ABSTRACT OF HABILITATION THESIS

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GENOTYPIC VARIATION IN REACTION OF WHEAT (*TRITICUM AESTIVUM* L.) TO *FUSARIUM CULMORUM* (W.G. SM.) SACC.

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Key words: *Fusarium*, Fusarium seedling blight, Fusarium head blight, mycotoxins, wheat

Objectives

The major aim of the work was to compare the susceptibility of selected wheat genotypes to Fusarium seedling blight (FSB) and Fusarium head blight (FHB). The experiments involved both winter and spring genotypes, because earlier research of the author showed that wheat genotypes at various development stages react differently to infection by *Fusarium* spp. Polish spring wheat cultivars were used in these studies to demonstrate the variation in susceptibility to *Fusarium culmorum*. Also plant materials from a resistance nursery of CIMMYT (International Maize and Wheat Improvement Centre) in Mexico were used, as intensive research is conducted there to introduce FHB resistance to the wheat genome, from various available sources. The pathogenicity of a *F. culmorum* isolate to wheat plants at the vegetative stage as compared to flowering stage was also studied.

The additional aims were to select spring wheat lines from CIMMYT with an increased resistance to FHB and FSB under Polish conditions, as well as to introduce the resistance to a Polish spring wheat cultivar, and to produce a doubled haploid (DH) line with significant transgressive effects in respect of resistance to FHB. Yet, another goal of the research was to identify *Fusarium* species and the accumulation of mycotoxins in wheat grain from two parts of Poland, as a result of natural infection by pathogens of the genus *Fusarium*.

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Fusarium seedling blight (FSB)

The original publications constituting this habilitation thesis document the pathogenicity of *F. culmorum*, and the influence of deoxynivalenol (DON, a phytotoxic secondary metabolite produced by the species) on wheat seedlings. At the cell and tissue level, its influence was reflected in: inhibition of seed germination, delayed root and shoot growth and disturbances in cell divisions in root meristems of seedlings as well as an increase in concentration of an osmophilic metabolite (proline) in cells of inoculated seedlings.

On the basis of these studies, wheat susceptibility to FSB was found to be more variable in winter cultivars than in spring cultivars whose seedlings were moderately or severely affected. Among the studied Polish spring wheat cultivars, the most resistant were seedlings of cv. 'Olimpia', but the cultivar was the most sensitive at the flowering stage, and accumulated the highest amounts of DON in grain after inoculation.

Fusarium head blight (FHB)

When studying the pathogenicity of *F. culmorum* to wheat plants at the flowering stage, the experiments involved 42 lines of spring wheat, coming from the CIMMYT resistance nursery, and 12 Polish spring wheat cultivars, and for comparison also two control (resistant) cultivars 'Sumai 3' and 'Frontana'. The inoculation experiment on pathogenicity of the isolate *F. culmorum* KF 846 to spring wheat at the flowering stage was conducted in 1998–2001 under field conditions. Point inoculation was combined with misting, which was necessary for spore germination. For the selected material, various types of resistance were studied: spread of the pathogen in the spike, grain colonization by *Fusarium* spp. and DON accumulation in grain.

Results of three years of experiments showed that the most susceptible Polish cultivars were: 'Olimpia', 'Sigma', and 'Henika'. Two of them, 'Olimpia' and 'Sigma', showed a high head infection score, a high percentage of *Fusarium*-damaged kernels (% FDK), and a high concentration of DON in kernels after spike inoculation. In cv. 'Henika' a low head infection score was observed and a low % FDK, but the cultivar accumulated a high concentration of DON in grain, which could have been due to various types of active resistance.

Wheat lines from CIMMYT were more variable in respect of the analyzed features, and had lower head infection scores, and lower % FDK than Polish cultivars. Among the studied lines, on the basis of four years of experiments, line IPG-SW-14 (now cv. 'Gondo') proved least sensitive to FHB, and accumulated a small amount of DON in grain after spike inoculation. It was resistant to *Puccinia recondita* subsp. *tritici*, and was only slightly affected by *Blumeria graminis*. The line was crossed with a Polish spring cultivar ('Henika'), and a doubled haploid (DH) lines was produced and tested for resistance to FHB in the field. The studied lines displayed a high variation of resistance to FHB under varied environmental conditions. The ob-

served differences in infection score of spring wheat DH lines indicated the difficulty of developing homozygotic wheat lines with considerable transgression effects in respect of FSB and FHB, so breeding programmes must be based on very large populations. This conclusion is confirmed by breeders' problems with selection of such forms in breeding programmes and the lack of Polish cultivars resistant to *Fusarium* spp. The lack of transgressive forms in the studied material could be due to an insufficient number of analyzed lines (21), but within this rather small population some cultivars were more susceptible than cv. 'Henika'. This suggests that resistance is inherited quantitatively. From the point of view of quantitative genetics, the small number of transgressive lines can be due to cis-acting gene linkage, while the dominance of lines with negative effects may result from complementary epistasis of additive genes.

Analysis of variance indicated a significant effect of weather conditions in individual years and of genotypes on variation of all the studied lines and cultivars.

When studying the dependence of the *F. culmorum* isolate pathogenicity to wheat plants at the vegetative stage (seedlings) as compared to the flowering stage, no correlation was found between FSB (infection of seedling leaves and roots) and FHB (head infection score, % FDK, grain weight per spike and concentrations of DON and its derivatives).

Three years of research on identification of *Fusarium* spp. and accumulation of mycotoxins in wheat grain as a result of natural infection of spikes by pathogens of the genus *Fusarium* in two parts of Poland, showed that in Poland (considered a country with a moderate threat by FHB) epidemics of the disease can break out in some regions under favourable conditions (high precipitation and high temperature during flowering of spring wheat, and the presence of *Fusarium* spp. spores). This is always associated with a decrease in grain quality and yield. In Poland, Żuławy (the alluvial delta of the Vistula river) is an area constantly threatened by epidemics of the disease, because of growth conditions favourable for these pathogens (moist climate and frequent cultivation of wheat on the fertile soils for economic reasons). It must be noted that also in the study area (Wielkopolska), epidemics of the disease can break out under favourable weather conditions.

Every year *F. avenaceum* and *F. culmorum* were found on naturally infected wheat spikes. Besides, an increase in frequency of *F. graminearum* in Poland was documented in the last few years. In infected spikes, after natural infection, a specific profile of trichothecene toxins was detected (deoxynivalenol, nivalenol, and moniliformin).

Conclusions

It seems that the occurrence of FSB and FHB, as well as accumulation of mycotoxins in wheat grain, are consequences of a complex interaction: aggressiveness of the *Fusarium* spp. population, plant genotype, developmental stage of the plant, developmental type of the plant (spring or winter cultivar) and climatic conditions (temperature and humidity, particularly during inoculation and shortly afterwards).

The pathogenicity of *F. culmorum* and the phytotoxic activity of its secondary metabolite (DON) in relation to wheat seedlings, was observed at the level of cells and tissues.

Research on FHB in wheat showed that spike infection by various *Fusarium* species resulted in a specific profile of trichothecene toxins in infected grain, whereas intensity of the infection, differences in resistance between genotypes, and environmental conditions during flowering and grain formation in wheat, all affected the amount of toxins accumulated in grain.

Wheat biodiversity can be increased by means of introduction of resistance to FHB and FSB from other cultivars, whose higher resistance to the disease has been confirmed in field experiments.

Research papers constituting the habilitation thesis

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