Epidemiological investigations on winter oilseed rape (*Brassica napus* L. var. *napus)* infected by *Phoma lingam* (Teleomorph. *Leptosphaeria maculans*) and the effects of different fungicide applications with Folicur® (tebuconazole)

[1]**Torben Kruse,** [2]**Joseph-Alexander Verreet**
Christian-Albrechts-University, Institute of Phytopathology, Hermann-Rodewald-Str. 9,
D-24118 Kiel, Germany, tkruse@phytomed.uni-kiel.de[1], javerreet@phytomed.uni-kiel.de[2]

ABSTRACT

Epidemiological investigations were conducted in winter oilseed rape to study *Leptosphaeria maculans* ascospore flight and the infection of foliage and root collar through *Phoma lingam* and its resulting damage in relationship to weather conditions at different sites in northern Germany (Schleswig-Holstein).

The effects of different fungicide applications in autumn, in spring, at flowering and combinations thereof using Folicur® (tebuconazole) and Derosal® (carbendazim) were also investigated for their control of infection.

The results emphasised that the weather factor precipitation, especially in September, was of particular importance with regard to ascospore release from *Leptosphaeria maculans*. Also a very close relationship could be determined between *Leptosphaeria maculans* ascospore flight and leaf infection by Phoma lingam in autumn. Leaf infection was reduced through a fungicide application in autumn as well as in spring. An effective control of *Phoma lingam* on the root collar resulted only through autumn treatment. On average of year and site increased yield of 3.4 dt/ha resulted from the combined autumn/flowering application (AF), 4.9 dt/ha from the spring/flowering treatment (SF) and 6.5 dt/ha from the combined autumn/spring/flowering (ASF) sprays. The yield addition from the flowering treatment (F) alone was 3.0 dt/ha.

Key words: ***Phoma lingam*, *Leptosphaeria maculans,* ascospore release, winter oilseed rape, tebuconazole**

INTRODUCTION

In the European Union the area sown to oilseed rape has increased by 20% in the last decade with a similar trend shown in Germany with strongest expansion occurring in 2002 with 1,297,000 ha of the crop (FAO 2003) being grown. In northern Germany (Schleswig-Holstein) winter oilseed rape is the most important crop after winter wheat being grown in a three-course winter rape, winter wheat, winter barley rotation. On a federal basis the most significant pathogen of winter rape is *Phoma lingam* (Teleomorph. *Leptosphaeria maculans*). (PAUL et al. 1991) *Leptosphaeria maculans* creates multiply septulated 30 – 70 µm long cylindrical ascospores within pseudothecia on plants infected from remaining harvest surface trash (PUNITHALINGAM & HOLLIDAY 1972). These are expelled mainly from September to November in Central Europe (KRÜGER & WITTERN 1985, SCHRAMM 1989, THÜRWÄCHTER 1995) and infect rape plants after a few hours of leaf wetness thus causing the primary infection of the young plants (MC GEE 1977, HAMMOND et al. 1985, SCHRAMM 1989, SCHRAMM & HOFFMANN 1992). In its further progress, the systematic expansion of the pathogen enables colonisation of leaf stalk and root collar (HAMMOND et al. 1985, GLADDERS et al. 1999).

The aim of the investigation was the analysis of distribution and infection by the pathogen *Leptosphaeria maculans* / *Phoma lingam* in relationship to the weather conditions in northern Germany and to study the effects of different fungicide applications in autumn, in spring, at flowering and combinations thereof for their control of infection using Folicur® (tebuconazole) and Derosal® (carbendazim).

MATERIALS AND METHODS

Epidemiological investigations of infections through rape pathogen fungi were conducted at three trial sites in the Schleswig-Holstein named Birkenmoor, Tolk and Westcoast. All the trials had a randomised block design comprising harvest and sample plots with four repetitions per variant featuring the commercially relevant variety *Express* (varietal proportion in Schleswig-Holstein: 40%). Alongside the untreated control variant, all sites and all years featured differentiated fungicide applications with Folicur® (active ingredient: tebuconazole) and Derosal® (carbendazim). The differentiated fungicide applications comprised a combined autumn and flowering treatment (AF), a spring and flowering one (SF), an autumn, spring and flowering one (ASF) and a sole flowering treatment (F), The autumn treatment was applicated at GS 15-18 (A= 0,5 l Folicur/ha), the spring treatment at GS 32-51 (S= 0,75 l/ha Folicur) and the flowering treatment at GS 65 (F= 0,5 l/ha Folicur + 0,5 l /ha Derosal). The recording of weather data at all sites was by agro-meteorological weather stations (type Weihofen, Adolf Thies GmbH & Co. Kg, Göttingen).

For determining *Leptosphaeria maculans* (teleomorphic) ascospore flight, a Burkhard spore trap was used (Thermo-Dux, Wertheim am Main, induction height: 45 cm, suction volume: 10 l/min) at all sites from September to November; ascospore were counted by microscope. Investigations into the epidemiological spread of *Phoma lingam* (anamorphic) as well as the measuring of the biological effect of the differentiated fungicide applications were conducted by plant sampling (40 plants, 10 plants/repetition) taken out of the sample plots from September to November and from March until harvest (end of July) in the following year.

RESULTS

a) Epidemiology of *Leptosphaeria maculans* and *Phoma lingam* at Birkenmoor site

Presented in fig. 1 are the daily *Leptosphaeria maculans* ascospore recordings in relationship with weather and the resulting epidemiological spread of *Phoma lingam* on leaves at the trial site Birkenmoor 2000-2002. It was clear that there were substantial variations in the quantity of the spore flight in association with precipitation dispersal over the individual years and sites. In 2000 the dominating precipitation from beginning to mid-September led from the middle of the month on the sites Birkenmoor to more intensive spore ejections. The rest of the vegetation period to mid-October was characterised through sporadic precipitation with associated reduced spore flight. Increasing precipitation intensity and distribution end of October to end of November induced in November at the Birkenmoor site spore releases. The premature ascospore flight (mid-September) led from the beginning of October to the initial P*homa lingam* (DS, pycnidia per plant) population expansion on leaves. In the further vegetation period of 2000 there was a low level of *Phoma lingam* infection.

September 2001 was characterised by the most intense precipitation of the whole trial period. In the comparison of the years the highest daily spore ejections of *Leptosphaeria maculans* and, as a result, from beginning of October the most intense leaf infection through *Phoma lingam,* were registered as correlating. The reduced intensity and distribution of rainfall in October in association with pathogen and senescence-caused dying-back of the lower and advanced middle leaves resulted in a reduction in leaf infection intensity (DS).

Contrary to this, the precipitation deficit dominating during September 2002 prevented an intensified ascospore release from *Leptosphaeria maculans* and an increased infection development of *Phoma lingam* in foliage. Sporadic rain showers from end of September to mid October led to first increased ascospore releases but did notpermit the development of *Phoma lingam* infection on leaves because of the low temperatures occurring in October. Increased frequency of showers from the end of October induced more releases of ascospores. The reduction in the increased precipitation frequency from the end of October induced increased ascospore release although because of the reducing temperatures as winter began these remained without epidemiological importance for foliage infection in the remainder of the vegetation period. The low ascospore ejections in September caused by the precipitation deficit was, together with the lower temperatures in October, responsible for the low starting inoculum potential for foliage, which was determined before winter. These described tendencies of ascospore release in relation to wheather conditions were studied at the other trial sites Tolk and Westcoast as well.

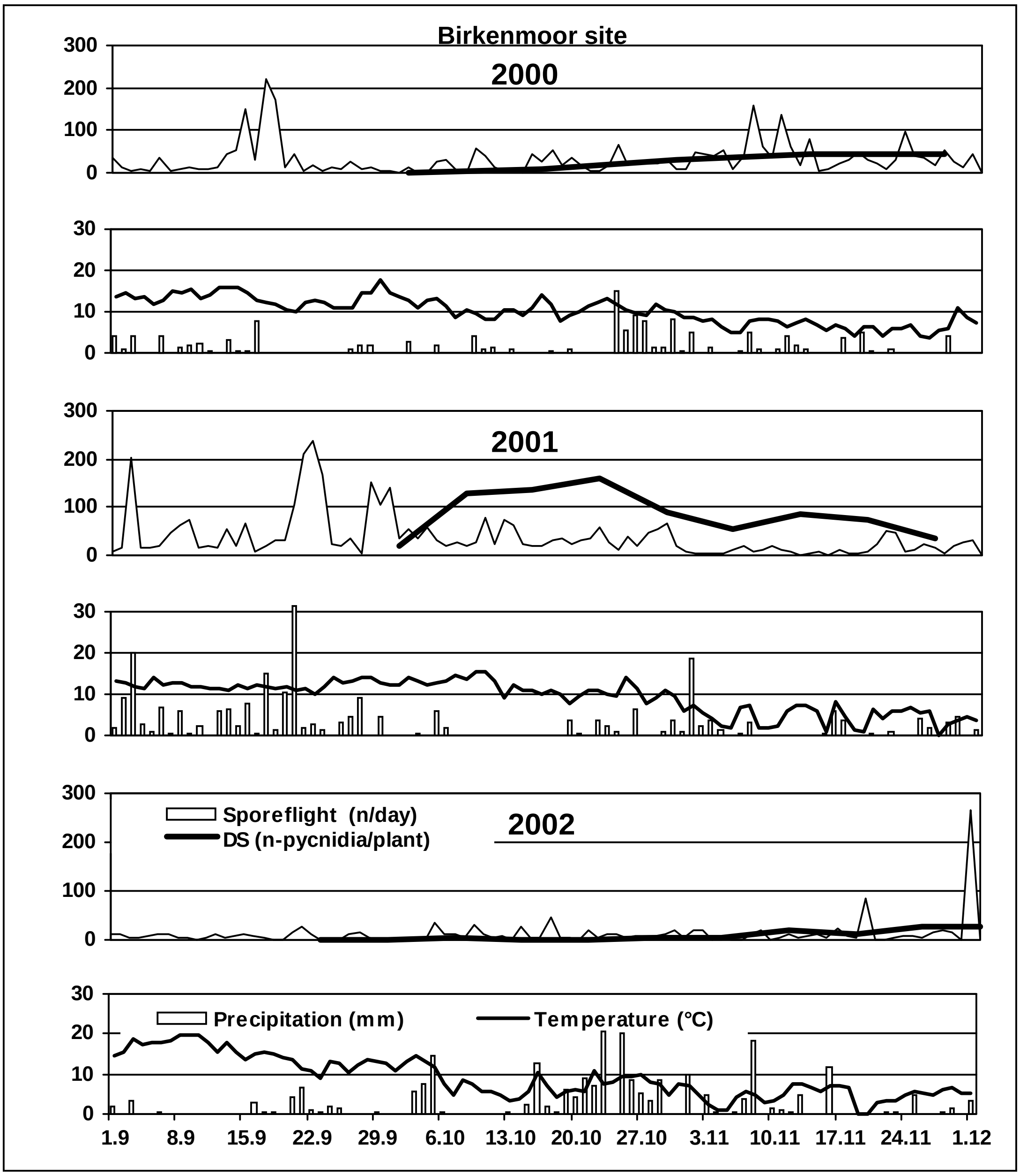

Fig. 1: *Leptosphaeria maculans* ascospore flight, diesease severity (DS) of *Phoma lingam* on leaves. September to December. Weather parameters: precipitation (mm), temperature (°C), Birkenmoor site, 2000-2002

b) Effects of differentiated fungicide applications

The fungicide application in autumn (0.5 l Folicur®, variant AF, ASF, BBCH 15-18) led to a reduction of infection severity from *Phoma lingam* in foliage when compared over year untreated control in October and November (Fig. 2) at the Birkenmoor site. The early indication controlling influence was evident right through to, and including, March. In spring (March, April), a strong increase in the pathogen population could be determined in the untreated control as temperatures rose. An appropriate spring application (0.75 l Folicur®, variant SF, ASF, BBCH 32-51) reduced the degree of infection in foliage in April. The effects of differentiated fungicide applications on the visible infection development from the beginning of May of *Phoma lingam* on the root collar was shown (Fig. 3) through average values from six assessment dates in the vegetation period from May to July over the years 1998 – 2002. The autumn treatment (0.5 l Folicur®, variant AF, ASF, BBCH 15-18) led, in comparison to the untreated control, to a reduction of infection intensity (DS) on the root collar. Taking the average of all individual trials the autumn treatment variant recorded a reduction in the spread of *Phoma lingam* regarding the pycnidia count on root collars (DS) of 41.1% (AF) or 44.7% (ASF). Compared with this, the spring treatment variant (0.75 l Folicur®, variant SF, ASF, BBCH 32-51) had a reduced influence on infection (DS) at the root collar which led to an infection reduction of 11.6 %.

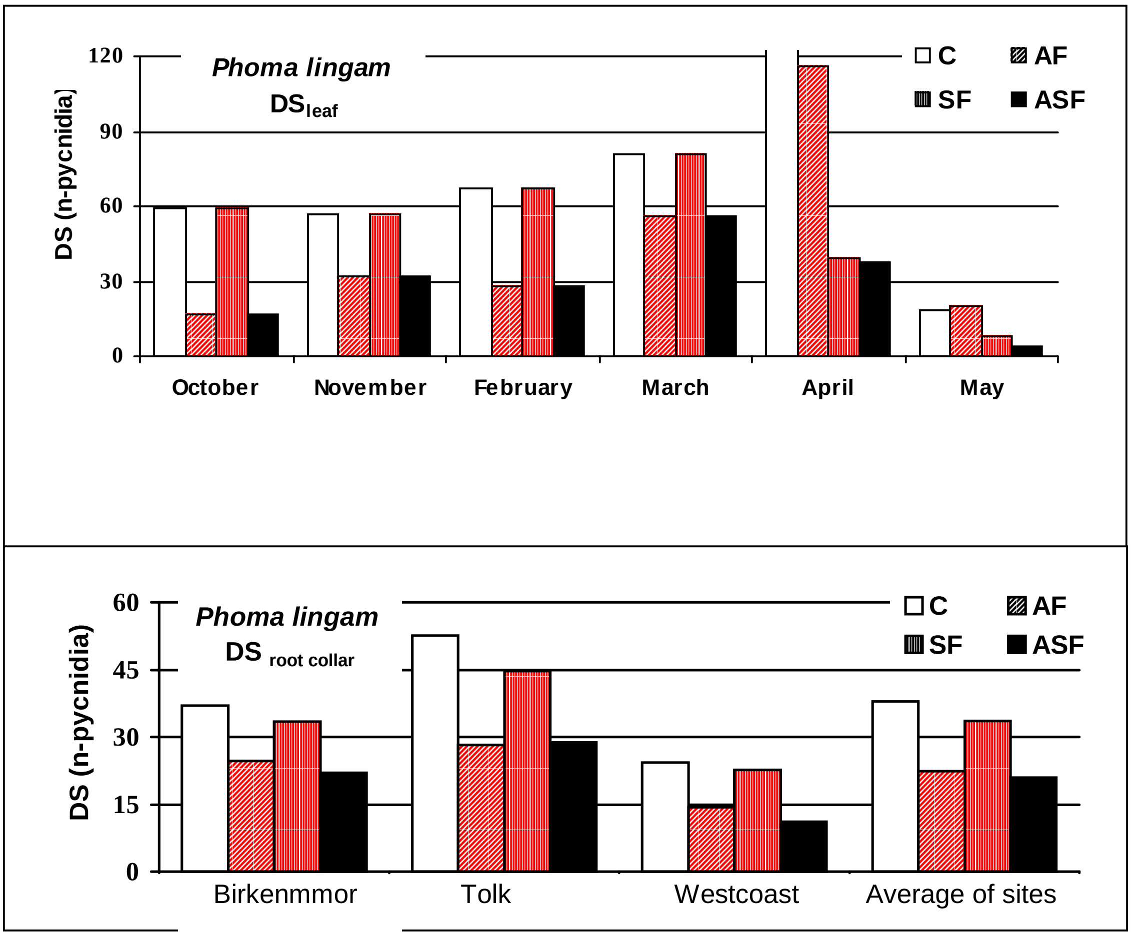

Fig. 3: Effects (... le treatments on disease severity (DS) of *Phoma l...gam* infections on r ... average of the years 1997-2002.

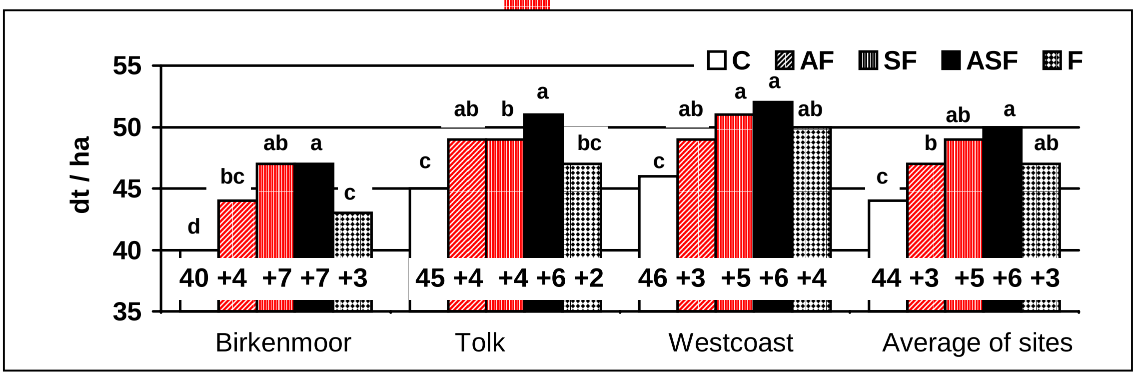

Fig. 4: Effects of different fungicide treatments on yield (dt/ha) , average of the years 1997-2002.

In all years the fungicide applications terminated at different times led, in almost all variants, to a reduction in losses in the form of a yield increase compared to untreated control (C). The recorded yields over the years (1998 – 2002) and sites emphasised that through the combined autumn, spring and flowering treatments (ASF) a significant yield increase of 0.65t/ha resulted as a maximum loss reduction compared to untreated controls (C). The combined spring / flowering applications (SF) achieved on average of all trials a statistically significant yield increase of 0.49t/ha. Compared with this, the autumn/flowering treatment (AF) and the flowering treatment on its own (F) resulted in a reduced yield effect and led on the average of the years to a yield increase of 0.34t/ha (AF) and 0.30 t/ha (B) respectively (Fig.4).

DISCUSSION

The importance of the weather factors precipitation and temperature for the epidemiological development and spread of the pathogens *Leptosphaeria maculans* and *Phoma lingam* has been described by various authors (KRÜGER & WITTERN 1985, VANNIASINGHAM & GILLIGAN 1989, WEST et al. 2001) and these factors can be regarded as the cause of these year and site specific variations. The disease-reducing effect on pathogen leaf infection of the differentiated fungicide applications in autumn and spring was confirmed through the findings of GARBE (2000) and WOHLLEBEN & VERREET (2002). HALL (1992) and WEST et al. (1999) attribute a definitely higher yield effect from root collar infection compared with leaf infection. The higher efficacy of the autumn treatment on root collar infection compared with spring sprays determined in own investigations confirms the statements from different authors (SCHRAMM 1989, THÜRWÄCHTER et al. 1999, GARBE 2000). The demonstrated limited effect on root collar infection through the spring treatment with 0.75 l Folicur® could be explained through leaf infection at this time being only of low importance for the root collar infection as stated by HALL (1992) and other authors (HAMMOND, 1985; FESER 1992; WEST et al., 1999a). Even Root collar infection was reduced by the autumn treatment the yield increase was lower compare to the spring application. This was confirmed in investigations by THÜWÄCHTER (1995) and SCHMIEDEL & KÖPPL (1996). Two aspects appear to be of importance in an assessment of the yield-effective importance of autumn treatments. The variety Express, used in nearly all the trials, was classified by the Bundessortenamt (ANONYM 2002) as having limited susceptibility to *Phoma lingam* (assessment score 3, scale 1-9). This means there exists in Express a high level of tolerance to the pathogen compared to older varieties with increased susceptibility. Over and above this, the site-specific dominating infection pressure has an influence on the yield loss reduction resulting from fungicide treatments. Thus at Tolk site where there was increased root collar infection a comparatively high infection reduction and yield increase could be achieved through the autumn treatment. The higher yield increasing effect of the spring treatment has to be discussed in contents with growth regulatory effects (stem axis shortening, reduction of lodging). Results from BAYLIS & WRIGHT (1990) document, in trials with artificial induced lodging, a direct relationship between the intensity of lodging and the harvest yield whereby yield losses of up to 52% were determined where extensive lodging was induced. The yield effect of a combined autumn, spring and flowering treatment can be attributed on the one hand to the accumulated effect from biological control of the infection process at the root collar and on foliage and, on the other hand, to the exhibited positive effect of the fungicide Folicur® on the plant morphogenesis (stem axis shortening, reduced tendency to lodging).
Detailed results of this study will be published by KRUSE and VERREET (in press, accepted 2003).

REFERENCES

Anomymous (2002): Beschreibende Sortenliste 2002: Getreide, Mais, Ölfrüchte, Leguminosen (großkörnig), Hackfrüchte (außer Kartoffeln). Landbuchverlag, Hannover.

Baylis, A.D. & I.T.J. Wright (1990): The effects of lodging and a paclobutrazol–chlormequat chloride mixture on the yield and quality of oilseed rape. Annals of Applied Biology 116, 287-295.

FAO, (2003): http://apps.fao.org/page/collections?subset=agriculture, 08.01.2003.

Garbe, V. (2000): Fungizide im Winterraps. Raps 18, 60-65.

Gladders, P., B.D.L Fitt & J.A. Turner (1999): Improving strategies to control canker in the UK. Proceedings of the 10th International Rapeseed Congress, September 26. - 29. 1999, Canberra, Australia.

Hall, R. (1992): Epidemiology of blackleg of oilseed rape. Canadian Journal of Plant Pathology 14, 46-55.

Hammond K.E., B.G. Lewis & T.M. Musa (1985): A systemic pathway in the infection of oilseed rape plants by Leptosphaeria maculans. Plant Pathology 34, 557-565.

Feser, M. (1992): Die Integration chemischer Pflanzenschutzmaßnahmen gegen Leptosphaeria maculans (Desm.) Ces. et de Not. (Imperfektstadium Phoma lingam (Tode ex Fr.) Desm.), dem Erreger der Wurzelhals- und Stengelfäule an Winterraps. Dissertation, Technical University of Munich.

Krüger, W. & I. Wittern (1985): Epidemiologische Untersuchungen bei der Wurzelhals- und Stengelfäule des Rapses, verursacht durch Phoma lingam. Phytopathologische Zeitschrift, 113, 125-140.

McGee, D.C. (1977): Black leg (Leptosphaeria maculans (Desm.) Ces et de Not.) of rapeseed in Victoria: Sources of infection and relationship between inoculum, environmental factors and disease severity. Australian Journal of Agricultural Research 28, 53-62.

Paul, V.H., K.-J. Gerdiken & A. Günzelmann (1991): Neue Erkenntnisse über die Reaktion von 00-Sorten und die Wirkung von Fungiziden auf die Wurzelhals- und Stengelfäule des Winterrapses Nachrichtenblatt des Deutschen Pflanzenschutzdienstes, 43, 89-92.

Punithalingam, E. & P. Holliday (1972): Leptosphaeria maculans, CMI Descriptions of Pathogenic Fungi and Bacteria No. 331. In: Commonwealth Mycological Institute (Edit.) Kew, Surrey, England, Set 34.

Schramm, H. (1989): Zur Epidemiologie von Leptosphaeria maculans (Desm.) Ces et de Not. (Imperfektstadium Phoma lingam (Tode ex Fr.) Desm.), dem Erreger der Wurzelhals- und Stengelfäule an Winterraps als Grundlage eines integrierten Pflanzenschutzes. Dissertation, Technical University of Munich

Schramm, H. & G..M. Hoffmann (1992): Der Einfluß von Fungizidapplikationen auf die Entwicklung des Befalls durch Phoma lingam an Winterraps. Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz 99, 145-158.

Schmiedel, J. & H. Köppl (1996): Lohnt sich der Fungizideinsatz im Raps. Raps 14, 16-19.

Thürwächter, F. (1995): Kriterien für die Bekämpfung von Rapskrankheiten unter besonderer Berücksichtigung der Wurzelhals- und Stengelfäule. Dissertation, University of Göttingen.

Thürwächter, F., V. Garbe & H.-H. Hoppe (1999): Ascospore discharge, leaf infestation and variation in pathoganicity as criteria to predict impact of Leptosphaeria maculans on oilseed rape. Phytopathologische Zeitschrift 147, 215-222

Vanniasingham, V.M. & C.A. Gilligan (1989): Effects of host, pathogen and environmental factors on latent period and production of pycnidia of Leptosphaeria maculans on oilseed rape leaves in controlled environments. Mycological Research 93, 167-174.

West, J.S., J.E. Biddulph, B.D.L. Fitt & P. Gladders (1999): Epidemiology of Leptosphaeria maculans in relation to forecasting stem canker severity on winter oilseed rape in the UK. Annals of Applied Biology 135, 535-546.

West, J.S., P.D. Kharbanda, M.J. Barbetti & B.D.L. Fitt (2001): Epidemiology and management of Leptosphaeria maculans (phoma stem canker) on oilseed rape in Australia, Canada and Europe. Plant Pathology 50, 10-27.

Wohlleben, S. & Verreet, J.-A. (2002): Epidemiologie, Schadrelevanz und Bekämpfung von Phoma lingam (Teleomorph Leptosphaeria maculans) an Winterraps (Brassica napus L.var. napus). Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, 109, 227-242.