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THE EFFECT OF RETARDANTS ON GROWTH OF *FUSARIUM OXYSPORUM* AND SEVERITY OF CARNATION FUSARIOSIS

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Abstract

Health status of carnation plants inoculated with two *Fusarium oxysporum* f. sp. *dianthi* isolates (FOD 1 and FOD 30) and treated with retardants (Cycocel 460 SL, B-Nine 85 SP and Topflor 015 SL) was assessed. Six carnation cultivars ('Campari', 'Campari Pink', 'Mondrian', 'Rembrandt', 'Sunflower Pink Surprise' and 'White Surprise') were investigated.

The effect of the retardants on the growth of *F. oxysporum* mycelium *in vitro* was also investigated.

The best performance in inhibition of mycelium growth and in reducing plant infection was found when Topflor 015 SL (flurprimidol) in concentration of 0.15% was used, whilst the poorest result was obtained for Cycocel 460 SL (chlormequat chloride) in concentration of 0.2%.

Key words: retardants, *Fusarium oxysporum* f. sp. *dianthi*, carnation plants

Introduction

For many centuries carnations have been very popular ornamental plants and studies were conducted in order to breed new cultivars. Recently production of greenhouse carnation (*Dianthus caryophyllus semperflorens* flore pleno hort.) has decreased, being replaced by new species of ornamental plants. However, due to relatively easy growing and cultivation connected with modest requirements of these plants, particularly in Western Europe increasing interest has been observed in growing and breeding of clove pink. These plants of small height, compact habit and interesting colour of flowers form beautiful compositions with other plants planted on flower beds or rock gardens. However, their cultivation is threatened by

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varied susceptibility to infection by *Fusarium oxysporum* f. sp. *dianthi*, which leads to premature dieback of plants (Booth 1971, Gerlach and Nirenberg 1982). Fungicide sprays are effective to some extent only for species and cultivars exhibiting high resistance to the pathogen (Evans 1976, Glaser 1966, Orlikowski 1978). Attempts to apply biological protection did not lead to expected results (Frużyńska-Jóźwiak 1994). Apart from fungicides, several growth retardant preparations are used in ornamental plants, affecting their health conditions and decorative value (Nowak and Grzesik 1997). Retardants inhibit plant growth, causing internodes' shortening and compact habit, they effect intensity of petal colour, delay ageing processes and increase resistance to many harmful factors (Jankiewicz 1997). Czerwiński (1976) reported a beneficial effect of retardants on plant resistance to stress, drought tolerance, cold hardiness, high-temperature tolerance, smog tolerance, as well as tolerance to adverse soil pH and salinity.

The aim of this study was to assess *Dianthus caryophyllus* resistance to fusariosis, to compare pathogenicity of two *Fusarium oxysporum* f. sp. *dianthi* isolates, to evaluate *in vitro* effect of growth retardants on the pathogen mycelium growth, as well as to evaluate the effect of the applied retardants on health status of *D. caryophyllus* plants under greenhouse conditions.

Materials and methods

Two isolates of *F. oxysporum* f. sp. *dianthi* were used: FOD 1 (collection of the Department of Phytopathology, Poznań University of Life Sciences) and FOD 30 – IMI 141130 (International Mycological Institute in Egham, Great Britain).

Cuttings of the following *D. caryophyllus* cultivars were used in the greenhouse experiment: 'Campari', 'Campari Pink', 'Mondrian', 'Rembrandt', 'Sunflower Pink Surprise' and 'White Surprise'. The retardants applied were: Cycocel 460 SL (chlormequat chloride) at a concentration of 0.2%, B-Nine 85 SP (daminozide) at 0.1 and 0.2%, and Topflor 015 SL (flurprimidol) at 0.08 and 0.15%.

For the *in vitro* experiment on mycelium growth, the pathogen cultures were inoculated into PDA medium containing the retardants at different concentrations, on Petri dishes. The mycelium diameter was measured after seven days.

For infection experiments inocula of FOD 1 and FOD 30 were produced on sterile wheat grain (Frużyńska-Jóźwiak 1994). After three weeks of incubation the pathogen inoculum was mixed with an appropriately prepared peat substrate at 4.4 g per 1 dm^3 (Frużyńska-Jóźwiak 1994), and next sterile plastic pots were filled with the mixture. After one week carnations cuttings of the six cultivars were planted into the pots. In control combination pots were filled with peat with no inoculum added. During the experiment plants were sprayed with retardants twice, at four-week intervals. The first treatment was performed six weeks after planting. Every two weeks health condition of plants was evaluated. Infested plants were evaluated according to a scale for disease development dynamics, applied at the Department of Phytopathology, Poznań University of Life Sciences: 0 –

healthy plants, 1 – the number of diseased plants on the date of experiment completion, 2 – the number of diseased plants recorded in the 14–20 weeks before the completion of the experiment, 3 – the number of diseased plants recorded prior to the 14-week period before the completion of the experiment.

The infection index was calculated according to the formula of Towsend-Heuberger (Püntener 1981).

Isolations into PDA medium were performed from the root crown of infested plants to confirm their infestation with *F. oxysporum* f. sp. *dianthi*.

Results

Some retardants added to PDA medium inhibited mycelium linear growth of FOD 1 and FOD 30 (Table 1). Topflor 015 SL at a concentration of 0.15% was the most effective one in limiting the tested isolates growth. Cycocel 460 SL did not have a statistically significant effect on the linear growth of isolate FOD 30. Retardant B-Nine 85 SP had a slight effect decreasing mycelial growth of FOD 1 and FOD 30.

Table 1

The effect of retardants on linear growth of *Fusarium oxysporum* isolates FOD 1 and FOD 30 on PDA (mm)

Trade name of retardant (active substance)	Concentration (%)	Isolate FOD 1	Isolate FOD 30
Cycocel 460 SL (chlormequat chloride)	0.2	79.2 d	90.0 d
B-Nine 85 SP (daminozide)	0.1	76.6 d	79.2 c
	0.2	68.1 c	77.4 c
Topflor 015 SL (flurprimidol)	0.08	36.5 b	39.5 b
	0.15	24.1 a	37.0 a
Control	0	90.0 e	90.0 d

In columns values denoted with identical letters do not differ significantly at $\alpha = 0.05$.

In the greenhouse experiment symptoms of fusariosis were observed on almost all tested *D. caryophyllus* cultivars. Differences occurred in the number of diseased plants and the disease severity.

The smallest percentage of plants infested by FOD 1 (Table 2) was recorded in the combination with Topflor 015 SL at 0.15% in 'Campari' (3.95), while the biggest number of infested plants was found in the combination with Cycocel 460 SL at 0.2% in 'Sunflower Pink Surprise', 'Rembrandt' and 'White Surprise' (69.05, 70.00, 79.84%). In turn, in the control the lowest percentage of infested plants was recorded in 'Campari' – 27.69%. The highest number of infested plants, i.e. 79.84%, was observed in 'White Surprise'.

Table 2

The effect of growth retardants on infected plants percentage in six carnation cultivars growing on substratum with *Fusarium oxysporum* f. sp. *dianthi* FOD 1

Carnation cultivar	B-Nine 85 SP		Topflor 015 SL		Cycocel 460 SL	Control
	0.1%	0.2%	0.08%	0.15%	0.2%	
'Campari'	14.8 bcd	14.8 bcd	7.8 ab	3.9 a	10.0 ab	27.7 def
'Campari Pink'	25.0 def	15.3 bcde	19.3 bcdef	11.1 abc	48.7 gh	48.7 gh
'Mondrian'	24.5 cdef	19.3 bcdef	15.3 bcde	10.0 ab	48.9 gh	48.9 gh
'Rembrandt'	19.3 bcdef	15.0 bcde	19.3 bcdef	10.0 ab	70.0 hi	70.0 hi
'Sunflower Pink Surprise'	25.0 def	24.5 cdef	23.7 cdef	10.0 ab	69.0 hi	69.0 hi
'White Surprise'	35.0 fg	19.1 bcdef	29.6 defg	24.5 cdef	79.8 i	79.8 i

In columns values denoted with identical letters do not differ significantly at $\alpha = 0.05$.

Table 3

The effect of growth retardants on infected plants percentage in six carnation cultivars growing on substratum with *Fusarium oxysporum* f. sp. *dianthi* FOD 30

Carnation cultivar	B-Nine 85 SP		Topflor 015 SL		Cycocel 460 SL	Control
	0.1%	0.2%	0.08%	0.15%	0.2%	
'Campari'	7.8 bcd	3.9 c	10.0 cde	3.0 b	7.8 bcd	29.7 f
'Campari Pink'	0 a	0 a	0 a	0 a	0 a	7.8 bcd
'Mondrian'	0 a	0 a	0 a	0 a	0 a	10.0 cde
'Rembrandt'	0 a	0 a	0 a	0 a	0 a	7.8 bcd
'Sunflower Pink Surprise'	15.0 de	7.8 bcd	15.0 de	3.9 bc	10.0 cde	29.6 f
'White Surprise'	19.3 ef	15.0 de	7.8 bcd	2.8 b	10.0 cde	59.4 g

In columns values denoted with identical letters do not differ significantly at $\alpha = 0.05$.

In the combination with FOD 30 (Table 3), no symptoms of vascular fusariosis were observed in 'Campari Pink', 'Mondrian' and 'Rembrandt'. In case of 'Campari', 'Sunflower Pink Surprise' and 'White Surprise' the percentage of plants infested by FOD 30 ranged from 2.83 to 19.34%. In the control combination the percentage of infested plants ranged from 7.78 in 'Campari Pink' and 'Rembrandt' to 59.42% in 'White Surprise'.

Infection index (Table 4) by FOD 1 in the control combination with no retardants applied ranged from 53.3 (in 'Campari') to 73.3 (in 'White Surprise'). In the combinations with FOD 1 and retardants the index ranged from 10.0 to 46.6. In the combinations with FOD 30 without retardants (Table 5) the index values reached from 20.0 (in 'Campari Pink') to 40.0 (in 'White Surprise'). In turn, in combinations with FOD 30 and retardants, infection index ranged from 0 to 20.0.

Table 4

Effect of retardants on carnation infection with *Fusarium oxysporum* f. sp. *dianthi* FOD 1 – infection index (%)

Carnation cultivar	B-Nine 85 SP		Topflor 015 SL		Cycocel 460 SL	Control
	0.1%	0.2%	0.08%	0.15%	0.2%	
'Campari'	16.6 bc	16.6 bc	13.3 b	10.0 a	13.3 b	53.3 hi
'Campari Pink'	23.3 de	16.6 bc	20.0 cd	13.3 b	46.6 gh	56.6 ij
'Mondrian'	23.3 de	20.0 cd	16.6 bc	13.3 b	46.6 gh	56.6 ij
'Rembrandt'	26.6 e	20.0 cd	20.0 cd	13.3 b	46.6 gh	66.6 kl
'Sunflower Pink Surprise'	33.3 f	33.3 f	23.3 de	13.3 b	43.3 g	63.3 jk
'White Surprise'	36.6 f	26.6 e	26.6 e	23.3 de	46.6 gh	73.3 l

In columns values denoted with identical letters do not differ significantly at $\alpha = 0.05$.

Table 5

Effect of retardants on carnation infection with *Fusarium oxysporum* f. sp. *dianthi* FOD 30 – infection index (%)

Carnation cultivar	B-Nine 85 SP		Topflor 015 SL		Cycocel 460 SL	Control
	0.1%	0.2%	0.08%	0.15%	0.2%	
'Campari'	10.0 d	6.6 c	6.6 c	3.3 b	16.6 ef	33.3 h
'Campari Pink'	0 a	0 a	0 a	0 a	0 a	20.0 fg
'Mondrian'	0 a	0 a	0 a	0 a	0 a	23.3 g
'Rembrandt'	0 a	0 a	0 a	0 a	0 a	23.3 g
'Sunflower Pink Surprise'	16.6 ef	10.0 d	16.6 ef	6.6 c	16.6 ef	33.3 h
'White Surprise'	20.0 fg	13.3 de	10.0 d	6.6 c	16.6 ef	40.0 i

In columns values denoted with identical letters do not differ significantly at $\alpha = 0.05$.

Plants in the control combination (planted in pure peat substrate) remained healthy until the end of the experiment. This was confirmed by isolations performed on the day of the experiment completion.

Discussion

Studies on the effect of retardants on ornamental plants are abundant. However, there are only few publications on growth retardants application resulting in increase of disease resistance of plants.

The effect of retardants on plants depends on the species, cultivar and the preparation with which plants are treated. The retardants applied in the experiment reduced growth of carnations. A study by Pobudkiewicz and Nowak (1994) on the

effect of retardants on carnation growth showed that after a double spraying with Topflor 015 SL elongation growth in carnations was markedly reduced; moreover, plants exhibited a better habit. The effect of B-Nine and Cycocel 460 SL on the decorative value of plants was confirmed by Startek (2000, 2001) in a study on the effect of these compounds on pansies. Better tillering and limitation of excessive shoot elongation was caused by Cycocel 460 SL in rose geranium (Zawadzińska 2000).

Halevy and Wittwer (1965) reported a reduced number of yellowing and dropping leaves thanks to delayed ageing. Plants treated with retardants become more resistant to environmental stresses such as drought, high temperature, transport or even inappropriate substrate reaction as well as high salinity (Kopcewicz and Lewak 2002). Nowak and Grzesik (1997) mentioned that some retardants protect ornamental plants against adverse external conditions and decrease the incidence of diseases and pests. In the greenhouse experiment in this study, with three retardants and six carnation cultivars, a protective effect of the tested preparations on the development of fusariosis was also found. The best effect was obtained with Topflor 015 SL, with flurprimidol active substance.

The few papers on retardants effect on plant disease severity deal mainly with Regalis®, whose active substance is prohexadione calcium. Sobiczewski and Bubán (2004) claimed that Regalis® applied in apple trees reduced the severity of fireblight and apple scab. Other authors (Bazzi et al. 2003) found out that the retardant reduced the secondary fireblight in pears and apples, apple scab and gray mould in grapevines.

The effect of Topflor 015 SL described in this study suggest that the retardant could be also of use to control fusariosis in carnations. The physiological mechanism of this phenomenon needs further investigation.

Conclusions

1. Isolate FOD 1 was more pathogenic for carnation plants than isolate FOD 30.

2. All the retardants in question limited linear the *in vitro* growth of both *F. oxysporum* f. sp. *dianthi* isolates mycelium. It may be connected with the protective effect of the retardants on carnations infected with the pathogen.

3. The best protective properties were displayed by Topflor 015 SL at a concentration of 0.15%, and thus the preparation could be recommended as a retardant with considerable protective effect.

Streszczenie

WPŁYW RETARDANTÓW NA WZROST *FUSARIUM OXYSPORUM* I NA NASILENIE FUZARIOZY GOŹDZIKA

Badano wpływ trzech retardantów: Cycocel 460 SL, B-Nine 85 SP, Topflor 015 SL, zastosowanych w różnych stężeniach, na wzrost liniowy grzybni *Fusarium oxysporum* f. sp. *dianthi* oraz na zdrowotność sześciu odmian goździka: 'Campari', 'Campari Pink', 'Mondrian', 'Rembrandt', 'Sunflower Pink Surprise' i 'White Surprise' zakażonych dwoma izolatami patogenu. Rośliny opryskiwano dwukrotnie, w odstępach czterotygodniowych (po raz pierwszy sześć tygodni po wysadzeniu).

Spośród zastosowanych retardantów najbardziej ograniczał wzrost patogenu i porażenie roślin Topflor 015 SL (flurprimidol) w stężeniu 0,15%, a najmniej skuteczny był Cycocel 460 SL (chloromekwat) w stężeniu 0,2%.

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