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THE INHIBITORY EFFECT OF FRACTIONS CONTAINING RED PIGMENT FORMED DUE TO MECHANICAL DAMAGE OF *Hippeastrum* × *hybr.* Hort. SCALES ON GROWTH AND DEVELOPMENT OF FORMAE SPECIALES OF *Fusarium oxysporum* SCHLECHT.

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Introduction

Phoma narcissi ADERH. (syn. *Stagonospora curtisii* (BERK.) SACC.) is a world wide recorded pathogen of *Hippeastrum*, *Narcissus*, *Hymenocallis* and various species of *Amaryllidaceae*. This pathogen causes red or reddish-brown spots on various organs of *Hippeastrum* and different species of *Amaryllidaceae*. Reddish, ragged streaks on the leaves and scapes of *Hippeastrum* can be induced by infestation with mite, *Steneotarsonemus laticeps* HALB. [TAPIO 1966; SANIEWSKA, ORLIKOWSKI 1984; ŁABANOWSKI et al. 1990]. It is well known that mechanical injury to the scales, basal plate, roots, stamens, leaves and scape of *Hippeastrum* induces a reddish colouration of the tissues. After mechanical injuries, when intensive reddish colouration develops on scales and basal plate of *Hippeastrum*, the fungus *Phoma narcissi* does not induce disease symptoms [SANIEWSKA 1992].

Fraction B obtained from red wounded scales of *Hippeastrum* and containing two red compounds (Hpp-1 and Hpp-2) showed inhibitory effect on the growth and development of *Phoma narcissi*. Fraction B obtained in the same way from white scales of *Hippeastrum* did not inhibit mycelium growth of *P. narcissi in vitro* [SANIEWSKA, BUDZIANOWSKI 2001].

Subfraction B_5 (containing mostly red compound Hpp-1) showed the strongest inhibitory effect on mycelium growth of *P. narcissi*. Subfraction B_8 at the same cencentration, containing mostly red compound Hpp-2 and a small amount of red compound Hpp-1, had a small antifungal activity against *P. narcissi*. Subfractions B_2 and B_3 free from red compounds, also limited the growth of *P. narcissi* in comparison to the control. This suggests that the other colourless compounds occurring in red wounded scales of *Hippeastrum* also play a defensive role against *P. narcissi* development [SANIEWSKA, BUDZIANOWSKI 2001].

Two red compounds, responsible for the red colouration of wounded *Hippeastrum* bulb scales, named as Hpp-1 and Hpp-2, have been found to have a phenolic (flavans) nature [WINK, LEHMAN 1996; SANIEWSKA, BUDZIANOWSKI 1997].

The present studies concerned antifungal activity of some fractions

obtained from red wounded *Hippeastrum* tissues, against *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria, F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae*, non-pathogenic fungi for *Hippeastrum*.

Material and methods

Hippeastrum 'Red Lion' colourless scales were cut into small pieces about 2 mm square. One portion was kept at 20–22°C in closed Petri dishes with high humidity, and after five days, when intensive reddish colour developed on the surface of scales, they were dried at room temperature (open Petri dishes). The second portion of small scales pieces was kept also at 20–22°C; but in open Petri dishes and dried without formation of red colouration. This way obtained red and white dry scales were used for extraction of different fractions.

Fractions A, B, C and D and subfractions B_1, B_2, B_3, B_5 and B_8 from fraction B were obtained according to previously described methods [SANIEWSKA, BUDZIANOWSKI 1997, 2001].

Fractions A, B, C and D from white and red scales and subfractions of fraction B from red scales (B_1, B_2, B_3, B_5 and B_8) were examined for their antifungal activity against *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*, *F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae in vitro*.

Analyzed fractions and subfractions of fraction B were dissolved in 0.4 cm^3 50% ethanol and added to 100 cm^3 of potato-dextrose-agar (PDA) after sterilization. Mycelial plugs (3 mm diam.) of formae speciales of *Fusarium oxysporum* taken from seven-day-old culture were put in the centre of 90 mm Petri dishes with PDA. The *in vitro* growth of mycelium of tested pathogens on PDA supplemented with fractions at concentration 250 and 500 $\mu g \cdot cm^{-3}$, and control (PDA with or without ethanol) was measured after 2, 4 and 6 days incubation at 25°C in darkness.

In the next trial, microscopic observation of the effect of fraction B on spore germination and germ tube growth of formae speciales of *Fusarium oxysporum* on PDA was tested. The spores were harvested from 5-day-old cultures of *Fusarium oxysporum* grown on potato-dextrose-agar (PDA). About 4×10^3 spores were added to a 90 mm Petri dishes and 10 cm^3 of sterilized PDA supplemented with fraction B at concentration 125, 250 and 500 $\mu g \cdot cm^{-3}$ poured over them. Germination of spores and length of germ tube were observed under microscope after 22 h of incubation at temperature 25° in the dark.

In both trials five dishes constituted an experimental unit and the tests were repeated three times.

The dates were subjected to an analysis of variance and Duncan's multiple range test was used for means separation (5%).

Results and discussion

The linear mycelium growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria, F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae* on potato-dextrose-agar (PDA) and PDA supplemented with ethanol (0.4 $cm^3 \cdot 100$ cm^{-3} of medium) was similar, or ethanol slightly stimulated mycelium growth of these pathogens.

Table 1; Tabela 1

The effect of fractions A, B, C and D obtained from white and red wounded scales of *Hippeastrum* on mycelium growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*

Wpływ frakcji A, B, C i D otrzymanych z niewybarwionych i wybarwionych na czerwono mechanicznie uszkodzonych łusek *Hippeastrum* na wzrost grzybni *Fusarium oxysporum* SCHLECHT. izolowanego z *Fritillaria*

Fractions, conc. in $\mu g \cdot cm^{-3}$ PDA Frakcje, stężenie w $\mu g \cdot cm^{-3}$	Diameter of mycelium (mm) after days of incubation Średnica grzybni (mm) po dniach inkubacji		
	2	4	6
Check; Kontrola	17.4 de	32.0 e	44.5 g
Fractions from white scales; Frakcje z białych łusek			
A 500	17.7 d	29.4 d	40.0 ef
B 500	18.8 de	28.1 d	39.4 de
C 500	15.0 c	28.7 d	38.0 de
D 500	18.5 de	30.2 de	42.1 fg
Fractions from red scales; Frakcje z czerwonych łusek			
A 250	17.2 de	28.5 d	37.2 d
A 500	14.7 c	24.0 c	31.2 c
B 250	10.0 b	19.0 b	25.5 b
B 500	5.5 a	10.7 a	14.7 a
C 250	15.0 c	30.0 de	40.5 ef
C 500	16.7 cd	29.5 de	39.7 d-f
D 250	19.4 e	30.0 de	42.2 fg
D 500	18.9 de	29.8 de	39.0 ef

Means in columns followed by the same letters are not significantly different at 5% level
Średnie w kolumnach oznaczone tą samą literą nie różnią się istotnie przy poziomie 5%

Fraction B obtained from red wounded scales of *Hippeastrum* and containing two red compounds (Hpp-1 and Hpp-2) showed the strongest inhibitory effect on the growth of tested formae speciales of *Fusarium oxysporum* (Tab. 1, 2 and 3). After 6 days of incubation, linear growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*, *F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae* was limited by fraction B at a concentration of 500 $\mu g \cdot cm^{-3}$ respectively, 67.0%, 67.1% and 49.3% in the comparison to the control (Tab. 1, 2 and 3).

Fractions A and C from red wounded scales at concentrations of 250 and 500 $\mu g \cdot cm^{-3}$ had a weaker antifungal activity on mycelium growth of tested pathogens *in vitro* (Tab. 1, 2 and 3). Fractions D used at the same concentrations had only a slight antifungal activity against formae speciales of *Fusarium oxysporum* or did not inhibit the pathogens (Tab. 1, 2 and 3).

Fractions A, B and D obtained in the same way from white scales of *Hippeastrum* did not inhibit mycelial growth of *F. oxysporum* SCHLECHT. from *Fritillaria* (Tab. 1) and *F. oxysporum* f. sp. *tulipae in vitro* (Tab. 3). Fraction C at a concentration of 500 $\mu g \cdot cm^{-3}$ showed a slight inhibition of the *F. oxysporum* from *Fritillaria* (Tab. 1). All fractions (A, B, C and D) at a concentration of 500 $\mu g \cdot cm^{-3}$ obtained from white scales of *Hippeastrum* showed a slight inhibition of the *F. oxysporum* f. sp. *callistephi in vitro* (Tab. 2).

Table 2; Tabela 2

The effect of fractions A, B, C and D obtained from white and red wounded scales of *Hippeastrum* on mycelium growth of *Fusarium oxysporum* f. sp. *callistephi*

Wpływ frakcji A, B, C i D otrzymanych z niewybarwionych i wybarwionych na czerwono mechanicznie uszkodzonych łusek *Hippeastrum* na wzrost grzybni *F. oxysporum* f. sp. *callistephi*

Fractions, conc. in $\mu g \cdot cm^{-3}$ PDA Frakcje, stężenie w $\mu g \cdot cm^{-3}$ PDA	Diameter of mycelium (mm) after days of incubation Średnica grzybni (mm) po dniach inkubacji		
	2	4	6
Check; Kontrola	25.5 h	51.6 i	81.1 k
Fractions from white scales; Frakcje z białych łusek			
A 500	20.2 f	43.6 f	81.4 k
B 500	21.7 g	48.7 h	81.6 k
C 500	19.4 e	40.0 d	54.5 d
D 500	20.0 f	45.0 g	61.1 e
Fractions from red scales; Frakcje z czerwonych łusek			
A 250	15.0 d	39.6 d	63.1 f
A 500	12.7 c	34.2 c	48.1 b
B 250	10.2 b	24.0 b	50.0 c
B 500	7.1 a	19.2 a	40.0 a
C 250	15.0 d	45.3 g	68.0 j
C 500	15.2 d	43.3 f	67.3 i
D 250	15.0 d	43.6 f	64.1 h
D 500	15.4 d	42.2 e	63.7 g

Means in columns followed by the same letters are not significantly different at 5% level
Średnie w kolumnach oznaczone tą samą literą nie różnią się istotnie przy poziomie 5%

Table 3; Tabela 3

The effect of fractions A, B, C and D obtained from white and red wounded scales of *Hippeastrum* on mycelium growth of *Fusarium oxysporum* f. sp. *tulipae*

Wpływ frakcji A, B, C i D otrzymanych z niewybarwionych i wybarwionych na czerwono mechanicznie uszkodzonych łusek *Hippeastrum* na wzrost grzybni *Fusarium oxysporum* f. sp. *tulipae*

Fractions, conc. in $\mu g \cdot cm^{-3}$ PDA Frakcje, stężenie w $\mu g \cdot cm^{-3}$ PDA	Diameter of mycelium (mm) after days of incubation Średnica grzybni (mm) po dniach inkubacji		
	2	4	6
Check; Kontrola	24.6 e	43.0 d	55.0 ef
Fractions from white scales; Frakcje z białych łusek			
A 500	25.2 ef	45.0 de	56.2 fg
B 500	24.8 e	45.7 de	55.0 ef
C 500	26.0 ef	45.7 de	57.5 fg
D 500	27.2 f	50.0 f	59.7 g
Fractions from red scales; Frakcje z czerwonych łusek			
A 250	20.5 d	41.0 c	49.5 d
A 500	18.1 c	37.2 b	43.7 c
B 250	10.7 b	21.2 a	29.0 b
B 500	5.0 a	11.7 a	18.1 a
C 250	20.7 d	40.5 c	50.0 d
C 500	20.0 cd	44.5 d	50.0 d
D 250	24.8 e	49.0 f	51.7 de
D 500	25.8 ef	47.7 ef	60.5 g

Means in columns followed by the same letters are not significantly different at 5% level
Średnie w kolumnach oznaczone tą samą literą nie różnią się istotnie przy poziomie 5%

Fraction B from red scales at a concentration of 500 $\mu g \cdot cm^{-3}$ greatly inhibited germination of spores as well as germ tube growth of the tested formae speciales of *Fusarium oxysporum* (Tab. 4 and 5).

Table 4; Tabela 4

The effect of different concentrations of fraction B from red scales of *Hippeastrum* on spore germination of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*

Wpływ różnych koncentracji frakcji B otrzymanych z wybarwionych na czerwono łusek *Hippeastrum* na kiełkowanie zarodników *Fusarium oxysporum* SCHLECHT. izolowanego z *Fritillaria*

Fractions, conc. in $\mu g \cdot cm^{-3}$ PDA Frakcje, stężenie w $\mu g \cdot cm^{-3}$ PDA	Percentage of germinated spores after time of incubation Procent kiełkujących zarodników po czasie inkubacji		Length of germ tube in μm Długość strzępki kiełkowej w μm
	24 h	48 h	
Check; Kontrola	34.2 c	44.0 d	31.3 c
B 125	6.7 b	8.7 c	31.0 c
B 250	3.9 ab	5.1 b	27.6 c
B 500	0.3 a	2.7 ab	18.9 b
B 1000	0.0 a	0.0 a	0.0 a

Means in columns followed by the same letters are not significantly different at 5% level
Średnie w kolumnach oznaczone tą samą literą nie różnią sie istotnie przy poziomie 5%

Table 5; Tabela 5

The effect of different concentrations of fraction B from red scales of *Hippeastrum* on spore germination of *Fusarium oxysporum* f. sp. *tulipae*

Wpływ różnych koncentracji frakcji B otrzymanych z wybarwionych na czerwono łusek *Hippeastrum* na kiełkowanie zarodników *Fusarium oxysporum* f. sp. *tulipae*

Fractions, conc. in $\mu g \cdot cm^{-3}$ PDA Frakcje, stężenie w $\mu g \cdot cm^{-3}$ PDA	Percentage of germinated spores after time of incubation Procent kiełkujących zarodników po czasie inkubacji			Length of germ tube in μm Długość strzępki kiełkowej w μm
	12 h	28 h	76 h	
Check; Kontrola	27.6 d	28.2 d	32.8 c	69.0 c
B 125	9.1 c	11.4 bc	6.8 ab	28.9 b
B 250	9.6 c	16.0 c	13.9 b	22.4 b
B 500	5.1 b	6.1 ab	2.8 a	19.5 b
B 1000	0.3 a	0.3 a	0.8 a	5.7 a

Means in columns followed by the same letters are not significantly different at 5% level
Średnie w kolumnach oznaczone tą samą literą nie różnią się istotnie przy poziomie 5%

Subfractions B_2 and B_3, free from red compounds, and subfraction B_5 (containing mostly red compound Hpp-1), greatly limited the growth of tested pathogens in comparison to the control (Fig. 1, Phot. 1, 2 and 3). Subfraction B_8, containing mostly red compound Hpp-2 and a small amount of red compound Hpp-1, applied at the same concentration did not inhibit or had little antifungal activity against tested pathogens.

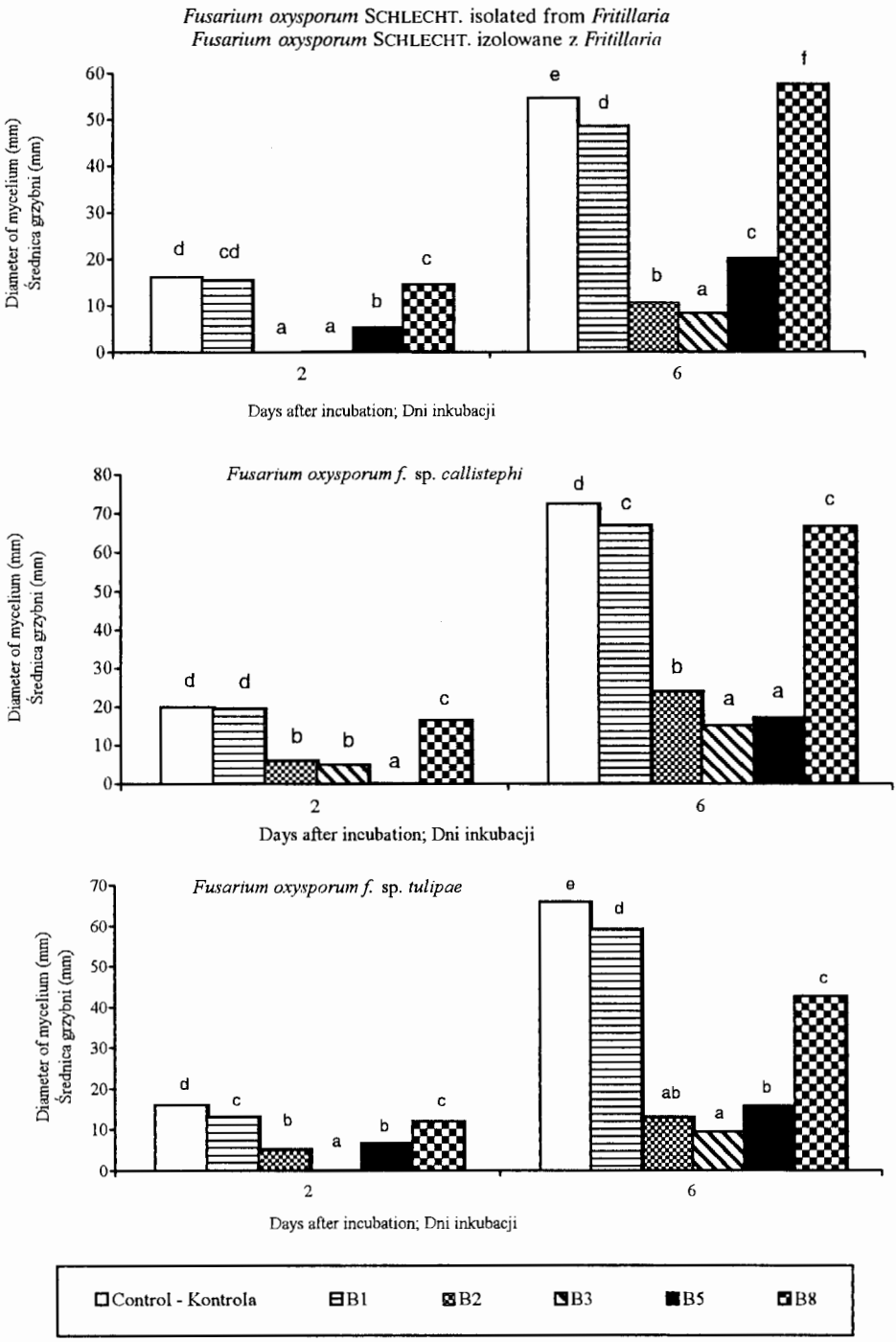

Fig. 1. Influence of subfraction B_1, B_2, B_3, B_5 and B_8 (500 $\mu g \cdot cm^{-3}$) obtained after column fraction and thin layer chromatography of fraction B obtained from

red scales of *Hippeastrum* after wounding on mycelium growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*, *F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae* after two and six days of incubation on potato-dextrose-agar. In days of incubation, means followed by the same letter are not significantly different at P = 0.05 according to Duncan's test; values are calculated separately for each formae speciales of *F. oxysporum*;

Rys. 1. Wpływ subfrakcji B_1, B_2, B_3, B_5 i B_8 (500 $\mu g \cdot cm^{-3}$) po rozdziale metodą chromatografii kolumnowej i cienkowarstwowej frakcji B otrzymanej z wybarwionych na czerwono łusek *Hippeastrum* po ich mechanicznym uszkodzeniu na wrost grzybni *Fusarium oxysporum* SCHLECHT. wyizolowanej z *Fritillaria*, *F. oxysporum* f. sp. *callistephi* i *F. oxysporum* f. sp. *tulipae* po 2 i 6 dniach inkubacji na pożywce agarowo-ziemniaczano-glukozowej. Średnie dla każdego dnia inkubacji oznaczone tą samą literą nie różnią się istotnie przy P = 0,05 (test Duncana); obliczeń różnic dokonano oddzielnie dla każdej z badanych f. sp. *F. oxysporum*

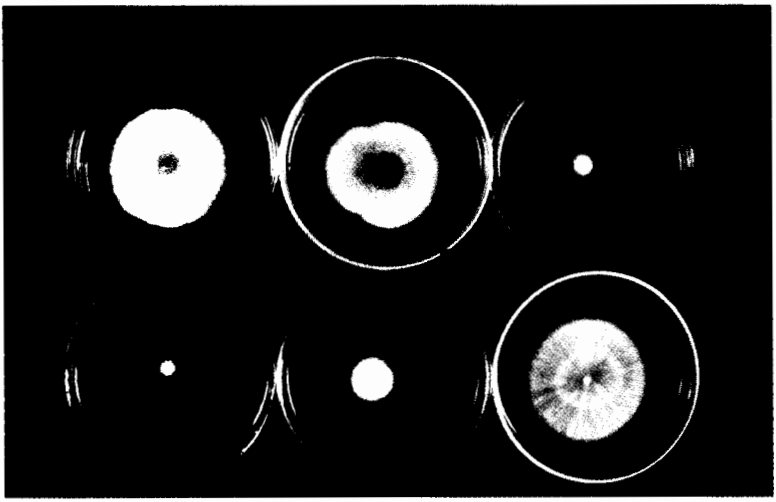

Photo 1. Influence of subfractions B_1, B_2, B_3, B_5 and B_8 (500 $\mu g \cdot cm^{-3}$) from fraction B obtained from red scales of *Hippeastrum* after wounding on mycelium growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria* on potato-dextrose-agar;

Fot. 1. Wpływ subfrakcji B_1, B_2, B_3, B_5 i B_8 ($\mu g \cdot cm^{-3}$) otrzymanych z frakcji B pozyskanej z wybarwionych na czerwono łusek *Hippeastrum* po mechanicznym uszkodzeniu na wzrost grzybni *Fusarium oxysporum* SCHLECHT. wyizolowanej z *Fritillaria* na pożywce agarowo-ziemniaczano-glukozowej

It suggests that both coloured and other colourless compounds occurring in red wounded scales of *Hippeastrum* have an antifungal activity. It is interesting that *Phoma narcissi*, fungus pathogenic to *Hippeastrum*, showed a greater tolerance for both coloured and other colourless compounds occurring in red wounded scales of *Hippeastrum* than investigated formae speciales of *Fusarium oxysporum*. It is well known that some flavonoids induced in plants during attacks by pathogens or after mechanical injuries play an important role in plant resistance and defence against microbial infections [LEATHAM et al. 1980; MATTERN, KNEUSEL 1988; NICHOLSON, HAMMERSCHMIDT 1992; SCHWALB, FEUCHT 1998].

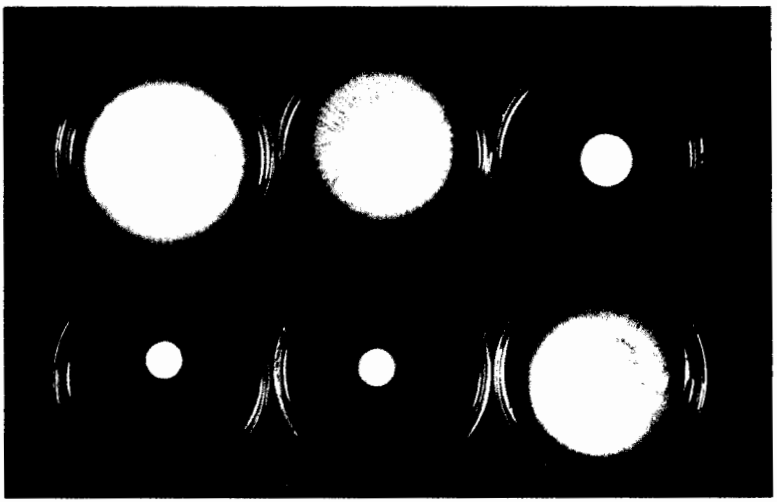

Photo 2. Influence of subfractions B_1, B_2, B_3, B_5 and B_8 (500 $\mu g \cdot cm^{-3}$) from fraction B obtained from red scales of *Hippeastrum* after wounding on mycelium growth of *Fusarium oxysporum* f. sp. *callistephi* on potato-dextrose-agar;

Fot. 2. Wpływ subfrakcji B_1, B_2, B_3, B_5 i B_8 (500 $\mu g \cdot cm^{-3}$) otrzymanych z frakcji B pozyskanej z wybarwionych na czerwono łusek *Hippeastrum* po mechanicznym uszkodzeniu na wzrost grzybni *Fusarium oxysporum* f. sp. *callistephi* na pożywce agarowo-ziemniaczano-glukozowej

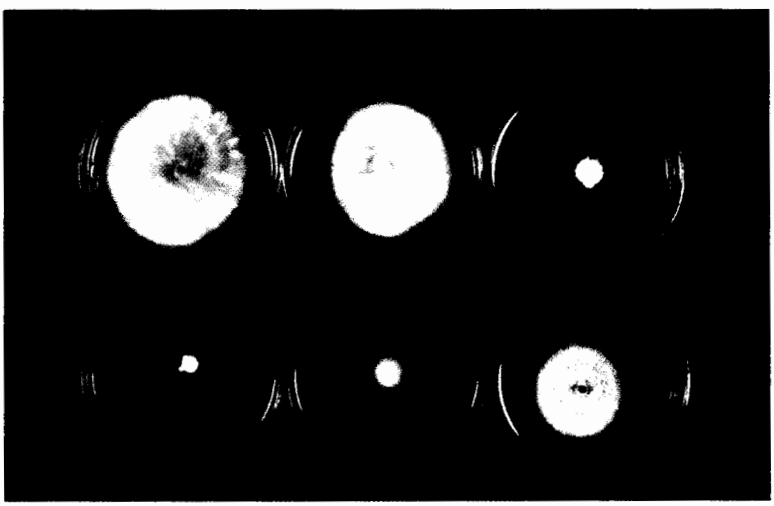

Photo 3. Influence of subfractions B_1, B_2, B_3, B_5 and B_8 (500 $\mu g \cdot cm^{-3}$) from fraction B obtained from red scales of *Hippeastrum* after wounding on mycelium growth of *Fusarium oxysporum* f. sp. *tulipae* on potato-dextrose-agar

Fot. 3. Wpływ subfrakcji B_1, B_2, B_3, B_5 i B_8 (500 $\mu g \cdot cm^{-3}$) otrzymanych z frakcji B pozyskanej z wybarwionych na czerwono łusek *Hippeastrum* po mechanicznym uszkodzeniu na wzrost grzybni *Fusarium oxysporum* f. sp. *tulipae* na pożywce agarowo-ziemniaczano-glukozowej

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Key words: *Hippeastrum*, red pigment, formae speciales of *Fusarium oxysporum*, growth, development, *in vitro*

Summary

Studies concerned the effect of different fractions obtained from white scales of *Hippestrum* after drying and from scales after red colouration as a result of wounding of fresh white scales, on the growth and development of formae speciales of *Fusarium oxysporum*, non-pathogenic fungi for *Hippeastrum*.

Fraction B, at the concentration of 250 and 500 $\mu g \cdot cm^{-3}$ obtained from red wounded scales of *Hippeastrum* and containing two red compounds (Hpp-1 and Hpp-2) showed a strong inhibitory effect on the linear growth of mycelium, germination of spores and germ tube growth of *Fusarium oxysporum* SCHLECHT. isolated from *Fritillaria*, *F. oxysporum* f. sp. *callistephi* and *F. oxysporum* f. sp. *tulipae*.

Fractions A, C and D from red wounded scales at the same concentrations did not inhibit or had a slight antifungal activity on mycelium growth of tested pathogens *in vitro*.

Fractions A, B and D obtained in the same way from white scales of *Hippeastrum* did not inhibit mycelial growth of *F. oxysporum* SCHLECHT. from *Fritillaria* and *F. oxysporum* f. sp. *tulipae*. Fraction C at a concentration of 500 $\mu g \cdot cm^{-3}$ showed a slight inhibition of the *F. oxysporum* from *Fritillaria*. All fractions (A, B, C and D) at a concentration of 500 $\mu g \cdot cm^{-3}$ obtained from white scales of *Hippeastrum* showed a slight inhibition of the *F. oxysporum* f. sp. *callistephi in vitro*. Subfractions B_2 and B_3, free from red compounds, and subfraction B_5 (containing mostly red compound Hpp-1), greatly limited the growth of tested pathogens in comparison to the control. Subfraction B_8, containing mostly red compound Hpp-2 and a small amount of red compound Hpp-1, applied at the same concentration did not inhibit or had little antifungal activity against tested formae speciales of *F. oxysporum*.

HAMUJĄCY WPŁYW FRAKCJI ZAWIERAJĄCYCH CZERWONY BARWNIK POWSTAŁY W WYNIKU MECHANICZNEGO USZKODZENIA *Hippeastrum* × *hybr.* Hort. NA WZROST I ROZWÓJ FORM SPECJALNYCH *Fusarium oxysporum* SCHLECHT.

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Słowa kluczowe: *Hippeastrum*, czerwony barwnik, formy specjalne *Fusarium oxysporum* SCHLECHT., wzrost, rozwój, *in vitro*

Streszczenie

W pracy przedstawiono wyniki badań nad wpływem różnych frakcji otrzymnych z białych łusek bezpośrednio po uszkodzeniu *Hippeastrum* i z łusek po wytworzeniu czerwonego zabarwienia w wyniku uszkodzenia łusek białych na wzrost i rozwój form specjalnych *Fusarium oxysporum*, grzybów nie patogenicznych dla *Hippeastrum*.

Frakcja B w stężeniu 250 i 500 $\mu g \cdot cm^{-3}$ uzyskana z czerwonych łusek *Hippeastrum* i zawierająca dwa związki o czerwonym zbarwieniu Hpp-1 i Hpp-2 najsilniej ograniczała wzrost grzybni, kiełkowanie zarodników i wzrost strzępki kiełkowej *Fusarium oxysporum* SCHLECHT. – patogena *Fritillaria*, *F. oxysporum* f. sp. *callistephi* i *F. oxysporum* f. sp. *tulipae*. Frakcja A, C i D w tych samych stężeniach były mało aktywne.

Frakcja A, B i D uzyskana w ten sam sposób z białych łusek *Hippeastrum*, nie wpłynęły hamująco na wzrost liniowy grzybni *F. oxysporum* SCHLECHT. izolowanego z *Fritillaria* i *F.* oxysporum f. sp. *tulipae*. Frakcja C uzyskana z białych łusek w niewielkim stopniu hamowała wzrost grzybni *F. oxysporum* SCHLECHT. z *Fritillaria*.

Frakcja A, B, C i D w stężeniu 500 $\mu g \cdot cm^{-3}$ uzyskane z białych łusek *Hippeastrum* wykazały słaby inhibicyjny wpływ na wzrost grzybni *F. oxysporum* f. sp. *callistephi in vitro*.

Otrzymane z czerwonych łusek (w wyniku uszkodzenia) *Hippeastrum* subfrakcje typu B; B_2 i B_3 (brak barwników Hpp-1 i Hpp-2), i B_5 (zawierająca głównie barwnik Hpp-1), silnie hamowały wzrost grzybni testowanych patogenów w porównaniu do kontroli. Subfrakcja B_8, zawierająca barwnik Hpp-2 i śladowe ilości Hpp-1 nie wykazała takiej aktywności w ograniczaniu wzrostu testowanych form specjalnych *F. oxysporum*.

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