Sooty Blotch Research – a Progress Report

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Abstract

Sooty blotch causes heavy losses in Lake Constance organic apple production. In the last years research has been done at the Research station for fruit growing (Kompetenzzentrum Obstbau – Bodensee, KOB) on disease development, on timing of spray applications, on control strategies with different agents and on cultivars suceptibility. After considering all the separate trial results, a positive conclusion can be drawn. From the 2008 and 2009 results it appears that a potential product is available that can give satisfactory control of sooty blotch even when the disease pressure in the orchard is very high. To reduce the number of spray applications to the desired level of 4 per year will require further research and this will certainly also depend on the seasonal conditions. Attention should be given to early treatments in June until the middle of July. Infection can take place over the whole season. Decisive for the severity of the infection, is when the infection takes place and when the fruit is exposed to weather conditions. The efficacy of spray products depends on the disease pressure. In new plantings with susceptible cultivars control measures should begin early in the season.

Keywords: sooty blotch, disease development, bagging experiments, treatments, cultivar susceptibility

Disease development in 2009 in Lake Constance region

Untreated 'Topaz' apple trees growing outdoors were regularly monitored for sooty blotch symptoms and the disease cycle tracked and recorded. Two times per week, from the end of June, 250 apples were assessed for symptoms and scored in 5 severity classes (Fig. 1).

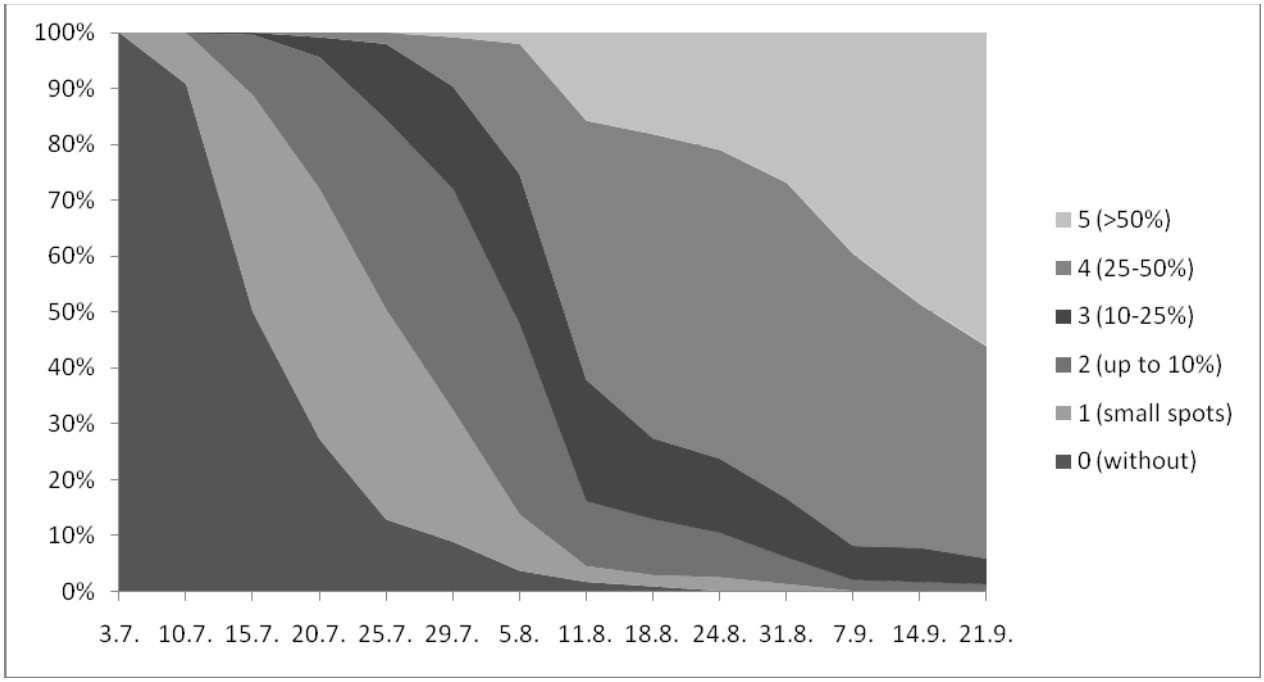

Fig. 1: Sooty blotch symptom development 2009; Proportion (%) of infection class by date.

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This disease survey has been carried out at the KOB each year since 2005 and allows for seasonal comparisons of disease development. In 2009, the first symptoms were recorded on 7 July and in 2008 on 15 July, and this was around 3 weeks later than in 2007. At 24 August 2009 all apples were showing sooty blotch symptoms, while in 2008 this level of infection had already occurred at 5 September and at 31 July in 2007. Because of the later disease development in 2008 the incidence at harvest was lower at 86% compared to 98% in 2007 and 90% in 2009. The occurrence of sooty blotch in 2008 was later and less severe than in the other two years.

Disease severity can be calculated as an index that allows the severity of a particular orchard infection to be expressed. This index is derived from a formula that takes account of number of apples scored in each disease severity class.

Comparisons from the years 2005 – 2009

An overview of the apple growth stages and sooty blotch life cycle shows that the full bloom date was 14 days later in 2008 compared to 2007 (Tab. 1) and the T-stage also was correspondingly approximately 14 days later. In 2009 compared to 2008 the full bloom was 7 days and T-stage approximately 14 days earlier. The T-stage appears to play a role in the pathogen's biology as from around this stage a process known as 'leaching' starts when soluble substances are released by the young fruitlet out through the cuticle. Sooty blotch pathogens live only on the cuticula surface and feed on the substances released from the fruit. So it appears that the leaching process is linked with the disease infection cycle. Possibly this means sooty blotch infection can only develop after developmental stage.

Table 1: Growth stages and Sooty Blotch Life Cycle for 2005-2009 at KOB, Bavendorf.

	2005	2006	2007	2008	2009
full bloom	30.04.	06.05.	18.04.	02.05.	25.04.
"petal fall"	09.05.	16.05.	27.04.	08.05.	04.05.
T-stage	18.06.	28.06.	31.05.	14.06.	27.05.
harvest time	04.10.	27.09.	13.09.	22.09.	22.09.
First symptoms of sooty blotch	20.07.	05.08.	20.06.	15.07.	07.07.
number of days between full bloom and the first symptoms	81	91	63	74	73
summation of wetness hours: full bloom - first symptoms	425	420	305	221	366
amount of wetness hours calculated by Sutton	278	285	241	205	240
precipitations: full bloom -first symptoms	236	230	250	189	306

In the USA Sutton et. al. (2002) developed a wetness-hour summation method for predicting the development of sooty blotch symptoms. Based on Sutton's method, the number of wetness-hours (WH) (wetness periods exceeding 4 hours) are accumulated, starting from the first rainfall event to occur 10 days after petal fall. In the USA, the first sooty blotch symptoms appear after 275 wetness-hours are accumulated. At KOB, in the years between 2005 and 2009 (with the exception 2007), 240 to 285 wetness-hours were required for symptoms to first appear. These values are very similar to the amount calculated by Sutton (Table 1). In 2008 the first symptoms appeared later than in 2007, as there were clearly less wetness-hours recorded (205 WH).

Bagging Experiments

Interesting aspects regarding the sooty blotch life cycle have been shown in an experiment 2008 where 30 apples were always bagged at different dates. The aim of this study was to find out when the sooty blotch infection periods occur. Starting from the T-stage and weekly thereafter, apples were enclosed in bags. The waterproof bags protect the apples from infection. The results of this work are shown in Fig. 2. The upper grey bars show the results when apples were bagged at weekly intervals (starting from 02 June). The lower bars show the opposite treatment (bag removal). The disease severity is shown on the right hand axis.

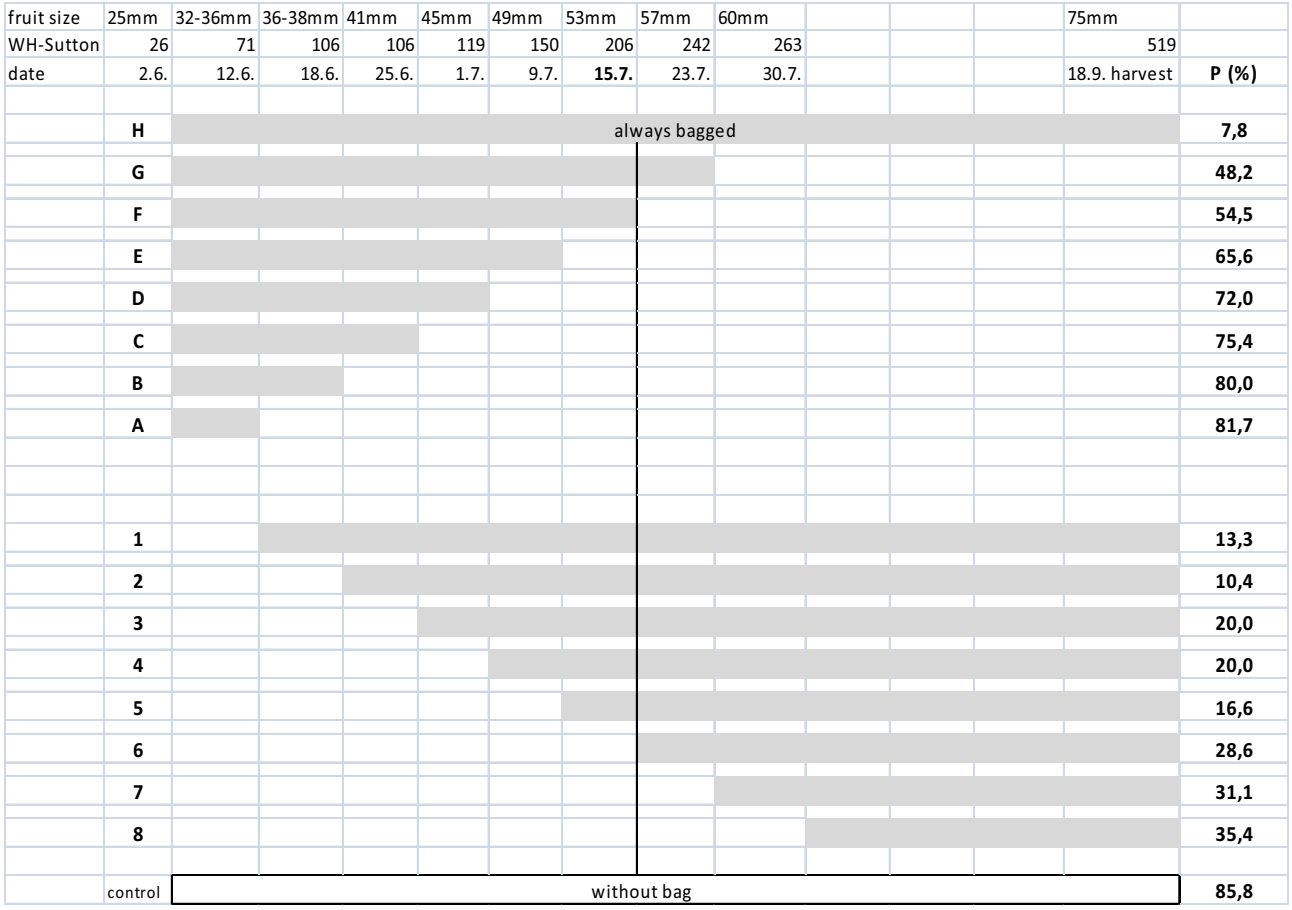

Fig. 2: Results from bagging and bag removal

Treatment A, as seen in the upper bars in Fig. 2 (bagged only from 02 until 12 June) shows the highest infection index at 81,7 by time of harvest. Treatment H (bagged for the longest period from 02 June until harvest) shows an infection index of only 7,8. That the

completely bagged apples still show some sooty blotch incidence can be explained by condensation within the bags and that the bags were not 100% water tight around the stem end where small spots of sooty blotch occurred. Interestingly, the infection index shows a linear relationship with exposure time where the longer the apples were unprotected by a bag and thus exposed to rain and spores, the higher the infection index was at harvest. The most important conclusion is that sooty blotch infection is possible over the whole season, and there are no clearly defined high risk infection periods. The total infection incidence that develops by harvest is dependant on the time that the apples are exposed to weather conditions. When the infection occurs later in the season, the fungus has less time to colonise and spread. The severity of infection is closely related to time between infection and harvest. Because of the long incubation period late infections cannot develop a high severity index. It is known from the literature (Grabowski & Wrona 2004), that the infections time is shorter if the infections occur earlier in the season.

These results make clear that the early infections and their treatment within the disease control strategy are much more important than the late spraying. The experimental approach with the opposite bagging treatment (i.e. placed in bags versus bag removal) confirms this assumption.

Timing of Spray Applications

In another experiment carried out over two seasons at the KOB, the same conclusions can be drawn. In this experiment the usual apple scab (*Venturia inaequalis*, Cooke) treatments with lime sulphur and wettable sulphur sprayed at different times. A part of the trial trees were only treated during June, and another part additionally treated in July. The control was untreated (no sprays).

In the 2007 season, a total of 5 spray applications (1x lime sulphur & 4x wettable sulphur) were applied during June as experimental treatment 1. As treatment 2 an additional 6 spray applications were made during July. When the fruit were scored by severity class, the proportion of marketable apples with less than 10% of the fruit surface infected with sooty blotch (severity classes 0-2) in both the treatments 1 (only June) and 2 (June + July) was nearly the same (Table 2).

Table 2: Results 2007/2008 of spray applications made in June and June plus July

infection class	0 without	1 small spots	2 up to 10%	3 10-25%	4 25-50%	5 >50%
2007						
control (P=59,67%)	3,8	10,7	22,3	21,2	30,6	11,4
June (P=32,31%)	7,1	38,4	41,8	11,3	1,4	0,0
June + July (P=28,59%)	14,1	37,4	40,6	7,4	0,6	0,0
2008						
control (P=45,4%)	4,1	12,9	47,1	24,0	11,6	0,2
June (P=6,8%)	73,2	19,7	6,9	0,2	0,0	0,0
June + July (P=3,6%)	84,8	12,6	2,6	0,0	0,0	0,0

The marketable percentage of apples from the 5 spray applications in June was approximately 87% and in the treatment with 11 spray applications (up until the end of July) was 92%. In the untreated control the marketable percentage was clearly lower at

37%. Over 40% of the untreated control showed a severe infection with over 25% of the apples' surface covered with sooty blotch.

These results were confirmed again in 2008. In this season, 4 spray applications during July in addition to the 5 already applied during June did not appreciably increase the percentage of marketable fruit. In both spray treatments, the amount of marketable fruit was nearly 100%, while the untreated control had only 63% marketable fruit.

This experiment supports the conclusion that avoiding early infection is the key to a low total incidence at harvest as the fungus requires a long development period and this also reduces the risk of secondary infection. When the first infection occurs late in the season, the fungus has less time to develop and produce visual mycelium.

Trials with Different Control Agents

Over the last 3 years, in addition to the experiments on sooty blotch biology and infection dynamics, a range of different control agents of practical potential have been evaluated under the framework of the DBU project. This project has been previously described (Buchleither & Späth 2007, Mayr & Späth 2008). During the previous season at the KOB in Bavendorf, different products were tested: wettable sulphur; lime-sulphur; 'Vitisan' (potassium hydrogen carbonate); 'Armicarb' (potassium bicarbonate); and Ventex (potassium carbonate with a soap formulation); and in addition 'Armicarb' and 'Vitisan' both in combination with wettable sulphur. These treatments were applied six times. Applications were based on leaf wetness and applied following severe infection periods (after Mills apple scab infection table). The results are given in table 3 with an infection severity index (P%) of 80,5% in the untreated control and the lowest infection level is achieved by the 'Ventex' treatment. This product also showed good results in 2007 with only 3 applications. With seven applications in 2008 'Ventex' gave 96.5% marketable fruit as compared to the untreated control with 7.0%.

Table 3: Trials with different products in 2009

	Infection classes							Marketable apples [%]	Russeting [%]
	0	1	2	3	4	5	P (%)		
Control	0,1	1,3	5,9	16,3	41,2	35,1	80,5	7,4	8,8
Lime sulphur	8,2	16,9	37,2	28,8	8,3	0,6	42,8	62,3	5,5
Cocana	3,2	15,3	32,5	36,0	10,6	2,3	48,5	51,0	9,36
Armicarb + WS	20,8	29,2	35,2	13,8	0,9	0,0	29,0	85,2	7,4
Vitisan + WS	7,5	18,3	42,2	24,3	7,2	0,5	41,4	68,0	6,6
Vitisan + Cocana	11,6	31,1	34,5	16,2	6,1	0,4	35,1	77,3	9,96
Ventex	39,2	24,3	26,6	9,4	0,5	0,0	21,6	90,1	16,7

The efficacy of biological products in general depends on the disease pressure and increasing inoculum load. When trial results from very severely infected orchard sites show efficacy the results can judged with more confidence. Lime sulphur as expected shows a better result than wettable sulphur. Also the efficacy of potassium hydrogen carbonate

'Armicarb' and 'Vitisan' with the addition of wettable sulphur can be improved as already shown in previous black spot trials. The efficacy of both these products for sooty blotch control is comparable with lime sulphur although the 'Armicarb' formulation shows overall better efficacy than 'Vitisan'.

Cultivar Susceptibility

In the apple scab resistance trial plantings at the KOB, there are over 60 different cultivars with differing parentage and planting years (from 2001). Except for the green tip spray applications there are no fungicide treatments applied to these trees, so it is possible to observe sooty blotch disease susceptibility for a wide range of different cultivars growing at one location.

In 2007 (Späth & Mayr 2008) and 2008, after harvest 250 apples per cultivar were assessed for sooty blotch with the disease severity scored in 0-5 classes.

Our observations confirm that apple cultivars with a late harvest date show a higher incidence of sooty blotch than early season cultivars (Fig. 3). This difference in disease incidence is explained by the longer time period over which infection can take place. In 2008, average disease severity across all cultivars was 50% lower than in 2007, but the tendencies in sooty blotch susceptibility for individual cultivars were similar in both seasons.

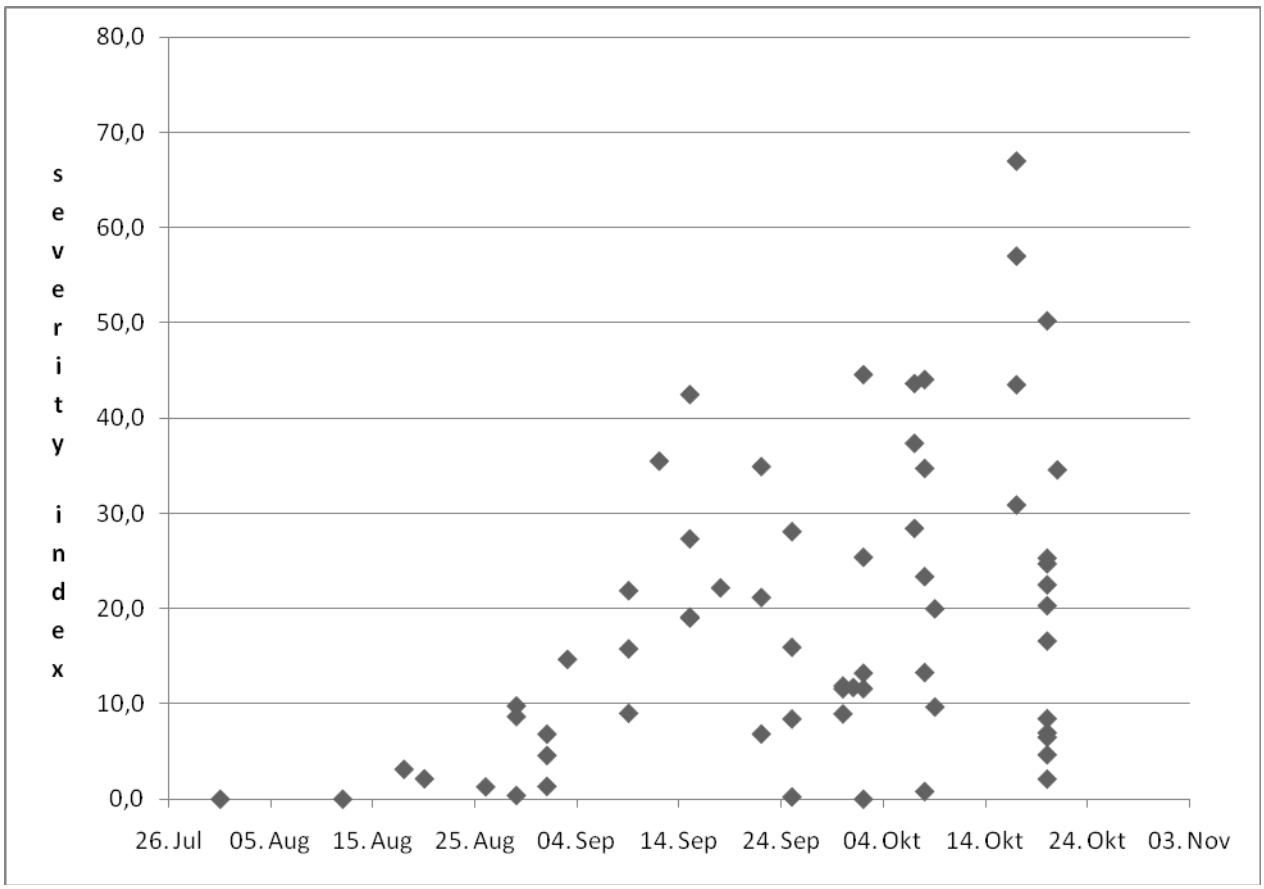

Fig. 3: Effect of harvest date on sooty blotch severity in apple scab resistant cultivars, 2008

The cultivars ‘Primiera’ and ‘Coop 44’ (harvest date in 2008 of 17 & 20 Oct respectively) showed the highest disease incidence in 2007 and 2008 (2004). Both have the cultivar ‘Coop 17’ as one parent and both are clear skinned. ‘Coop 17’ is recorded in the literature as being very susceptible for sooty blotch.

‘Topaz’ and its crosses were less affected in 2008 as in 2007. In 2008 they showed an average amount of sooty blotch.

Crosses with ‘Florina’ were less affected in 2008. Exceptions were ‘Delfloki’ and ‘Deltana’, which both are crosses from (‘Golden’ x ‘Grieve Rouge’) x ‘Florina’ planted in 2005 (Table 4).

Table 4: Sooty blotch susceptibility of different varieties

Varity	cross partners		planting year	harvest 2008	P (%) 2007	P (%) 2008	%-comparasion 07/08
COOP 17							
Primiera	Coop 17	Golden	2001	17.10.	86,2		
Primiera	Coop 17	Golden	2002	17.10.	93,4	67,0	-28,2
Primiera	Coop 17	Golden	2003	17.10.	86,8	57,0	-34,3
Coop 44	Coop 17	PRI 1983-201	2001	20.10.	83,8	50,3	-40,0
FLORINA							
FAW 7242	Gala	Florina	2001	22.09.	22,0	6,9	-68,9
Delfloga	Tenroy	Florina	2005	01.10.	28,5	11,7	-58,8
FAW 8159	Florina	A 814-105	2001	08.10.	9,2	0,8	-91,2
FAW 7962	Florina	A 871-25	2001	20.10.	20,7	2,1	-89,8
Delfloki	(GDxGrive Rouge)	Florina	2005	20.10.		20,3	
Galarina	Gala	Florina	2006	20.10.	6,9	8,5	22,5
Deltana	(GDxGrive Rouge)	Florina	2005	21.10.	61,2	34,6	-43,4
TOPAZ + Eltern							
UEB 3241-3	Vanda	Rubinola	2002	22.09.	62,4	21,2	-66,0
Goldsweet			2005	25.09.	73,3	28,1	-61,7
Heliodor	Golden	Topaz	2005	25.09.	57,8	16,0	-72,3
UEB 3531-3	Topaz	Rajka	2006	25.09.		0,2	
Topaz	Rubin	Vanda	2003	07.10.	85,2		
Topaz	Rubin	Vanda	2002	07.10.	75,4	43,7	-42,1
UEB 3322-5	Vanda	Bohemia	2002	07.10.	69,6	28,4	-59,1
Opal	Golden	Topaz	2002	07.10.	92,7	37,4	-59,7
UEB 3374/2	Golden	Topaz	2005	09.10.	72,7	20,0	-72,5
UEB 3185/2	Golden	Vanda	2006	09.10.	6,7	9,7	45,3

Conclusions

After considering all the separate trial results, a positive conclusion can be drawn. From the 2009 results it appears that a potential product is available that can give satisfactory control of sooty blotch even when the disease pressure in the orchard is very high. Reducing the number of spray applications to the desired level of 4 per year will require further research and this will certainly also depend on the seasonal conditions. Attention should be given to early treatments in June until the middle of July. Infection can take place over the whole season. Decisive for the severity of the infection, is when the

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