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Distribution Frequency and Incidence of Seed-borne Pathogens of Some Cereals and Industrial Crops in Serbia

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SUMMARY

A total of 41 species of fungi were isolated from seed samples of barley, maize, soybean, and sunflower collected at different locations in Serbia. The majority of detected species occurred on barley (35 of 41 species or 87.8%) comparing to soybean (17 of 41 species or 41.5%), sunflower (16 of 41 species or 39.0%) and maize (15 of 41 species or 36.9%). Species belonging to genera *Alternaria, Chaetomium, Epicoccum, Fusarium, Penicillium* and *Rhizopus* were present on seeds of all four plant species. *Alternaria* species were dominant on soybean, barley and sunflower seeds (85.7%, 84.7% and 76.9%). *F. verticillioides* and *Penicillium* spp. were mainly isolated from maize seeds (100 and 92.3% respectively), while other species were isolated up to 38.5% (*Chaetomium* spp. and *Rhizopus* spp.). *F. graminearum, F. proliferatum, F. poae* and *F. sporotrichioides* were the most common *Fusarium* species isolated from barley (51.1-93.3%), while on the soybean seeds *F. oxysporum* (71.4%), *F. semitectum* (57.1%) and *F. sporotrichioides* (57.1%) were prevalent. Frequency of *Fusarium* species on sunflower seeds varied from 7% (*F. equiseti, F. graminearum, F. proliferatum* and *F. subglutinans*) to 15.4% (*F. verticillioides*). Statistically significant negative correlation (r = −0.678*) was determined for the incidence of *F. graminearum* and *Alternaria* spp., as well as, *Fusarium* spp. and *Alternaria* spp. (r = −0.614*), on barley seeds. The obtained results revealed that seed-borne pathogens were present in most seed samples of important cereals and industrial crops grown under different agroecological conditions in Serbia. Some of the identified fungi are potential producers of mycotoxins, thus their presence is important in terms of reduced food safety for humans and animals. Therefore, an early and accurate diagnosis and pathogen surveillance will provide time for the development and the application of disease strategies.

Keywords: Fungy; Seed; Cereals; Sunflower; Soybeans; Frequency; Incidence

INTRODUCTION

Seed-borne pathogens have significant influence on seed production and food industry because they: (i) can affect germination, growth and crop productivity (Bhattacharya and Raha, 2002; Medić-Pap et al., 2007; Singh et al., 2011); (ii) cause seed and seedling diseases resulting in the development of systemic or local infections (McGee, 1998; Logrieco et al., 2003; Somda et al., 2008; Singh et al., 2011); (iii) cause biochemical changes, such as the reduction of carbohydrate, protein and total oil content or the increase of moisture and free fatty acid content as well as some other biochemical changes (Bhattacharya and Raha, 2002; Kakde and Chavan, 2011); and (iv) cause contamination of grains with mycotoxins that represent a health risk to humans and animals (Marasas et al., 1984; El-Margaghy and El-Maghraby, 1986; Logrieco et al., 2003; Magan and Olsen, 2004; Barros et al., 2011). Damages such as seed death, seedling and plant abnormalities or decreased seed vigour caused by seed-borne pathogens are not always recognised by users (Mukhtar, 2009).

According to their occurrence and geographic distribution, species belonging to genera *Alternaria* and *Fusarium* are the most common on barley and other small grains (Kosiak et al., 2004). The species predominantly found associated with head blight of wheat and other small-grain cereals in the Mediterranean region are *F. graminearum* Schw., *F. culmorum* (W.G. Smith) Sacc., and *F. avenaceum* (Fr.) Sacc. (Logrieco et al., 2003). On the other hand, *F. poae* (Peck) Wollen., *F. equiseti* (Corda) Sacc., *F. sporotrichioides* Sherb., and *F. tricinctum* (Corda) Sacc are less frequently isolated. Other species encountered sporadically include *F. acuminatum* (Ell.) Everh., *F. subglutinans* (Wollen. & Reink.) Nelson, Toussoun & Marasas, *F. solani* (Mart.) App. & Wollen., *F. oxysporum* Schlecht., *F. semitectum* Berk. & Rav., *F. verticillioides* (Sacc.) Nirenberg, and *F. proliferatum* (Mats.) Nirenberg.

Studies on the mycobiota associated with sunflower seeds and their significance have been conducted by researchers in Pakistan (Dawar and Ghaffar, 1990; Mukhtar, 2009). *Alternaria tenuissima* (Kunze ex Leman) Wilts, *Aspergillus flavus* Link, *A. niger* (Fr.) P. Karst, *F. verticilllioides*, *F. semitectum*, *Trichoderma* spp. and *Nigrospora oryzae* (Berk. & Br.) Petch. were detected on various seed parts (Dawar and Ghaffar, 1990) while *Rhizoctonia solani* Kühn, *F. solani* and *Macrophomina phaseolina* (Tessi) Goid. Hollidey were isolated from seed axis. A reduced number of fungal species on surface sterilised seeds suggested that most of the fungi were located on pericarp.

Roy et al. (2000) presented a review of the fungi associated with soybean seeds, pods or flowers in North America. With regard to number of taxa from separate mycobiota, 63 genera and about 108 species occur in seeds, 65 genera and about 88 or more species occur in pods, and 36 genera and approximately 47 or more species occur in flowers. Most of the fungi which occur in flowers and the majority of those occurring on seeds could be cultured from pods.

Many studies have been carried out in Serbia on mycobiota of maize grain, but little has been done on barley, sunflower and soybean grain. One hundred fungal species, classified in 38 genera were identified on maize grain on the territory of the former Yugoslavia, including Serbia (Penčić and Lević, 1994). The numerous species belong to genus *Fusarium* (22), *Penicillium* (16) and *Aspergillus* (12). The most common damages are caused by the species from genus *Fusarium*, and by *N. oryzae* and *Bipolaris zeicola* Shoem.

The objective of present study was to determine the composition of seed-borne mycobiota occurring on maize, barley, sunflower and soybean. In Serbia these four crops are dominant both in terms of areal dispersion and production. Seed testing for the presence of seed-borne pathogens is an important step in crop disease management. Early and accurate diagnoses and pathogen surveillance will provide time for the development and the application of disease strategies.

MATERIAL AND METHODS

Seed samples of maize, barley, sunflower and soybean were collected in 2008 under different environmental conditions in Serbia. A standard method for fungal isolation and identification was applied. Briefly, a hundred seeds of each sample were rinsed for one hour in running water, then surface-sterilised in 1% sodium hypochlorite, rinsed three times with distilled water and then dried between two layers of soft paper. This way, all impurities that fungi could have encompassed were cleaned from seeds, and also getting incorrect information on seed infection was prevented. Depending on a seed size, five (maize, sunflower and soybean) or eight (barley) seeds were placed in each Petri dish (∅ 100 mm) on PDA and incubated for seven days under laboratory conditions, at 25°C and usual day/night regime. Seeds were then examined for a fungal growth under a stereomicroscope. In order to reliably identify individual species of fungi, the fragments of colonies developed on seeds were transferred to carnation leaf agar (CLA) and synthetic nutrition agar (SNA) and incubated at 12h day/night regime, using combined fluorescent and near ultraviolet light during the daily period. The CLA and SNA media were prepared according to Burgess et al. (1994) and Nirenberg (1976), respectively.

The frequency and the incidence of seed-borne fungi were analysed on 13, 45, 13 and 7 samples of maize, barley, sunflower and soybean seeds, respectively. The frequency (F) and the incidence (I) of certain fungi were estimated according to Lević et al. (2011): F (%) = (number of seed samples in which a species occurred/total number of seed samples) x 100; I (%) = (number of seeds in which a species occurred/total number of seeds) x 100. The frequency distribution and incidence of fungal species on seed samples were classified as 0 to ≤ 20 (low), >21 to ≤ 50 (moderate) and over 50% (high).

The correlation coefficient between the incidence of *F. graminearum* and *Alternaria* spp., as well as, between *Fusarium* spp. and *Alternaria* spp. on seed samples of barley was calculated using Pearson Product-Moment Correlation in Microsoft Office Excel 2007.

RESULTS

Seed-borne pathogens detected on maize

Results on the frequency and the incidence of each fungal species are presented separately for cereals (Table 1) and industrial crops (Table 2). Out of 15 identified fungal species on maize seeds (Table 1), only *F. verticillioides* and *Penicillium* spp. had high frequency (100.0% and 92.3%, respectively) and high incidence (up to 92.0% and 57.0%, respectively). *Aspergillus* spp., *F. graminearum*, *F. subglutinans*, *N. oryzae*, *Acremonium strictum* W. Gams, *Alternaria* spp., *Chaetomium* spp. and *Rhizopus* spp. had moderate frequency (23.1-38.5%) and low incidence (up to 16.0%).

Table 1. Frequency (F) and incidence (I) of fungi on maize and barely grain in Serbia in 2008

No.	Species	Maize		Barley	
		F (%)	I (%)	F (%)	I (%)[a]
1.	*Acremonium* spp.	0.0	0.0	42.2	1.0-9.6
2.	*Acremonium strictum*	23.1	2.0-15.0	0.0	0.0
3.	*Alternaria* spp.	23.1	2.0-14.0	84.4	25.0-99.0
4.	*Aremoniella atra*	0.0	0.0	22.2	1.0-4.8
5.	*Aspergillus niger*	15.4	4.0-16.0	8.9	1.0-2.9
6.	*Aspergillus* spp.	23.1	4.0-8.0	13.3	1.0*
7.	*Bipolaris sorokiniana*	0.0	0.0	8.9	1.0-3.8
8.	*Bipolaris spicifera*	0.0	0.0	15.6	1.0-1.9
9.	*Chetomium* spp.	38.5	1.0-4.0	6.7	1.0*
10.	*Curvularia prasadii*	0.0	0.0	2.2	1.0*
11.	*Curvularia* spp.	0.0	0.0	2.2	1.0*
12.	*Drechslera* spp.	0.0	0.0	8.9	1.0-1.9
13.	*Epicoccum* spp.	7.7	1.0*	40.0	1.0-8.7
14.	*Fusarium acuminatum*	0.0	0.0	4.4	1.0-1.9
15.	*Fusarium arthrosporioides*	0.0	0.0	6.7	1.0-1.9
16.	*Fusarium avenaceum*	0.0	0.0	11.1	1.0-1.9
17.	*Fusarium equiseti*	0.0	0.0	37.7	1.0-8.7
18.	*Fusarium graminearum*	23.1	5.0-7.0	93.3	1.9-82.7
19.	*Fusarium langsethiae*	0.0	0.0	4.4	1.0*
20.	*Fusarium oxysporum*	15.4	1.0*	13.3	1.0-12.5
21.	*Fusarium poae*	0.0	0.0	51.1	1.0-3.8
22.	*Fusarium polyphialidicum*	0.0	0.0	2.2	1.0-1.0
23.	*Fusarium proliferatum*	7.7	2.0*	55.6	1.0-11.5
24.	*Fusarium semitectum*	0.0	0.0	28.9	1.0-2.9
25.	*Fusarium sporotrichioides*	0.0	0.0	51.1	1.0-6.7
26.	*Fusarium* spp.	0.0	0.0	24.4	1.0-2.0
27.	*Fusarium subglutinans*	23.1	4.0-7.0	20.0	1.0-1.9
28.	*Fusarium tricinctum*	0.0	0.0	2.2	1.0*
29.	Fusarium verticillioides	100.0	10.0-92.0	28.9	1.0-1.9
30.	*Microdochium nivale*	0.0	0.0	2.2	1.0*
31.	*Nigrospora oryzae*	23.1	1.0-3.0	6.7	1.0*
32.	*Penicillium* spp.	92.3	4.0-57.0	17.8	1.0-5.8
33.	*Periconia* spp.	0.0	0.0	2.2	1.0*
34.	*Phoma* spp.	0.0	0.0	2.2	1.0*
35.	*Rhizopus* spp.	38.5	1.8-20.0	11.1	1.0-11.5
36.	*Trichoderma* spp.	15.4	1.8-8.9	0.0	0.0
37.	*Ulocladium* spp.	0.0	0.0	4.4	1.0*

[a] Minimum and maximum values of positive samples
* There is no difference between the minimum and the maximum values of positive samples

Seed-borne pathogens detected on barley

The highest number of fungi species was identified on barley seeds (Table 1). Out of 41 isolated fungi from all four crops, 31 species were isolated from barley seeds, out of which 16 belong to genus *Fusarium*. Out of 19 fungal species that do not belong to genus *Fusarium*, only species from genus *Alternaria* were noticed in high frequency (up to 84.4%) and with high incidence (up to 99.0%), while species from genera *Acremonium* and *Epicoccum* were moderately frequent (42.2% and 40.0%, respectively) with low incidence (up to 4.8% and 8.7%, respectively). *F. graminearum* was the only important species from genus *Fusarium*, with both, high frequency (93.3%) and incidence (up to 82.7%). *F. poae* and *F. sporotrichioides* had high frequency (51.1%), but low incidence (up to 3.8 and 6.7%, respectively), while *F. equiseti* and *F. semitectum* were moderately frequent (33.7 and 28.9%, respectively) with low incidence (up to 8.7 and 2.9%, respectively). *F. langsethia* was isolated from barley for the first time in Serbia.

Statistically significant negative correlation ($r = -0.678^*$) was determined between the incidence of *F. graminearum* and *Alternaria* spp., as well as, between *Fusarium* species and *Alternaria* spp. ($r = -0.614^*$), on barley seeds.

Seed-borne pathogens detected on sunflower

Species belonging to genus *Alternaria*, followed by *Cladosporium* spp. developed most frequently on sunflower seeds (76.9 and 53.8%, respectively) and with high (52.9%) to moderate incidence (25.0%), respectively (Table 2). The frequency of *Epicoccum* spp. and *Rhizopus* spp. was high (53.8%) and moderate (25.0%), while the incidence was ranging from low (up to 12.5%) to moderate (25.0%), respectively. *Penicillium* spp. and *N. oryzae* were moderately frequent (38.5 and 30.8%, respectively) with low incidence (11.2 and 12.5%, respectively). Nonetheless, *F. graminearum* (7.7%) and *F. verticillioides* (15.4%) had low frequency with moderate incidence (33.3 and 46.0%, respectively).

Table 2. Frequency (F) and incidence (I) of fungi on sunflower and soybean grain in Serbia in 2008

No.	Species	Sunflower		Soybean	
		F (%)	I (%)[a]	F (%)	I (%)[a]
1.	*Alternaria* spp.	76.9	4.2-52.9	85.7	14.0-50.0
2.	*Aspergillus niger*	7.7	1.4*	0.0	0.0
3.	*Aspergillus* spp.	7.7	4.8*	0.0	0.0
4.	*Chetomium* spp.	15.4	4.2*	14.3	0.6*
5.	*Cladosporium* spp.	53.8	8.3-25.0	0.0	0.0
6.	*Epicoccum* spp.	53.8	0.5-12.5	28.8	0.6*
7.	*Fusarium arthrosporioides*	0.0	0.0	14.3	1.0*
8.	*Fusarium equiseti*	7.7	4.2*	42.9	0.6-1.0
9.	*Fusarium graminearum*	7.7	33.3*	57.1	1.0-3.8
10.	*Fusarium oxysporum*	0.0	0.0	71.4	0.6-2.5
11.	*Fusarium proliferatum*	7.7	8.2*	42.9	0.6-2.9
12.	*Fusarium sambucinum*	0.0	0.0	14.3	1.0*
13.	*Fusarium semitectum*	0.0	0.0	57.1	3.1-21.5
14.	*Fusarium solani*	0.0	0.0	14.3	1.0*
15.	*Fusarium sporotrichioides*	0.0	0.0	57.1	1.9-7.5
16.	*Fusarium* spp.	7.7	2.4*	71.4	3.1-19.4
17.	*Fusarium subglutinans*	7.7	0.5*	14.3	1.9*
18.	*Fusarium verticillioides*	15.4	6.3-46.0	0.0	0.0
19.	*Macrophomina phaseolina*	0.0	0.0	14.3	1.0*
20.	*Nigrospora oryzae*	30.8	0.5-12.5	0.0	0.0
21.	*Penicillium* spp.	38.5	3.8-11.2	28.8	1.3*
22.	*Rhizopus* spp.	38.5	3.8-25.0	42.9	5.0-6.3*
23.	*Sordaria* spp.	7.7	0.5*	0.0	0.0

[a] Minimum and maximum values of positive samples

* There is no difference between the minimum and the maximum values of positive samples

Seed-borne pathogens detected on soybean

Alternaria species and *F. semitectum* were the most frequent species (85.7 and 57.1%, respectively), with high (up to 50.0) and moderate incidence (21.5%) on soybean seeds, respectively (Table 2). Three species (*F. oxysporum*, *F. graminearum* and *F. sporotrichioides*) had high frequency (71.4, 57.1 and 57.1%, respectively), but their incidence was low (2.5, 3.8 and 7.5%, respectively). Other three species (*F. equiseti*, *F. proliferatum* and *Rhizopus* spp.) had moderate frequency (42.9%) and low incidence (up to 6.3%). The frequency for both *Epicoccum* spp. and *Penicillium* spp. was moderate (28.8%), while the incidence was low (0.6% and 1.3%, respectively).

DISCUSSION

The data on dominant fungal species on maize grains in Serbia are similar to those previously described worldwide (Abdel-Mallek et al., 1993; Mubatanhema et al., 1999; Hussein et al., 2002; Pacin et al., 2002; Logrieco et al., 2003; Somda et al., 2008; Ramos et al., 2010). However, when comparing the data on the incidence of mycobiota on maize seeds obtained and presented in this study with previously published results by Lević et al. (1997) it can be deduced that the incidence of *F. graminearum*, *F. oxysporum, F. subglutinans* and *F. verticillioides* has changed over last 15 years. These changes are especially pronounced in reduced incidence of *F. subglutinans* and increased incidence of *F. verticillioides*. Furthermore, changes have also occurred in the mycopopulation of *Alternaria* species because the frequency of these species on maize grains was reduced by two-thirds during two centuries (Lević et al., 1993).

Microdochium nivale (Fr.) Samuels has rarely been detected on barley seed (2.2% of positive samples) as previously established in Norway (3.8% of positive samples). The technique of a separate isolation of *Fusarium* species and *M. nivale* adopted by Ioos et al. (2004) has proved to be efficient and very satisfactory (23.1-44.1%). According to these authors *M. nivale* develops on agar at low temperatures (4±1°C) for 6 days even in the presence of faster growing *Fusarium* species. A further 10 days incubation at 22±2 °C with a 12 h light period enabled *M. nivale* to sporulate and it could be easily identified by morphological characteristics.

The results gained by Kosiak et al. (2004) indicate a negative interaction between *F. graminearum* and *Alternaria* spp., as well as, between *F. graminearum* and other *Fusarium* spp. Similar results we obtained for these pathogens on barley grains. According to obtained results, regarding statistically negative correlation between frequency of *F. graminearum/Fusarium* spp. and *Alternaria* spp., a question can be asked: is a higher frequency of *Alternaria* spp. on barley seeds a result of barley selection for FHB (*F. graminearum*) resistance and/or application of fungicides? Eitherway, it can be stated that the process of barley breeding for resistance to these two fungal species will be very complex and difficult.

High frequency of *F. proliferatum* (55.6%) and moderate frequency of *F. verticillioides* (28.9%) on barley seeds are interesting, since it is the most often phenomenon on maize seeds. These results confirm our previous statement that mentioned species are important not only for maize but also for small grains (Lević et al., 2009).

The results on mycobiota on sunflower seeds differed from those in literature regarding the incidence of *F. semitectum*, *F. solani*, *M. phaseoina*, *Rhizoctonia solani* and *Trichoderma* spp. (Dawar and Ghaffar, 1990; Abdullah and Al-Mousawi, 2010). *N. oryzae* has been commonly detected on cob and maize grains in Serbia (Penčić and Lević, 1994; Milošević et al., 1995), and the results achieved in this study show that this fungus was also present on sunflower grains. This is the first report on the occurrence of *N. oryzae* on sunflower grains in Serbia, although according to Dawar and Ghaffar, it (1990) it is commonly occurring on this plant in Pakistan.

The analysis of mycobiota presented by Pozzi et al. (2005) revealed the presence of *F. verticillioides* in 70% and *A. alternata* in 46% of sunflower samples. Our study proves that the frequency and the incidence of these fungi were also high on sunflower grains.

The results on both the frequency and the incidence of *Rhizopus* spp. indicate that this fungal species could be a significant factor for damage occurrence in sunflower production in Serbia. According to Gulya et al. (1991) Rhizopus head rot is the most common sunflower disease in California, occurring in more than 70% of seed production fields. Mechanical and biological damage (from insects and birds) increase the intensity of incidence of this fungus (Gulya et al., 1991; Yildirim et al., 2010).

If the results obtained in our study for soybean mycobiota are compared with the data gained by Medić-Pap et al. (2007), which refer to soybean grains originating from Vojvodina, Serbia, there are certain similarities regarding the frequency and the intensity of *Fusarium* spp. (especially *F. graminearum* and

F. semitectum), and *Alternaria* spp. Furthermore, there are certain differences in the incidence of *Peronospora mancshurica* (Naum.) Syd. and *Phomopsis* spp., which were not established in this study. Jasnić and Vidić (2008) also found that in all production regions in Serbia species of *Diaporthe/Phomopsis* complex were predominant (*D. phaseolorum* var. *caulivora* Athow and Caldwell, *D. phaseolorum* var. *sojae* (Leh.) Wehm. and *Phomopsis longicola* Hobbs). The obtained differences between the results of our and other studies can be explained by different agro-meteorological conditions under which the research was carried out. According to Jasnić and Vidić (2008) the agents affecting seed decay favour longterm rain and warm periods during soybean maturation and harvest. However, the data from the Hydrometeorological Institute of Serbia show that in August 2008, in time of soybean maturation in Serbia, the weather was warm (maximum temperatures above 30°C) and dry without rainfall. Similar conditions were recorded during the first two weeks in September 2008.

According to Roy et al. (2000) there are 80 genus and 109 species recorded from reproductive structures of soybean in North America. Genera with the biggest number of species representatives include *Aspergillus* (15 species), *Fusarium* (11 species), *Chaetomium* and *Penicillium* (6 species each), and *Colletotrichum* and *Alternaria* (4 species each). In Mississippi, the most common fungi on soybean seed include *Alternaria* spp., *Cercospora kikuchii* Matsu. & Tomoyasu, *Cladosporium* spp., *Phomopsis/Diaporthe* complex, *Fusarium* spp. and *Verticillium* spp. (Villarroel et al., 2004).

In conclusion, regarding the frequency of certain fungi on seeds of four tested crops, *Alternaria* species are important for barley, sunflower and soybean, but not for maize. *F. graminearum* is the main seed-borne pathogen of maize and barley, while *F. verticillioides* and *Penicillium* species are significant pathogens only of maize grain. *F. oxysporum* is important for sunflower grain, while *Epicoccum* spp. is the most frequent on soybean grain. Regarding the intensity of incidence, *Alternaria* species are important for barley, sunflower and soybean, while *F. graminearum* and *F. verticillioides* are the most significant pathogens of barley and maize, respectively. The data on the frequency of the same fungal species on several crops is important for the application of strategy, which will reduce their incidence on maize, barley, sunflower and soybean seeds. The dominance of toxigenic fungi on seeds of all four plants points out the risk of their usage for human and animal nutrition.

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REFERENCES

Abdel-Mallek, A.Y., El-Maraghy, S.S.M. and Hasan, H.A.H.: Mycotoxin-producing potential of some *Aspergillus*, *Penicillium* and *Fusarium* isolates found on corn grains and sunflower seeds in Egypt. Journal of Islamic Academy of Sciences, 6: 189-192, 1993.

Abdullah, S. K. and Al-Mousawi, K.A.: Fungi associated with sunflower (*Helianthus annuus* L.) cultivars grown in Iraq. Phytopathologia, 57: 11-20, 2010.

Barros, G.G., Oviedo, M.S., Ramirez M.L. and Chulze, S.N.: Safety aspect in soybean food and feed chains: fungal and mycotoxins contamination. In: Soybean – Biochemistry, Chemistry and Physiology (Tzi-Bun Ng, ed.), InTech, 2011, pp. 8-12.

Bhattacharya, K. and Raha, S.: Deteriorative changes of maize, groundnut and soybean seeds by fungi in storage. Mycopathologia, 155: 135-141, 2002.

Burgess, L.W., Summerell, B.A., Bullock, S., Gott, K.P. and Backhouse, D.: Laboratory Manual for Fusarium Research. University of Sydney and Royal Botanic Gardens, Sydney, 1994.

Dawar, S. and Ghaffar, A.: Location of fungi in sunflower seed. Pakistan Journal of Botany, 22: 117-120, 1990.

El-Margaghy, S.S. and El-Maghraby, O.M.O.: Mycoflora and mycotoxins of sunflower (*Helianthus annuus* L.) seeds in Egypt. 1. Sugar fungi and natural occurrence of mycotoxins. Qatar University Science Bulletin, 6: 107-121, 1986.

Gulya, T.J., Woods, D.M., Bell, R. and Mau Cly, M.K.: Diseases of sunflower in California. Plant Disease, 75: 572-574, 1991.

Hussein, H.M., Christensen, M.J. and Baxter, M.: Occurrence and distribution of *Fusarium* species in maize fields in New Zealand. Mycopathologia, 156: 25-30, 2002.

Ioos, R., Belhadj, A. and Menez, M.: Occurrence and distribution of *Microdochium nivale* and *Fusarium* species isolated from barley, durum and soft wheat grains in France from 2000 to 2002. Mycopathologia, 158: 351-362, 2004.

Jasnić, S. i Vidić, M.: Paraziti semena soje. Biljni lekar, 36(3-4): 222-226, 2008.

Kakde, R.B. and Chavan, A.M.: Deteriorative changes in oilseeds due to storage fungi and efficacy of botanicals. Current Botany, 2: 17-22, 2011.

Kosiak, B., Torp, M., Skjerve, E. and Andersen, B.: *Alternaria* and *Fusarium* in Norwegian grains of reduced quality – a matched pair sample study. International Journal of Food Microbiology, 93:151-62, **2004.**

Lević, J., Penčić, V., Ivanović, D. and Bočarov-Stančić, A.: Maize ear and associated fungi in field and crib environment. Arhiv za biološke nauke, 45: 37-44, 1993.

Lević, J., Petrović, T., Stanković, S., Krnjaja, K. and Stanković, G.: Frequency and incidence of *Pyrenochaeta terrestris* in root internodes of different maize hybrids. Journal of Phytopathology, 159: 424-428, 2011.

Lević, T.J., Stanković, Ž.S., Krnjaja, S.V. and Bočarov-Stančić, S.A.: *Fusarium* species: The occurrence and the importance in agriculture of Serbia. Matica Srpska Proceedings for Nature Sciences, 116: 33-48, 2009.

Lević, J., Tamburić-Ilinčić, Lj. and Petrović, T.: Maize kernel infection by *Fusaria* in the period 1994-1996. Cereal Research Communications, 25: 773-775, 1997.

Logrieco, A., Bottalico, A., Mulé, G., Moretti, A. and Perrone, G.: Epidemiology of toxigenic fungi and their associated mycotoxins for some Mediterranean crops. European Journal of Plant Pathology, 109: 645-667, 2003.

Magan, N. and Olson, M.: Mycotoxins in Food. Detection and Control. Woodhead Publishing Ltd. and CRS Press LLC, 2004.

Marasas, W.F.O., Nelson, P.E. and Toussoun, T.A.: Toxigenic *Fusarium* species. Identity and Mycotoxicology. The Pennsylvania State University Press University Park and London, 1984.

McGee, D.C.: Maize Disease. A Reference Source for Seed Technologists. APS Press, St. Paul, Minnesota, 1998.

Medić-Pap, S., Milošević, M. and Jasnić, S.: Soybean seedborne fungi in the Vojvodina province. Phytopathologia Polonica, 45: 55-65, 2007.

Milošević, M., Konstantinović, B., Zlokolica, M. i Draganić, M.: Mikoflora semena pšenice, ječma i kukuruza. Zaštita bilja, 46(3): 221-227, 1995.

Mubatanhema, W., Moss, M.O., Frank, M.J. and Wilson, D.M.: Prevalence of *Fusarium* species of the *Liseola* section on Zimbabwean corn and their ability to produce the mycotoxins zearalenone, moniliformin and fumonisin B_1. Mycopathologia, 148: 157-163, 1999.

Mukhtar, I.: Sunflower disease and insect pests in Pakistan: A review. African Crop Science Journal, 117: 109-118, 2009.

Nirenberg, H.: Untersuchungen über die morphologische biologische Differenzierung in der *Fusarium* – Sektion Liseola. Mitt. Biol. Bundesans. Land-Forstwirtsch., Berlin-Dahlam, 1976, 1-117.

Pacin, A.M., Boca, R.T., González, H.H.L., Resnik, S.L., Burak, R., Broccoli, A.M. and de Souza, J.C.: Natural occurrence of mycotoxins and mycoflora of Argentinien popcorn. Mycotoxin Research, 18: 90-96, 2002.

Penčić, V. i Lević, J.: Pregled identifikovanih gljiva na semenu i zrnu kukuruza u Jugoslaviji. Selekcija i semenarstvo, 1: 173-177, 1994.

Pozzi, C.R., Braghini, R., Arcaro, J.R., Zorzete, P., Israel, A.L., Pozar, I.O., Denucci, S. and ***Corrêa, B.***: Mycoflora and occurrence of alternariol and alternariol monomethyl ether in Brazilian sunflower from sowing to harvest. Journal of Agriculture and Food Chemistry, 53: 5824-5828, 2005.

Ramos, A.T.M, Moraes, M.H.D., Carvalho, R.V. and Camargo, L.E.A.: Survey of mycoflora in grains and kernels of maize. Summa Phytopathologica, 36: 257-259, 2010.

Roy, K.W., Baird, R.E. and Abney, T.S.: A review of soybean (*Glycine max*) seed, pod, and flower mycofloras in North America, with methods and a key for identification of selected fungi. Mycopathologia, 150: 15-27, 2000.

Singh, S., Srivastava, S., Shikha Sinha, A. and Bose, B.: Studies on seed mycoflora of wheat (*Triticum aestivum* L.) treated with potassium nitrate and its effect on germination during storage. Research Journal of Seed Science, 4: 148-156, 2011.

Somda, I., Sanou, J. and Sanon, P.: Seed-borne infection of farmer-saved maize seeds by pathogenic fungi and their transmission to seedlings. Plant Pathology Journal, 7: 98-103, 2008.

Villarroel, D.A., Baird, R.E., Trevathan, L.E., Watson, C.E. and Scruggs, M.L.: Pod and seed mycoflora on transgenic and conventional soybean [*Glycine max* (L.) Merrill] cultivars in Mississippi. Mycopathologia, 157: 207-215, 2004.

Yildirim, S., Turhan, H. and Özgen, B.: The effects of head rot disease (*Rhizopus stolonifer*) on sunflower genotypes at two different growth stages. Turkish Journal of Field Crops, 15: 94-98, 2010.

Pojava i učestalost patogena semena žita i industrijskih biljaka u Srbiji

REZIME

Ukupno je izolovana 41 vrsta gljiva iz uzoraka zrna ječma, kukuruza, soje i suncokreta, koji su prikupljeni u različitim lokalitetima u Srbiji. Najveći broj gljiva je utvrđen na zrnu ječma (35 vrsta ili 87,8%) u odnosu na zrno soje (17 vrsta ili 41,5%), suncokreta (16 vrsta ili 39,0%) i kukuruza (15 vrsta ili 36,9%). Vrste rodova *Alternaria*, *Chaetomium*, *Epicoccum*, *Fusarium*, *Penicillium* i *Rhizopus* su utvrđene na zrnu sve četiri biljne vrste.

Vrste roda *Alternaria* su dominirale na zrnu ječma (99,5%), suncokreta (52,9%) i soje (50,0%). *F. verticillioides* (do 92,0%) i *Penicillium* spp. (do 57,0%) su najčešće izolovane vrste sa zrna kukuruza, dok su ostale vrste izolovane do 38,5% (*Chaetomium* spp. and *Rhizopus* spp.). *F. graminearum*, *F. proliferatum*, *F. poae* i *F. sporotrichioides* su najčešće *Fusarium* vrste izolovane sa zrna ječma (51,1-93,3%), dok su na zrnu soje dominirale *F. oxysporum* (71,4%), *F. semitectum* (57,1%) i *F. sporotrichioides* (57,1%). Učestalost *Fusarium* vrsta na zrnu suncokreta je varirala od 7% (*F. equiseti*, *F. graminearum*, *F. proliferatum* and *F. subglutinans*) do 15,4% (*F. verticillioides*). Na zrnu ječma utvđena je statistički značajna negativna korelacija između intenziteta napada *F. graminearum* i *Alternaria* spp. (r = –0,678*), kao i između *Fusarium* spp. i *Alternaria* spp. (r = –0,614*).

Dobijeni rezultati pokazuju da su patogene gljive učestale i u visokom intenzitetu pojave prisutne na zrnu važnih žita i industrijskog bilja gajenih u različitim agroekološkim uslovima u Srbiji. Neke od identifikovanih gljiva su potencijalni proizvođači mikotoksina i njihovo prisustvo je važno zbog smanjene bezbednosti hrane za ljude i životinje. Stoga, rana i pouzdana identifikacija patogenih gljiva i procena njihovog značaja u proizvodnji kukuruza, strnih žita i industrijskih biljaka, omogućuje da se pravovremeno razvije i primeni strategija za njihovo suzbijanje i ublažavanje šteta.

Ključne reči: Gljive; seme; žita; suncokret; soja; učestalost; intenzitet napada