Fungicide evaluation to rate efficacy to control leaf late blight for the EuroBlight table
Results 2006 - 2015

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Summary

Late blight caused by *Phytophthora infestans* is the most important foliar disease in the cultivation of potatoes. It is important to use fungicides that effectively protect leaves against this disease. A whole range of fungicides was or became registered in the last years. New fungicides to control late blight will enter the market in future. Each fungicide has its own mode of action and efficacies and therefore has specific characteristics. To evaluate each characteristic a EuroBlight table was set up to get an overview of the value of each characteristic. Until 2007 the ratings were based upon expert judgement, both from agrochemical companies and independent researchers. To evaluate the effectiveness of fungicides harmonised protocols were discussed at Tallinn. At Hamar the first decimal ratings for preventative efficacy of fungicides were presented.
In fact 31 field experiments were set up to compare the effectiveness against leaf late blight by measuring the protection of leaves against infection by late blight given by application of a fungicide in a standard 7-day spray schedule (this standard spray schedule is not necessarily related to the label recommendations). Dose rates tested were the highest preventative doses registered in Europe. In agricultural practice lower dose rates might be used.
During the growing season the percentage foliar infection was assessed at least weekly. To evaluate the epidemic, the Area under the Disease Progress Curve (AUDPC) was determined.
Not all fungicides were tested at every location in each year. Ratings of fungicides for the EuroBlight table can be calculated when field experiments are carried out over at least 2 years in a minimum of 3 European countries. Thus fungicides were tested in a different number of experiments, with a minimum of 6. REML analysis was conducted to analyse the data, using GENSTAT 18th ed. Based on the average StAUDPC, ratings for the effectiveness of the fungicides to control late blight were calculated, according to formula 0. Ratings were calculated for the whole season (Table 0).

$$\mathrm{ER}_k = 3\frac{\mathrm{MAX}(y) - y_k}{\mathrm{MAX}(y)} + 2\,, \qquad (0)$$

ER_k = efficacy rating of the fungicide *k* to control potato late blight during the whole growing season.
y = mstAUDPC
MAX (y) = mstAUDPC of the fungicide with the highest mstAUDPC determined in the series of experiments.

Table 0. Effectiveness of fungicides to control potato late blight during the **whole season**.

Fungicide[4]	**Active ingredient**	Dose rate Kg or L /ha	StAUDPC[1]	Decimal rating[2]	
				current[3]	proposed[3]
Acrobat DF (Invader)	dimethomorph + mancozeb	2.0	-[5]	3.0	-
Acrobat DF (Invader)	dimethomorph + mancozeb	2.4	-	3.1	-
Canvas + mancozeb	amisulbrom + mancozeb	0.5 + 2.0	-	4.5	-
Consento (Tyfon)	fenamidone + propamocarb	2.0	-	2.5	-
Dithane DG	mancozeb	2.0-2.25	23.3	2.0	-
Infinito	fluopicolide + propamocarb	1.6	-	3.8	-
Orvego Duo (Decabane)	ametoctradin + mancozeb	2.5	-	3.7	-
Ranman + adjuvant	cyazofamid	0.2 + 0.15	-	3.8	-
Revus	mandipropamid	0.6	-	4.0	-
Sereno (Sonata)	fenamidone + mancozeb	1.5	-	2.6	-
Shirlan	fluazinam	0.4	-	2.9	-
Tattoo C (Merlin)	chlorothalonil + propamocarb	2.7	-	3.4	-
Unikat Pro (Electis)	zoxamide + mancozeb	1.8	-	2.8	-
Valbon	benthiavalicarb + mancozeb	2.0	-	3.7	-
Banjo-Forte	dimethomorph + fluazinam	1.0	-	3.7	-
Fantic M	benalaxyl M + mancozeb	2.5	-	3.0	-
EXP13-07;	mandipropamid + cymoxanil	0.6	-	4.4	-
Reboot (Lieto) + fluazinam	(zoxamide + cymoxanil) + fluazinam	0.45 + 0.4	-	4.3	-
Presidium + fluazinam	(zoxamide + dimethomorph) + fluazinam	1.0 + 0.4	2.8	-	4.6[6]

[1] : Value established by REML Analysis
[2] : Decimal ratings based on a minimum of 6 and a maximum of 31 experiments in years 2006-2015; D 9; DK 2; NL 10 and UK 10.
[3] : The ratings are intended as a guide only and will be amended in future if new information becomes available.
[4] : Fungicides were not tested in each experiment; for details see Materials & Method and appendix 2.
[5] : No new data available
[6] : Provisional rating based on 5 EuroBlight experiments.

A new, more dynamic rating system for fungicide efficacy in controlling leaf blight was implemented in Hamar. The ratings are based on non-transformed StAUDPC values. The main advantage is that ratings are determined using a system that is more objective than that used to produce table ratings up until the Bologna meeting in 2007. Another advantage is that there is scope for future, more effective fungicides to be rated higher than 3, the maximum up until Bologna. Now the maximum rating will be 5. Furthermore ratings once given are not fixed, thus relative changes in the effectiveness of fungicides can be made apparent. The ratings proposed are exclusively based on the results of the 31 trials described in this report.

1 Introduction

Late blight caused by *Phytophthora infestans* is the most important foliar disease in the cultivation of potatoes. The crop needs to be protected from *P. infestans* by spraying fungicides regularly during the growing season. It is important to use fungicides that effectively protect leaves against this disease. A whole range of fungicides was or became registered in the last years. Each fungicide has its own mode of action and efficacies and therefore has specific characteristics. To evaluate each characteristic a EuroBlight table was set up to get an overview of the value of each characteristic. Up until the Bologna meeting in 2007 the ratings are based upon expert judgement, both from agrochemical companies and independent researchers. To evaluate the effectiveness of fungicides harmonised protocols were discussed at Tallinn. It was proposed that ratings of fungicides for the EU-table are calculated when field experiments are carried out over 2 years in 3 European countries. Each year from 2006 to 2015 at least three experiments were carried out. In fact 31 field experiments were set up to compare the effectiveness against leaf late blight by measuring the protection of leaves from application of a fungicide in a standard 7-day spray schedule (this standard spray schedule is not necessarily related to the label recommendations). This protection originates from the protectant and/or curative properties of the active ingredients and in the rapid growth phase of the crop also protection of new growth can contribute to the effectiveness of the fungicide for leaf blight control. Dose rates were the highest preventative doses registered in Europe. The results of the trials were used to re-evaluate the effectiveness of fungicides to control potato late blight. This report describes the analysis of the efficacy of fungicides to control potato late blight during the whole season.

2 Materials and methods

2.1 Trial set up

Experiments were conducted in Denmark, Germany, The Netherlands and United Kingdom. Full details are contained in the individual trial reports. Experiments were carried out in ten consecutive years, 2006 to 2015. The experiments were carried out according to the harmonised protocol as discussed during the Workshops of the "European network on Potato Late Blight" in Tallinn (2005), Bologna (2007), Hamar (2008), Arras (2010), St. Petersburg (2011) , Limassol (2013) and Brasov (2015). The protocol can be found on the EuroBlight website (http://www.euroblight.net/EuroBlight.asp) and is given in Appendix 1.
In general the trials conformed to local good agricultural practice, only the fungicide sprayings against *P. infestans* were carried out more or less weekly. The experiments were carried out in accordance with GEP.

2.2 Fungicides

In the Netherlands fungicide applications were carried out using a SOSEF sprayer at first and a CDH-sprayer in recent years with Teejet XR110.04 nozzles approximately 50 cm above the foliage. Sprayings were carried out with 250 l/ha.
In Denmark Hardi flat fan (ISO) LD 025 was used. The fungicides were sprayed with pressure of 3.0 bar, at 4.0 km/h and with 300 l water / ha.
In Germany the plots were sprayed by Technik TUM
In the UK in 2006 and 2008 to 2015 fungicides were applied using a tractor-mounted AZO compressed air sprayer with Lurmark F03-110 nozzles. Fungicides were applied in 300 litres of water per hectare at a pressure of 3.5 bar. In the UK in 2007 fungicides were applied using a hand held Oxford Precision Sprayer in 250 litres of water per hectare operating at 200 kPa through 110° flat fan nozzles.
Potato plants were sprayed for the first time at 100 % emergence or when the foliage was meeting along the rows in each experiment. Fungicides were sprayed weekly, according to protocol. Fungicides evaluated are listed in Table 1. If necessary the crop was sprayed full field with Signum or Amistar to control early blight. These fungicides were not applied to the UK trials.

Table 1. Fungicides sprayed in the experiments.

Fungicide	Active ingredient	Dose rate	Company
Acrobat DF (Invader)	dimethomorph + mancozeb	2.0 kg/ha	BASF
Acrobat DF (Invader)	dimethomorph + mancozeb	2.4 kg/ha	BASF
Banjo-Forte	dimethomorph + fluazinam	1.0 l/ha	Adama
Canvas + mancozeb	amisulbrom + mancozeb	0.5 l/ha + 2.0 kg/ha	Nufarm
Consento (Tyfon)	fenamidone + propamocarb	2.0 l/ha	Bayer CropScience
Dithane DG [1]	mancozeb	2.0 kg/ha for first spray then 2.25 kg/ha	DOW Agrosciences
EXP13-07[2]	mandipropamid + cymoxanil	0.6 l/ha	Syngenta
Fantic M	benalaxyl M + mancozeb	2.5 kg/ha	Isagro
Infinito	fluopicolide + propamocarb	1.6 l/ha	Bayer CropScience
Orvego Duo (Decabane)	ametoctradin / initium+ mancozeb	2.5 kg/ha	BASF
Presidium + fluazinam	(zoxamide + dimethomorph) + fluazinam	1.0 l/ha+ 0.4 l/ha	Gowan
Ranman + adjuvant	cyazofamid	0.2 l/ha + 0.15 l/ha	Belchim Crop Protection
Reboot (Lieto) + fluazinam	(zoxamide + cymoxanil) + fluazianam	0.45 kg/ha + 0.4 l/ha	Gowan
Revus	mandipropamid	0.6 l/ha	Syngenta
Sereno (Sonata)	fenamidone + mancozeb	1.5 kg/ha	Bayer CropScience
Shirlan	fluazinam	0.4 l/ha	Syngenta
Tattoo C (Merlin)	chlorothalonil + propamocarb	2.7 l/ha	Bayer CropScience
Unikat Pro (Electis)	zoxamide + mancozeb	1.8 kg/ha	Gowan
Valbon	benthiavalicarb + mancozeb	2.0 kg/ha	Certis Europe B.V.

[1]: DK: 2006 Dithane NT 2.0 kg/ha, 2007 Tridex DG 2.0 kg/ha (Cerexagri), UK: 2009 Laminator Flo 3.3 for first spray then 3.7 L / ha.
[2]: EXP13-07 will be marketed under the name Pergovi Flex/Regulance Flex/Carial Flex/Amphore Flex

2.3 Experimental conditions

The experimental conditions are presented in Tables 2 to 10. Artificial inoculation was not necessary in 2007 in the Netherlands and the UK. One plant in the spreader rows adjacent to each plot was artificially inoculated with a mixture of *P. infestans* isolates in 2006. The artificial inoculation was carried out 1 or 2 times.

Table 2. Experimental conditions at the different locations in 2006.

	The Netherlands 2006	Denmark 2006	UK 2006
Location	Lelystad	Flakkebjerg	Ayr
Soil	Clay	Clay	Sandy loam
Planting	3 May	6 May	May
Variety	Bintje	Dianella	King Edward
Rotary tillage	9 May	Approx. 7 June	-
Inoculation 1	2 June	27 June	24 July
Inoculation 2	26 June	4 July	-
Specific sprayings June	2, 8, 16, 23 and 29 June	28 June	-
Haulm killing spreader rows			-
Specific sprayings July	6, 13, 20 and 27 July	5, 13, 21, 28 July	13, 20, 27 July
Specific sprayings August	3, 9, 16, 23 and 30 August	3, 9, 16, 22, 31 August	5, 14, 22, 31 August
Specific sprayings September	6 and 13 September	6, 13, 21 September	8, 19, 26 September
Haulm killing	19 September		29 September

Table 3. Experimental conditions at the different locations in 2007.

	The Netherlands 2007	Denmark 2007	UK 2007	D 2007
Location	Lelystad	Flakkebjerg	Llaniar, Aberystwyth	Kirchheim near Munich
Soil	Clay	Clay	Clay loam	Pararendzina
Planting	15 May	19 April	2 May	28 March
Variety	Bintje	Folva	King Edward	Maxilla
Rotary tillage	24 May	Approx 11 May		
Inoculation	-	20 June		
Specific sprayings June	13, 19, 26 June	12, 19, 26 June	28 June	11, 19 June
Haulm killing spreader rows	9 July			
Specific sprayings July	2, 9, 16, 23, 30 July	3, 12, 23, 25 July	7, 15, 23, 30 July	3, 7, 17, 31 July
Specific sprayings August	6, 13, 20, 27 August	1, 8, 12 August	5, 13 August	15 August
Haulm killing	29 August			

Table 4. Experimental conditions at the different locations in 2008.

	The Netherlands 2008	Germany 2008	UK 2008
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate, Ayr
Soil	Clay	Pararendzina	Sandy Loam
Planting	7 May	11 April	16 May
Variety	Bintje	Maxilla	King Edward
Rotary tillage	14 May		-
Inoculation	11 June		15 July
Specific sprayings June	6, 12, 20, 27 June	9, 16, 24 June	-
Haulm killing spreader rows			-
Specific sprayings July	4, 10, 17, 25, 31 July	1, 7, 15, 22, 29 July	4, 11, 20, 28 July
Specific sprayings August	8, 15, 22, 29 August	5, 11, 19, 26 August	5, 11, 19, 26 August
Specific sprayings September			2 September
Haulm killing	5 September		4 September

Table 5. Experimental conditions at the different locations in 2009.

	The Netherlands 2009	Germany 2009	UK 2009
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate, Ayr
Soil	Clay	Pararendzina	Sandy Loam
Planting	5 May	5 April	30 May
Variety	Bintje	Maxilla	King Edward
Rotary tillage	12 May	-	-
Inoculation	25 June	-	15 July
Specific sprayings June	12, 19, 26 June	18, 29 June	-
Haulm killing spreader rows	-	-	-
Specific sprayings July	3, 9, 16, 23, 29 July	9, 16, 21, 28 July	7, 14, 23, 29 July
Specific sprayings August	4, 10, 17, 24 August	4, August	5, 12, 21, 27 August
Specific sprayings September	-	-	4 September
Haulm killing	1 September	-	11 September

Table 6. Experimental conditions at the different locations in 2010.

	The Netherlands 2010	Germany 2010	UK 2010
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Sandy Loam
Planting	18 May	30 March	19 May
Variety	Bintje	Albatros	King Edward
Rotary tillage			
Inoculation	29 June		28th July
Haulm killing spreader rows			-
Specific sprayings June	10, 17, 24 June	10, 18, 28 June	-
Specific sprayings July	1, 8, 15, 22, 29 July	6, 13, 20, 28 July	6, 13, 20, 27 July
Specific sprayings August	5, 12, 19, 25 August	3, 11, 20, 26 August	3, 11, 19, 27 August
Specific sprayings September	1, 9 September	-	4, 11, 18, 27 September
Haulm killing	17 September	-	30 September & 7 October

Table 7. Experimental conditions at the different locations in 2011.

	The Netherlands 2011	Germany 2011	UK 2011
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Sandy Loam
Planting	6 May	3 April	10 June
Variety	Bintje	Albatros	King Edward
Rotary tillage			-
Inoculation	1 July		19th July
Haulm killing spreader rows			-
Specific sprayings June	8, 15, 22, 28	6, 14, 21, 28	-
Specific sprayings July	5, 12, 19, 25	4, 12, 19, 26	18, 26 July
Specific sprayings August	1, 10, 17, 24, 31	3, 10, 18, 25	2, 9, 17, 24 August
Specific sprayings September	8, 15, 22, 28	2	1, 9, 16 September
Haulm killing	7 September	-	30 September

Table 8. Experimental conditions at the different locations in 2012.

	The Netherlands 2012	Germany 2012	UK 2012
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Sandy Loam
Planting	7 May 2012	2 April	24 May
Variety	Bintje	Maxilla	King Edward
Rotary tillage			
Inoculation			Natural infection
Haulm killing spreader rows	-		-
Specific sprayings June	11, 19, 26	22, 29	-
Specific sprayings July	2, 10, 16, 23, 30	6, 13, 20, 27	5, 12, 19, 27
Specific sprayings August	6, 13, 20, 27	3, 10, 17, 24, 31	3, 10, 16, 23, 30
Specific sprayings September	-	6	6
Haulm killing	3 September	-	-

Table 9. Experimental conditions at the different locations in 2013.

	The Netherlands 2013	Germany 2013	UK 2013
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Silty Sandy Loam
Planting	3 June 2013	18 April	22 & 23 May
Variety	Bintje	Maxilla	King Edward
Rotary tillage	-		-
Inoculation	11 July (VK98014 / Blue13)		24 July (Blue 13)
Haulm killing spreader rows	-		-
Specific sprayings June	-	13, 20, 27	-
Specific sprayings July	1, 8, 15, 22, 29	4, 11, 18, 25	3, 10, 17, 24 & 31
Specific sprayings August	5, 12, 19, 26	1, 8, 15, 22, 29	8, 16, 23 & 30
Specific sprayings September	-	5, 12, 19	6, 14, 21 & 28
Haulm killing	2 & 6 September		5 October

Table 10. Experimental conditions at the different locations in 2014.

	The Netherlands 2014	Germany 2014	UK 2014
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Silty Sandy Loam
Planting	16 May 2014	31 March	6 June 2014
Variety	Bintje	Maxilla	King Edward
Rotary tillage			-
Inoculation	24 June (VK98014 / Blue13)[1]		Natural (13_A2)
Haulm killing spreader rows	-		-
Specific sprayings June	17 & 24	From 13 June	-
Specific sprayings July	1, 7, 15, 22, 29		9, 17, 24, 31
Specific sprayings August	5, 12, 20, 25		7, 15, 22, 28
Specific sprayings September	-	to 2 Sept. weekly	-
Haulm killing	3 & 10 September		2 September 2014

[1]) At the time of inoculation also potato late blight was already established in the spreader rows.

Table 11. Experimental conditions at the different locations in 2015.

	The Netherlands 2015	Germany 2015	UK 2015
Location	Lelystad	Kirchheim near Munich	Auchincruive Estate , Ayr
Soil	Clay	Pararendzina	Silty Sandy Loam
Planting	1 May 2015	14 April 2015	16 June 2015
Variety	Bintje	Maxilla	King Edward (3)
Rotary tillage			-
Inoculation	25 June		Trial field on 16 July (6_A1)
Haulm killing spreader rows	-		-
Specific sprayings June	15, 22 & 29		-
Specific sprayings July	6, 14, 20 & 29		17, 24, 30
Specific sprayings August	4, 11, 18 & 25		7, 15, 22, 30
Specific sprayings September	1		7, 15, 22, 30
Specific sprayings October			8
Haulm killing	10 & 17 September		-

[1]) At the time of inoculation also potato late blight was already established in the spreader rows.

2.4 Disease observations

During the growing season the percentage foliar infection was assessed at weekly intervals. To evaluate the epidemic, the Area under the Disease Progress Curve (AUDPC) was determined. StAUDPC values were calculated by dividing the AUDPC value by the number of days between the first and last disease observation. Obviously, for each fungicide within an experiment the same number of days was used. The number of days from the first to last disease observation varied for each experiment and ranged between 29 and 71 days. The StAUDPC provides an indicator for the efficacy of the fungicides during the whole growing season. Appendix 2 lists StAUDPC values for fungicides tested in each experiment, for each replicate separately.

2.5 Statistical analyses

Thirty one experiments were carried out. Each experiment was laid out as a randomised complete block design with one treatment factor, the fungicides being tested, and four replicates. A mixed model analysis (REML) was performed on StAUDPC measured per experimental plot. REML analysis was used because not every fungicide was present in all 31 experiments. A mixed model consists of fixed treatment terms (here fungicide) and random block terms (here experiment, block and plot; formula 1):

$$stAUDPC_{ijkp} = \mu + E_i + B_{ij} + \beta_k + P_{ijp}, \qquad (1)$$

where

μ = overall mean

E_i = effect of experiment $i \sim N(0, \sigma_E^2)$

B_{ij} = effect of block j within experiment $i \sim N(0, \sigma_B^2)$

P_{ijp} = effect of plot p within block $B_{ij} \sim N(0, \sigma_P^2)$

β_k = effect of fungicide k

StAUDPC was analysed instead of AUDPC because the assessment period was not equal in all trials. StAUDPC equals the AUDPC divided by the number of days between first and final disease assessments. The code of the Genstat 18th ed. (Payne et al., 2009) used for the statistical analysis and the essential output are presented (Appendix 3).

Plots with high residuals were identified to establish non – consistent performance of fungicides. Replicates 1 and 2 of the 2006 experiment in the Netherlands were omitted from the analysis. The stability of fungicide effectiveness between experiments was evaluated. The mean StAUDPC per fungicide (mstAUDPC) is reported in Appendix 3.
Based on the average StAUDPC (mstAUDPC), ratings for the effectiveness of the fungicides to control late blight were calculated, according to formula (2)

$$\mathrm{ER}_k = 3\frac{\mathrm{MAX}(y) - y_k}{\mathrm{MAX}(y)} + 2, \qquad (2)$$

ER_k = efficacy rating of the fungicide k to control potato late blight during the whole growing season.
y = mstAUDPC
MAX (y) = mstAUDPC of the fungicide with the highest mstAUDPC determined in the series of experiments.

The experiments were conducted in four countries during ten seasons. Disease pressure varied with each experiment. The REML directive takes the specific conditions of the experiment into account. Assume that fungicide A was tested in experiments with a relatively high disease pressure and fungicide B in experiments with a relatively low disease pressure. Then the arrhythmic mean of mSTAUDPC of fungicide A would be adjusted with a decrease and fungicide B would be adjusted with a rise of mSTAUDPC. By doing so the disease pressure for all the fungicides is adjusted to the same level, making a fair comparison between fungicides in different experiments possible.

Literature

Montgomery, D.C. and Peck, E.A., (1982). Introduction to Linear Regression Analysis. John Wiley & Sons. New York.

Payne, R.W., Harding, S.A., Murray, D.A., Soutar, D.M., Baird, D.B., Glaser, A.I., Channing, I.C., Welham, S.J., Gilmour, A.R., Thompson, R., Webster, R. (2009). *The Guide to GenStat Release 12, Part 2: Statistics*. VSN International, Hemel Hempstead.

3 Results and discussion

3.1 Late blight epidemic

3.1.1 2006
The late blight epidemic started well after flowering in 2006 (Table 11). During the first part of the season hardly any rain fell. At the end of July, a period of consecutive days with precipitation started. This led to the start of the potato late blight epidemic, but also triggered new growth of the crop as was witnessed in the UK.

3.1.2 2007
In 2007, due to very favourable circumstances for the development of late blight early in the growing season artificial inoculation was not necessary in the Netherlands. The late blight epidemic already started in June.

3.1.3 2008
The late blight epidemic started relatively late in the UK in 2008. Both in Germany and The Netherlands the late blight epidemic started about a month earlier than in the UK.

3.1.4 2009
In 2009, late blight occurred first in The Netherlands, followed a week later in Germany and three weeks later in the UK.

3.1.5 2010
The late blight epidemic started at the end of July 2010. Both in Germany and in The Netherlands the late blight epidemic developed strongly in August. Within two to three weeks the plots were almost completely destroyed.

3.1.6 2011
In 2011 the late blight epidemic in the UK did not progress until the beginning of September. However in the second half of September disease severity increased rapidly from 5% to 74% in 9 days' time. Although lesions were found in the beginning of July, the late blight epidemic really started at the end of July in the Netherlands. In Germany the late blight epidemic started at the beginning of August, approximately one week later than in The Netherlands.

3.1.7 2012
In 2012 early late blight epidemics were observed in The Netherlands and the UK, whereas the late blight epidemic in Germany occurred late. In Germany due to hot summer weather by the end of August next to late blight also early blight was found. Therefore the last observation date was 14 August. In the UK the late blight epidemic started by the end of July and progressed throughout August.

3.1.8 2013
In 2013 the late blight epidemic in both the UK and Germany occurred late. The first lesions in the plots were found on 29 August in Germany. An increase was found in the next week, mainly on new growth. In the UK the late blight epidemic started in August and continued until the end of September. The untreated control was destroyed at the end of August. In the Netherlands the first lesions caused by *P. infestans* were found on 16 July. Disease severity increased rapidly during the first week of August. Within two to three weeks the crop was almost completely destroyed in some of the treatments.

3.1.9 2014
In 2014 the late blight epidemic in The Netherlands started early. Late blight was observed in the untreated

controls on 12 June. At that time also 2 lesions were found in plot 18 (treatment C). Then the late blight epidemic lingered for almost four weeks before a significant increase in disease severity occurred in the untreated control. At the end of July also the late blight epidemic increased in the treated plots, which marks the real start of the late blight epidemic. In Germany the late blight epidemic started in the untreated control in the first week of July. In the treated plots the first lesions were observed in the second week of August. In the UK early and severe natural late blight infection occurred. Consequently, in the untreated plots blight severity was 27% on 25 July, the date when the first lesions were found in the treated plots.

3.1.10 2015

The year 2015 was not conducive for potato late blight development. In The Netherlands and Germany large parts of June and July were warm and dry. In the UK May, June and July were considerably cooler, and September was much drier, than normal.
In The Netherlands late blight was observed in the untreated controls on 15 July. At that time also 1 lesion was found in plot 37 (treatment F). The exponential phase in the untreated control started at the last week of July. For the reference treatment Dithane and treatment K this was approximately one week later.
In Germany potato late blight was already observed on 8 June in the untreated control and a week later in the plots. However the late blight epidemic was stopped due to extremely high temperatures between 24 June and 8 July. This was followed by extremely hot and dry weather from 15 July onwards. Thus no progressive potato late blight epidemic occurred until the end of the season.
In the UK potato late blight was observed late. The first lesions were found on 20 August. The progressive stage of the epidemic was reached by the end of September. Disease severity reached 100% in untreated plots on 24 September (in an adjacent trial). However, severity in the fungicide-treated plots did not exceed 4.5%.

Table 11. First observation of *P. infestans* infected foliage in the untreated control and in treated plots, during the experiments.

	Untreated				Treated			
Year	D	DK	NL	UK	D	DK	NL	UK
2006	-	20-7	4-8	18-8	-	20-7	4-8	25-8
2007	-	4-7	19-6	8-7	-	28-6	19-6	8-7
2008	19-6	-	< 27-6	< 2-8	2-7	-	27-6	2-8
2009	4-7	-	-	<27-7	14-7	-	8-7	27-7
2010	20-6	-	6-7	19-7	16-8	-	6-7	13-8
2011	11-7	-	7-7	< 10-8	1-8	-	7-7	10-8
2012	3-7	-	3-7	< 25-7	6-8	-	3-7	25-7
2013	26-6	-	< 9-7	7-8	29-8	-	16-7	7-8
2014	6-7	-	12-6	< 25-7	11-8	-	12-6	25-7
2015	8-6	-	15-7	< 20-8	15-6	-	15-7	20-8

-: no experiment.

The effectiveness of fungicides to control potato late blight epidemic for each experiment separately is given in Figures 1-30

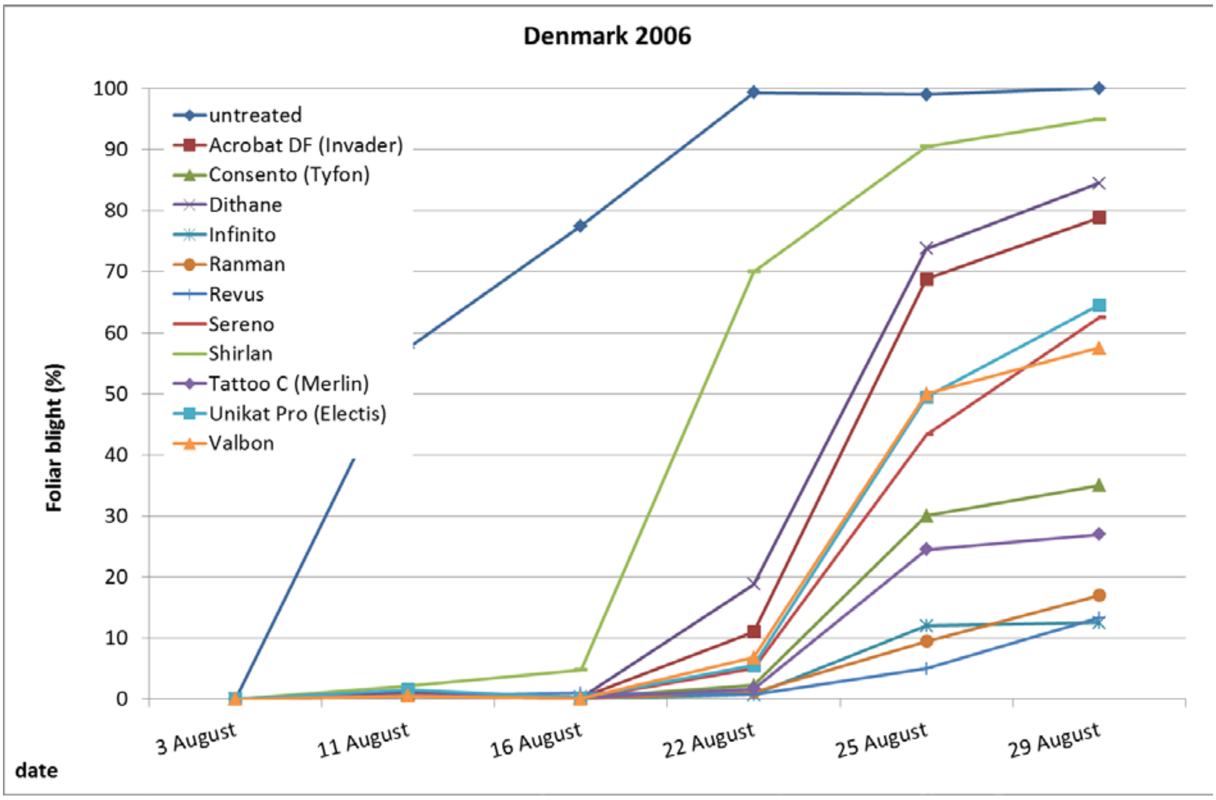

Figure 1. The development of foliar blight during the growing season in Denmark 2006.

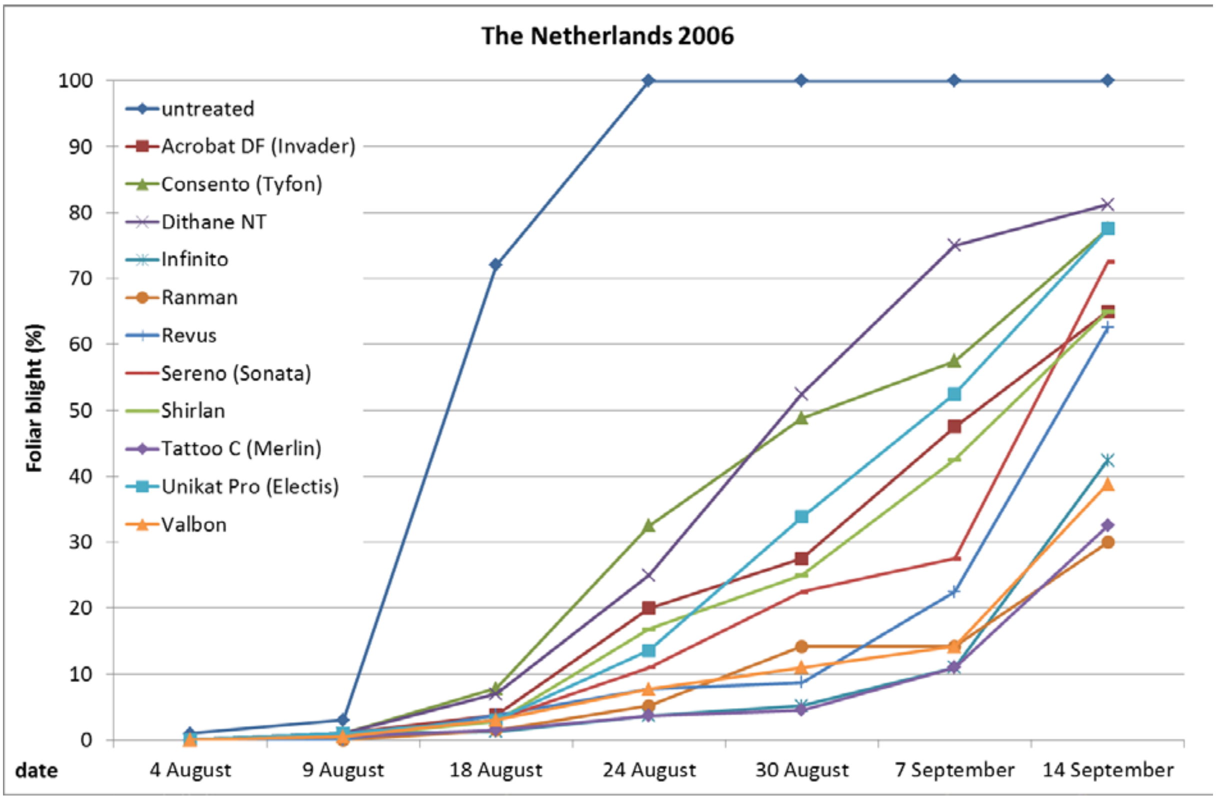

Figure 2. The development of foliar blight during the growing season in the Netherlands 2006.

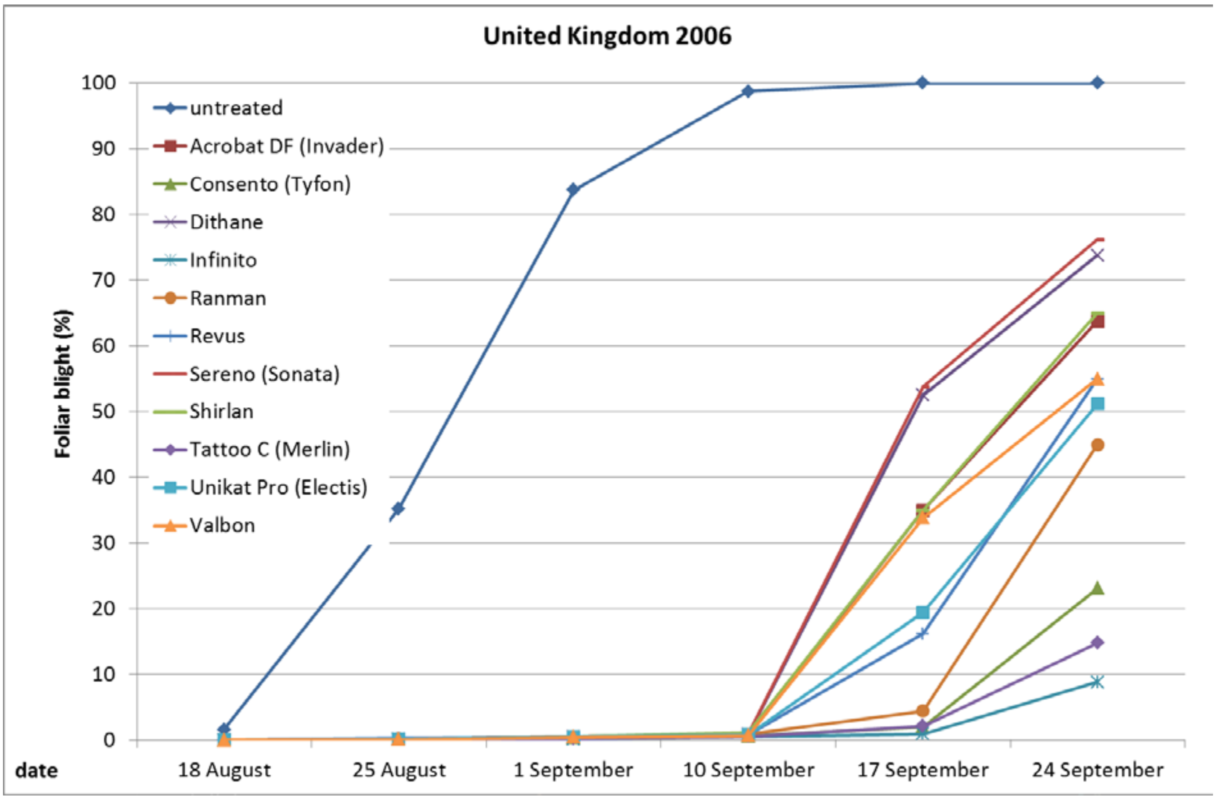

Figure 3. The development of foliar blight during the growing season in the United Kingdom 2006.

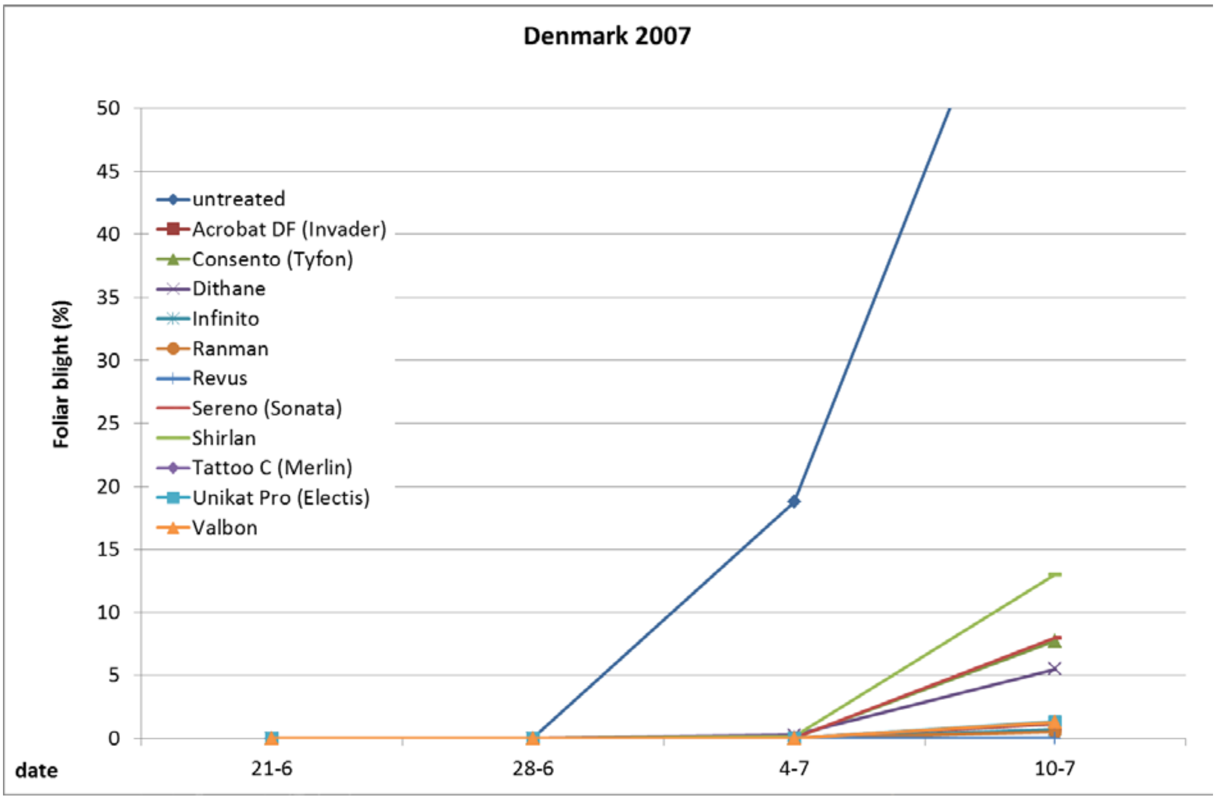

Figure 4. The development of foliar blight during the growing season in the Denmark 2007.

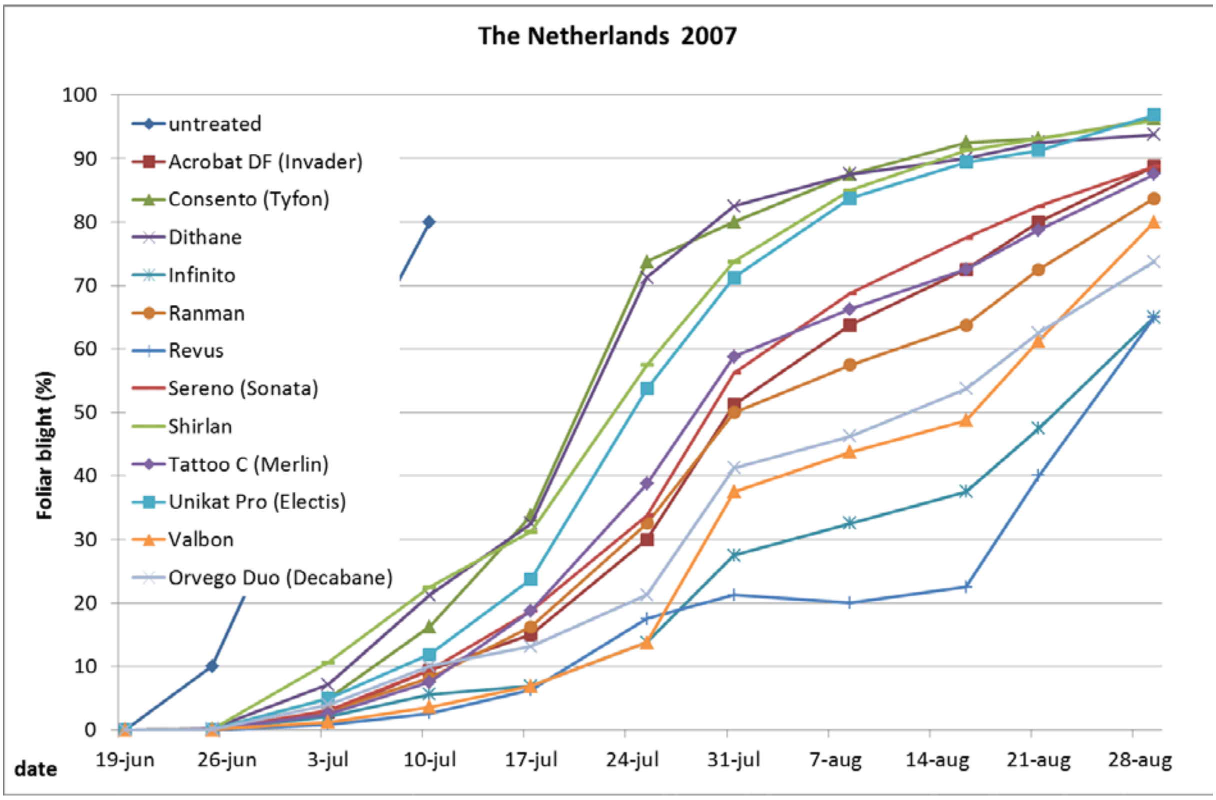

Figure 5. The development of foliar blight during the growing season in the Netherlands 2007.

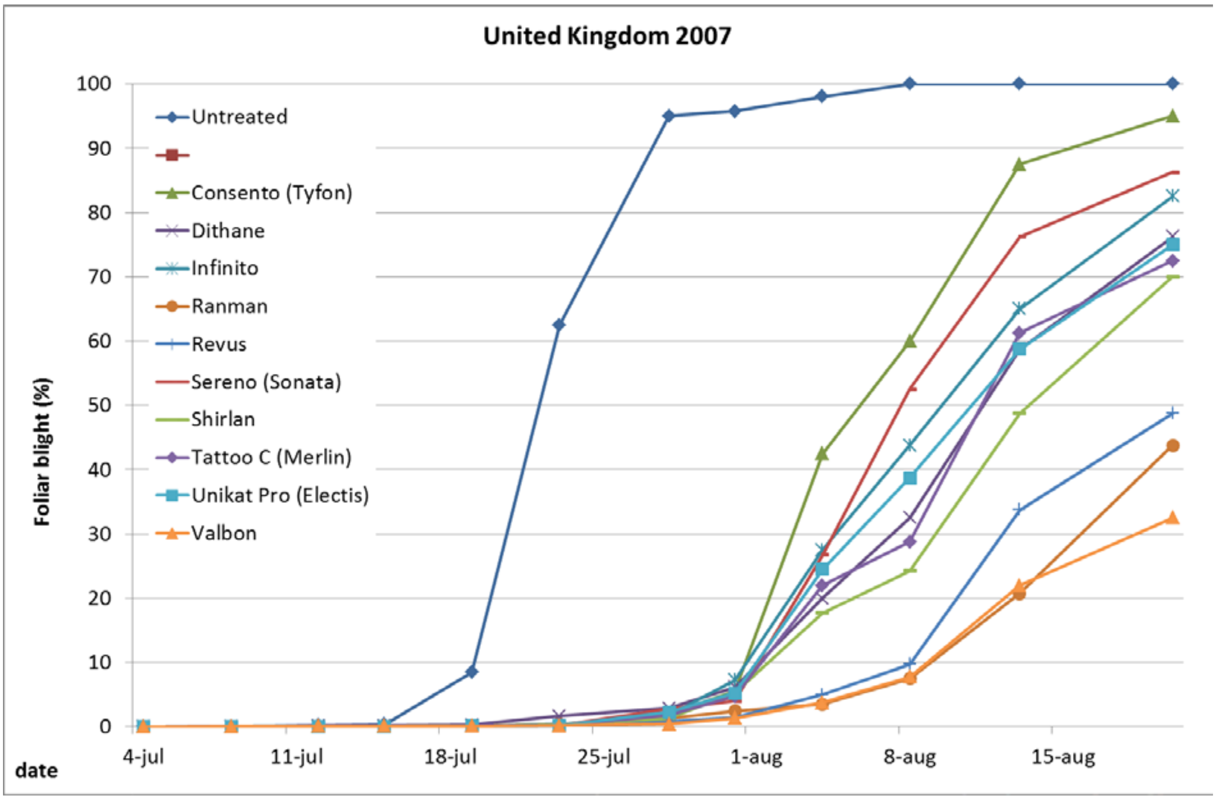

Figure 6. The development of foliar blight during the growing season in the United Kingdom 2007.

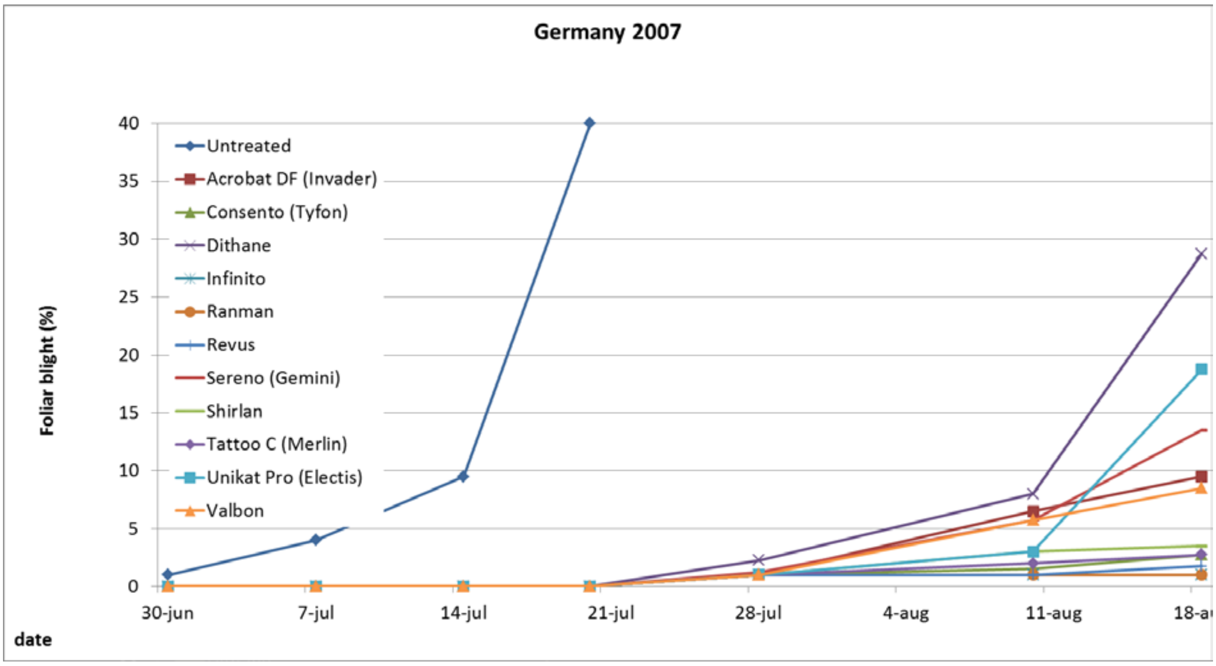

Figure 7. The development of foliar blight during the growing season in Germany 2007.

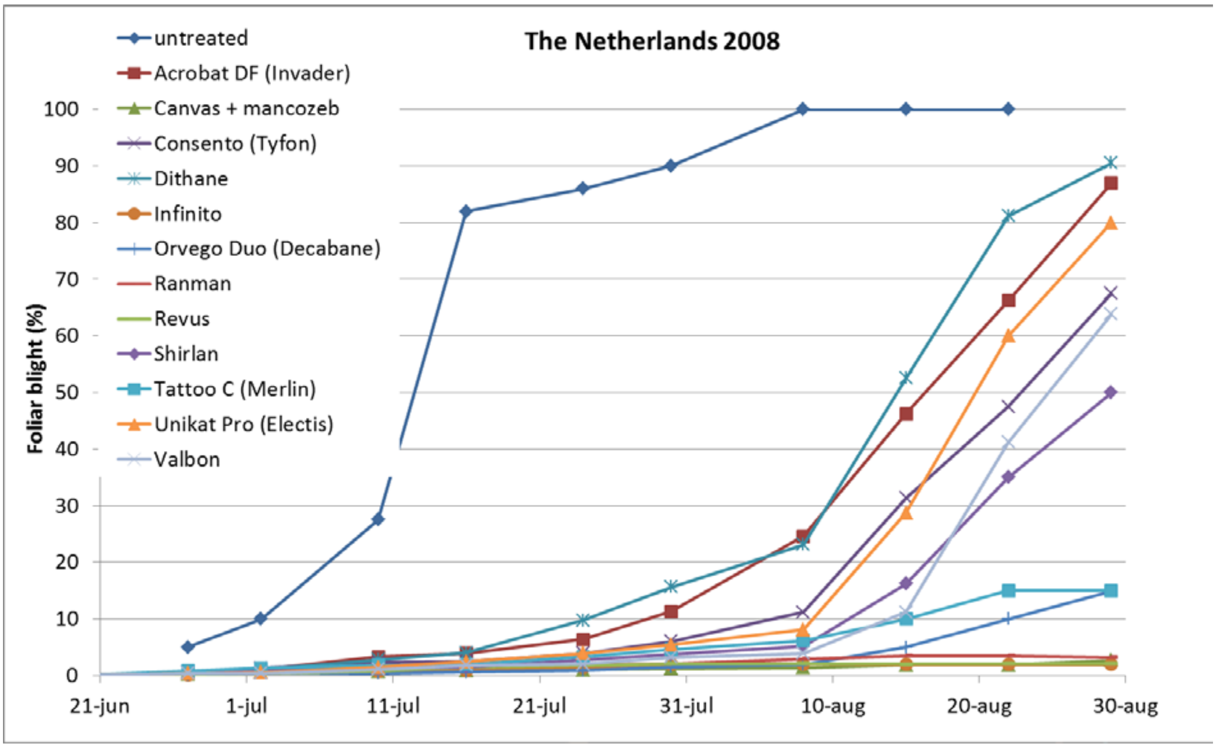

Figure 8. The development of foliar blight during the growing season in the Netherlands 2008.

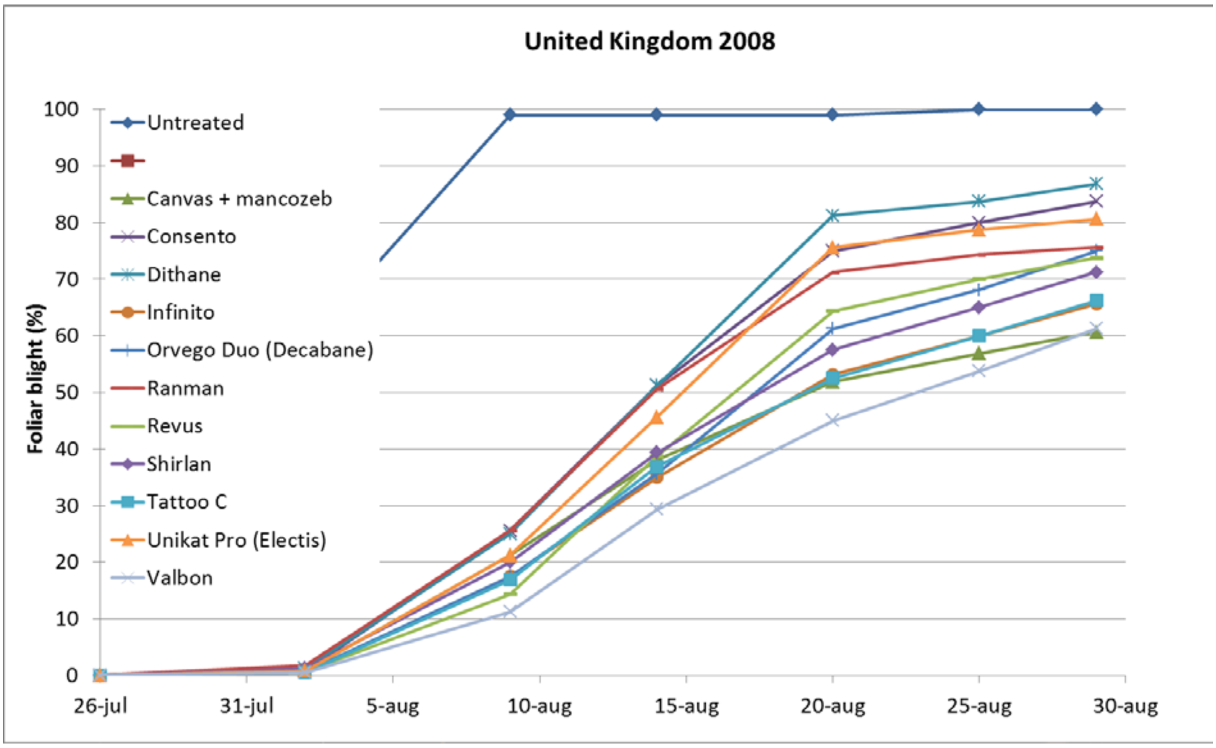

Figure 9. The development of foliar blight during the growing season in the United Kingdom 2008.

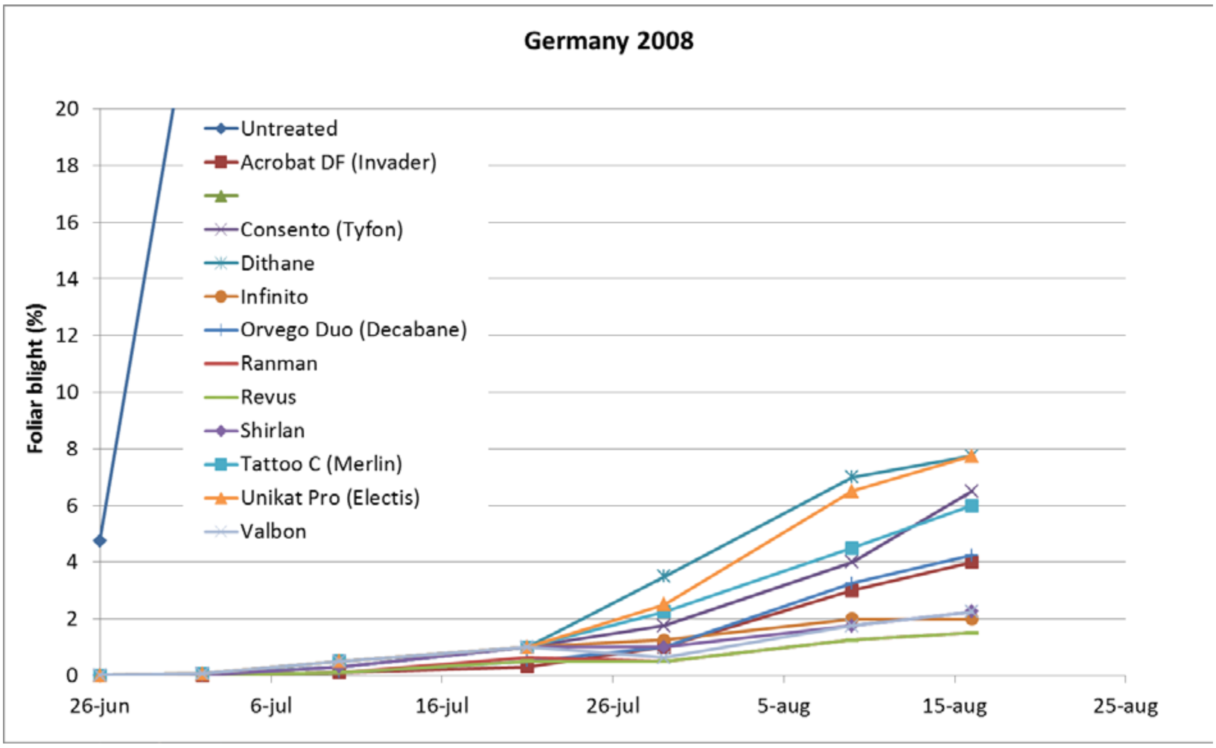

Figure 10. The development of foliar blight during the growing season in Germany 2008.

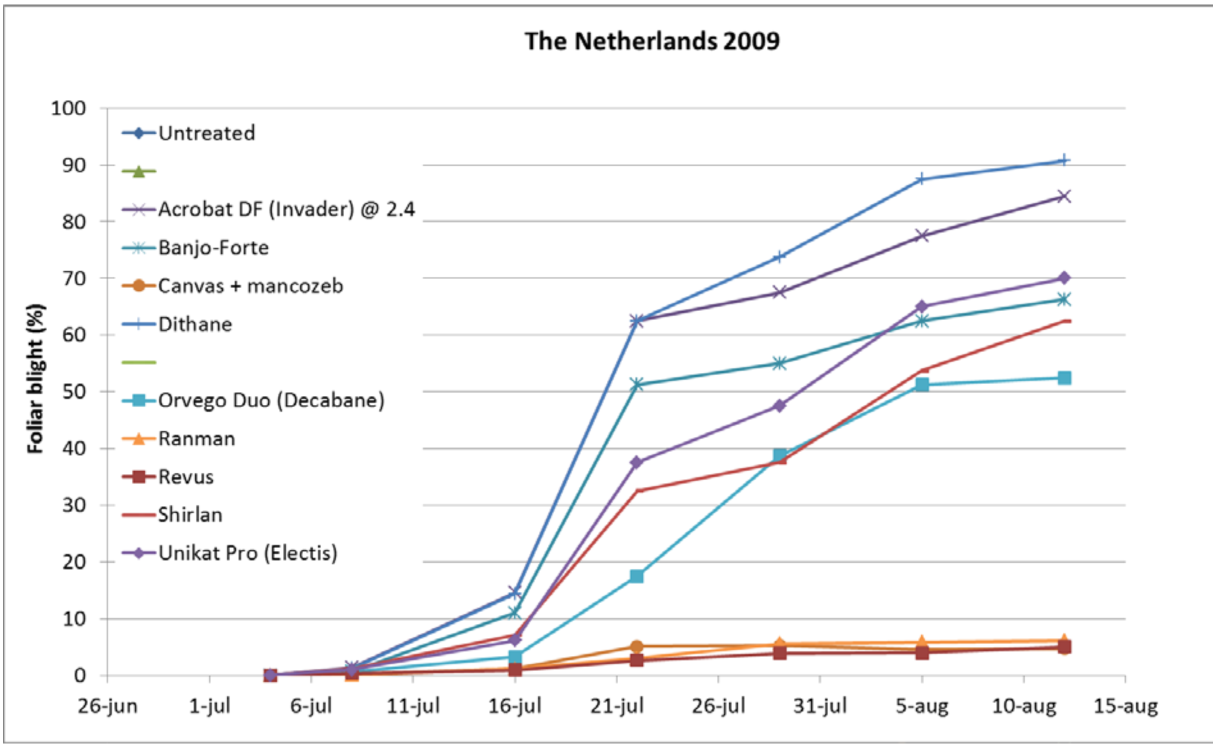

Figure 11. The development of foliar blight during the growing season in the Netherlands 2009.

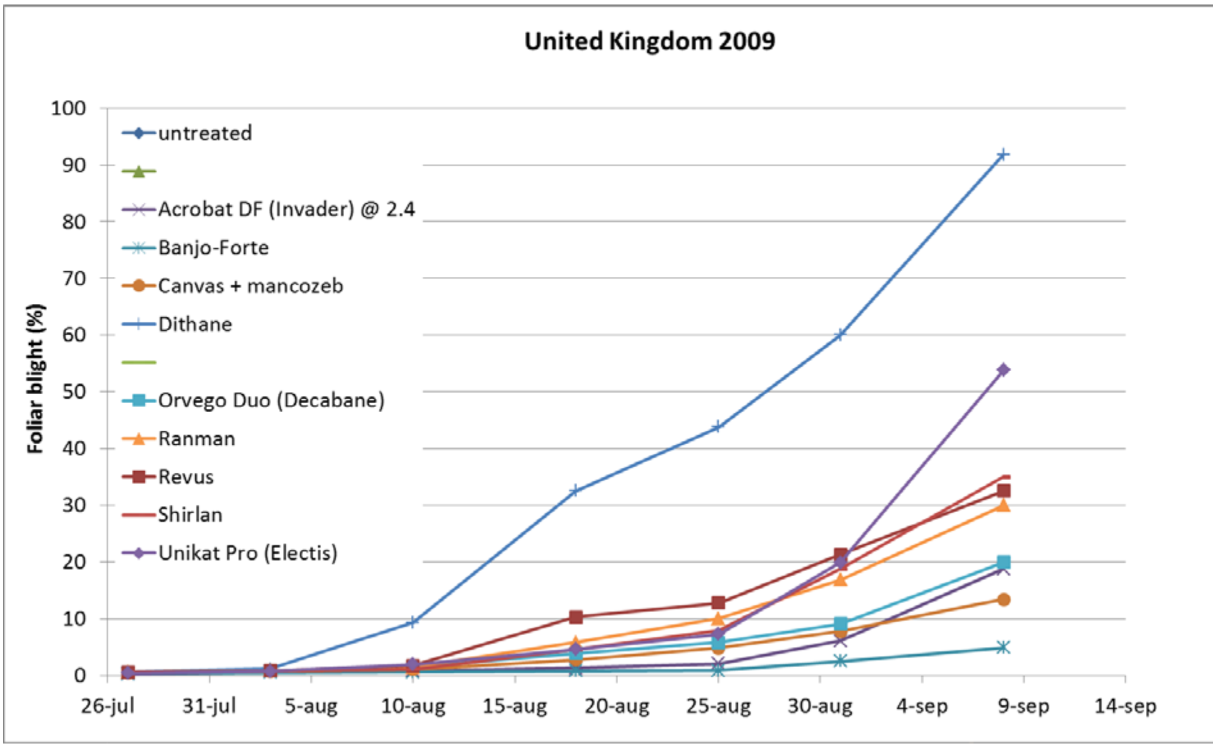

Figure 12. The development of foliar blight during the growing season in the United Kingdom 2009.

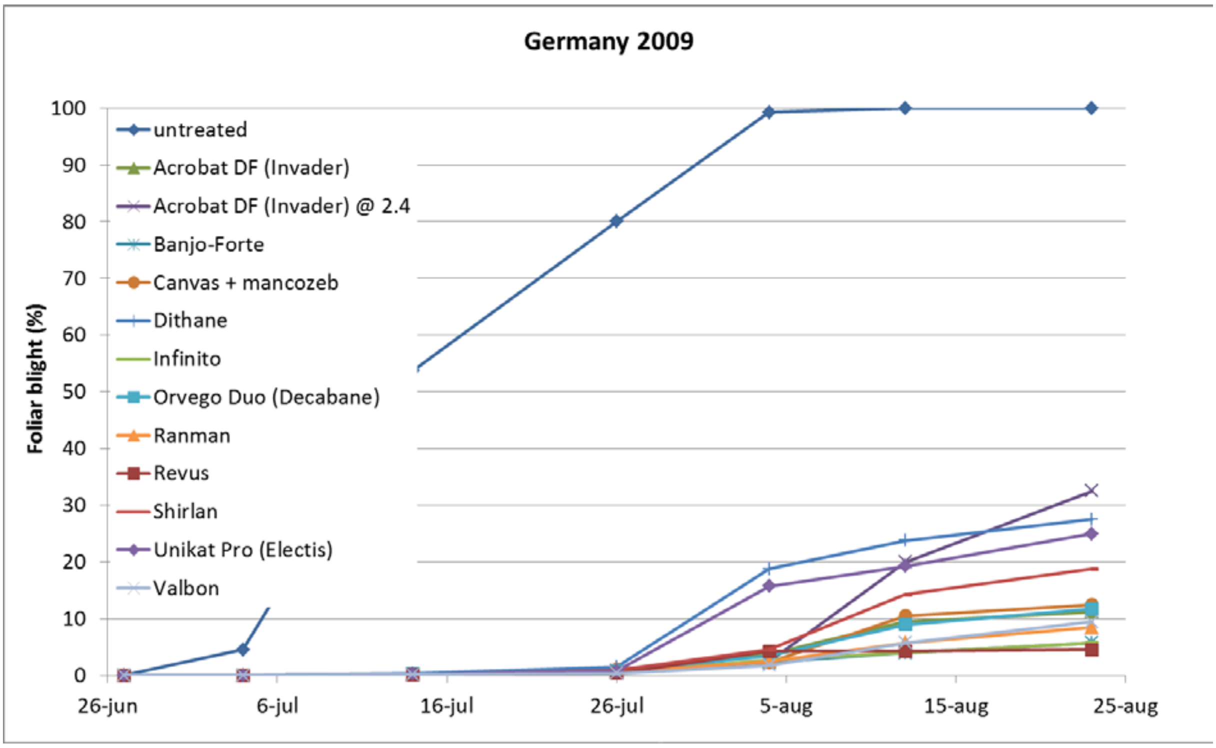

Figure 13. The development of foliar blight during the growing season in Germany 2009.

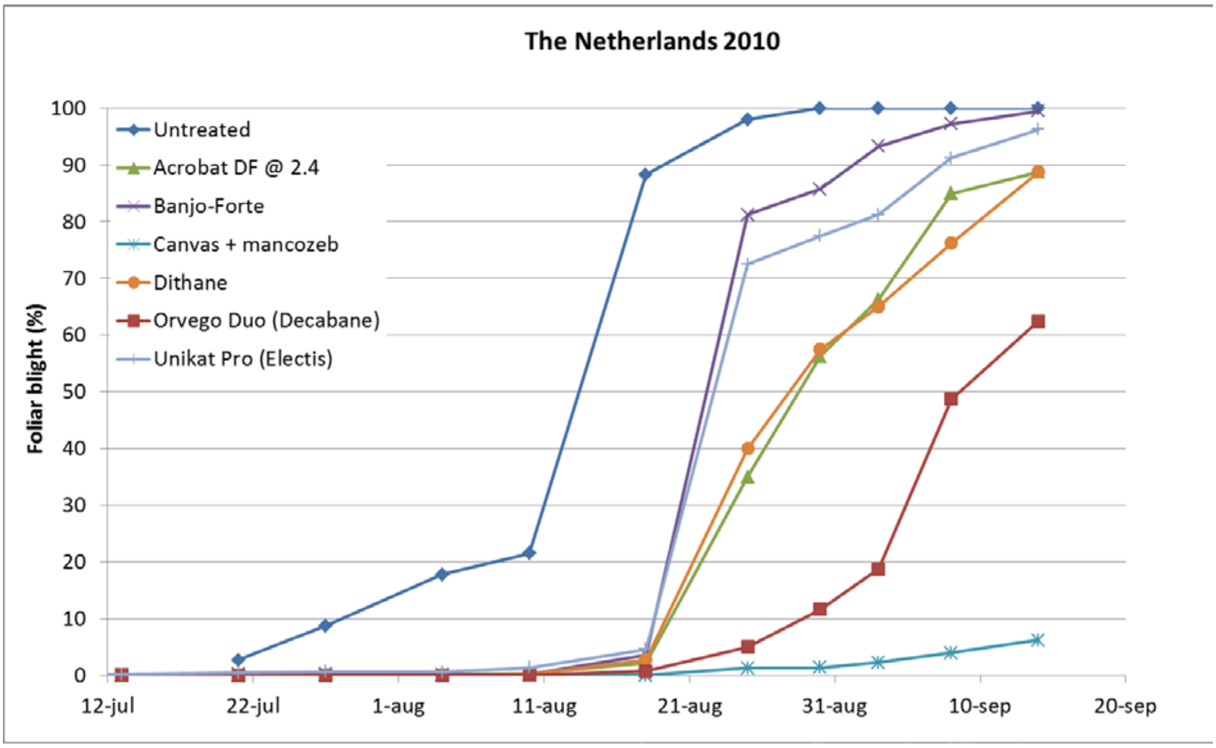

Figure 14. The development of foliar blight during the growing season in the Netherlands 2010

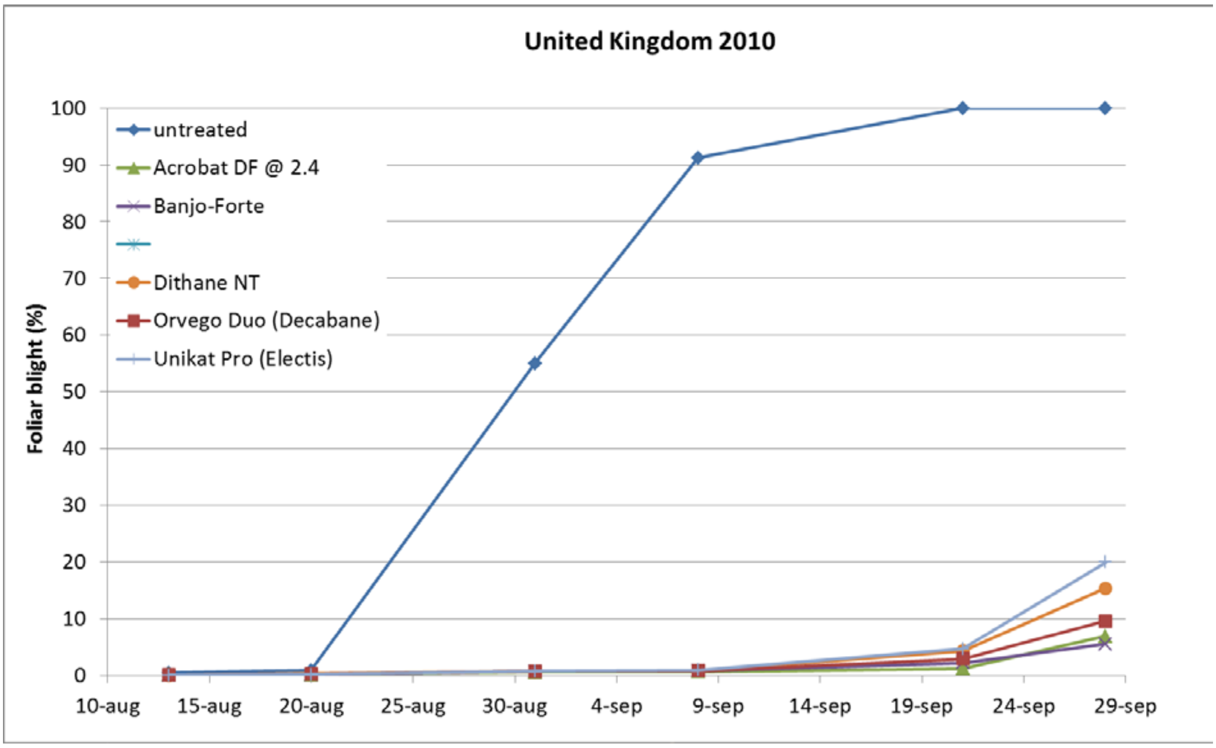

Figure 15. The development of foliar blight during the growing season in the United Kingdom 2010.

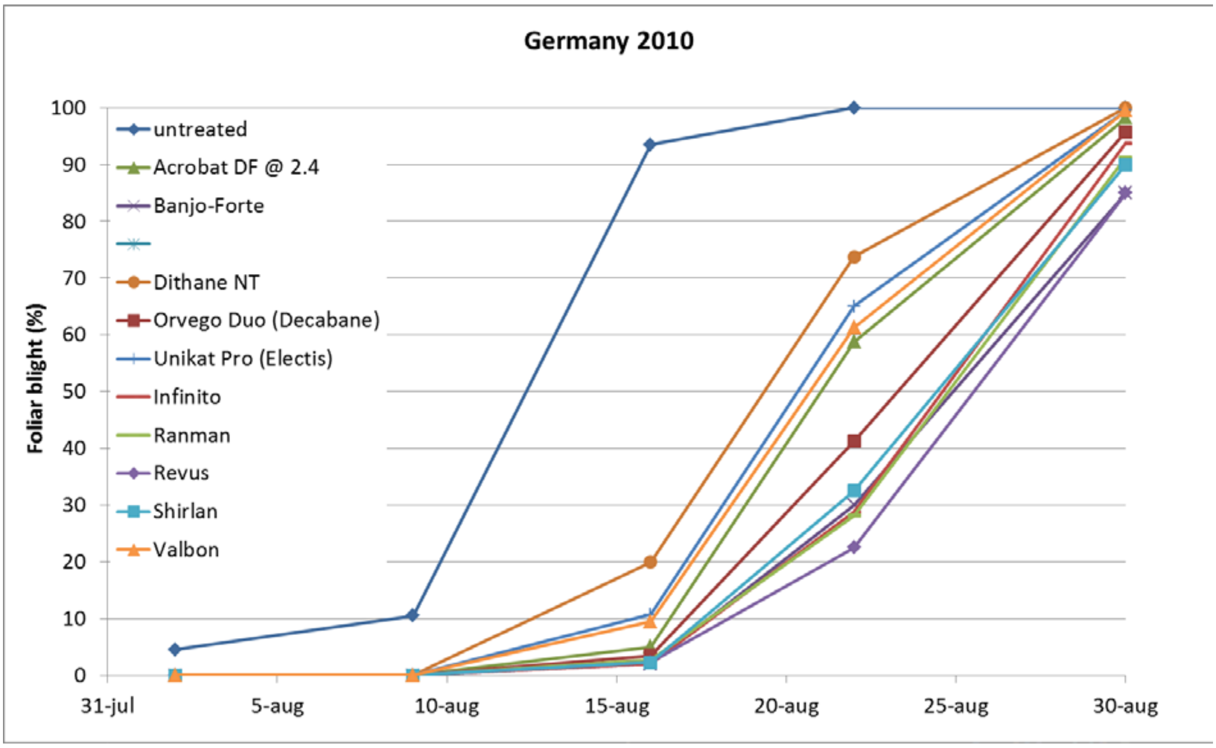

Figure 16. The development of foliar blight during the growing season in Germany 2010.

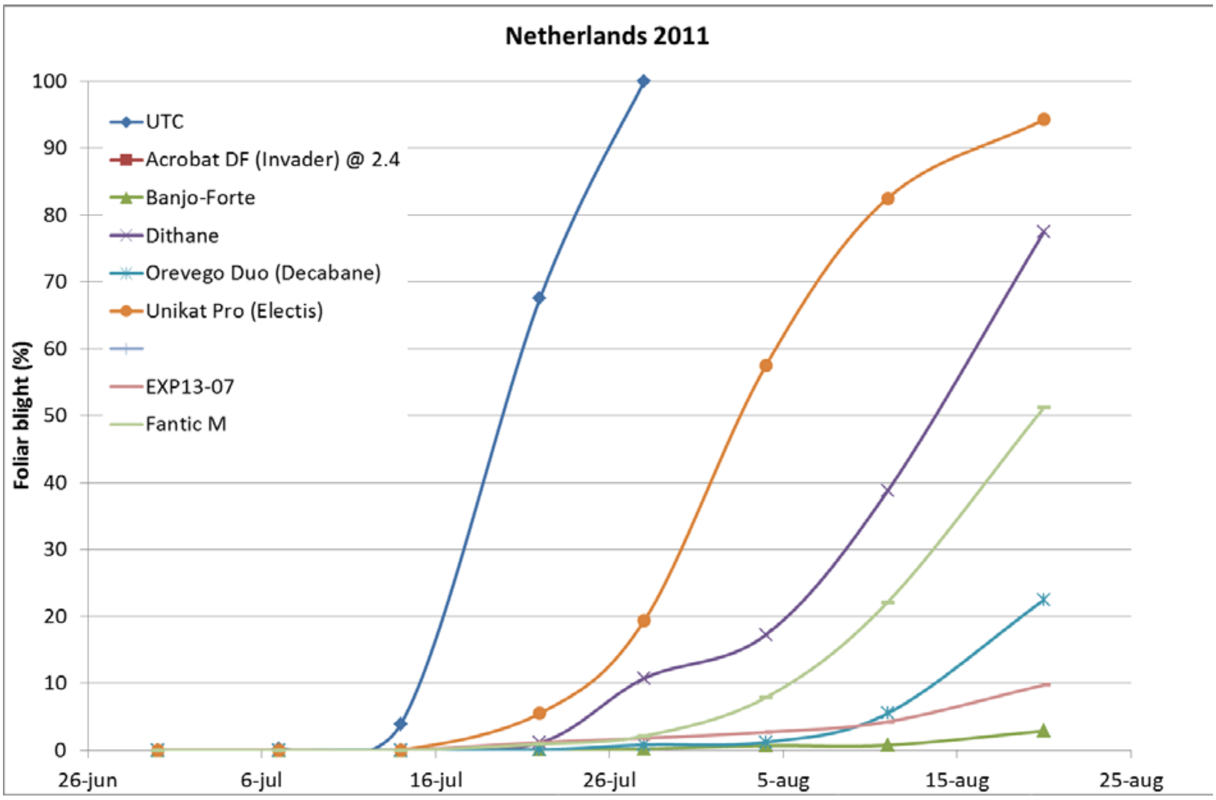

Figure 17. The development of foliar blight during the growing season in the Netherlands 2011

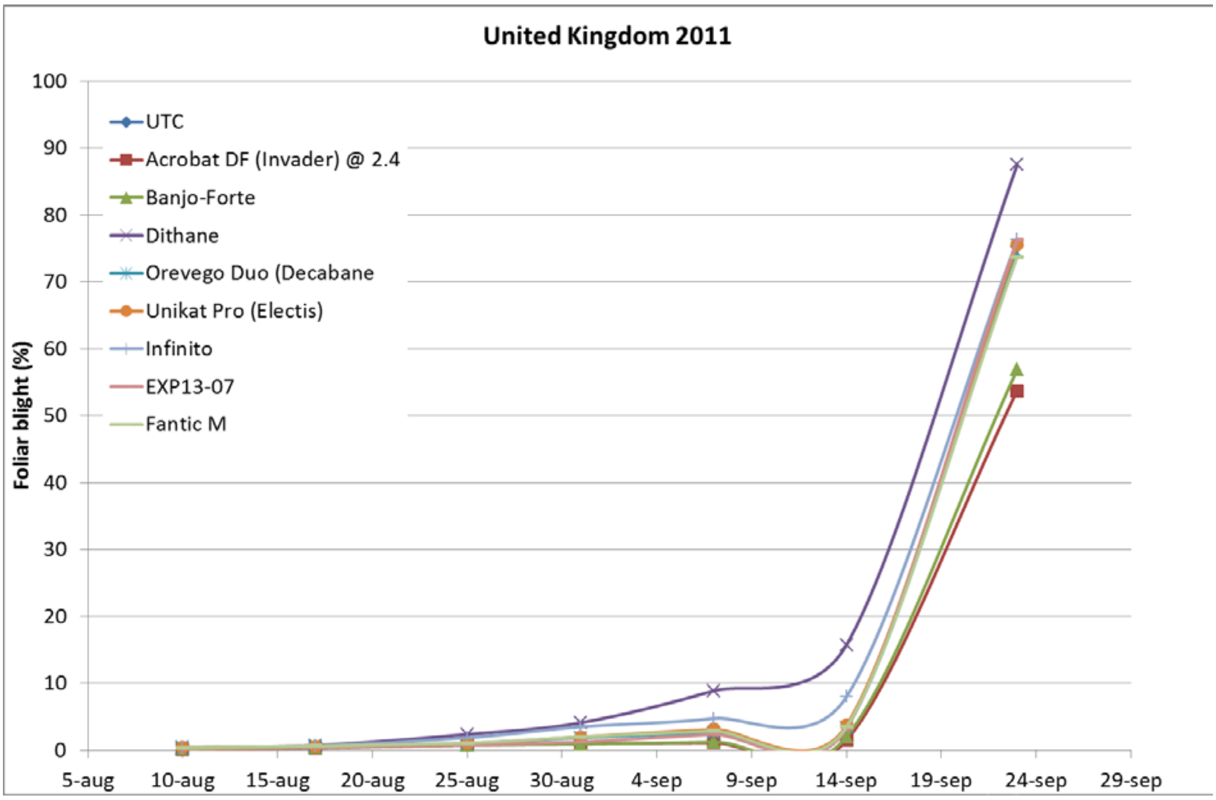

Figure 18. The development of foliar blight during the growing season in the United Kingdom 2011. The untreated control was assessed in an adjacent trial in the same field.

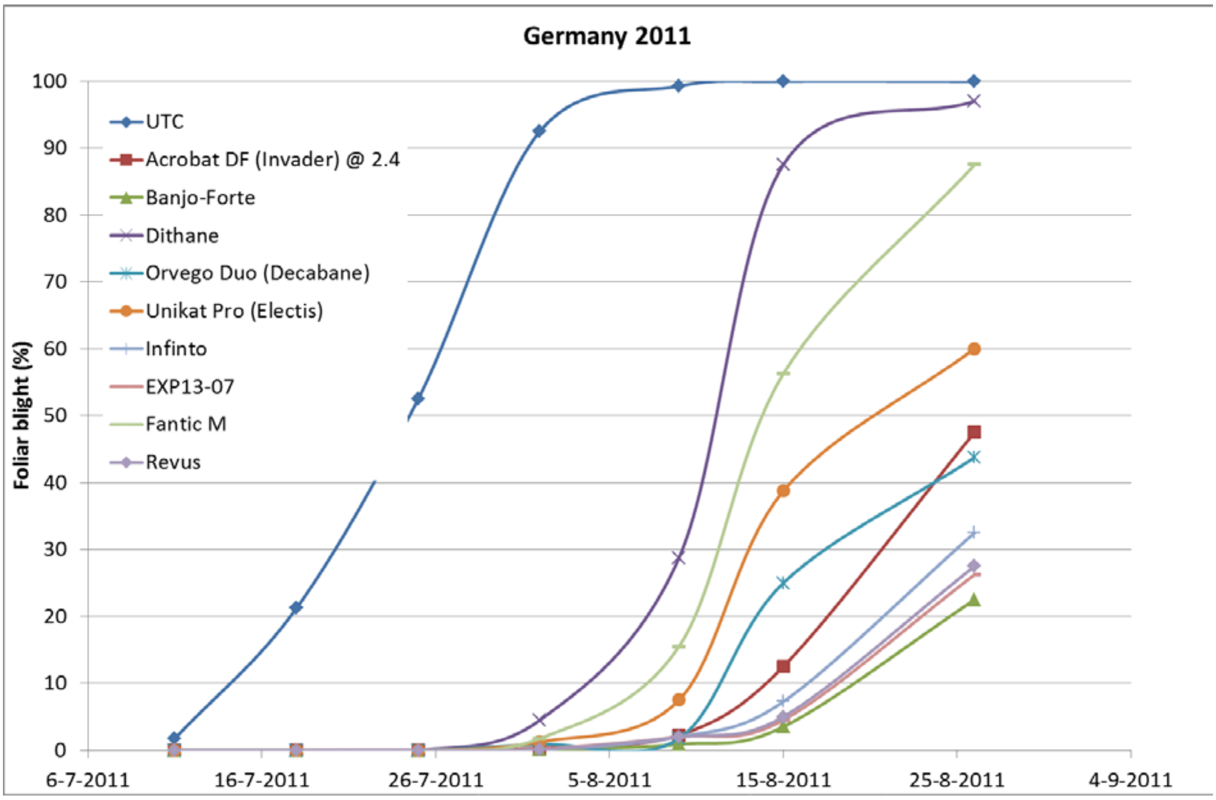

Figure 19. The development of foliar blight during the growing season in Germany 2011

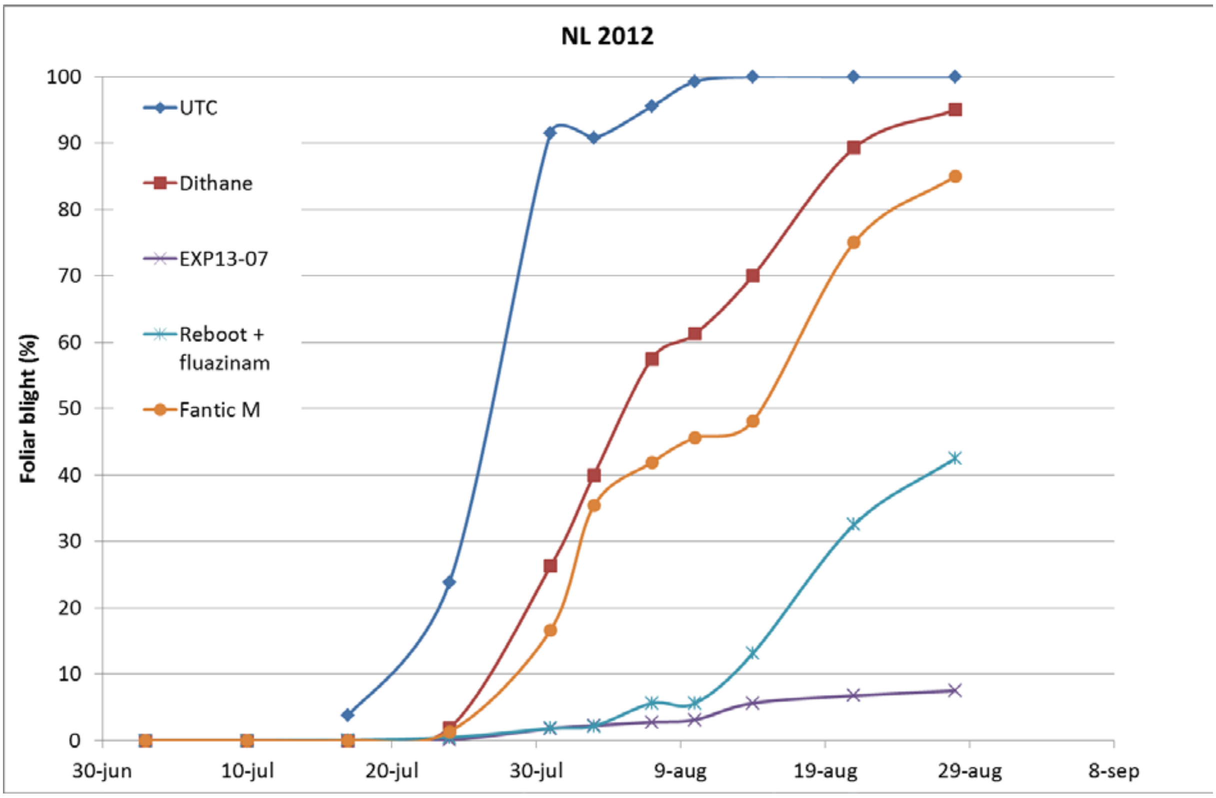

Figure 20. The development of foliar blight during the growing season in the Netherlands 2012

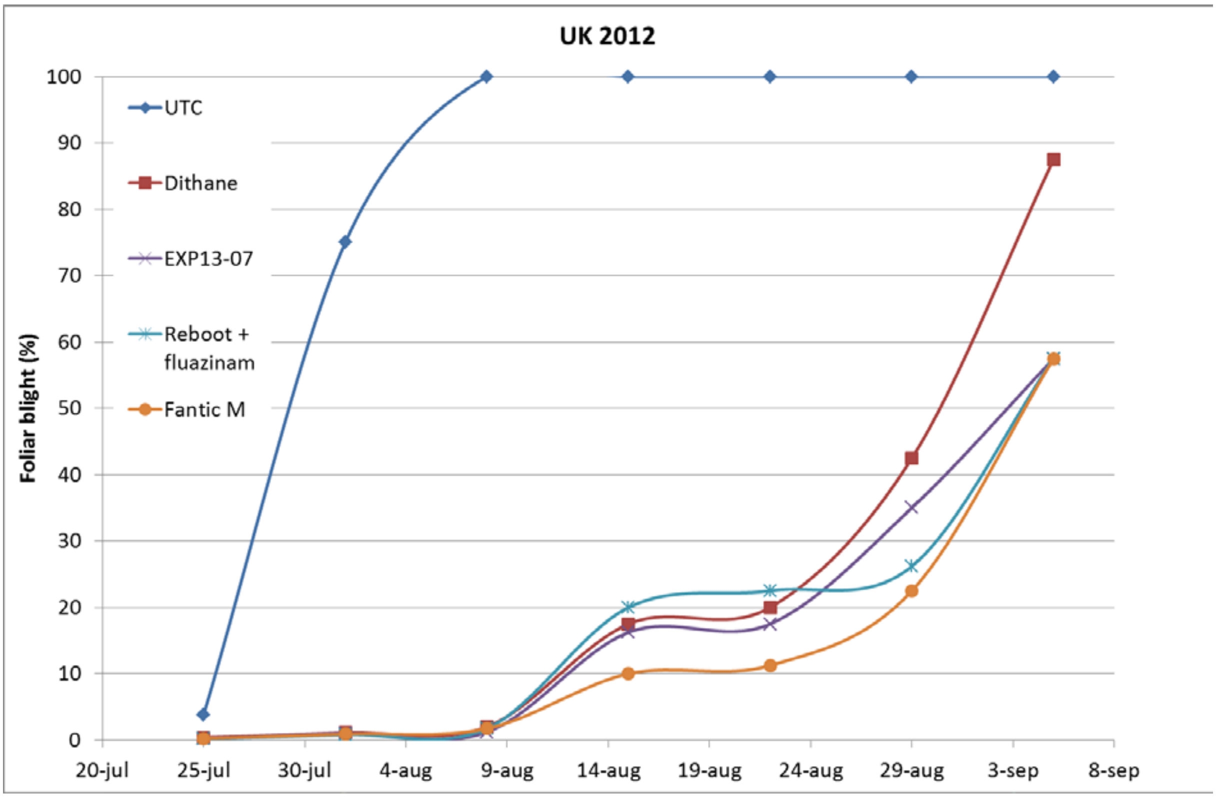

Figure 21. The development of foliar blight during the growing season in the United Kingdom 2012

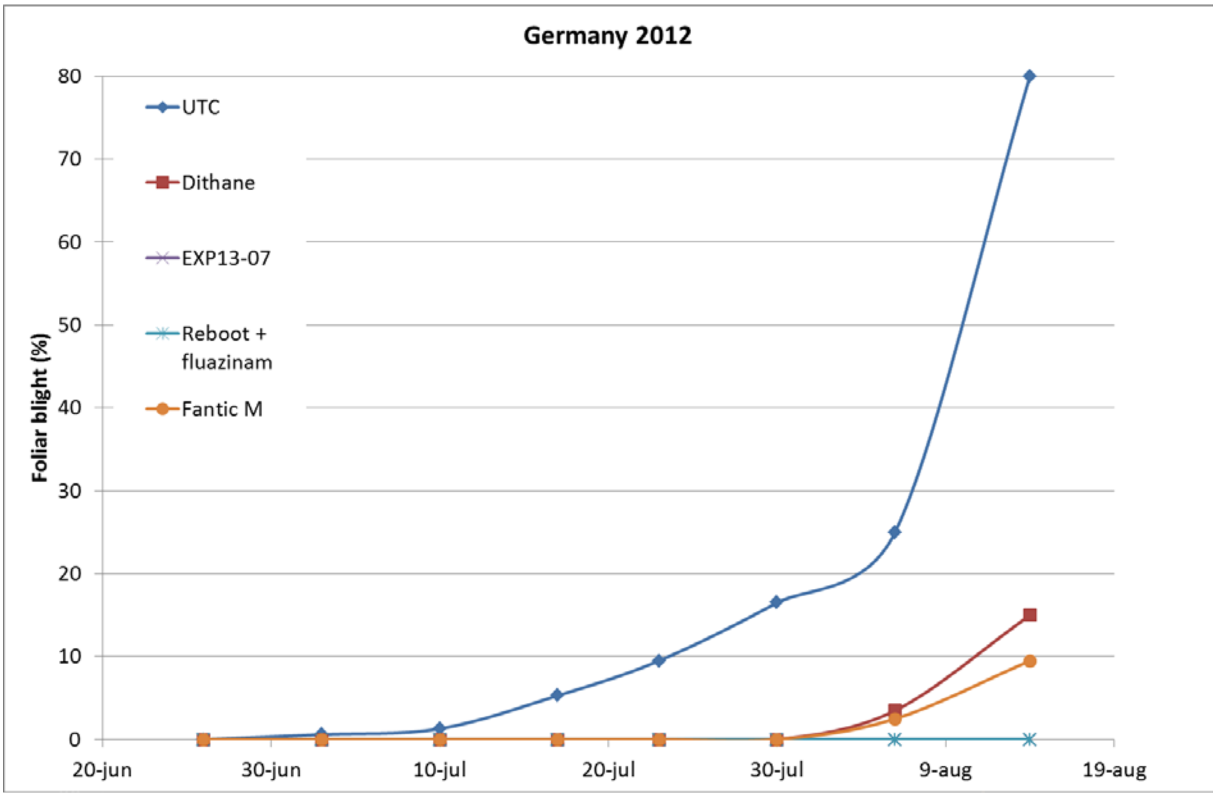

Figure 22. The development of foliar blight during the growing season in Germany 2012

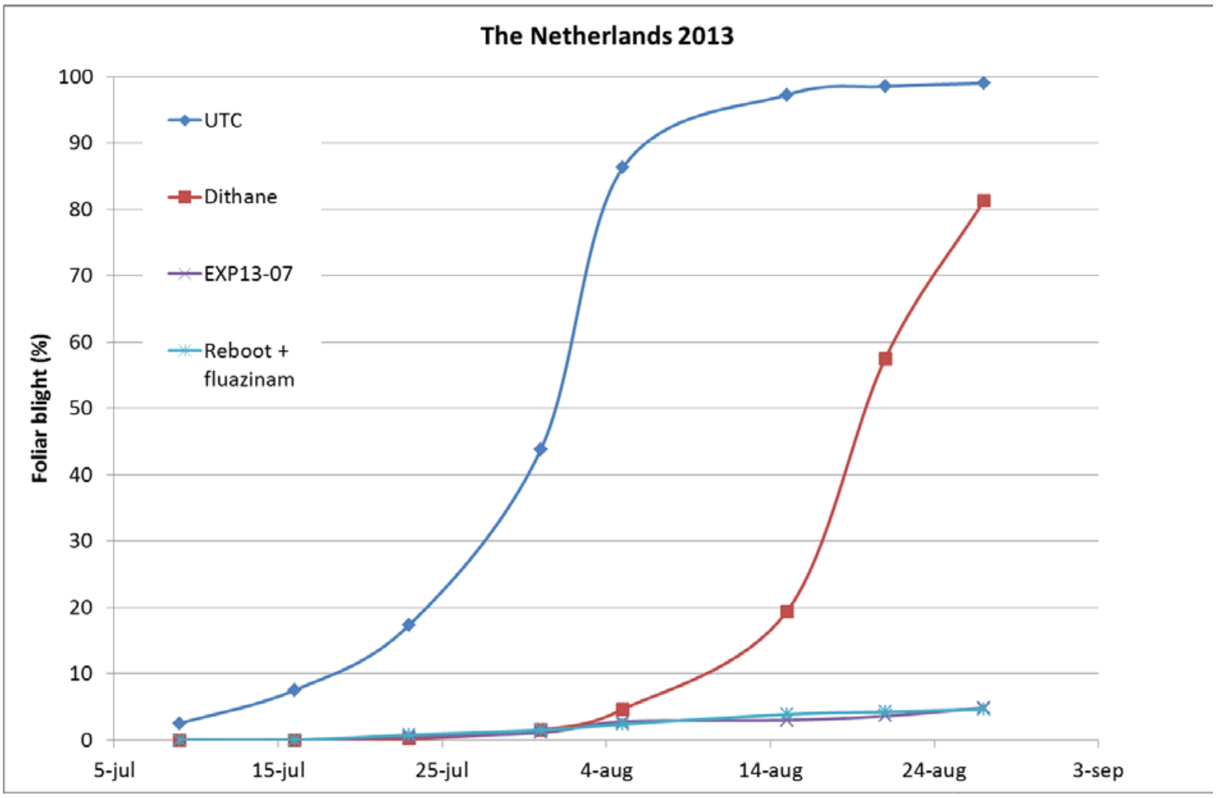

Figure 23. The development of foliar blight during the growing season in the Netherlands 2013

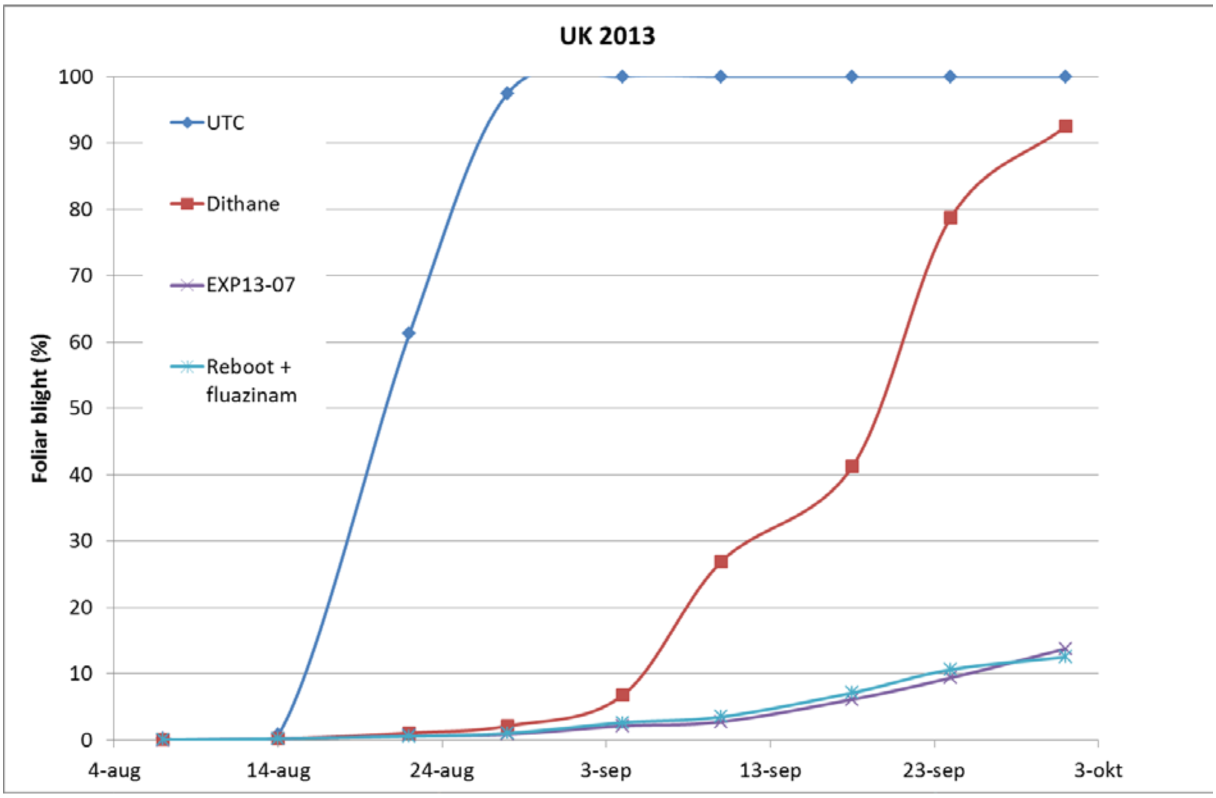

Figure 24. The development of foliar blight during the growing season in the United Kingdom 2013

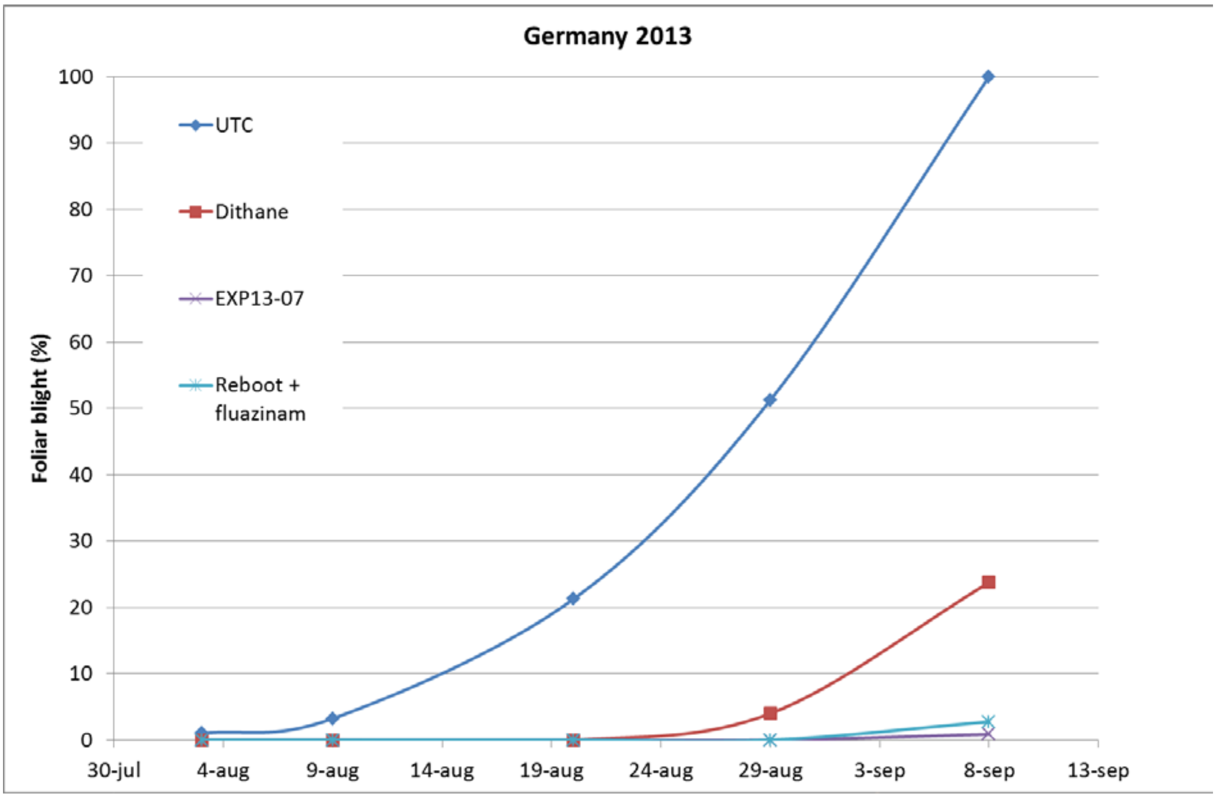

Figure 25. The development of foliar blight during the growing season in Germany 2013

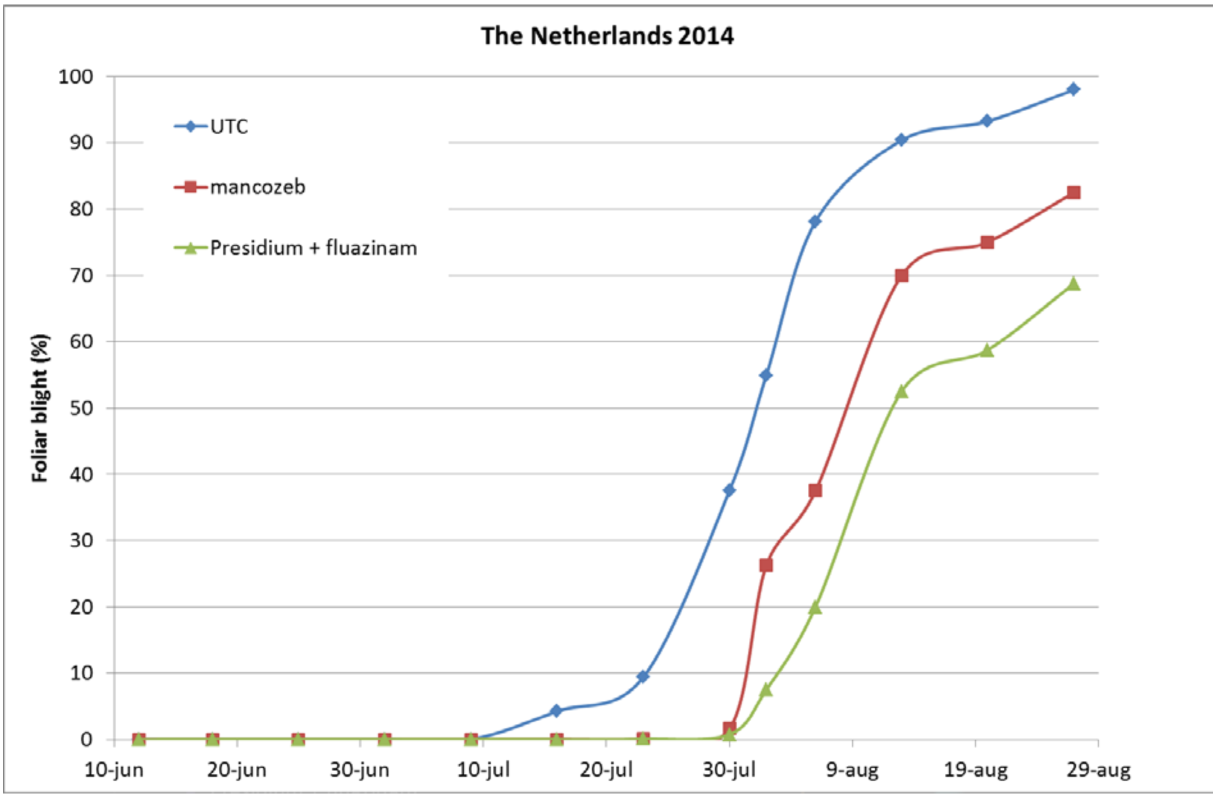

Figure 26. The development of foliar blight during the growing season in the Netherlands 2014

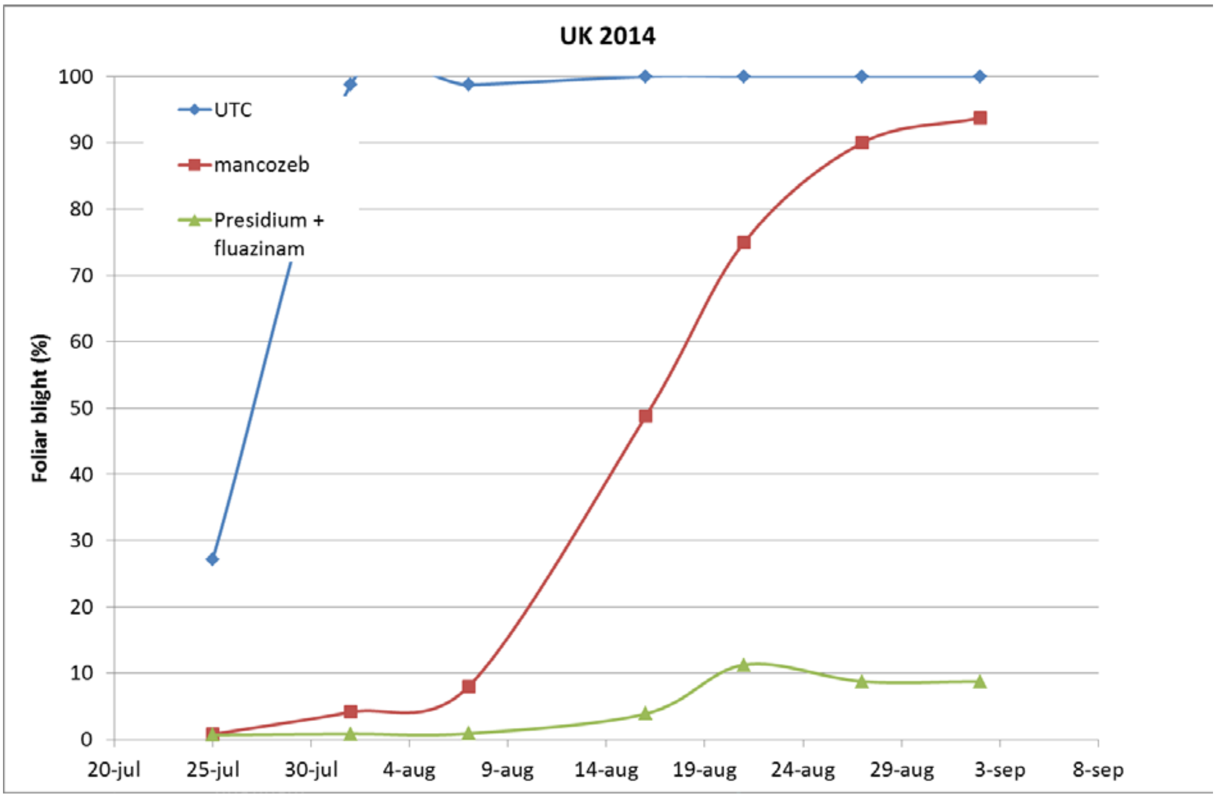

Figure 27. The development of foliar blight during the growing season in the United Kingdom 2014

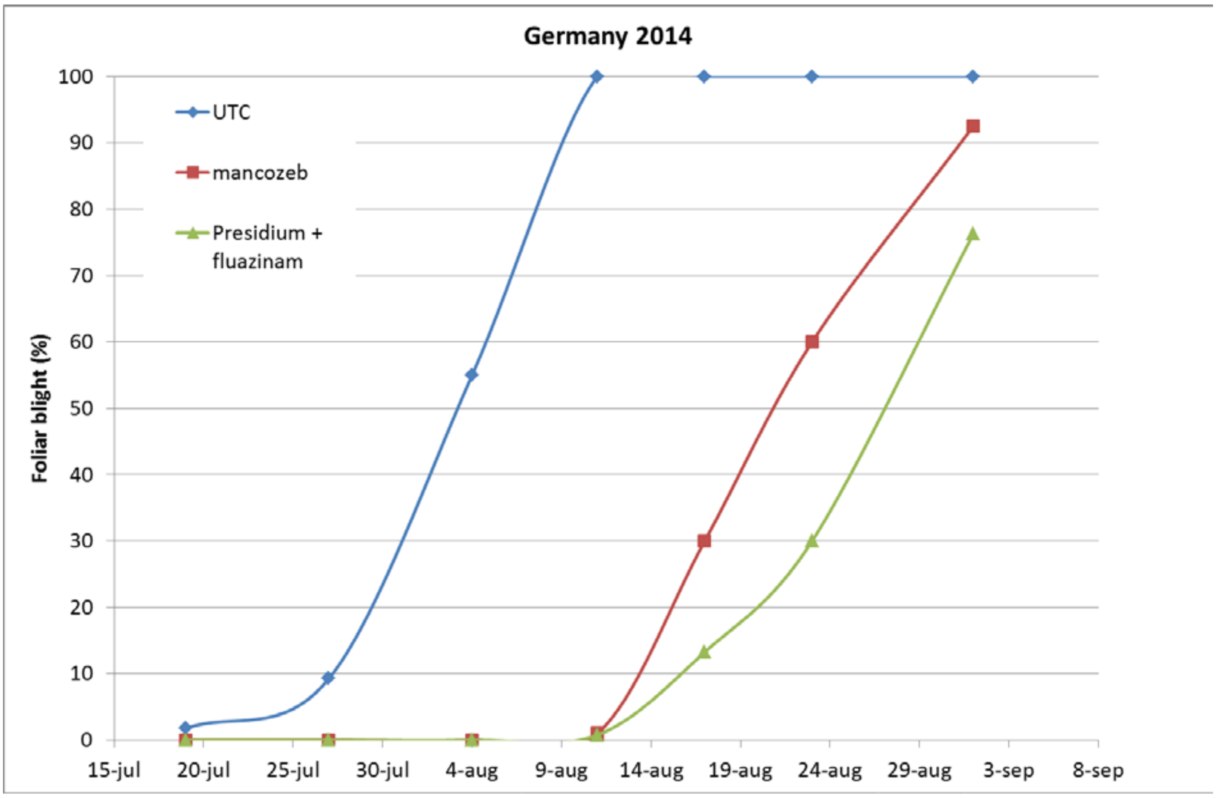

Figure 28. The development of foliar blight during the growing season in Germany 2014

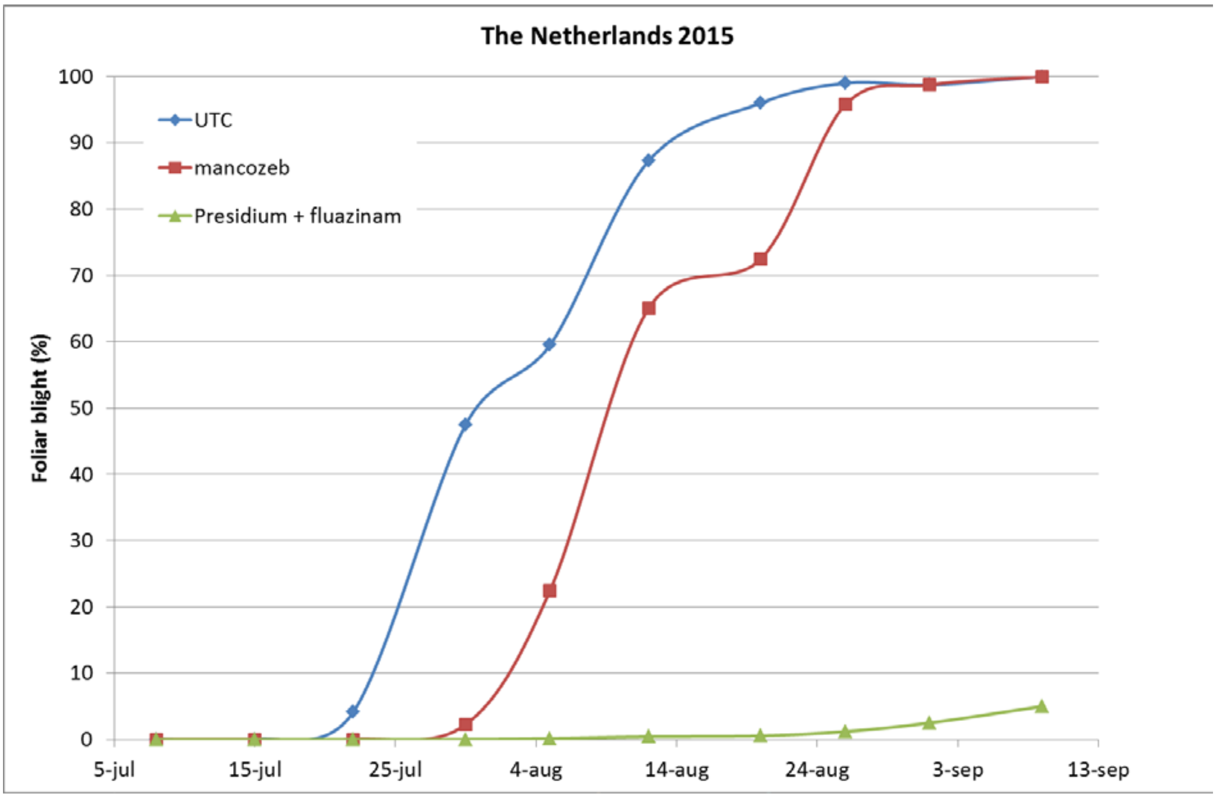

Figure 29. The development of foliar blight during the growing season in the Netherlands 2015

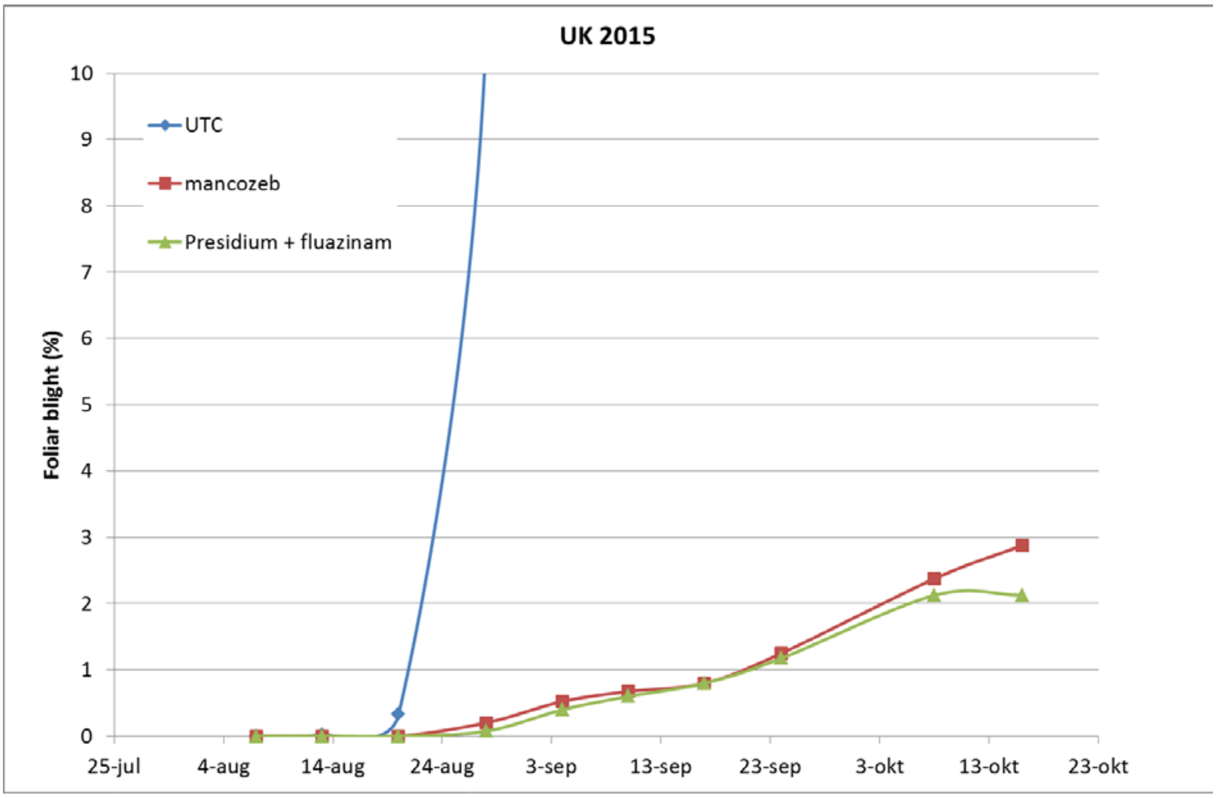

Figure 30. The development of foliar blight during the growing season in the United Kingdom 2015

Due to very hot and dry weather no late blight epidemic developed in Germany in 2015. Maximum disease severity found was 0.1%. Differences between treatments were small.

3.2 Effectiveness of the fungicides (StAUDPC)

The AUDPC or the StAUDPC can be used as a measure for the severity of the late blight epidemic. Control of late blight by fungicides will decrease the rate of the epidemic, and therefore reduce the AUDPC and StAUDPC value.
Due to circumstances a spray interval of more than 8 days was applied in some of the experiments. We have carefully looked at all the trials and we decided that in the trials carried out in DK in 2006 and 2007 the long spray intervals coincided with critical periods. We therefore restricted the AUDPC data from these trials to the period in which spray intervals were according to the protocol. Therefore StAUDPC values for the Danish experiments were calculated until 29 August 2006 and 10 July 2007.
In Germany the last spray application was on 4 August 2009. Therefore we decided to include the disease rating of 12 August, but leave out the disease observation on 23 August. At 23 August potato late blight disease severity might have been partly the result of an infection on an insufficiently or unprotected crop.
In The Netherlands at the end of the 2009 season the crop senesces and it became more difficult to assess potato late blight accurately. Therefore we skipped the last two disease observations. The StAUDPC was calculated until 12 August 2009.

In other experiments the prolonged spray intervals did not occur during periods with high infection risks. Adjusting the StAUDPC values for these trials had only minimal effect on the final ratings. Therefore the StAUDPC was not adjusted in these experiments.
Prolonged spray intervals occurred in Germany and UK in 2009. Spray intervals of 11 and 10 days occurred in June and the beginning of July, due to bad weather in Germany. However late blight was observed first in the middle of July, almost equally for each treatment. Therefore we assume that the prolonged spray interval had no effect on the performance of the fungicides.
Between 14 and 23 July 2009 no fungicides were sprayed in the UK trial due to bad weather. Late blight was found first on 27 July . Significant differences between the fungicides tested were not found at that time, except for Unikat Pro. However at the next assessment date Unikat Pro had the same efficacy as the other fungicides tested, except for Laminator Flo which had a higher disease severity than all other treatments. Therefore we assume that the spray interval of 9 days at the beginning of the season had no or little effect on the preventative performance of the fungicides.
In the UK, 2010 the very last spray interval was 9 days. This delay was due to bad weather. However the final assessment was on 28 September. This was 3 days after the final fungicide spray should have been applied. Also there were no high risk conditions between 24 and 27 September inclusive. Therefore the final assessment on the 28 September was included in the calculations.
In The Netherlands a spray interval of 9 days occurred between 20 and 29 July 2015 due to rain fall and adverse spray conditions. For most treatments no significant increase of the late blight epidemic was observed immediately after the occurrence. In the reference treatment Dithane and treatment EXP14-02 an increase was found on 5 August, which might have been partly caused by the 2 day delay from a 7 day interval. Nevertheless the result of both treatments are consistent with previous years.
In Germany 2015 the late blight epidemic did not develop, therefor these data were omitted from the data analysis.

Disease severity differed between the 31 trials and the range of observed StAUDPCs was higher in trials with high disease pressure. Evaluation of the power transformation according to Box and Cox (Montgomery and Peck, 1982) showed the log transformation stabilized the variance. However we did not use this transformation because with it trials with low and high disease incidence have more or less equal weight. Without transformation results of trials with high disease incidence will have greater influence on the arithmetical means for each fungicide. Another argument not to use the logarithmic transformation was that the interaction between trial and fungicide was only partly reduced by the logarithmic transformation. Scaling the StAUDPC to values between 2 and 5 for each trial separately, transforms absolute differences to relative differences. Also in that case trials with low disease intensity get equal weight relative to trials with higher disease intensity. The interaction between trial and fungicide remained significant. Therefore we decided to analyse the StAUDPC without transformation and use the arithmetical means for scaling to a score between 2 and 5.

Tables 12 to 16 list StAUDPC values after spraying fungicides during the whole season. In general it can be assumed that the efficacy of the fungicide is higher when the StAUDPC value is lower.

Table 12. Effectiveness of the fungicides to control potato late blight as represented by the StAUDPC

Fungicide	2006				2007				
	DK	NL	UK	Average	DK	NL	UK	D	average
mancozeb	13.0	38.9	16.8	22.9	1.0	53.3	18.5	7.7	20.1
Acrobat DF (Invader)	11.3	25.5	12.6	16.5	0.2	37.0	-[1]	4.0	14.9
Consento (Tyfon)	4.8	35.9	2.7	14.5	1.2	53.1	27.6	1.3	20.8
Infinito	1.9	8.4	1.2	3.8	0.1	20.7	21.2	0.9	10.7
Orvego Duo (Decabane)	-[2]	-	-	-	-	29.0	-	-	-
Ranman	1.9	9.7	5.3	5.6	0.1	34.6	7.1	0.9	10.7
Revus	1.3	14.3	8.4	8.0	0.0	16.5	9.3	1.0	6.7
Sereno (Sonata)	7.6	19.5	17.3	14.8	1.3	39.5	23.5	4.4	17.2
Shirlan	21.6	23.1	12.8	19.2	2.1	51.5	15.5	1.9	17.8
Tattoo C (Merlin)	3.8	7.3	1.9	4.3	0.2	38.8	18.0	1.5	14.6
Unikat Pro (Electis)	8.5	27.6	8.6	14.9	0.2	48.0	19.1	4.0	17.8
Valbon	8.1	10.8	11.5	10.1	0.2	25.8	6.3	3.6	9.0

[1]: Acrobat DF was not included in the UK experiment in 2007
[2]: no data available

Table 13. Effectiveness of the fungicides to control potato late blight as represented by the StAUDPC

Fungicide	2008				2009			
	NL	UK	D	Average	NL	UK	D	Average
mancozeb	24.0	42.3	3.3	23.2	50.3	32.4	7.0	29.9
Acrobat DF (Invader)[1]	21.1	-[2]	1.3	17.0	-	-	2.0	-
Canvas + mancozeb	1.1	29.6	-	-	3.3	4.0	1.9	3.1
Consento (Tyfon)	14.2	40.6	2.1	19.0	-	-	-	-
Infinito	1.3	29.3	1.2	10.6	-	-	1.2	-
Orvego Duo (Decabane)	2.9	32.3	1.5	12.2	24.5	5.3	2.0	10.6
Ranman	2.0	38.9	0.7	13.9	3.3	8.5	1.3	4.4
Revus	1.4	33.0	0.6	11.7	2.5	10.7	1.5	4.9
Sereno (Sonata)	-	-	-	-	-	-	-	-
Shirlan	9.3	32.3	1.1	14.2	28.9	8.6	2.7	13.4
Tattoo C (Merlin)	5.3	29.4	2.3	12.3	-	-	-	-
Unikat Pro (Electis)	15.2	38.7	3.0	19.0	34.0	10.6	5.7	16.8
Valbon	9.8	24.9	1.0	11.9	-	-	1.1	-
Acrobat (Invader) @ 2.4	-	-	-	-	46.9	3.5	2.9	17.8
Banjo-Forte	-	-	-	-	-	1.3	1.1	-

[1]: Acrobat DF was applied at a higher dose rate in the UK experiment in 2008, and was therefore omitted from the analysis.
[2]: no data available

Table 14. Effectiveness of the fungicides to control potato late blight as represented by the StAUDPC

Fungicide	2010				2011			
	NL	UK	D	Average	D	NL	UK	Average
mancozeb	19.8	2.5	29.9	17.4	46.2	16.8	14.4	25.8
Canvas + mancozeb	0.9	-	-	-	-	-	-	-
Infinito	-[2]	-	16.8	-	7.5	-	11.0	9.2
Orvego duo (Decabane)	8.3	1.7	19.8	9.9	14.1	3.1	9.2	8.8
Ranman	-	-	16.6	-	-	-	-	-
Revus	-	-	14.6	-	6.1	-	-	-
Shirlan	-	-	17.2	-	-	-	-	-
Unikat Pro	26.3	3.0	26.4	18.6	21.7	32.4	9.5	21.2
Valbon	-	-	25.4	-	-	-	-	-
Acrobat (Invader) @ 2.4	19.9	1.1	23.9	15.0	11.3	-	6.3	8.8
Banjo-Forte	28.4	1.3	16.1	15.3	4.7	0.5	6.7	4.0
Fantic M	-	-	-	-	32.7	9.5	9.2	17.1
EXP-1307[1]	-	-	-	-	5.8	2.3	9.2	5.8

[1]: Brand names listed in table 1
[2]: no data available

Table 15. Effectiveness of the fungicides to control potato late blight as represented by the StAUDPC

Fungicide	2012				2013			
	D	NL	UK	Average	D	NL	UK	Average
mancozeb	5.8	41.7	21.2	22.9	8.3	16.1	25.1	16.5
Fantic M	3.8	32.9	12.5	16.4	-[2]	-	-	-
EXP13-07[1]	0.0	2.9	16.6	6.5	0.2	1.9	3.6	1.9
Reboot (Lieto)+fluazinam	0.0	10.4	16.7	9.0	0.7	2.1	3.9	2.3

[1]: Brand names listed in table 1
[2]: no data available

Table 16. Effectiveness of the fungicides to control potato late blight as represented by the StAUDPC

Fungicide	2014				2015			
	D	NL	UK	Average	D	NL	UK	Average
mancozeb	37.6	21.2	42.7	33.8	-[1]	50.4	0.9	25.7
Presidium + fluazinam	23.3	15.3	4.7	14.4	-	0.9	0.4	0.7

[1]: no data available

3.3 Effectiveness of the fungicides during the whole season

A new rating system became necessary since fungicides were introduced on the market with better control properties than existing fungicides. At the Tallinn and Bologna meetings it was decided to re-evaluate the fungicide ratings. A protocol for evaluating the efficacy of fungicides during the whole season was agreed upon and is given in Appendix 1.
Fungicides were rated according to formula 2 in which the StAUDPC was converted into a decimal rating (Table 17). It was decided to put the decimal ratings in the EuroBlight fungicide table and not round the values up or down to the nearest whole number. The decimal rating reflects the preventative efficacy of a fungicide more accurately than the rounded up or down value.

Table 17. Effectiveness of fungicides to control potato late blight during the **whole season**.

Fungicide[4]	**Active ingredient**	Dose rate Kg or L /ha	StAUDPC[1]	Decimal rating[2] current[3]	Decimal rating[2] proposed[3]
Acrobat DF (Invader)	dimethomorph + mancozeb	2.0	-[5]	3.0	-
Acrobat DF (Invader)	dimethomorph + mancozeb	2.4	-	3.1	-
Canvas + mancozeb	amisulbrom + mancozeb	0.5 + 2.0	-	4.5	-
Consento (Tyfon)	fenamidone + propamocarb	2.0	-	2.5	-
Dithane DG	mancozeb	2.0-2.25	23.4	2.0	-
Infinito	fluopicolide + propamocarb	1.6	-	3.8	-
Orvego Duo (Decabane)	ametoctradin + mancozeb	2.5	-	3.7	-
Ranman + adjuvant	cyazofamid	0.2 + 0.15	-	3.8	-
Revus	mandipropamid	0.6	-	4.0	-
Sereno (Sonata)	fenamidone + mancozeb	1.5	-	2.6	-
Shirlan	fluazinam	0.4	-	2.9	-
Tattoo C (Merlin)	chlorothalonil + propamocarb	2.7	-	3.4	-
Unikat Pro (Electis)	zoxamide + mancozeb	1.8	-	2.8	-
Valbon	benthiavalicarb + mancozeb	2.0	-	3.7	-
Banjo-Forte	dimethomorph + fluazinam	1.0	-	3.7	-
Fantic M	benalaxyl M + mancozeb	2.5	-	3.0	-
EXP13-07;	mandipropamid + cymoxanil	0.6	-	4.4	-
Reboot (Lieto) + fluazinam	(zoxamide + cymoxanil) + fluazinam	0.45 + 0.4	-	4.3	-
Presidium + fluazinam	(zoxamide + dimethomorph) + fluazinam	1.0 + 0.4	2.8	-	4.6[6]

[1] : Value established by REML Analysis
[2] : Decimal ratings based on a minimum of 6 and a maximum of 31 experiments in years 2006-2015; D 9; DK 2; NL 10 and UK 10.
[3] : The ratings are intended as a guide only and will be amended in future if new information becomes available.
[4] : Fungicides were not tested in each experiment; for details see Materials & Method and appendix 2.
[5] : No new data available
[6] : Provisional rating based on 5 EuroBlight experiments.

Using formula 2 the minimum rating will be 2.0, and is given to the fungicide with the highest stAUDPC value **over all the experiments**. In these trials that fungicide is Dithane. Therefore the proposed rating for Dithane is 2.0, and that is in accordance with the rating in the Arras, Tallinn and Bologna tables. A disadvantage of this method is that Dithane is used as a reference. If in future Dithane was no longer included in the experiments the ratings for the fungicides would shift, because the second least effective fungicide would be rated 2.0.

The highest possible rating is 5.0. A fungicide can only be rated 5.0 exactly when no late blight occurs in any of the experiments. Obviously a rating of 5.0 is almost impossible to achieve, because some late blight occurs in the experiments irrespective of treatment.
Formula 2 generates a 2-5 scale. Obviously the scale can be adjusted to 1-5 or even a 1-9 scale if desired by changing the formula. The 2-5 scale was proposed in Hamar because it stays close to the ratings in the Bologna table and provides differentiation for the better fungicides. In the present situation there is no need to change.
The ratings of the fungicides are linearly, negatively correlated with the average StAUDPC established in the trials. An advantage of the method is that fungicides with a better performance than the fungicides with the highest performance so far can be rated better. For instance new fungicides like Infinito and Revus are rated the maximum +++ in the Bologna table. Another advantage of the method is that ratings once given are not fixed. With new data a rating could be adjusted to the current performance of the fungicide. However when the database expands changes in the ratings will become rare. For instance adding the 2008 data, and including the German data of 2007 to the database led to changes in the decimal rating of 0.1 to 0.2. Including the data of the 2009 experiments most ratings went up 0.2 points. Possibly this was due to the relatively good performance of the test fungicides relative to the mancozeb standard.
At Arras it was agreed, as an interim measure, that products with decimal ratings that were not put forward for further evaluation would keep their decimal ratings for 7 years without the need for further trials. Seven years after a product was rated it will need to be included in three new trials. This measure was reviewed by the Control Strategies Subgroup at the 2015 workshop.). The proposal that the decimal rating for a fungicide product needs to be confirmed (through an additional three EuroBlight trials) 7 years after the rating was conferred was not accepted. Instead, where there is suspicion of a discrepancy between a fungicide's rating and its current efficacy, advisors need to report this to EuroBlight with supporting evidence (Bain, 2015 PPO-Special Report no. 17: 131 – 138).

3.4 Conclusions

In Hamar a more dynamic ratings system for fungicide efficacy in controlling leaf blight was presented. The ratings are based on non-transformed StAUDPC values. The main advantage is that ratings are determined using a system that is more objective than that used to produce table ratings up until the Bologna meeting in 2007. Another advantage is that there is scope for future, more effective fungicides to be rated higher than 3, the current maximum. Furthermore ratings once given are not fixed, thus relative changes in the effectiveness of fungicides can be made apparent. It was agreed at the Arras meeting that as soon as new ratings are calculated from trials and are approved the fungicide table on the EuroBlight website will be updated.
The ratings proposed are exclusively based on the results of the 31 trials described in this report. It should be noted that most fungicides were only tested in a limited number of trials, with a minimum of six.
The ratings are based on fungicides tested in the highest dose rate registered in Europe. In agricultural practise lower dose rates are and will be used. The ratings do not reflect the efficacy of the fungicide when lower dose rates are used.

Appendix 1. Protocol for testing "Effectiveness: leaf late blight" (*Phytophthora infestans).*

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Purpose/aim of trials

To compare the "Effectiveness to leaf late blight" by measuring the protection of leaves against infection by late blight caused by application of a fungicide in a standard 7-day spray schedule (this standard spray schedule is not necessarily related to the label recommendations). This protection originates from the protectant and/or curative properties of the active ingredients and in the rapid growth phase of the crop also protection of new growth can contribute to the effectiveness of the fungicide for leaf blight control.

EPPO guideline PP 1/2 (3) (revised in 1996) describes the standard requirements of the field trial.

Specific additional requirements:

- A susceptible local ware potato variety. The growth habit of the cultivar should be recorded i.e. determinate or indeterminate growth.
- In order to obtain a long-lasting infection pressure, one or more measures can be chosen according to local conditions.
    - o 2 untreated spreader rows along the complete length of the trial that consist of a susceptible (Bintje) and an intermediate resistant variety (for example Nicola)
    - o Spreader rows with one variety and selective fungicide use on the spreader row
    - o Surrounding the trial with maize
    - o Include untreated plots in every replicate
- Individual plants in the spreader rows are artificially inoculated with a recently isolated, metalaxyl-sensitive, *P. infestans* isolate (or a mixture). When the length of the plots is e.g. 10 m, 1 plant is infected per 10 m. So, one plant (susceptible) adjacent to each plot is inoculated with *P. infestans*. The artificial inoculation is carried out 3 days before the first spray until 7 days after the first spray. When the inoculation is not successful it will be repeated.
- Misting is permissible when conditions are exceptionally dry and disease is not progressing.
- Each treatment consists of applications of the fungicide to be tested throughout the season, regardless of the limited application numbers on the label
- First spray depends on local conditions, but needs to be applied before the first attack (preventive).
- Crop cover provides information on how much of the fungicide spray was intercepted by the crop. Crop cover is defined as the percentage of the soil surface obscured by foliage when viewed from above. A grid divided into 20 equal squares allows cover to be assessed to the nearest 5%. Assess by holding the grid at a fixed height above the crop and estimate what percentage of the grid area is filled by leaf material. Assessments should be made at each fungicide application until crop cover reaches 100%. They can also be made if cover declines from 100% towards the end of the growing season.
- Crop growth stage should be recorded on the days that the trial is sprayed. The BBCH key should be used.
- Spray frequency is **every 7 days** (+/- 1 day) until desiccation
- Dose rate is highest preventative dose registered in Europe
- Assessment: every week (or more frequently when necessary) in spreader rows and plots by rating the % infected leaf area. To assess blight we recommend using the assessment key in the EPPO-guideline combined with the key published in Trans. Brit. Mycol. Soc. 31 (1947): 140-141 (is attached). It is also possible to use the Dutch PD scale guideline.
- Although the trial is carried out to assess effectiveness to leaf blight, we recommend to also assessing stem blight when stem lesions occur. We recommend assessing stem blight by

placing a 0.5 m square quadrate at four to six places in the plot and assess the surface area of visible stem that has symptoms of stem blight. The scale used is 0, 0.1, 0.5, 1, 2.5, 5, 7.5, 10, 12.5, 15, 17.5 and 20% and then increasing in 5% increments. The assessments should be made when the stem tissue is still mainly green otherwise it is difficult to distinguish stem blight from other symptoms.

- Desiccation: timing and method according to GAP.
- It is not strictly necessary to harvest the trial. To assess tuber blight a specific protocol is made.
- A method for determining the rating for the “Euroblight Fungicide Table” will be proposed when 6 successful trials (2 seasons x 3 trials) have been carried out by independent research institutes in at least 3 different growing regions/countries in Europe. The proposed methodology will be agreed by independent researchers and the agrochemical manufacturers and where possible will be used to analyse data from registration trials, in which the relevant standard products are included. In this way a robust dataset will form the basis of the rating given for the “Effectiveness against leaf blight”.

N.B. A successful trial is one that is strictly carried out according to this protocol and late blight is observed in the plots (>10% foliar infection in the worst treatment). The rating is set by determination and comparison of the AUDPC’s of the 6 successful trials. **A validation of this method will have to be carried out with existing trial data to find out whether a linear, a logarithmic or another transformation has to be carried out on the data.** It will be investigated whether it is possible to determine a rating for “Effectiveness leaf blight”

- o Until flowering
- o During the whole growing season

Dividing the rating in this way will account for the specific additional characteristics of products in specific growing phases of the crop.

Appendix 2. Raw data

Plot data of late blight stAUDPC from each experiment in 2006 and 2007

fungicide	rep	DK 06	NL 06	UK 06	DK 07	NL 07	UK 07	D 07
Acrobat DF	1	11.6	30.9	17.7	0.2	37.1	-	2.5
Acrobat DF	2	10.9	20.1	10.9	0.3	35.9	-	1.9
Acrobat DF	3	10.5	-	15.0	0.2	36.1	-	2.5
Acrobat DF	4	12.2	-	6.7	0.1	38.8	-	1.8
Consento	1	6.7	33.5	5.1	1.6	51.7	26.6	0.5
Consento	2	5.2	38.3	3.0	2.4	58.2	27.7	0.8
Consento	3	3.9	-	1.1	0.8	52.1	31.7	0.6
Consento	4	3.4	-	1.8	0.2	50.6	24.6	0.8
Dithane	1	13.9	40.2	19.6	1.7	48.2	31.5	4.2
Dithane	2	9.8	37.5	17.3	1.3	50.7	13.1	4.4
Dithane	3	13.8	-	16.4	0.6	57.8	14.8	3.8
Dithane	4	14.5	-	13.6	0.2	56.6	14.6	4.2
Infinito	1	3.0	8.0	1.8	0.1	23.0	19.9	0.5
Infinito	2	3.0	8.8	1.3	0.2	19.4	23.1	0.5
Infinito	3	0.9	-	0.8	0.2	24.3	17.9	0.5
Infinito	4	0.6	-	0.8	0.0	16.0	24.1	0.5
Orvego Duo (Decabane)	1	-	-	-	-	28.2	-	-
Orvego Duo (Decabane)	2	-	-	-	-	23.4	-	-
Orvego Duo (Decabane)	3	-	-	-	-	21.5	-	-
Orvego Duo (Decabane)	4	-	-	-	-	42.8	-	-
Ranman	1	4.1	7.8	7.7	0.1	32.9	11.9	0.5
Ranman	2	1.6	11.6	3.5	0.1	29.4	7.0	0.5
Ranman	3	1.0	-	4.5	0.1	36.5	7.2	0.5
Ranman	4	0.9	-	5.5	0.0	39.8	2.5	0.5
Revus	1	2.2	15.3	10.4	0.0	14.5	13.9	0.5
Revus	2	1.0	13.4	7.7	0.0	15.6	6.6	0.5
Revus	3	0.8	-	8.1	0.0	14.5	7.4	0.6
Revus	4	1.1	-	7.3	0.0	21.3	9.4	0.5
Sereno	1	7.4	16.9	21.6	0.8	36.0	25.3	2.3
Sereno	2	6.8	22.0	17.0	1.6	35.3	25.9	2.3
Sereno	3	8.3	-	13.2	0.3	47.1	19.3	2.8
Sereno	4	7.8	-	17.4	2.4	39.6	23.8	2.1
Shirlan	1	23.6	28.0	12.8	4.0	50.0	23.7	1.0
Shirlan	2	21.6	18.3	15.1	2.5	47.7	13.7	1.1
Shirlan	3	20.5	-	11.4	0.8	62.9	14.8	1.0
Shirlan	4	20.5	-	12.0	1.1	45.2	9.7	1.0
Tattoo C	1	3.9	7.3	4.6	0.2	42.1	15.6	0.8
Tattoo C	2	3.2	7.2	1.3	0.3	35.3	15.4	0.7
Tattoo C	3	3.8	-	1.2	0.2	33.2	21.0	0.8
Tattoo C	4	4.4	-	0.7	0.2	44.8	20.0	0.8
Unikat Pro	1	9.0	19.6	10.4	0.3	45.2	28.3	2.3
Unikat Pro	2	9.2	35.6	9.5	0.3	45.0	18.9	1.9
Unikat Pro	3	8.0	-	8.6	0.1	53.2	18.2	2.3
Unikat Pro	4	7.6	-	5.9	0.1	48.5	11.0	2.3
Valbon	1	8.4	11.7	8.0	0.2	22.4	4.3	1.8
Valbon	2	8.9	9.9	14.1	0.5	21.9	6.0	1.8
Valbon	3	8.2	-	12.6	0.1	29.5	8.6	1.8
Valbon	4	7.0	-	11.3	0.1	29.4	6.4	2.5

Plot data of late blight stAUDPC from each experiment in 2008 & 2009

fungicide	rep	NL 08	UK 08	D 08	NL 09	UK 09	D 09
Acrobat DF	1	9.9	-	1.4	-	-	2.1
Acrobat DF	2	22.5	-	1.0	-	-	2.0
Acrobat DF	3	17.4	-	1.9	-	-	1.7
Acrobat DF	4	34.8	-	1.0	-	-	2.3
Canvas + mancozeb	1	0.6	22.7	-	2.4	3.1	1.9
Canvas + mancozeb	2	1.3	36.2	-	2.4	2.8	1.9
Canvas + mancozeb	3	0.7	25.2	-	5.0	5.3	2.0
Canvas + mancozeb	4	1.9	34.2	-	3.3	5.0	1.9
Consento	1	9.1	42.8	2.6	-	-	-
Consento	2	9.1	38.4	2.2	-	-	-
Consento	3	20.6	43.4	1.6	-	-	-
Consento	4	17.9	37.9	2.1	-	-	-
Dithane	1	14.0	40.9	3.4	42.6	29.4	7.6
Dithane	2	36.5	41.2	2.4	53.6	30.7	5.7
Dithane	3	17.3	41.1	3.1	63.7	31.1	7.2
Dithane	4	28.2	46.0	4.0	41.3	38.6	7.5
Infinito	1	0.6	30.3	1.1	-	-	1.3
Infinito	2	0.9	30.1	1.4	-	-	0.8
Infinito	3	1.8	26.3	1.3	-	-	1.2
Infinito	4	1.6	30.4	0.8	-	-	1.3
Orvego Duo (Decabane)	1	1.5	25.0	1.3	18.2	5.2	2.0
Orvego Duo (Decabane)	2	1.7	32.4	1.3	24.5	4.6	1.7
Orvego Duo (Decabane)	3	4.5	37.4	2.2	31.3	5.2	2.3
Orvego Duo (Decabane)	4	3.7	34.4	1.1	23.8	6.3	1.9
Ranman	1	1.4	34.0	0.5	1.8	6.1	1.2
Ranman	2	2.0	42.2	0.9	1.9	7.2	1.5
Ranman	3	2.2	42.4	0.6	7.8	16.0	1.1
Ranman	4	2.2	36.9	0.6	1.8	4.4	1.3
Revus	1	1.3	28.8	0.5	2.5	7.4	1.7
Revus	2	1.6	36.9	0.6	2.4	6.7	1.8
Revus	3	0.4	30.3	0.5	3.3	20.3	1.0
Revus	4	2.2	35.7	0.9	2.0	8.3	1.5
Shirlan	1	4.6	32.2	1.1	17.8	9.6	3.0
Shirlan	2	5.2	26.0	1.2	21.1	6.7	2.6
Shirlan	3	11.2	32.6	0.9	48.5	10.3	2.5
Shirlan	4	16.1	38.2	1.1	28.1	8.0	2.8
Tattoo C	1	2.5	25.7	2.3	-	-	-
Tattoo C	2	6.2	25.0	1.6	-	-	-
Tattoo C	3	8.2	32.5	2.6	-	-	-
Tattoo C	4	4.4	34.3	2.8	-	-	-
Unikat Pro	1	12.3	35.1	2.5	26.2	7.7	4.9
Unikat Pro	2	15.6	36.5	3.2	25.7	8.1	5.2
Unikat Pro	3	13.8	39.6	3.7	48.4	14.5	6.7
Unikat Pro	4	19.2	43.5	2.6	35.6	12.2	6.0
Valbon	1	10.7	23.4	0.8	-	-	1.1
Valbon	2	9.6	23.8	1.4	-	-	1.1
Valbon	3	8.1	19.1	1.1	-	-	1.2
Valbon	4	10.7	33.1	0.8	-	-	1.1

Plot data of late blight stAUDPC from each experiment in 2008 & 2009

fungicide	rep	NL 08	UK 08	D 08	NL 09	UK 09	D 09
Acrobat @ 2.4	1	-	-	-	31.7	2.3	3.3
Acrobat @ 2.4	2	-	-	-	51.1	2.7	2.5
Acrobat @ 2.4	3	-	-	-	62.9	5.1	2.9
Acrobat @ 2.4	4	-	-	-	41.7	4.1	2.8
Banjo-Forte	1	-	-	-	-	1.5	1.0
Banjo-Forte	2	-	-	-	-	1.7	1.3
Banjo-Forte	3	-	-	-	-	1.0	1.2
Banjo-Forte	4	-	-	-	-	1.2	0.8

Plot data of late blight stAUDPC from each experiment in 2010 and 2011

fungicide	rep	D 10	NL 10	UK 10	D 11	NL 11	UK 11
Dithane	1	29.1	21.7	2.5	47.6	7.1	10.4
Dithane	2	30.1	20.0	1.8	44.3	18.5	21.8
Dithane	3	30.1	17.0	0.5	45.9	29.3	12.5
Dithane	4	30.1	20.3	5.2	47.0	12.3	12.8
Orvego Duo (Decabane)	1	18.7	10.1	1.1	15.4	4.6	9.0
Orvego Duo (Decabane)	2	19.9	7.9	1.3	14.4	4.6	9.8
Orvego Duo (Decabane)	3	22.8	6.8	2.9	13.3	2.7	8.7
Orvego Duo (Decabane)	4	18.0	8.3	1.7	13.4	0.7	9.3
Canvas + mancozeb	1	-	1.0	-	-	-	-
Canvas + mancozeb	2	-	0.5	-	-	-	-
Canvas + mancozeb	3	-	0.9	-	-	-	-
Canvas + mancozeb	4	-	1.1	-	-	-	-
Infinito	1	16.7	-	-	8.3	-	9.8
Infinito	2	16.2	-	-	7.3	-	9.3
Infinito	3	17.2	-	-	6.3	-	10.3
Infinito	4	17.2	-	-	8.1	-	14.5
Ranman	1	16.6	-	-	-	-	-
Ranman	2	16.4	-	-	-	-	-
Ranman	3	16.6	-	-	-	-	-
Ranman	4	16.7	-	-	-	-	-
Revus	1	14.5	-	-	6.7	-	-
Revus	2	14.3	-	-	5.7	-	-
Revus	3	14.1	-	-	5.7	-	-
Revus	4	15.7	-	-	6.3	-	-
Shirlan	1	17.3	-	-	-	-	-
Shirlan	2	16.7	-	-	-	-	-
Shirlan	3	17.7	-	-	-	-	-
Shirlan	4	17.2	-	-	-	-	-
Unikat Pro	1	30.1	25.3	2.3	22.8	36.3	9.6
Unikat Pro	2	25.2	28.0	3.2	19.3	34.5	9.5
Unikat Pro	3	25.9	29.7	1.9	22.6	27.5	9.8
Unikat Pro	4	24.2	22.1	4.5	22.2	31.2	9.1
Valbon	1	24.3	-	-	-	-	-
Valbon	2	24.8	-	-	-	-	-
Valbon	3	25.2	-	-	-	-	-
Valbon	4	27.3	-	-	-	-	-
Acrobat @ 2.4	1	22.8	23.1	1.8	12.1	-	6.4
Acrobat @ 2.4	2	24.8	22.0	0.9	11.0	-	6.4
Acrobat @ 2.4	3	24.4	17.1	0.7	11.6	-	7.1
Acrobat @ 2.4	4	23.7	17.5	1.0	10.7	-	5.2
Banjo-Forte	1	15.3	30.2	1.3	4.1	0.8	6.9
Banjo-Forte	2	15.3	29.6	0.5	5.5	0.6	7.1
Banjo-Forte	3	18.8	22.8	1.9	4.2	0.3	7.1
Banjo-Forte	4	14.9	31.2	1.3	5.0	0.3	5.8
Fantic M	1	-	-	-	32.3	5.4	9.5
Fantic M	2	-	-	-	33.3	5.1	9.9
Fantic M	3	-	-	-	35.2	23.5	8.0
Fantic M	4	-	-	-	29.9	3.9	9.7
EXP 13-07	1	-	-	-	6.1	0.4	9.3
EXP 13-07	2	-	-	-	5.7	4.4	8.7
EXP 13-07	3	-	-	-	6.0	4.0	9.2
EXP 13-07	4	-	-	-	5.5	0.4	9.6

Plot data of late blight stAUDPC from each experiment in 2012 and 2013

fungicide	rep	D 12	NL 12	UK 12	D 13	Nl 13	UK 13
Dithane	1	5.5	36.6	20.8	9.1	12.8	19.3
Dithane	2	7.3	49.5	22.2	8.1	13.6	19.3
Dithane	3	4.7	35.7	26.3	7.8	19.5	18.5
Dithane	4	5.5	44.9	15.4	8.1	18.6	43.2
Fantic M	1	3.2	38.1	12.9	-	-	-
Fantic M	2	3.1	44.9	14.7	-	-	-
Fantic M	3	3.1	37.6	11.4	-	-	-
Fantic M	4	5.7	10.8	11.1	-	-	-
EXP 13-07	1	0.0	2.0	14.5	0.3	1.4	4.9
EXP 13-07	2	0.0	6.1	22.3	0.1	1.7	2.3
EXP 13-07	3	0.0	1.4	11.1	0.3	2.1	3.9
EXP 13-07	4	0.0	2.1	18.6	0.3	2.3	3.1
Reboot + fluazinam	1	0.0	15.7	16.3	0.5	1.2	2.3
Reboot + fluazinam	2	0.0	16.7	19.6	0.5	1.6	3.2
Reboot + fluazinam	3	0.0	1.9	12.0	1.3	3.3	7.7
Reboot + fluazinam	4	0.0	7.2	18.9	0.5	2.3	2.5

Plot data of late blight stAUDPC from each experiment in 2014 and 2015

fungicide	rep	D 14	NL 14	UK 14	D 15	Nl 15	UK 15
Dithane	1	38.0	21.4	26.8	-	44.4	1.03
Dithane	2	36.9	26.5	52.1	-	52.9	0.89
Dithane	3	38.4	15.6	39.6	-	52.0	0.78
Dithane	4	37.0	21.3	52.3	-	52.4	0.95
Presidium + fluazinam	1	23.4	18.9	6.8	-	0.7	0.46
Presidium + fluazinam	2	24.0	15.9	2.7	-	0.4	0.30
Presidium + fluazinam	3	24.5	12.0	5.6	-	0.3	0.34
Presidium + fluazinam	4	21.4	14.3	3.7	-	2.4	0.42
EXP14-04	1	34.7	22.7	36.5	-	41.6	1.49
EXP14-04	2	34.7	19.5	50.0	-	42.5	1.73
EXP14-04	3	32.4	17.2	46.7	-	51.6	0.66
EXP14-04	4	31.2	13.0	55.1	-	47.6	0.68
EXP14-06	1	19.1	26.2	20.9	-	3.0	0.65
EXP14-06	2	19.5	22.5	25.3	-	2.0	1.30
EXP14-06	3	16.8	14.3	33.5	-	1.5	0.66
EXP14-06	4	31.1	15.9	35.3	-	1.0	0.64
EXP14-09	1	31.2	19.8	28.9	-	18.2	0.95
EXP14-09	2	32.2	21.0	33.6	-	14.0	1.82
EXP14-09	3	33.3	19.0	26.5	-	22.6	1.00
EXP14-09	4	28.5	15.7	49.4	-	22.6	0.82
EXP15-02	1	-	-	-	-	11.0	1.08
EXP15-02	2	-	-	-	-	11.5	0.67
EXP15-02	3	-	-	-	-	14.1	0.74
EXP15-02	4	-	-	-	-	9.1	0.64
EXP15-03	1	-	-	-	-	0.0	0.23
EXP15-03	2	-	-	-	-	0.0	0.23
EXP15-03	3	-	-	-	-	0.1	0.11
EXP15-03	4	-	-	-	-	0.0	0.17
EXP15-04	1	-	-	-	-	0.6	1.16
EXP15-04	2	-	-	-	-	1.0	0.99
EXP15-04	3	-	-	-	-	0.8	1.50
EXP15-04	4	-	-	-	-	2.2	0.81
EXP15-05	1	-	-	-	-	4.5	0.35
EXP15-05	2	-	-	-	-	2.8	0.21
EXP15-05	3	-	-	-	-	3.8	0.21
EXP15-05	4	-	-	-	-	3.6	0.23
EXP15-09	1	-	-	-	-	0.0	0.24
EXP15-09	2	-	-	-	-	0.3	0.04
EXP15-09	3	-	-	-	-	0.0	0.05
EXP15-09	4	-	-	-	-	0.0	0.19

Appendix 3. REML and fungicide rating

```
IMPORT 'M:/evenhuis/2015/euroblight2015/DataEuroblight 2006-2015.xls'; \
   ISAVE = isave;                                                     \
   SHEET = 'genstat'

TABU [ CLASS = jaar, Exp; PRIN = c ]
TABU [ CLASS = jaar, country; PRIN = c ]
TABU [ CLASS = Exp, herhaling; PRIN = c ]

GETA [ ATTR = label ] fungicide; SAVE = save
TEXT [ VAL = #save[] ] label

BLOC Exp / herhaling
TREA expr * fungicide

VCOM [ FIXED = fungicide ] Exp / herhaling

TABU [ CLASS = jaar; PRIN = mean; IP = as ] AUDPC,   stAUDPC


FOR [ INDEX = i ] y =     AUDPC,   stAUDPC  ; \
                  m   =  mAUDPC,  mstAUDPC ; \
                  mSq = SqAUDPC, SqstAUDPC,

  REML [ PRIN = #, mean ] y; RESI = resi; FITT = fitt
  VKEE fungicide; MEAN = MEAN
  VARI [ VAL = #MEAN ] m
  GRAP [ NR = 21; NC = 51 ] resi; fitt

ENDFOR

PRIN label, mAUDPC, mstAUDPC; F = 10
DSCA        mAUDPC, mstAUDPC


FOR [ INDEX = i ] y = mAUDPC, mstAUDPC,

    CALC y = 3 * ( MAX ( y )  - y ) / MAX ( y ) + 2

ENDFOR

CAPTION '2 - 5'; META
PRIN label, mAUDPC,  mstAUDPC,  F = 10

STOP
```