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The impact of tillage and fertilization on wheat grain infection

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Abstract
During two years period (2008 and 2009) effect of tillage and fertilization on fungal infection of wheat grain was examined. Research of different soil tillage was conducted at marsh gley (hipogley) hydromeliorated soil type in eastern Croatia. Twelve fungal genera were determined: *Fusarium, Alternaria Cladosporium, Penicillium, Epicoccum, Septoria, Helminthosporium, Acremonium Trichotecium, Gonatobotrys, Mucor* and *Aspergillus*. Regardless of the year, tillage and fertilization, majority of fungi were from *Alternaria* genus, but there were not significant differences in incidence of *Alternaria* sp. between treatments. A significantly higher grain contamination with *Fusarium* sp. was found in the no-tillage system in 2008 and reduced system tillage in 2009. Nitrogen fertilization treatments did not significant influenced of the fungal populations.

Key words: soil tillage, fertilization, wheat, fungi

Introduction

One of the most important components of soil management is soil tillage which at the same time has great influence on intensity of plant diseases. Various soil tillage systems leave different amount of plant residue on the soil surface (Jug et al., 2011) and have different effects on pests, diseases and weeds (Jordan and Hutcheon, 2003). Several authors have studied relationships between plant pathogen and no-tillage cultivation (Supronienė et al., 2012, Perez-Brandan et al., 2012). Plant residues has important role in epidemiology of plant disease since many plant pathogens can survive on plant debris (Poštić at al., 2012). Ploughing has traditionally been used to incorporate crop residues into the soil. The no-tillage system offers the best conditions to conserve and improve soil structure, contributes to the good soil quality, increases level of microbial activity, microbial diversity and enhances natural disease suppression (Perez-Brandan at al., 2012). Crop residues and disease are related but it is necessary to consider and other parameters involved in the disease epidemiology (Almeida et al., 2001).

In Croatia, Jurkovic et al. (1995) have studied relationship between reduced soil tillage for winter wheat and appearance of diseases and pests during two year period. The most severe infection of wheat roots and crowns was by *Fusarium graminearum*. Other *Fusarium* species were less established. They were concluded that reduced soil tillage for winter wheat did not significantly affect the occurrence of root and crown rot.

The aim of this research was to evaluate influence of year, tillage and fertilization on wheat grains disease incidence.

Material and methods

During two years (2008 and 2009) stationary research of reduced soil tillage was conducted for wheat, at marsh gley (hipogley) hydromeliorated soil type in eastern Croatia (Brestovac site; 45°37′ N and 18°42′ E, elevation 83 m). Research was conducted with four soil tillage treatments (mean factor, TT), with size of the basic soil tillage plot of 540 m^2, and three nitrogen fertilization treatments (sub-factor N), with basic fertilization plot size of 165 m^2, set up in split-plot design in four repetitions. The experiment was conducted on the same homogeneous field at the same location with as forecrop in each experimental year. Chemical properties of investigated soil (in plowing layer 0-30 cm) were as follows: $pH_{(H2O)}$ = 5.61; $pH_{(KCl)}$ = 4.52; OM =2.13; P = 86.0 mg kg^{-1} and K = 242.3 mg kg^{-1} (determined by the Egner-Riehm Domingo AL- method) and Hy = 8.79 mm $100g^{-1}$. The following four TT were applied in continuation: 1) Conventional tillage (CT) based on autumn mouldboard ploughing on 30 cm depth; 2) Multiple disk harrowing (MD) to a depth of 15 cm and 10 cm depth; 3) Chiselling (CH) to a depth of 25 cm and No-tillage (NT) without any tillage treatments. Nitrogen fertilization treatment had three levels of applied nitrogen: N1=35, N2=70 and N3=110 kg N ha^{-1}. Fertilization with phosphorus and potassium was uniform for all tillage treatments in all investigated years (150 kg ha^{-1} P and 90 kg ha^{-1} K as basic dressing). No-till grain drill John Deer 750A was used for all TT at a depth of 3-5 cm and inter-row spacing at 33 cm. In all experimental years, wheat was sown in optimal terms.

Health analysis of wheat grains was done by deep freezing method. Wheat grains were washed under running water, disinfected for 30 sec. with 96% ethanol and washed in distilled water three times. For each sample 4x100 grains were analysed and average value of diseases incidence calculated for each sample in percentages. Petri dishes with moisture filter paper were kept in chamber for 24 h on 22°C and light regime 12 hours day/12 hours night, then 24 h in freezer on -18°C and finally 12 days in chamber on 22°C. Examination was performed after 14 days with stereo microscope (Olympus SZX9) and microscope (Olympus BX41). Grain infection with *Fusarium* was evaluated for each sample for 4x100 grains by determining mycelia development on grain surface with stereo microscope. Mycelia developed on wheat grain was transferred to potato dextrose agar (PDA) for further determination and for growing pure fungal cultures. Identification to genus level was done based on fungal morphological characteristics. Data was statistically processed with SAS software (1999).

Results and discussion

During two year research influence of different TT, fertilization and year on mycopopulation of wheat grain, the following fungal genera were determined: *Fusarium, Alternaria Cladosporium, Penicillium, Epicoccum, Septoria, Helminthosporium, Acremonium Trichotecium, Gonatobotrys, Mucor* and *Aspergillus*. Presence of fungal genera depending on the treatments are presented in Tables 1 and 2. Fungi from genera *Trichotecium, Gonatobotrys, Mucor, Aspergillus* were not statistically analysed due to sporadic incidence. Regardless of the year, tillage and fertilization, majority of fungi were from *Alternaria* genus, but there were not statistically differences in incidence of *Alternaria* sp. between treatments. The genus *Alternaria* is widely distributed on many aerial plant surface and seeds/grains and it is the most common genera of wheat grains (Broggi et al., 2007; Bensassi, 2011). The fungi from this genus could be plant pathogens or represent saprophytic mycoflora.

Fusarium head blight (FHB) is the most important disease of wheat grains in our country but also throughout many of the world wheat growing areas. The highest percentage of wheat grains infected with *Fusarium* sp. was in 2009 (19,25%). Between CT and reduced tillage significant differences on infection level was determined. In 2008 year there number of grains infected with *Fusarium* species were significantly higher with reduced NT (13%) compared to CT (9.08%), as well as in 2009 year where infection level on reduced tillage system (NT, CH and MD) were statistically significant higher than on CT.

Nitrogen fertilization treatments did not significant influenced of the fungal population.

Table 1. Percentage (%) of wheat grains infection in 2008 depending of tillage treatment and nitrogen fertilization.

	Fusarium	Alternaria	Cladosporium	Penicillium	Epiccocum	Septoria	Helminthos porium	Acremonium
				Tillage treatment (TT)				
CT	9.08 B	36.25 A	0.66 A	1.66 A	0.58 A	0.58 A	0.33 A	0.00 A
MD	10.00 B	35.0 A	0.65 A	1.08 A	0.50 A	0.66 A	0.35 A	0.08 A
CH	10.75 AB	36.17 A	1.25 A	1.16 A	0.33 A	0.25 A	0.38 A	0.00 A
NT	13.0 A	35.58 A	1.58 A	1.00 A	0.08 A	0.50 A	0.10 A	0.00 A
				Fertilization (N)				
N1	11.37 A	35.00 A	1.37 A	1.00 A	0.43 A	0.43 A	0.37 A	0.00 A
N2	10.05 A	35.93 A	0.81 A	1.18 A	0.37 A	0.62 A	0.43 A	0.00 A
N3	10.25 A	36.31 A	0.93 A	1.12 A	0.31 A	0.43 A	0.06 A	0.06 A

(CT) - conventional tillage; (MD) -multiple disk harrowing; (CH) - chiselling to a depth of 25 cm; (NT) - no-tillage. N1=35 kg N ha^{-1}, N2=70 kg N ha^{-1} and N3=110 kg N ha^{-1}.

Table 2. Percentage (%) of wheat grains infection in 2009 depending of tillage treatment and nitrogen fertilization.

	Fusarium	Alternaria	Cladosporium	Penicillium	Epiccocum	Septoria	Helminthos porium	Acremonium
				Tillage treatment (TT)				
CT	13.33 B	20. 75A	0.33 B	3.08A	0.66A	0.00A	0.00A	0.41A
MD	18.58 A	21.08A	1.25 AB	4.25A	0.00A	0.00A	0.25A	0.66A
CH	16.83 A	21.75A	1.58 A	3.08A	0.91A	0.80A	0.00A	0.58A
NT	19.25 A	23.72A	0.91 AB	2.91A	0.33A	0.86A	0.00A	1.00A
				Fertilization (N)				
N1	16.75A	21.12A	1.25A	2.93A	0.31A	0.60A	0.00A	0.75A
N2	17.00A	22.12A	0.87A	3.06A	0.37A	0.70A	0.07A	0.68A
N3	17.25A	22.25A	0.93A	4.00A	0.75A	0.36A	0.18A	0.56A

(CT) - conventional tillage; (MD) -multiple disk harrowing; (CH) - chiselling to a depth of 25 cm; (NT) - no-tillage. N1=35 kg N ha^{-1}, N2=70 kg N ha^{-1} and N3=110 kg N ha^{-1}.

In June 2009 amount of precipitation during vegetation was significantly higher than in June 2008. Development of FHB is highly influenced by environmental conditions, especially temperature, rainfall and moisture during heading and flowering periods. Except stated, the number of days with precipitation from heading to the end of vegetation is extremely important. In May 2008 and 2009 the number of days with precipitation were 12 and 15, respectively, while the number of days with rainfall in June 2008 and 2009 were 16 and 23, respectively. Since the genus *Fusarium* is the most important fungal genus in our research in Table 3 percentage of grains infection with *Fusarium* sp. depending of tillage treatment and nitrogen fertilization regardlles of the year are presented. Infection level on reduced tillage system (NT, CH and MD) were significant higher than on CT.

Table 3. Percentage (%) of wheat grains infection with *Fusarium* sp. (both years) depending of tillage treatment and nitrogen fertilization.

Tillage treatment (TT)	
CT	11.20 C
MD	14.29 AB
CH	13.79 B
NT	16.12 A
Fertilization (N)	
N1	14.06 A
N2	13.62 A
N3	13.87 A

(CT) - conventional tillage; (MD) -multiple disk harrowing; (CH) - chiselling to a depth of 25 cm; (NT) - no-tillage. N1=35 kg N ha^{-1}, N2=70 kg N ha^{-1} and N3=110 kg N ha^{-1}.

Reports of results from the research the effect of tillage practice on *Fusarium* infection in wheat are contradictory. Lori et al. (2009) find out that no till may result in increased *Fusarium* incidence and severity but favourable weather for FHB is likely to be more important than tillage practice and fertilizer treatments, Fernandez et al. (2005) also concluded that environment was the most important factor affecting disease development. A significantly higher grain contamination with *Fusarium* sp. was found in the no-tillage system, but no significant effect on grain contamination with mycotoxins (Baliukoniene et al., 2011). No-tillage increased wheat grain infection by *Alternaria*, *Aspergillus* and *Cladosporium* species (Suproniene et al. 2012).

Our data indicate a significant effect of tillage system on the detection frequency of *Fusarium* sp. in wheat grain, but no significant effect on grain contamination with other fungal genera.

References

Almeida, A.M.R., Saraiva O.F., Farias, J.R.B., Gaudencio, C.A., Torres, E. (2001). Survival of pathogens on soybean debris under no-tillage and conventional tillage systems. Pesquisa Agropecuaria Brasileira. 36 (10): 1231-1238.

Baliukoniene, V., Bakutis, B., Januskeviciene, G., Miseikiene, R. (2011): Fungal contamination and *Fusarium* mycotoxins in cereals grown in different tillage systems. Journal of Animal and Feed Sciences, 20: 637–647.

Bensassi, F., Mahdi, C., Bacha, H., Hajlaoui M.R. (2011): Survey of the mycobiota of freshly harvested wheat grains in the main production areas of Tunisia. African Journal of Food Science 5(5): 292 – 298.

Broggi, L.E., Gonzalez, H.H., Resnik, S.L., Pscin, A. (2007): *Alternaria alternata* prevalence in cereal grains and soybean seeds from Entre Ríos, Argentina. Rev Iberoam Micol. 24(1):47-51.

Fernandez, M. R., Selles, F., Gehl, D., DePauw, R. M., Zentner, R. P. (2005): Crop production factors associated *Fusarium* head blight in spring wheat in Eastern Saskatchewan. Crop Science 45: 1908–1916.

Jordan, V.W.L., Hutcheon, J.A. (2003): Influence of Cultivation Practices on Arable Crop Diseases. In: El-Titi A, editor. Soil tillage in Agroecosystems. Boca Raton, FL, USA: CRC Press, pp. 187-207.

Jug, I., Jug, D., Sabo, M., Stipešević, B., Stošić, M. (2011): Winter wheat yield and yield components as affected by soil tillage systems. Turk J Agric For 35: 1-7.

Jurkovic, D., Ivezic, M., Pancic, S, Zugec, I. (1995): Relationship between reduced soil tillage for winter wheat and appearance of diseases and pests in agroecological conditions of eastern Croatia. Fragmenta Agronomica, 12(46).

Lori ,G. A., Sisterna, M. N., Sarandon, S. J., Rizzo I., Chidichimo, H. (2009): *Fusarium* head blight in wheat: impact of tillage and other agronomic practices under natural infection. Crop Protection 28: 495–502.

Perez-Brandan, C., Arzeno, J.L., Huidobro, J., Grümberg, B., Conforto, C., Hilton, S., Bending, G.D., Meriles, J.M., Vargas-Gil, S. (2012): Long-term effect of tillage systems on soil microbiological, chemical and physical parameters and the incidence of charcoal rot by *Macrophomina phaseolina* (Tassi) Goid in soybean. Crop protection 40: 73-82.

Poštić, J., Ćosić, J., Vrandečić, K., Jurković, D., Saleh, A.A., Leslie, J.F. (2012): Diversity of *Fusarium* Species Isolated from Weeds and Plant Debris in Croatia. Journal of Phytopathology-Phytopathologische Zeitschrift 160(2):76-81.

SAS/STAT. (1999): User’s guide, version 8. Cary: SAS Institute; 1999.

Supronienė, S., Mankevičienė A, Kadžienė G, Kačergius A, Feiza V, Feizienė D, Semaškienė R, Dabkevičius Z, Kęstutis T (2012). The impact of tillage and fertilization on *Fusarium* infection and mycotoxin production in wheat grains. Žemdirbystė Agriculture 99 (3): 265–272.

Suproniene, S., Mankeviciene, A., Kadziene, G., Kacergius, A., Feiza, V., Feiziene, D., Semaskiene, R., Dabkevicius, Z., Tamosiunas, K., (2012): The impact of tillage and fertilization on *Fusarium* infection and mycotoxin production in wheat grains. Zemdirbyste-Agriculture 99(3): 265-272.