VIII  Resistance stability of Septoria tritici blotch

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The level of Septoria varies across years and locations, and resistance stability is dependent on weather conditions and local Septoria populations. Virulence differences were detected between Septoria populations located 200 km apart. Intensive cultivation of Mariboss over a number of years has led to resistance breakdown due to increased selection pressure on the resistance gene. Pyramiding of several resistance genes in a breeding line and cultivating of several varieties or variety mixtures will prolong the lifetime of the resistance genes.

In a project financed by the Danish Research Council and the Pajbjerg Foundation, the variation in Septoria symptoms across years and locations was evaluated using data from the national observation plots (https://tystofte.dk). One of the most important strategies in order to avoid losses due to Septoria is the cultivation of resistant varieties. In breeding it is therefore important to develop varieties which show a broad resistance across several years and sites. Data from the national observation plots indicate significant differences of STB symptoms across years in selected varieties (Figure 1). Furthermore, a trend towards increasing susceptibility of the varieties is observed. This is according to previous findings on resistance stability concerning Septoria in varieties in Denmark (Vagndorf et al., submitted 2018).

![Figure 1. Septoria assessments from national observation plots over four seasons for selected varieties. An average of all locations each year was used. Significance was calculated by ANOVA. P-value < 0.05 * and p-value < 0.01 ***.](image-url)
Several varieties become more and more susceptible over the years (Figure 1). Mariboss, which has been one of the most cultivated varieties in Denmark, has become more susceptible towards Septoria over time. The cultivation of Mariboss stopped in 2016. The varieties Torp and Benchmark have also been highly resistant in the years 2014-2016. However, data from 2017 demonstrate an increasing susceptibility of these varieties too.

Furthermore, data from the national observation plots show variations in the degree of Septoria across locations (Figure 2).

Figure 2. Data from the national observations plots in 2016. Selected varieties and locations in Denmark were assessed for Septoria symptoms over one week in July 2016 at growth stage 73-75.

ANOVA of the data indicated that some varieties are significantly more susceptible than other varieties. However, significant differences were also observed between locations. The variety Hereford was one of the most susceptible varieties in Bramming. However, in Horsens, Hereford was one of the most resistant varieties. The susceptible check, MS Septoria, can be used as an indicator of the disease pressure at individual locations. Thus, the locations Karise and Flakkebjerg seem to have a fairly low disease pressure indicated by the low level of disease on MS Septoria.

The data from the national observation plots indicate significant variations in Septoria levels across years and across locations. These variations can be due to differences in weather conditions. More humid conditions at one location contra another location will favour the development of Septoria (Shaw & Royle, 1993). Similarly, years with more precipitation will also provide more favourable conditions for development and spreading of Septoria. Additionally, the variations can be due to differences in virulence genes of Septoria. The pathogen is known to have a high mutation rate and widespread sexual recombination, which can lead to rapid development of new virulences and overcoming corresponding resistance genes in the varieties (Zhan et al., 2003). Thus, differences among local populations of Septoria are believed to exist (Schilly et al., 2011).

In this project, a virulence test was performed on seedlings in the greenhouse in order to test if populations of Septoria sampled from two locations in Denmark possessed differences in virulence (Figure 3).
Single isolates were sampled in a field in Flakkebjerg and in a field in Horsens located approximately 200 km apart (Figure 3). Two inoculums were prepared; one with five isolates from Horsens and one with five isolates from Flakkebjerg. Seven-day-old seedlings were spray-inoculated with these two populations of *Septoria*. Clear differences in the degree of *Septoria* on the leaves could be seen 21 days after inoculation (Figure 3). Percentage leaf area covered with *Septoria* was assessed on 21 dpi (Figure 4). ANOVA revealed significant differences in the degree of *Septoria* between the two locations and among varieties. Furthermore, a significant interaction was detected indicating that the degree of *Septoria* was dependent on the population used for inoculation.

Varieties like Sleipner and MS Septoria were highly susceptible when inoculated with both populations (Figure 4), whereas varieties like NOS 7191-06.28 and KWS Magic were fairly resistant when inoculated with both populations. However, the variety NOS 16104-01 was resistant when inoculated with the population from Horsens and susceptible when inoculated with the population from Flakkebjerg. In contrast, the variety Contact was fairly resistant when inoculated with the population from Flakkebjerg and susceptible when inoculated with the population from Horsens (Figure 4). Thus, the varying susceptibility of specific varieties when inoculated with two different *Septoria* populations and the significant interaction strongly indicate that virulence differences exist between local populations of *Septoria*.
This study confirmed the variation in resistance stability to Septoria across years and locations. Weather conditions and local differences in virulence between Septoria populations are believed to be the main reasons for the variation in resistance. Earlier studies have described a boom and bust cycle of disease (Stakman, 1957), where the intensive cultivation of a resistant variety leads to resistance breakdown. High selection pressure on a single resistance gene will make it easier for the pathogen to overcome the specific resistance gene. Data from the national observation plots indicate that the reason for the rapid resistance breakdown in Mariboss could be attributed to intensive cultivation. The percentage wheat area cultivated with Mariboss in Denmark increased from below 15% in 2011 to 40% in 2014 when it began to decrease again. The degree of Septoria in Mariboss was relatively constant in the years 2011-2015. However, from 2015 to 2016 the level of Septoria increased from 10% to 25% (Figure 5). Thus, the sudden increase in the degree of Septoria on Mariboss combined with the intense cultivation indicates that Mariboss has been subjected to the boom and bust cycle.

**Figure 4.** The degree of Septoria on seedlings inoculated in the greenhouse with a population of Septoria sampled at Flakkebjerg (blue) and at Horsens (red). Significance was calculated by ANOVA. P-value < 0.05 * and p-value < 0.01 **.  

**Figure 5.** Data from the national observation plots. The cultivation of Mariboss is shown for the years 2011-2016 and the percentage of STB in the same period.
Earlier studies on *Septoria* have identified and localised 18 resistance genes. Many of these resistance genes have initially demonstrated an effective and specific resistance (Brown et al., 2015). However, the specificity is contributing to the fact that *Septoria* relatively easily can overcome the resistance gene and the variety become susceptible. In practice, resistance breakdown have been demonstrated after only 3-4 years of cultivation (Cowger et al., 2000). Besides the specific resistance, several regions on the wheat genome have been found to possess quantitative resistance genes (Vagndorf et al., 2017). The quantitative resistance is not as efficient as the qualitative; however, it is more durable. Wheat breeding is typically aiming to stack or pyramid these different kinds of resistance genes in single lines. This will provide a more durable and efficient resistance compared to varieties containing only a qualitative resistance gene or a quantitative resistance gene (Chartrain et al., 2004). Cultivation of several varieties or variety mixtures will also decrease the selection pressure on single resistance genes. Additionally, it is important to test the resistant varieties across several locations and several years. Differences in virulence can be present, thus it is important to breed a variety that is resistant over many years and locations (Vagndorf et al., submitted 2018).

References


