Nauka Przyroda Technologie

2011
Tom 5
Zeszyt 6

ISSN 1897-7820 http://www.npt.up-poznan.net
Dział: Ogrodnictwo

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EFFECT OF HYDROPRIMING ON GERMINATION AND LOCATION OF FUNGI IN *ZINNIA ELEGANS* JACQ. SEEDS

WPŁYW HYDROKONDYCJONOWANIA NA KIEŁKOWANIE I LOKALIZACJĘ GRZYBÓW W NASIONACH *ZINNIA ELEGANS* JACQ.

Summary. Seven samples of naturally infected zinnia (*Zinnia elegans* Jacq.) seeds (achene), unprimed and hydroprimed, were studied using germination test performed for disinfected and non-disinfected seeds. Location of inoculum in the seeds was determined by two histopathological methods: mycological analysis of non-disinfected and disinfected seeds and component plating. Priming improved significantly germination capacity at first and second count and decreased the percentage of diseased seedlings and dead seeds. After priming in both non-disinfected and disinfected seeds, increase of the number of seeds infested with *Fusarium* spp. was recorded. Moreover, total seed infestation increased after the treatment. Before priming fungi infested mainly outer layers of seeds, but inner infection, especially infection of embryo, was higher after priming.

Key words: fungi, location of inoculum, hydropriming, seed germination, zinnia seeds

Introduction

For many years seed priming (conditioning) has been used as a valuable tool in improving speed, synchrony and percentage of seed germination. The process permits partial seed hydration so that pregerminative metabolic activities proceed but germination is prevented (HEYDECKER and COOLBEAR 1977). Since seventies, several priming methods have been developed. They can be broadly divided into three groups, namely: hydro-, matry- and osmopriming (MCDONALD 2000). Hydration by seed moistening in specific amount of water followed by dehydration seems to be one of the simplest hydropriming techniques, commercially used as drum priming (WARREN and BENNETT

1997, WRIGHT et AL. 2003 a). However, presence of water and mixing of the seeds favour spreading the contamination in infested seed lots (TYLKOWSKA and VAN DEN BULK 2001). Increase in seed infestation with pathogenic and saprotrophic microorganisms after seed hydropriming has been reported by some authors. It was observed in primed seeds of carrot (*Daucus carota* L.), leek (*Allium porrum* L.), parsnip (*Pastinaca sativa* L.), and sugar beet (*Beta vulgaris* subsp. *vulgaris* convar. *crassa* Alef. var. *altissima* Döll) (TYLKOWSKA and VAN DEN BULK 2001, WRIGHT et AL. 2003 a, 2003 b, JENSEN et AL. 2004).

Zinnia (*Zinnia elegans* Jacq.) has been cultivated commonly worldwide for cut flowers and flowerbeds. According to many authors *Alternaria zinniae* is the most important fungal seed-borne pathogen of zinnia plants, causing spotting of petals, foliage and stems, and rotting of roots (DIMOCK and OSBORN 1943, RICHARDSON 1990, ŁACICOWA et AL. 1991, PALACIOS et AL. 1991, WU and YANG 1992). *Alternaria alternata*, *A. zinniae*, *Botrytis cinerea*, *Fusarium* spp. and *Penicillium* spp. have been frequently detected in zinnia seeds produced in Poland (ŁACICOWA et AL. 1991, BIELERZEWSKI 2006). ŁACICOWA et AL. (1979) reported that *A. zinniae*, *Fusarium culmorum*, *F. solani*, *F. oxysporum* and *Sclerotinia sclerotiorum* were in most cases responsible for severe damages of zinnia plants in the field.

Viability of pathogen in seeds depends on many factors such as host plant species, morphology of seed and stage of its development, type, amount and location of inoculum, presence of antagonistic microorganisms and storage conditions (AGARWAL and SINCLAIR 1987). Most of the seed-borne species may be transmitted on the surface of the seeds, e.g. *Alternaria alternata*, *Bipolaris sorokiniana, Fusarium avenaceum*, *F. culmorum*, *Stemphylium botryosum* and *S. consortiale* (NEERGAARD 1977). GAMBOGI et AL. (1976) found that superficial *A. zinniae* seed infection usually caused diseases on zinnia plants after emergence, however deeply seated infections may affect the true seed, leading to pre-emergence death of seedlings.

Location of inoculum in the seed may be determined by several methods, but comparison of percentage of non-disinfected and disinfected seeds and component plating have been applied most commonly as the most simple and efficient tests (MADEN et AL. 1975, MATHUR et AL. 1975, SINHA and KHARE 1977, RANGANATHAIAH and MATHUR 1978, SINGH 1983, SINGH et AL. 1993).

The experiments were conducted to study the influence of hydropriming on seed germination and location of pathogenic and saprotrophic fungi in zinnia seeds.

Materials and methods

Experiments were carried out on seven samples of zinnia seeds: 'Golden Dawn' (330196/289 – sample I), 'Jowita' (530/64/13135/149 – sample II), 'Kirke' (530/64/13135/139 – sample III), 'Orys' (430/64/3433/799 – sample IV), 'Red Man' (330/196/225 – sample V), 'Scarlet Flame' (530/64/13135/122 – sample VI), and 'Talia' (530/64/1315/129 – sample VII), obtained from Horticultural Seed and Nursery Company (CNOS-PNOS) in Poznań.

Hydropriming

Seeds were placed in 100 ml flasks and 200 µl of distilled water per 1 g of seeds was added. Then flasks were sealed with parafilm and an aluminium foil and incubated in darkness at 15°C for 24 h. Afterwards, the seeds were placed in semi-open Petri dishes and dried back at 20°C and 45% relative humidity for 24 h to equilibrium moisture content.

Seed germination

Seeds of each sample were hydroprimed, then both primed and unprimed seeds were surface sterilised with 1% aqueous solution of sodium hypochlorite (NaClO) for 10 min, followed by three rinses in sterile distilled water and drying with sterile blotting paper. Six replicates of 50 seeds from each treatment were placed in Petri dishes containing six layers of moistened blotters and incubated in the darkness, at 20°C. Percentage of normal seedlings (germination capacity at the first and final count) and diseased seedlings and dead seeds were determined after four and ten days according to the ISTA rules (INTERNATIONAL RULES... 2006).

Location of fungi in seeds

Two separate experiments were performed to determine the location of fungi in unprimed and primed zinnia seeds: mycological analysis of non-disinfected and disinfected seeds and component plating.

Mycological analysis of non-disinfected and disinfected seeds

Hydroprimed and unprimed seeds of each sample were disinfected with 1% aqueous solution of NaClO for 10 min, and then three times rinsed with sterile distilled water and dried with sterile blotting paper. 200 seeds (20 seeds per Petri dish) from each treatment were tested by the standard deep-freeze blotter method. The seeds were incubated for 24 h at 20°C in darkness, then transferred to –20°C for 20 h and subsequently incubated at 20°C under alternating cycles of 12 h NUV light and 12 h darkness for eight days. The fungi were identified on the basis of their growth and sporulation using stereomicroscope and a compound microscope (MACHADO et AL. 2002, MATHUR and KONGSDAL 2003). The same analysis was performed for non-disinfected seeds. Location of fungi was determined on the basis of differences in their incidence on disinfected and non-disinfected seeds.

Component plating

For disinfection osmoprimed and unprimed seeds of each sample were soaked with 1% aqueous solution of NaClO for 10 min, and then three times rinsed with sterile distilled water. From each sample 100 unprimed and 100 primed seeds were tested. Each seed was dissected aseptically under a stereomicroscope and all components, i.e: pericarp, integuments with endosperm and embryo were placed on potato dextrose agar medium (PDA, Scherlau Chemie, Spain) in 9 cm diameter Petri dish, two sectioned seeds per dish. Streptomycine at 100 ppm was added to the medium to prevent the de-

velopment of bacteria. Petri dishes were placed at 20°C under alternating cycles of 12 h NUV light and 12 h darkness for 10 days. The fungi grown around separate parts of seeds were identified on the basis of their growth and sporulation visible under a stereomicroscope and a compound microscope (MACHADO et AL. 2002, MATHUR and KONGSDAL 2003).

Statistical analysis

The results obtained were evaluated by analysis of variance followed by Duncan's multiple range test (KALA 2002).

Results

All the samples characterised very low germination capacity connected with severe seed infestation with fungi, expressed as a percentage of diseased seedlings and dead seeds. Seed priming accelerate speed of germination (germination capacity at first count) and positively affected germination capacity at final count, regardless of sodium hypochlorite treatment, even if the observed differences were not statistically significant. Percentage of diseased seedlings in non-disinfected samples I, VI and VII, and in disinfected samples I and III-VI, decreased significantly after priming. Decrease of the number of dead seeds was observed in hydroprimed, non-disinfected samples I-IV and VI, and in primed samples II, III and VI after disinfection (Table 1).

Table 1. Effects of priming and disinfection on zinnia seed germination (%)
Tabela 1. Wpływ kondycjonowania i odkażania na kiełkowanie nasion cynii (%)

Sample Próba	Non-disinfected seeds Nasiona nieodkażane		Disinfected seeds Nasiona odkażane	
	unprimed niekondycjonowane	primed kondycjonowane	unprimed niekondycjonowane	primed kondycjonowane
1	2	3	4	5
Germination capacity at first count – Energia kiełkowania				
I	6.0 a	20.7 b	7.3 a	32.3 b
II	19.3 a	25.3 a	15.7 a	33.3 b
III	8.3 a	9.3 a	1.3 a	18.0 b
IV	5.7 a	23.3 b	3.7 a	20.3 b
V	6.7 a	13.0 b	0.7 a	22.0 b
VI	13.3 a	27.3 b	5.3 a	38.3 b
VII	7.7 a	25.7 b	6.7 a	26.7 b

Table 1 – cont. / Tabela 1 – cd.

1	2	3	4	5
Germination capacity at final count – Zdolność kiełkowania				
I	8.0 a	33.3 b	23.7 a	37.0 b
II	27.3 a	41.7 b	20.0 a	37.0 b
III	17.0 a	26.3 b	9.0 a	34.0 b
IV	9.0 a	30.7 b	11.7 a	25.3 b
V	30.7 a	45.7 b	25.7 a	41.3 b
VI	14.0 a	38.7 b	11.7 a	44.3 b
VII	19.7 a	37.7 b	16.3 a	32.0 b
Diseased seedlings – Siewki chore				
I	67.3 b	54.3 a	69.0 b	50.0 a
II	49.3 a	46.3 a	67.0 a	59.3 a
III	54.0 a	59.3 a	73.0 b	52.0 a
IV	61.3 a	60.3 a	79.0 b	63.7 a
V	47.3 a	41.3 a	59.7 b	35.7 a
VI	68.0 b	52.0 a	76.7 b	47.3 a
VII	69.3 b	41.0 a	66.7 a	56.3 a
Dead seeds – Nasiona martwe				
I	16.3 b	4.0 a	3.7 a	5.3 a
II	15.7 b	3.3 a	10.3 b	1.7 a
III	17.3 b	5.0 a	14.0 b	2.3 a
IV	17.7 b	2.0 a	5.3 a	3.0 a
V	2.7 a	2.7 a	0.7 a	2.3 a
VI	18.0 b	3.7 a	6.0 b	1.0 a
VII	9.0 a	9.0 a	11.3 a	6.7 a

Means in the same row, separately for non-disinfected and disinfected seeds, followed by the same letter are not significantly different at $\alpha = 0.05$ level according to Duncan's test.

Średnie w tych samych rzędach, oddzielnie dla nasion nieodkażanych i odkażanych, oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$ według testu Duncana.

The following fungi were identified in tested seeds: *Acremoniella atra* (Corda) Sacc., *Acremonium strictum* W. Gams, *Alternaria alternata* (Fr.) Keissler, *A. zinniae* M.B. Ellis, *Aspergillus niger* van Tieghem, *Botrytis cinerea* Pers. ex Pers., *Cladosporium* spp., *Colletotrichum* spp., *Epicoccum purpurascens* Ehrenb. ex Schlecht., *Fusarium* spp., *Gonatobotrys simplex* Corda, *Mucor* sp., *Papulaspora* sp., *Penicillium* spp., *Rhizopus nigricans* Ehrenberg, *Trichothecium roseum* (Pers.) Link ex S.F. Gray and *Ulocladium* spp. Among them *A. alternata*, *A. zinniae*, and *Fusarium* spp. were occurring the most frequently.

In non-disinfected seeds percentage of seeds infested with *A. alternata*, *A. zinniae* and *Botrytis cinerea* was usually not statistically different before and after priming (Table 2). Moreover, percentage of seeds infested with *A. alternata* and *A. zinniae* decreased significantly in sample V and in samples I, V and VII, respectively. However, percentage of seeds infested with *Fusarium* spp. increased in five out of seven tested samples, and increase of seed infection with *B. cinerea* was observed in sample VII.

Table 2. Effects of priming and disinfection on the infestation of zinnia seeds with fungi (%)
Tabela 2. Wpływ kondycjonowania i odkażania na zasiedlenie nasion cynii przez grzyby (%)

Sample Próba	Non-disinfected seeds Nasiona nieodkażane		Disinfected seeds Nasiona odkażane	
	unprimed niekondycjonowane	primed kondycjonowane	unprimed niekondycjonowane	primed kondycjonowane
1	2	3	4	5
Alternaria alternata				
I	60.0 a	60.0 a	35.0 a	50.0 b
II	62.0 a	74.0 a	53.0 a	70.0 b
III	86.0 a	78.0 a	23.0 a	46.0 b
IV	62.0 a	70.0 a	51.0 b	38.0 a
V	83.0 b	67.0 a	56.0 a	56.0 a
VI	64.0 a	73.0 a	57.0 a	58.0 a
VII	70.0 a	70.0 a	66.0 a	58.0 a
Alternaria zinniae				
I	76.0 b	67.0 a	50.0 a	44.0 a
II	56.0 a	38.0 a	35.0 a	26.0 a
III	57.0 a	52.0 a	–	–
IV	72.0 a	64.0 a	51.0 a	54.0 a
V	17.0 b	0 a	–	–
VI	51.0 a	57.0 a	42.0 a	50.0 a
VII	20.0 b	7.0 a	8.0 b	3.0 a
Botrytis cinerea				
I	–	–	–	–
II	5.0 a	4.0 a	16.0 a	21.0 a
III	1.0 a	1.0 a	1.0 a	2.0 a
IV	1.0 a	1.0 a	–	–
V	–	–	2.0 a	0 a
VI	–	–	–	–
VII	1.0 a	20.0 b	7.0 a	16.0 b

Table 2 – cont. / Tabela 2 – cd.

1	2	3	4	5
		Fusarium spp.		
I	80.0 a	77.0 a	71.0 a	65.0 a
II	53.0 a	86.0 b	51.0 a	74.0 b
III	81.0 a	67.0 a	53.0 a	45.0 a
IV	74.0 a	99.0 b	60.0 a	87.0 b
V	70.0 a	86.0 b	60.0 a	77.0 b
VI	79.0 a	98.0 b	54.0 a	63.0 a
VII	70.0 a	96.0 b	54.0 a	66.0 a

Means in the same row, separately for non-disinfected and disinfected seeds, followed by the same letter are not significantly different at $\alpha = 0.05$ level according to Duncan's test.

"–" – not-detected.

Średnie w tych samych rzędach, oddzielnie dla nasion nieodkażanych i odkażanych, oznaczone tą samą literą nie różnią się istotnie na poziomie $\alpha = 0,05$ według testu Duncana.

„–" – nie znaleziono.

Generally, surface disinfection caused decrease in seed infestation. The treatment with sodium hypochlorite removed completely *A. zinniae* from seeds of samples III and V, and *B. cinerea* from seeds of sample IV. At the same time negative effect of priming on seed health was detected in some cases. Statistically significant increase of seed infestation with *A. alternata* was noted in samples I-III, with *B. cinerea* in sample VII, and with *Fusarium* spp. in samples II, IV and V.

After analysis of fungal colonies growing around particular parts of unprimed seeds, both pathogenic and saprotrophic fungi were detected in higher percentage in outer layers of the seeds, mainly in pericarp, integument and endosperm (Table 3). After priming increase of embryo infestation with all the fungi was observed. In outer layers this relationship was found for *A. zinniae* and *Fusarium* spp. in all tested samples, for *A. alternata* in sample III, V and VII, and for *B. cinerea* in sample III and VII.

After hydropriming increase of a total infestation of seeds with fungi was recorded for six out of seven tested samples, ranging from 69.0-94.0% before the treatment to 94.0-100.0% after priming (Table 4).

Discussion

Hydropriming is one of the methods of physiological seed treatments that improve or enhance seed performance (KHAN 1992). The results of the experiment showed that priming improved speed of germination and germination capacity at final count, and decreased the number of diseased seedlings and dead seeds, both in non-disinfected and disinfected lots. Nevertheless, regardless of treatment, high percentage of diseased seedlings and dead seeds showed severe infestation of zinnia seeds with saprotrophic and

Table 3. Presence of fungi in different seed parts before and after priming (%)
Tabela 3. Obecność grzybów w poszczególnych częściach nasion przed kondycjonowaniem i po nim (%)

Sample Próba	Unprimed seeds Nasiona niekondycjonowane			Primed seeds Nasiona kondycjonowane		
	pericarp owocnia	integument + endosperm osłonka + bielmo	embryo zarodek	pericarp owocnia	integument + endosperm osłonka + bielmo	embryo zarodek
1	2	3	4	5	6	7
Alternaria alternata						
I	26.0	26.0	5.0	18.0	23.0	6.0
II	16.0	14.0	3.0	8.0	6.0	7.0
III	8.0	8.0	0	26.0	13.0	8.0
IV	36.0	40.0	8.0	26.0	26.0	12.0
V	4.0	4.0	2.0	24.0	31.0	4.0
VI	32.0	22.0	10.0	28.0	31.0	17.0
VII	38.0	41.0	13.0	34.0	30.0	17.0
Alternaria zinniae						
I	36.0	34.0	16.0	40.0	39.0	14.0
II	17.0	28.0	1.0	26.0	15.0	12.0
III	16.0	13.0	4.0	30.0	22.0	16.0
IV	34.0	24.0	7.0	42.0	38.0	32.0
V	2.0	2.0	0	7.0	7.0	0
VI	26.0	27.0	18.0	24.0	29.0	21.0
VII	4.0	6.0	1.0	13.0	8.0	8.0
Botrytis cinerea						
I	–	–	–	–	–	–
II	8.0	1.0	2.0	8.0	6.0	6.0
III	2.0	1.0	3.0	5.0	5.0	5.0
IV	1.0	0	0	0	2.0	3.0
V	–	–	–	–	–	–
VI	1.0	0	0	1.0	1.0	0
VII	0	1.0	1.0	4.0	5.0	4.0
Fusarium spp.						
I	48.0	53.0	18.0	72.0	65.0	26.0
II	68.0	62.0	56.0	86.0	87.0	72.0
III	58.0	40.0	19.0	42.0	50.0	35.0

Table 3 – cont. / Tabela 3 – cd.

1	2	3	4	5	6	7
IV	78.0	84.0	54.0	86.0	98.0	66.0
V	62.0	54.0	19.0	65.0	66.0	44.0
VI	69.0	61.0	29.0	78.0	75.0	85.0
VII	63.0	62.0	26.0	69.0	63.0	59.0

"–" – not-detected.
„–" – nie znaleziono.

Table 4. Total number of seeds infested with fungi before and after priming (%)
Tabela 4. Ogólna liczba nasion zasiedlonych przez grzyby przed kondycjonowaniem i po nim (%)

Sample Próba	Unprimed seeds Nasiona niekondycjonowane	Primed seeds Nasiona kondycjonowane
I	93.0	100.0
II	94.0	100.0
III	89.0	94.0
IV	69.0	90,0
V	93.0	98.0
VI	100.0	99.0
VII	92.0	100.0

pathogenic organisms. Generally disinfection had a minor influence on the seed health. This probably resulted from considerable primary inner seed infestation with fungi. In all tested lots *Alternaria alternata*, *A. zinniae*, *Botrytis cinerea* and *Fusarium* spp. were frequently detected on and in the seeds. This observation confirmed ŁACICOWA et AL. (1991) and BIELERZEWSKI (2006), who obtained similar results for zinnia seeds produced in Poland.

Several authors reported increased seed infestation with fungi after hydropriming (TYLKOWSKA and VAN DEN BULK 2001, WRIGHT et AL. 2003 a, 2003 b, JENSEN et AL. 2004). In the study, priming affected total seed infestation. The inner layers of seeds were also infested to a higher degree after the treatment. Increase of the numbers of pathogenic and saprotrophic fungi were observed specially in the embryos. Large mobilization of storage reserves occurs during priming that provides substrates which are readily utilized for rapid and uniform germination. Osmopriming increased the amylase activity in pea, tomato, and spinach, and peroxidase activity in tomato and spinach seeds (KHAN 1992). HABDAS et AL. (1997) observed hydrolysis of storage proteins in endosperm and embryo of matriprimed carrot and onion seeds. Moreover, the priming affected health of these seeds. Fungal pathogens were found on seed coat, in endosperm and embryo, causing necrotic condensation of cytoplasm and disintegration of nucleus

chromatin in both species. Because the amount of water absorbed by the seed is precisely controlled during hydropriming, the physiological mechanism that results in greater seed performance is considered the same as that for osmopriming and matripriming (MCDONALD 2000). The zinnia seeds are typically exalbuminous (nonendospermic), and the most of metabolic activity take place just in the embryo itself. Breakdown of seed reserves and the production of simple compounds as a result of enzymes activity may be a cause of expansive growth of fungi inside the seed tissues. SZOPIŃSKA and TYLKOWSKA (2003) observed this phenomenon in osmoprimed lettuce seed. The authors reported that *A. alternata*, *B. cinerea* and *Cladosporium* spp. showed tendency to grow inside seed after priming. Similar results were obtained for carrot seeds. TYLKOWSKA and VAN DEN BULK (2001) found that after hydro- and osmopriming inner infection of the seeds with *Alternaria* spp. increased. Several authors reported that this location is not typical of necrotrophic fungi such as *Alternaria* spp. and *B. cinerea*. These organisms were generally found in seeds coat tissues, while the embryos remained unaffected (MATHUR et AL. 1975, NEERGAARD 1977, MAUDE 1996). GAMBOGI et AL. (1976) hinted that deeply seated infection of zinnia seeds with *A. zinniae* may affect the true seed, leading to pre-emergence death of seedlings. Moreover, the information about severe zinnia seed infestation with *Fusarium* spp. seems to be very disturbing. The role of seeds in transmission of these fungi is still unclear and in connection with their pathogenicity should be necessarily investigated. TYLKOWSKA and VAN DEN BULK (2001) suggested avoiding priming of significantly infested seeds. Therefore, fungal contamination levels must be considered in the selection of seed lot for priming. The other possibility is treating seeds against pathogenic fungi to eliminate seed infection. It is the question of further experiments if additional physical, chemical or biological treatment may be or not combined with zinnia seed hydropriming.

Conclusions

1. Hydropriming improved speed and germination capacity of zinnia seeds and decreased the number of diseased seedlings and dead seeds.

2. Total seed infestation with fungi increased after priming.

3. All examined fungi, i.e.: *Alternaria alternata*, *A. zinniae*, *Botrytis cinerea* and *Fusarium* spp. showed tendency to penetrate inner seed tissues during hydration, and were more often presented in the embryos of zinnia seeds after the treatment than before.

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WPŁYW HYDROKONDYCJONOWANIA NA KIEŁKOWANIE I LOKALIZACJĘ GRZYBÓW W NASIONACH *ZINNIA ELEGANS* JACQ.

Streszczenie. Hydrokondycjonowanie, polegające na nawilżeniu nasion określoną ilością wody, należy do najczęściej stosowanych metod kondycjonowania nasion. Nasiona (niełupki) siedmiu prób cynii (*Zinnia elegans* Jacq.) umieszczano w 100-mililitrowych kolbkach i nawilżano 200 µl wody sterylnej na 1 g nasion. Kolbki zabezpieczano parafilmem i folią aluminiową, a następnie przetrzymywano 24 h w ciemności, w temperaturze 15°C. Po kondycjonowaniu nasiona suszono przez 24 h w temperaturze 20°C, przy wilgotności względnej powietrza 45%. Określano kiełkowanie nasion zarówno kondycjonowanych, jak i niekondycjonowanych. Testy wykonano na nasionach odkażanych w 1-procentowym wodnym roztworze podchlorynu sodowego i na nasionach nieodkażanych. Lokalizację inokulum w nasionach określano za pomocą dwóch metod histopatologicznych: analizy mikologicznej nasion nieodkażanych i odkażanych oraz analizy grzybów wyrosłych na poszczególnych częściach nasion wyszczepionych na pożywkę dekstrozowo-ziemniaczaną (PDA). Kondycjonowanie poprawiało istotnie energię i zdolność kiełkowania nasion i zmniejszało liczbę siewek chorych oraz nasion martwych zarówno u prób nieodkażanych, jak i odkażanych. Po kondycjonowaniu obserwowano istotny wzrost porażenia nasion przez grzyby rodzaju *Fusarium*. Również ogólne zasiedlenie nasion przez grzyby zwiększało się po kondycjonowaniu, zarówno u nasion nieodkażanych, jak i odkażanych. Bez względu na traktowanie grzyby głównie zasiedlały zewnętrzne warstwy nasion, tj. owocnię, osłonkę i bielmo, ale infekcja zarodka była większa po kondycjonowaniu.

Słowa kluczowe: grzyby, lokalizacja inokulum, hydrokondycjonowanie, kiełkowanie nasion, nasiona cynii

Szopińska D., Wojtaszek A., 2011. Effect of hydropriming on germination and location of fungi in *Zinnia elegans* Jacq. seeds. Nauka Przyr. Technol. 5, 6, #117.

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Accepted for print – Zaakceptowano do druku:
25.05.2011

For citation – Do cytowania:
Szopińska D., Wojtaszek A., 2011. Effect of hydropriming on germination and location of fungi in Zinnia elegans *Jacq. seeds. Nauka Przyr. Technol. 5, 6, #117.*