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# FUNGI INFECTED THE *Zinnia elegans* Jacq. CONCERNING SUSCEPTIBILITY OF CULTIVARS TO SELECTED PATHOGENS

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**Abstract**. *Zinnia elegans* is an annual plant recommended for cultivation for cut flowers as well as flowerbeds. This ornamental plant can be infected by: viruses, bacteria, phytoplasms and by a number of fungi species. Presented studies were conducted in 2006 in three localities of the Lublin region: in the vicinity of Zamość, near Krasnystaw and near Opole Lubelskie. Those studies included three cultivars of *Zinnia elegans* Jacq.: Golden Dawn, Lawa, Scarlet Flame as well as the mixed material of the cultivars belonging to the dahlia group. Six weeks after the sowing, the seedling's healthiness was assessed. The proportion of seedlings with disease symptoms ranged from 7% to 44%. The main cause of root infection at the seedling stage proved to be the species of *F. equiseti* and *S. sclerotiorum*. Considerable amounts of *B. cinerea* and *F. culmorum* and *A. alternata* were also detected from diseased seedlings. Studies on the susceptibility of analyzed cultivars and the mixed material of elegans zinnia to infection by *B. cinerea* and *F. avenaceum*, *F. culmorum* and *F. equiseti* were conducted in a growth chamber. Results obtained from this experiment confirmed considerable harmfulness of the species *B. cinera* and *F. equiseti* towards the seedlings of elegans zinnia, which can be reduced introducing less susceptible varieties to the cultivation. However, none of the studied varieties of elegans zinnia, only its mixed material, showed such properties.

**Key words:** healthiness, seedlings, pathogenicity, *Fusarium* spp., *Botrytis cinerea, Sclerotinia sclerotiorum*

## INTRODUCTION

One of the annual plant recommended for cultivation for cut flowers as well as flowerbeds is elegans zinnia (*Zinnia elegans* Jacq.). This species is more and more frequently used as an attractive pot and balcony flower [Mynett and Zawadzińska 2001].

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Zinnia can be infected by the viruses of turnip mosaic potyvirus (TMP), cucumber mosaic virus (CMV) and tomato spotted wilt virus (TSWV) [Brunt et al. 1996, Kryczyński 2007]. Dangerous pathogens of *Z. elegans* include Aster yellows (AY) phytoplasma. Most reports on the occurrence of this pathogen on ornamental plants come from Italy [Kamińska 2005]. Pathogens of bacterial origin that are of considerable importance to ornamental plants, including zinnia, are the species of *Ralstonia solanacearum* (Smith) Yabuuchi et al., *Xanthomonas campestris* pv. *zinniae* Hopkins & Dawson (syn. *X. nigromaculans* f. sp. *zinniae* Hopkins & Dawson ) [Terry-Lewandowski and Strimart 1983, Verma and Sharma 1999].

Elegans zinnia, at various stages of its development, can be infected by a number of fungi species. Dangerous pathogens of this plant include the species of *Sclerotinia sclerotiorum* (Lib.) de Bary and *Fusarium culmorum* (W.G. Sm.) Sac., which are the cause of the seedling blight and the necrosis of the root neck [Łacicowa et al. 1979, Saniewska 1998]. Other species from *Fusarium* genus found on zinnia are *F. solani*, *F. avenaceum* (Fr.) Sacc. and *F. oxysporum* Schlecht. [Łacicowa et al. 1979; Palacios et al. 1991]. The healthiness of *Z. elegans* seedlings is also decreased by the polyphagous species of *Botrytis cinerea* Pers. [Saniewska 1998]. It follows from the studies by Łacicowa et al. [1979] that the species of *Alternaria zinniae* Pape colonizing the achenes of this plant can cause pre- and post-emergence blight of zinnia seedlings. In India, the seedlings of zinnia are injured by *Colletotrichum acutatum* Simmonds (teleomorph of *Glomerella acutata* Guerber & J.C. Correll), while in the 1990's the occurrence of *Colletotrichum falcatum* Went. (teleomorph of *Glomerella tucmanensis* Speg.) was observed on *Z. elegans* in Venezuela [Kulshrestha according to Łacicowa et al. 1979, Sutton 1980, Palacios et al. 1991].

The increasing assortment of *Zinnia elegans* cultivars recommended for cultivation provoked studies on the seedling healthiness of this plant considering the susceptibility of selected cultivars to some pathogens.

## MATERIAL AND METHODS

Studies were conducted in 2006 in three localities of the Lublin region: in the vicinity of Zamość, near Krasnystaw and near Opole Lubelskie. Those studies included three cultivars

of elegans zinnia (Golden Dawn, Lawa, Scarlet Flame) as well as the mixed material of the cultivars belonging to the dahlia group. In all stands, the experiment was set up on 29 April 2006 with the forecrop for the cultivation of elegans zinnia being the root crops. Elegans zinnia was sown directly to the soil and achenes of selected cultivars were sown in four replications – on 4 plots with the area of 2 $m^2$ each, using 1g of the sowing material per 1 $m^2$. No chemical treatment was used during the vegetation and the plots were manually weeded.

Six weeks after the sowing, the seedlings' healthiness was assessed. To this aim, 100 seedlings of each cultivar grown in the three analyzed locations were taken (25 seedlings from each replication). In laboratory percentage of seedlings with necrosis

symptoms on the roots and hypocotyls were recorded. Disease symptoms were classified using the following scale:

| Disease score | Symptoms |
|---|---|
| I | 1/3 roots with necrosis |
| II | over ½ of roots with necrosis |
| III | necrosis of roots and hypocotyls and brown spots on the leaves |
| IV | seedlings with total necrosis |

The seedlings scored as above were counted and the disease index for each replicate was estimated according to McKinney's formula [Łacicowa 1969]. Thereafter, the mean disease index for each cultivar and localisation was calculated. The results were statistically analysed using T-Tukey multiple range test [Żuk 1989].

A mycological analysis of the diseased seedlings was conducted in the laboratory. 50 fragments prepared from the roots and 50 fragments from hypocotyl of the infected plants were analyzed. A mineral medium [Łacicowa 1970] was used to isolate the fungi. The fungi were identified using the monographs and manuscripts previously described by Kiecana et al. [2009]. Studies on the susceptibility of analyzed cultivars and the mixed material of elegans zinnia to infection by *Botrytis cinerea* and three species from genus *Fusarium*: *F. avenaceum*, *F. culmorum* and *F. equiseti* (Corda) Sacc. were conducted in a growth chamber at the temperature of 23–24$^{o}$C and relative air humidity of 85%. The studies used the strain whose pathogenicity had been earlier checked in the laboratory using the method of Mishra and Behr [1976].

The fungi inoculum consisted of 14-days' cultures of the studied fungi strains: *Botrytis cinerea* no. 42 and *F. avenaceum* no. 11, *F. culmorum* no. 15, *F. equiseti* no. 3 growing on PDA medium in Petri dishes at the temperature of 22$^{o}$C.

The studies used only the achenes of the analyzed cultivars of elegans zinnia the seedlings of which reached the length of 10 mm and which were normally formed. The selected material was placed on plasters of the medium with the fungus in plastic pots with the diameter of 10 cm filled with universal subsoil with an addition of sand in the proportion of 2:1, with pH 6.5, previously sterilized twice in an autoclave for 2 hours at the temperature of 121$^{o}$C, the atmospheric pressure of 1.21 atm. (0.12 MPa) [Mańka 1989]. The control consisted of pots where the pregerminated achenes were placed on plasters of the medium without the fungus. The experiment was set up on 13 July 2006 and each experimental combination was repeated four times, with 25 plants in each repetition. The plants grew for 24 days, after which the degree of the seedlings' infection was established according to the above-mentioned scale. Next, the disease indexes were calculated and they were submitted to a statistical analysis like in the case of plants growing in field conditions.

Ten seedlings with disease symptoms from each combination of the growth chamber experiment were taken for mycological analysis. Fifty fragments from the roots and the hypocotyl were analyzed from each experimental combination. Appropriate methods were used to mark the fungi isolated from the diseases seedlings just like in the case of plants growing in field conditions.

## RESULTS

In field conditions and in the case of each examined variety, the studies observed seedlings with the symptoms of root necrosis, reduction of the root system and necrotic, brown spots on the hypocotyl, cotyledon and leaves of the seedlings; besides completely necrotized (dying) plants occurred (photo 1, 2). The proportion of seedlings with disease symptoms on the plots in the vicinity of Zamość ranged from 8.0% in the case of the mixed material of the cultivars to 19.0% in the case of Lawa cultivar, in the vicinity of Krasnystaw from 7.0% (mixed material of cultivars) to 24.3% (cv. Lawa), whereas the proportion of diseased seedlings from the plots near Opole Lubelskie was from 40.0% (cv. Scarlet Flame) to 44.0% (cv. Lawa) (tab. 1).

Table 1. Percentage of diseased seedlings and values of the disease index for zinnia cultivated in three regions of Lublin Province

Tabela 1. Procentowy udział chorych siewek oraz wartości wskaźników chorobowych dla odmian cynii wytwornej uprawianej w trzech rejonach Lubelszczyzny

| Cultivar Odmiana | Zamość | | Krasnystaw | | Opole Lubelskie | | Mean – Średnio | |
|---|---|---|---|---|---|---|---|---|
| | % diseased seedlings chorych siewek | Disease index wskaźnik chorobowy | % diseased seedlings chorych siewek | Disease index wskaźnik chorobowy | % diseased seedlings chorych siewek | Disease index wskaźnik chorobowy | % diseased seedlings chorych siewek | Disease index wskaźnik chorobowy |
| Golden Dawn | 11.0 | $7.75^{b}_{A}$ | 15.0 | $8.75^{b}_{A}$ | 42.0 | $15.50^{a}_{B}$ | 22.7 | $10.67^{b}$ |
| Lawa | 19.0 | $8.50^{b}_{A}$ | 24.0 | $9.25^{b}_{A}$ | 44.0 | $16.00^{a}_{B}$ | 29.0 | $11.25^{b}$ |
| Scarlet Flame | 10.0 | $3.50^{a}_{A}$ | 13.0 | $4.75^{a}_{A}$ | 40.0 | $14.75^{a}_{B}$ | 21.0 | $7.67^{a}$ |
| Mixed material Cynia mieszana | 8.0 | $3.00^{a}_{A}$ | 7.0 | $3.50^{a}_{A}$ | 43.0 | $15.25^{a}_{B}$ | 19.3 | $7.25^{a}$ |
| Mean Średnio | 11.8 | 5.69 | 14.8 | 8.75 | 42.3 | 15.38 | 22.9 | 9.94 |

a, b – means values in columns followed by the different small letters differ significantly at $P \leq 0.05$ – średnie wartości w kolumnach oznaczone różnymi małymi literami różnią się istotnie przy $P \leq 0,05$

A, B – means values in lines followed by the different big letters differ significantly at $P \leq 0.05$ – średnie wartości w wierszach oznaczone różnymi wielkimi literami różnią się istotnie przy $P \leq 0,05$

The statistical analysis showed that significantly higher values of mean disease index were observed in the case of Golden Dawn and Lawa cultivars grown in the areas near Zamość and Krasnystaw, whereas in the case of seedlings grown near Opole Lubelskie no significant differences were observed in the size of disease index for particular cultivars of elegans zinnia. Comparing disease index for the seedlings of the analyzed cultivars and the mixed material from three regions of the Lublin area, significantly higher values were found in the case of all genotypes grown in the vicinity of Opole Lubelskie as compared with the plants growing near Zamość and Krasnystaw (tab. 1). Irrespective of the place of cultivation, the highest disease index was characteristic of Lawa cultivar (tab. 1).

Photo 1. Disease symptoms on seedlings of zinnia cv. Lawa
Fot. 1. Objawy chorobowe sadzonek zinnii odmiany Lawa

Photo 2. Disease symptoms on seedling of zinnia cv. Scarlet Flame
Fot. 1. Objawy chorobowe sadzonek zinnii odmiany Scarlet Flame

Table 2. Fungi isolated from elegans zinnia seedlings in 2006 year
Tabela 2. Grzyby wyizolowane z siewek cynii wytwornej w 2006 roku

| Fungi species<br>Gatunki grzybów | Analised localisations of Lublin region – Analizowana lokalizacja w regionie Lublina | | | | | | | | | Total ogólem | | Total number of isolates Ogólna liczba izolatów % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Zamość | | | Krasnystaw | | | Opole Lub | | | | | |
| | Number of isolates – Liczba izolatów, % | | | | | | | | | | | |
| | r | h | r+h | r | h | r+h | r | h | r+h | r | h | |
| *Alternaria alternata* (Fr.) Keissler | 2 (2.6) | 43 (26.2) | 45 (18.8) | 4 (5.9) | 63 (31.0) | 67 (24.7) | 6 (6.5) | 26 (13.4) | 30 (10.5) | 12 (5.1) | 132 (23.5) | 144 (18.0) |
| *Auerobasidium pullulans* de Bary. Arnaud | 10 (13.2) | 38 (23.2) | 48 (20.0) | - | 57 (28.1) | 57 (21.0) | 1 (1.1) | 30 (15.5) | 31 (10.80) | 11 (4.6) | 125 (22.3) | 136 (17.0) |
| *Botrytis cinerea* Pers. | 12 (15.8) | 18 (11.0) | 30 (12.5) | 4 (5.9) | 21 (10.3) | 25 (9.2) | 17 (18.3) | 24 (12.4) | 41 (14.3) | 33 (13.9) | 63 (11.2) | 96 (12.0) |
| *Cladosporium cladosporioides* (Fres.) de Vries | - | - | - | - | - | - | - | 2 (1.0) | 2 (0.7) | - | 2 (0.4) | 2 (0.3) |
| *Fusarium avenaceum* (Fr.) Sacc. | - | - | - | - | 9 (4.4) | 9 (3.3) | 6 (6.5) | 12 (6.2) | 18 (6.3) | 6 (2.5) | 21 (3.7) | 27 (3.4) |
| *Fusarium culmorum* (W.G.Sm.) Sacc. | 12 (15.8) | 21 (12.8) | 33 (13.8) | 2 (2.9) | 17 (8.4) | 19 (7.0) | 2 (2.2) | 40 (20.6) | 42 (14.6) | 16 (6.8) | 78 (13.9) | 94 (11.8) |
| *Fusarium equiseti* (Corda) Sacc. | 11 (14.5) | 3 (1.8) | 14 (5.83) | 15 (22.1) | 15 (7.4) | 30 (11.1) | 25 (26.9) | 33 (17.0) | 58 (20.2) | 51 (21.5) | 51 (9.1) | 102 (12.8) |
| *Fusarium oxysporum* Schlecht. | 1 (1.3) | 8 (4.9) | 9 (3.8) | 14 (20.6) | 9 (4.4) | 23 (8.5) | 12 (12,9) | 12 (6.2) | 24 (8.4) | 27 (11.4) | 29 (5.2) | 56 (7.0) |
| *Fusarium sporotrichioides* Sherb. | - | - | - | 9 (13.2) | 5 (2.5) | 14 (5.2) | - | - | - | 9 (3.8) | 5 (0.9) | 14 (1.8) |
| *Mucor hiemalis* Wehmer | 5 (6.6) | 9 (5.5) | 14 (5.8) | - | - | - | - | - | - | 5 (2.1) | 9 (1.6) | 14 (1.8) |
| *Penicillium verrucosum* Dierckx var. *cyclopium* (West.) Samson et al. | 2 (2.6) | 13 (7.9) | 15 (6.3) | 6 (8.8) | 4 (2.0) | 10 (3.7) | 13 (14.0) | 3 (1.6) | 16 (5.6) | 21 (8.9) | 20 (3.6) | 41 (5.1) |
| *Sclerotinia sclerotiorum* (Lib.) de Bary | 21 (27.6) | 11 (6.7) | 32 (13.3) | 14 (20.6) | 3 (1,5) | 17 (6.3) | 11 (11.8) | 12 (6.2) | 23 (8.0) | 46 (19.4) | 26 (4.6) | 72 (9.0) |
| Total – Razem | 76 | 164 | 240 | 68 | 203 | 271 | 93 | 194 | 287 | 237 | 561 | 798 |

r – roots – korzenie; h – hypocotyl – hypokotyl

The mycological analysis of the seedlings of 3 cultivars of elegans zinnia, namely Golden Dawn, Lawa and Scarlet Flame as well as the mixed material of the varieties cultivated in 2006 in the areas of Zamość provided 240 fungi isolates, including 76 from the roots and 164 from the hypocotyl (tab. 2). Colonies of those fungi belonged to 9 species. On the other hand, 271 fungi isolates (68 from the roots and 203 from the hypocotyl) belonging to 10 species were isolated from elegans zinnia seedlings growing on the plots near Krasnystaw, whereas 287 isolates (93 from the roots and 194 from the hypocotyl) represented by 9 fungi species. In the case of the seedling roots of elegans zinnia grown in the vicinity of Zamość, the dominating species proved to be *Sclerotinia sclerotiorum* – 27.6% of all colonies obtained from the roots. On the other hand, the species *Fusarium equiseti*, whose isolates constituted, respectively 22.1% and 26.9% of all root isolations, was obtained in the greatest quantities from the seedling roots of elegans zinnia grown near Krasnystaw and Opole Lubelskie. Among the species pathogenic to plants, *Fusarium culmorum*, whose isolates constituted 15.79% of all fungi obtained from the roots, *F. equiseti* (14.5%) and *Botrytis cinerea*, whose isolates constituted 15.8% of all root isolations, were also obtained in big quantities from the seedling roots of elegans zinnia grown near Zamość. In the case of elegans zinnia growing near Krasnystaw, *S. sclerotiorum*, whose colonies constituted 20.6% of all isolations from the roots, and *F. sporotrichioides* Sherb., whose isolates constituted 13.2% of all fungi obtained from the roots were isolated in a considerable proportion. Among the plants growing in the vicinity of Opole Lubelskie, the species pathogenic to plants included *B. cinerea* – 18.3% of all root isolations, *S. sclerotiorum* – 11.8%, *F. avenaceum* – 6.5%, *F. culmorum* whose isolates constituted 2.2%, of all root isolations (tab. 2).

As for isolations from the hypocotyl, a considerable quantity of fungi from genus *Fusarium* was obtained and its isolates constituted 19.5% of all fungi obtained from the hypocotyl of plants growing near Zamość, 27.1% of all isolations from plants growing near Krasnystaw and 50.0% of plants growing near Opole Lubelskie (tab. 2). Colonies from genus *Fusarium* were represented by the species of *F. avenaceum, F. culmorum, F. equiseti, F. oxysporum* and *F. sporotrichioides* In all the locations, the species of *F. culmorum* was represented the most, and its isolates constituted 12.8% (near Zamość), 8.4% (near Krasnystaw) and 20.6% (near Opole Lubelskie) of all isolations from the hypocotyl (tab. 2). Besides, considerable quantities of *B. cinerea* isolates were obtained from the hypocotyl of he seedlings growing in all analyzed regions of Lublin. Colonies of this fungus obtained from plants growing near Zamość, Krasnystaw and Opole Lubelskie constituted, respectively, 11.0%, 10.3% and 12.4% of isolations of all fungi from the hypocotyl. On the other hand, species *S. sclerotiorum* constituted 6.7% of all isolations from the hypocotyl of elegans zinnia grown in the vicinity of Zamość, 1.48 hypocotyl of plants grown in the vicinity of Krasnystaw and 6.2% of all isolations from the hypocotyl of the seedlings growing near Opole Lubelskie. Colonies of other fungi obtained from the hypocotyl of elegans zinnia seedlings belonged to *A. alternata* (Fr.). Keissler*, A. pullulans* de Bary. Arnaud*, Cladosporium cladosporioides* (Fres.) de Vries*, P. verrucosum* Direckx var. *cyclopium* (West.) Samson, Stolk et al. (tab. 2).

In the growth chamber experiment, seedlings with signs of infection occurred in all combinations (tab. 3). In the combination with *B. cinerea*, diseased plants were characterized by necrosis covering the roots and the lower fragment of the hypocotyl and in

the case of strong infection, watery spots were visible above the necrosis. The fungus also caused reduction of the root system. The greatest pathogenicity of *B. cinerea* was shown in relation to Lawa cultivar, when the disease index was 98.25, while the lowest was found for Scarlet Flame cultivar, where it was 93 (tab. 3).

Table 3. Mean values of the disease index for seedlings of elegans zinnia obtained in growth chamber conditions with artificial inoculation of subsoil with *Fusarium* spp. and *Botrytis cinerea*

Tabela 3. Średnie wartości wskaźników chorobowych dla siewek cynii wytwornej uzyskanych w doświadczeniu fitotronowym ze sztucznym zakażaniem podłoża przez *Fusarium* spp. i *Botrytis cinerea*

| Fungi strains<br>Szczepy grzybów | Zinnia cultivars – Odmiany cynii | | | | Mean<br>średnia |
|---|---|---|---|---|---|
| | Golden Dawn | Scarlet Flame | Lawa | Mixed material<br>Cynia mieszana | |
| *Botrytis cinerea* nr 42 | 96.25* | 93.00* | 98.25* | 95.00* | 95.62* |
| *Fusarium avenceum* nr 11 | 87.75* | 94.75* | 89.25* | 77.25* | 87.25* |
| *Fusarium culmorum* nr 15 | 93.25* | 96.00* | 87.25* | 72.00* | 87.12* |
| *Fusarium equiseti* nr 3 | 92.25* | 95.75* | 93.25* | 93.50* | 93.43* |
| Control – Kontrola | 6.00 | 11.50 | 12.25 | 5.75 | 8.88 |

*Means values differ significantly compared to the control at $P \leq 0.05$

* Średnie wartości różnią się istotnie w porównaniu z kontrolą przy $P \leq 0,05$

Plants in the experimental combination with *Fusarium avenaceum* were inhibited in their growth and they had a reduced root system. Necrotic streaks occurred on the hypocotyl surface of the seedlings. Necrotic spots with a chlorotic ring formed on the edge of the leaf blade were visible on the leaves. Disease index for the seedlings in this combination of the experiment were from 77.25 (mixed zinnia) to 94.75 (cv. Scarlet Flame). Disease symptoms on the seedlings in the experiment with *Fusarium culmorum* were like in the case of *F. avenaceum;* besides, necrosis of the roots and the base of the leaf blade was observed. Disease index for all studied cultivars in the above discussed experimental combinations ranged from 72.00 for mixed zinnia to 96.00 for Scarlet Flame cultivar. Necrotic streaks on the leaf bottom and small, chlorotic and necrotic spots on the leaves occurred on plants in the combination with *F. equiseti*. The seedlings infected by this fungus showed symptoms of the root rot. Disease symptoms in the case of plants from the experimental combination with *F. equiseti* constituted from 92.25 for cv. Golden Dawn to 95.75 for cv. Scarlet Flame.

The control combination included single seedlings with symptoms of weak root necrosis. Values of disease symptoms for control seedlings ranged from 5.75 in the case of mixed zinnia to 12.25 for cv. Lawa (tab. 3). The statistical analysis of disease symptoms pointed to significant differences as compared to the control in all cultivars of elegans zinnia and in all analyzed fungi strains.

The mycological analysis of the seedlings with disease symptoms confirmed infection of the fungi used in the studies (tab. 4). Apart from the species used for artificial

Table 4. Fungi isolated from roots of *Zinnia elegans* seedlings obtained from experiments with artifical infection of subsoil
Tabela 4. Grzyby wyizolowane z korzeni siewek *Zinnia elegans* uzyskanych z doświadczenia ze sztucznym zakażaniem podłoża

| Fungi species Gatunki grzybów | *B. cinerea* | | | | *F. avenaceum* | | | | *F. culmorum* | | | | *F. equiseti* | | | | Control | | | | Total of isolates Ogólna liczba izolatów |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | I | II | III | IV | I | II | III | IV | I | II | III | IV | I | II | III | IV | |
| *Alternaria alternata* (Fr.) Keissler | | | | | | | | 1 | | 1 | | | 3 | | | | | | 6 | 3 | 14 |
| *Aspergillus niger* Tieghem | | | | | | | | | | | | | | | | | | | | 2 | 2 |
| *Botrytis cinerea* Pers. | 4 | 3 | 10 | 6 | | | | | | | | | | | | | | | | | 23 |
| *Fusarium avenaceum* (Fr.) Sacc. | | | | | 8 | 2 | 5 | 2 | | | | | | | | | | | | | 17 |
| *Fusarium culmorum* (W.G.Sm.) Sacc. | | | | 4 | | | | | 10 | 13 | 13 | 11 | | | | | | | | | 51 |
| *Fusarium equiseti* (Corda) Sacc. | | | | | | | | | | | | | 4 | 13 | 9 | 1 | | | | | 27 |
| *Fusarium oxysporum* Schlecht. | | | | | | | | | | | | | | | | | | | | 1 | 1 |
| *Mucor hiemalis* Wehmer | | | | | | | | | | | | 2 | | | | | | | 10 | 4 | 16 |
| *Penicillium verrucosum* Dierckx var. *cyclopium* (West.) Samson et al. | | | 1 | | 3 | | | | | | | | 1 | | | | | | 3 | 3 | 11 |
| *Periconia macrospinosa* Lefebrre and A.G. Johnson | | | | | | | | 1 | | | | | | | | | | | | | 1 |
| *Trichoderma koningii* Oudemans | | 4 | 2 | 4 | | 6 | 2 | | | | 1 | | | | | 8 | 7 | 5 | | | 39 |
| Total | 4 | 7 | 13 | 14 | 11 | 8 | 7 | 4 | 10 | 14 | 14 | 13 | 8 | 13 | 9 | 9 | 7 | 5 | 19 | 13 | 202 |

I – cv. Golden Dawn, II – cv. Ilumination, III – cv. Scarlet Flame, IV – mixed material of the cultivars (mixed zinnia) – materiał mieszany odmian

infection of the soil, scarce isolates of the following were obtained as a result of the mycological analysis: *Alternaria alternata, Aspergillus niger, Fusarium oxysporum, Mucor hiemalis, Penicillium verrucosum* var. *cyclopium, Periconia macrospinosa* and *Trichoderma koningii*.

## DISCUSSION

Studies conducted in field conditions pointed to the occurrence of elegans zinnia seedlings showing disease symptoms in the case of all studied cultivars and the mixed material growing in three different regions of the Lublin area.

The main cause of root infection at the seedling stage proved to be the species of *F. equiseti* and *Sclerotinia sclerotiorum*, commonly regarded as pathogens causing pre- and post-emergence blight of seedlings as well as the rot of the roots, bulbs and the stem base of a number of species of ornamental plants [Łacicowa and Kiecana 1992, Saniewska 1998, Orlikowski 2001, Pięta and Laskowska 2004].

Studies conducted in the field and in the growth chamber, together with earlier information from literature on ornamental and herbaceous plants point to a considerable proportion of *F. equiseti* species injuring the seedlings of elegans zinnia [Łacicowa and Kiecana 1992, Machowicz-Stefaniak and Zalewska 2004]. This species can also colonize the sowing material of ornamental plants including *Zinnia elegans* [Łacicowa et al. 1991]. *Fusarium equiseti* is mainly regarded as a species colonizing the senescent tissues and as a secondary colonizer of the host plant as well as a dangerous pathogen of some plants, especially the species from family *Cucurbitaceae* [Desjarins 2006].

The species *S. sclerotiorum* belonged to the fungi frequently isolated from the infected seedlings of elegans zinnia. In the studies by Łacicowa et al. [1979], this fungus proved to cause the seedling blight, the rot of the roots, the root crown and the stem base of *Zinia elegans*. Saniewska [1998] also reports on considerable harmfulness of *S. sclerotiorum* towards this plant. The fungus can cause yellowing of the leaves, rot of the stem base and dying out of different ornamental plants, including *Eustoma* sp., *Cuphaea* sp., *Gazania regens* [Orlikowski 2001, Gulya et al. 2006, Holcomb 2006].

Elad [2000] as well as Pastucha and Patkowska [2005] report on the effectiveness of *T. hartzianum* and *T. viride* in limiting the development of *S. sclerotiorum,* while Ting Zhou and Reedler [1991] point to the antagonistic properties of *E. purpurascens* towards this pathogen. On the other hand, the latter species obtained from elegans zinnia seedlings was also considered as a dangerous pathogen to *Gypsophila paniculata* L. seedlings and the cause of leaf spot of wheat leaves in India [Goel and Glupta according to Ting Zhou and Reedler 1991, Bartyńska and Kochmańska 1998]. According to Pięta et al. [2004], such preparations as Biosept, Biochicol and Polywersum also inhibit the growth of the mycelium and other morphological elements of this pathogen.

The results presented here also point to the role of species *F. culmorum* in the seedling infection of *Z. elegans.* The harmfulness of this fungus for plants is bigger at a higher temperature [Kiecana et al. 2003, 2009]. In the studies by Łacicowa et al. [1979], *F. culmorum* in glasshouse conditions proved less pathogenic towards elegans zinnia seedlings as compared to *F. solani* and *F. oxysporum*. Although this species has

a wide range of host plants and its role as a root pathogen is well-known, its pathogenic effect on the root system of cereals is especially emphasized [Kiecana and Kocyłak 1999, Kiecana et al. 2009, Desjardins 2006]. Laboratory studies showed that seed dressing with the microbiological material of strains *Pseudomonas fluorescens* MKB 100 and *Pseudomonas* sp. MKB 158 and 249 reduces the seedling blight caused by *F. culmorum* [Khan et al. 2006].

In the Lublin area, *F. avenaceum* was also isolated from the infected plants of elegans zinnia. This fungus is a well-known pathogen to ornamental plants [Łacicowa et al. 1979, Łacicowa and Kiecana 1992, Kopacki and Wagner 2005, Kowalik and Wendzel 2005]. *F. avenaceum* proved to be considerably harmful to elegans zinnia seedlings in the conditions of a growth chamber experiment. On the other hand, *F. sporotrichioides* obtained from *Z. elegans* seedlings is a weak pathogen to different plants, including cereals [Kiecana and Kocyłak 1999, Machowicz-Stefaniak et al. 2002]. Frequent isolation of *B. cinerea* from necrotized roots and the bottom part of the leaves of diseased seedlings, from three different cultivation environments and from the growth chamber experiment make it possible to consider this fungus as the cause of the disease symptoms enumerated above.

*Botrytis cinerea* species was also recognized as the cause of the spot on the leaves and flowers and of zinnia stems dying out [Palacios et al. 1991, Saniewska 1998]. The cultivation of varieties that are resistant to the infection by *B. cinerea* is an important element in reducing the occurrence of the grey mould on cultivated plants [Kułek and Floryszak-Wieczorek 2005]. According to Orlikowski et al. [2001], the compounds in the grapefruit extract, which are active substances of Biosepct 33 SL, inhibit the sporulation of *B. cinerea* spores as well as limiting the growth of the germ tube.

*Alternaria alternata,* which is considered to be the pathogen of the leaf spot of *Zinnia elegans* and *Dendranthema grandiflora* , proved to be the species isolated from the analyzed locations [Łacicowa et al. 1979, Bartyńska 1998]. The pathogenic character of this fungus is connected with the formation of secondary metabolites which have the character of phytotoxins, for example tenausonic acid [Thomma 2003].

Different methods are used to determine the susceptibility of genotypes to pathogens and their choice depends on the amount of the tested plant material and the conditions in which the studies are conducted [Łacicowa et al. 1979, Mańka 1989, Kiecana et al. 2009].

The studies on the harmfulness of selected pathogens towards elegans zinnia seedlings, in the conditions of a growth chamber experiment, made use of an inoculum of 14-days' trial cultures of the analyzed strains of *Botrytis cinerea* no. 42, *F. avenaceum* no. 11, and *F. culmorum* no. 15, *F. equiseti* no. 3 growing on the glucose-potato medium like in the studies by Mańka [1989]. The choice of the inoculum in the form of a fungus culture grown on PDA medium was based on the results by Takegami and Sasaij according to Mańka [1989]. This is an easy way of obtaining big quantities of infection material. In the studied conditions, this method proved to be very effective because seedlings with the signs of pre- and post-emergence blight of the examined varieties of elegans zinnia occurred in all experimental combinations.

## CONCLUSIONS

The main cause of root infection at the seedling stage proved to be the species of *F. equiseti* and *Sclerotinia sclerotiorum*, commonly regarded as pathogens causing pre- and post-emergence blight of seedlings.

Results obtained from the growth chamber experiment confirmed considerable harmfulness of the species *B. cinera* and *F. equiseti* towards the seedlings of elegans zinnia, which can be reduced introducing less susceptible varieties to the cultivation. However, none of the studied cultivars of elegans zinnia, only its mixed material, showed such properties. Big harmfulness of the tested pathogens towards the cultivars of Golden Dawn, Lawa and Scarlet Flame suggests avoiding their cultivation in the conditions of the Lublin area.

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## GRZYBY PORAŻAJĄCE CYNIĘ WYTWORNĄ (*Zinnia elegans* Jacq.) Z UWZGLĘDNIENIEM PODATNOŚCI ODMIAN NA WYBRANE PATOGENY

**Streszczenie**. *Ziania elegans* polecana jest głównie do uprawy na kwiat cięty oraz na rabatach. Ta roślina ozdobna porażana jest przez: wirusy, bakterie, fitoplazmy i różne gatunki grzybów. Prezentowane badania przeprowadzono w 2006 r. w trzech lokalizacjach woj. lubelskiego: w okolicach Zamościa, w okolicach Krasnegostawu i w okolicach Opola Lubelskiego. Objęto nimi 3 odmiany cynii wytwornej (Golden Dawn, Lawa, Scarlet Flame) należące do grupy daliowatych oraz materiał mieszany odmian. Po 6 tygodniach od wysiewu przeprowadzono ocenę zdrowotności siewek. Udział siewek z objawami chorobowymi wahał się od 7 do 44%. Główną przyczyną porażenia korzeni w stadium siewki okazały się gatunki *F. equiseti* i *S. sclerotiorum.* Z chorych siewek w znacznych ilościach uzyskiwano także *B. cinerea* i *F. culmorum* oraz *A. alternata.* Badania podatności siewek analizowanych odmian i materiału mieszanego cynii wytwornej na porażenie przez *B. cinerea* oraz *F. avenaceum*, *F. culmorum* i *F. equiseti* przeprowadzono w fitotronie. Uzyskane wyniki potwierdziły szczególnie dużą szkodliwość dla siewek cynii wytwornej gatunków *B. cinera* i *F. equiseti*, którą można zmniejszyć wprowadzając do uprawy odmiany mniej podatne, jednak takiej właściwości nie wykazywała żadna z badanych odmian cynii wytwornej, jedynie materiał mieszany odmian.

**Słowa kluczowe**: zdrowotność, siewki, patogeniczność, *Fusarium* spp., *Botrytis cinerea, Sclerotinia sclerotiorum*

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