Forecasting System for Infection Risk of Phoma Stem Canker in Selected Regions of the Czech Republic in 2009–2011

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Abstract

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In the period 2009–2011 monitoring of the incidence of phoma stem canker was carried out at selected sites of the Czech Republic (Šumperk and Opava regions in North Moravia). The risk of infection was evaluated by assessing the autumn release of *Leptosphaeria* spp. ascospores and with the proPlant prediction model. In recent years, the incidence of phoma stem canker has been relatively low and this corresponded with the total count of ascospores released in the autumn period but not with an increased level of infection risk announced by the proPlant model. During the monitored period the ascospore concentration reached maximally 2 ascospores/1 m^3 per day. Maximum ascospore release was recorded in 2010 as a result of favourable weather conditions. The first incidence of phoma leaf spot has been observed in mid-October. The higher values of ascospores concentration were recorded in the Opava region, but the total number of the trapped ascospores was more often higher in the Šumperk region.

Keywords: *Leptosphaeria* spp.; phoma stem canker; ascospore release; spore traps; weather conditions; proPlant model

Phoma stem canker (blackleg), caused by *Leptosphaeria maculans* (Desm.) Ces. et de Not. and *Leptosphaeria biglobosa* (Shoemaker & Brun 2001), is a serious disease of oilseed rape (canola, rapeseed, *Brassica napus*, *Brassica juncea*, *Brassica rapa*) causing seedling death, lodging or early senescence in Australia, Canada, and Europe (West *et al.* 2001; Jedryczka *et al.* 2010). Where the disease occurs, usual yield losses at harvest are < 10%, although they can reach 30–50% (West *et al.* 2001). Hall *et al.* (1993) estimated maximal yield losses in winter rape in the fields examined within 1986–1989 in Ontario at 29.2%. As published by Zhou *et al.* (1999), in the UK yield losses of up to 50% have been reported in susceptible cultivars when incidence of severe stem canker was high. In the Netherlands, a yield loss of about 30% was recorded for susceptible cultivars, such as Primor, in a cultivar trial with a high incidence of stem canker.

The epidemiology and severity of phoma stem canker varies between continents because of differences depending e.g. on the pathogen population structure, oilseed rape type (spring or winter type), cultivar grown, climate, and agricultural practices. Epidemics are most severe in Australia, where only *L. maculans* occurs, and can be damaging in Canada and West Europe, where both *Leptosphaeria* species are represented, although their proportions vary within regions and in the course of the year (West *et al.* 2001).

Epidemics of phoma stem canker on oilseed rape are largely initiated by airborne ascospores of *Leptosphaeria* species, released from maturing pseudothecia on exposed woody remains of infested stubble, predominantly from crops harvested in the previous season (Salam *et al.* 2007).

There are differences in the timing of the onset of seasonal ascospore release among different countries. Regardless of the season – autumn (Europe), spring (Canada) or winter (Australia), recent views indicate that the most severe stem-base (crown) cankers, caus-

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ing substantial yield loss, originate from cotyledons and leaf lesions produced on young plants early in the growing season. However the relationship between sowing date and severity of phoma stem canker at the end of the crop season is unclear because of variability in the timing of the ascospore release onset. It is therefore important to know these clues to make decisions in phoma stem canker management at the regional as well as farm level. The differences of ascospore release were confirmed both between locations within a country and between seasons at a location (Salam *et al.* 2007).

The effects of environmental factors on maturation of ascospores have been studied in other host-pathogen systems as a basis for developing systems to forecast the release of ascospores. A degree-day model for maturation of ascospores of *Venturia inaequalis* for estimating cumulative release of mature ascospores over time has been in use in many countries. A few attempts have been made to develop a weather-based system for predicting the onset of seasonal ascospore release. In France, a preliminary forecast based on daily rainfall predicts that the first release of *L. maculans* ascospores will occur when 16–19 days with rain will have elapsed since harvest and the daily average temperature will fall to 14°C. In Australia, the Blackleg Sporacle forecast, based on temperature and rainfall, predicts that the onset of seasonal ascospore release will occur after 43 days will have elapsed since harvest, with a 10-day average temperature < 22°C and weekly rainfall ≥ 4 mm (Salam *et al.* 2007). Other weather-based models (Improved Sporacle and SporacleEzy) to predict the onset date of seasonal release of ascospores of *Leptosphaeria maculans* or *L. biglobosa* from oilseed rape debris were developed and tested with data from diverse environments in Australia, Canada, France, Poland, and the UK. These models are capable of estimating the first seasonal release of ascospores of pathogens causing phoma stem canker on oilseed rape in many climates and thus could contribute to the development of strategies for controlling the disease (Salam *et al.* 2007).

Another forecasting system used in Poland is SPEC (System for Forecasting Disease Epidemics). It is the first system in Poland aimed at forecasting the risk of stem canker of oilseed rape – one of the most dangerous diseases of rapeseed in Poland and worldwide. The system is based on an estimation of the concentration of pathogenic fungi ascospores (*Leptosphaeria maculans* and *L. biglobosa*) in the air. Ascospores of these fungal species are the main source of infection of oilseed rape plants, thus monitoring of their spore formation is an important contribution to decision making in stem canker control. The system has been continuously expanding since 2004. At present SPEC is the largest system aimed at monitoring stem canker in the world (Jedryczka *et al.* 2008).

A forecasting system of phoma stem canker on winter oilseed rape was introduced in the Czech Republic in 2008. The main method used is to monitor the *Leptosphaeria maculans*/*L. biglobosa* ascospore release at 5 locations in the period from sowing the winter oilseed rape till mid-November. The potential risk of infection can be estimated in conjunction with weather conditions by the increase of ascospore concentration in the air and recommendations can be made for fungicidal protection. The prediction model from the German company proPlant Gesellschaft für Agrar- und Umweltinformatik mbH evaluates the risk of infection on the basis of meteorological data for 7 observation posts in the Czech Republic (Poslušná & Plachká 2012). The aim of this study is to report the results of utilization of different predicting models, obtained from experimental sites situated in North Moravia during the years 2009–2011.

MATERIAL AND METHODS

Locations. Significant disease occurrence was recorded in two districts of the Czech Republic, in the Opava and Šumperk regions of North Moravia. The GPS position of spore trap placement was 49°55'49.338''N, 17°52'41.953''E in Opava (OPA) and 49°58'24.316''N, 16°57'59.613''E in Šumperk (SUM). Experimental fields in the Opava region were located in a warmer climatic district (relative to conditions in the Czech Republic) and were in a sugar-beet cropping area. The average annual temperature and precipitation were +8.23°C and 592.6 mm, respectively. The experimental fields in the Šumperk region lied near the village of Rapotín. This locality was at an altitude of 325 m and was in a potato cropping area. The average annual temperature and precipitation were +7.27°C and 702.2 mm, respectively.

Field trials. To evaluate the incidence of phoma stem canker on winter oilseed rape, the cv. Benefit susceptible to fungal diseases was used. The oilseed rape was sown on different sowing dates and according to local practices. The experimental trials included randomly located untreated plots, i.e. without fungicidal treatments for phoma stem canker, intended to monitor estimated disease incidence in 4 replications.

The experimental trials were sown according to the recommended agronomical practices suitable for the selected planting regions to assess the risk of infection and the natural level of phoma stem canker incidence. The study assessed the first occurrences of phoma leaf spots, the infestation intensity of oilseed rape stands in autumn, and phoma stem canker incidence before harvest. Phoma leaf spot and phoma stem canker incidence were evaluated according to the EPPO standards PP 1/78 (3): Root, stem, foliar, and pod diseases on rape. In the experimental trials 25 randomly chosen plants in each replication were evaluated, taken from the whole area of untreated plots in selected developmental stages (BBCH 14–16, BBCH 18–19 in autumn and before harvest in growth stage BBCH 81–85). The phoma stem canker damage level was evaluated on rape leaves in autumn; on stems, root necks, and roots before the harvest. The damage level of oilseed rape leaves assessed in autumn was evaluated as a percentage of affected leaf area and assigned into one of the following five classes: 1, 5, 10, 25, or 50% of affected leaf area. The root and root neck damage assessment was evaluated in November according to the EPPO method PP 1/78 (3). The damage level assessed before harvest was classified according to categories: (1) 0% – no infection, no necrotic area; (2) 25% – about 25% of the root neck is corky or 25% of the stem shows symptoms; (3) 50% – 50% of the root neck and/or 50% of the stem shows symptoms, the plant is still green; (4) 75% – about 75% of the root neck and/or 75% of the stem display symptoms, pycnidia are usually visible, the plant is yellowing; (5) 100% – about 100% of the root neck and/or 100% of the stem show symptoms, the plant is prematurely ripening or already dead.

Ascospore trapping. The spore traps were located near the institute Agritec, Research, Breeding Services, Ltd., Šumperk and OSEVA Development and Research Ltd., Opava. The AMET spore traps (Litschmann & Suchý Association, Velké Bílovice, Czech Republic) were used. The traps were placed either directly on the field of winter rape (SUM), or in a place near the source of inoculum (OPA). In addition, traps were deployed around rape debris infected with phoma stem canker collected in the previous season to ensure the natural infection. Ascospores were captured from September, 1st till mid-November. The air with ascospores was sucked through a small opening behind which there was a rotating cylinder and the spores were collected on a Melinex tape coated with a thin layer of petroleum jelly. The ascospore traps worked continuously for 7 days. The tape was always changed at the same time to ensure exact 7-day intervals. Then the tape was divided into 7 identical pieces. The cut up sections with the daily quantum of ascospores in the air were placed on slides and preserved with Gelvatol with Trypan Blue. The number of ascospores on a slide representing a one-day release was evaluated under a light microscope. Ascospores in Šumperk were observed under the light microscope Carl Zeiss Jena JENAVAL (magnification of eyepiece 10× and lens 25×), in Opava the light microscope Carl Zeiss Jena NU2 (magnification of eyepiece 12.5× and lens 25×) (both Carl Zeiss Jena, Jena, Germany) was used. To express the concentration of ascospores in 1 m^3 of air the total number of ascospores per slide was recalculated (Lacey & Caulton 1995; Dawidziuk *et al*. 2010). Within 24 h, a standard spore trap sampled 14.4 m^3 (10 l/min × 60 min × 24 h), depositing its content of spores on the trapping surface. The concentration of spores per 1 m^3 was calculated as $N/14.4$, where N was the total number of spores per one slide.

Meteorological data. Meteorological data were obtained from automatic meteorological stations located near the spore trap placement, 300 m apart from Šumperk and 10 km from Opava. The total daily precipitation and average daily temperature were recorded.

The proPlant model. The forecasting model developed by the company proPlant GmbH was used. The model exploited meteorological data such as the sum of daily precipitation, average daily temperature, and level of sunshine. The prognosis graphs were published on the company website with limited access. The proPlant model indicated the possible infection risk (low, medium, and strong). It calculated the predicted phoma stem canker infection risk for several monitored localities in the Czech Republic and highlighted days with optimal conditions for *Leptosphaeria* spp. development. The proPlant locality Ústí nad Orlicí was linked to the experimental trials in Šumperk (40 km from Šumperk) and the locality Otice was linked to the experimental trials in Opava (10 km from Opava).

RESULTS

2009. The experimental oilseed rape trials in the Opava and Šumperk regions were sown on August 27, 2009. Early September was very dry with measured temperatures slightly above normal (Figures 1). The trial sowings emerged slowly in the dry soil conditions.

The first *Leptosphaeria* spp. ascospore release was recorded at the end of September at both selected sites

– in Šumperk it was on September 19, 2009, in Opava on September 26, 2009. Peak ascospore release was observed the next day (SUM) and after 27 days (OPA). The first symptoms of phoma leaf spot occurred in Šumperk on October 13, 2009, 7 days after the second peak of recorded ascospores release. In Opava the first symptoms of phoma leaf spot occurred on October 20, 2009, 9 days before the first peak of recorded ascospore release. The total number of ascospores trapped before the date of the first observed symptoms amounted to 119 ascospores (SUM) and 28 ascospores (OPA), respectively. The maximum spore concentration was estimated at 0.972 ascospores/m^3 in Šumperk and 1.458 ascospores/m^3 in Opava. These results indicated a very low risk of infection.

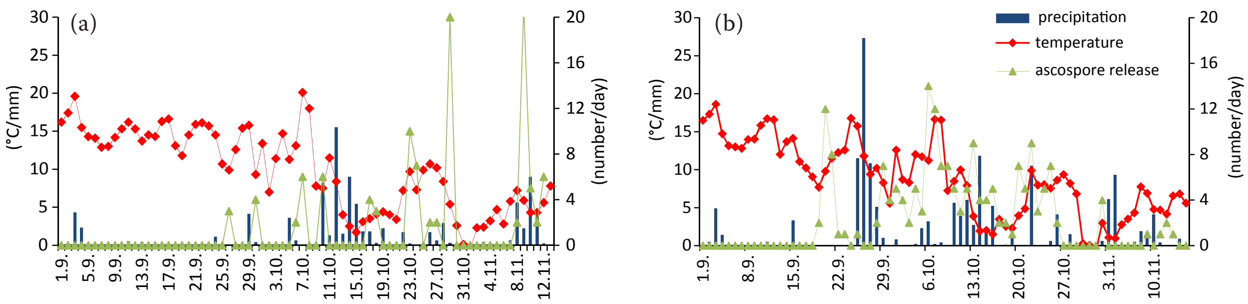
The number of rainy days (with a daily precipitation higher than 0.1 mm) till the first ascospore release was 5 (SUM) and 6 (OPA), the total precipitation amounted to 10.6 mm (SUM) and 10.2 mm (OPA). The number of rainy days till the first phoma leaf spot occurrence was 20 (SUM) and 21 (OPA), the total precipitation amounted to 91.6 mm (SUM) and 66 mm (OPA). The cumulative temperature over the monitored period calculated from September 1st, 2009 till the first ascospore release amounted to 261.2°C (SUM) and 381.6°C (OPA), the cumulative temperature calculated till the first phoma leaf spot occurrence amounted to 520.4°C (SUM) and 606.2°C (OPA).

The proPlant model indicated low and medium risk levels at both monitored locations in 2009 (Figure 4). In the Šumperk region, in the monitored period till October 12, 2009 the model assessed risk of infection as low and after that date as medium. The maximum ascospores daily release reached only 15 spores per slide on October 6, 2009; this corresponded to the proPlant forecast of a low level of risk in this period. The following medium risk of infection was confirmed neither by ascospores concentration in the air, nor by damage degree of infested oilseed rape stands. The proPlant forecast of infection risk for the Opava region was similar to that for Šumperk. In the monitored period till November 8, 2009 the model assessed risk of infection as low, after that date as medium. The maximum number of trapped ascospores reached 21 spores on November 9, 2009. According to the re-calculating formula it meant a low level of risk, but it did not confirm the medium risk of infection announced by the proPlant model. The probable date of infection risk was given as 6 days (SUM) and 8 days (OPA) before the first phoma leaf spot occurrence in the oilseed rape stands monitored. The days with announced optimal conditions for *Leptosphaeria* spp. development were October 6–7, 2009 (SUM) and October 10–12, 2009 (OPA) followed by real infestation.

Weather conditions did not favour the progress of the disease, its incidence was at a very low level, phoma leaf spot symptoms occurred sporadically. The oilseed rape crops showed 5% damage in the autumn of 2009. The pre-harvest assessment of phoma stem canker in the summer of 2010 confirmed that surface damage predominated; the damage severity was calculated as 40% (SUM) and 41% (OPA).

2010. Late August was rainy and sowing of winter oilseed rape was postponed until the beginning of September (September 7, 2010 – SUM, September 8, 2010 – OPA). The early September period was slightly dry in the Opava region, but in the Šumperk region weather conditions, after rape sowing and early crop development, were favourable for oilseed rape growth (Figures 2). The trial sowings emerged on September 13, 2010 (SUM) and on September 17, 2010 (OPA).

The first *Leptosphaeria* spp. ascospore release was recorded at the beginning of September at both selected sites – in Šumperk it was on September 9, 2010 and in Opava on August 27, 2010. Peak ascospore release was observed after 8 days (SUM) and 49 days (OPA). The first symptoms of phoma



Figures 1. Weather conditions (temperature in °C/precipitation in mm) and daily ascospore release recorded (number/day) in autumn 2009 (a) in Šumperk and (b) in Opava

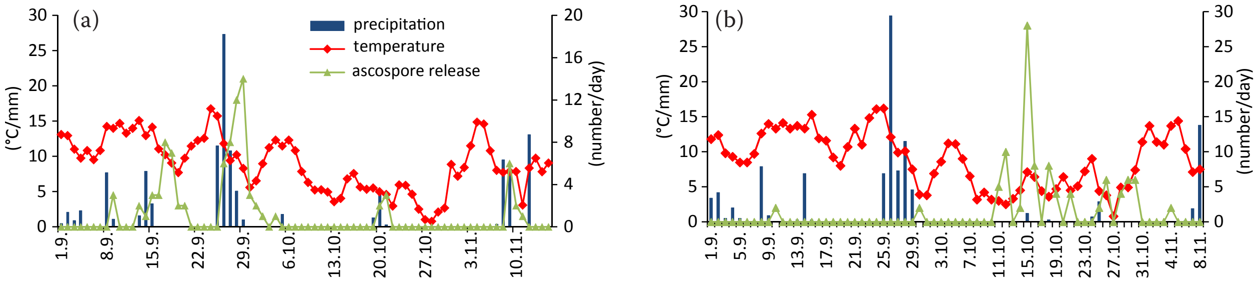


Figure 2. Weather conditions (temperature in °C/precipitation in mm) and daily ascospore release recorded (number/day) in autumn 2010 (a) in Šumperk and (b) inOpava

leaf spot occurred in Šumperk on October 24, 2010, 25 days after recorded peak of ascospores release. In Opava the first symptoms of phoma leaf spot occurred on October 11, 2010, 4 days before the recorded peak of ascospore release. The total number of trapped ascospores before the date of the first observed symptoms amounted to 83 (SUM) and 11 (OPA). The maximum spore concentration of 0.972 ascospores/m^3 was calculated for Šumperk and 1.944 ascospores/1 m^3 for Opava. These results of ascospore release evaluation indicated a low risk of infection again.

The number of rainy days (with a daily precipitation higher than 0.1 mm) till the first phoma leaf spot occurrence was 18 (SUM) and 23 (OPA), respectively. The total precipitation amounted to 92 mm (SUM) and 87.7 mm (OPA). The cumulative temperature over the monitored period calculated from September 1, 2010 till the first ascospore release amounted to 106°C (SUM) and 109.9°C (OPA), the cumulative temperature calculated till the first phoma leaf spot occurrence amounted to 518.8°C (SUM) and 416.6°C (OPA).

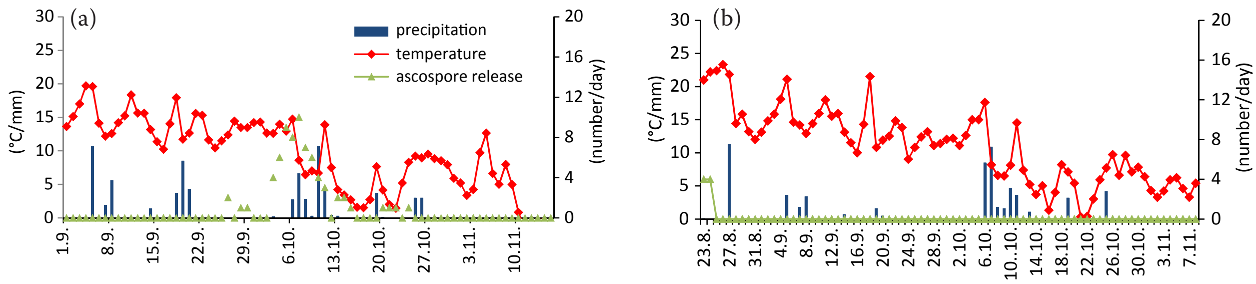
The proPlant model indicated low, medium, and high risk levels at both monitored locations in 2010 (Figures 4). In the Šumperk region, the model assessed the risk of infection as low till September 15, 2010, from September 16, 2010 till November 13, 2010 as medium, and after that time as high. The maximum ascospores daily release reached 14 spores per slide on September 29, 2010. However, this value did not correspond to the proPlant forecast of medium risk in this period. For the Opava region, the proPlant model assessed the risk of infection as low till September 28, 2010, from September 29, 2010 till November 22, 2010 as medium, and after that date as high. The maximum number of trapped ascospores reached 28 spores on October 15, 2010. It meant a low level of risk and it did not confirm the medium risk of infection announced by the proPlant model. The probable terms of infection risk with subsequent infestation were dated October 20, 2010 for the Šumperk region and October 10–12, 2010 for the Opava region. Optimal conditions for *Leptosphaeria* spp. development occurred 4 days (SUM) and 13 days (OPA) before the first phoma leaf spot occurrence in experimental oilseed rape trials.

Weather conditions did not favour progress of the disease and the disease incidence was thus at a low level. The damage to oilseed rape leaf area assessed on untreated plots in the autumn of 2010 was 10%. The pre-harvest assessment of phoma stem canker in the summer of 2011 confirmed that surface damage predominated; the damage severity was calculated as 18% (SUM) and 32% (OPA).

2011. The experimental trials were sown on August 24, 2011 in the Šumperk region and seedlings were fully emerged on September 2, 2011. In the Opava region the trials were established on August 30, 2011 and seedlings emerged on September 9, 2011. The meteorological data and daily ascospore release are displayed in Figure 3.

The first *Leptosphaeria* spp. ascospore release was recorded in late September (on September 26, 2011) in Šumperk. In Opava the ascospore release was observed only in late August (on August 23, 2011), before sowing of oilseed rape. Peak ascospore release was observed after 11 days in Šumperk and in Opava no other ascospores were trapped. The first symptoms of phoma leaf spot occurred in Šumperk on October 11, 2011, 4 days after peak recorded ascospore release. In Opava the first symptoms of phoma leaf spot occurred on November 4, 2011. The total number of ascospores trapped before the date of the first observed symptoms amounted to 61 ascospores in Šumperk. The maximum spore concentration in Šumperk was 0.694 ascospores/m^3 and in Opava it was 0.277 ascospores/m^3. These results of ascospore release evaluation indicated a low risk of infection.

The number of rainy days (daily precipitation higher than 0.1 mm) till the first phoma leaf spot occurrence



Figures 3. Weather conditions (temperature in °C/precipitation in mm) and daily ascospore release recorded (number/day) in autumn 2011 (a) in Šumperk and (b) in Opava

was 14 (SUM) and 16 (OPA). The total precipitation amounted to 63.6 mm (SUM) and 51.7 mm (OPA). The cumulative temperature for the monitored period calculated from September 1, 2011 till the first ascospore release amounted to 370.6°C (SUM), the cumulative temperature calculated till the first phoma leaf spot occurrence amounted to 549.8°C (SUM) and 675.3°C (OPA).

The proPlant model indicated low and medium levels of infection risk for the Šumperk region and a low level of infection risk for the Opava region in 2011 (Figure 4). In the Šumperk region, the low level of infection risk was assessed till October 11, 2011, after that date the risk assessed by the model was medium. The ascospores daily release reached maximally 10 spores per slide on October 7, 2011. This value corresponded to the proPlant forecast of low level of infection risk in this period. The low level of infection risk was assessed for the whole monitored period in the Opava region. The maximum number of trapped ascospores attained to 4 spores on August 23–24, 2011. After these days no spores were trapped. These results meant a low level of risk and they confirmed the low level of infection risk announced by the proPlant model. The most probable date of infection risk was determined at 4 days (SUM) and 28 days (OPA) before the first phoma leaf spot occurrence in the monitored oilseed rape stands. The days with optimal conditions for pathogen's development with subsequent infestation were dated to October 7, 2011 for both Ústí nad Orlicí (linked to SUM) and Otice (linked to OPA) localities.

Weather conditions did not favour the progress of the disease and the incidence of the disease was

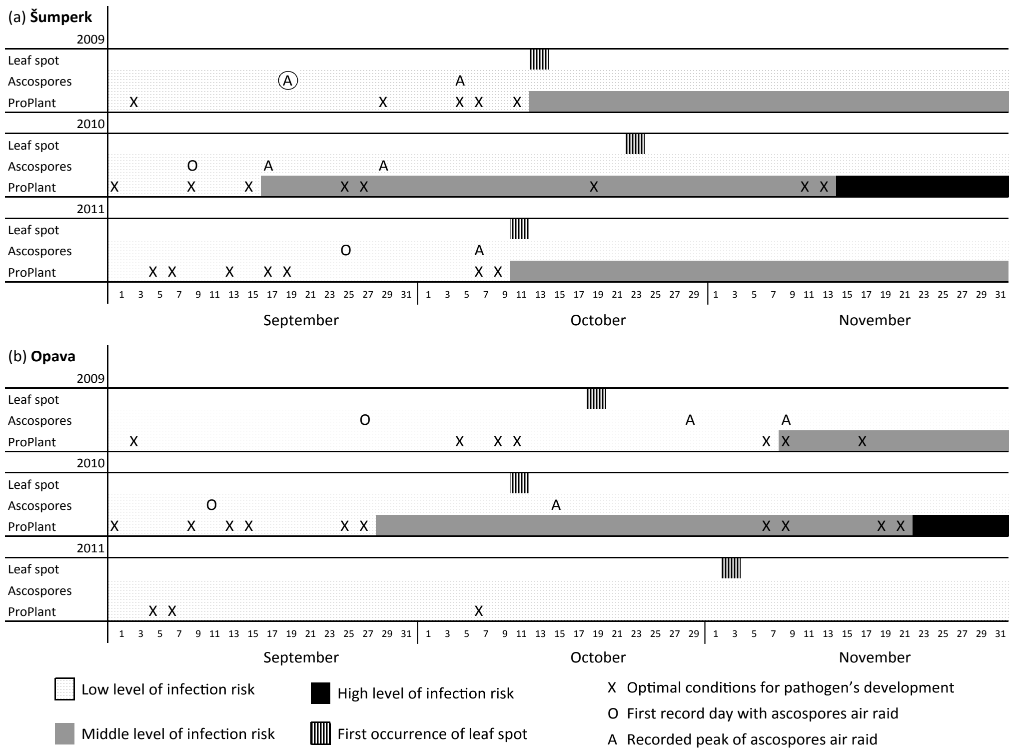


Figure 4. Comparison of prediction models of phoma stem canker infection risk (a) in Šumperk and (b) in Opava

at a very low level. Symptoms occurred sporadically with damage to leaf area reaching less than 5% on average. The pre-harvest assessment of phoma stem canker in the summer of 2012 confirmed higher level of incidence of phoma stem canker; the damage severity was calculated as 50% (SUM) and 30% (OPA).

DISCUSSION

North Moravia is a region with a higher incidence of phoma stem canker in the Czech Republic (Poslušná *et al.* 2012). However, autumn weather conditions did not favour the development of the pathogen throughout the whole monitored period. Phoma leaf spot caused minor damage to leaves on untreated parts of our experimental trials and the roots were not damaged at all. Although an increased level of release of *Leptosphaeria* spp. Ascospores has not been recorded, the disease symptoms were observed. As a result, the first disease symptoms were observed only in advanced growth stages of the oilseed rape (BBCH 14–16). The total number of trapped ascospores corresponded to the average damage to oilseed rape stands. The maximum damage to leaf area through the monitored period reached 10%. The observed level of oilseed rape crop damage at monitored locations in the Czech Republic was similar to the results reported by Dawidziuk *et al.* (2010), who monitored the ascospore release in south-east Poland. They reported that in the years 2005 and 2007 the short exposition to spore showers and very small concentrations of *L. maculans* and *L. biglobosa* ascospores in the air samples were the most probable reasons of a relatively small damage of oilseed rape crops at the Carpathian foothills region in Poland. The total concentration of ascospores during the autumn season recorded in the years 2005–2007 was 12, 10, and 9 ascospores/m^3, respectively. Comparing concentration results within other five Polish regions (Kujavia, Maritime region, Opole region, Pomerania, and Upper Silesia), which moved from 23 to 323 ascospores/m^3 in 2005, from 81 to 910 ascospores/m^3 in 2006, and from 508 to 4347 ascospores/m^3 in 2007, at the Carpathian foothills the ascospores concentration was significantly lower. The *Leptosphaeria* spp. ascospore concentrations in the North Moravian regions in the years 2009–2011 were lower than in Poland. The re-calculated concentration was maximally 2 ascospores/m^3. These low values of ascospore concentrations in North Moravia really responded to the situation in experimental fields located near the operating spore traps.

The differences between the observed and expected ascospores amounts may be attributed to different weather conditions in autumn and mainly to the low level of precipitation in late August and in September. Kaczmarek and Jedryczka (2008) demonstrated that regular rainfall events throughout the whole summer season created very good conditions for pseudothecial maturation and led to abundant release of ascospores of *L. maculans* and *L. biglobosa*. Huang *et al.* (2005) confirmed that wetness provided by rainfall was essential for release of ascospores of both *L. maculans* in the UK and *L. biglobosa* in Poland; temperature did not affect release of ascospore over the range of 5–20°C. In comparison with experiments conducted in controlled conditions, most spores were released from mature pseudothecia at 15°C, but many were still released at 20°C and at temperature as low as 5–8°C (Biddulph *et al.* 1999; West *et al.* 2002). Climatic conditions prevailing at the Czech experimental locations could be compared to those in Poland, especially when the data were collected near the borders with Poland, generally in Central Europe. The average daily temperature measured in September in both Czech regions moved prevalently under 15°C and subsequent ascospore release was observed mostly after rainy days especially in the Šumperk region, where the climate was more humid. A higher total ascospore release during the monitored period was observed in the Šumperk region, but recalculated values of ascospores concentration in the air were higher in the Opava region. The total amounts of trapped ascospores in individual years of the autumn period monitored were 184, 94, and 70 in the Šumperk and 105, 101, and 8 in the Opava regions. In 2010 the total amount of trapped ascospores was comparable in both regions; weather conditions were more favourable compared to the drier years 2009 and 2011. The higher the daily precipitation, the higher the total number of released *Leptosphaeria* spp. ascospores. Dawidziuk *et al.* (2010) reported that the intensity of pseudothecial maturation of *L. maculans* and *L. biglobosa* to a great extent depended on weather conditions – higher humidity increases pseudothecia maturation. The release of ascospores from pseudothecia depended also on humidity and rainfall.

In our experimental work the date of the first phoma leaf spot occurrence was recorded as another rating factor. In the studies performed in the Šumperk and Opava regions phoma leaf spotting in 2009 occurred 24 days after the first ascospore release in both the regions; in the drier year 2010 it was 44 days after the first ascospore release in the Opava region and 45 days after it in the Šumperk region. The results from the year 2011 were the most different. In Opava the first symptoms occurred 72 days after the first trapped ascospores, in the Šumperk region it was 15 days after the first ascospore release. This may be caused by different climatic condition prevailing at the monitored sites, although they were only 65 km apart. West *et al.* (2002) observed appearance of phoma leaf spotting 14–25 days after ascospores first autumn detection in the UK; in Poland leaf spotting was uncommon. Our data obtained from a wide range of incubation periods are comparable with those from Poland.

When comparing announced levels of infection risk generated by both methods (proPlant model, ascospores trapping), annual results differed. The total number of trapped ascospores was significantly lower than e.g. in Poland, but it was sufficient for low infestation of oilseed rape stands followed by phoma leaf spot symptoms occurrence. We suppose that even a small number of distributed ascospores in the air could cause the infection, even if the forecast based on spore concentration in air announced a low level of infection risk. According to the results of real incidence of phoma leaf spot on oilseed rape, which ranged from sporadic occurrence to 10% damage, we noted that the evaluation of ascospore release indicated actual concentration of ascospore release. Although this method was more laborious, it was also more accurate. The main difference between these forecast systems was in the use of different methods to calculate the infection risk. The proPlant model operated only with meteorological data, while evaluation of ascospores release operated with real source of inocula in the air. However, pseudothecial maturation and subsequent ascospore release depended on weather conditions.

The proPlant model correlated with the time of the first occurrence of phoma leaf spot symptoms. Generally, leaf spot occurred in the second decade of October and the proPlant model predicted the medium level of infection risk, just when the first symptoms were observed (SUM 2009 and 2011) or appeared during this period (OPA 2010). In 2011, the proPlant model prediction for the Opava region was in accordance too, when the low level of infection risk was announced and the first symptoms occurred later in November. Nevertheless the proPlant model also highlighted the days with optimal conditions for *Leptosphaeria* spp. development and in this case the forecast did not directly correspond to ascospores release. Only in some cases the predicted optimal days matched with the real increased spore release. This could be due to different placement of the experimental trials and the proPlant meteorological stations.

The monitoring of inocula of fungal pathogens in the air samples is used as a support tool for decisions of oilseed rape protection in many countries such as Poland, Germany, the UK, France, Sweden etc. (Jedryczka *et al.* 2011). The results concerning life cycle development of plant pathogenic fungi, including *Leptosphaeria* spp., are of vital importance for effective chemical treatments (Dawidziuk *et al.* 2010). The proPlant method used only selected meteorological data such as rain precipitation, daily temperature, and wetness in growth stands to calculate the risk of infection. Both methods were suitable for predicting the risk of infection and providing the growers with specific information on crop protection.

CONCLUSION

(1) The infection risk of phoma stem canker on oilseed rape in the Czech Republic was estimated according to the proPlant model and monitoring of *Leptosphaeria* spp. ascospore release.

(2) The proPlant model in our experimental work overestimated the number of days of infection risk, but the first occurrence of phoma leaf spot fell predominantly into the medium level of the infection risk.

(3) In the last few years (2009–2011) phoma stem canker did not cause serious damage in the Czech Republic in the autumn period. This was confirmed by both predicting systems – monitoring of *L. maculans*/*L. biglobosa* ascospores release and the proPlant model.

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