.3 e	2.6 c	176 de
Tridemorph	187.5								
+ epoxiconazole	+62.5	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	0.0 a	4.6 e	69 a

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

less spots than on control plants. Chrysanthemums treated with other tested fungicides had really less spots than control plants. Next, infected leaves of control plants had almost 17 spots per leaf (Tab. 1). All investigated fungicides really reduced the number of spots on infected leaves comparing to control. Average over 3 spots per infected leaf were recorded on plants treated with fenarimol, folpet and mancozeb. Observations made after 2 and 4 weeks from beginning of tests did not show any disease symptoms on plants treated with azoxystrobin, myclobutanil + mancozeb, tebuconazole + triadimefon and tridemorph + epoxiconazole.

After 2 weeks of investigations percentage of infected leaves amounted to 30, and was similar as on plants protected with folpet, mancozeb and prochloraz + carbendazim. After next 2 weeks of tests percentage of infected leaves on control plants increased 1.7 times. Over 40% of infected leaves were recorded on chrysanthemums sprayed with fenarimol and folpet. On plants treated with other tested fungicides less leaves with disease symptoms were confirmed comparing to control plants. No infected leaves were found on plants sprayed with azoxystrobin, myclobutanil + mancozeb, tebuconazole + triadimefon and tridemorph + epoxiconazole.

2. Curative effect of fungicides used after first visible spots

After 2 weeks, on average about 12.7 pustules on control plants were observed (Tab. 2) similar as in treatment with prochloraz + carbendazim. On leaves of plants sprayed with carbendazim there were even more pustules than on control plants.

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 and 4 weeks after first spraying (1998.03.20)

Fungicides	Conc. in mg/dm ³	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves		Diam. of spots (mm)	Height of plants (mm)
		2 weeks	4 weeks	2 weeks	4 weeks	2 weeks	4 weeks	4 weeks	
Check	–	12.7 e	18.2 i	19.3 f	24.4 i	63.9 g	63.2 i	4.3 e–g	405 ef
Azoxystrobin	250	0.1 a	0.1 ab	1.5 ab	1.4 bc	7.3 bc	6.3 b	4.7 gh	369 cd
Carbendazim	500	16.7 f	16.0 i	19.7 f	25.0 i	85.4 h	63.6 i	3.8 de	357 c
Chlorothalonil	1000	1.6 b	3.4 d	5.7 c	8.4 e	29.0 e	40.7 f	4.1 ef	393 de
Fenarimol	36	8.4 d	9.6 g	10.4 d	16.9 gh	62.5 g	56.4 h	1.7 ab	386 c–e
Folpet	800	4.4 c	5.9 e	9.3 d	12.1 f	46.6 f	48.6 g	3.3 cd	362 cd
Mancozeb	1600	1.2 b	1.6 c	5.7 c	6.0 d	21.0 d	27.4 e	5.2 h	364 cd
Myclobutanil	25								
+ mancozeb	+1195	0.0 a	0.1 a	1.9 ab	1.8 bc	2.0 a	4.0 a	4.4 fg	427 f
Prochloraz	150								
+ carbendazim	+40	11.5 e	11.9 h	18.9 ef	19.2 h	60.1 g	61.4 i	3.2 c	389 c–e
Tebuconazole	125								
+ triadimefon	+100	0.1 a	0.1 ab	1.1 a	1.3 b	9.7 c	11.5 c	2.0 b	311 b
Tetraconazole	31.25								
+ chlorothalonil	+125	0.1 a	0.4 b	1.7 ab	2.4 c	7.2 bc	15.1 d	1.5 a	370 cd
Tiophanate-methyl	700	9.3 d	7.7 f	15.8 e	15.8 g	59.4 g	49.2 g	4.0 ef	370 cd
Tridemorph	187.5								
+ epoxiconazole	+62.5	0.1 a	0.0 a	2.3 b	0.6 a	5.0 b	3.1 a	1.5 a	276 a

Explanation – see table 1

Less than one spot per leaf was observed on plants treated with azoxystrobin, myclobutanil + mancozeb, tebuconazole + triadimefon, tetraconazole + chlorothalonil and tridemorph + epoxiconazole. Next on infected leaves of control plants over 19 pustules were noted, similar as on plants protected with carbendazim and prochloraz + carbendazim. Other tested compounds reduced the number of pustules on infected leaves comparing to control.

After 4 weeks of investigations there were over 18 pustules on control plants, similar as using carbendazim. Other tested compounds reduced the number of pustules on chrysanthemum's leaves. Next, on infected untreated chrysanthemum's leaves over 24 pustules were recorded, similar as on plants protected with carbendazim. On leaves sprayed with azoxystrobin, myclobutanil + mancozeb, tebuconazole + triadimefon, tetraconazole + chlorothalonil and tridemorph + epoxiconazole from 10.1 to 40-time less pustules were observed.

After 2 weeks percentage of infected leaves on control plants was almost 64 and was similar as on plants treated with fenarimol, prochloraz + carbendazim and thiophanate-methyl. On chrysanthemums sprayed with carbendazim 1.3-time higher percentage of infected leaves than on control plants was found. After 2 more weeks percentage of infected leaves on control plants did not change. Similar percentage of infected leaves on plants treated with carbendazim and prochloraz + carbendazim was calculated. On plants sprayed with azoxystrobin, myclobutanil + mancozeb and tridemorph + epoxiconazole from 10 to 20-time less infected leaves than on control plants were observed.

3. Curative effect of fungicides used after first visible pustules

After 2 weeks of leaf protection on control plants there were about 33 pustules (Tab. 3), similar as on these protected with thiophanate-methyl. On leaves sprayed with azoxystrobin and myclobutanil + mancozeb there were from 8 to 16-time less pustules than on untreated chrysanthemums. The number of spots on diseased leaves of control plants was almost 40, similar as on plants treated with fenarimol, mancozeb and prochloraz + carbendazim. On plants sprayed with chlorothalonil, folpet, tetraconazole + chlorothalonil and thiophanate-methyl even more pustules on leaves were found comparing to control plants. After 4 weeks of tests the number of spots on control plant leaves increased up to 42 and was similar as using chlorothalonil, fenarimol, folpet, tetraconazole + chlorothalonil and thiophanate-methyl. On chrysanthemums protected with prochloraz + carbendazim even more spots on leaves than on control plants were found. The number of spots on infected control plant leaves was almost 44 (Tab. 3) and was similar as on plants sprayed with chlorothalonil, fenarimol, folpet, tetraconazole + chlorothalonil and thiophanate-methyl. Prochloraz + carbendazim stimulated development of pustules on protected plants.

After 2 weeks of investigations percentage of infected leaves was almost 83 (Tab. 3). In case of tested fungicides really lower percentage of infected leaves than on control plants was recorded. The lower number of infected leaves, about 6–8-time was found on chrysanthemums sprayed with azoxystrobin and mixture myclobutanil + mancozeb. After next 2 weeks, percentage of infected leaves in-

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

Fungicides	Conc. in mg/m ³	Mean number of spots/leaf		Mean number of spots/diseased leaf		% of diseased leaves	
		2 weeks	4 weeks	2 weeks	4 weeks	2 weeks	4 weeks
Check	–	32.9 i	42.0 e–g	39.5 de	43.9 fg	82.7 j	95.9 fg
Azoxystrobin	250	2.1 a	5.6 a	21.2 a	19.9 a	10.2 a	28.6 a
Carbendazim	500	18.5 f	32.9 d	32.7 c	37.5 d	56.6 f	87.9 de
Chlorothalonil	1000	20.7 g	39.9 e	45.4 g	42.6 ef	48.0 e	95.7 fg
Fenarimol	36	30.1 h	43.5 fg	41.5 ef	46.7 g–i	72.6 h	95.1 e–g
Folpet	800	29.3 h	44.7 g	43.5 fg	44.7 f–h	67.6 g	100.0 h
Mancozeb	1600	15.4 e	31.1 d	38.4 d	39.4 de	39.4 d	78.1 c
Myclobutanil	25						
+ mancozeb	+1195	4.1 b	9.5 b	29.8 b	36.1 d	14.1 b	28.3 a
Prochloraz	150						
+ carbendazim	+40	30.5 h	47.5 h	41.8 ef	50.1 i	73.0 h	98.5 gh
Tebuconazole	125						
+ triadimefon	+100	7.8 c	15.6 c	34.0 c	31.1 c	22.9 c	50.6 b
Tetraconazole	31.25						
+ chlorothalonil	+125	20.0 fg	41.0 ef	44.2 fg	47.8 g–i	45.3 e	86.0 cd
Thiophanate-methyl	700	34.3 i	44.5 g	44.9 g	48.6 hi	76.5 i	92.0 d–f
Tridemorph	187.5						
+ epoxiconazole	+62.5	13.2 d	10.2 b	34.7 c	22.7 b	38.3 d	44.8 b

Explanation – see table 1

creased up to 96 on untreated chrysanthemums and was similar as these protected chlorothalonil, fenarimol, prochloraz + carbendazim and thiophanate-methyl. On chrysanthemums protected with folpet all leaves had disease symptoms. Over 3-time less infected leaves were noted on chrysanthemums sprayed with azoxystrobin and myclobutanil + mancozeb.

4. Influence of fungicides on diameter of spots

Diameter of spots on control plant leaves was 3.2 mm and was similar as on chrysanthemums protected with fenarimol, folpet and mancozeb. On leaves sprayed with carbendazim, chlorothalonil and mixture prochloraz + carbendazim even bigger diameter of necrotic spots than on untreated control plants was registered.

In the next tests after 4 weeks of disease progress, diameter of pustules on control plants was 4.3 mm (Tab. 2) and was similar as using azoxystrobin, carbendazim, chlorothalonil, myclobutanil + mancozeb and thiophanate-methyl. On plants treated with mancozeb even bigger diameter of spots than on control plants was recorded. Diameter of pustules was 3-time lower when tetraconazole + chlorothalonil or tridemorph + epoxiconazole were applied.

5. Influence of fungicides on chrysanthemum growth

After 4 weeks of investigations, height of plants increased from 50–60 mm to 217 mm (Tab. 1). Similar height of plants was confirmed in case of usage azoxystrobin, fenarimol and carbendazim. Other tested compounds significantly inhi-

bited growth of plants but in case of chrysanthemums protected with tridemorph + epoxiconazole almost completely inhibition of growth was noted.

In another investigation, after 4 weeks, height of control plants was 405 mm (Tab. 2). Similar height was obtained on plants treated with chlorothalonil, fenarimol, myclobutanil + mancozeb and prochloraz + carbendazim. Other investigated chemical compounds inhibited chrysanthemum's growth. Mixture of tridemorph + epoxiconazole inhibited plants growth very severely.

6. Phytotoxicity effect of tested fungicides

From all tested chemical compounds tridemorph + epoxiconazole turned out to be phytotoxic towards protected plants. After 2–3-time of its usage on chrysanthemum leaves, big, brown, dried spots situated in the centre of leaf surface appeared. Damaged leaves dried and with time they died.

DISCUSSION

From all investigated fungicides the highest effectiveness showed azoxystrobin (Amistar 250 SC) (Fig. 1). On chrysanthemums sprayed preventively using this fungicide no disease symptoms appeared. These data disagree with earlier results obtained by Krebs (1997), who proved only preventive effect of strobilurin on *P. horiana*. While curative fungicides are applied, depending on disease incidence, drying out of spots, browning or total disintegration of pustules might be observed. High effectiveness of azoxystrobin confirmed earlier tests made by O'Neill and Pye (1997) and also



Fig. 1. Sporadic, completely destroyed pustules of teliospores on leaves treated by azoxystrobin (right) comparing to numerous pustules on control leaves (left)

Sugimura and Nishizaki (2001). Cook (2002) showed decrease of effectiveness of azoxystrobin against *P. horiana* what could have been connected with possible appearance of resistance on this group of fungicides. All investigations conducted in 2003 in Poland did not confirm decrease of azoxystrobin effectiveness against *P. horiana* (Wojdyla unpublished). Performed investigations showed high diversity of effectiveness of azole compounds or their mixtures with chlorothalonil or mancozeb used against *P. horiana*. Except fungicide Sportak Alpha 380 EC containing prochloraz (azoles) and chlorothalonil other investigated azoles myclobutanil, tebuconazole, tetraconazole and triadimefon which are compounds of tested fungicides (Eminent Star 312 SL, Folicur BT 225 EC and Systhane MZ 61 WP) showed very high effectiveness in the control of this pathogen. On chrysanthemums sprayed preventively with these chemical compounds no disease symptoms were noted. In case of curative control using these fungicides we proved very strong inhibition of disease symptoms development and after 2–3 treatments total browning and disintegration of existing pustules (Fig. 2). Obtained results confirm earlier investigations which proved high effectiveness of azoles in the control of *P. horiana* (Domark 100 EC – tetraconazole and Systhane 12 EC myclobutanil) Wojdyla (2002). High effectiveness of myclobutanil against *P. horiana* was also proved by O'Neill and Pye (1997); Sugimura and Nishizaki (2001). Next, low effectiveness of mixture prochloraz with mancozeb is confirmation of earlier investigations with prochloraz used separately (Wojdyla 2002). Very high effectiveness showed mixture of azoles tebuconazole + triadimefon (Folicur BT 225 EC), however, this compound strongly inhibited plants growth. Its application caused shortening of internodes so this compound acted like retardant. This feature can be

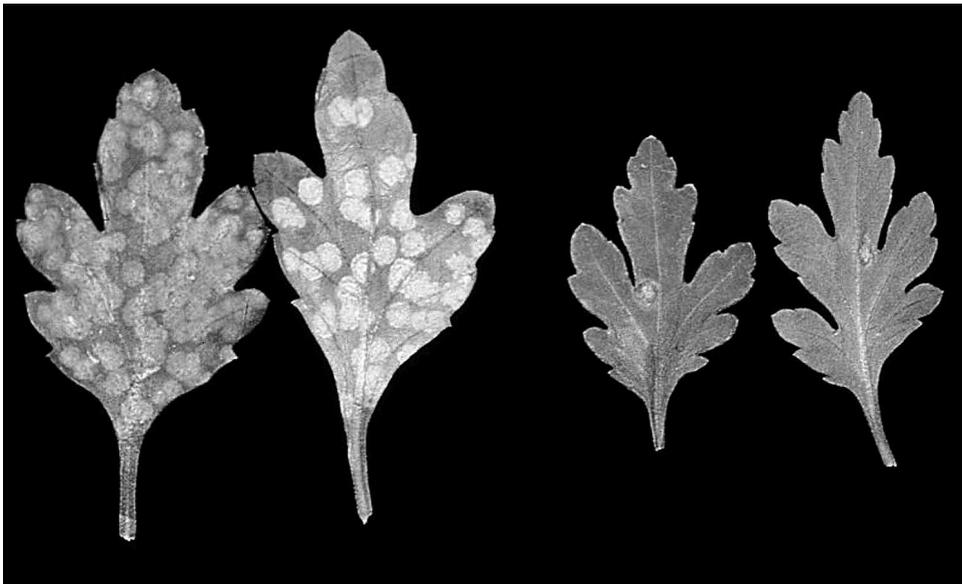


Fig. 2. Sporadic, destroyed pustules on leaves treated by tetraconazole + chlorothalonil (right) comparing to numerous pustules on control leaves (left)

very useful to production of pot chrysanthemums, however in cut flowers production, this feature is not recommended. High effectiveness of triadimefon the constituent of Folicur BT 225 EC against investigated fungus was proved by earlier surveys conducted by (Orlikowski and Wojdyla 1981). Very low effectiveness showed benzimidazole fungicides (Sarfun 500 SC and Topsin M 500 SC) used curatively. In spite of very high preventive and curative effectiveness mixture tridemorph + epoxiconazole (Tango 500 SC) showed to be phytotoxic for protected plants. After 4-treatments this mixture caused very intense leaf spot and drying. Probably leaf damages were connected with intense inhibition of chrysanthemum's growth. Mancozeb (Dithane M-45 80 WP) used preventively and curatively after appearance of spot symptoms showed high effectiveness in reduction the number of forming pustules (Fig. 4). Mancozeb used when pustules were formed on leaves only insignificantly reduced grown of *P. horiana*. In case of its usage no drying pustules were found. High effectiveness of mancozeb against *P. horiana* proved also researches made by Rolim et al. (1982) and Vis (1981). Other tested compounds, chlorothalonil (Bravo 500 SC), folpet (Folpan 80 WP) and fenarimol (Rubigan 12 EC) used preventively showed good effectiveness. Their usage after first symptoms appearance as a spots decreased the number of spots however, spot browning was not confirmed. Next, these fungicides were less effective when pustules were formed on leaves (Fig. 3). Significantly low effectiveness of

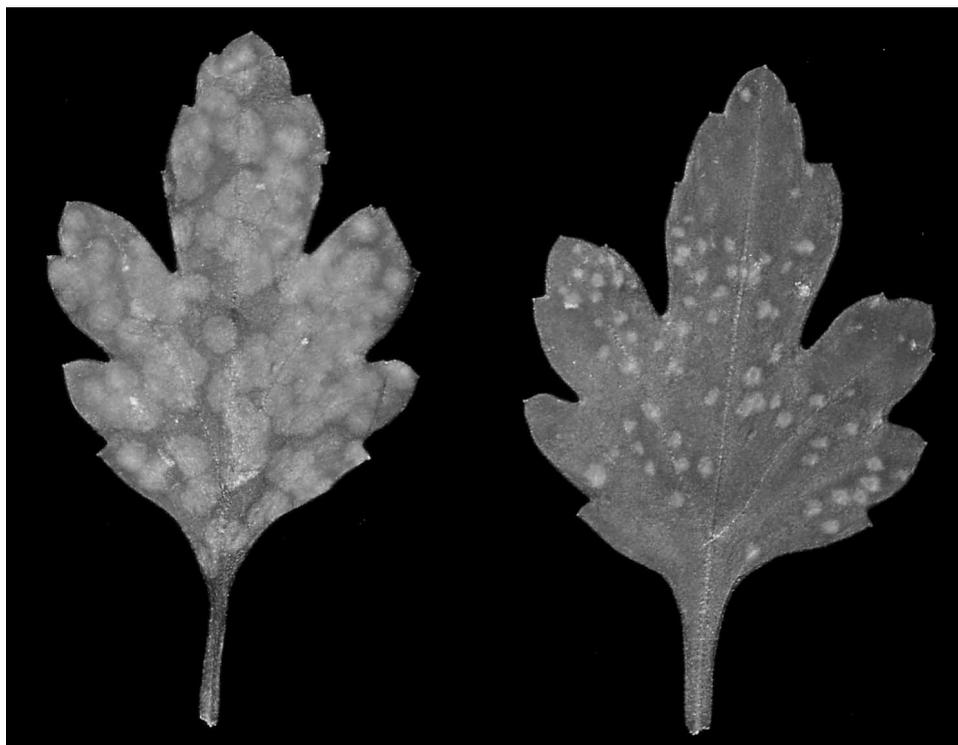


Fig. 3. Numerous pustules of teliospores on leaves sprayed with fenarimol (right) compared to control leaves (left)

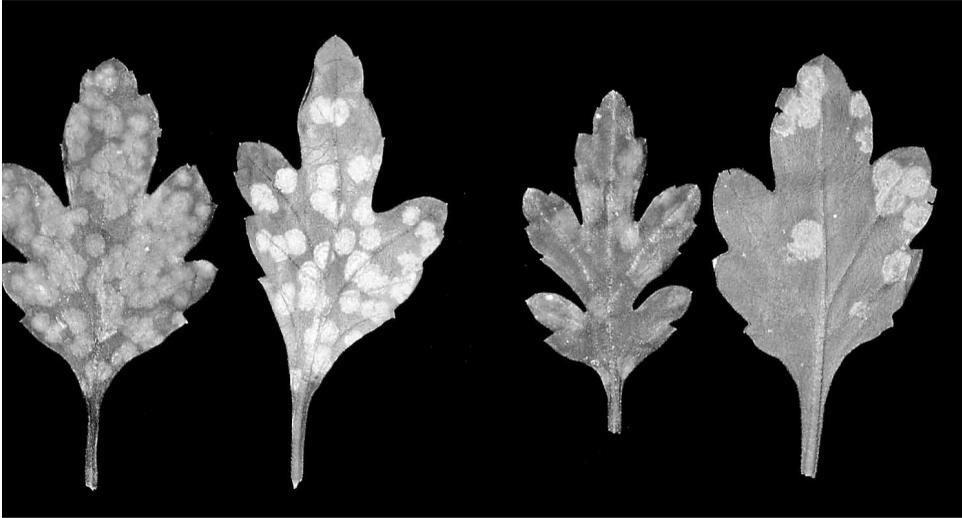


Fig. 4. Comparison of similar diameter of pustules on leaves treated by mancozeb (right) to leaves control leaves (left)

chlorothalonil and mancozeb used separately could not really influenced on effectiveness of two compound fungicides myclobutanil + mancozeb (Systhane MZ 61 WP) and tetraconazole + chlorothalonil (Eminent Star 312 SL). Tested fungicides used preventively proved very high effectiveness that was successively reduced with time starting from the beginning of infection. As first disease symptoms appeared as spots on leaves, except carbendazim (Sarfun 500 SC), fenarimol (Rubigan 12 EC) and prochloraz + carbendazim (Sportak Alpha 380 EC) all other fungicides very efficiently reduced disease development. After appearance of disease symptoms as pustules on leaves, high effectiveness was obtained only with fungicides containing derivatives of azoles or strobilurine.

CONCLUSIONS

1. From all tested chemical compounds the highest effectiveness showed azoxystrobin (Amistar 250 SC), myclobutanil + chlorothalonil (Systhane MZ 61 WP), tebuconazole + triadimefon (Folicur BT 225 EC) and tetraconazole + chlorothalonil (Eminent Star 312 SL). These chemical compounds completely protected new leaves against infection.
2. Over 95% of dried spots/pustules and their disintegration were found while using azoxystrobin, myclobutanil + chlorothalonil, tebuconazole + triadimefon and tetraconazole + chlorothalonil.
3. Among 12 tested fungicides fenarimol (Rubigan 12 EC), carbendazim (Sarfun 500 SC) and prochloraz + chlorothalonil (Sportak Alpha 380 EC) used curatively were highly less effective as compared to the other.
4. Effectiveness of tested compounds depended on phase of disease development. The highest effectiveness provided fungicides used preventively and after appearance of

- first disease symptoms as a spots. Beginning of treatment with fungicides after when pustules were formed on leaves was connected with reduction of their effectiveness.
5. Tridemorph + epoxiconazole (Tango 500 SC) showed strong phytotoxicity to tested chrysanthemum cultivars.

REFERENCES

- Bonde M.R., Peterson G.L., Rizvi S.A., Smilanick J.L. 1995. Myclobutanil as a curative agent for chrysanthemum white rust. *Plant Disease* 79, 5: 500–505.
- Cook R.T.A. 2001. First report in England of changes in the susceptibility of *Puccinia horiana*, the cause of chrysanthemum white rust, to triazole and strobilurin fungicides. *Plant Pathology* 50, 6, p. 792.
- Dickens J., Potter R. 1983. Chrysanthemums. Spraying for white rust. *Grower* 100, 18: 35–37.
- Firman I.D., Martin P.H. 1968. White rust of chrysanthemum. *Ann. Appl. Biol.*, 62: 429–442.
- Gullino G., Armato B., Garibaldi A. 1979. Experiments on the control of *Puccinia horiana* of chrysanthemum. *Informatore Fitopatologico* 29, 3: 7–10.
- Krebs E.K. 1997. Problematical control of chrysanthemum white rust. *TASPO Gartenbaumagazin* 6, 3: 40–41.
- O'Neil T.M., Pye D. 1997. Evaluation of fungicides for control of chrysanthemum white rust (*Puccinia horiana*). *Tests of Agrochemicals and Cultivars* 18: 8–9, *Annals of Applied Biology* 130, Supplement.
- Orlikowski L.B., Wojdyła A.T. 1981. Chemical control of chrysanthemum white rust. *Acta Horticulture* 125: 201–206.
- Pei C.L., Sun S.K. 1981. Investigation on fungicide-tolerant strain of pathogenic fungi in Taiwan (2) Occurrence of oxycarboxin-resistant strains of *Puccinia horiana* P. Hennings, the white rust of chrysanthemum. *Plant Protection Bulletin, Taiwan* 23, 4: 221–227.
- Rolim P.R.R., Pitta G.P.B., Cardoso R.M.G., Oliveira D.A. 1982. Chemical control of white rust (*Puccinia horiana* P. Henn.) of *Chrysanthemum* spp. *Biologico* 48, 12: 311–317.
- Strider D.L. 1995. White rust of chrysanthemum morifolium – a review. *Revista – Chapingo. Serie – Horticultura* 1, 3: 109–112.
- Sugimura T., Nishizaki M. 2001. Relation between evaluation of effectiveness of fungicides using pieces of leaf and their control effect to chrysanthemum white rust (*Puccinia horiana*). *Bulletin of the Nara Prefectural Agricultural Experiment Station* 32: 40–42.
- Vis E. De. 1981. The control of Japanese rust on chrysanthemums on rockwool. *Verbondsnieuws Voor de Belgische Sierteelt* 25, 2: 70–71.
- Wojdyła A.T. 1999a. Susceptibility of chrysanthemum cultivars to *Puccinia horiana*. *Folia Horticulturae* 11/2: 115–122.
- Wojdyła A.T. 1999b. Azoxystrobin in the control of *Puccinia horiana* on chrysanthemum. *Prog. Plant Protection/Post. Ochr. Roślin* 39 (2): 831–834.
- Wojdyła A.T. 2002. Azoles in the control of *Puccinia horiana*. *J. Plant Protection Res.*, 42 (3): 261–270.
- Wojdyła A.T., Orlikowski L.B. 1999. Strobilurin compounds in the control of rust, powdery mildew and black spot on some ornamental plants. *Med. Fac. Landbouww. Univ. Gent* 64, 3b: 539–545.

POLISH SUMMARY

MOŻLIWOŚCI ZWALCZANIE *PUCCINIA HORIANA* NA CHRYSZANTEMACH

W prowadzonych badaniach oceniano skuteczność działania 12 środków chemicznych (azoksystrobina (Amistar 250 SC), chlorotalonil (Bravo 500 SC), fenarymol (Rubigan 12 EC), folpet (Folpan 80 WP), karbendazym (Sarfun 500 SC), mankozeb (Dithane M-45 80 WP), mychlobutanil + mankozeb (Systhane MZ 61 WP), prochloraz + karbendazym (Sportak Alpha 380 EC), tebukonazol + triadimefon (Folicur BT 225 EC), tetrakonazol + chlorotalonil (Eminent Star 312 SL), tiofanat metylowy (Topsin M 500 SC), tridemorf + epoksikonazol (Tango 500 SC) w zwalczaniu *Puccinia horiana* na chryzantemach odm. Fiji Yellow uprawianej w szklarni. 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 liści, wysokość oraz ewentualną fitotoksyczność.

Z badanych środków chemicznych najwyższą skuteczność wykazywały azoksystrobina, mychlobutanil + mankozeb, tebukonazol + triadimefon oraz tetrakonazol + chlorotalonil. W przypadku ich stosowania na nowych liściach nie notowano objawów chorobowych. Natomiast jeśli do ochrony przystąpiono po wystąpieniu objawów, notowano ponad 95% zasychanie tkanek liścia w obrębie plam lub brązowienie i rozpad telii. Stosunkowo niską skuteczność wykazywały fenarymol, karbendazym oraz prochloraz + chlorotalonil. Wymienione środki stosowane profilaktycznie wykazywały dobrą skuteczność. Z kolei stosowanie fungicydów po wystąpieniu objawów w postaci brodawek na liściach wysoką skuteczność stwierdzono jedynie przy stosowaniu pochodnych azoli lub strobiluriny. Tebuconazol + triadimefon silnie ograniczał wzrost roślin, nie powodując fitotoksyczności. Z kolei mieszanina tridemorf + epoksikonazol okazała się silnie fitotoksyczną powodując zasychanie brzegów blaszek liściowych.