SESSION 5

WORKSHOP I – CLIMATE CHANGE AND ITS EFFECTS ON INVASIVE SPECIES

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Occurrence of *Guignardia bidwellii*, the causal fungus of black rot on grapevine, in the vine-growing areas of Rhineland-Palatinate, Germany

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ABSTRACT

During the years 2003 and 2004 attacks of black rot on grapevine, causing strong economical losses, were observed in some of the vine-growing areas of Rhineland-Palatinate. The regions of Mosel-Saar-Ruwer, Mittelrhein and Nahe have been especially affected. Suitable climatic conditions and a large number of overgrown vineyards favoured the development of the disease in these regions. Fungicide treatments with dithiocarbamates, strobilurines and azoles resulted in sufficient disease control, indicating that the development of a practicable protection strategy seems to be possible.

INTRODUCTION

The ascomycete fungus *Guignardia bidwellii*, the cause of black rot on grapevine, is a dangerous disease in viticulture and is able to cause considerable economic losses under favourable climatic conditions in insufficient protected vineyards. The fungus has been transferred from North America to Europe (just as was downy and powdery mildew of grapevine) with rootstock material in the 19th century (Pearson & Goheen, 1988).

Whereas downy and powdery mildew have been able to spread rapidly over all vine-growing areas of Europe, problems with black rot have been limited to temperate regions of northern Italy and southwestern France that have high summer precipitation. In 1988, the disease was been detected for the first time in Switzerland, and spread also to the vine-growing area of Champagne (Pezet & Jermini, 1989). In the past, observations of black rot in Germany have been extremely rare and of no economic importance (Müller, 1934; Lüstner, 1935; Kast, 1990), so the disease symptoms have been unknown to growers.

In 2002, on overgrown vineyards, the symptoms of *G. bidwellii* were observed by Holz (2003) for the first time in the area of Mosel-Saar-Ruwer. Since 2003, massive infections (which resulted in considerable yield losses, especially in the vine-growing areas of Mosel-Saar-Ruwer, Mittelrhein and Nahe) have been reported. During the last two years, the work of the official plant protection service of Rhineland-Palatinate and the BBA was concentrated on investigating possible reasons for the appearance of the disease and developing practicable protection strategies.

MATERIAL AND METHODS

Observation of disease development

In 2003 and 2004, the appearance and development of the disease have been observed in various vine-growing areas, in trial sites and vineyards with high disease risk. Disease development was compared with weather conditions and fungicide treatments.

Fungicide trials

At different locations in the valleys of Mosel (Trier, Niedermennig, cv. Riesling) and Mittelrhein (Kaub, cv. Pinot Noir), where (in 2003) heavy attacks were observed, protection trials with various fungicides were done in 2004. Experiences from other countries and observations from our own trials in 2003, showed that fungicides belonging to the chemical groups of dithiocarbamates, strobilurines and inhibitors of sterolbiosynthesis (azoles) were also effective against black rot on grapevine (Bolay *et al.*, 1994; Hoffmann & Wilcox, 2003). A number of these chemicals are registered as plant protection products in Germany, for use in viticulture against other fungal diseases. Therefore, the main emphasis was placed on these products. Other important fungicides with different modes of action were also included in the trials. The tested products are listed in Table 1.

Table 1. Tested fungicides against black rot in Rhineland-Palatinate (2004).

Chemical group	Active ingredients	Trade name	Base rate (kg or litres/ha	Number of trials
Dithiocarbamates	Mancozeb	Dithane NeoTec	0.8	2
	Mancozeb + zoxamide	Electis	0.72	1
	Metiram	Polyram WG	0.8	2
Strobilurines	Azoxystrobin + folpet	Quadris max	0.4	2
	Kresoxim-methyl	Discus	0.06	2
	Kresoxim-methyl + boscalid	Collis	0.16	2
	Pyraclostrobin + metiram	Cabrio Top	0.8	2
	Trifloxystrobin	Flint	0.06	2
Azoles	Fluquinconazol	Castellan	0.08	1
	Myclobutanil	Systhane 20 EW	0.06	2
	Penconazol	Topas	0.06	2
	Tebuconazol + tolylfluanid	Folicur EM	1.0	2
Quinones	Dithianon	Delan WG 700	0.2	2
Phtalimides	Folpet	Folpan 80 WDG	0.4	2
Morpholines	Spiroxamine	Prosper	0.2	2

The trials were arranged in a randomized block design (30 m^2 per plot) with, depending on the size of the experimental vineyard, three or four replicates of each treatment. Fungicide applications started from the phenological stage 'five leaves unfolded' (BBCH growth stage 15) and continued until the 'beginning of maturation' (BBCH growth stage 81), in regular intervals of 12 to 14 days. The fungicide rate and spray volume were adapted to the different development stages of the canopy (400–800 litres/ha). Altogether, eight treatments were done per variant. Disease development was recorded three times on leaves and bunches of grapes, according to EPPO Guidline No. 31. To protect the experimental plots from infections by downy and powdery mildew, vineyards were been treated with dimethomorph (as Forum) @ 0.48 litres/ha or quinoxyfen (as Fortress 250) @ 0.8 litres/ha. Dimethomorph and quinoxyfen had no effect on *G. bidwellii*.

RESULTS AND DISCUSSION

Since 2002, *G. bidwellii* has been observed in various vine-growing areas of Rhineland-Palatinate. Mostly affected are the regions of Mosel-Saar-Ruwer, Mittelrhein and Nahe. In this areas (in 2004), in some vineyards, from 30 to 80% of grape bunches have been destroyed by the fungus.

During the past three years, disease incidence and severity has increased continuously. Whereas, in 2002, symptoms of black rot were limited to untreated abandoned plots, throughout the Mosel areas in 2004 the fungus could be found also in regularly treated vineyards, indicating that the disease had successfully established in the past three years. Significant disease symptoms on bunches of grapes were been observed in July and at the end of August 2004 after intensive rainfall. This was surprising and atypically, because until then leaf infections had not occurred or had been recorded only on minor scale. In contrast, in the areas of Ahr, Pfalz and Rheinhessen, infections have been rare and of no economic importance.

Recent observations have shown that the reasons for the strong disease development, especially in the areas of Mosel and Mittelrhein, have been favourable weather conditions for the fungus and, above all, the high number of overgrown vineyards in the affected regions.

In general, higher temperatures have been detected since 2000 in the different vine-growing areas of Rhineland-Palatinate (Table 2). The yearly average temperatures ranged from 0.8 to 1.4°C above the long-term average in the last five years, indicating a development to a warmer climate. Though precipitation of 2003 and 2004 ranged below the long-term average, the highest disease severity of black rot could be observed in there years. The reason has been found in intensive rainfalls in July and August, especially in the Mosel valley (Table 3). In this period, main infections take place normally. The combination of heavy precipitation in summer, and increasing average temperatures during the period of highest susceptibility of grape bunches, led to improved conditions for the disease.

The existence of many overgrown vineyards in the affected regions was the second important factor that enhanced fungal development. Overgrown vineyards with untreated vines allowed the fungus continuous uncontrolled propagation, and led to the present high disease pressure.

The source of these outbreaks were vineyards that had been abandoned by their growers without clearing the vines.

Table 2: Yearly average temperature (°C) and precipitation (mm) at different weather stations in Rhineland-Palatinate (2000–2004).

Year	Mosel (Trier)		Nahe (Bad Kreuznach)		Pfalz (Neustadt a. d. W.)	
	Temp.	Precipitation	Temp.	Precipitation	Temp.	Precipitation
2000	10.4	1060.3	10.7	750.6	11.5	705.6
2001	9.9	996.5	10.2	707.4	10.9	666.6
2002	10.5	957.6	10.8	715.6	11.3	760.1
2003	10.5	780.7	11.0	404.4	11.2	439.1
2004	10.0	724.5	10.3	467.1	11.0	609.6
Long-term average	9.1	784.3	9.5	512.0	10.1	643.9

Table 3. Monthly average temperature and precipitation at different weather stations in Rhineland-Palatinate (May–August 2004).

Year	Mosel (Trier)		Nahe (Bad Kreuznach)		Pfalz (Neustadt a. d. W.)	
	Temp. [°C]	Precipitation [mm]	Temp. [°C]	Precipitation [mm]	Temp. [°C]	Precipitation [mm]
May	13.0	84.2	13.2	40.4	14.1	38.2
June	16.8	57.3	17.3	52.8	18.1	62.0
July	18.2	94.6	18.6	69.0	19.6	79.1
August	19.3	133.8	19.6	73.2	20.0	86.5
Average (sum)	16.8	(369.9)	17.2	(235.4)	18.0	(265.8)
Long-term average	15.8	282.2	16.6	219.0	17.2	249.5

For a successful protection strategy against *G. bidwellii*, sanitary measures, cultural techniques and the use of effective fungicides should be combined. Much attention has to be placed on the eradication of sources of inoculum, such as overgrown vineyards or mummified berries (overwintering place of the fungus!) from infested vineyards. Only by this way is a significant reduction of disease pressure in the affected regions likely to be possible.

The fungicide trials showed good results with all active substances belonging to the groups of dithiocarbamates and strobilurines and azoles. Efficiency, related to disease severity on grape bunches, varied from 77% to 98% for dithiocarbamates, from 95% to 100% for strobilurines and from 91% to 100% for azoles. Other fungicides tested were less effective (Table 4). The results showed that successful protection of vineyards against *G. bidwellii* is possible (under the predominant climatic conditions and disease pressure) with the registered local fungicide rates recommended for use against downy and powdery mildew. Depending on weather conditions, effective fungicides should be applied from between five to seven leaves unfolded (BBCH growth stage 15–7) up to bunch closing or to the beginning of maturation (BBCH growth stage 79–1). Fungicide treatments can be completed with optimally timed measures of canopy management, which favours the adherence of fungicides and reduces the duration of leaf wetness.

Table 4. Degrees of efficiency of fungicide treatments on bunch attacks of black rot in Rhineland-Palatinate (2004).

Chemical group	Active ingredients	Kaub (31.8.04)		Mosel[1,2] (17.9.04)	
		DE_{di} [%]	DE_{ds} [%]	DE_{di} [%]	DE_{ds} [%]
Dithio-carbamates	Mancozeb	76	86	97[2]	98[2]
	Mancozeb + zoxamide	-	-	92[2]	95[2]
	Metiram	64	77	96[1]	98[1]
Strobilurines	Azoxystrobin + folpet	97	99	99[1]	99[1]
	Kresoxim-methyl	90	96	95[2]	98[2]
	Kresoxim-methyl + boscalid	89	96	90[2]	95[2]
	Pyraclostrobin + metiram	98	99	100[1]	100[1]
	Trifloxystrobin	95	98	100[1]	100[1]
Azoles	Fluquinconazol	-	-	95[2]	93[2]
	Myclobutanil	92	97	99[1]	99[1]
	Penconazol	94	97	89[2]	91[2]
	Tebuconazol + tolylfluanid	96	99	100[2]	100[2]
Quinones	Dithianon	18	32	60[2]	67[2]
Phtalimides	Folpet	17	26	58[2]	61[2]
Morpholines	Spiroxamine	47	64	14[2]	0[2]

DE = degree of efficiency; di = disease incidence; ds = disease severity
Control: Kaub: di = 84 %, ds = 3,4; Trier: di = 64 %, ds = 2,8;
Niedermennig: ds = 55 %, ds = 2,4
[1]trial site Trier; [2]trial site Niedermennig

Further problems will be expected for organic farms, because fungicides containing copper or sulphur exhibited no satisfactory levels of control (data not shown) and grape cultivars with a sufficient level of resistance against the black rot fungus are unknown. Cultivars with good levels of resistance against downy and powdery mildew (e.g. cv. Regent) were shown to be highly susceptible to *G. bidwellii*.

The results of the trials give hope that a suitable protection strategy can be developed and implemented within the existing integrated protection strategies against downy and powdery mildew with the fungicides currently registered. However, further research is needed on spore release, to improve the understanding of the epidemiology of the fungus and to discover effective products for organic viticulture.

ACKNOWLEDGEMENTS

We thank all involved chemical companies for providing us with fungicides. We also thank the growers who put vineyards for the trials to our disposal.

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Introduction and possible spread of the planthopper *Metcalfa pruinosa* in Austria

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ORIGIN AND INTRODUCTION IN EUROPE

The planthopper *Metcalfa pruinosa* (Cicadina: Flatidae) has its origin in North America, where it lives in the eastern part of the continent. Its distribution ranges from Quebec to Mexico. In Europe, it was first found in Italy (at Veneto in 1979), later in other Mediterranean countries (France in 1986; Spain and Slovenia in 1991; Croatia in 1992) and also in central Europe (Switzerland in 1995; Austria in 1996 and 2003; the Czech Republic in 2002; Hungary in 2004). This insect is not listed in any of the annexes of the EU Council Directive 2000/29 concerning Quarantine Pests.

BIOLOGY

During June, the young nymphs of *M. pruinosa* hatch from their overwintering eggs, which are hidden in corky parts of the bark (e.g. lenticels). The nymphs suck phloem sap, and thereby produce large amounts of honeydew. After passing through 5 nymphal instars adult planthoppers appear, typically at the beginning of August, and oviposition commences soon afterwards. Each female is able to lay up to 90 eggs. Only one generation of the pest can develop each year. More than 200 host plants from different families are known. Especially favourable host plants include *Acer campestre*, *A. platanoides*, *Clematis vitalba*, *Cornus sanguineus*, *Crataegus monogyna*, *Hibiscus syriacus*, *Ligustrum vulgare*, *Malus domestica*, *Parthenocissus quinquefolia*, *Prunus domestica*, *Rhamnus catharticus*, *Robinia pseudoacacia*, *Rubus fruticosus*, *Salix* spp., *Sambucus nigra*, *Ulmus* spp., *Urtica dioica*, *Viburnum lantana* and *V. opulus*. For a comprehensive review of the literature concerning *M. pruinosa* see Lucchi (2000).

SIGNIFICANCE FOR PLANTS

All nymphal stages produce masses of white wax, which makes them very easily detectable and which is responsible for the damage of ornamentals and fruits. Adults and nymphs also produce much honeydew, which is collected by bees. This has since become an important source of the alimentation of bees during the summer months; this observation has been made in areas with very high population densities of *M. pruinosa*, as in Italy. Nymphal sucking does not lead to the crippling of leafs or shoots. Nevertheless, it is possible that sooty mould could cover parts of the plant and render harvested products unmarketable. Another matter of concern is the ability of many planthoppers to act as vectors for viruses and phytoplasmas. Though *M. pruinosa* does not transfer important diseases, the large list of host plants might represent a potential danger, as by this way diseases may come into contact with host plants which are not adapted to them and might show no resistance against them. It is assumed that *M. pruinosa* will play a major role in locations that are treated only rarely with 'soft' insecticides (e.g. in organic farming) or remain untreated (e.g. public green areas).

CONTROL MEASURES

As a non-chemical control measure, twigs of infested trees bearing eggs of *M. pruinosa* can be cut-off in winter, in order to reduce the infestation in the next season. According to experiments conducted in 2004, the nymphs of *M. pruinosa* are susceptible to some insecticides (e.g. chlorpyriphos and imidacloprid). In southern European countries the pest is controlled successfully by mass-releases of the dryinid wasp *Neodryinus typhlocybe*. As this insect also originates from North America, it has to be made sure that it does not attack any indigenous planthoppers from Austria before it can be released for biocontrol. This question is being studied by Gudrun Strauss in a project concerning *M. pruinosa* in Austria.

PRESENT DISTRIBUTION AND SPREAD IN AUSTRIA

In Austria, a single specimen was found in Graz (Styria) in 1996 (Holzinger, 2003). This individual had been transferred to an insect collection and did not give rise to a population. In 2003, a mass outbreak was recorded in a small park in Leopoldau (Vienna). In 2004, infested horse chestnut trees were detected in the courtyard of a house in the third district in Vienna; a small infested area of 1,000 m² was also discovered in Graz (Styria).

The infested area of the first mass outbreak in Leopoldau covered approximately 3,000 m². It had not been conspicuous for neighbouring gardeners in the years before. At the time of its detection, in July 2003, the population of *M. pruinosa* contained several thousand individuals. Therefore, we assume that the introduction happened 3 or 4 years earlier. In July 2004, the infested area had increased by up to 50 m in each direction (as a result of 'natural' dispersion by the flight of adults). In contrast to this, the dispersal caused by transport of infested plants cannot be estimated. It may take 2 or 3 years for a single transferred specimen of *M. pruinosa* to give rise to a conspicuous population. The already-known populations from the Tessin in Switzerland do not grow rapidly, but remain more or less stable (M Jermini, personal communication). It seems very probable, that this is correlated with the high precipitation of 1,700 mm per year observed in the Tessin. Generally, it is believed that warm and dry weather favours planthoppers. Therefore, we assume that *Metcalfa pruinosa* will reach high population densities only in eastern Austria, where warm weather is combined with low precipitation ('vine growing climate').

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Introduction and distribution of the American eastern cherry fruit fly (*Rhagoletis cingulata*) in the Rhine Valley, Germany

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ABSTRACT

In 1983, the American eastern cherry fruit fly (*Rhagoletis cingulata*) was found in Switzerland. This was the first record outside the western hemisphere. In Germany, the first specimens were discovered near Freiburg/Breisgau in 1993, and a single female was found near Kaub in the middle Rhine valley in July 1999. Since 2001, the pest has also occurred in the Netherlands. A monitoring programme was started in 2002 in the cherry-growing area of Rhineland-Palatinate. The dispersal and seasonal abundance of the pest was surveyed by using yellow (attractant) traps. The data obtained in three years revealed that, during this time, the insect had spread throughout the northern parts of the cherry-growing area (Rheinhessen) and also to the south. The peak of flight activity of this introduced pest is about two weeks later than the peak of the European cherry fruit fly (*Rhagoletis cerasi*).

INTRODUCTION

The American eastern cherry fruit fly (AECFF) (*Rhagoletis cingulata*) is known as a pest of cherries in the western hemisphere. Primary hosts are sour cherry (*Prunus cerasus*) and wild cherry (*Prunus avium*); secondary hosts are black cherry (*P. serotina*), choke cherry (*P. virginiana*) and St. Lucie Cherry (*P. mahaleb*). Outside the western hemisphere the pest was found for the first time in Switzerland, in 1983, and in the northern parts of Italy, in 1998. In Germany, the first specimens were discovered near Freiburg/Breisgau in 1993, and a single female was found near Kaub in the middle Rhine Valley in July 1999. Since 2001, AECFF has also occurred in the Netherlands. In 2003, the status of AECFF was monitored. It has been described as: "present, widespread in the coastal area" (EPPO, 2004). In the cherry-growing area of Rhineland-Palatinate a first monitoring programme was started in 2002 and repeated in 2003. The results gave reason to believe that the pest is now spread all over Rhineland-Palatinate. The monitoring in 2004 was expected to confirm this assumption. At the same time, the efficiency of the Rebell® amarillo yellow trap (Switzerland) was to be considered. Perhaps the traps are more efficient in catching European cherry fruit fly (ECFF) (*R. cerasi*) than AECFF. For comparison, Pherocon® AM traps (USA) were ordered. This type of trap has not been used in Rhineland-Palatinate before. The aims of this investigation were (i) to monitor the distribution of AECFF in Rhineland-Palatinate, (ii) to compare the different types of traps, and (iii) to study the seasonal abundance of AECFF.

MATERIALS AND METHODS

Traps

To monitor the distribution of cherry fruit flies, yellow traps and AM traps were used. The yellow trap 'baits' the flies by visual attraction. By crossing the boards, the trap becomes three-dimensional. The AM trap 'baits' the flies in two ways: on the one hand by visual attraction and on the other by means of a pheromone; the glue on the trap contains the attractant (the exact chemical composition of which has not been published). The producer describes the ingredients as non-toxic synthetic insect pheromones. On inquiry, the producer confirmed that the glue contained ammonium acetate. Unlike other bait traps, the AM trap is exposed vertically, not horizontally. By joining the sides of the trap together the trap becomes two-dimensional. This type of traps was not used throughout Rhineland-Palatinate, but only in the region of Rheinhessen.

Locations

During 2002 and 2003, the locations for the monitoring of cherry fruit flies included mainly the picturesque, steep slopes on the Rhine near Kaub and cherry orchards, some of them neglected. The following year it was necessary to find suitable wild cherry hedges and neglected orchards in the region, where the AECFF was caught in 2003. Locations with mixed plantings of hosts such as black cherry, St. Lucie cherry, sour cherry and wild cherry were preferred. The first catches of flies were expected mainly in slopes and unmanaged orchards. The distribution and the number of traps in the various cherry-growing regions of Rhineland-Palatinate varied from year to year (see below).

Evaluation

One yellow trap was suspended at every site. AM traps were not available in great numbers, so they were used in unmanaged orchards and on slopes. The traps were placed at distances of 10 m. Monitoring started at the beginning of the flight period of ECFF (in the middle of May), because the beginning of the flight period of AECFF was not known exactly. In the region of Rheinhessen, the traps were checked twice a week and, in the region of Pfalz and Ahrweiler, once a week. The date of examination, and the number of flies caught on the trap were noted. The two species of cherry fruit flies can be distinguished by the wing pattern. The number of captured flies was tabulated for each location. Thus, we obtained data on the distribution of AECFF, the duration of the flight period and the efficiency of the traps.

RESULTS AND DISCUSSION

In the cherry-growing area of Rhineland-Palatinate the first monitoring programme was started in 2002. In that year no AECFFs were found on the 74 yellow traps used. In 2003, the monitoring was repeated with 45 traps. In this year, 11 AECFFs were found. Except one specimen, all of them were detected on two of the yellow traps located in two nearby wild cherry hedges. These places are situated about 60 km from Kaub, in the area of Mainz/Rheinhessen. This was the reason to assume that AECFF is now spread throughout Rheinhessen. In 2004, the monitoring in Rhineland-Palatinate was repeated. A total of 49 cherry orchards were selected, and AMCFF was found in 27 of them (Figure 1).

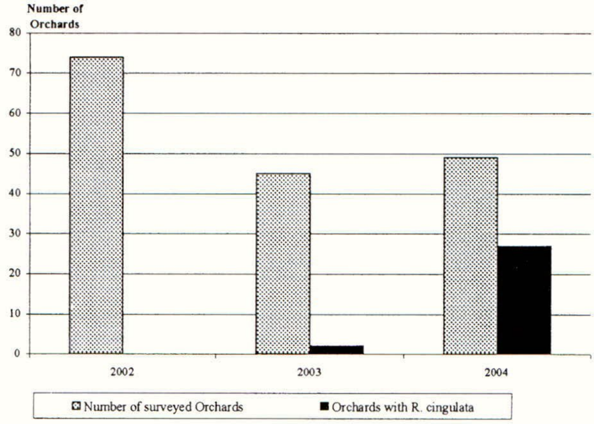

Figure 1. Surveyed orchards and number of places where American eastern cherry fruit flies were caught with yellow or TM traps.

In 2004 in Rhineland-Palatinate 16,529 ECFFs and 1,113 AECFFs were caught in 64 traps. In this year, 263 specimens of AECFF were found in the same places where the pest had occurred in 2003. Only in the nearby orchard called 'Orbel' did we find more specimens of AECFF than of ECFF. There were about 510 AECFFs on the traps (see Figures 4a and 4B). Nearby, there is the large housing area Uhlerborn, until recently used by the American Armed Forces. In the whole region of Rheinhessen, 1,075 AECFFs were found, in the region of Pfalz 37 and in Ahrweiler just one individual.

The assumption that AECFF had expadned its range in the Rhine Valley was confirmed. Now, this species can be described as 'widespread' throughout the northern parts of the cherry-growing area in Rheinhessen and 'present' towards the south, in the area of Pfalz (Figure 2).

In order to compare the suitability of different traps, TM traps and yellow traps were placed in the same orchards. The number of AECFFs caught in the former, in 2004, was significantly greater than in the latter, whereas the yellow traps proved were more attractive to ECFFs (Figure 3).

The AM traps caught considerably more AECFFs than did the yellow traps (Figure 3). At the beginning, and in the middle of July, peaks of flight are identifiable. However, the yellow

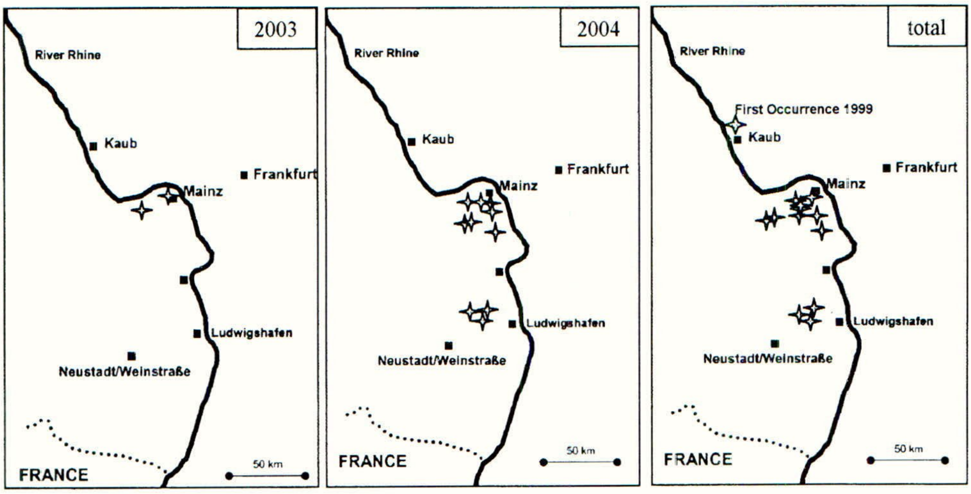

Figure 2. The regional distribution of American eastern cherry fruit fly in the Rhine Valley in the years 2003 and 2004 and in total (one star presents the occurrence of the pest).

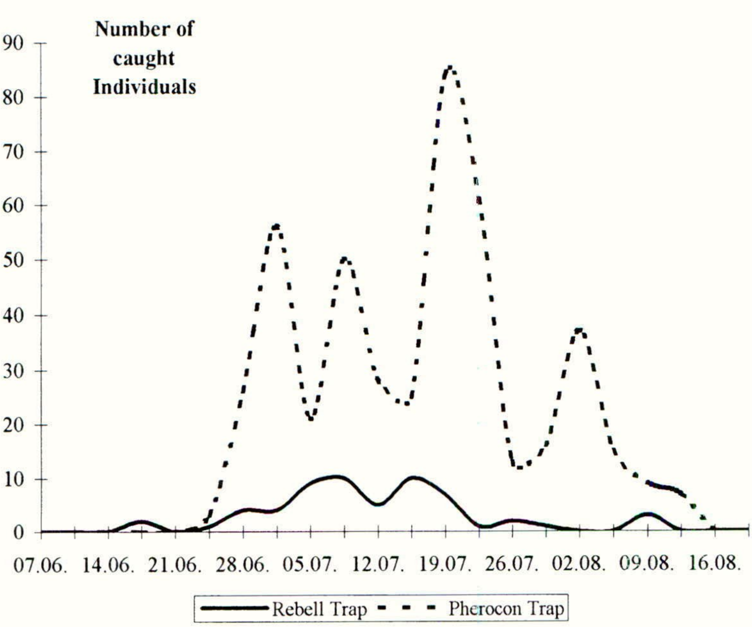

Figure 3. Comparison of the efficacy of yellow traps and AM traps for American eastern cherry fruit fly in the orchard 'Orbel' in 2004.

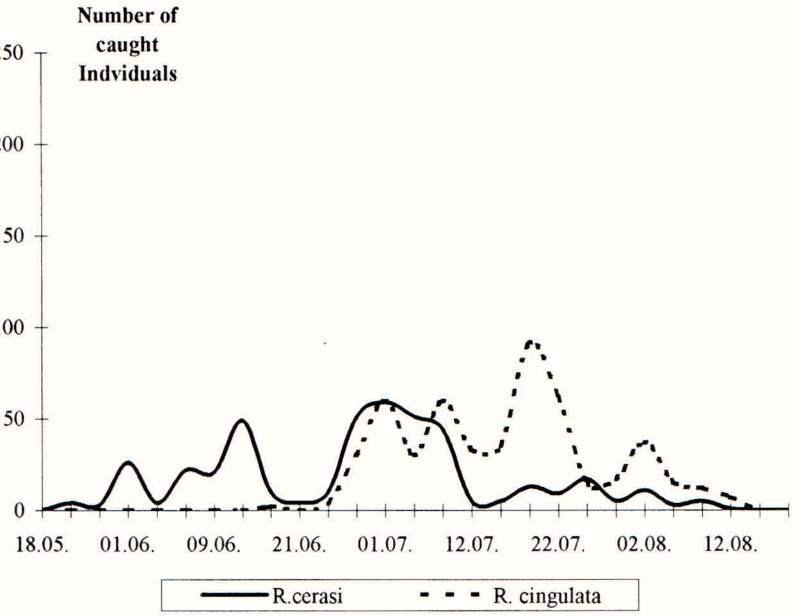

Figure 4a. Comparison of the flight periods of American eastern cherry fruit fly and European cherry fruit fly in the orchard 'Orbel', with data from yellow traps and AM traps.

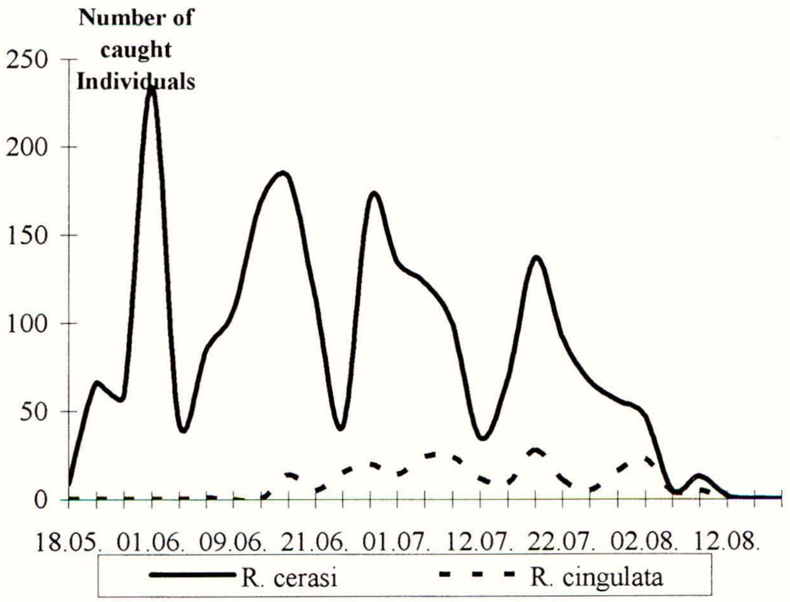

Figure 4b. Comparison of the flight periods of American eastern cherry fruit fly and European cherry fruit fly in the orchard 'Heuweg', with data from yellow traps and AM traps.

traps do not show the peaks of flight of AECFF as detected by AM traps. In orchards where the population of AECFF was smaller than in the orchard 'Orbel', the efficacy of the traps sometimes showed higher catches; in comparison with AM traps, the yellow traps showed better results under these conditions.

Before the start of monitoring, it was discussed whether the flight period of AECFF might start a few weeks later than that of ECFF, and whether the period of flight might last longer. Also, the start of the flight period of AECFF could not predicted. Data for ECFF could be derived from routine monitoring in this region. According to the literature ECFF emerges from the pupae after 430 DD; the soil temperature is measured at a depth of 5 cm, based on a threshold of 5°C, and measuring starts on 1 January (Boller, 1966). According to Jupp & Cox (1974), in AECFF the development after diapause to the emergence of the adults takes 918 to 1,234 DD, with an average of 930 DD; the base temperature is 4.4°C, and measuring starts on 1 March. This indicates that the pupae of AECFF require a higher temperature sum to reach maturity than those of ECFF. Our results confirm these observations: the first specimens of AECFF were caught in mid-June, two or three weeks after the first records of ECFF. In 2004, the flight period of AECFF did not last longer than that of ECFF – both species were observed until mid-August

At the peak of emergence, the flies were noticed in many orchards at about harvest time (mid- to late July) (Howitt, 1993). However, in 2004, in Rheinhessen, the peaks of flight varied in the different orchards and were not synchronous. The course of flight and the peaks extended over a long period, from calendar week 24 to 32. It is hoped to obtain detailed data in the coming years. AECFFs were caught later in the season than ECFFs (Figures 4a and 4b). The sites 'Orbel' and 'Heuweg' are wild (unmanaged) cherry orchards. In managed cherry orchards, the flight began later and the number of ACEFFs caught was lower than in wild cherry orchards.By the middle and end of May, the first flies were found. The very long flight period of ECFF was surprising. Thus, sour cherry was heavily attacked by cherry fruit flies. In the orchards, we caught mainly AECFFs, but also a considerable number of ECFFs.

According to the literature, ECFF does not infest late cultivars of sour cherries. This does not correspond with the number of the caught flies or the observations made during the monitoring in 2004. The flight and the appearance of AECFF by the end of June may become a problem for the sour cherry orchards in the next few years. Particularly wild cherry trees, and alternative hosts, are permanent sources for re-infestation of cultivated cherry orchards.

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Risks posed by the spread and dissemination of grapevine pathogens and their vectors

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ABSTRACT

Several diseases of grapevine are transmissible by grafting as well as by aerial vectors. Risks of spread and dissemination of these diseases evolve from the potential introduction of the associated pathogens into new areas, and from the vectors extending their range, either passively with plant material or by active migration. Changing biotic, cultural or environmental conditions, but climatic factors in particular, favour many insect vectors of grapevine diseases and allow them to extend their range northwards. Examples of actual risks by virus and phytoplasma diseases are presented.

INTRODUCTION

A number of grapevine pathogens are spread by aerial vectors. Viruses that are associated with grapevine leafroll and diseases of the rugose wood complex are transmitted by mealybugs (Pseudococcidae) and/or soft scales (Coccidae) (Gugerli, 2003). Grapevine yellows diseases, caused by phytoplasmas, are vectored by phloem-feeding Auchenorrhyncha (Boudon-Padieu, 2003), whereas *Xylella fastidiosa,* the causal agent of Pierce's disease of grapevine, is spread by a wide variety of xylem-feeding Auchenorrhyncha species (Redak *et al.*, 2004). All of these diseases are graft transmissible. Therefore, long-distance movement of propagation material implies the risk of spreading such pathogens. Risks of new disease outbreaks evolve from (a) the introduction of new pathogens to areas where potential vectors occur; (b) passive or active movement of vectors into the natural range of a grapevine pathogen; (c) spread of both pathogens and vectors to areas so far unaffected.

Transmission cycles of the pathogens mentioned above are more or less complex. In the case of viruses, only grapevine and vectors are involved and transmission is accomplished in a non-propagative, semi-persistent manner. Phytoplasmas, on the other hand, are transmitted more specifically in a propagative and persistent way, either from grapevine to grapevine or in more complex systems from alternative wild hosts to grapevine. *X. fastidiosa,* which is considered not to be introduced into Europe, has a wide range of wild and cultivated hosts plants and also of vectors.

Certification schemes for grapevine propagation material and quarantine regulations have been set-up to minimize the risk of dissemination of regulated grapevine pathogens. However, the still-rising trade and exchange of grapevine material between viticultural regions increase the chances of accidental introductions of new pathogens or new strains of already-present pathogens into new areas. Vectors are also carried with dormant wood of grapevines or other plant material; interregional traffic is another potential means of dissemination of insect vectors. Introduction of the leafhopper *Scaphoideus titanus* into France, and the subsequent outbreak of Flavescence dorée in the 1950s (Caudwell, 1983), is an example of the detrimental consequences of such incidents. Many vectors of grape diseases are xerothermic species that are essentially restricted to southern viticultural areas. Changing climatic conditions enable them to extend their range to the north or to establish viable populations in previously unsuitable geographic regions after accidental introduction. Such changes of climatic conditions are already evident in German viticultural regions, where significant positive trends of average temperatures affect grape phenology (Figure 1). Examples of actual developments and risks will be presented in this paper.

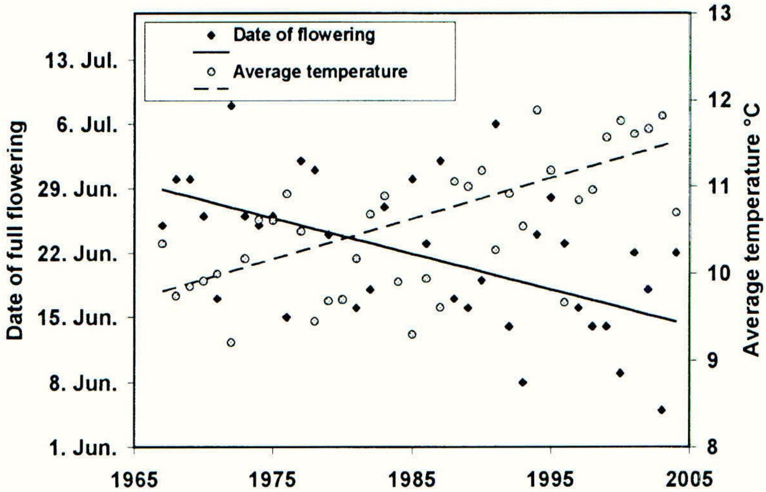

Figure 1. Trends of average yearly temperatures and dates of full flowering at Bernkastel-Kues, Germany, from 1967 to 2004. Mann-Kendall-Test (Salmi *et al.*, 2002 – flowering: 13.4 days, $\alpha \leq 0,05$; average yearly temperature: +1.78°C, $\alpha \leq 0,01$).

GRAPEVINE VIRUSES AND INSECT VECTORS

Grapevine leafroll is considered to be a major virus disease of grapevine, which occurs in most viticultural areas world wide. Spread by infected planting material is assumed to be the principal means of dissemination, but transmission of some associated viruses (GLRaV-1, GLRaV-3, and GLRaV-5) by scale insects has been proved (Gugerli, 2003). Extensive spread of leafroll in the field has been reported in Mediterranean countries and overseas (Cabaleiro & Segura, 1997; Habili *et al.*, 1997; Petersen & Charles, 1997). The prevalent virus detected in these studies was GLRaV-3. In northern grape-growing regions, where GLRaV-1 seems to be the most important leafroll virus, no such spread has been observed. However, Sforza *et al.* (2003) have reported the experimental transmission of GLRaV-1 and GLRaV-3 with scale insects (Coccidae) and mealybugs (Pseudococcidae) that are endemic to the northern viticultural regions of France and Germany, but the importance of such vectors for the epidemiology of grapevine leafroll in these areas is still not clear.

Although both coccid (soft) scales and mealybugs are rather immobile insects, immature stages of the latter seem to be easily dispersed by wind, human activities or ants (Gullan & Kosztarab, 1997) and, at the same time, represent the efficient vectoring stages (Petersen & Charles, 1997). Mealybugs of the genera *Planococcus* and *Pseudococcus* were found to be common in vineyards where leafroll spread naturally (Cabaleiro & Segura, 1997; Tanne *et al.*, 1989). Meanwhile, some of those species known to transmit GLRaV-3 (such as *Planococcus citri*, *Pseudococcus affinis* and *Ps. longispinus*) occur in greenhouses in Germany (Hoffmann, 2002). More favorable climatic conditions in the future might enable them to escape to the field and then also to spread grapevine leafroll efficiently in the northern viticultural areas.

FLAVESCENCE DORÉE AND *SCAPHOIDEUS TITANUS*

Flavescence dorée (FD), an A2 quarantine 'pest' in the EPPO region, is the most important phytoplasma disease of grapevine. Without control, FD spreads epidemically and causes severe economic loss. For example, six years after the first detection of FD in the French department of Aude in 1982 c. 80,000 of 110,000 ha of vineyards were affected (Laurent & Agulhon, 1989). Following a first outbreak of FD in south-west France in the 1950s, the disease spread over southern France to northern Italy (1973) and northern Spain (1997). *Scaphoideus titanus* is the only known natural vector of FD. This Nearctic leafhopper was introduced to southern France from North America in the first half of the 20^{th} century, presumably with grapevine material (Caudwell, 1983). It is common on wild grapevines in North America (Maixner *et al.*, 1993), but cultivated grapevine is its only known host in Europe.

Nymphs of *S. titanus* acquire the FD phytoplasma from infected vines, and adults subsequently transmit the disease efficiently from vine to vine, thus causing an epidemic spread of the disease. In Europe, *S. titanus* is distributed around the 45^{th} parallel, from northern Portugal and Umbria in Italy to France and northern Italy, southern Switzerland, Slovenia, Croatia and Serbia (Lessio & Alma, 2004). This vector has been constantly extending its range to the north for about a decade (Boudon-Padieu, 2000), and is now present in western Switzerland; it was detected in Austria for the first time in 2004 (N Zeisner, personal communication). Areas in France that were assigned as non-permanently settled zones in the beginning of the 1990s are now inhabited by stable populations, for example in northern Burgundy (Boudon-Padieu, 2000).

Since the range of this vector is limited by climatic conditions that provide sufficient summer temperatures to complete lifecycle (Boudon-Padieu, 2000), it can be expected that the actual climate change enables this vector to reach the northernmost viticultural areas in Germany and France along the 50^{th} parallel. The average temperatures in the viticultural area of Baden, in southern Germany, are similar to those along the actual northern border of the range of *S. titanus* (Figure 2). Colonization of these regions could be achieved by an active spread of the insects to the north, but also by passive dissemination of vectors either with grapevine material containing eggs or by traffic. In the Trentino area of Italy, for example, the first populations of *S. titanus* were found along the main highway heading north (L Mattedi, personal communication).

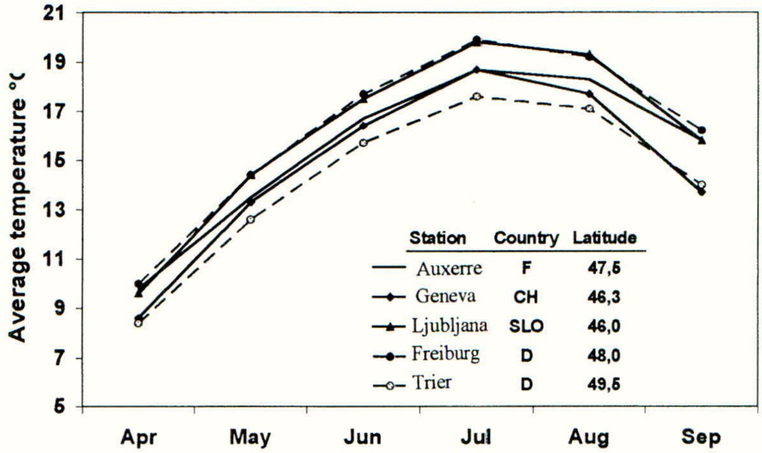

Figure 2. Average temperatures of locations at the actual northern border of the range of *Scaphoideus titanus* (solid lines) and of a southern (Freiburg) and a northern (Trier) viticultural area in Germany (broken lines). Data obtained from http://www.klimadiagramme.de and http://www.worldclimate.com

The range of *S. titanus* is still much wider than the area affected by FD. This situation is a severe threat to viticulture, because the introduction of a single infected vines into an area inhabited by this vector implies the risk of new foci and subsequent new outbreaks of FD. However, so far, no grapevines infected by FD have been detected in Germany, although most of the rootstocks originate from areas that are affected by the disease. Nevertheless, the introduction or immigration of *S. titanus* to Germany would cause severe problems for viticulture, since systematic insecticide applications would be necessary to contain the first foci of this vector and to prevent its further spread. Such treatments would significantly interfere with current systems of integrated and organic grape production. Mandatory control and eradication programmes, as already established in France and Italy, will be necessary whenever and wherever FD occurs. With *S. titanus* coming closer to Germany, a regular monitoring programme would help to locate the first infestations so they can be eradicated with minimal impact on German viticulture.

BOIS NOIR AND *HYALESTHES OBSOLETUS*

In contrast to FD, Bois noir (BN), or 'Vergilbungskrankheit' as it is called in German, is endemic to Europe and the Mediterranean, where it is widespread in almost all vine-growing regions. Phytoplasmas of the stolbur group (16SrXII-A group) are associated with this disease. The only known vector is a cixiid planthopper, *Hyalesthes obsoletus*, a polyphagous species that lives on various herbaceous plants from which it acquires the pathogen and transmits it to grapevine only occasionally. Significant spread and increasing incidence of BN is currently reported from various viticultural areas, e.g. in Austria and northern Italy. In Germany, the disease is mainly restricted to climatically preferred sites, such as vineyards on the steep slopes of the valleys of the Rhine and Mosel rivers, which provide favorable conditions for the xerothermic vector. BN spread considerably during the 1990s, and is now present in most German viticulture areas. Various isolates of BN phytoplasma can be distinguished by RFLP analysis (Langer & Maixner, 2004). They appear to be associated with different wild herbaceous hosts, either *Convolvulus arvensis* or *Urtica dioica*. Populations of *H. obsoletus* on these plants also show differences with regard to feeding adaptation and time required to complete the lifecycle. *C. arvensis* is still the preferred host plant in Germany, but more and more *H. obsoletus* are being detected on *U. dioica*. This is of particular relevance in the light of reports about the preferred host plants of *H. obsoletus* from different geographic regions. *C. arvensis* is preferred in Germany (Weber & Maixner, 1998), whereas *U. dioica* is the principal host in northern Italy (Alma *et al.*, 2002). Based on these observations it can be hypothesized that different epidemiological cycles of BN phytoplasma exist in Europe (Figure 3). They probably include different natural reservoir plants and isolates of the phytoplasma, as well as populations of the vector that are adapted to these specific hosts. If so, the increasing significance of the 'Urtica-cycle' in Germany could indicate a shift in the predominant populations of the vectoring plant hopper and/or the causal agent of BN. Characterization of phytoplasmas from grapes in recent new outbreaks of BN

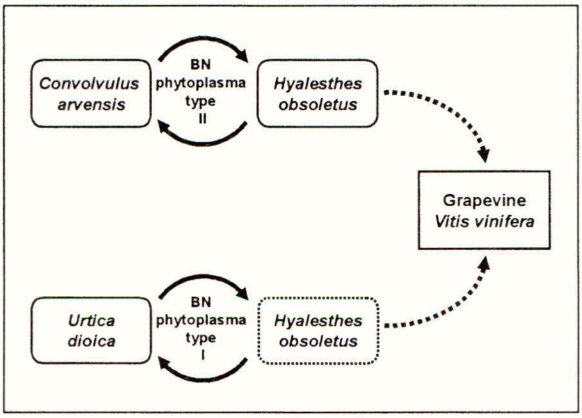

Figure 3. The two hypothetic natural cycles of BN phytoplasma, that include different natural host plants as well as adapted isolates of the pathogen and populations of the vector. Grapevine is inoculated by occasional feeding of *H. obsoletus*. As a dead-end host it does not play a role in BN epidemiology.

(e.g. in the viticultural area of Württemberg and in the middle Rhine valley) indeed revealed the prevalence of the previously insignificant type of phytoplasma that is associated with *U. dioica* (Langer & Maixner, 2004). The data obtained so far are based on field observations and preliminary studies on a limited number of vines and insects. The current distribution and frequency of the different types of BN phytoplasma in Germany (and their association with the different host plants) should be investigated in more detail, in order to provide the base-line data for further studies on their spread. Furthermore, the population genetics of *H. obsoletus* on the different major host plants on the one hand, and from different geographic regions on the other, needs to be investigated. Information obtained from these studies could help to understand whether the current shift in the significance of the two major BN isolates is just a local phenomenon or is due to the introduction and subsequent spread of a presumably southern European phytoplasma strain in northern viticultural regions.

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