# FUSARIUM STALK ROT: A BIOTIC STRESS FACTOR DECISIVE FOR MAIZE STALK STRENGTH

*Csaba SZŐKE[1] – Tamás ÁRENDÁS[1] – Péter BÓNIS[1] – Árpád SZÉCSI[2]*

[1] Agricultural Research Institute of the Hungarian Academy of Sciences, H-2462 Martonvásár, Brunszvik 2. e-mail: szokecs@mail.mgki.hu
[2] Plant Protection Institute of the Hungarian Academy of Sciences, H-1525 Budapest, Herman Ottó 15. e-mail: aszecsi@nki.hu

**Abstract:** Maize stalk strength is determined by two main factors: the mechanical structure of the stalk and a biotic stress factor, fusarium stalk rot. The degree of infection of three hybrids and their parental lines to fusarium stalk rot was tested by artificial inoculation with two *Fusarium* isolates (FG36, FGH4) over three years (2006–2008). The greatest level of infection was recorded in 2007, and FGH4 proved to be the more pathogenic isolate. When testing for resistance to fusarium stalk rot it is not sufficient to observe only natural infection levels, but testing with a single *Fusarium* isolate may be enough, if it is wisely chosen. The resistance level of the female parent is probably decisive in the inheritance of fusarium stalk rot resistance.

**Keywords:** *Fusarium spp.*, maize, corn stalk rot

## Introduction

It is essential for Hungarian agriculture to prepare for the effects of current climate change, as all living organisms respond sensitively to a changed ecological environment. Experiments have shown that climate change will influence both the crops that can be grown and the yields of all major field crops (Harnos et al., 2007). Plant protection will also be affected. In addition to the appearance of new pests and pathogens, serious problems will also be caused by the resurgence of biotic stress factors for which the changed ecological environment is favourable. The dry weather of 2007 again drew attention to the importance of maize stalk strength, which is determined by two main factors: the mechanical structure of the stalk and *fusarium* stalk rot, which is caused by various species of *Fusarium* and *Macrophomina* (Koehler 1960, Christensen, Wilcoxson 1966). The degree of fusarium stalk rot infection depends greatly on environmental factors, the genotype × environment interaction and the resistance of the given maize genotype to the pathogens (Kommedahl and Windels 1981, Mesterházy 1983, Todd and Kommedahl 1994, Buhinicek et al. 2005, Palaversic et al. 2007, Szőke et al. 2007, Mesterházy et al. 2008, Reinprecht 2008). The present paper will discuss the importance of fusarium stalk rot in influencing maize stalk strength.

## Materials and methods

Three single-cross hybrids and their six parental lines were inoculated with two *Fusarium graminearum* isolates (FG36, FGH4) in 2006–2008. The two isolates were selected as being the most aggressive on the basis of preliminary pathogenicity studies in the phytotron. The genotypes were sown in a split-plot design in four replications, with the maize genotypes in the main plots and the treatments (FG36, FGH4, sterile, natural infection) in the subplots. Inoculation was carried out on the $12^{th}$ day after flowering by placing infected wheat grains in the second internode from the roots on six plants per plot. The wheat grains were soaked in a 1 g/l N-chlorobenzenesulfonamide

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sodium salt solution for 3 min and then rinsed twice with distilled water. The grains were then sterilised in a 60°C water bath for 2×5 min, after which they were placed in test tubes with 2 ml of a $10^6$ conidia/ml suspension of the above isolates at 27°C for 14 days. Sterile wheat grains were placed in the maize stalks as a control, and natural infection was scored on the fourth plot. After placing the grains in holes made in the stalks with a 2 mm hand-drill, the holes were sealed with sticking plaster to prevent external infection. The collection and processing of samples was begun on October 10th. The stalk samples were cut in half lengthwise and all the samples were photographed with a digital camera to determine the area of the lesions on the pith using the Colim 4.0 image analysing program. Percentage values were calculated from the complete area of the internode and the infected area. The data were evaluated using analysis of variance (Sváb 1981).

## Results and discussion

In response to artificial inoculation both the hybrids and lines suffered considerable infection from the two *Fusarium graminearum* isolates, of which FGH4 proved to be more pathogenic at the $LSD_{5\%}$ level of probability averaged over the whole experiment in the case of both hybrids ($LSD_{5\%}$ = 5.034%) and lines ($LSD_{5\%}$ = 3.203%). It is clear from Figure 1, however, that in 2008 isolate FG36 caused greater infection in both hybrids and lines, the difference being significant for the latter ($LSD_{5\%}$ = 5.54%). The lines were more severely infected than the hybrids, the level of infection being 10% greater for the lines in 2006 and 2008, though in 2007 the level of infection was similar for lines and hybrids. A relatively high rate of infection was also recorded in both hybrids and lines after treatment with sterile grains (*figure 1*). This could be attributed to the fact that the experiment was set up on an area used as a pathological nursery for several decades (until the appearance of the corn rootworm), so the soil was heavily infected with conidia and chlamydospores. In addition European corn borer caused considerable damage, especially in 2007 (data not shown). The extent of natural infection in untreated subplots was 1.6%, averaged over genotypes and years. The greatest natural infection was recorded in 2007.

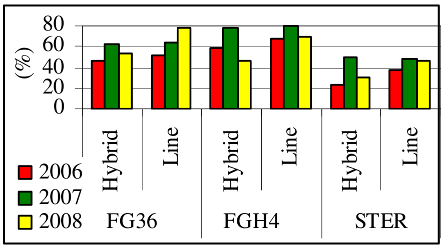


*Figure 1.* Effect of treatments on hybrids and lines, 2006–2008 ($LSD_{5\%}$=5.54% for lines, 8.72% for hybrids)

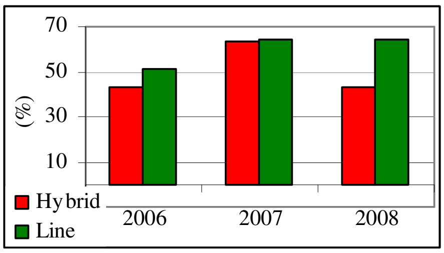


*Figure 2.* Degree of infection of hybrids and lines, 2006–2008 ($LSD_{5\%}$=3.20% for lines, 5.03% for hybrids)

Of the three years, the hybrids suffered the greatest infection (63.55%) in 2007, when the weather was extremely hot and dry at flowering, while rainfall quantities in

September and October were close to the long-term mean. Due to the heat and drought stress at flowering there was a reduction in the carbohydrate content of the stalk tissues, which were destroyed to a great extent by the cell wall-decomposing enzymes of the *Fusarium* species playing a major role in the course of the disease (Szécsi 1985). In 2006 and 2008 the hybrids exhibited similar extents of infection (42.68%). The year effects were greater for the lines than for the hybrids, with infection levels of around 65% in 2007 and 2008 and 51.42% in 2006 (*figure 2*).

An analysis of the infection of the hybrids and their parental partners (*figure 3*) revealed that, over the grand average of the treatments, the MV3 hybrid exhibited the greatest infection, followed by MV1 and MV2, but the difference between the hybrids was only significant between MV3 and the other two hybrids ($LSD_{5\%}$ = 5.03%). More pronounced differences were observed between the lines. In the case of the most sensitive hybrid, the infection level of the parental lines was also the highest of all the lines. Lines E and F, which were the female and male parents of this hybrid, had the highest level of infection in all three years. A comparison between the natural infection and artificial inoculation data showed that these three genotypes tended to have a similar response to spontaneous infection with stalk rot.

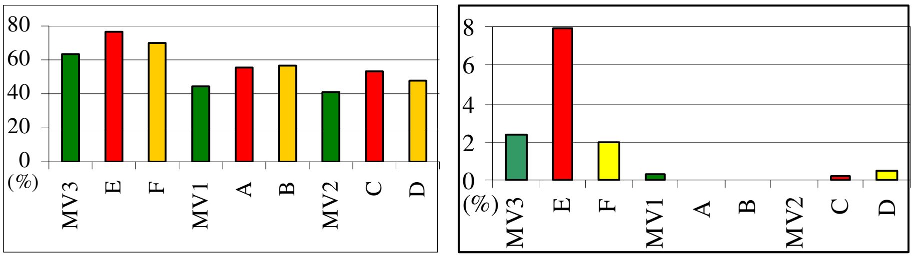


*Figure 3.* Level of infection of hybrids (green) and their parental components (female: red, male: yellow) averaged over treatments (left) and natural infection (right). For artificial inoculation, $LSD_{5\%}$=4.53% for lines and 5.03% for hybrids; for natural infection: $LSD_{5\%}$=2.54% for lines and 1.78% for hybrids.

The parental components of hybrid MV1 (A and B) exhibited a sensitive response to artificial inoculation, but not to natural infection. Hybrid MV2 had the lowest level of infection, but again considerable differences were recorded for the response of the hybrid and its parental components to artificial inoculation and natural infection. These data draw attention to the fact that exact information on the resistance or susceptibility of a given population to stalk rot can only be obtained from artificial inoculation data. Due to the small sample number the present data are not suitable for drawing far-reaching conclusions on the inheritance of stalk rot, but they suggest that the resistance level of the female parent is of prime importance. For hybrids MV3 and MV2 the female suffered greater infection than the male parent at the $LSD_{5\%}$ level of probability.

## Conclusions

Due to the increasing frequency of extreme weather conditions, renewed attention must be paid to the development of maize lines and hybrids with resistance to stalk rot. The present results indicated that both natural infection and artificial inoculation produced

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the greatest level of infection in 2007, among the years tested. This year was ideal for the development of stalk rot (little rainfall at flowering, wet weather in the autumn months). Of the two *F. graminearum* isolates used for the artificial inoculation, although FG36 caused significantly greater infection to the lines in 2008, in 2006 and 2007 the FGH4 isolate was more pathogenic to both hybrids and lines. It is suggested that, it may be enough a single *Fusarium* isolate for the testing of breeding materials and hybrids, if it is wisely chosen. The high infection rate observed in the sterile grain treatment draws attention to the fact that the development of fusarium stalk rot is greatly facilitated by any type of injury to the stalk (pests, cultivation tools, hail), so the mechanical parameters of the stalk (thickness, strong outer layer) should also be considered in the course of selection. Natural infection data are not sufficient for successful selection for stalk rot resistance. The genotypes examined had different levels of resistance to fusarium stalk rot. The data suggest that the resistance level of the female parent could be decisive in the inheritance of fusarium stalk rot resistance, but further tests will be required to confirm this conclusion.

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