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## The effects of soil tillage and crop rotation on the development of winter wheat leaf diseases

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### Abstract

Winter wheat is one of the most profitable crops in Latvia. Different growing technologies, including reduced soil tillage and continuous wheat sowing, have become more popular in recent years. The aim of this study was to characterise the development of winter wheat leaf diseases with respect to the soil tillage method and crop rotation under typical wheat growing conditions in the central region of Latvia. Experiments were carried out at the Pēterlauki Study and Research Farm of Latvia University of Agriculture in 2010, 2012 and 2013. Trials were conducted in two blocks: 1) conventional tillage with mouldboard ploughing at a depth of 22–23 cm and 2) reduced tillage with disc harrowing at a depth of 10–12 cm. Different crop rotations were established in each block, but crop sequences differed slightly depending on the year. Continuous wheat sowing and reduced soil tillage increased the level of tan spot infection, especially when these two factors were combined. The level of infection with *Septoria* leaf blotch was influenced by the soil tillage method and the year.

Key words: *Pyrenophora tritici-repentis*, reduced soil tillage, *Zymoseptoria tritici*.

### Introduction

Winter wheat is one of the most profitable crops in Latvia, especially in the central part of Latvia, where the most fertile soils are located. Leaf diseases are important risk factors for wheat grain production. Different growing technologies, especially reduced soil tillage and monoculture of wheat, affect the development of diseases, but systematic investigations were not conducted in Latvia until 2010.

Tan spot, caused by *Pyrenophora tritici-repentis*, and *Septoria* leaf blotch, caused by *Zymoseptoria tritici*, are the most widespread wheat leaf diseases. The severity of rusts and mildew is significantly lower in most of the cases in Latvia. Plant residues on the soil surface are the main source of infection. Many pathogens continue to sporulate on the plant debris if it is not buried in the soil (Krupinsky et al., 2007 b). Wheat straw residues used in the conservation tillage system are considered to be the main factor influencing the risk of tan spot (Schuh, 1990; Carignano et al., 2008). The strong influence of crop rotation on the level of tan spot was proved in the

United States of America, where tan spot was a dominant wheat disease. Growing alternative previous crops significantly decreased the severity of leaf blotch under no-till management conditions (Krupinsky et al., 2007 b). Continuous wheat sowings increased development of leaf blotch, especially tan spot, but did not affect diseases caused by biotrophs. The higher severity of mildew was observed on the plants grown after oilseed rape compared with the wheat grown after wheat. Development of brown rust did not depend on the pre-crop, but the influence of cultivars was significant (Wyczling et al., 2010). Similar results were obtained by Polish researchers. Higher mildew severity was reported on wheat plants grown after pea compared with continuously grown wheat. In contrast, tan spot severity was higher in continuous wheat, whereas the results regarding *Septoria* leaf blotch development were contradictory depending on the year (Sawinska et al., 2006). Most researchers indicate that intensive winter wheat production and non-inversion tillage are the most important factors influencing the

severity of tan spot (Jørgensen, Olsen, 2007). However, effect of soil tillage is affected by crop rotation and vice versa. Mouldboard ploughing reduces the severity of tan spot in continuous wheat production in comparison with other soil tillage systems (Bockus, Claassen, 1992). Nevertheless, conventional soil tillage is not a universally effective method of leaf disease control. For example, mouldboard ploughing did not reduce the severity of wheat leaf diseases in Poland (Sawinska et al., 2006).

The influence of the soil tillage system can be minimised by meteorological conditions. In dry years, the pressure of diseases was low, and non-tillage did not increase the level of tan spot (Krupinsky et al., 2007 a). Various investigations related to disease development and agronomic measures have been conducted across the world, but the conclusions drawn were inconsistent.

The aim of this study was to characterise the development of winter wheat leaf diseases with respect to the soil tillage method and crop rotation.

## Materials and methods

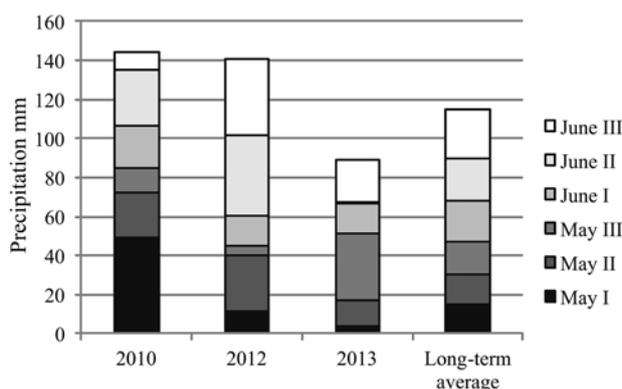
A long-term field experiment was established at the Pēterlauki Study and Research Farm of Latvia University of Agriculture. Between 2010 and 2013, trials were conducted in two blocks: 1) conventional tillage with mouldboard ploughing at a depth of 22–23 cm and 2) reduced tillage with disc harrowing at a depth of 10–12 cm. Different crop rotations were established in each block, but crop sequences differed slightly depending on the year: 1) winter wheat after spring or winter oilseed rape, 2) winter wheat after winter wheat. The trial conditions were very similar to actual crop production conditions; the total plot area was 6 ha, and the area for each treatment was 0.25 ha.

Altogether, 12 plots of winter wheat were surveyed each year. The cultivar ‘Zentos’ was used every year. This cultivar is popular because it is productive and medium resistant against diseases and has good winter hardiness. The incidence and severity of diseases were assessed for each plot. Wheat plots were categorised according to the previous crop and the soil tillage system. A similar method was used by Fernandez et al. (2009). Data of disease development in 2010, 2012 and 2013 was used to evaluate different technologies. The results from 2011 were excluded due to the extremely bad overwintering, when part of the winter wheat fields were reseeded with spring wheat. Diseases were assessed weekly. The incidence and severity of the disease were noted for the whole plant until growth stage 31, for the 3 upper leaves until growth stages 32–69, and for the 2 upper leaves until later stages. Growth stages were noted according to BBCH scale.

The total impact of the diseases during the vegetation period was estimated by calculating the area under the disease progress curve (AUDPC). For statistical analyses of the total impact of the diseases, expressed as the value of AUDPC, a three-way analysis of variance (ANOVA) was performed, which included year ( $i = 1 \dots 3$ ), crop rotation (continuous wheat sowing/pre-crop

other than wheat) and soil tillage method (conventional ploughing/reduced tillage). The efficiency of various combinations of crop rotation and soil tillage method (continuous wheat and ploughing, other pre-crop and ploughing, continuous wheat and reduced tillage, and other pre-crop and reduced tillage) and the influence of year was analysed by two-factor ANOVA. The factor was considered statistically significant when  $p < 0.05$ . All agronomic measures were applied uniformly, according to the requirements of agronomic practice in Central Latvia. Foliar fungicides (epoxiconazole 84 g L<sup>-1</sup> and fenpropimorph 150 g L<sup>-1</sup>, 1.5 L ha<sup>-1</sup>) were sprayed across all wheat plots at the heading stage.

The meteorological conditions differed during the investigations. Temperatures fluctuated around the long-term average. Observed deviations were not recognised as an important factor influencing the development of diseases. However, the level of precipitation was significantly different in May and June, the time of stem elongation and heading, which is the most crucial period for the spread of leaf diseases (Fig. 1).

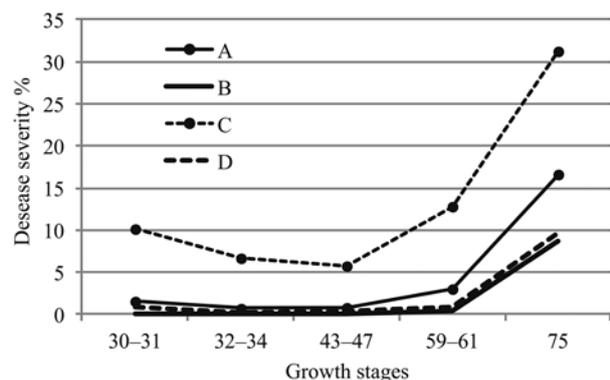


**Figure 1.** Precipitation during the crucial period of wheat leaf disease spread in Pēterlauki, Latvia

The total amount of precipitation was higher in 2010 and 2012 compared with the long-term average in this period. The first ten-day period of May was significantly more humid in 2010, particularly compared with 2013.

## Results

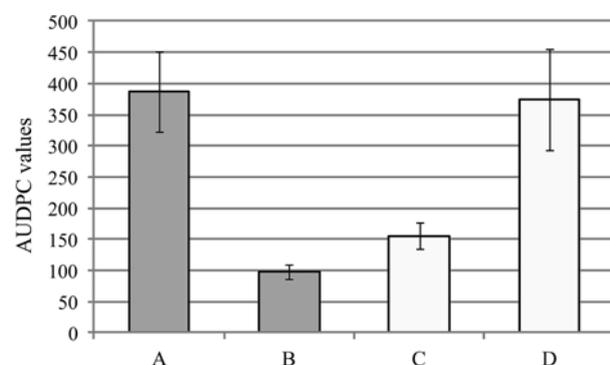
Tan spot, caused by *Pyrenophora tritici-repentis*, and Septoria leaf blotch, caused by *Zymoseptoria tritici*, were the most prevalent wheat leaf diseases during the study. Mildew, caused by *Blumeria graminis*, was observed in the majority of wheat plots. Although the incidence of mildew fluctuated from 1% to 45%, the severity of this disease was low and did not exceed 0.5% in any plot. The dynamics of tan spot feature development were affected by the crop rotation and soil tillage method (Fig. 2). The severity of the first symptoms differed sharply depending on the technologies. Reduced soil tillage in combination with continuous wheat sowing promoted the development of more severe symptoms in the spring and during the whole vegetation season.



A – continuous wheat and ploughing, B – other pre-crop and ploughing, C – continuous wheat and reduced tillage, D – other pre-crop and reduced tillage

**Figure 2.** Dynamics of tan spot development in winter wheat cv. 'Zentos' with respect to the technologies used (data represents the average)

The influence of continuous sowing and soil tillage on the severity of Septoria leaf blotch and mildew was not clearly noticeable. The total impact of tan spot (expressed as the AUDPC value) was not significantly affected by the year, but pre-crop ( $p < 0.01$ ) and soil tillage ( $p < 0.05$ ) influenced the development of this disease (Fig. 3).

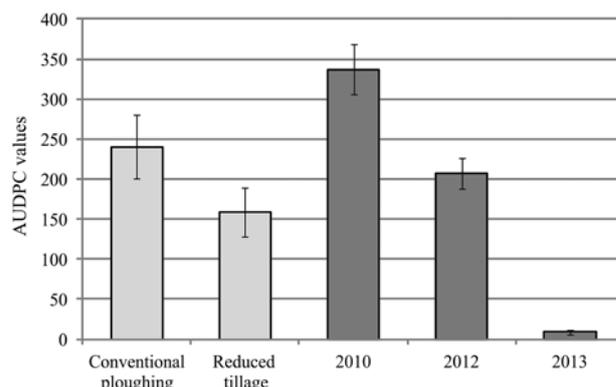


A – continuous wheat fields, B – other pre-crop fields, C – ploughing fields, D – reduced tillage fields

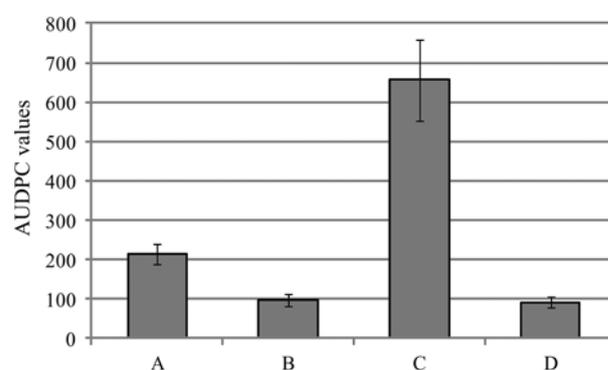
**Figure 3.** Values of tan spot area under the disease progress curve (AUDPC) in winter wheat cv. 'Zentos' with respect to the technologies used

Severity of Septoria leaf blotch was influenced by the year ( $p < 0.05$ ) and soil tillage ( $p < 0.1$ ) but not by pre-crop (Fig. 4).

Disease development was influenced by the combination of agrotechnical measures ( $p < 0.01$ ), namely, crop rotation and soil tillage (Figs 5 and 6). The level of tan spot was significantly higher if reduced soil tillage was combined with continuous sowing of wheat. Conventional ploughing essentially decreased the severity of tan spot, even in continuous wheat sowings. Crop rotation is the most important agrotechnological measure to control tan spot in both cases, irrespective of the soil tillage method.

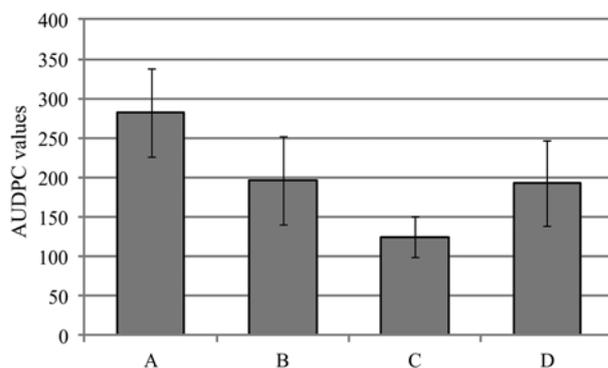


**Figure 4.** Values of Septoria leaf blotch area under the disease progress curve (AUDPC) in winter wheat cv. 'Zentos' with respect to the soil tillage and year



A – ploughing and continuous wheat plots, B – ploughing and other pre-crop plots, C – reduced tillage and continuous wheat plots, D – reduced tillage and other pre-crop plots

**Figure 5.** Tan spot area under the disease progress curve (AUDPC) values in winter wheat cv. 'Zentos' with respect to the technologies used



A – ploughing and continuous wheat plots, B – ploughing and other pre-crop plots, C – reduced tillage and continuous wheat plots, D – reduced tillage and other pre-crop plots

**Figure 6.** Septoria leaf blotch area under the disease progress curve (AUDPC) values in winter wheat cv. 'Zentos' with respect to the technologies used

The development of Septoria leaf blotch was not strongly correlated with the agrotechnical methods used. A significant difference was observed only between the plots in which conventional soil tillage was combined with continuous wheat sowing and those in which reduced soil tillage was combined with continuous wheat sowing. The level of mildew was low; therefore, clear regularity was not established, but some tendencies were observed. The progression of mildew was influenced only by the year, and the pre-crop and soil tillage method were not influential factors. The severity of this disease was observed to be slightly higher in the conventionally ploughed fields when compared with reduced tillage fields.

## Discussion

For the last couple of years, leaf blotches (caused by *Pyrenophora tritici-repentis* and *Zymoseptoria tritici*) have been dominant in Latvia. Mildew is observed frequently, but this disease is rarely devastating, whereas rusts occur only in a small minority of cases. A similar situation has also been noted in these trials; therefore, investigation of the influence of different agronomic measures on the development of this disease group is very important.

The influence of agrotechnical measures on the epidemiological situation in the winter wheat fields depends on the dominant disease in a particular year, because the peculiarities of tan spot and Septoria leaf blotch development are different. The development of tan spot clearly depends on agrotechnical measures. The severity of the first symptoms of this disease is higher in plots that lack crop rotation and reduced soil tillage. Our results confirmed the importance of the level of primary inoculum in the development of tan spot. The significance of ploughing under wheat monoculture was observed in Argentina, where reduction of wheat debris by ploughing decreased the level of disease if the prevalent disease was tan spot (Simon et al., 2011). Both investigated factors – soil tillage systems and crop rotation – are important measures to control tan spot, but combinations of these two factors (reduced soil tillage and lack of crop rotation) significantly increase the risk of tan spot. Similar results were obtained by other researchers – continuous wheat sowing combined with reduced tillage significantly increased the level of tan spot (Bockus, 1998; Ronis et al., 2009).

Nevertheless, different results have been obtained across the world. Bailey and Duczek (1996) noted the importance of variable meteorological conditions, which can minimise the differences in soil tillage systems. Also, Fernandez et al. (2009) did not find a correlation between the level of leaf blotches and the soil tillage system or cropping sequence. A similar situation was observed in Canada, where wheat leaf spot diseases were not affected by soil tillage systems in any of the years during a four-year study (Kutcher et al., 2011). Bailey et al. (2001) did not find a correlation between the wheat leaf disease

severity and the soil treatment, except in certain years. Annual environmental factors have been found to be the most important factors influencing the severity of wheat diseases. Krupinsky and Tanaka (2001) noted the influence of environmental factors: in years favourable for leaf disease development, the lowest level of disease was observed under conventional soil tillage; but in years with low disease pressure, this trend was not observed.

Differences in the obtained results could possibly be explained by the different spectrum of diseases. The level of tan spot was not essentially influenced by different meteorological situations during the study, but the method of soil tillage and the pre-crop were important. The converse situation was observed if Septoria leaf blotch was the dominant disease. The year significantly influenced the development of Septoria leaf blotch in our investigations. The highest AUDPC value was obtained in 2010, when an extremely high amount of precipitation occurred in May and June. The conditions are especially important in the first half of May, during stem elongation, which is the crucial period of this disease's development. The importance of rain splash for the development of this disease is widely known, and different studies across the world have demonstrated this relationship (Gladders et al., 2001).

The highest level of tan spot was observed in plots where a lack of crop rotation was combined with reduced soil tillage. We did not have sufficient data concerning mildew development with respect to the technologies, because the level of this disease was too low. Nevertheless, a tendency toward a higher level of mildew was observed under better wheat-growing conditions – crop rotation and conventional ploughing promoted the development of this disease. Reduced soil tillage combined with a lack of crop rotation significantly increased the risk of tan spot development. The relevant Septoria leaf blotch results were inconclusive. Further investigations are necessary to evaluate the significance of the pre-crop and continuous usage of the reduced soil tillage system.

## Conclusions

1. Tan spot, caused by *Pyrenophora tritici-repentis*, and Septoria leaf blotch, caused by *Zymoseptoria tritici*, were the most widespread and devastating diseases of winter wheat in Latvia.

2. Development of tan spot was significantly influenced by the crop rotation and soil tillage method. The highest level of wheat diseases was observed when continuous wheat was grown under reduced soil tillage.

3. Development of Septoria leaf blotch was influenced by the year and the soil tillage system. The previous crop did not significantly affect the level of disease.

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## **Žemės dirbimo būdo ir sėjomainos įtaka žieminių kviečių lapų ligų vystymuisi**

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### **Santrauka**

Žieminiai kviečiai yra vieni pelningiausių žemės ūkio augalų. Pastaruoju metu išpopuliarėjo įvairios auginimo technologijos, pavyzdžiui, minimalus žemės dirbimas ir kviečių atsėliavimas. Tyrimo tikslas – apibūdinti žieminių kviečių lapų ligų vystymąsi, priklausomai nuo žemės dirbimo būdo ir sėjomainos Vidurio Latvijos regiono sąlygomis. Bandymai vykdyti Latvijos žemės ūkio universiteto Peterlaukio mokomajame ir tyrimų ūkyje 2010, 2012 ir 2013 m. Bandymai vykdyti dviem blokais: 1) tradicinis žemės dirbimas taikant verstuvinį arimą 22–23 cm gyliu ir 2) minimalus žemės dirbimas taikant lėkštinį purenimą 10–12 cm gyliu. Kiekviename bloke buvo įrengtos skirtingos sėjomainos, tačiau sėjomainos rotacijos priklausomai nuo metų skyrėsi nedaug. Kviečių dryžligės infekcijos lygį padidino kviečių atsėliavimas ir minimalus žemės dirbimas, ypač kai šie du veiksniai taikyti kartu. Lapų septoriozės infekcijos lygiui turėjo įtakos žemės dirbimo būdas ir metai.

Reikšminiai žodžiai: minimalus žemės dirbimas, *Pyrenophora tritici-repentis*, *Zymoseptoria tritici*.