Differences between spring wheat cultivars for emergence and early development after seed infection with *Fusarium culmorum*

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Key words: Spring wheat, Fusarium seedling blight, organic breeding, development of organic agriculture

Abstract

Infection of wheat seeds with Fusarium spp. causes seedling blight. As a result of this disease, fields sown with infected seeds show a reduced plant density. This is especially a problem in organic agriculture, for which currently no practical seed disinfection methods are available. In the present project we investigated whether spring wheat cultivars differ in sensitivity to seedling blight, whether the possible differences could be linked to cultivar differences in early growth rates, and what size the delay in canopy closure resulting from the plant reductions was. Six spring wheat cultivars (Melon, Lavett, SW Kungsjet, Epos, Pasteur, Thasos), containing three infection levels (averages 5, 15 and 27%) of Fusarium culmorum were obtained and were sown in a field experiment in 2006 in 4 repetitions. Measurements included percentage of emergence, light interception and above ground dry matter to calculate relative growth rates. Infection of seeds with F. culmorum resulted in lower plant densities and a delay in time to 10% light interception of up to 5 days. First preliminary results also show that cultivars differ for sensitivity to seedling blight, and that cultivars with higher early growth rates appeared to be less sensitive to seedling blight, with the exception of cultivar Thasos. If future experiments confirm this relation, it could be used to select cultivars which are more resistant to seedling blight.

Introduction and Objectives:

Fusarium head blight (FHB) is caused by one or more Fusarium species, including *F. graminearum* (Schwabe) and *F. culmorum* (W.G. Smith) Sacc. Part of the seeds obtained from FHB infected crops are infected (Jones and Mirocha, 1999). Use of the infected seeds without treatment results in lower plant densities (Gilbert *et al.* 1997) due to a loss of viability, reduced emergence and post emergence seedling blight (Jones, 1999). A reduced plant density does not necessarily affect yield (Gooding *et al*., 2002). However, lower plant densities due to seedling blight could reduce the speed of canopy closure and hence make the crop less competitive against weeds. Control options of seedling blight in organic agriculture include effective hot-water treatments and biological control by micro organisms (Osman, *et al*., 2004: Johansson *et al*. 2003). However, these options are currently not available for large scale use in practice, and there remains scope for new, potentially preventative control options.

The aim of the current research is to investigate whether varieties differ in resistance against Fusarium seedling blight. Furthermore we try to link the possible variation to early development rate of the cultivars as an additional tool for future selection.

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Results give also insight in the importance of crop density reductions by seedling blight in terms of delay in canopy closure.

Methods

In 2006 seeds of six spring wheat cultivars (Melon, Lavett, SW Kungsjet, Epos, Pasteur, Thasos) containing three Fusarium infection levels (5, 15 and 27 %) were used. Infection levels were created by using seeds of an experiment in 2005, in which all six cultivars were present. The experiment contained an inoculated part (inoculated with *F. culmorum*), in which 75 % of the seeds were infected, and a control part of which 15 % of the seeds were infected. Seeds of the control part were used for the 15 % infection level, and the 27 % infection level was created mixing seeds of the inoculated part with seeds of the control part. The 5 % infection level was created by warm water treatment of the seeds of the control part. Finally, precise infection levels were measured in a Blottertest (De Tempe, 1958). Seeds were sown in a field experiment on an organic farm (Colijnsplaat, The Netherlands) on a clay soil.

Percentage of seedling emergence was measured for each cultivar. Light interception measurements were done using a Sunscan light interception measurement system (Delta−T Devices, Cambridge, UK). Measurements of above-ground dry matter were done in the lowest infection treatment. The time from sowing to 10% light interception was calculated, performing a nonlinear regression analysis with the logistic equation y=A+(C/(1+exp(-B*(X-M)))) on the measured time series of light interception for each field plot. Resulting equations were used to calculate time to 10% of light interception for each plot. Relative growth rates of above ground dry matter were calculated by nonlinear regression analyses of the exponential growth equation ($W_t=W_0$*exp(rgr*time), in which W_t and W_0 represent plant weights on time t and 0, respectively) on measured data of above ground dry weights. All statistics were performed using GenStat Seventh Edition version 7.2.0.208, VSN International LTD.

Results

The percentage of emerged seeds of the six spring wheat cultivars decreased with increasing percentage of *F. culmorum* in seeds (Fig. 1). Percentages of emerged seeds ranged from maximally 81.9 % to a minimum of 41.3 %. Trends for all cultivars were linear.

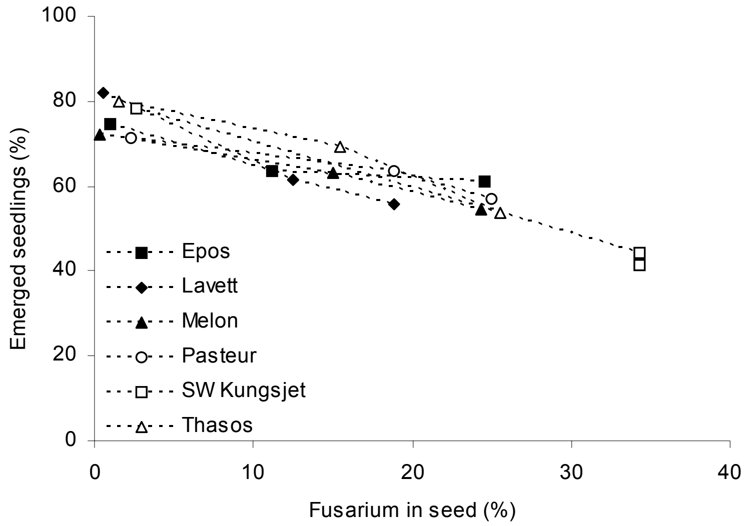

Figure 1. The percentage of emerged seeds for the six spring wheat cultivars (different symbols) in relation to percentage of seeds infected with *F. culmorum*.

Emergence reduction resulted also in significant differences in rate of increase of light interception of young crops (Table 2). Averaged over all cultivars, number of days needed from sowing to reach 10 % of light interception was 34.0 days at the level of 5 % *F. culmorum* infection. This increased significantly to 35.8 days at 15 % of *F. culmorum* infection and to 36.5 days at 27 % *F. culmorum*. If looked at each cultivar separately, it can be seen that all cultivars, except for Lavett, had the same trend. Differences were clearest (significant) for cultivar Pasteur, ranging from 33.2 to 35.8 days, and for SW Kungsjet, ranging from 32.9 to 37.4 days from sowing to reach 10 % of light interception.

Relative sensitivity of the cultivars for seedling blight, indicated by the percentage of emergence reduction per percentage of *F. culmorum* in the seed, differed significantly (Fig. 2.) Spring wheat cultivars Lavett and Thasos were the most sensitive, with 1.4 and 1.3 % emergence reduction per percent of infected seeds. Cultivar SW Kungsjet was in the middle with 0.9 % emergence reduction per percent of infected seeds, and cultivars Melon, Pasteur and Epos were the least sensitive to seedling blight with 0.7, 0.7 and 0.6 % emergence reduction per percent of infected seeds.

Table 2. Time duration from sowing to 10% light interception for the six spring wheat cultivars (in days), as calculated with logistic equations (y=A+(C/(1+exp(-B*(X-M))))) derived from non-linear regression analysis (R^2=0.975) on light interception measurement data. Different letters indicate significant differences ($p<0.05$).

Spring wheat cultivar	Infection level of seeds with *F. culmorum* (%)		
	5	15	27
Lavett	35.1	34.8	35.6
Epos	34.5	36.2	36.4
Melon	34.4	35.9	36.4
Thasos	34.1	36.5	37.3
Pasteur	33.2 (a)	34.2 (ab)	35.8 (b)
SW Kugsjet	32.9 (a)	37.3 (b)	37.4 (b)

Measured relative growth rates ranged from 0.0726 g above-ground dry matter per g dry matter per day for cultivar Lavett up to 0.0856 g above-ground dry matter per g dry matter per day for cultivar Thasos. Strikingly, with the exception of Thasos, the spring wheat cultivars with higher relative growth rates also had lower sensitivities to seedling blight (Fig. 2).

Discussion

F. culmorum infection in seeds caused plant density reductions, the importance of which is underlined by a significant time delay (of up to 5 days) in canopy closure. Such a delay is expected to reduce weed control (Kruepl *et al.*, 2006, Olsen *et al.*, 2006). In the Netherlands the infection limit for Fusarium for seed certification is 25% and indeed in years with heavy Fusarium infection organic seeds with infection levels of 20-25% are marketed. This indicates that time delays in crop closure as measured in the current experiment are not unrealistic.

Although results are preliminary and only from one growing season, and should not be used without information on resistance to FHB, it is clear that variation in sensitivity to seedling blight is present between currently available spring wheat cultivars. Furthermore, preliminary data show that this variation is potentially linked to early growth rates of cultivars. Such a relation provides possibilities for cultivar selection in organic breeding.

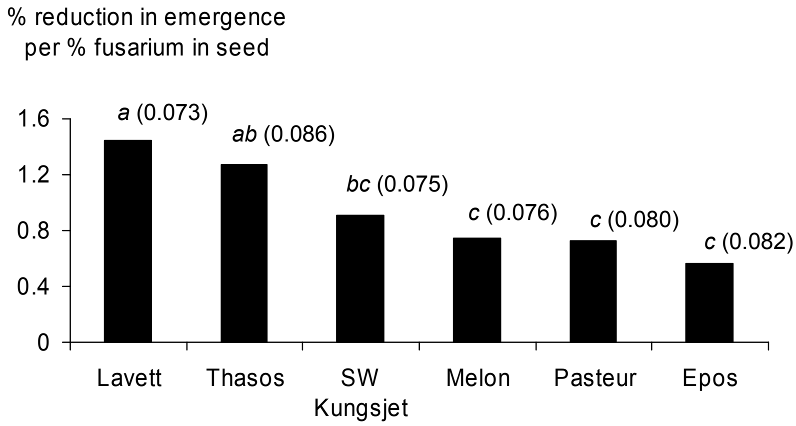

Figure 2 Percentage of reduction in emergence (compared to uninfected control) per percentage of seeds infected with *F. culmorum* for the six spring wheat cultivars. Different letters indicate significant differences ($p< 0.05$), numbers in brackets indicate relative growth rates of cultivars (d^{-1}).

Conclusion

-Relatively moderate infection rates of spring wheat seeds with *F. culmorum* caused significant delays in cannopy closure of young crops of up to 5 days.

-Between spring wheat cultivars currently available for organic agriculture, variation in tolerance to Fusarium seedling blight is present.

-This variation may be related to the early development rate of the cultivars.

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Acknowledgements

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358. Fusarium infected seeds for this research were produced in a collaborative research project on varietal resistance of spring wheat against Fusarium Head Blight of Plant Research International (PRI) and Louis Bolk Institute. This project is funded by the Dutch Ministry of Agriculture, Nature and Food Quality (DLO Programme 388-II, Breeding for Organic Farming). We thank our colleagues Olga Scholten, Greet Steenhuis and Gerrit Huisman of PRI, for helping us with obtaining and preparing the seeds. We thank seed company Bejo for conducting the warm water treatment of the seeds. We acknowledge Theo Heijboer and his staff of Experimental Farm “Rusthoeve” for the sowing, management and harvesting of the trial.

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