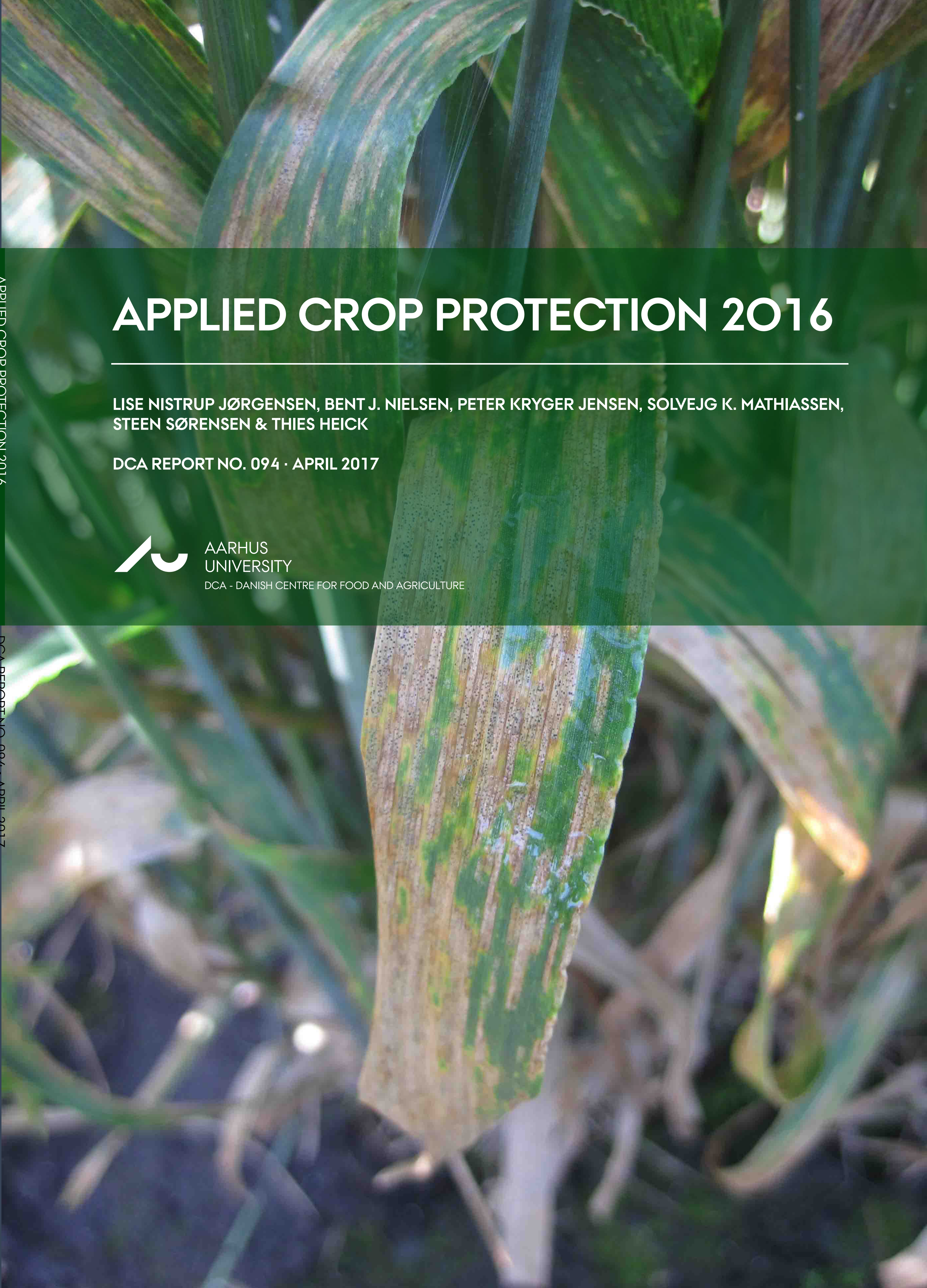

APPLIED CROP PROTECTION 2016

LISE NISTRUP JØRGENSEN, BENT J. NIELSEN, PETER KRYGER JENSEN, SOLVEJG K. MATHIASSEN, STEEN SØRENSEN & THIES HEICK

DCA REPORT NO. 094 · APRIL 2017

AARHUS UNIVERSITY
DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE

APPLIED CROP PROTECTION 2016
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Applied Crop Protection 2016

Supplementary information and clarifications (October 2019)

In an effort to ensure that this report complies with Aarhus University's guidelines for transparency and open declaration of external cooperation, the following supplementary information and clarifications have been prepared in collaboration between the researcher (s) and the faculty management at Science and Technology:

The Publication Applied Crop Protection is a yearly report providing output to farmers, advisors, industry and researchers in the area of crop protection. The publication typically summarizes data, which is regarded to be of relevance for practical farming and advice. It covers information on the efficacy profiles of new pesticides, effects of implementation of IPM principles (integrated pest management) aiming at reducing the use of pesticides and illustrates the use of Decision Support Systems (DSS) in combination with resistant cultivars. It also includes an update on pesticides resistance to ensure that only effective strategies are used by the farmers to minimize build-up of resistance.

The report was initiated in 1991, when Danish Research Service for Plant and Soil Science (Statens Planteavlsforsøg) as part of the Ministry of Agriculture was responsible for Biological testing of pesticides and provided a certificate for biological efficacy based on the level of efficacy in field trials. Later this system was replaced by EU's rules for efficacy data. Efficacy testing of pesticides was opened up to all trial units, which had obtained a GEP approval (Good Efficacy Practice) and fulfilled the requirements based on annual inspections.

Since 2007 the report has been published by Aarhus University (AU) and since 2015 it has been published in English to ensure a bigger out-reach. The choice of topics, the writing and publishing of the report is entirely done by staff from Aarhus University and the report content is not shared with the industry before publication. All authors and co-authors are from AU. The data on which the writing is based is coming from many sources depending on the individual chapter. Below is a list with information on funding sources for each chapter in this report.

Chemical companies have supplied pesticides and advice on their use for the trials and plant breeders have provided the cultivars included in specific trials. Trials have been located either on AU's research stations or in fields owned by private trial hosts. AU has collaborated with local advisory centres and SEGES on several of the projects e.g. when assistance is needed regarding sampling for resistance or when looking for specific localities with specific targets. Several of the results have also been published in shared newsletters with SEGES to ensure a fast and direct communication with farmers.

Chapter 1: Climate data for the growing season 2015/2016 and specific information on disease attack 2016
Information collected by AU.

Chapter 2: Disease control in cereals
Trials in this chapter have been financed by ADAMA, Dow, Dupont, Bayer Crop Science, BASF, Syngenta, Nordic seed, KWS and Sejet Plantbreeding, but also certain elements have been based on AU's own funding and from Innovation Fund Denmark.

Chapter 3: Control strategies in different cultivars
Trials in this chapter have been financed by income from selling the DSS system Crop Protection Online, as well as input from Bayer Crop Science and BASF. Certain elements have been based on AU's own funding.

Chapter 4: Disease control in grass seed crops
Data presented is a summary of data from the GUDP project (seed production in 2020).

Chapter 5: Disease control in sugar beet
Data presented is a summary of results from trials financed by BASF, Bayer Crop Science and AU. Elements are data from a Master's thesis carried out by Rose Kristoffersen.

Chapter 6: Disease control in grain maize
Data presented is a summary of results from trials financed by BASF, as well as data from a collaboration between Kiel University, SEGES and AU - testing of a risk model for disease development.

Chapter 7: Fungicide resistance-related investigations
Testing for fungicide resistance is carried out based on a shared cost covered by projects and the industry. In 2016 ADAMA, Bayer, BASF and Syngenta were involved from the industry. The Swedish part is financed by Swedish Board of Agriculture and also AU-agro have been included.

Chapter 8: Testing different Septoria models
Results have been generated during a project from The Danish Environmental Protection Agency's research funding (Miljøstyrelsens forskningsmidler).

Chapter 9: Control of late blight (Phytophthora infestans) and early blight (Alternaria solani & A. alternata) in potatoes
Trials in this chapter have been financed by income from Nordisk Alkali, Bayer, BASF, Syngenta. Certain elements have been based on AU’s own funding as part of a PhD project (Isaac Abuley). Several of the trial plans have been carried out in collaboration with SEGES, which include the testing of DSS.

Chapter 10: Longevity of seeds of Italian rye-grass following different stubble cultivation treatments
The project was financed by agricultural tax funds (promille afgiftsmidler) via SEGES.

Chapter 11: Effect of new adjuvants, N32 and pH of the spray solution on herbicide efficacy
The project was financed by agricultural tax funds (promille afgiftsmidler) via SEGES.

Chapter 12: Results from testing of herbicides, growth regulators and desiccants in agricultural crops in 2016
The trials presented was financed by the chemical companies Syngenta and BASF.

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Scientific report
The reports contain mainly the final reportings of research projects, scientific reviews, knowledge syntheses, commissioned work for authorities, technical assessments, guidelines, etc.

Contents

Preface

This publication contains results from crop protection trials in agricultural crops and focuses to a major extent on results with different pesticides. To a great extent the results are presented through graphics and in the form of tables. Trial results from specific IPM-related activities which are not specifically related to pesticides are also included.

The present publication also gives a description of the climate as well as the pest incidence in the crops. The publication is a summary of the publicly available results generated every year by the Department of Agroecology.

The results concerning new products and marketed pesticides will moreover be included in the annual updating of the advisory programme “Crop Protection Online”. Many of the results in this year’s publication are results from single trials or trial series. Trials from several years are also summarised in several cases.

The publication was compiled and edited by Lise Nistrup Jørgensen, Department of Agroecology, Aarhus University, Flakkebjerg, Denmark in collaboration with other scientists in the team at Flakkebjerg.

Thanks are due to all who have contributed to generating the results described in this book. Special acknowledgement is given to both the chemical companies selling pesticides, private trial hosts, staff at local advisory centres, SEGES and staff at the Department of Agroecology.

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Aarhus University, Flakkebjerg

I Climate data for the growing season 2015/2016

Verner Lindberg, Henrik Jespersen & Steen Sørensen

The growing season (September 2015–August 2016) began with a warm and wet autumn; especially November had high precipitation. The average precipitation for the whole country was 269 mm, which was 18% above normal and the highest since the autumn 1998. The first frost came very late (late October), and the number of frosty days was low (only 3). The average temperature was 10.1°C, which was 1.3°C above average. The wet and warm weather continued during the winter; the average temperature was 3.1°C, which was 2.6°C above normal. 24 consecutive hours with frost occurred 36 times during the winter 2015-16, which was below average (53 times). The precipitation was 39% above normal; especially December had a high precipitation. The spring (2016) temperature and precipitation were above normal, but the sunny intervals during the spring were below average except for May, which was sunnier than normal. The precipitation was unevenly distributed across the country; hence the growing conditions differed from area to area. The average precipitation for Denmark was 144 mm, which was 7% above average. The average temperature was 7.7°C, which was 1.5°C above average. The summer of 2016 had an average temperature of 16.1°C with sunny intervals close to average. The precipitation was above average (224 mm).

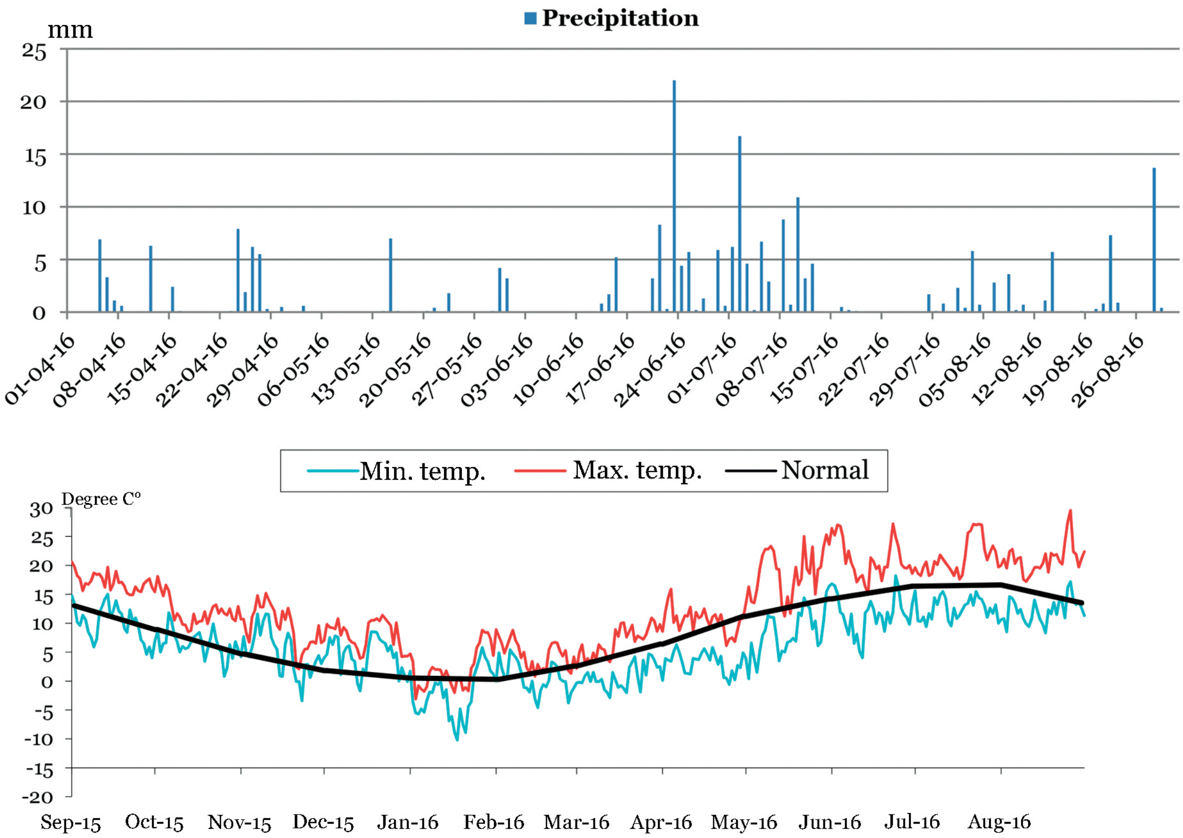


Figure 1. Daily values of precipitation and temperatures from, the growing season 2016 at Flakkebjerg.

At Flakkebjerg the **autumn and winter** (September–February) were generally warm with a high surplus of precipitation (112/118 mm in November/December – the average is 52/54 mm). The warm and wet conditions in the autumn provided favourable conditions for slugs; hence in some fields they caused severe damage to the winter crops. The first night with frost did not occur until late November, and there were only a few frosty nights in December. The first snow fell in November, but it lasted only a few days. The average temperature in January was lower than normal with frosty nights throughout the first three weeks of the year. January was the only month with frost during the day. **February and March** were warmer than normal; hence spring was early. But the spring was very dry, especially May when the precipitation was only 15 mm. The dry spell affected the crops and in the end the yields. Many of the trials were irrigated during the growing season. The harvest passed off quite easily due to dry weather in August.

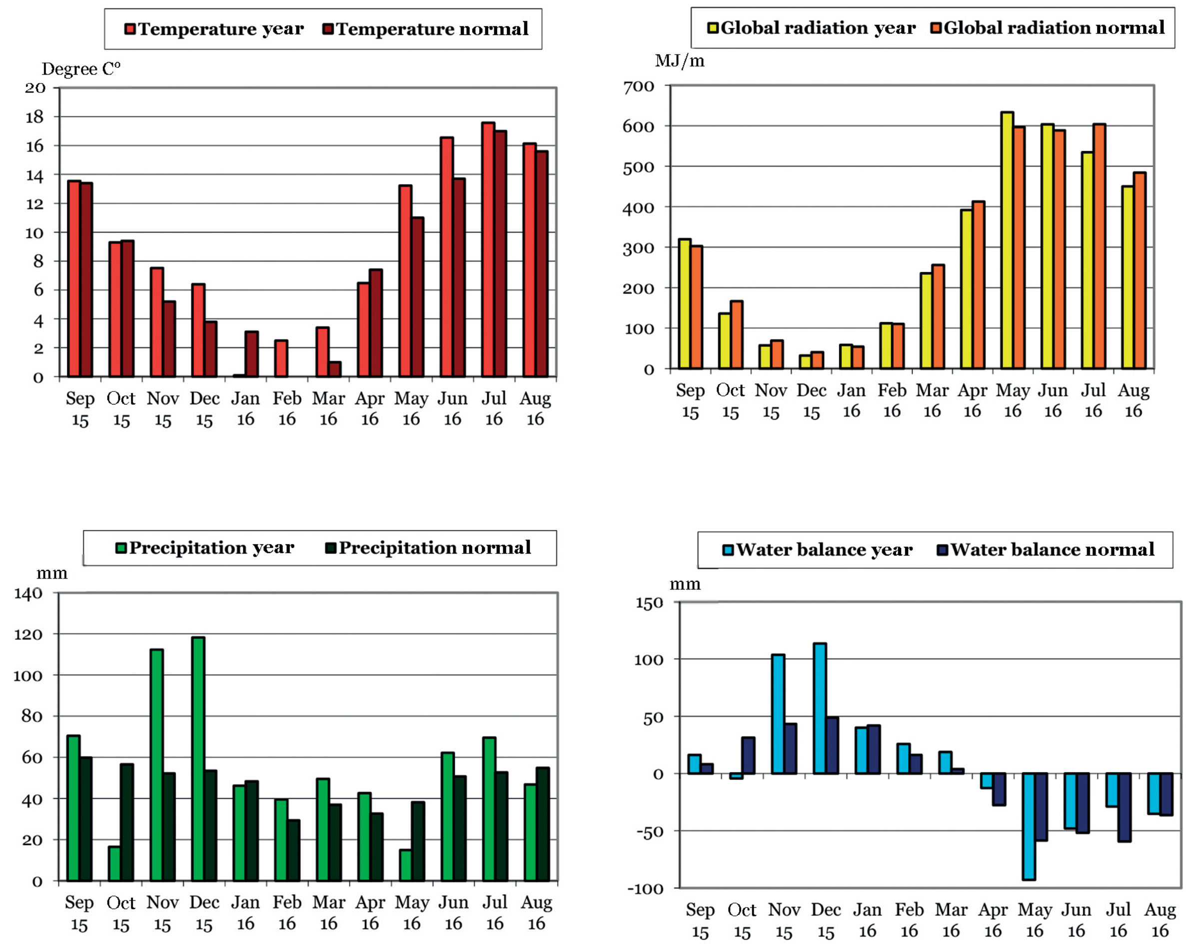
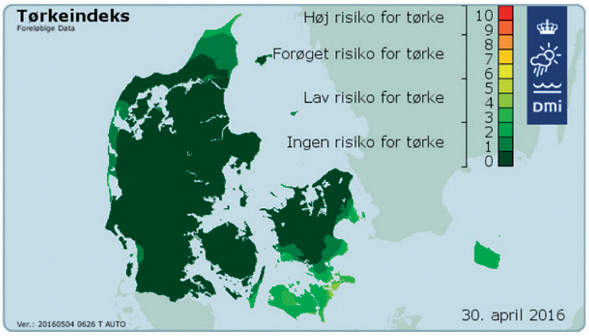
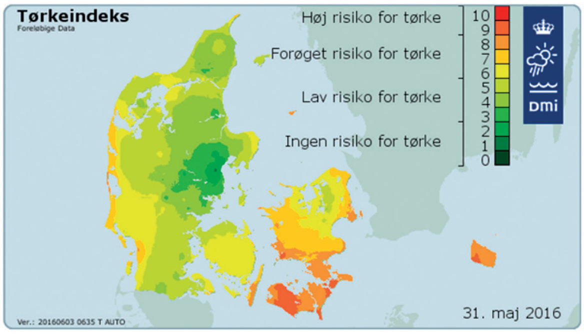


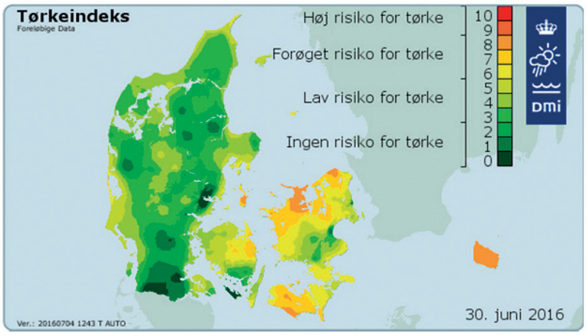
Figure 2. Climate data from Research Centre Flakkebjerg for the growing season September 2015–August 2016. The temperature is in °C, the global radiation is measured in MJ/m², the precipitation in mm and the water balance is the difference between precipitation and potential evaporation.



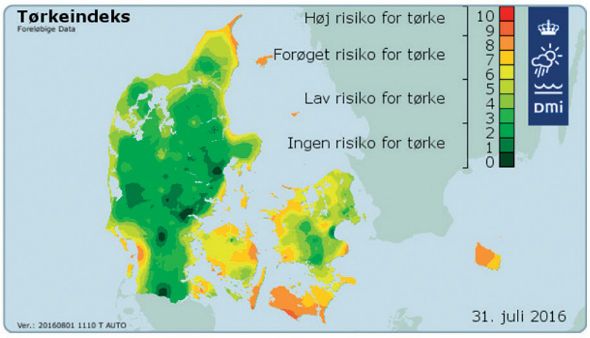
April



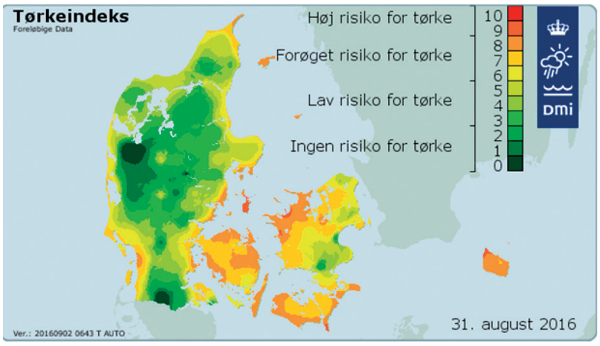
May



June



July



August

Drought Index 2016 (DMI)
Scale:

- 0-2 No risk of drought (green)
- 3-5 Low risk of drought
- 6-8 Increased risk of drought
- 9-10 High risk of drought (red)

Figure 3. Drought index for the growing season 2015. Danish Meteorological Institute (DMI).

1. Disease attacks in 2016

Lise Nistrup Jørgensen, Bent J. Nielsen, Niels Matzen, Helene Saltoft Kristjansen, Hans-Peter Madsen & Kasper Ingvordsen

In this chapter information is given about the diseases occurring in the trials carried out in 2016. This makes it possible to evaluate if the target diseases were present at a significant level and whether or not the trials gave representative results. Yield levels in cereal trials were also ranked and compared with the previous year's responses.

Wheat

Septoria leaf blotch (*Zymoseptoria tritici*). The level of *Septoria* attack varied and depended on locality but in general the attacks were moderate to high. The mild winter gave good conditions for inoculum to survive the winter. Particularly early sown fields were in part of the country seen to give increased levels of attack. Heavy and uneven rainfall across the country was also part of the reason for a varied attack. At Flakkebjerg in Western Zealand, lack of precipitation in May delayed development of attack during elongation. Higher precipitation in late June gave rise to an increased attack, developing especially on the flag leaf. As result of more rain events the trials in Jutland near Horsens (LMO) developed a more severe attack. Susceptible cultivars like Hereford and Nakskov provided good opportunities for assessing fungicide efficacy in the season. Data from SEGES showed a highly variable attack of *Septoria* across the country. Lolland, Falster and parts of Zealand had very dry conditions and only a minor attack, while particularly eastern parts of Jutland developed high *Septoria* levels.

Yellow rust (*Puccinia striiformis*). The attack in susceptible cultivars was generally severe. A severe attack developed especially in the cultivar Substance. The cultivars Substance and Ambition, which were used for fungicide trials, were inoculated in April to guarantee that attack would develop. The yellow rust race used for inoculation of Ambition developed only a moderate attack compared with Substance, which developed a massive attack.


The level of yellow rust was significant in the trials with Substance giving good possibilities to differentiate product performances. (Photo: Uffe Pilegaard Larsen).

Powdery mildew (*Blumeria graminis*). The attack in 2016 was generally of minor importance including localities on sandy soils. The specific mildew trials in wheat were carried out at Jyndevad trial station (Southern Denmark), which is well known for its severe attack of powdery mildew. In 2016 moderate attack developed. Recordings carried out by the advisors in the national monitoring system organised by SEGES also showed only minor attacks this year.

Brown rust (*Puccinia triticina*). Despite the mild winter, which gave some overwintering of this disease only a minor attack was seen during the growing season. Specific trials in the cultivar Hereford were inoculated with brown rust, but even so only a minor attack developed late in the season. In trials the level of attack never increased beyond 5% at GS 75.

Tan spot (*Drechslera tritici repentis*). The attack developed from early April in fields which had winter wheat as previous crop and minimal tillage. The attack developed significantly in these fields. Trials carried out at two localities gave rise to significant attacks, which gave good options for efficacy evaluations. In trials the level of attack increased to 69% at GS 71-77. Fields which had second year wheat but which had been ploughed before sowing only showed a minor attack of tan spot. Significant attacks also developed in several triticale trials which were situated close to the wheat field with tan spot. This clarified that also triticale can develop a severe attack of this disease.

Fusarium head blight (*Fusarium* spp.). Only minor attacks of fusarium head blight were seen in field trials at Flakkebjerg this year as the weather was mostly dry during flowering. Despite inoculation and use of irrigation the trials developed only relatively minor attacks. Even so, good conditions for distinguishing differences between fungicide and cultivar susceptibility were still given. Many fields in Jutland developed a significant attack of head blight following wet weather during heading and flowering. Even so, the level of mycotoxins stayed low, indicating that the trials were dominated by *Michrodochium* spp. or non-toxin producing *Fusarium* species.

In small plot trials with constant irrigation the level of *Fusarium* attack increased to a very high level. In both types of trials carried out at Flakkebjerg artificial inoculation with a spore solution of *Fusarium graminearum* and *Fusarium culmorum* took place.

Eye spot (*Tapesia herpotrichoides*). Attacks were assessed only in a few trials. Attack stayed low and the effect from fungicides was low. The activity with this disease has been very low for many years but the level in the last two seasons showed that the disease may still play a role and should not be forgotten.

Take-all (*Gaeumannomyces graminis*). No specific trials included control of this disease. Approximately 5% of the wheat area is treated with the seed treatment Latitude and seeds are imported from mainly Germany as Latitude is not approved in Denmark. The early sown winter wheat fields had most attack of take-all.

Barley yellow dwarf virus (BYDV). Due to the experience from 2015 when the virus caused loss of crop, farmers this year had extra focus on control of aphids in winter cereals. Only a slight attack of BYDV was seen in a few field sites at Aarhus University (AU) Flakkebjerg.

Triticale and rye

Yellow rust (*Puccinia striiformis*). Only a moderate attack of yellow rust developed in the triticale trials in 2016. The triticale trials were naturally infected, and trials were heavily infected from the early spring but did never develop very severely. An attack of yellow rust assessed at GS 75 reached a level which still provided good conditions for distinguishing the performances of the products.

***Rhynchosporium* (*Rhynchosporium secalis*)** developed a significant attack in rye. This gave rise to good assessments in the trials providing data with differences between fungicide performances.

Brown rust (*Puccinia recondita*) developed late in the season with a significant attack. This disease is known to reduce yields and most products were seen to provide good control if applied after heading.

Ergot (*Claviceps purpurea*). One field trial was inoculated with a Ergot spore suspension. A slight attack developed in the trial, and it was not possible to distinguish a clear performance from different fungicides which were tested.

Winter barley

Powdery mildew (*Blumeria graminis*). The attack in 2016 was generally slight, which only gave minor possibilities for ranking the performances of the products. Also, in the national monitoring system run by SEGES only minor attacks were recorded. In the specific trials the average attack of mildew occurred at a level of less than 1% at GS 65.

Brown rust (*Puccinia hordei*) occurred with significant and severe attacks in 2016 supported by a mild and early spring. The cultivars Wootan and Celtic in particular developed severe attacks which provided good options for separating the efficacy of the different fungicides in 2016. In the specific trials the average attack of brown rust reached a level of 30% at GS 73-81.

***Rhynchosporium* (*Rhynchosporium commune*).** The attack in 2016 was significant. In particularly the cultivar Frigg developed significant attack. This provided good opportunities to distinguish between the performances of the products. In the specific trials the average attack of *Rhynchosporium* reached a level of 15% at GS 65-73.

Net blotch (*Drechslera teres*) occurred with only a minor attack in winter barley fields and trials in 2016. The level was too low for separating fungicides performances. In trials with net blotch the average attack in the susceptible cultivars reached a level of approximately 10 % at GS 75.

Ramularia leaf spot (*Ramularia collo-cygni*). The trials developed a relatively late but significant attack of this disease in 2016, mainly in the cultivar Frigg. In the specific trials the average attack of Ramularia leaf spot reached a level of approximately 10% at GS 73-81.

Spring barley

Powdery mildew (*Blumeria graminis*). The attack in 2016 was moderate and limited to the cultivar Sissy and Propino, which do not carry mlo resistance. In the trials both cultivars provided good possibilities for ranking the performances of the product. The attack of powdery mildew reached a level between 4 and 27% at GS 75 (average of 4 trials: 11.3%).

Net blotch (*Drechslera teres*) appeared with significant attacks in some cultivars. Particularly the cultivar Chapeau developed a severe attack and was used in specific trials for ranking fungicide effect on this disease. Also the cultivars Quench and Propino developed minor attacks. The attack of net blotch in the trials carried out at Flakkebjerg reached a level between 4 and 40% at GS 73-85.

***Rhynchosporium* (*Rhynchosporium secalis*).** The attack in 2016 was very limited and without influence on the crop. A minor attack was assessed in the cultivar Quench.

Brown rust (*Puccinia hordei*) trials developed a severe attack in 2016 in the new cultivar Chapeau and the commonly grown and susceptible cultivars Quench and Propino. The attack at Flakkebjerg reached 12-50%, which also caused significant yield reductions if not controlled.

Ramularia leaf spot (*Ramularia collo-cygni*). The attack of this disease was relatively moderate to high in spring barley trials during the 2016 season. The attack did not develop until very late at GS 75-83 and reached a level of 20-30%.

Yield increases in fungicide trials in cereals

Yields in 2016 varied greatly from very high to moderate. The winter wheat trials generally yielded well and typically in the range of 90-110 dt/ha and in winter barley around 60-80 dt/ha. In spring barley the level was moderate around 50-70 dt/ha. The crops in Jutland had sufficient water supplies during the season, but in Zealand the season was very dry and some fields suffered from drought.

Yield increases following fungicide treatments in wheat were in line with 2015, but not as high as in 2014, where attack of *Septoria* was more severe. On average the response was approx. 11 dt/ha. The general yield response was low for winter barley but at the higher end of the scale in spring barley in 2015 (Table 1).

Table 1. Yield increases (dt/ha) for control of diseases using fungicides in trials. The responses are picked from standard treatments typically using 2 treatments per season. Numbers in brackets give the number of trials behind the figures. Data originate from SEGES and AU-Flakkebjerg's trials. Trials where yield was heavily reduced from severe attacks of yellow rust are not included.

Year	Winter wheat	Spring barley	Winter barley
2005	6.4 (126)	5.4 (43)	4.6 (60)
2006	8.0 (106)	3.3 (63)	5.1 (58)
2007	8.5 (78)	7.2 (26)	8.9 (13)
2008	2.5 (172)	3.1 (29)	3.2 (36)
2009	6.3 (125)	5.1 (54)	6.3 (44)
2010	6.6 (149)	5.6 (32)	5.9 (34)
2011	7.8 (204)	3.9 (43)	4.3 (37)
2012	10.5 (182)	6.7 (38)	5.1 (32)
2013	10.3 (79)	5.2 (35)	5.5 (27)
2014	12.0 (82)	3.0 (19)	4.1 (18)
2015	10.9 (73 SEGES + 29 AU)	9.1 (20)	7.3 (19)
2016	10.9 (59 SEGES + 34 AU)	8.0 (16 SEGES + 13 AU)	4.0 (11 SEGES + 10 AU)

Maize

Eye spot (*Kabatielle zeae*). Moderate to severe attack of eye spot in trials developed during the 2016 season. The trials were irrigated twice in the spring, and the first attack on leaves below the cob was assessed in late July. The attack increased during the summer, and assessments in early September gave the first opportunity to distinguish between the performances of the products. The attack increased during the season and reached a high level of attack between 57 and 67% on the upper leaves.

Northern leaf blight (*Setospharia turcica*) developed to a limited level and never caused more than a minor attack early in the season.

Grass seed - ryegrass
Moderate attacks of leaf rust developed at many sites and also in trials from the early spring. Initially, the attack was also mixed with a mildew attack. The attack looked like crown rust, but a specific analysis showed that the teliospores did not have the crown, and a DNA test revealed that it was not just crown rust, but a mixture consisting of both crown rust and a leaf rust – possibly *Puccinia holcina*. The trial at Flakkebjerg was inoculated with stem rust (*Pucccinia graminis*) in May to ensure attack of this disease. Stem rust developed and gave a significant attack particularly in the cultivar Calibra.

Potato
Potato early blight (*Alternari solani* & *A. alternata*)
Most of the *Alternaria* trials at Flakkebjerg were artificially inoculated at the end of June with autoclaved barley seeds inoculated with *A. solani* and *A. alternata*. The first attacks on the lower leaves were detected on 13 July. In general, there were several days with leaf wetness, high humidity and favourable temperatures for early blight attack during the season. However, the occurrence of dry weather on several days in the last two weeks in July restricted the development of early blight after the onset. Severe attacks of early blight were observed in the months of August and September. By mid-September most untreated potatoes had attack between 80% and 100%. The severe increase in the development of early blight in August also coincided with the critical age of rapid development in early blight attack with the critical period of 500 physiologic age (1 August), when the susceptibility of the potatoes increased.

Potato plots with attack of early blight (*Alternaria solani* & *A. alternata*) at Flakkebjerg, 6 September 2016. (Photo: Uffe Pilegard Larsen).

Potato late blight (*Phytophthora infestans*)

The trials at Flakkebjerg were artificially inoculated on 9 July 2016 by spraying with a sporangial suspension of *Phytophthora infestans* (1000 sporangia/ml) over spreader rows between the blocks. The first symptoms of natural infection were detected in the spreader rows and untreated plots as early as 11 July. Due to dry weather and low infection pressure of late blight, there was a slow disease development in the rest of July. Even though the infection pressure for Flakkebjerg was medium to high in August late blight developed very slowly especially in the variety Eurogrande, with only 30-40% leaf attack in the untreated plots at the end of August. The middle part of September was very hot and dry, which delayed the attack of late blight further. It was not until the end of September that all leaves in the untreated plots were destroyed.

Potato plots with attack of late blight (*P. infestans*). Untreated plots can clearly be seen to be defoliated. Flakkebjerg, 30 September 2016. (Photo: Uffe Pilegard Larsen).

Oilseed rape

***Sclerotinia (S. sclerotiorum)* and *Phoma* (*Leptosphaeria maculans*)**

The trials in oilseed rape were sited at Flakkebjerg in fields with narrow crop rotation and also without ploughing. There was an attack of *Sclerotinia* between 0 and 55% at the stems, and the infection at the pod was up to 5%. The attacks of *Phoma* were also recorded; there were attacks of between 0 and 20% at the stems. Only a very low level of attack of *Alternaria brassicae* was seen at Flakkebjerg in 2016.

II Disease control in cereals

Lise Nistrup Jørgensen, Thies M. Heick, Niels Matzen, Helene Saltoft Kristjansen, Sidsel S. Kirkegaard & Anders Almskou-Dahlgaard

Introduction

In this chapter field trials in cereals carried out with fungicides in 2016 are described in brief and results are summarised. In graphs or tables are also included results from several years if the trial plan concerns several years. Included are main results of major diseases from both protocols with new fungicides and protocols in which products applied at different rates and timings are compared. Part of the trial results are used as part of the Biological Assessment Dossier, which the companies have to prepare for new products or for re-evaluations of old products. Other parts of the results aim at solving questions related to optimised use of fungicides in common control situations for specific diseases.

Apart from the tables and figures providing main data, a few comments are given along with some concluding remarks.

Methods

All field trials with fungicides are carried out as GEP trials. Most of the trials are carried out as field trials at Aarhus University (AU) Flakkebjerg. But some trials are also sited in farmers' fields, at Jyndevad Experimental Station or near Hadsten in collaboration with a GEP trial unit at the advisory group LMO. Trials are carried out as block trials with randomised plots and 4 replicates. Plot size varies from 14 to 35 m^2, depending on the individual unit's equipment. The trials are sited in fields with different, moderately to highly susceptible cultivars, specifically chosen to increase the chances of disease development. Spraying is carried out using a self-propelled sprayer using atmospheric air pressure. Spraying is carried out using 150 or 200 l water per ha and a nozzle pressure of 1.7-2.2 bar.

Attacks of diseases in the trials are assessed at approximately 10-day intervals during the season. Per cent leaf area attacked by the individual diseases are assessed on specific leaf layers in accordance with EPPO guideline 1/26 (4) for foliar and ear diseases in cereals. At the individual assessments the leaf layer which provides the best differentiation of the performances of the fungicides is chosen. In most cases this is the 2 upper leaves. In this publication only some assessments are included - mainly the ones giving the best differentiation of the efficacy of the products.

Nearly all trials are carried through to harvest and yield is adjusted to 15% moisture content. Quality parameters like specific weight, % protein, % starch and % gluten content are measured using NIT instruments (Foss) and thousand grain weight is calculated based on 250 grains counted. In spring barley, which can potentially be used for malting grain, size fractions are also measured. For each trial LSD_{95} values are included or specific letters are included. Treatments with different letters are significantly different, using the Student-Newman-Keuls model.

When a net yield is calculated, it is converted to hkg/ha based on deducting the cost of used chemicals and the cost of driving. The cost of driving has been fixed at 70 DKK and the cost of chemicals extracted from the database at SEGES. The grain price used is 100 DKK/hkg (= dt).

1. Control of diseases in winter wheat

Control of powdery mildew (*Blumeria graminis*)

Denmark has few activies for control of powdery mildew. Flexity only performs moderately in line with or poorer than azole solutions. Input or Talius might both be authorised before the 2017 season and will provide new alternatives. Talius is well known for its long lasting control. Several of the grown cultivars (Benchmark, Sheriff, Pistoria) provide good resistance to mildew.

Several trials were carried out at Jyndevad experimental station, which is located on sandy soil close to the German border in Jutland and known for being a good locality for investigation of mildew efficacy. The cultivar Mariboss was used for the trials. In Denmark only few mildew products are available. Talius is still waiting for a new authorisation, so currently only Flexity (metrafenon) is available for specific mildew control. Azoles like tebuconazole and prothioconazole have also over the years been seen to provide good control if used at an early timing as also shown in Figure 2.

Input

In 2016 Input (spiroxamine + prothioconazole) is expected to achieve an authorisation based on mutual recognition. As seen in trials from both 2015 and 2016, this product provides good control on mildew (Table 1, Figures 1 and 2). The drawback of the product is that as the product included prothioconazole, it will as an early mildew treatment select for *Septoria* mutations, which might have a negative impact on later control options for *Septoria*.

Table 1. Control of powdery mildew using different mildewicides in 1 trial from 2016 (16330).

Treatments, l/ha		% powdery mildew				Yield and increase hkg/ha	Net increase hkg/ha
GS 31	GS 37-39	GS 55 L 1-2	GS 55 L 3-4	GS 71 L 1-2	GS 71 L 3-4		
1. Untreated	Untreated	5.0	15.0	7.0	20.0	41.8	-
2. Flexity 0.25	Viverda 0.75	2.5	12.8	6.0	15.0	3.1	-3.3
3. Talius 0.125	Viverda 0.75	0.2	1.7	1.3	3.9	3.1	-
4. Prosaro EC 250 0.5	Viverda 0.75	1.6	11.0	3.5	13.8	1.1	-5.1
5. Propulse 0.5	Viverda 0.75	1.4	6.5	3.3	12.5	-1.4	-8.0
6. Input 0.5	Viverda 0.75	1.3	10.5	3.0	12.5	-0.3	-
7. Talius + Prosaro EC 250 0.063 + 0.25	Viverda 0.75	1.1	3.8	1.5	6.8	0.6	-
8. Leander 0.25	Viverda 0.75	2.4	11.8	4.8	13.9	-0.8	-
9. Untreated	Viverda 0.75	3.0	13.8	5.5	16.3	-3.1	-
No. of trials	1	1	1	1	1	1	1
LSD_{95}		1.4	3.5	1.8	4.8	5.6	-

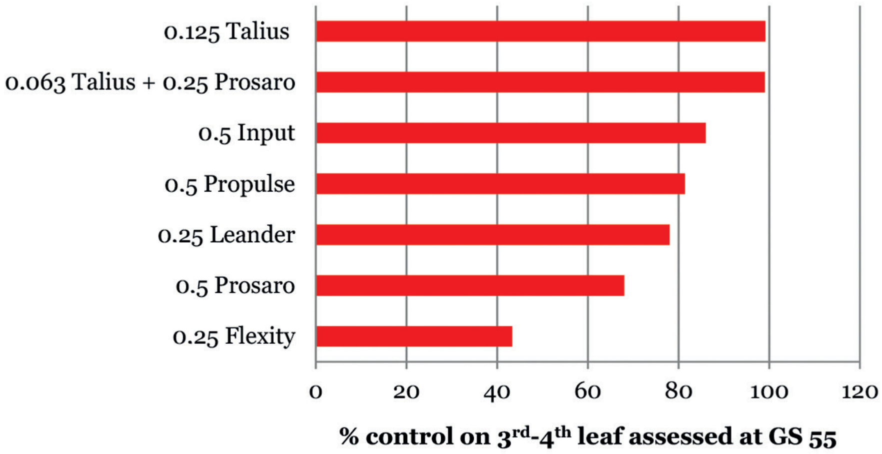


Figure 1. Per cent control of powdery mildew using different products with effect on mildew. 1 trial from Jyndevad 2016 (16330) assessed at GS 55 on leaf 3-4.

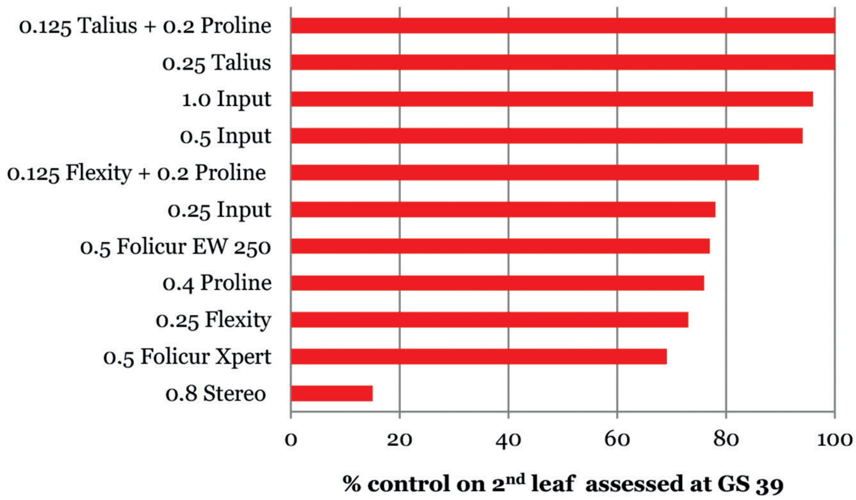


Figure 2. Per cent control of powdery mildew using different products with mildew effects. 1 trial from Jyndevad 2015 (15334) assessed at GS 39 on leaf 2 (14% attack on untreated).

Cultivar differences in susceptibility to wheat mildew

As part of a larger project several cultivars were screened for sensitivity to powdery mildew. The ranking is given in Figure 3 and is in accordance with ranking from the national trials (observation trials).

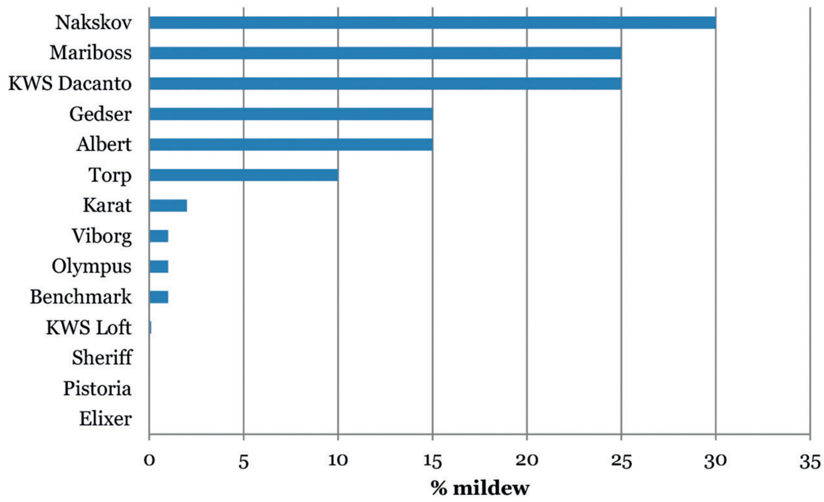


Figure 3. Attack of mildew assessed at GS 55 on leaves 3-4. Trial at Jyndevad.

Untreated plots at Jyndevad.

Plot treated with 0.25 Talius.

Control of tan spot (*Drechslera tritici repentis*)

Only few fungicides provide high levels of tan spot control. Bumper 25 EC and Proline EC 250 are the best products and provide very similar control. However, the effect of the products does not last when severe outbreaks occur, as in 2016. Cultivar resistance is generally moderate. Only Creator showed a clear reduction in the level of attack.

Six trials were carried out in 2016 testing the efficacy of different fungicides for control of tan spot. Straw infected with tan spot was spread in the autumn 2015 at the trial site, which is a method known to provide good attack of this disease. In early April the first clear symptoms of tan spot were recorded at the site. The trials developed minor attacks of *Septoria* and a severe attack of tan spot. Tan spot when first established is found to be the faster of the two diseases to develop, particularly when developing on the two upper leaves.

Different timings and combinations of treatments were tested (Table 3). As tan spot has a very short latent period (less than a week), it is important to keep on controlling this disease also during flowering. This is in contrast to *Septoria*, which due to its long latent period will stop creating a yield reducing attack at an earlier stage. As in previous seasons the late timing applied at GS 65 improved the control at the last assessments.

Both Bumper 25 EC and Proline EC 250 provided good control of tan spot. Bumper 25 EC is pricewise more competitive than Proline EC 250, although Bumper 25 EC is not providing sufficient control of *Septoria* in cases in which this disease is needed also to be addressed. When the two products were compared in two trials in 2016, it was seen that, although Proline EC 250 provided best control and yield response, Bumper 25 EC gave the best net yield (Table 2).

Using 4 applications with alternations between Bumper 25 EC, Proline EC 250 and Propulse, a similar control and yield was found when compared (Table 3). When Propulse was included in 3 spray strategies, this outperformed solutions only relying on Proline EC 250 and Bumper 25 EC. All treatments increased yields significantly.

In 3 trials Proline EC 250, Aviator Xpro and Prosaro EC 250 were compared for control of tan spot. Proline EC 250 and Prosaro EC 250 performed very similarly but were both inferior to the control achieved from Aviator Xpro (Table 4).

Ritmo with severe attack of tan spot.

Creator with good resistance to tan spot.

Table 2. Effects of different fungicides on tan spot and yield responses following 2 applications in wheat. 2 trials (16316).

Treatments, l/ha		% tan spot				Yield and increase hkg/ha	Net increase hkg/ha
GS 37-39	GS 65	GS 75/71 L1	GS 71/75 L 2	GS 77/75 L 1	GS 77 L2		
1. Untreated		17.2	55.0	61.3	82.5	61,5	-
2. Proline 0.8	Proline 0.8	6.1	18.1	33.4	57.5	10.6	1.4
3. Bumper 0.5	Bumper 0.5	6.2	18.7	32.6	65.0	7.7	4.3
No. of trials		2	2	2	1	2	2
LSD_{95}						2.8	-

Table 3. Effects of different fungicides on tan spot and yield responses following 2-4 applications in wheat. 1 trial (16326).

Treatments, l/ha				% tan spot			Yield and increase hkg/ha 2016	Net increase hkg/ha
GS 32	GS 37	GS 51-55	GS 61-65	GS 71 L 1	GS 71 L 2	GS 75 L 1		
1. Bumper 0.25	Proline 0.4	Bumper 0.5	Proline 0.4	0.3	3.9	33.8	7.4	-0.8
2. Bumper 0.25	Proline 0.4	Propulse 0.5	Bumper 0.5	0.3	5.5	35.0	9.7	1.4
3. Bumper 0.25	Proline 0.4	Bumper 0.5	Propulse 0.5	0.3	3.6	35.0	9.9	1.6
4. Bumper 0.25	Proline 0.4	Bumper 0.5	-	0.7	8.9	38.8	5.6	0.1
5. Bumper 0.25	Proline 0.4	Propulse 0.4	-	0.3	5.5	41.3	10.3	4.1
6. Bumper 0.25	Bumper 0.5	Bumper 0.5	-	0.7	9.5	41.3	4.3	-0.3
7. Bumper 0.25	Propulse 0.5	Proline Xpert 0.5	-	0.4	5.0	45.0	8.4	1.7
8. Bumper 0.25	Bell + Proline 0.375 + 0.2	Bell + Proline 0.375 + 0.2	-	1.6	17.0	53.8	6.1	-1.7
9. Bumper 0.25	Viverda + Proline 0.5 + 0.2	Viverda + Proline 0.5 + 0.2	-	0.9	7.4	42.5	7.7	-0.9
10. Bumper 0.25	0.4 Proline	Armure 0.4	-	1.1	12.5	46.3	6.8	0.5
11. Untreated			-	5.8	27.5	78.8	71.8	-
LSD_{95}				0.9	6.0	10.9	4.9	

Table 4. Effects of different fungicides on tan spot and yield responses following 2 applications in wheat. 3 trials (16320).

Treatments, l/ha		% tan spot				% GLA	Yield and increase hkg/ha	Net increase hkg/ha
GS 32-33	GS 51-55	GS 65 L3	GS 71 L 2	GS 71 L 1	GS 75 L 1	GS 75 L 2		
1. Untreated		25.6	57.4	22.6	62.5	0.0	59.3 a	-
2. Proline 0.8	Proline 0.8	5.7	28.3	11.7	42.9	1.9	10.0 b	0.8
3. Aviator Xpro 1.25	Aviator Xpro 1.25	5.3	20.0	7.5	31.8	6.3	11.7 b	-
4. Prosaro 1.0	Prosaro 1.0	6.7	23.9	9.8	37.7	3.2	10.0 b	1.7
No. of trials		3	3	3	3	2	3	3

Tan spot (DTR) in winter wheat
Approximately 20 cultivars were tested for sensitivity to tan spot. The cultivars were placed in a field with debris of infected straw spread in the field in the autumn 2015. Debris is known to stimulate the attack of tan spot. The trial layout was similar to the *Fusarium* trial using small plots with 2 x 1 metre row and 4 replicates. The trial was assessed 3 times; a few cultivars had a severe attack of yellow rust on the 2nd leaf and could not be assessed at the second assessment. The trial was treated with a rust fungicide to stop the development on the upper leaves. The ranking for DTR susceptibility among the cultivars was not very consistent, but Creator has now for 3 seasons proved to be one of the most resistant cultivars (Figure 4).

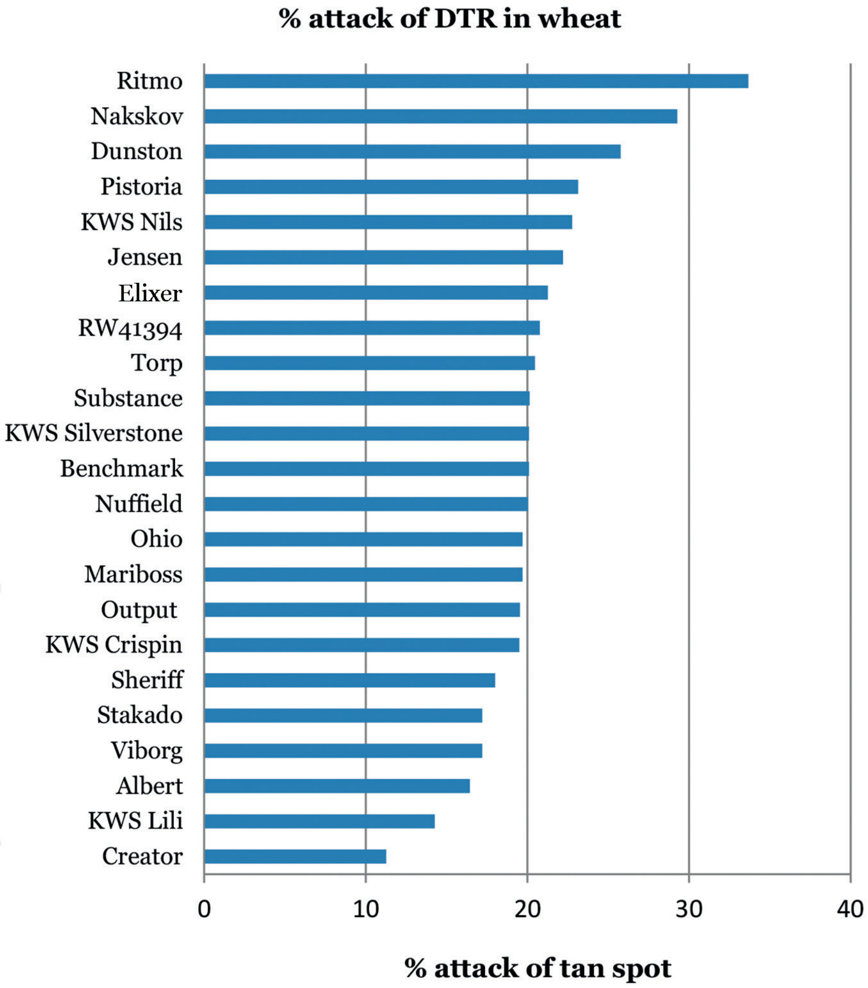


Figure 4. Ranking of cultivar resistance to tan spot. Data are based on data from a small plot trial with straw infected with tan spot spread out in the autumn to ensure good attack.

Control of *Septoria* (*Zymoseptoria tritici*)

Septoria attack in 2016 was moderate to high. In line with data from two previous seasons triazoles showed reduced control from epoxiconazole and prothioconazole. Mixtures with triazoles showed better efficacy than single azoles. Mixtures of triazoles and SDHIs showed generally better control than azoles used as solo products.

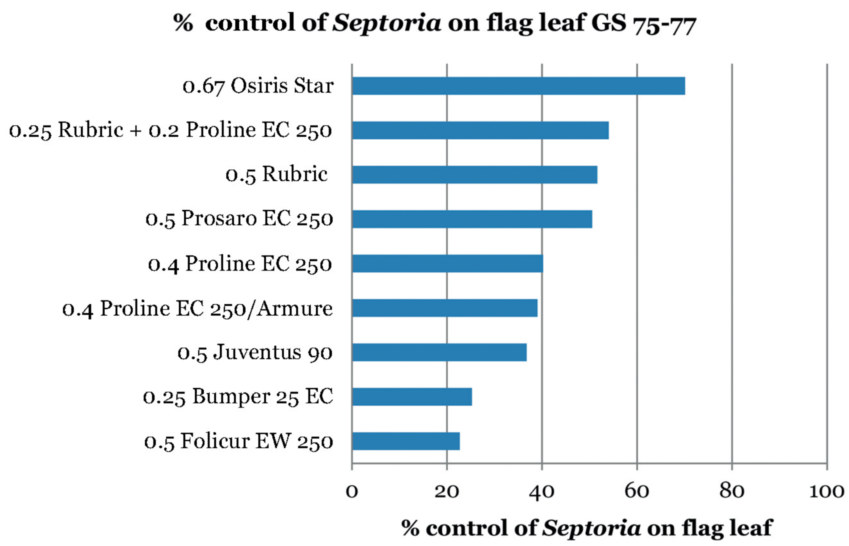
Comparison of triazoles (16329)

Two trials testing different triazoles were carried out in the cultivars Hereford at Flakkebjerg and Sheriff at Horsens. In line with previous seasons the trials showed a clear ranking in the efficacy of triazoles (Table 5, Figure 5). Including data from all triazoles across several years showed a clear drop in efficacy from all triazoles. Compared with previous years the last three years have particularly shown a reduced control from epoxiconazole and prothioconazole. In the 2016 season prothioconazole and epoxiconazole performed very similarly, whereas in the previous season the better of the two varied between years and sites (Figure 7). Summarised across years the trials represent results from two sites – Flakkebjerg and LMO (Horsens/Hadsten).

Looking at the performance of azoles during a longer time spell, the drop in performance initiated in 2014 was less pronounced in 2015 but continued in 2016 (Figure 6). Some of the yearly variations can be linked to the levels of attack, but as discussed in chapter VII the *Septoria* populations have changed and do now include many more mutations than previously, which is known to influence the sensitivity to triazoles in general but also seen to influence specific triazoles differently. The drop in efficacy from tebuconazole has been known since about 2000 and has been quite stable. The poor performance is still seen when tebuconazole is used alone, but in mixture with prothioconazole the performance is improved as the two actives support each other when it comes to controlling the different strains with different mutations. Table 5 shows data from 2016, and Table 6 summarises results with triazoles across more seasons with Armure performing best overall. Table 7 summarises results with full and half rates of epoxiconazole and prothioconazole from 2015 and 2016.

Table 5. Effects of triazoles on *Septoria* and yield responses following 2 applications in wheat. 2 trials (16329).

Treatments, l/ha		% *Septoria*		Yield and increase hkg/ha	Net yield hkg/ha
GS 33	GS 51-55	GS 73 Leaf 2	GS 75-77 Leaf 1		
1. Rubric 0.5	Rubric 0.5	7.9	26.3	6.2	0.9
2. Proline EC 250 0.4	Proline EC 250 0.4	9.9	32.5	6.8	1.5
3. Juventus 90 0.5	Juventus 90 0.5	10.2	34.4	7.3	3.5
4. Bumper 25 EC 0.25	Bumper 25 EC 0.25	9.8	40.6	4.7	2.3
5. Folicur EW 250 0.5	Folicur EW 250 0.5	14.4	41.9	4.0	0.1
6. Proline EC 250 0.4	Armure 300 EC 0.4	10.7	33.1	6.7	1.5
7. Prosaro EC 250 0.5	Prosaro EC 250 0.5	7.8	26.9	7.5	2.6
8. Osiris Star 0.67	Osiris Star 0.67	6.8	16.3	7.0	1.4
9. Rubric + Proline 250 EC 0.25 + 0.2	Rubric + Proline EC 250 0.25 + 0.2	9.1	25.0	6.3	1.0
10. Untreated	Untreated	21.3	54.4	94.0	-
No. of trials		2	2	2	2
LSD_{95}			6.5	3.0	



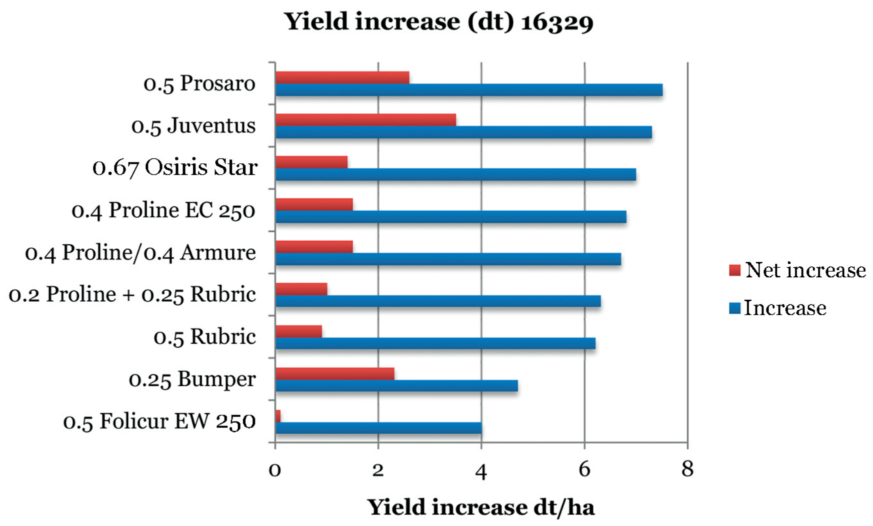


Figure 5. Control of *Septoria* and yield increases from treatments with azoles. Average of 2 trials from 2016 (16329). Untreated with 11.3% *Septoria* attack on 1st leaf and 27% on 2nd leaf. Yield in untreated = 94 dt/ha. LSD95 = 2.1 hkg/ha. Treatments were applied at GS 33 and 51-55.

The drop in performance for the triazoles is worrying and the reason for the change is being investigated. Similar drops in performances have been seen in Ireland and the UK.

Table 6. Effect of triazoles on *Septoria* and yield responses following 2 applications in wheat. 6 trials from 3 seasons (14329, 15329, 16329).

Treatments, l/ha		% *Septoria*		Yield and increase hkg/ha 2014-16	Net yield hkg/ha
GS 33	GS 51-55	GS 73-75 Leaf 1 2014-16	GS 73-77 Leaf 2 2014-16		
1. Rubric 0.5	Rubric 0.5	22.8	35.2	8.6	3.3
2. Proline EC 250 0.4	Proline EC 250 0.4	17.5	29.5	12.0	6.7
3. Juventus 90 0.5	Juventus 90 0.5	25.5	43.3	7.1	3.3
4. Bumper 25 EC 0.25	Bumper 25 EC 0.25	32.9	53.4	4.1	1.7
5. Folicur EW 250 0.5	Folicur EW 250 0.5	34.0	56.3	5.0	1.1
6. Proline EC 250 0.4	Armure 300 EC 0.4	19.1	32.5	13.4	8.3
7. Prosaro EC 250 0.5	Prosaro EC 250 0.5	18.3	33.4	11.3	6.4
8. Osiris Star 0.67	Osiris Star 0.67	13.4	29.4	9.5	3.9
9. Rubric + Proline EC 250 0.25 + 0.2	Rubric + Proline EC 250 0.25 + 0.2	23.0	43.2	8.9	3.6
10. Untreated	Untreated	47.5	76.2	91.2	-
No. of trials		6	5	6	6
LSD_{95}		-	-	4.9	-

Table 7. Average effect of epoxiconazole and prothioconazole for control of *Septoria* using full and half rates applied between GS 37 and 51. Data were extracted from different trial plans in which the two products were included - in most cases as reference products. Data are summarised for 2015 and 2016.

	Opus/Rubric		Proline EC 250	
	Flag leaf	Leaf 2	Flag leaf	Leaf 2
Full rate (9 trials) 2015	65	63	73	68
Half rate (8 trials) 2015	59	48	68	55
Full rate (9 trials) 2016	64	50	72	48
Half rate (8 trials) 2016	48	37	33	32

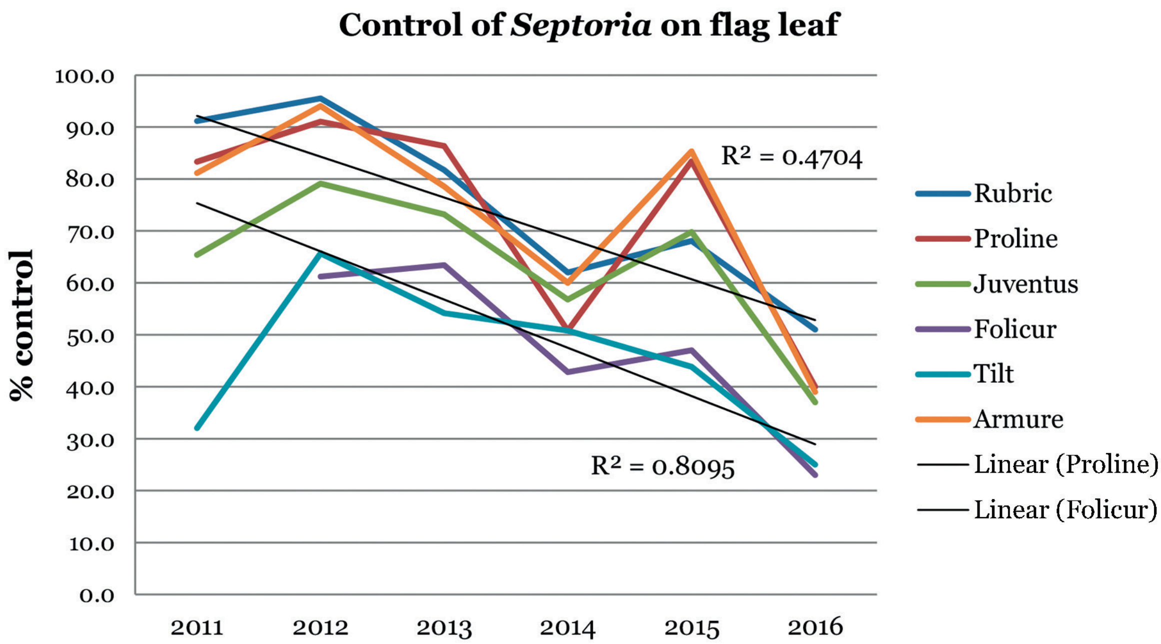


Figure 6. Per cent control of *Septoria* using 2 half rates of different triazoles. Average of two applications applied at GS 33-37 and 51-55.

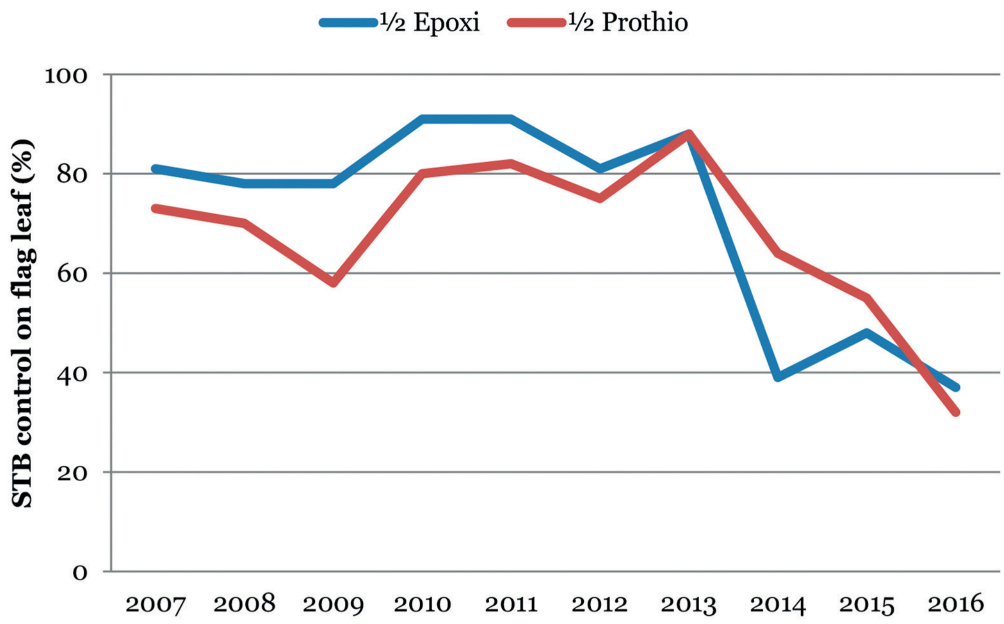


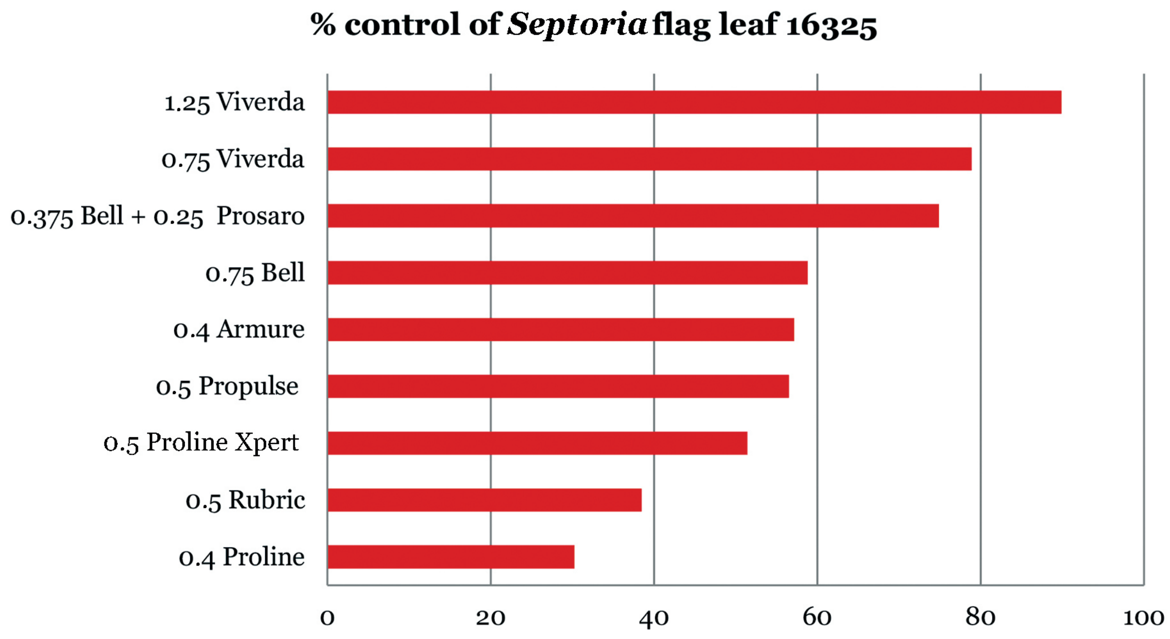
Figure 7. Per cent control of *Septoria* using half rates of Proline EC 250 and Rubric/Opus. The better of the two products varies from site to site.

Comparison of available solutions for ear treatments

In line with trials from previous years treatments with different fungicides were tested when applied during heading (GS 51-55) (Table 8). A cover spray was applied at GS 31-32 using a low rate of Ceando (0.5 l/ha). The level of control on the 2nd leaf was moderate (approx 50%) and quite similar for most treatments. The control of *Septoria* on the flag leaf varied between 30 and 90%. 1.25 l/ha Viverda provided the best control and 0.4 l/ha Proline EC 250 and 0.5 l/ha Rubric gave least control (Figure 8). The benefit from adding SDHI was clear compared to using triazoles alone. This is illustrated in Figure 9, which indicates that the differences between Viverda and Rubric have increased. This is not because SDHI perform better but is a result of the reduced efficacy of triazoles. The differences seen in Jutland and Flakkebjerg were quite similar, and the difference between Proline EC 250 and Rubric was relatively small. Yield increases in all 3 single trials were significant. As an average of the 3 trials the best yield increases gave approximately 14.1 hkg/ha in increase and were measured from the high rate of Viverda. Also solutions with Bell performed well, both when used alone and in mixture with Prosaro. Ceando (0.5 l/ha) used at the early timing as a single treatment provided an insufficient control and did not add anything to the final net yield. The best net yield result was obtained from solutions with Viverda, Propulse, Bell, Bell + Prosaro and Armure. Despite a high cost the highest rate of Viverda still gave the best net yield result in 2016. In Table 8 and Figure 10 results from 4 years' trials have been summarised and the ranking of the solutions shows an advantage to Viverda compared with other solutions.

Table 8. Effect of ear applications for control of *Septoria* in wheat. 3 trials (16325) and summary of 12 trials from 4 seasons.

Treatments, l/ha		Results from 2016					Results from 2013-2016			
		% *Septoria*			% GLA	Yield and increase hkg/ha	% *Septoria*		Yield and increase hkg/ha	Net yield hkg/ha
GS 31-32	GS 51-55	GS 73 leaf 1	GS 73 leaf 2	GS 77 leaf 1	GS 77 leaf 2		GS 77 leaf 1	GS 77 leaf 2		
1. Ceando 0.5	Rubric 0.5	2.6	15.1	50.3	45.0	6.5	39.7	24.1	9.4	3.8
2. Ceando 0.5	Proline EC 250 0.4	3.5	16.3	57.3	39.4	5.9	37.2	22.8	10.6	5.0
3. Ceando 0.5	Bell 0.75	3.9	13.5	33.5	57.5	10.2	30.8	18.5	11.0	4.1
4. Ceando 0.5	Armure 300 EC 0.4	2.8	12.3	34.8	63.2	8.6	32.9	23.1	10.2	4.8
5. Ceando 0.5	Viverda + Ultimate S 0.75 + 0.75	1.7	8.1	17.4	83.2	10.9	26.5	19.1	12.6	5.6
6. Ceando 0.5	Viverda + Ultimate S 1.25 + 1.0	1.6	8.3	8.3	91.3	14.1	19.8	14.5	15.3	6.2
7. Ceando 0.5	Bell + Prosaro 0.375 + 0.25	2.3	8.9	20.5	71.3	10.6	-	-	-	-
8. Ceando 0.5	Proline Xpert 0.5	2.4	14.8	39.7	63.2	7.6	-	-	-	-
9. Ceando 0.5	Propulse SE 250 0.5	2.8	10.2	35.5	66.3	9.4	-	-	-	-
10. Ceando 0.5	Untreated	5.9	22.9	73.9	21.9	2.1	50.5	44.8	3.2	0.3
11. Untreated	Untreated	16.6	32.1	81.7	10.7	85.5	49.4	51.2	85.6	-
No. of trials		3	3	3	3	3	12	12	12	12
LSD_{95}						2.6			3.1	-



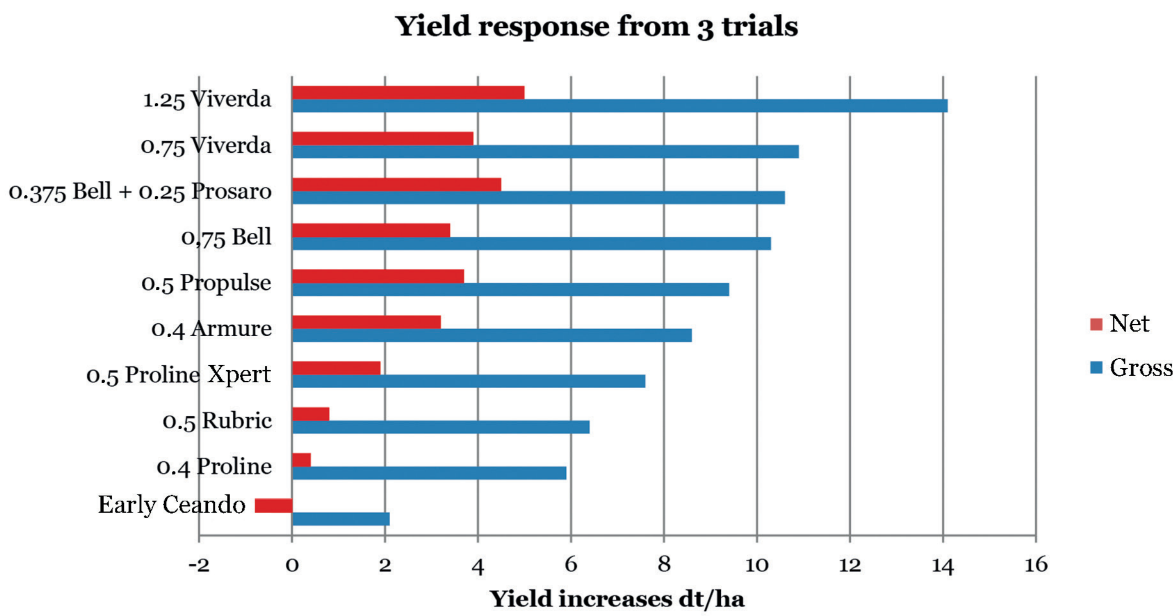


Figure 8. Per cent control of *Septoria* and yield responses using half rates of several solutions. Average of one application at GS 45-51.

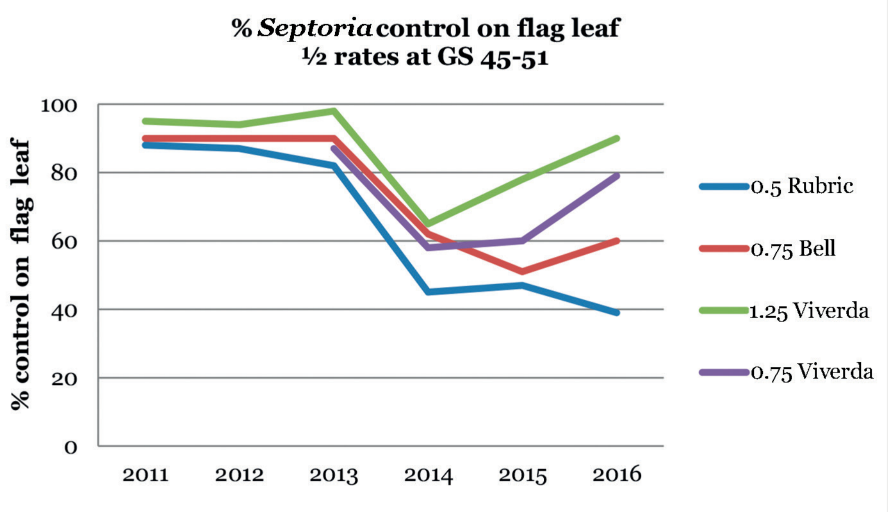


Figure 9. Per cent control of *Septoria* using half rates of several solutions looked across several years for Rubric, Bell and Viverda. Average of one application at GS 45-51.

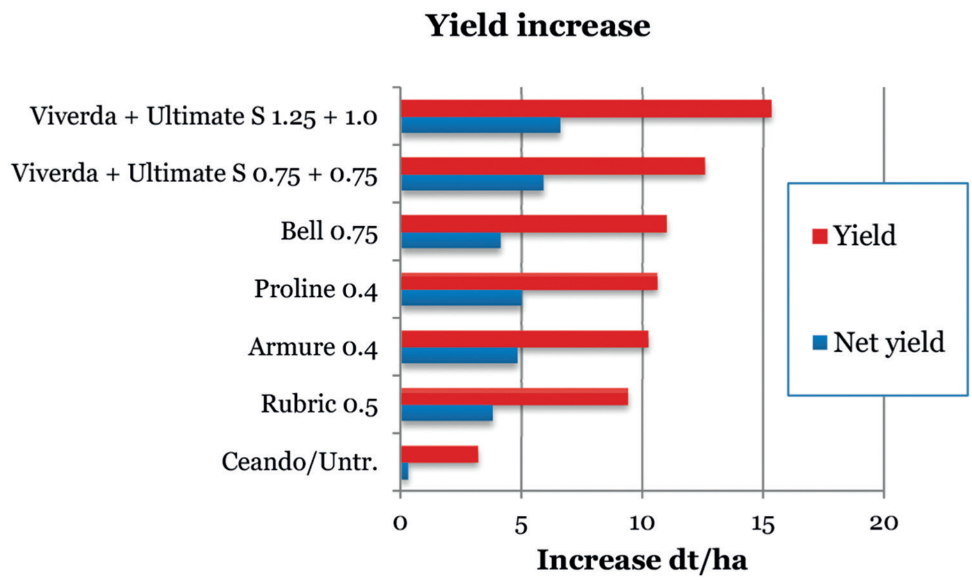


Figure 10. Average of 12 trials (13325, 14325, 15325 and 16325). All the trials were treated with 0.375/0.5 l/ha Ceando at GS 31-32 and an ear treatment was applied at GS 51-55. LSD_{95}=3.1 hkg/ha.

Eurowheat: Test of triazoles against *Septoria* and yellow rust in winter wheat

The Eurowheat project was initiated in 2015 when 26 trials were carried out across Europe. In 2016 14 trials were similarly carried out – 2 of those were carried out in Denmark. The project aims at testing the current European situation regarding control from 4 different single triazole and 2 mixed triazole products against *Septoria*, brown rust and yellow rust in 10 different European countries. The compositions of CYP51 mutations of *Septoria* populations have been investigated and isolates were analysed for EC50 values to main triazoles. The data are being presented on the platform www.EUROwheat.au.dk.

Two Danish trials from 2016 had focus on *Septoria* in one trial and yellow rust in the second trial. The trial in Jutland in the cultivar Hereford developed a significant attack of *Septoria* and the trial at Flakkebjerg in the cultivar Substance developed moderate attacks of both yellow rust and *Septoria* (Table 9 and Figure 11). Regarding control of yellow rust all products performed well; only at the later assessments were inferior control seen from Caramba and Proline EC 250. Regarding control of *Septoria* the mixtures Osiris and Prosaro clearly provided superior control compared with single actives and only limited differences were seen between the two rates for these two products. Opus Max and Proline EC 250 still outperformed Caramba and Folicur for control of *Septoria*, but the differences in efficacy between these products were smaller than seen in other years. Yields increased significantly in both trials and varied between 8 and 13 dt/ha. The mixtures provided better yields than the single treatments. The Danish results are much in line with results obtained in other countries, which also clearly showed that the mixtures performed better than the single products. However, the better of the 4 single actives varied much between sites.

Yield results from 15 trials in 2015 and 9 trials in 2016 carried out across Europe have shown that the average yield response from single triazoles has dropped and that the mixtures Osiris and Prosaro overall are performing better with respect to both control and yields (Figures 12 and 13).

Table 9. Per cent control of *Septoria* and yellow rust at specific times. Yield and yield increase, relative yield and net yield increase as an average of the two trials.

Septoria		% *Septoria*				% yellow rust		% GLA		Yield and increase	Yield relative	Net yield increase
	Leaf	1		2		1	2	1	2			
	GS	73	75	73	75	75	75	83	83	hkg/ha	%	hkg/ha
	DAA	28	42	28	42	42	42	49-53	49			
	Trials	1	2	1	2	1	1	2	1	2	2	
Treatment	l/ha											
Untreated	-	8.7	84.0	24.0	97.2	16.0	17.0	2.9	0.5	84.2	100	-
Opus Max	1.5	3.3	17.0	6.0	74.3	0.0	0.0	18.8	13.3	10.0	112.0	5.4
Opus Max	1.0	3.3	20.3	7.7	75.7	0.0	0.0	20.8	6.5	10.3	112.4	6.7
Opus Max	0.75	4.0	28.3	9.3	81.0	0.0	0.1	9.7	4.3	8.9	110.7	6.2
Proline	0.8	4.3	25.3	10.0	76.0	0.8	1.2	18.6	4.8	8.0	109.7	3.4
Proline	0.4	5.3	63.3	14.3	83.7	3.0	3.0	13.4	1.0	8.0	109.5	5.4
Caramba	1.0	3.0	37.0	6.7	81.7	2.3	2.4	9.8	3.0	9.6	111.4	6.5
Caramba	0.5	7.0	61.0	12.7	89.3	1.3	1.7	3.8	1.0	8.4	109.8	6.5
Folicur	1.0	3.7	41.5	9.0	79.7	0.0	0.1	6.8	1.5	9.8	111.6	6.6
Folicur	0.5	6.2	66.5	5.5	88.7	0.0	0.0	5.7	1.5	8.6	110,3	6.7
Osiris	3.0	1.1	6.4	2.3	31.4	0.0	0.0	51.3	18.5	13.0	115.5	3.0
Osiris	1.5	2.3	13.3	7.0	59.0	0.0	0.0	23.8	6.0	13.0	114.4	7.6
Prosaro	1.0	1.4	11.7	3.0	47.3	0.1	0.3	25.7	5.8	12.2	114.6	8.0
Prosaro	0.5	1.4	11.4	2.6	32.9	0.0	0.1	22.2	2.3	12.2	114.7	9.8
LSD_{95}										3.5		

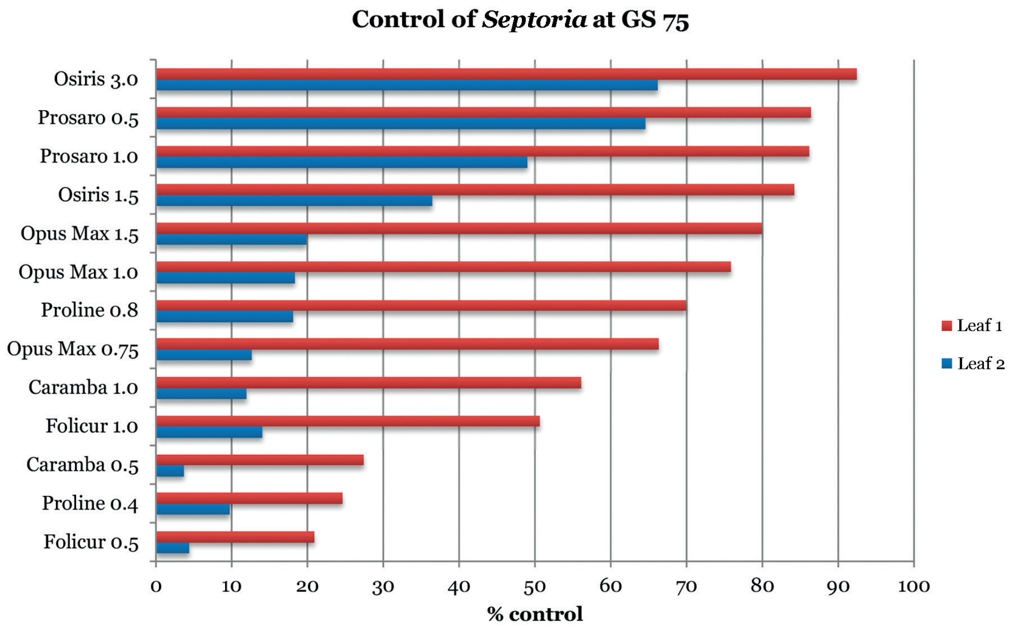


Figure 11. Per cent control of *Septoria* assessed on leaf 1 and leaf 2 at GS 75. Data represent average values from 2 trials assessed 42 days after application (16380).

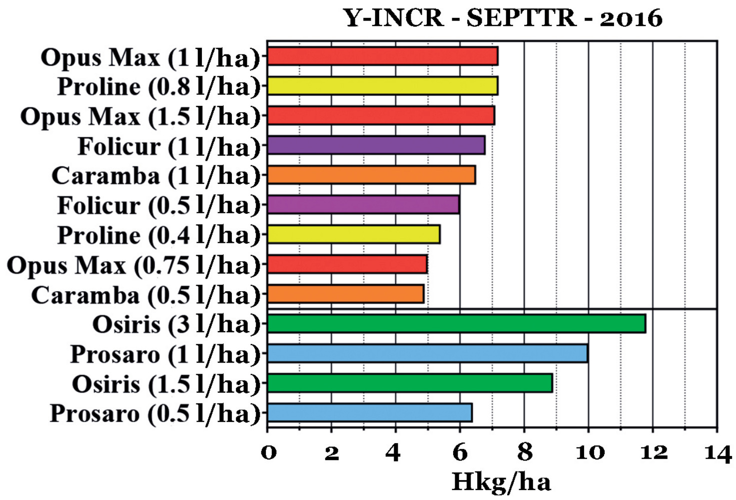


Figure 12. Yield increase from 9 trials across Europe in 2016 which had *Septoria* as the main disease.

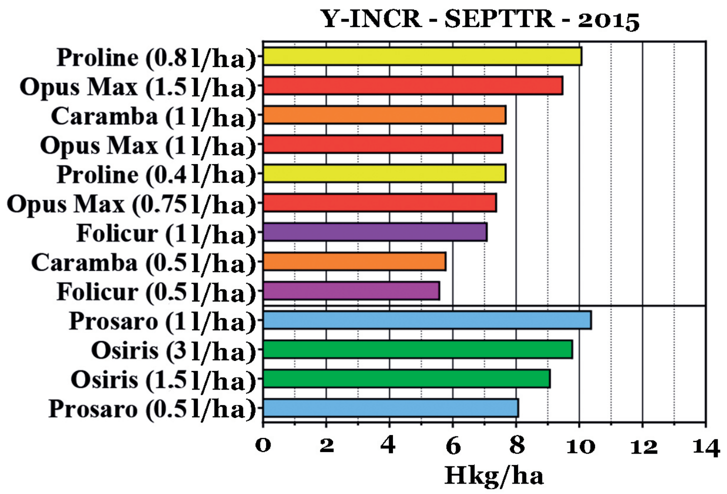


Figure 13. Yield increase from 15 trials across Europe in 2015 which had *Septoria* as the main disease.

Effects from the use of Folpan 500 SC in different strategies

Folpan 500 SC was authorised for use in cereals in Denmark in 2014. The product has been tested in several trials and shown moderate control of *Septoria*. The main argument behind recommending Folpan is to minimise the risk of developing resistance to more specific fungicides like azoles or SDHIs. Adding Folpan 500 SC to a standard programme used at the early timing is believed to be the best timing for using the product. Data have generally shown a visual benefit from adding Folpan 500 SC to triazole solutions, although this did not reflect in higher net yields compared with using triazoles alone. Using either Folpan 500 SC or Dithane alone at the two early timings gave inferior yield responses compared with treatments in which triazoles were included at all timings.

Two trials in 2016 compared Folpan 500 SC used alone with Prosaro at the early treatment (T1). These two treatments provided similar control and yields under moderate diseases pressure (Figure 14). However, neither of the two early treatments did pay for an early treatment as 2 treatments (T2 + T3) gave the best net return (Table 10). The same trials also showed several solutions for T2 and T3, which generally provided very similar levels of *Septoria* control and also yieldwise did not differ from each other (Figure 14).

The same trials were also investigated for specific CYP51 mutations, and similarly to other trials it was clear that particularly Brisk (difenoconazole + propiconazole) was best at reducing the selection pressure for new evolving mutations, but using a SDHI mixture at T2 also helped to reduce the selection pressure (Figure 15).

Table 10. Control of *Septoria* and yield increases from different treatments in wheat in which Folpan was part of the control strategy. 2 trials (16332).

Treatments, l/ha			% *Septoria*			% GLA	Yield and increase hkg/ha	Net increase hkg/ha
GS 31-32	GS 37-39	GS 59-61	GS 71 leaf 1	GS 73/75 leaf 1	GS 73/75 leaf 2	GS 75/77 leaf 1		
1. Untreated	Untreated	Untreated	3.3	20.9	40.4	0.7	86.2	-
2. Prosaro EC 250 0.35	Viverda 0.6	Proline Xpert 0.4	0.7	3.5	9.1	17.1	8.2	0.8
3. Prosaro EC 250 0.35	Viverda 0.6	Brisk 0.2	0.6	2.7	9.8	33.8	8.9	-
4. Folpan 1.0	Viverda 0.6	Proline Xpert 0.4	0.7	2.6	8.0	15.7	7.4	-0.4
5. Prosaro EC 250 + Folpan 0.25 + 1.0	Viverda 0.6	Proline Xpert 0.4	0.5	2.9	8.4	22.9	6.6	-2.1
6. Folpan 1.0	Propulse 0.4	Proline Xpert 0.4	0.3	1.9	3.8	22.9	8.3	1.3
7. Folpan 1.0	Bell + Proline EC 250 0.375 + 0.2	Proline Xpert 0.4	0.6	2.9	6.4	24.4	6.9	-0.6
8. Prosaro EC 250 0.35	Propulse 0.4	Brisk 0.2	0.4	1.4	3.3	44.4	9.4	-
9. Prosaro EC 250 0.35	Propulse 0.4	Topsin 0.55	0.3	2.5	3.9	21.9	8.8	-
10. Folpan 1.0	Bell + Juventus 90 0.375 + 0.25	Proline Xpert 0.4	0.5	3.0	7.6	21.3	9.2	1.7
11. Untreated	Viverda 0.6	Proline Xpert 0.4	0.9	3.8	12.0	10.0	7.6	2.1
No. of trials			2	2	2	2	2	2
LSD_{95}			0.2	2.5	3.2	9.9	3.0	-

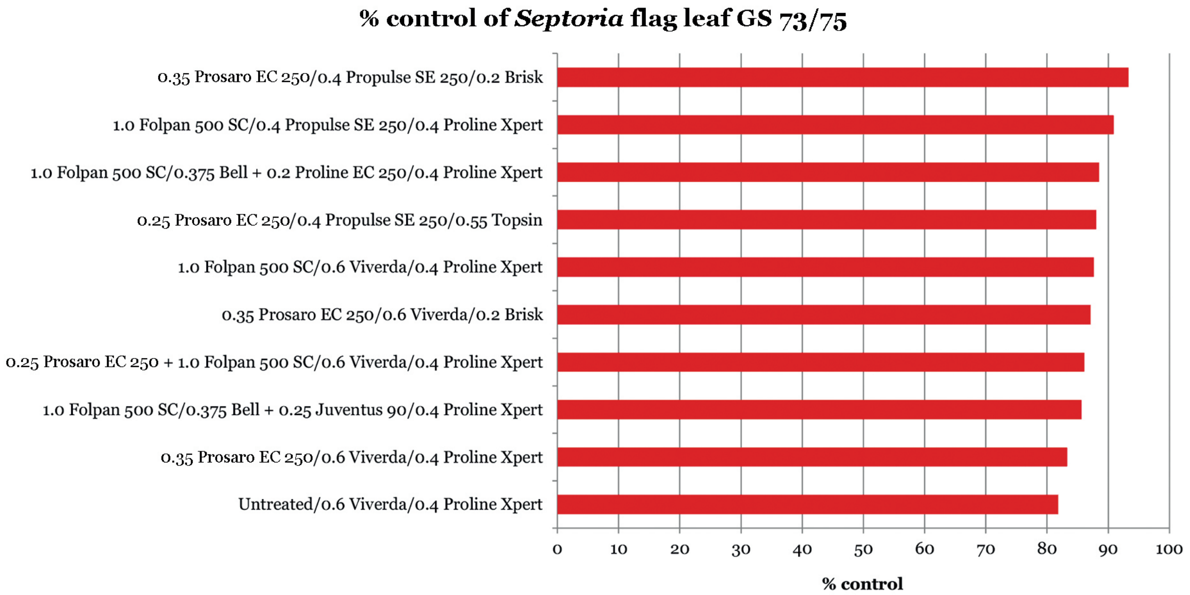


Figure 14. Per cent control of *Septoria*, GS 73-75. Data represent average values of 2 trials which had 3 applications with different fungicides (16332).

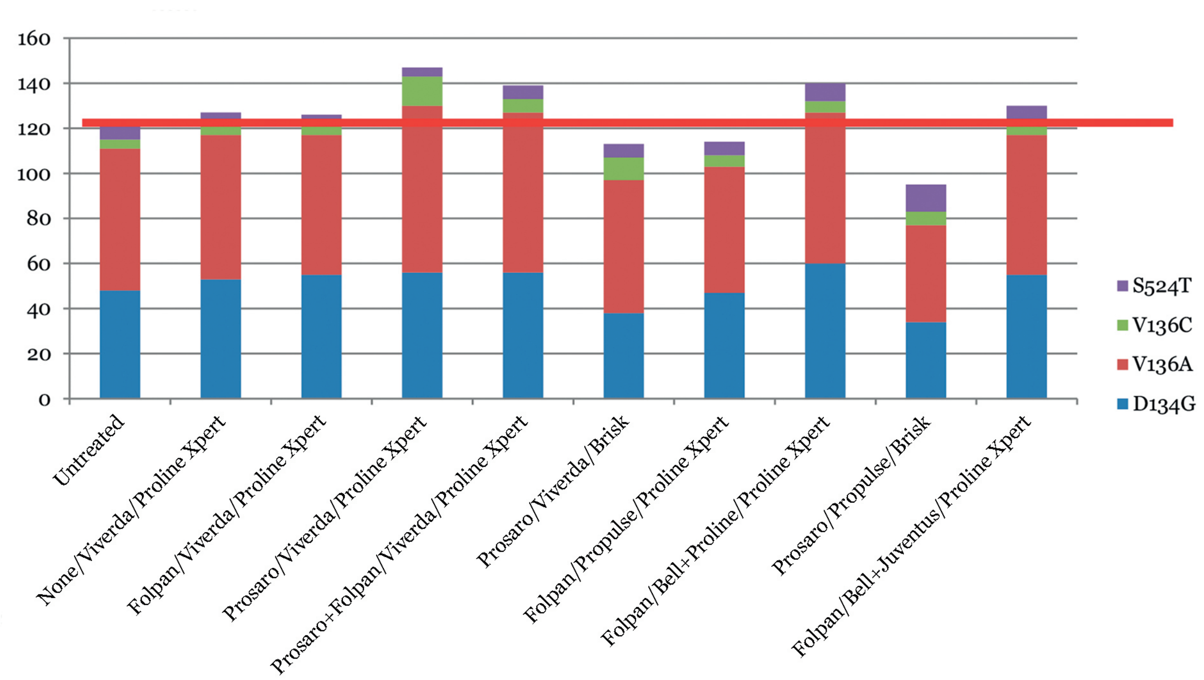


Figure 15. Per cent CYP51 mutations in the population of *Zymoseptoria tritici* measured from leaf samples collected at GS 73-75. Data represent average values of 2 trials which had 3 applications with different fungicides (16332).

Mixing Folpan with different products was also tested at the early timing (T1) in a single trial in 2016 (16308). This trial did, however, not provide any clear benefit with respect to either control or yield from and early T1 application (Table 11).

Table 11. Control of *Septoria* and yield increases from different treatments in wheat at which Folpan was used as a mixing partner at the early timing (GS 32). 1 trial (16308).

Treatment				% *Septoria*				Yield and increase	
	GS 32	GS 37-39	GS 55-61	GS 65 leaf 3	GS 65 leaf 4	GS 75 leaf 1	GS 75 leaf 2	hkg/ha	hkg/ha
1.	Untreated	-	-	9.5	1.3	35.0	95.0	97.0	-
2.	Prosaro EC 250 0.35	Viverda 0.75	Proline Xpert 0.4	5.0	0.0	5.5	45.0	9.0	1.0
3.	Prosaro EC 250 + Folpan 500 SC 0.25 + 0.75	Viverda 0.75	Proline Xpert 0.4	4.5	0.0	4.5	45.0	10.0	1.1
4.	Prosaro EC 250 + Folpan 500 SC 025 + 0.75	Viverda + Folpan 500 SC 0.5 + 0.75	Proline Xpert 0.4	4.0	0.1	4.5	45.0	8.0	-1.1
5.	Comet + Folpan 500 SC 0.25 + 0.75	Viverda + Folpan 500 SC 0.5 + 0.75	Proline Xpert 0.4	4.5	0.2	5.5	50.0	5.0	-4.3
6	Leander + Folpan 500 SC 0.25 + 0.75	Viverda + Folpan 500 SC 0.5 + 0.75	Proline Xpert 0.4	5.0	0.0	7.0	55.0	6.0	-
7.	Bumper 25 EC + Folpan 500 SC 0.25 + 0.75	Viverda + Folpan 500 SC 0.5 + 0.75	Proline Xpert 0.4	4.0	0.4	9.8	65.0	6.0	-2.7
8.	-	Viverda + Folpan 500 SC 0.5 + 0.75	Proline Xpert 0.4	7.3	0.4	9.8	60.0	6.0	-0.3
	LSD_{95}			1.5	0.4	4.1	13.6	0.5	-

Treatment in wheat following 2 x 0.4 l Proline EC 250, applied at 19 May and 7 June. As indicated, the level of control was poor and not much better than untreated. Photo taken 7 July.

Untreated.

Control strategies and impact on CYP_{51} selection in *Septoria*

During two seasons different control strategies were tested with the specific aim of investigating the impact on field control, yield and selection for CYP_{51} mutations. The results from 2016 are shown it Figures 16 + 17 and Table 12. Treatments with only one or two treatments or where Folpan replaced the T1 treatment gave inferior *Septoria* control, which was also seen from 3 x Proline EC 250. The trial data showed that the more diverse the fungicide programme, the better the level of *Septoria* control and yield response.

The new fungicides GF 3307 and GF 3309 were included in the trial plan. These contain Inatreq, which is a new active, which provided a significant better control that the triazole-based solutions and which did also yield significantly better than all other treatments (Table 12 and Figure 16).

The different treatments showed a different selection pattern for selection of the 4 evolving CYP_{51} mutations related to triazole resistance (Figure 17). Least selection for the evolving mutations was seen when reducing the number of treatments, using Armure at T3 or replacing the first treatment with Folpan. When using the same triazole repeatedly, the selection was most pronounced. Even when including new chemistry like SDHI and Inatreq, selection still takes place if triazoles are still included in the co-formulations. Based on results from these trials new recommendations for use of triazoles have been proposed.

Table 12. Per cent control of *Septoria* and yield increases in winter wheat using 3 spray strategies. Average of 2 trials from 2016. Treatments were applied at GS 31-32, 37-39 and 59-61 (16332).

Treatments, l/ha				% *Septoria*			% GLA	Yield and increase hkg/ha	Net increase hkg/ha
GS 31-32		GS 33-37	GS 55	GS 75 leaf 1	GS 75 leaf 2	GS 77 leaf 1	GS 75/77 leaf 1		
1.	Untreated			50.3	81.9	85.0	7.5	84.3	-
2.	Proline EC 250 0.4	Proline EC 250 0.4	Proline EC 250 0.4	24.8	41.9	38.8	51.3	9.5	1.7
3.	Proline EC 250 0.4	Bell 0.5	Proline EC 250 0.4	21.4	41.3	27.5	60.0	12.2	4.1
4.	Proline EC 250 0.4	Bell 0.5	Prosaro 0.5	17.2	32.8	36.3	43.8	13.2	5.3
5.	Proline EC 250 0.4	Bell 0.5	Armure 0.4	15.2	32.8	16.3	78.8	13.6	5.6
6.	Proline EC 250 + Folpan 0.4 + 1.0	Folpan + Bell 1.0 + 0.5	Prosaro 0.5	17.3	29.8	20.0	66.3	15.1	3.9
7.	Folpan 1.5	Bell 0.5	Prosaro 0.5	29.0	50.3	35.0	46.3	9.2	0.8
8.	Serenade + Proline EC 250 2.0 + 0.4	Serenade +Bell 2.0 + 0.5	Serenade + Prosaro 2.0 + 0.5	21.4	42.2	21.3	65.0	12.6	-
9.	-	Bell 0.5	Prosaro 0.5	30.3	51.3	50.0	32.5	10.0	4.7
10.	-	Bell 1.0		38.1	58.2	33.8	52.5	8.6	3.5
11.	Proline Xpert 0.5	Bell + Proline EC 250 0.375 + 0.2	Proline Xpert 0.5	18.9	34.8	16.3	73.8	13.3	4.8
12.	Prosaro 0.5	Propulse 0.5	Prosaro 0.5	20.4	37.9	18.8	70.0	15.2	7.6
13.	-	GF 3307 1.0	GF 3307 1.0	1.4	5.7	3.8	91.3	21.5	-
14.	-	GF3309 1.0	GF 3307 1.0	1.9	6.7	3.8	90.0	21.4	-
15.	GF 3309 1.0	Bell 0.5	GF 33071.0	3.4	11.7	4.0	93.8	20.5	-
No. of trials				2	2	1	1	2	2
LSD_{95}						8.6		3.9	

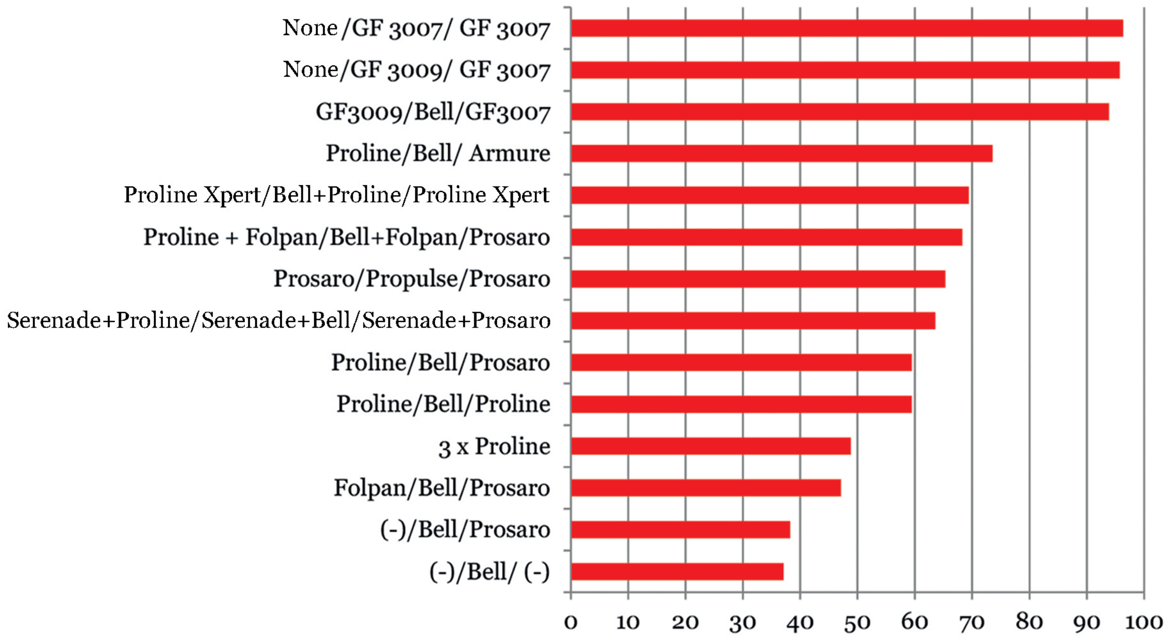


Figure 16. Per cent control of *Septoria* on flag leaf at GS 75 from different control strategies using 1-3 treatments. Average of two trials from 2016 (16328).

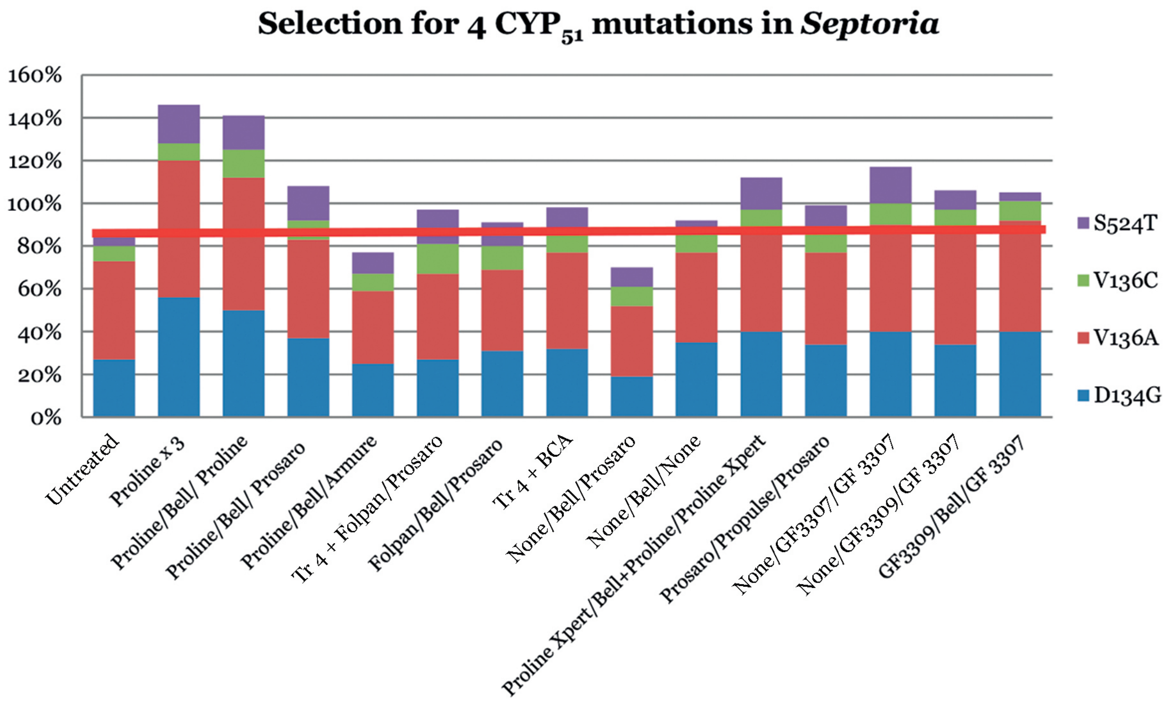


Figure 17. Level of evolving CYP_{51} mutations in the population of *Zymoseptoria tritici* following the use of different control strategies. Average of 2 trials in 2016 (part of Thies Heick's PhD).

Control of eye spot (*Tapesia yallundae* and *Tapesia acuformis*) in wheat/rye

Eye spot in winter cereals have in recent years given fewer problems compared with 20-30 years ago and the disease tend to be overlooked. A number of products are authorised for control of eye spot but farmers do not commonly pay much attention to this disease. Breeders have built in resistant genes to eye spot, which also help to minimise the risk. Fungicides show only low to moderate control of this disease.

In order to screen the effect on eye spot from the products authorised two trials were carried out in 2016; one in wheat and one in rye.

The two trials showed slight to moderate attack of eye spot when stems were investigated of straw picked at GS 75-77. Best effects were seen in rye where the attack was relatively slight. In wheat all products performed equally weakly. No lodging was detected in the trials. Data are shown in Table 13. Neither wheat nor rye gave any clear yield improvement from the early treatment and in both cases it was the last treatment, which raised the yield most. In rye the early treatment had a major reducing impact on *Rhynchosporium* on which all products with the exception of Flexity and Cantus reduced the attack significantly.

Table 13. Effect of early applications on control of eye spot in wheat (16333-1) and rye (16333-2).

Treatments, l/ha			Results from wheat				Results from rye			
			% *Septoria*		% eye spot GLA	Yield and increase hkg/ha	% *Rhynchosporium*		Eye spot index GS 77	Yield and increase hkg/ha
	GS 31-32	GS 51-55	GS 39 leaf 4	GS 77	GS 77 index		GS 77 leaf 3	GS 77 leaf 3		
1.	Untreated		5	8	71	82.9	17.5	37.5	12	88.1
2.	Stereo 1.6	Viverda 0.75	3	3	64	5.8	0.6	3.3	4	12.5
3.	Proline EC 250 0.8	Viverda 0.75	2	4	58	4.0	0.6	10.5	3	14.2
4.	Cantus 0.7 + Silwet Gold 0.1%	Viverda 0.75	3	3	63	5.3	14.5	16.3	3	8.9
5.	Prosaro 1.0	Viverda 0.75	3	3	64	5.9	1.1	6.5	4	11.4
6.	Flexity 0.5	Viverda 0.75	4	4	64	4.5	17.5	20.0	5	9.9
7.	Proline EC 250 0.4	Viverda 0.75	3	4	58	2.1	0.6	5.5	3	11.8
8.	Bell 0.75	Viverda 0.75	3	4	58	2.9	1.4	15.0	3	11.2
9.	Prosaro 0.5	Viverda 0.75	4	3	61	3.5	1.1	20.0	4	13.5
10.	Proline Xpert 0.5	Viverda 0.75	3	3	62	1.5	0.8	14.5	2	11.9
11.	Untreated	Viverda 0.75	5	4	66	5.4	4.5	18.8	9	12.3
No. of trials			1	1	1	1	1	1	1	1
LSD_{95}			1.0	2	9.4	NS	3.0	7.8	5.1	5.1

Early attack of eye spot.

Summer attack of eye spot.

Summer attack of sharp eye spot.

2. Results from fungicide trials in spring barley

Brown rust, net blotch and *Rhynchosporium* are the most severe diseases in spring barley. Many combinations of fungicides using triazoles and strobilurins provide similar control and yield responses. Much season 1 treatment at GS 37-39 will provide sufficient control using approximately 33-50% rates.
In case of early attack of net blotch and *Rhynchosporium* two treatments might be needed.

In 3 trials in spring barley different fungicide solutions using half rates were compared for control of specific diseases. Results from the 3 trials are shown in Table 14. The trial sited in the cultivar Milford developed a severe attack of powdery mildew (*Blumeria graminis*). One trial developed a severe attack of net blotch (*Pyrenophora teres*) in Chapeau. All three trials showed significant attacks of brown rust (*Puccinia hordei*) and two trials developed ramularia leaf spot (*Ramularia collo-cygni*) late in the season. As shown in Table 14, most of the tested solutions provided very similar and good control of all assessed diseases, with the exception of Propulse for control of rust and Prosaro for control of net blotch.

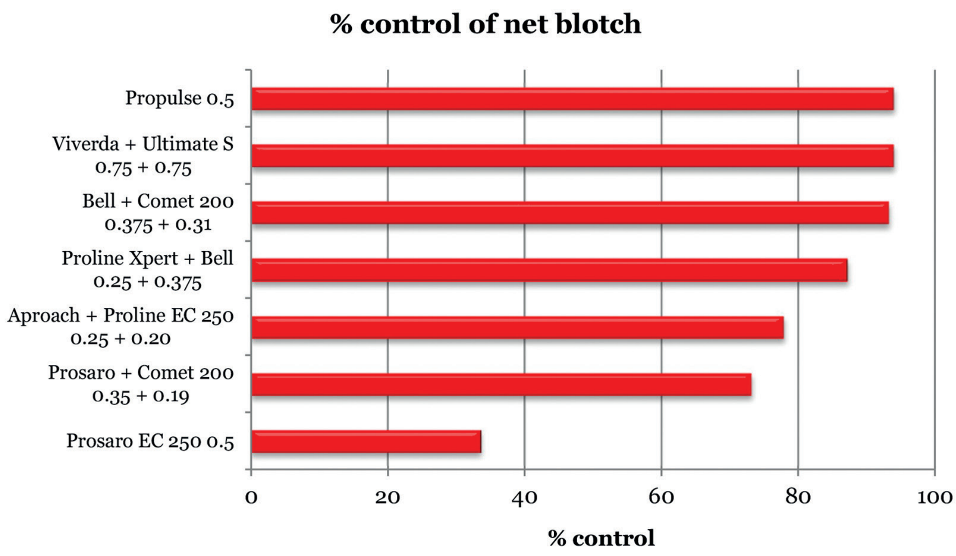
The attack of ramularia leaf spot developed relatively late but still differences were seen between solutions. Best control of ramularia leaf spot was obtained from Viverda, Propulse and mixtures which included Bell (Figure 18). Prosaro and Aproach + Proline EC 250 gave inferior control of *Ramularia*.

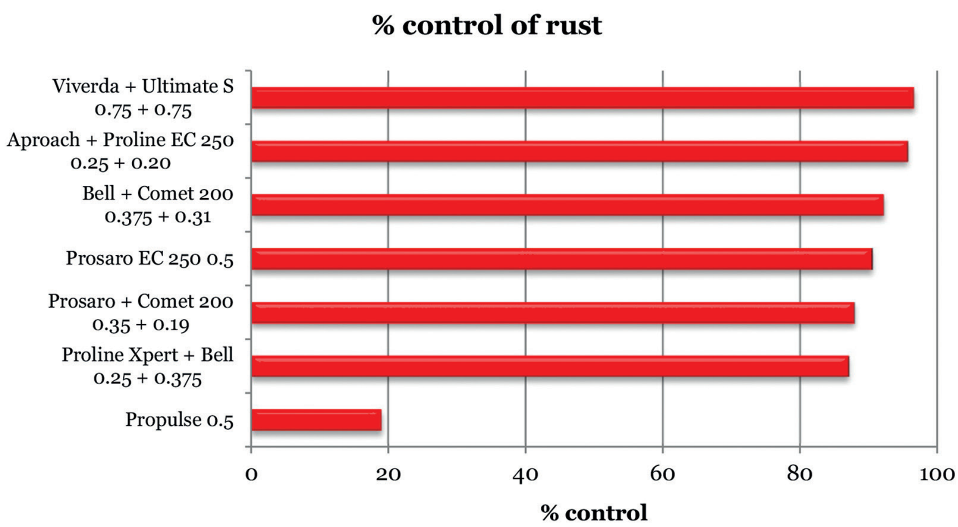
Yield responses were quite significant from most treatments in this year's trials and all treatments were significantly different from untreated. Particularly the trials with severe attacks of brown rust gave high yield increases.

One other trial was carried out (Table 15) comparing control of powdery mildew by different products. This trial provided good control from all treatments, but best yield responses were harvested from the broad spectrum fungicides, like Bumper 25 EC and Proline EC 250.

Table 14. Disease control using different fungicides applied at GS 33-37 in spring barley. 3 trials 2016 (16343).

Treatment, l/ha	% barley rust	% mildew	% net blotch	% *Ramularia*	Yield and increase hkg/ha	Net yield hkg/ha
GS 33-37	GS 75/83	GS 73	GS 75	GS 83		
1. Proline Xpert + Bell 0.25 + 0.375	1.5	0.2	1.9	9.7	6.6	3.2
2. Prosaro + Comet 200 0.35 + 0.19	1.4	0.5	4.0	16.0	7.1	4.5
3. Bell + Comet 200 0.375 + 0.31	0.9	0.2	1.0	11.3	8.8	5.4
4. Viverda + Ultimate S 0.75 + 0.75	0.4	0.1	0.9	9.2	8.7	4.6
5. Propulse 0.5	9.4	0.1	0.9	9.0	6.8	4.0
6. Prosaro 0.5	1.1	0.7	9.9	19.4	4.9	2.5
7. Aproach + Proline 0.25 + 0.2	0.5	0.4	3.3	19.7	7.5	5.0
8. Untreated	18.3	6.5	14.9	28.7	74.7	-
No. of trials	3	1	3	3	3	3
LSD_{95}			1.4	3.7	3.5	





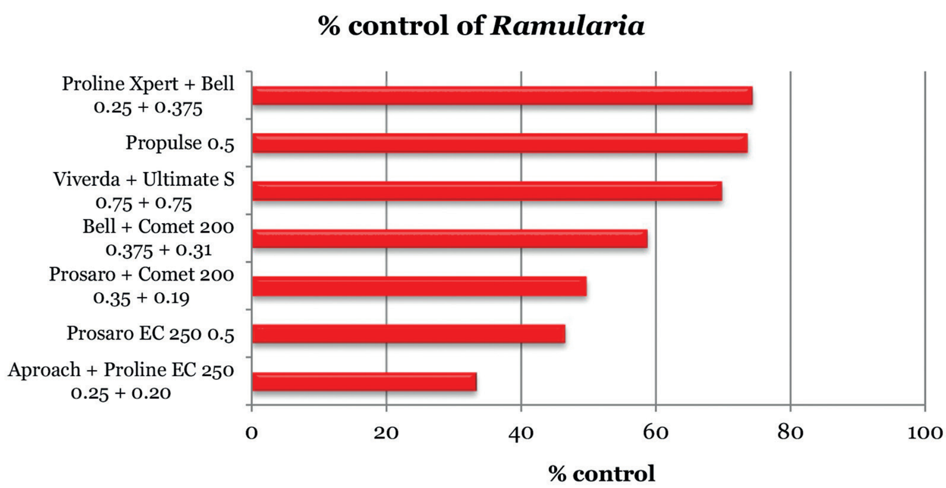


Figure 18. Control of net blotch, brown rust and ramularia leaf spot in spring barley (16343). Average of 3 trials with 14.9% attack of net blotch in untreated, 11.6% attack of brown rust in untreated and 28.8% *Ramularia* in untreated.

Table 15. Control of leaf diseases and yield responses in 1 trial with spring barley (16348). The trial was treated at GS 32-37 (16348).

Treatments, l/ha GS 32-37	% net blotch		% barley rust		% *Ramularia*	Yield and increase hkg/ha	Net yield hkg/ha	TGW
	GS 71	GS 75	GS 75	GS 83	GS 83			G
1. Leander 0.5	2.3	3.8	0.7	5.3	13.0	4.0		52.6
2. Flexity 0.25	3.5	5.8	11.3	20.0	21.3	1.0	-1.6	52.4
3. Bumper 0.5	3.1	7.0	1.9	10.8	10.0	6.0	4.3	52.7
4. Proline EC 250 0.4	1.0	3.5	0.9	10.8	11.3	6.0	3.4	52.5
5. Untreated	4.6	11.0	13.3	30.0	25.0	67.0	-	53.5
No. of trials	1	1	1	1	1	1	1	1
LSD_{95}	1.3	3.6	3.4	8.5	6.4	5.7		2.5

The spraying team. Ready to spray using two sprayers.

3. Results from fungicide trials in winter barley

Brown rust, net blotch and *Rhynchosporium* are the most severe diseases in winter barley. Many combinations of fungicides using triazoles and strobilurins provide similar control and yield responses. Much season 1 treatment at GS 37-39 will provide sufficient control using 33-50% rates. In case of early attack of net blotch and *Rhynchosporium* two treatments might be needed.

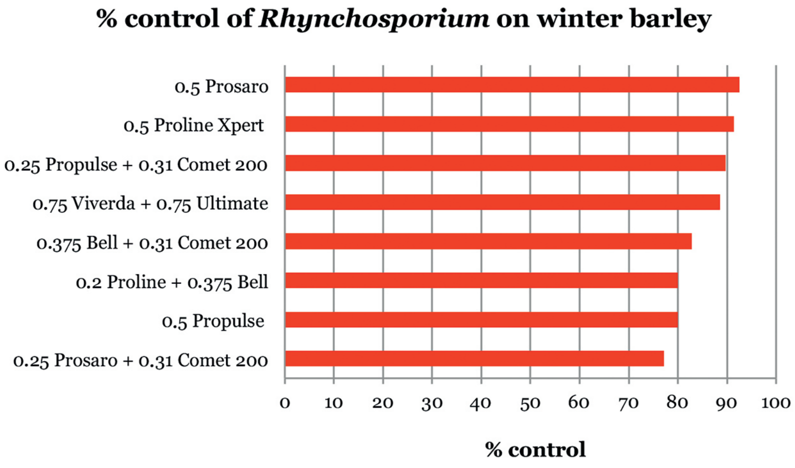
In 2016 3 trials in winter barley were carried out testing different combinations of fungicide solutions against specific diseases. Treatments were applied at GS 37-39 using half rates, which have typically been seen as economically optimal solutions. Results from the trials are shown in Table 17. The trials in 2016 were dominated by *Rhynchosporium* (*Rhynchosporium commune*) and brown rust (*Puccinia hordei*). As shown in Table 16 and Figure 19 most of the tested solutions provided very similar and good control of all assessed diseases. All treatments gave quite good and similar control of *Rhynchosporium*. With the exception of Propulse all treatments gave also good control of brown rust. The attack of brown rust was significant in two of the three trials. The attack of net blotch was slight to moderate and no clear differences were seen from the various treatments. Yield increases varied between 5.0 and 8.1 hkg/ha. Treatments which combined azoles and strobilurins generally performed well but so did also Prosaro. Due to the dominace of brown rust, Propulse was inferior on yields. Table 17 summarises results from different years, which indicates very similar results from different strategies using a total of a half rate.

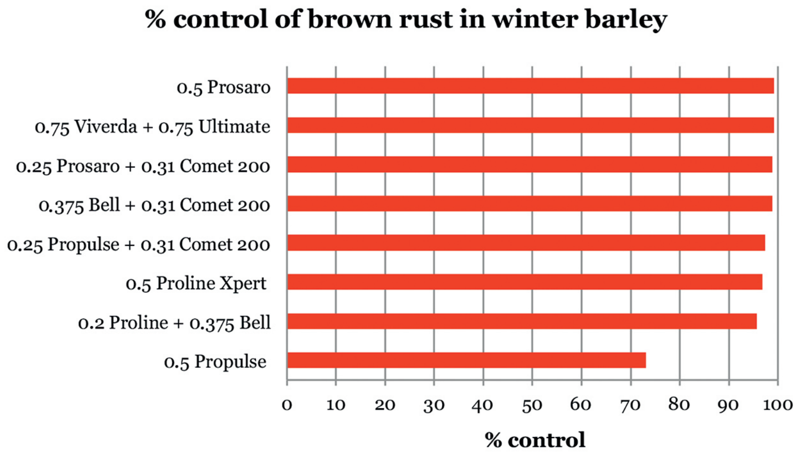
Table 16. Control of diseases and yield in winter barley. Average of 3 trials from 16381. The trials were treated at GS 39.

Treatments, l/ha GS 39	% *Rhynchosporium* GS73 Leaf 2	% net blotch GS 77/73 Leaf 2	% brown rust GS 71/69 Leaf 2 - 3	% brown rust GS 73 +81 Leaf 2	% green leaves GS 77-81 Leaf 1-2	Yield and increase hkg/ha	Net yield hkg/ha
1. Proline Xpert 0.5	1.5	1.5	0.1	1.1	33.8	7.9	5.1
2. Bell + Comet 200 0.375 + 0.31	3.0	0.8	0.1	0.4	41.7	8.1	4,7
3. Viverda + Ultimate 0.75 + 0.75	2.0	0.7	0.1	0.3	51.3	8.0	3.9
4. Prosaro + Comet 200 0.25 + 0.31	4.0	1.1	0.1	0.4	42.5	8.0	5.3
5. Propulse 0.5	3.5	1.3	1.9	9.4	25.0	5.0	2.2
6. Propulse + Comet 200 0.5 + 0.31	1.8	0.7	0.1	0.9	32.9	9.3	6.5
7. Prosaro EC 250 0.5	1.3	1.9	0.1	0.3	32.9	6.8	4.4
8. Proline EC 250 + Bell 0.2 + 0.375	3.5	1.1	0.2	1.5	40.4	7.6	4.3
9. Untreated	17.5	2.0	12.9	35.0	12.9	62.1	-
No. of trials	1	1	2	2	2	3	3
LSD_{95}	2.1	1.3	0.8	1.8	8.8	3.2	-

Table 17. Yield increases from disease control in winter barley using treatments at GS 37-39. Averages from different years.

Treatments GS 37-39	l/ha	Yield increase hkg/ha				
		2013+2014+2015	2010-2016	2013-2016	2015-2016	Netto hkg/ha
1. Untreated		67.7	70.1	66.2	59.5	
2. Bell + Comet	0.375 + 0.25	+7.9	+7.8	8.0	8.7	5.3
3. Viverda	0.75	+8.4		8.3	8.4	4.3
4. Prosaro	0.5	+6.9	+6.5	6.8	8.1	5.7
5. Prosaro + Comet Pro	0.25 + 0.31				8.4	5.7
6. Proline + Bell	0.2 + 0.375		-		7.3	4.0
No. of trials		8	19		6	6
LSD_{95}		3.0	1.9	2.5	2.6	





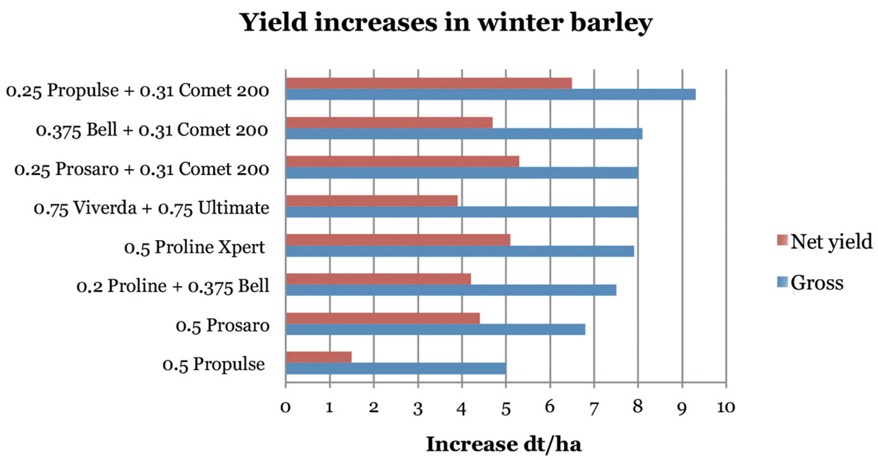


Figure 19. Control of brown rust and *Rhynchosporium* in winter barley as well as yield responses from one treatment at GS 37-39 (16381). Average of 3 trials with 35% attack of brown rust in untreated (3 trials) and 17% attack of *Rhynchosporium* in untreated (1 trial).

With the specific aim of controlling *Rhynchosporium* 1 trial was carried out in the cultivar Frigg, known to be very susceptible to this disease. A significant attack developed and two treatments were applied using half rates of different solutions traditionally expected to provide good control of this disease. Apart from *Rhynchosporium* also brown rust and ramularia leaf spot developed in the trial (Table 18; Figure 20). All treatments with the exception of Bumper 25 EC provided good control of *Rhynchosporium* (Figure 16). With respect to control of brown rust, both Proline EC 250 and Propulse provided inferior control compared with other treatments.

Table 18. Control of diseases and yield in winter barley (16387). The trial was treated at GS 31-32 and 39-51.

Treatments, l/ha	% *Rhyncho-sporium*	% *Rhyncho-sporium*	% brown rust	% *Ramularia*	% green leaves	Yield and increase hkg/ha	Net yield hkg/ha
GS 31-32 & 39-51	GS 65 Leaf 3-4	GS 73 Leaf 2-3	GS 81 Leaf 2 - 3	GS 81 Leaf 2-3	GS 81 Leaf 2		
1. Bumper 25 EC 0.25	10.0	8.3	2.3	3.5	45.0	2.0	-0.4
2. Armure 0.4	11.0	5.5	1.8	4.3	50.0	1.3	-3.7
3. Proline EC 250 0.4	2.5	1.9	0.8	3.0	65.0	5.5	0.3
4. Proline EC 250 0.2	6.0	2.5	8.3	5.3	56.3	0.6	-2.8
5. Viverda 0.75	3.3	1.0	0.9	0.8	68.8	6.2	-1.4
6. Viverda 0.5	4.3	1.8	0.3	1.3	75.0	5.7	0.1
7. Propulse 0.5	1.5	0.7	5.3	1.0	71.3	6.6	1.0
8. Prosaro 0.5	2.8	0.7	0.3	2.5	71.3	6.9	2.1
9. Comet Pro 0.6	6.5	3.8	0.8	3.3	58.8	5.1	-0.5
10. Acanto 0.5	7.3	2.5	0.8	4.0	57.5	7.3	2.6
11. Untreated	21.3	26.3	17.5	8.8	25.0	68.8	-
No. of trials	1	1	1	1	1	1	1
LSD_{95}	3.2	2.8	4.6	2.4	12.5	4.1	0

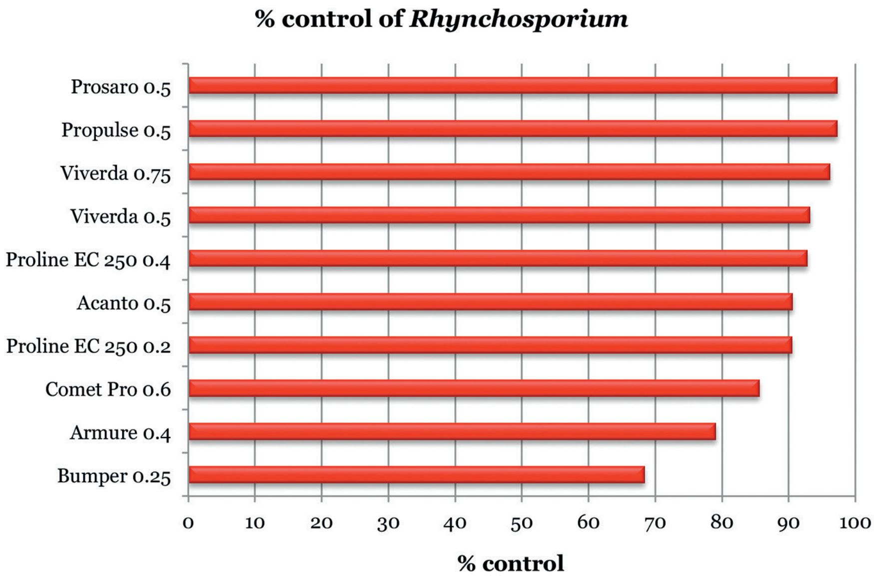


Figure 20. Control of *Rhynchosporium* in winter barley. 1 trial from 2016 (16387-1), treated at GS 31-32 and 39-51, 26.3% attack in untreated.

Net blotch in barley.

Brown rust in barley.

Control of rust using Bumper 25 EC or Comet 200
Two trials were carried out generating data for re-registration of actives. One trial with Bumper 25 EC showed that the product still provide very good control of brown rust if applied at full rate and using double treatments. The level of control from full rate of Bumper 25 EC was approximately similar to half rate of Proline EC 250 (Table 19).

In another trial Comet 200 was tested and compared with several other treatments (Table 20). Brown rust was also the main disease in this trial. Initially, all treatments provided good control of brown rust. However, at the very last assessment at GS 81 it was clear that some treatments had a better long-term effect than others. Tilt 25 EC and Proline were seen as the two products providing the briefest control, while the mixture with Proline EC 250 and Comet 200 gave a very good long season control.

Table 19. Control of leaf diseases in a winter barley trial from 2016 (16386). Treated at GS 31-32 and 45-51. 1 trial.

Treatment, l/ha	% rust	% rust	% net blotch	% *Rhynchosporium*	Yield and increase hkg/ha	Net yield hkg/ha
GS 33-37	GS 69 Leaf 2	GS 73 Leaf 2	GS 73 Leaf 2-3	GS 61 Leaf 2-3		
1. Bumper 25 EC 0.5	0.3	2.0	0.4	0.2	8.0	4.6
2. Bumper 25 EC 0.25	4.0	11.3	0.6	0.2	7.0	4.6
3. Bumper 25 EC 0.125	17.5	28.8	0.7	0.2	4.0	2.2
4. Proline EC 250 0.4	0.3	1.4	0.3	0.2	15.0	9.8
5. Untreated	32.5	45.0	1.1	1.3	63,0	-
LSD_{95}	4.5	6.0	0.4	0.6	7.6	-

Table 20. Control of leaf diseases in a winter barley trial from 2016 (16382). Treated at GS 31-32 and 45-51.

Treatment, l/ha	% rust	% rust	% net blotch	% *Rhynchosporium*	Yield and increase hkg/ha	Net yield hkg/ha
GS 33-37	GS 73 Leaf 1	GS 81 Leaf 2	GS 73 Leaf 2-3	GS 61 Leaf 2-3		
1. Untreated	9.3	30.0	15.0	7.5	61.5	
2. Comet 200 0.15	0.2	5.0	2.3	0.6	3.1	0.6
3. Comet 200 0.25	0.1	5.0	1.1	0.2	3.6	0.4
4. Comet 200 0.5	0.0	8.8	0.3	0.1	9.0	4.1
5. Comet 200 0.75	0.0	5.3	0.3	0.1	9.7	3.0
6. Proline 0.8	0.0	27.5	1.3	0.2	6.7	-2.5
7. Proline + Comet 200 0.8 + 0.25	0.0	1.3	0.1	0.0	9.6	-1.4
8. Opus 1.0	0.0	2.0	0.9	0.1	6.7	-2.5
9. Tilt 250 EC 0.5	0.0	15.0	3.5	1.1	4.5	1.1
No. of trials	1	1	1	1	1	1
LSD_{95}					5.7	

4. Control of diseases in rye and triticale

Rhynchosporium and brown rust are the most severe diseases in rye, and yellow rust, brown rust and stagnospora nodorum blotch are the most important diseases in triticale. In most seasons 1 treatment at GS 37-39 will provide sufficient control using approximately 50% rates. In case of severe yellow rust or late brown rust more treatments will be needed.

In 2016 4 trials were carried out in triticale and 3 trials in rye. The trials in triticale had yellow rust (*Puccinia striiformis*) as the dominant disease although the disease only developed moderately compared with attacks seen in other season. Late in the season an attack of tan spot developed in triticale, which moved into the site from the nearby wheat field, which was inoculated with tan spot. In rye scald (*Rhynchosporium secalis*) and a late attack of brown rust (*Puccinia recondita*) were the dominant diseases. Furthermore 1 rye trial was inoculated with ergot.

Disease control in triticale

In one trial different timings were tested for control of yellow rust. Specific timing gave good control of yellow rust, but only 2 treatments were needed to provide full control of the disease throughout the season (Table 21), which was in contrast to 2015 – when the attack was very severe and 4 treatments were needed in order to keep down the disease. Yields increased significantly from all treatments. The most broad spectrum solutions – Viverda and Prosaro – provided the best yield increases.

Table 21. Results from control of yellow rust using different timings of Rubric. The trial was carried through to harvest (16363-1).

Treatments, l/ha	Time of treatment	% yellow rust		Green leaf area		Yield and increase hkg/ha	Net yield hkg/ha
		GS 65 Leaf 3- 4	GS 73 Leaf 2-3	GS 77 Leaf 1-2	GS 77 Leaf 1		
1. Untreated		25.0	30.0	31.3	26.3	71.4	-
2. Rubric 0.25 Rubric 0.25 Rubric 0.25 Rubric 0.25	GS 30 GS 32-33 GS 39-40 GS 55	5.3	0	69.3	57.5	11.6	4.9
3. Rubric 0.5 Rubric 0.5	GS 30 GS 39-40	5.0	0	76.3	60.0	15.0	9.7
4. Rubric 0.5 Rubric 0.5	GS 32-33 GS 51-55	5.8	0	70.0	51.3	11.3	6.0
5. Prosaro EC 250 0.5 Prosaro EC 250 0.5	GS 32-33 GS 51-55	4.5	0	77.5	61.3	16.0	11.1
6. Viverda 0.75 Viverda 0.75	GS 32-33 GS 51-55	5.0	0	72.5	61.3	17.4	9.8
LSD_{95}	-	4.1	-	11.9	12.1	4.5	-

Disease control in rye

Three trials were carried out in 2016 in rye. Data from one of the trials are shown in Table 22. Three timings were included using two-spray strategies (GS 32 & 55-61 or 39 & 65). The attack of scald (*Rhynchosporium secalis*) was quite significant in the early part of the season, and late in the season a moderate attack of brown rust also occurred, resulting in a quite severe attack. *Rhynchosporium* was best controlled using early treatments at GS 32 (Table 22). Viverda and Prosaro both performed well for control of this disease. Brown rust (*Puccinia recondita*) only developed late and all treatments provided good control of this disease. The trial was artificially inoculated with ergot (*Claviceps pupurea*) during flowering. An attack did develop, but significant control could not be measured from any of the treatments. Yields increased significantly from Viverda and Prosaro. Bumper 25 EC proved to be the weaker of the tested solutions.

Table 22. Results from control of brown rust and ergot in rye using two different timings. The trial was carried through to harvest (16367).

Treatments, l/ha	Timings GS	% *Rhynchosporium*		% brown rust	Ergot	Yield and increase hkg/ha	Net yield hkg/ha
		GS 73 Leaf 2	GS 73 Leaf 3	GS 73 Leaf 2	GS 75		
1. Untreated		10.0	43.8	3.8	6.0	87.8	-
2. Bumper 25 EC 0.5 Bumper 25 EC 0.5	GS 39-45 GS 59-65	5.0	18.8	0.7	2.8	7.5	4.1
3. Bumper 25 EC 0.5 Bumper 25 EC 0.5	GS 32-33 GS 59-65	3.0	15.5	1.3	4.3	4.9	1.5
4. Prosaro 0.5 Prosaro 0.5	GS 39-45 GS 59-65	3.5	43.8	1.6	4.5	6.3	1.4
5. Prosaro 0.5 Prosaro 0.5	GS 32-33 GS 59-65	2.3	11.3	1.6	2.5	12.8	7.9
6. Viverda 0.75 Viverda 0.75	GS 39-45 GS 59-65	2.0	30.0	1.3	5.0	10.2	2.6
7. Viverda 0.75 Viverda 0.75	GS 32-33 GS 59-65	0.6	5.3	0.1	4.5	10.5	2.9
LSD_{95}		2.3	11.7	1.5	3.6	7.1	-

Attack of ergot in rye. Different fungicides were tested for control, but none gave significant control.

5. Control of diseases in spring wheat

In 2016 1 trial was carried out in spring wheat in the cultivar Trappe, which is very susceptible to yellow rust. The trial was naturally infected with yellow rust (*Puccinia striiformis*) and treated twice with the fungicides at a 2-week interval using different azoles, strobilurins and a SDHI. Initially, the control of yellow rust was very similar and good from all treatments. Later in the season the persistence of the products proved to be different (Table 23). Propulse proved to be inferior to other treatments but strobilurins and triazoles performed quite similarly (Figure 21). Yield increased significantly from all treatments with Prosaro performing best.

Table 23. Results from control of yellow rust in spring wheat using two treatments. The trial was carried through to harvest (16365).

Treatments l/ha	Timings GS	% yellow rust			Green leaf area	Yield and increase hkg/ha	Net yield hkg/ha
		GS 65 Leaf 1-4	GS 73 Leaf 1-3	GS 75 Leaf 1	GS 75 Leaf 2		
1. Acanto 0.5	31-32 & 37-39	1.0	2.0	20.8	65.0	9.1	4.4
2. Amistar 0.5	31-32 & 37-39	1.5	3.3	15.0	72.5	8.4	4.0
3. Comet Pro 0.5	31-32 & 37-39	2.8	3.0	16.3	72.5	10.9	6.0
4. Rubric 0.5	31-32 & 37-39	1.9	2.1	14.5	75.0	10.4	5.1
5. Folicur EW 250 0.5	31-32 & 37-39	0.9	0.7	13.8	72.5	10.2	6.3
6. Propulse SE 250 0.5	31-32 & 37-39	7.0	5.3	33.8	57.5	8.6	2.9
7. Prosaro EC 250 0.4	31-32 & 37-39	0.9	1.1	17.0	72.5	13.4	9.2
8. Bumper 25 EC 1.0	31-32 & 37-39	0.4	1.3	5.8	87.5	11.4	6.1
9. Viverda + Ultimate S 0.75 + 0.75	31-32 & 37-39	0.5	0.7	2.8	91.3	11.6	3.4
10. Untreated		35.0	32.5	70.0	6.3	57.9	-
LSD_{95}		2.3	32.5	8.0	10.4	3.9	-

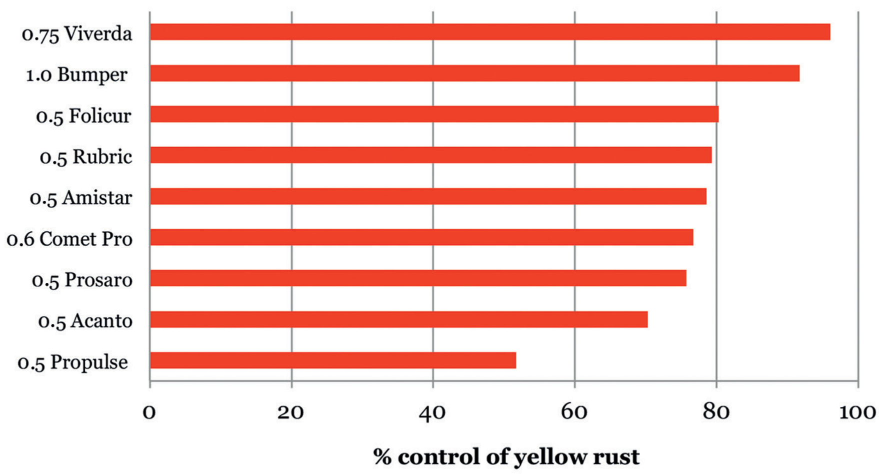


Figure 21. Control of yellow rust (*Puccinia striiformis*) in spring wheat. 1 trial from 2016 treated at GS 32 & 39. Untreated had 70% attack. By mistake Bumper 25 EC was applied at double rate.

6. Cultivar susceptibility to fusarium head blight

Fusarium head blight (*Fusarium* spp.) can cause significant problems with toxins in wheat. By avoiding wheat after maize or wheat in combination with reduced tillage the risk can be reduced significantly. Cultivar resistance is also a good way of reducing attack and major differences exist between cultivars. Fungicides only provide moderat control and will not provide sufficient reductions in high risk situations.

In line with previous years the susceptibility to fusarium head blight and tan spot of the cultivars most commonly grown in Denmark was investigated in a project partly financed by the breeders. In this year's trials 25 cultivars were included. Two parallel trials were conducted, one with inoculum being added during flowering and one with inoculum being added to the soil surface during elongation.

Trial with inoculation during flowering. Two rows of 1 metre were drilled in the autumn per cultivar and four replicates were included. The trial was inoculated 3 times (6 June, 8 June and 10 June) using a spore solution consisting of both *Fusarium culmorum* and *Fusarium graminearum*. To stimulate the development of the disease, the trial was irrigated by a mist irrigation system 2 times per day. Wheat is most susceptible during flowering, and at the time of inoculation the degree of flowering was assessed to ensure that all cultivars were inoculated during flowering. Approximately 15 days after inoculation the first symptoms of fusarium head blight were seen.

Trial with inoculum placed at the soil. In this part of the trial grain with attack of *Fusarium* prepared in the lab was placed on the soil around flag leaf emergence (19 May). To stimulate the development of the disease, the trial was irrigated by a mist irrigation system 2 times per day. The attack in this part of the trial is normally less severe compared with attack in the other trial. But in 2016 this trial developed similar levels of attack as in the spray-inoculated trial.

Both trials were assessed counting the attack on 100 ears per cultivar per replicate. The degree of attack was also scored as an average of the ears attacked. Results are shown in Figure 22 and Tables 24+25.

The small plots were hand harvested and grains were investigated from both trials; samples were ground and investigated for content of the mycotoxins – deoxynivalenol (DON), nivalenol (NIV), zearalenone (ZEA), HT-2 and T-2. The content of nivalenol, zearalenol, HT2 and T-2 were very low in the trials and therefore not included in the table. Toxins were measured in both trials and the level of DON was quite similar in the two trials. All cultivars had DON levels much higher that the maximum acceptable limit of 1250 ppb. There was quite a good correlation between degree of attack and content of DON and between content of DON and NIV (Figure 23). The content of ZEA was also quite high, but this linked poorly to other measured data.

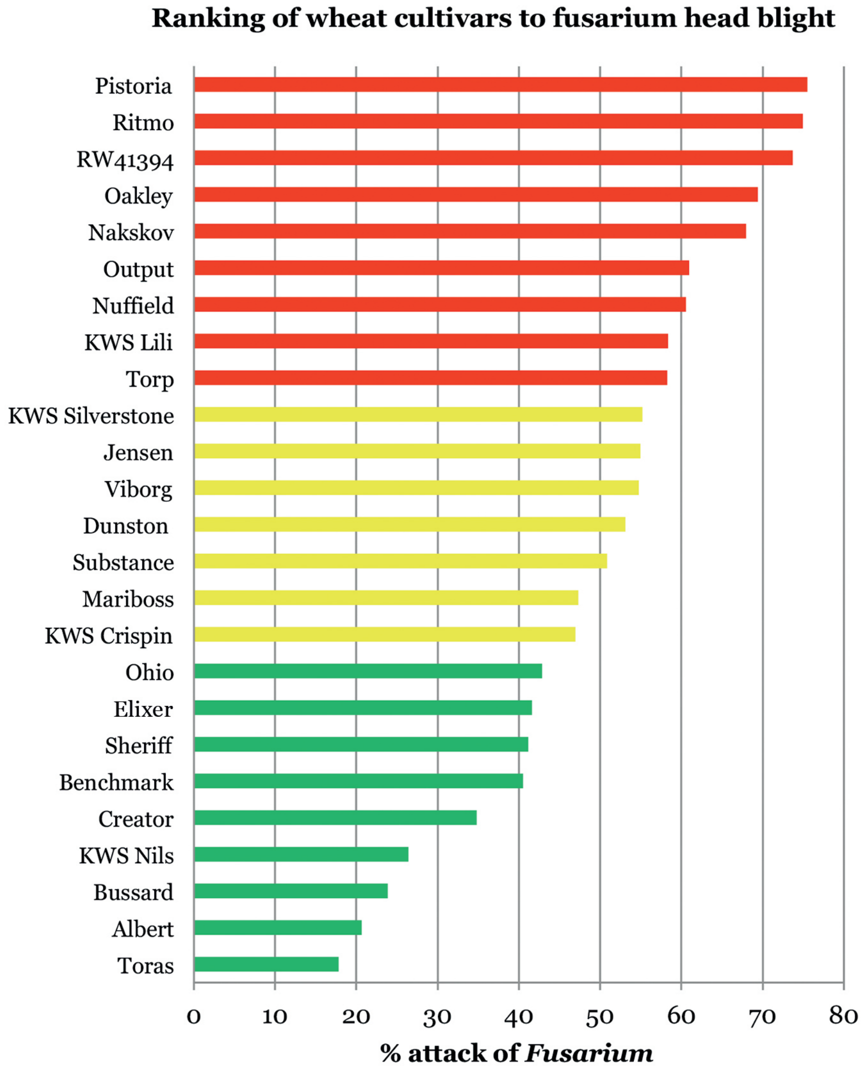
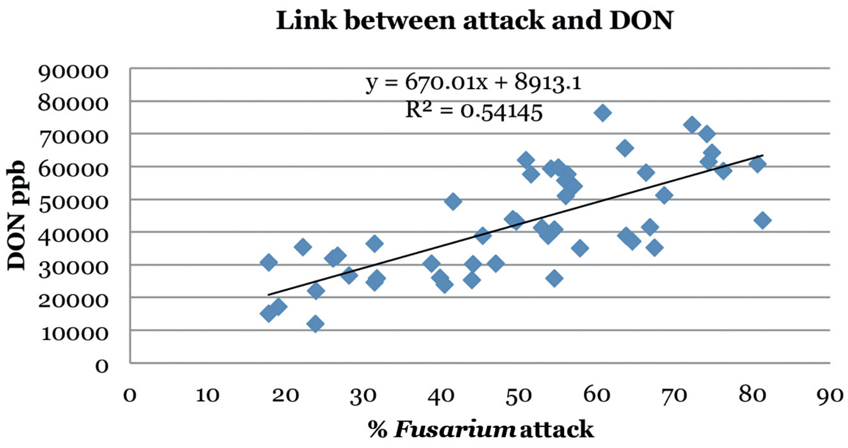


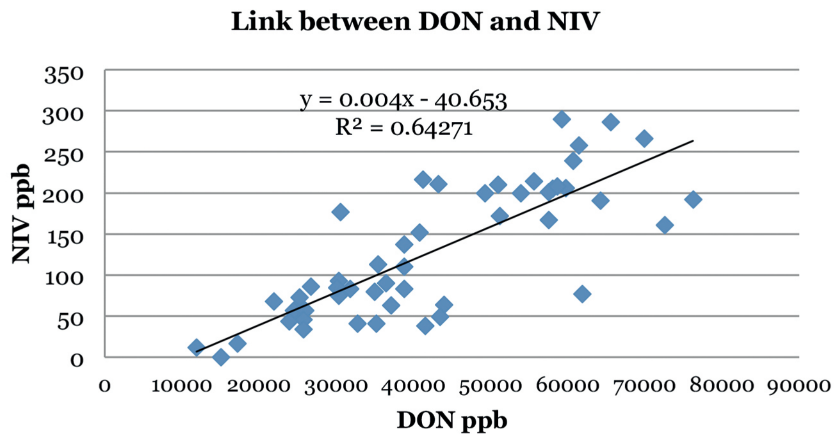
Figure 22. Per cent attack of fusarium head blight in late July. Average of both trials. The LSD_{95} value = 6.9.

In Table 24 the ranking of cultivars to *Fusarium* susceptibily is summarised, including also data from previous years in the final ranking.

Table 24. Grouping of cultivars by susceptibility to fusarium head blight. Based on results from both 2015 and previous years.

Low susceptibility	Moderate to high susceptibility	High susceptibility
Albert, Benchmark, Bussard, Creator, Elixer, KWS Nils, Ohio, Toras	Dunston, Hereford, JB Asano, Jensen, KWS Dacanto, KWS Crispin, KWS Silverstone, Mariboss, Sheriff, Viborg	Oakley, Pistoria, Ritmo, Torp, KWS Cleveland, KWS Lili, Output, Nakskov, Nuffield





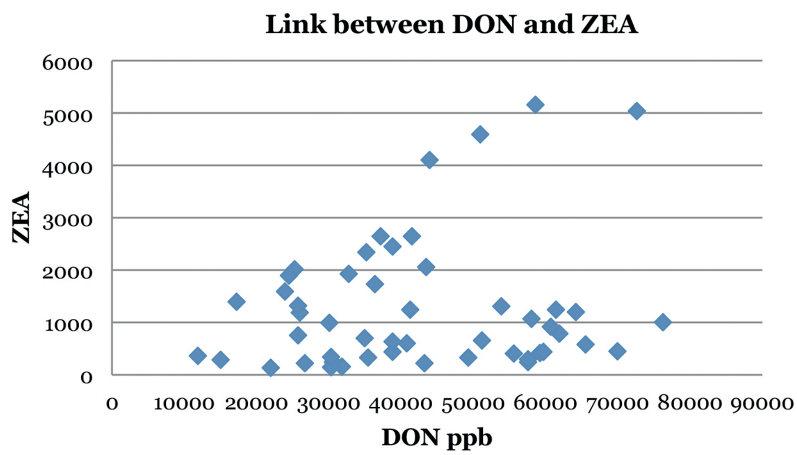


Figure 23. At the top, correlation between % heads attacked with *Fusarium* and content of DON measured in harvested grain. In the centre, the correlations between the two mycotoxins DON and NIV and at the bottom, correlation between DON and ZEA. Average of the 2 trials.

Table 25. Results from *Fusarium* cultivars in 2016. Data from 2 different inoculation methods are included. (Continues on the next page).

Disease (spore-inoculated during flowering) 16301-2		*Fusarium* spp.	*Fusarium* spp.	*Fusarium* spp.	*Fusarium* spp.	NIV	DON	ZEA
Date of assessment		22-06-2016	28-06-2016	28-06-2016	28-06-2016			
Assessment method		Number of ears per 2 m	Degree of attack in ears 1-10	% attacked ears	Index	ppb	ppb	ppb
Growth stage BBCH		73	75	75	75			
1	Pistoria	41.3	6.8	99.8	74.8	191	64205	1193
2	Substance	27.8	5.5	94.5	57.8	80	34955	700
3	Creator	7.5	4.5	82.5	41.5	398	49277	327
4	Benchmark	20.3	4.8	92.8	49.6	211	43208	223
5	Sheriff	31.5	4.8	96.5	50.9	77	61899	780
6	Jensen	26.3	5.5	91	56.2	167	57530	235
7	Mariboss	26.5	5.3	95.8	55.9	214	55588	407
8	Nuffield	65	6.8	98.8	74.1	266	69910	446
9	Torp	52.5	5.8	99.5	63.6	286	65540	573
10	Nakskov	46.3	6.5	100	72.2	161	72580	5030
11	KWS Silverstone	42.5	6	99.5	66.3	205	58015	1071
12	KWS Crispin	28.8	5	97	54.1	290	59229	410
13	KWS Lili	56.3	5.5	99.3	60.7	192	76221	1003
14	KWS Nils	4.3	3.3	73	26.1	83	31799	151
15	Viborg	50	5	98.3	55	206	59715	438
16	Elixer	26.5	5	90	51.5	201	57530	290
17	Ohio	15	4.5	90.3	45.3	137	38839	433
18	Albert	3	2.5	80.8	22.2	113	35440	324
19	RW41394	82.5	7.3	100	80.6	239	60686	918
20	Dunston	26.3	5.3	97	57	200	53889	1309
22	Output	20.3	5	98	54.5	152	40781	599
23	Toras	1	2.3	71	17.8	177	30585	239
24	Bussard	8.8	3	73	23.9	68	21944	136
25	Oakley	32.5	6.8	99	74.3	258	61414	1239
26	Ritmo	45	6.3	98.5	68.6	172	51219	648
LSD (P=.05)		27	1.2	7.9	14.2			
Standard Deviation		19	0.8	5.7	10.1			

Table 25. Results from *Fusarium* cultivars in 2016. Data from 2 different inoculation methods are included. (Continued).

	Disease (inoculated grain on ground) 16301-1	*Fusarium* spp.	*Fusarium* spp.	*Fusarium* spp.	*Fusarium* spp.		NIV	DON	ZEA
	Date of assessment	22-06-2016	28-06-2016	28-06-2016	28-06-2016				
	Assessment method	Number of ears per 2 m	Degree of attack in ears 1-10	% attacked ears	Index		ppb	ppb	ppb
	Growth stage BBCH	73	75	75	77				
1	Pistoria	31.3	7	98	76.2	ab	208	58622	5147
2	Substance	19.3	4.3	93	43.9	c-i	73	25245	2009
3	Creator	3.3	3.5	68	28.1	f-j	86	26702	218
4	Benchmark	5.3	3.5	76.5	31.4	e-j	57	24517	1895
5	Sheriff	5.3	3.5	78.5	31.4	e-j	90	36411	1729
6	Jensen	35.3	5.8	82.3	53.7	b-f	83	38839	633
7	Mariboss	7.8	4.8	71.8	38.7	d-j	93	30343	145
8	Nuffield	37.8	5	84.5	47	c-h	75	30343	334
9	Torp	34	5.3	89.8	52.9	b-g	216	41266	1237
10	Nakskov	21.5	6.5	87	63.7	a-d	110	38839	2442
11	KWS Silverstone	16.5	4.5	87.8	44.1	c-i	85	30100	993
12	KWS Crispin	17.8	4	87.8	39.8	d-j	57	25973	1188
13	KWS Lili	40	5.5	91.3	56	b-e	210	50976	4589
14	KWS Nils	12.8	3.5	69.5	26.7	g-j	41	32770	1929
15	Viborg	38.8	5.5	88	54.5	b-f	46	25731	752
16	Elixer	14.3	3.5	81.5	31.7	e-j	34	25731	1317
17	Ohio	48.8	4.5	80.5	40.4	d-j	44	23934	1589
18	Albert	10.5	2.3	74.3	19.1	ij	17	17210	1390
19	RW41394	67.5	6.5	92	66.8	abc	38	41509	2645
20	Dunston	22.5	5	88.5	49.2	c-h	64	43936	4097
22	Output	52.5	6.5	93	67.4	abc	41	35198	2336
23	Toras	3	2.3	68.3	17.8	j	0	15074	283
24	Bussard	10.3	2.8	76.3	23.8	hij	12	11894	355
25	Oakley	46.3	6.3	90.5	64.5	a-d	63	37140	2645
26	Ritmo	65	7.8	94.3	81.3	a	49	43451	2051
LSD (P=.05)		30	1.3	13.9	15.3				
Standard Deviation		21	0.9	9.9	10.8				

Field trial with different cultivars screened for susceptibility to fusarium head blight. To the left, the very susceptible cultivar Oakley and to the right, one of the most resistant cultivars - Skalmeje.

In spring barley a significant attack of *Michodochium* spp. developed on the heads. Brown colouring was seen on the leaf sheath. As the heads did not stretch fully through, the heads were kept partly covered by the leaf sheath.

III Control of diseases in different cultivars

Lise Nistrup Jørgensen, Hans-Peter Madsen, Helene Saltoft Kristjansen, Sidsel Kirkegaard & Anders Almskou-Dahlgaard

Control strategies in 6 wheat cultivars

Six different control strategies were compared in 3 different wheat cultivars and 3 mixtures of cultivars (Table 1). One of the treatments included the use of the decision support system Crop Protection Online to evaluate the need for treatments. The trials were sited at two localities – one at Aarhus University (AU) Flakkebjerg and one near Horsens with LMO. The treatments according to Crop Protection Online are shown in Table 2.

The following strategies were tested:
1. Untreated
2. 0.75 l/ha Ceando/0.75 l/ha Viverda + 0.75 l/ha Ultimate S (GS 37-39 & 55)
3. 1.25 l/ha Viverda + 1.0 l/ha Ultimate S (GS 39-45)
4. 0.5 l/ha Propulse/0.5 l/ha Proline Xpert (GS 37-39 & 55)
5. 1.0 l/ha Folpan 500/0.75 l/ha Viverda + 0.75 l/ha Ultimate S/0.5 l/ha Proline Xpert (GS 31-32 & GS 37-39 & 55)
6. Crop Protection Online (CPO) (Table 2)
7. Moist model
8. 0.5 l/ha Prosaro/1.0 l/ha Librax/0.5 l/ha Proline Xpert (GS 31 & 33-37 & 55)

Results from the two trials are listed in Table 3.

Table 1. Included cultivars and mixtures in the trials and their disease and yield score from 2015.

	Cultivars	% *Septoria*	% yellow rust	Yield (relative)
Mixture 1	Benchmark Torp Nuffield KWS Lissy	11 9 9 6 Ave. 8.8	8 0.1 0.08 0.8 Ave. 2.2	108 105 104 106 Ave. 106
Mixture 2	Pistoria Creator Albert Sheriff	3.8 2.0 3.3 3.5 Ave. 3.2	0 5 4 0.4 Ave. 2.4	102 91 100 99 Ave. 98
Mixture 3	Ohio Jensen Viborg KWS Nils	4.3 7.0 9.0 8.0 Ave. 7.1	0.01 1.4 0.04 0.01 Ave. 0.4	97 95 100 100 Ave. 98
Benchmark		11	8	108
Substance		8	64	102
Torp		9	0.1	108

Table 2. Treatments applied following recommendations from Crop Protection Online. 16350-1 and 16350-2.

Cultivars 16350-1	Date and GS	Products l/ha	TFI	Costs hkg/ha
Mixture 1	01-06-2016 (GS 55)	0.3 Bell + 0.2 Proline	0.36+0.25	3.0
Mixture 2	01-06-2016 (GS 55)	0.3 Bell + 0.2 Proline	0.36+0.25	3.0
Mixture 3	01-06-2016 (GS 55)	0.3 Bell + 0.2 Proline	0.36+0.25	3.0
Benchmark	25-5-2016 (GS 39) 01-06-2016 (GS 55)	0.47 Proline Xpert 0.3 Bell + 0.2 Proline	0.53 0.36+0.25	5.6
Substance	04-05-2016 (GS 31) 25-5-2016 (GS 51)	0.29 Prosaro 0.47 Proline Xpert	0.36 0.32	4.3
Torp	01-06-2016 (GS 55)	0.3 Bell + 0.2 Proline	0.36+0.25	3.0

Cultivars 16350-2	Date and GS	Products l/ha	TFI	Costs hkg/ha
Mixture 1	25-05-2016 (GS 37)	0.47 Proline Xpert	0.53	2.6
Mixture 2	25-05-2016 (GS 37)	0.47 Proline Xpert	0.53	2.6
Mixture 3	25-05-2016 (GS 37)	0.47 Proline Xpert	0.53	2.6
Benchmark	25-05-2016 (GS 37)	0.47 Proline Xpert	0.53	2.6
Substance	25-05-2016 (GS 37) 07-06-2016 (GS 55)	0.47 Proline Xpert 0.12 Rubric + 0.12 Comet Pro	0.53 0.22	4.2
Torp	25-05-2016 (GS 37)	0.47 Proline Xpert	0.53	2.6

Use of cultivar mixtures is one way of reducing disease attack and possibly making the selection for new aggressive *Septoria* strains less likely. This applies to both strains which are resistant to fungicides and strains which develop aggressiveness to resistant cultivars. The two trials from 2016 showed that cultivar mixture 2 of cultivars which has good resistance against *Septoria* could stand alone without a need for treatments and still be high yielding (Figure 1). More exploitation of these options should be looked into in order to sustain future control of *Septoria*.

Overall the best net yield results were obtained from 2 treatments using Propulse followed by Proline Xpert. Substance gave the highest net yield responses and in this crop 1 treatment was inferior.

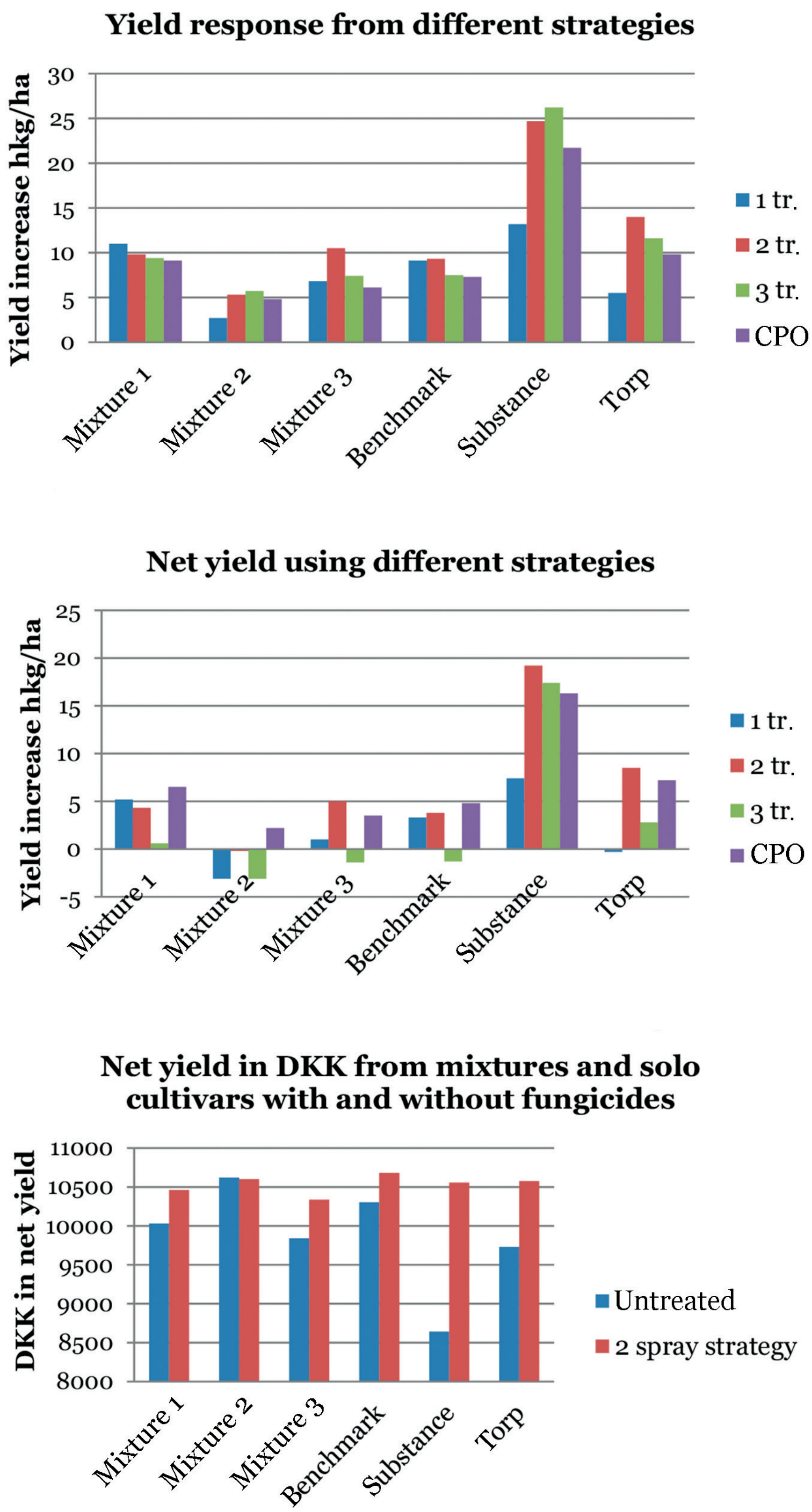


Figure 1. Data from 2 field trials with different cultivars and mixtures. Response to different control strategies using 1, 2 or 3 applications and final economic response.

Table 3. Control of *Septoria*, green leaf area and yield responses, 2 trials – 1 from Flakkebjerg and 1 from LMO with 6 winter wheat cultivars, using 5 different fungicide treatments (16350). (Continues on the next page).

Cultivars	% *Septoria*, leaf 1, GS 73-77						% *Septoria*, leaf 2, GS 73-77					
	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO
Mixture 1	16.9	7.5	4.4	4.9	5.7	9.4	43.7	23.5	12.0	13.0	14.5	22.5
Mixture 2	10.3	2.5	1.7	1.9	4.7	3.5	18.7	8.8	5.5	7.2	12.5	14.5
Mixture 3	21.2	5.7	5.2	4.9	8.2	11.2	42.5	19.2	16.0	17.5	21.0	25.4
Benchmark	19.5	7.8	6.0	5.5	5.1	11.4	58.3	24.4	20.0	20.4	15.5	28.4
Substance	21.7	16.7	6.7	8.4	9.2	9.2	50.0	38.4	21.7	25.0	24.2	27.5
Torp	28.9	8.9	7.8	7.7	6.8	12.7	55.0	27.5	22.2	18.7	17.8	30.9
Average	19.7	8.2	5.3	5.5	6.6	9.5	44.7	23.6	16.2	17.0	17.6	24.8
No. of trials	2						2					

Cultivars	% control, *Septoria*, leaf 1, GS 73-77						% control, *Septoria*, leaf 2, GS 73-77					
	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO
Mixture 1	16.9	55.6	74.3	71.3	66.6	44.7	43.7	46.2	72.5	70.3	66.8	48.5
Mixture 2	10.3	75.7	83.5	82.0	54.4	66.0	18.7	52.9	70.6	61.5	33.2	22.5
Mixture 3	21.2	73.3	75.7	77.1	61.6	47.4	42.5	54.9	62.4	58.8	50.6	40.4
Benchmark	19.5	60.0	69.2	71.8	74.1	41.8	58.3	58.2	65.7	65.1	73.4	51.4
Substance	21.7	23.3	69.4	61.5	57.8	57.8	50.0	23.3	56.7	50.0	51.7	45.0
Torp	28.9	69.4	73.2	73.5	76.6	56.1	55.0	50.0	59.7	66.1	67.6	43.9
Average	19.7	59.6	74.2	72.9	65.2	52.3	44.7	47.6	64.6	62.0	57.2	41.9
No. of trials	2						2					

Table 3. Control of *Septoria*, green leaf area and yield responses, 2 trials – 1 from Flakkebjerg and 1 from LMO with 6 winter wheat cultivars, using 5 different fungicide treatments (16350). (Continued).

Cultivars	% green area, leaf 2, GS 77						TGW (g)					
	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO
Mixture 1	6.9	40.9	40.0	33.4	31.7	25.0	41.7	44.3	46.2	46.2	42.9	44.5
Mixture 2	26.7	50.0	48.4	45.0	47.1	40.0	44.6	46.5	46.1	45.7	45.2	45.6
Mixture 3	0	31.7	45.9	38.4	36.7	14.2	44.1	45.4	46.1	46.0	45.5	45.2
Benchmark	0	8.4	18.4	25.0	21.7	0.0	46.6	46.8	47.0	46.3	45.9	44.9
Substance	0	25.0	35.0	37.5	38.4	24.2	42.1	44.5	46.1	46.5	45.9	45.9
Torp	1.7	22.5	31.7	36.7	29.2	6.7	42.9	44.0	44.7	45.3	45.3	45.9
Average	5.9	29.7	36.5	36.0	34.1	18.3	43.7	45.3	46.0	46.0	45.1	45.3
No. of trials	2						2					

Cultivars	Yield and increase hkg/ha						Net increase hkg/ha				
	Untr.	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO	0.75 Ceando / 0.75 Viverda + 0.75 Ultimate S	1.25 Viverda + 1.0 Ultimate S	0.5 Propulse / 0.5 Proline Xpert	1.0 Folpan / 0.75 Viverda + 0.75 Ultimate S / 0.5 Proline Xpert	CPO
Mixture 1	100.3	11.0	11.1	9.8	9.4	9.1	2.9	4.9	4.2	0.2	6.3
Mixture 2	106.2	3.5	2.7	5.3	5.7	4.8	-4.6	-3.5	-0.3	-3.5	2.0
Mixture 3	98.4	13.3	6.8	10.5	7.4	6.1	5.2	0.6	4.9	-1.8	3.3
Benchmark	103.1	8.2	9.1	9.3	7.5	7.3	0.1	2.9	3.7	-1.7	3.2
Substance	86.4	19.5	13.2	24.7	26.2	21.7	11.4	7.0	19.1	17.0	17.4
Torp	97.3	7.8	5.5	14.0	11.6	9.8	-0.3	-0.7	8.4	2.4	7.0
Average	44.6	10.5 a	8.0 a	12.2 a	11.3 a	9.8 a	2.5	1.8	6.7	2.1	6.5
No. of trials	2	2	2	2	2	2	2	2	2	2	2

Untr. = Untreated; 0.75 l/ha Ceando GS 37-39 and 0.75 l/ha Viverda + 0.75 l/ha Ultimate S GS 55 (costs = 8.1; 1.25 l/ha Viverda + 1.0 l/ha Ultimate S GS 39-45 (costs = 6.3 hkg/ha); 0.5 l/ha Propulse GS 37-39 and 0.5 Proline Xpert GS 55 (costs = 5.6 hkg/ha); 1.0 l/ha Folpan 500 GS 31-32 and 0.75 l/ha Viverda + 0.75 l/ha Ultimate S GS 37-39 and 0.5 l/ha Proline Xpert GS 55 (costs = 9.2 hkg/ha); CPO = Crop Protection Online.

Control strategies in different winter barley cultivars

In 4 winter barley cultivars 5 different control strategies including control and crop protection were tested. One trial was placed at Flakkebjerg and one at LMO - Jutland. The treatments given below were tested in the two trials. The treatments recommended with Crop Protection Online are given in Table 4, and results from the two trials are collected in Table 5. All treatments showed a marginal yield response and no or very low net yield results.

1. Untreated
2. 0.33 l/ha Prosaro EC 250/0.5 l/ha Viverda + 0.5 l/ha Ultimate S (GS 32 + GS 51)
3. 0.75 l/ha Viverda + 0.75 l/ha Ultimate S (GS 37-39)
4. 0.33 l/ha Prosaro 250EC/0.33 l/ha Propulse EC 250 (GS 32 + GS 51)
5. Crop Protection Online

Table 4. Treatments applied following recommendations from Crop Protection Online. 16351-1 and 16351-2.

Cultivars (16351-1)	Date and GS	Products	TFI	Costs hkg/ha
Frigg	04-05-2016 (GS 32)	Comet 0.15 + 0.1 Proline EC 250	0.15 + 0.12	1.8
Wootan	04-05-2016 (GS 32) 25-05-2016 (GS 59)	Comet 0.15 + 0.1 Proline EC 250 Bell 0.5	0.15 + 0.12 0.6	4.7
Matros	04-05-2016 (GS 32)	Comet 0.15 + 0.1 Proline EC 250	0.15 + 0.12	1.8
KWS Meridan	04-05-2016 (GS 32)	Comet 0.15 + 0.1 Proline EC 250	0.15 + 0.12	1.8

Cultivars (16351-2)	Date and GS	Products	TFI	Costs hkg/ha
Frigg	12-05-2016 (GS 39)	0.21 Comet + 0.18 Proline EC 250	0.21 + 0.22	2.4
Wootan	-	-	-	-
Matros	-	-	-	-
KWS Meridan	-	-	-	-

Table 5. Control of diseases in winter barley and yield responses from 2 trials in 4 winter barley cultivars using 4 different strategies.

Cultivars	% brown rust, leaf 2, GS 71					% *Rhynchosporium*, leaf 2-3, GS 71-73				
	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO
Frigg	0.1	0	0	0	0	18.9	4.2	3.1	1.0	6.2
Wootan	13.0	0	0	0	3.5	0.4	0	0.2	0	1.8
Matros	2.2	0	0	0	0	0.5	1.0	0	0	0.5
KWS Meridan	3.5	0	0	0.1	2.1	3.9	1.0	3.0	4.6	6.7
Average	4.7	0	0	0	1.4	5.9	3.1	3.2	2.8	3.8

Cultivars 16351-2	% mildew, leaf 2-3, GS 71					% *Ramularia*, leaf 2, GS 83				
	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO
Frigg	0	0	0	0	0	13.3	5.0	13.3	8.3	11.7
Wootan	1.7	0	0	0	1.7	0	0	0	0	0
Matros	2.7	0.3	0.4	0	3.3	20.0	20.0	20.0	20.0	13.3
KWS Meridan	0.1	0	0	0	0.7	6.7	5.0	1.7	3.3	6.7
Average	1.1	0.1	0.1	0	1.4	10.0	7.5	8.8	7.9	7.9

Cultivars	Yield and increase hkg/ha					Net increase hkg/ha				TGW				
	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO	Untr.	0.33 Prosaro / 0.5 Viverda + 0.5 Ultimate S	0.75 Viverda + 0.75 Ultimate S	0.33 Prosaro / 0.33 Propulse	CPO
Frigg	74.1	3.7	3.1	3.7	1.8	1.1	-1.0	-0.2	-0.3	45.9	48.1	46.5	46.9	46.8
Wootan	74.3	7.2	6.1	5.8	8.0	2.4	2.0	1.9	5.6	38.0	38.9	39.8	39.3	38.5
Matros	72.4	4.0	1.4	6.7	2.4	-0.8	-2.7	2.8	1.5	46.3	49.3	48.5	49.5	46.6
KWS Meridan	74.1	2.3	1.3	3.0	-1.2	-2.8	-2.8	-0.9	-2.1	45.3	47.4	44.3	46.3	44.4
Average	73.7	4.3 a	3.0 a	4.8 a	2.8 a	0.1	-1.1	0.9	0.2	43.9	45.9	44.8	45.5	44.1

Untr. = Untreated; 0.33 Prosaro GS 32 and 0.5 Viverda + 0.5 Ultimate GS 51 (costs = 4.8 hkg/ha); 0.75 Viverda + 0.75 Ultimate S GS 37-39 (costs = 4.1 hkg/ha); 0.33 Prosaro 250EC GS 32 and 0.33 Propulse GS 51 (costs = 3.9 hkg/ha); CPO = Crop Protection Online.

Control of strategies in different spring barley cultivars

In 5 spring barley cultivars 5 different control strategies including control and Crop Protection Online (CPO) were tested. One trial was sited at Flakkebjerg and one at LMO - Jutland. The treatments given below were tested in the two trials and Crop Protection Online according to data in Table 6. Results from the two trials are given in Table 7.

1. Untreated
2. 0.25 l/ha Prosaro EC 250/0.5 l/ha Viverda + 0.5 Ultimate S (GS 31 + GS 51)
3. 0.75 l/ha Viverda + 0.75 l/ha Ultimate S (GS 37-49)
4. 0.5 l/ha Propulse EC 250 (GS 37-49)
5. Crop Protection Online (CPO)

Table 6. Treatments applied following recommendations from Crop Protection Online. 16352-1 and 16352-2.

Cultivars 16352-1	Date and GS	Products l/ha	TFI	Costs hkg/ha
Propino	25-05-2016 (GS 31)	0.25 Orius SW	0.2	1.1
Cultivar mixture	-	-	-	-
Evergreen	-	-	-	-
Chapeau	-	-	-	-
Quench	21-06-2016 (GS 55)	0.16 Comet + 0.16 Prosaro	0.16 + 0.18	1.9

Cultivars 16352-2	Date and GS	Products l/ha	TFI	Costs hkg/ha
Propino	-	-	-	-
Cultivar mixture	-	-	-	-
Evergreen	28-06-2016 (GS 65)	0.48 Viverda	0.5	2.7
Chapeau	28-06-2016 (GS 65)	0.57 Viverda	0.6	3.0
Quench	28-06-2016 (GS 65)	0.57 Viverda	0.6	3.0
Costs: 0.25 l/ha Prosaro GS 31 + 0.5 l/ha Viverda + 0.5 l/ha Ultimate S GS 51 GS 51= 4.5 hkg/ha; costs: 0.75 l/ha Viverda + 0.75 l/ha Ultimate S GS 31-37 = 4.1 hkg/ha; costs: 0.5 l/ha Propulse GS 37-49 = 2.7 l/ha hkg/ha; CPO = Crop Protection Online.				

Table 7. Control of diseases in spring barley and yield responses from 2 trials in 5 different spring barley cultivars using 4 different strategies. Untr. = Untreated. CPO = Crop Protection Online (16352).

Cultivars	% brown rust, leaf 2-3, GS 71/75					% brown rust, leaf 2-3, GS 77				
	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO
Propino	19.4	3.1	2.0	3.9	10.0	20.0	10.0	2.7	8.3	16.7
Cultivar mixture	20.8	2.3	1.0	4.6	8.8	25.0	8.3	1.2	4.7	21.0
Evergreen	14.0	2.8	0.1	0.7	11.0	8.0	1.3	0.1	0.2	5.0
Chapeau	21.7	3.6	0.5	3.2	21.7	9.3	3.7	0.3	0.5	2.3
Quench	18.0	4.7	0.2	2.5	13.0	9.3	2.3	1.9	0.7	6.0
Average	18.8	3.3	0.8	3.0	12.9	14.3	5.1	1.2	2.9	10.2
No. of trials	2					1				

Cultivars	% net blotch, leaf 2-4, GS 71/75					% *Ramularia*, leaf 2-3, GS 77/85				
	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO
Propino	8.0	12.7	4.7	3.1	10.5	37.0	29.2	16.4	23.9	29.7
Cultivar mixture	16.7	6.9	0.7	1.3	12.7	35.0	30.0	14.2	24.7	31.7
Evergreen	14.2	6.5	0.3	0.4	14.4	26.7	13.0	4.3	3.2	19.2
Chapeau	34.2	16.8	1.6	4.0	22.5	21.7	14.7	6.5	11.0	18.3
Quench	10.7	7.3	0.2	1.2	8.7	28.4	16.4	8.9	8.4	22.5
Average	16.8	10.0	1.5	2.0	13.8	29.8	20.7	10.1	14.2	24.3
No. of trials	2					2				

Cultivars	GLA %					TGW g/1000				
	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO
Propino	36.7	58.3	61.7	55.0	6.7	47.7	49.7	50.3	47.3	47.4
Cultivar mixture	28.3	61.7	61.7	48.3	31.7	45.6	46.1	46.9	45.4	46.4
Evergreen	36.7	58.3	56.7	60.0	40.0	45.9	46.4	46.8	48.5	46.4
Chapeau	46.7	75.0	68.3	70.0	53.3	48.7	47.7	48.6	49.1	40.7
Quench	40.0	65.0	70.0	60.0	61.7	44.7	45.3	38.5	47.0	46.9
Average	37.7	63.7	63.7	58.7	48.7	46.5	47.0	46.2	47.5	45.6
No. of trials	1					2				

Cultivars	Yield and increase hkg/ha					Net increase hkg/ha			
	Untr.	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO	0.25 Prosaro 0.5 Viverda 0.5 Ultimate S	0.75 Viverda 0.75 Ultimate S	0.5 Propulse	CPO
Propino	62.4	2.6	4.7	2.9	-2.4	-2.0	0.6	0.1	-3.0
Cultivar mixture	62.4	6.7	7.7	3.0	1.1	2.1	3.6	0.2	1.1
Evergreen	63.8	3.3	2.9	3.3	0.5	-1.3	-1.2	0.5	-0.9
Chapeau	63.1	2.9	6.6	8.3	7.6	-1.7	2.5	5.5	6.1
Quench	63.4	3.7	6.7	9.1	6.6	-0.9	2.6	6.34	4.1
Average	63.0	3.8 ab	5.7 a	5.3 a	2.7 b	-1.5	1.6	2.6	1.9
No. of trials	2					2			
LSD_{95} = 3.5									

IV Disease control in grass seed crops

Lise Nistrup Jørgensen, Julian Rodriguez Algaba & Birte Boelt

Control of stem rust/leaf rust in common ryegrass (trial no. 1304)

As part of a GUDP project, trials were carried out in common ryegrass to investigate the impact from stem rust (*Puccinia graminis*) on yield and crop development. The protocol included two cultivars Esquire and Calibra in the trials and two ways of establishment using either an undersown crop in spring barley (A) or direct sowing in the late summer (B). In 2016 the directly sown crop was poorly established so this part of the trial was omitted. Results from the trial are shown in Tables 1 and 2.

From the end of May to the beginning of June a moderate attack of powdery mildew and leaf rust, respectively, was seen particularly in the cultivar Esquire, while only a minor attack of these two diseases were seen in Calibra. The crop was inoculated with stem rust on 20 and 23 May at the time of heading using spreader plants with stem rust, which were prepared in the greenhouse. A visible attack of stem rust appeared approximately 3 weeks after inoculation. In the beginning of July the attack of stem rust was very severe in Calibra, in which 75-95% of heads were infested with stem rust. The attack in Esquire was more moderate, and only 20% of the heads were infested at the end of the season.

Fungicides were applied at 3 timings (6 May, 25 May and 16 June). Plots were treated either twice (1^{st} and 2^{nd}) or three times (1^{st}, 2^{nd} and 3^{rd}). At all treatments 0.75 l/ha Bell + 0.5 kg/ha Comet was used as these two products are seen as being a strong solution for control of rust diseases. All treatments initially provided good control of both leaf rust and stem rust. However, at the late assessment, it was clear that the late fungicide timing – 16 June – was important in order to keep down the level of infection in the heads. The good control of stem rust on the heads of Calibra in 2016 resulted in 137 kg extra yield, whereas the response was only 85 kg in Esquire, which was much less attacked. Three sprays also improved the green leaf area significantly compared with untreated and 2 sprays, as shown in the photos.

Table 1. Yield responses in common ryegrass in the cultivars Esquire and Calibra 1^{st} year crop. Data from 3 seasons.

Fungicide treatments		Seed yield kg/ha 2014		Seed yield kg/ha 2015		Seed yield kg/ha 2016	
		Esquire	Calibra	Esquire	Calibra	Esquire	Calibra
X.	Untreated	1798	2246	1831	2089	2079	1756
Y.	0.75 l/ha Bell + 0.5 kg/ha Comet 6-5-16 0.75 l/ha Bell + 0.5 kg/ha Comet 25-5-16 0.75 l/ha Bell + 0.5 kg/ha Comet 16-6-16	1957	2437	2037	2522	2013	2488
Z.	0.75 l/ha Bell + 0.5 kg/ha Comet 6-5-16 0.75 l/ha Bell + 0.5 kg/ha Comet 25-5-16	2038	2556	2008	2233	1928	2351

	Sowing method	Fungicide treatments	Yield kg/ha 2014	Yield kg/ha 2015	Yield kg/ha 2016	Average
1.	A	X	2319	2161	1756	2079
2.	A	Y	2513	2539	2488	2513
3.	A	Z	2593	2349	2351	2431
4.	B	X	2172	2017	-	2094
5.	B	Y	2361	2505	-	2433
6.	B	Z	2518	2118	-	2318
Average			2413	2281	2198	2311

Table 2. Control of diseases in common ryegrass. Esquire and Calibra (1st year crops). Average infection following two sowing methods (undersown and direct sowing).

Esquire										
	Sowing method	Disease control	% mildew	% leaf rust		% stem rust		% stem rust	% green leaf area	% ears with stem rust
			25-05	25-05	14-06	ears 14-06	leaf 14-06	ears 03-07	leaf 03-07	ears 05-07
1.	A	X	1.0	2.5	50.0	1.8	0.5	28	3	15
2.	A	Y	0.0	0	0.2	0.0	0.0	0	85	1
3.	A	Z	0.0	0	2.3	0.8	0.0	15	13	14

Calibra										
	Sowing method	Disease control	% mildew	% leaf rust		% stem rust		% stem rust	% green leaf area	% ears with stem rust
			25-05	25-05	14-06	ears 14-06	leaf 14-06	ears 03-07	leaf 03-07	ears 05-07
1.	A	X	0.3	0.5	20.0	11.3	7.0	95	5	75
2.	A	Y	0.0	0.0	0.1	0.0	0.0	0	93	4
3.	A	Z	0.0	0.0	1.0	0.8	0.4	85	28	99

Inoculation with stem rust in the field. The plots were ”painted” with spreader plants infected with stem rust. Symptoms appeared approx. 3 weeks after inoculation.

Ears infected with stem rust. Lesions are lifting the epidermis and many spores are coming out. Attack on heads results in poor seed development, early ripening and seed loss.

Calibra – 3 fungicide applications.

Untreated Calibra with stem rust.

Plants of Calibra with different disease control strategies. Untreated to the left, 3 times fungicide application in the middle and 2 times fungicide applications to the right.

Semi-field trial with control of stem rust

In spring common ryegrass plants of the cultivar Calibra were dug up, planted in pots and placed in the semi-field area. Plants were fertilised with a minimum of nitrogen to keep down the leaf area. Plants were growth regulated with Moddus, which helped to stunt the growth of the plants and keep them upright. The plants in the pots were inoculated with stem rust at GS 45 just before heading and covered with black plastic for two days to ensure good humidity. Plants were sprayed either 5 or 3 days before inoculation, the same day as inoculation or 4 and 10 days after inoculation. Five different fungicides were tested using full and half rates. Each treatment was replicated 4 times. The pots were sprayed with a self-propelled sprayer, and the pots were placed on a grass strip on a row during treatment. Results are shown in Table 3 and Figure 1.

Treatments generally gave good control of stem rust, which developed nicely on the heads of the plants in the pots. The number of attacked heads per pot was counted. All treatments provided high levels of control. Treatments 5 and 3 days before inoculation with Folicur generally gave the lowest effect along with Aproach used 4 and 10 DAI. Using full rates, only 3 of the products gave reliable results. Generally strobilurins and DMIs gave quite similar control.

Table 3. Number per pot of attacked heads with stem rust. The trial had 5 different timings using half rate of 5 fungicides: 2 days before inoculation (5 and 3), at the day of inoculation and 2 days after inoculation (4 and 10).

Fungicides, l/ha	5 DBI	3 DBI	Day 0	4 DAI	10 DAI	Untreated
Viverda 0.75	2.4	3.9	0.0	1.4	3.8	31
Folicur 0.5	10.7	6.4	2.3	1.4	5.4	
Comet 0.5	2.1	4.3	0.0	0.9	10.9	
Aproach 0.5	12.5	4.7	2.7	8.9	14.9	
Amistar 0.5	8.4	4.5	1.9	5.3	8.0	

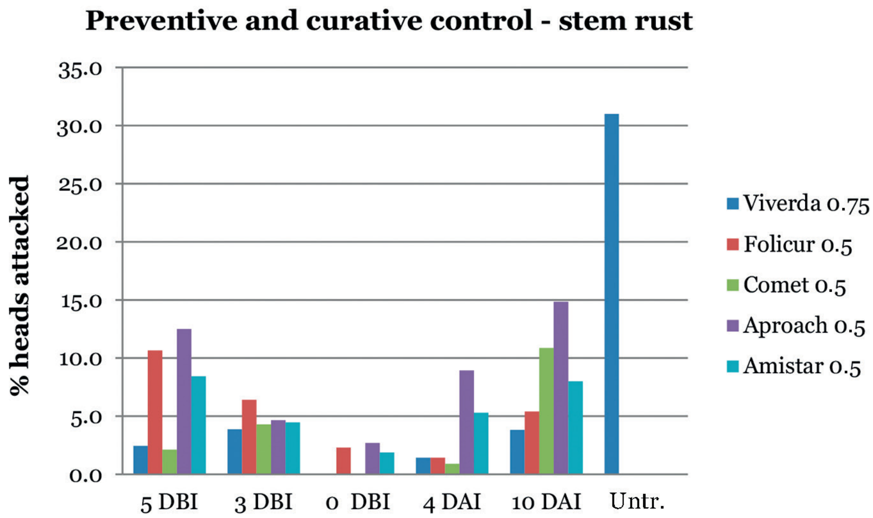


Figure 1. Effect of timing on efficacy of 5 fungicides tested at half rates.

V Disease control in sugar beet

Lise Nistrup Jørgensen, Rose Kristoffersen, Helene Saltoft Kristjansen, Sidsel Kirkegaard & Anders Almskou-Dahlgaard

Control of powdery mildew, rust and ramularia leaf spot

Two field trials were carried out in 2016 in sugar beet in order to test the efficacy of different fungicides. The trials were sited at Aarhus University (AU) Flakkebjerg and the cultivar Fairway was used. Products for which high efficacy against beet rust was expected were compared. The rate of each product was split into two applications, carried out on 25 July and 26 August. Rust was the first disease to appear in the field and the initial application was carried out when the first symptoms were detected. All treatments provided significant reduction of the leaf diseases present (Table 1 and Figure 1). Clear differences were observed between products and also between rates. Regarding control of rust Comet at full rate was superior to other products but half rate of Comet, Opera and Armure also provided good and very similar control. 0.5 l/ha Acanto, 0.25 l/ha Bumper 25 EC and 0.25 l/ha Rubric were least effective in controlling rust. The ranking of the products is shown in Figure 1. From mid-September significant attacks of mildew developed. For control of this disease Comet was superior as well followed by Opera and Armure. Ramularia leaf blotch developed late and the efficacy of the products ranked equal to the other diseases. At the time of the last assessment, plants treated with Comet had a more upright growth and looked healthier than other treatments.

The trial was harvested in November. During harvest the yield was measured in beets from 2 rows per plot and adjusted for content of soil. Samples from each treatment were analysed for sugar content. Yields increased significantly from most treatments varying between 2.3 and 10 t/ha. The better yields were linked to the treatments that provided best disease control (Figure 2).

Table 1. Effects of different fungicides on leaf diseases in sugar beet as well as yield responses following 2 applications. 1 trial (16391-1).

Treatments l/ha		% beet rust			% beet mildew		% *Ramularia*	Yield and increase	Sugar yield
		31-08	14-09	28-09	14-09	28-09	28-09	t/ha	t/ha
1.	Untreated	10.3	10.8	28.8	5.3	25.0	15.0	88.9	16.8
2.	Opera 2 x 0.25	2.8	9.8	20.8	3.0	13.0	9.5	+9.8	19.2
3.	Opera 2 x 0.5	0.7	4.5	13.5	1.1	11.0	5.8	+9.5	19.0
4.	Rubric 2 x 0.25	3.8	8.0	23.8	3.0	18.8	12.8	+2.6	17.2
5.	Rubric 2 x 0.5	2.8	7.3	19.3	2.0	13.5	9.5	+3.9	17.7
6.	Comet 2 x 1.0	0.4	1.6	6.3	0.8	6.5	2.5	+8.4	18.8
7.	Comet 2 x 0.5	0.5	3.8	11.0	1.0	10.3	4.0	+6.6	18.2
8.	Armure EC 2 x 0.3	0.9	5.3	11.8	1.6	11.0	6.8	+10.6	19.0
9.	Acanto 2 x 0.5	2.8	10.8	25.0	3.8	18.8	12.3	+5.0	18.1
10.	Bumper 25 EC 2 x 0.25	6.5	9.5	22.5	4.0	17.5	13.3	+2.3	17.5
LSD_{95}		1.8	3.5	4.8	2.1	5.1	2.3	4.0	0.8

Untreated crop with attack of mildew, rust and *Ramularia*.

Crop treated with double treatments of 1.0 l/ha Comet.

Rust and mildew in sugar beet. Photo from drone (Nov.), when clear differences between treatments were still visible. (Photo: Uffe Pilegård Larsen).

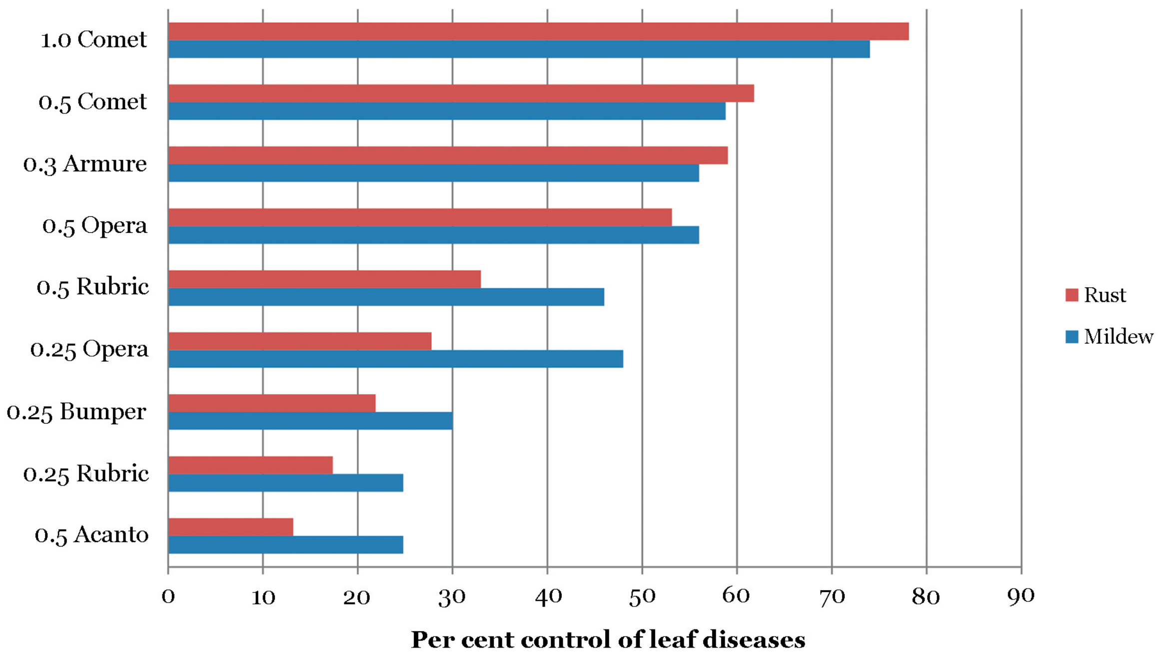


Figure 1. Relative control of rust and mildew in sugar beet following 2 treatments with different fungicides.

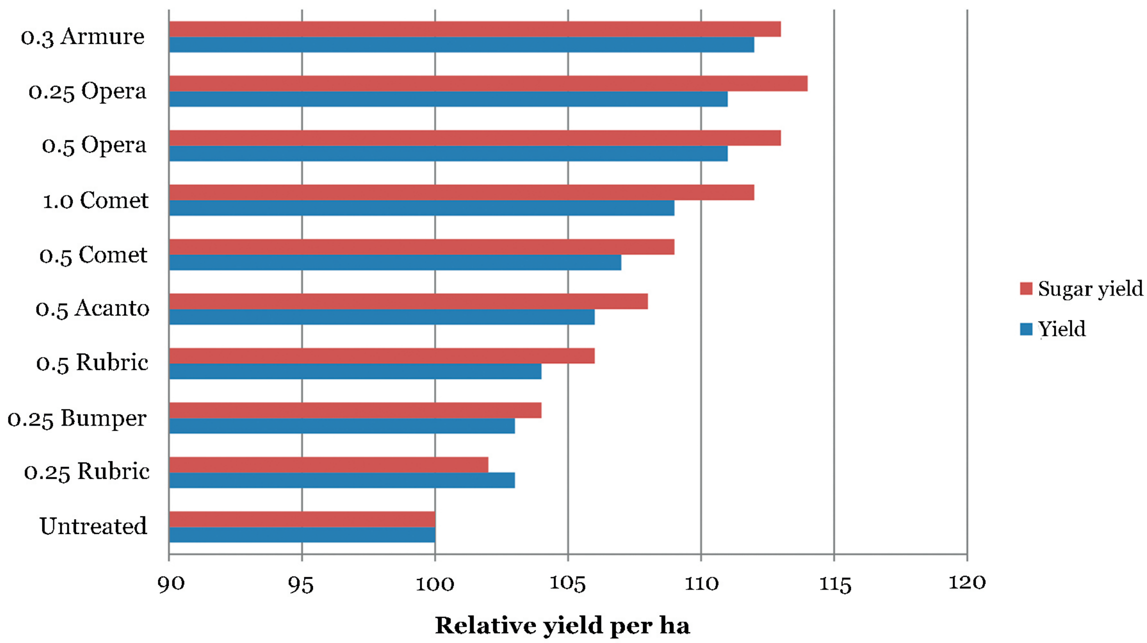


Figure 2. Relative yield of sugar beet roots measured in total and relative sugar yield.

In a second trial different treatments were compared. The standard treatments from the trial are shown in Table 2. Both Propulse and Opera provided good control of all 3 diseases. A slight dose response effect was measured for Propulse. Full rate of Propulse and Opera both provided significant yield increases, and an increase in sugar content was measured from treated plots.

Table 2. Effects of different fungicides on powdery mildew and rust in sugar beet as well as yield responses following 2 applications. 1 trial (16390-1).

Treatments, l/ha	% rust			% mildew		% *Ramularia*	Yield and increase	Sugar yield
Date	15-08	31-08	14-09	31-08	14-09	14-09	t/ha	t/ha
1. Untreated	1.4	9.0	9.5	2.3	15.0	5.8	94.1	16.4
2. Propulse 1.2	0.4	2.0	1.8	0.2	0.3	0.6	+8.1	18.4
3. Propulse 1.0	0.4	2.3	5.0	0.2	1.6	1.8	+5.4	17.5
4. Opera 1.0	0.4	0.8	1.3	0.0	0.7	0.7	+9.0	18.5
LSD_{95}	0.4	1.9	2.7	0.9	3.6	1.5	5.6	1.0

Powdery mildew in beet.

Rust in beet.

An additional greenhouse trial was conducted to test fungicide efficacy of both existing systemic products and new products that might have an effect against beet rust. The experiment was artificially inoculated with fresh rust spores collected from the field in late August. The cultivar used was Fairway as in the field trials. Products were tested for their preventive and curative effect and treatments were carried out on either 22 August or 30 August.

All products containing systemic fungicides reduced rust significantly (Table 3). Comet Pro reduced rust level the most as in the field trial, but was not significantly different from the other systemic products. For the possible resistance inducers Serenade had some effect when used preventively and hydrogen peroxide exhibited no or very little control.

Table 3. Efficacy of different fungicides as preventive or curative treatment against beet rust in sugar beet. Greenhouse experiment.

	Preventive treatment		Curative treatment	
Treatments, l/ha	Rust pustules/leaf	Significance letter	Rust pustules/leaf	Significance letter
1. Untreated	122.4	b	122.4	b
2. Comet Pro 1.25	0.0	a	0.1	a
3. Opera 1.0	0.2	a	6.4	a
4. Rubric 1.0	1.7	a	0.1	a
5. Armure 0.6	7.1	a	1.4	a
6. Serenade 6.0	29.1	b	131.1	b
7. Hydrogen peroxide 2.0	150.9	b	72.2	b

VI Disease control in grain maize

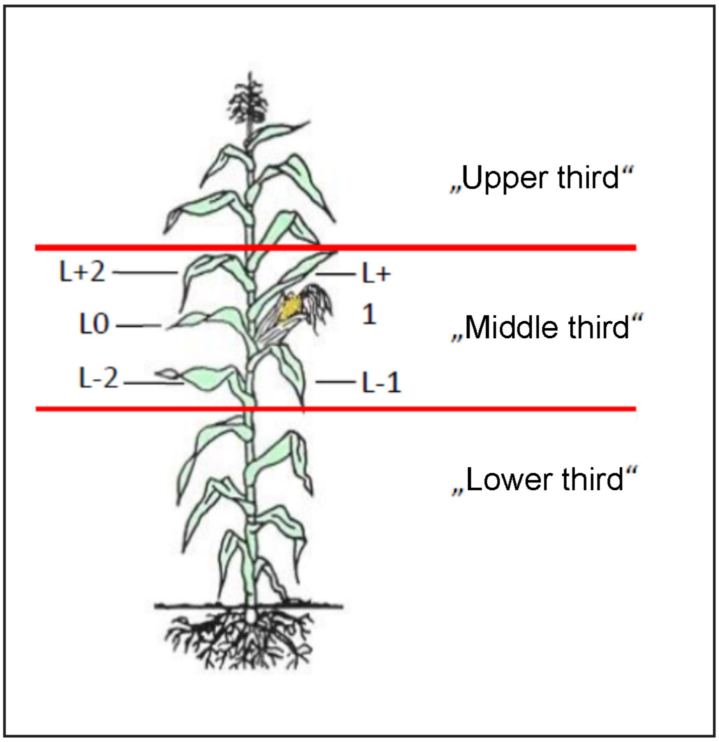
Lise Nistrup Jørgensen, Hans-Peter Madsen, Helene Saltoft Kristjansen, Sidsel Kirkegaard & Anders Almskou-Dahlgaard

Control of eye spot (*Kabatiella zeae*) in maize
Three trials were carried out in grain maize during 2016 testing the efficacy of different fungicides regarding control of leaf diseases. All trials were sited in fields with debris from maize and previous crop being maize for several years. Depending on the specific trial different timings were tested, varying from GS 37 to GS 65.

All trials were irrigated 2 weeks after sowing and this was repeated several times in June. Precipitation in late June and the first period of July was rather high, and even though August was dry the following precipitation in early September gave rise to an attack of *Kabatiella zeae* eye spot, which increased during the season.

Humidity model in maize
As a part of a project, Aarhus University (AU) Flakkebjerg and SEGES cooperated in testing a new German humidity model, together with Prof. Verreet from Kiel University. The model calculates the risk of attack of *Kabatielle zeae* based on local meteorological data together with an assessment of disease attack of L0 (Figure 1).

Previous crop, tillage, humidity and temperature are all parameters that influence the risk of attack of *Kabatiella zeae* in maize. Five fields with maize were picked in Jutland by SEGES and visited regulary from GS 32 to harvest by technicians from AU. The trial at Flakkebjerg was also included in the risk assessments as a high risk field with maize after maize and minimal tillage.



Maize diseases are assessed according to the drawing. Plants are divided into 3 sections and the middle section is further divided into specific leaf layers. L0 is used as indicator leaf for attack in the humidity model, which was tested in 2016.

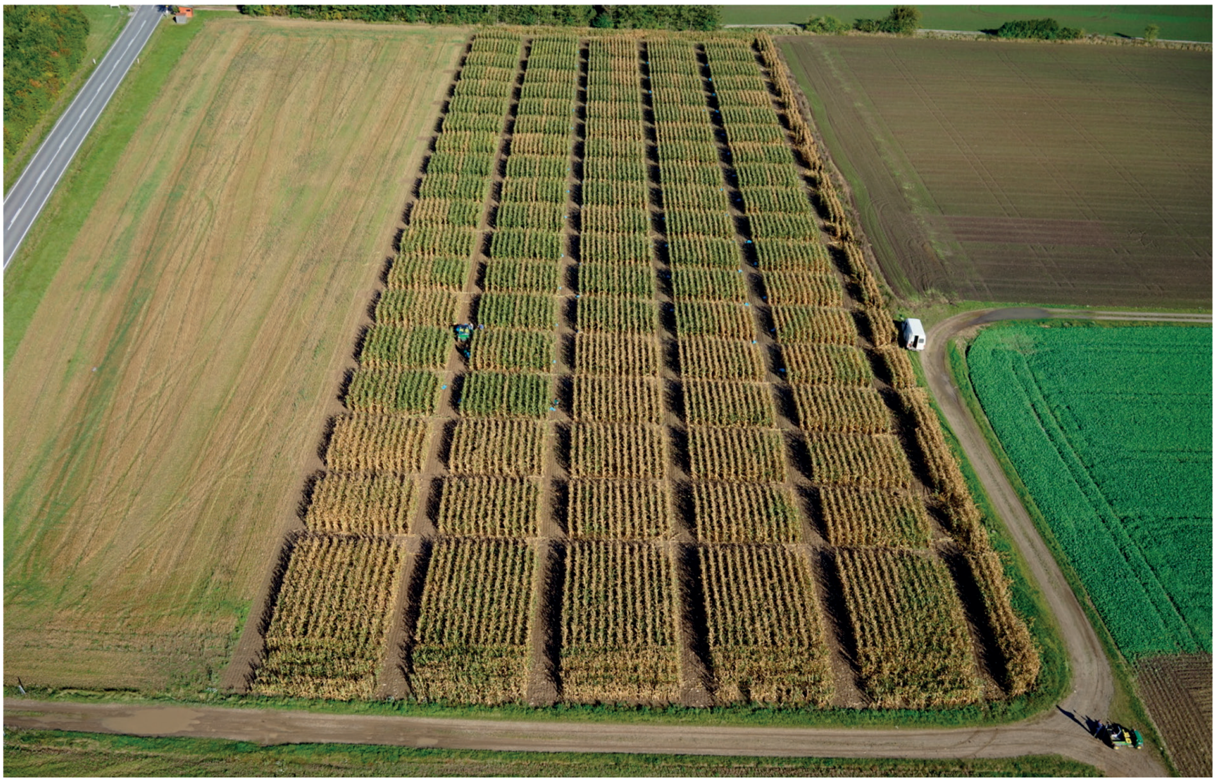


Photo from the maize field shows untreated plots at the front and different treatments behind. The green leaf area was significantly influenced by the different fungicide treatments. (Photo: Uffe Pilegaard Larsen).

In order to predict the risk of attack, weather data from local weather stations were recorded on a daily basis. That which generates the need for treatment is according to the model a combination of presence of *Kabatiella zeae* (60% leaves at the cob attacked by disease) together with a weather event at which the relative humidity reaches a level above 85% over a period of more than 36 hours. Weekly assessments were carried out on 100 plants in each trial to monitor disease events on the leaves of the main cob. The specifically same plants were assessed weekly. In all trials the model generated a need for treatment in the period from 22 July to 6 August. Treatment selected for all locations: 0.75 l/ha Opera (Table 1).

Comet Pro as a maize fungicide

In two trials Comet Pro was tested for its efficacy applied at two different timings. The product performed quite poorly when applied at the late timing (GS 65) (Table 2). Best control was achieved when treatments were applied at the early timing (GS 37) and the yield increases were also significantly improved when treatments were applied at this early timing. Yield increases reflected a clear dose response at both timings. Double treatments with Opera gave the best control and yield response.

Table 1. Effects of treatment according to standard treatment and climate model on eyespot in grain maize as well as yield responses following different applications applied at GS 65. Treatment 5 is treated twice (GS 37 & 65). (1 trial at AU Flakkebjerg, 16376-1.)

Treatments, l/ha	% eye spot			Weight of cob	Yield and increase
GS 65	GS 71 Above cob 10-08	GS 79 Cob leaf 09-09	GS 85 Cob leaf 23-09	g	hkg/ha
1. Untreated	10.0	13.9	18.3	188.7	66.7
2. Comet Pro 0.5 GS 65	9.5	9.0	12.8	204	3.9
3. Comet Pro 1.0 GS 65	7.5	7.8	10.8	202	9.0
4. Comet Pro 1.25 GS 65	8.1	9.3	13.3	196	10.5
5. Opera 0.75 GS 37 (15-07) + 65 (01-08)	5.4	4.0	5.6	215.1	13.4
6. Climate model 22-07	10	9.8	11.8	206.5	5.5
No. of trials	1	1	1	1	1
LSD_{95}	NS	7.5	8.0	NS	7.9
NS = not significant					

Table 2. Effects of treatment according to standard treatment on eye spot in grain maize as well as yield responses following different applications applied at GS 37. (1 trial at AU Flakkebjerg, 16375-1).

Treatments, l/ha		% eye spot			Weight of cob	Yield and increase
GS 37	GS 75 Above cob 26-08	GS 79 Cob leaf 09-09	GS 85 Cob leaf 23-09	GS 85 Top leaves 26-09	g	hkg/ha
1. Untreated	10.3	5.6	9.0	57.5	272	74.5
2. Comet Pro 0.5	6.5	3.1	3.5	40.0	290	11.0
3. Comet Pro 1.0	6.5	3.1	5.8	33.0	291	12.6
4. Comet Pro 1.25	6.5	2.8	3.3	21.3	294	15.2
LSD_{95}	NS	3.1	3.5	14.1	NS	6.7
NS = not significant						


Photo from untreated in early October to the left and plants from double treatments with 0.75 l/ha. Opera to the right.

The photos show attack of eye spot in early August and late September at AU Flakkebjerg. In general the maize at the locations in Jutland was very healthy and had only a minor attack of *Kabatiella zeae* and did not respond positively to fungicide treatments.

VII Fungicide resistance-related investigations

Thies Heick, Lise Nistrup Jørgensen, Hanne-Birgitte Christiansen & Birgitte Boyer Olsen

Triazole resistance of *Zymoseptoria tritici* in Denmark and Sweden

At Aarhus University Flakkebjerg, *Zymoseptoria tritici* (*Z. tritici*) isolates from Denmark and Sweden are *in vitro* tested for triazole resistance (epoxiconazole and prothioconazole) to survey potential shifts of resistance of the Northern European *Z. tritici* populations. For this purpose, wheat leaf samples around growth stage 73-77 showing symptoms of septoria leaf blotch are sent to Flakkebjerg and subsequently tested. Samples are collected in collaboration with SEGES, Jordbruksverket and local advisors. In 2016, a total of 220 Danish isolates from 24 localities and 212 Swedish isolates from 26 localities were investigated for sensitivity to both triazoles. The 50 localities were distributed throughout the two countries, and the aim was 10 isolates per locality.

The resistance tests were carried out according to the FRAC protocol for DMI sensitivity testing of *Z. tritici*. The single pycnidia isolates were used to produce spore suspensions by scarping off six-day-old *Z. tritici* spores and transferring them into demineralised water. Spore suspensions were homogenised and adjusted to a spore concentration of 2.4 x 10^4 spores ml^{-1}. Technical duplicates of each isolate were included in the study. Epoxiconazole and prothioconazole were mixed separately with 2 x potato dextrose broth (PDB) to obtain the following final microtitre plate fungicide concentrations (ppm): 10, 3.3, 1.0, 0.3, 0.1, 0.03, 0.01, 0 and 90, 30, 10, 3.3, 1.0, 0.3, 0.1, 0, respectively. A total of 100 µl of spore suspension and 100 µl of fungicide solution were added to 96-deep well microtitre plate. Microtitre plates were wrapped in tin foil and incubated at 20°C for six days in the dark. Plates were visually analysed in an Elisa reader at 620 nm. Fungicide sensitivities were calculated as the concentration of a fungicidal compound, at which fungal growth in vitro is inhibited by 50% (EC_{50}) by non-linear regression (curve fit) using GraphPad Prism (GraphPad software, La Jolla, CA, USA). Isolates IPO323 and OP15.1 were used as reference isolates.

Results - Denmark

The isolation of single pycnidia isolates from leaf samples from 2016 was challenging. Thus the aim of 10 isolates was not reached for all localities. The average EC_{50} values for both triazoles epoxiconazole and prothioconazole were significantly higher in 2016 compared to previous years (Figure 1). The average EC_{50} for epoxiconazole was 1.39 ppm (2015: 0.48 ppm) (Table 1). This increase can be explained by the high number of outliers; 77 isolates out of a total of 220 showed EC_{50} of > 1 ppm, seven isolates were above the test limit of 10 ppm. The average resistance factor (RF) for epoxiconazole, as compared to the reference isolate IPO 323, was 66, compared to 19 in the period 2011-2015. Isolates with high EC_{50} values were mainly found in Jutland and in Zealand; however, the disease pressure in other parts of the country such as Lolland/Falster was comparatively low in 2016 (Table 2). These results support for the first time the trend to more outliers in recent years and coincide with changes in mutations and ongoing decline in field efficacy of triazoles seen since 2008 (see chapter II Disease control in cereals).

Also for prothioconazole the average EC_{50} values were significantly higher than in 2015. As epoxiconazole and prothiconazole show cross resistance, the results for prothioconazole confirm the trend. The average EC_{50} for Danish isolates was 22.12 ppm (2015: 11.27 ppm). As for epoxiconazole resistance factors for prothioconazole vary greatly between localities, from 1 to 500, compared with the control isolate IPO323.

Table 1. Summary of measured EC_{50} (ppm) values and resistance factors (RF) for epoxiconazole and prothioconazole assessed for *Z. tritici* in Denmark. Total numbers of tested isolates are given in brackets. * indicates the years in which an additional concentration for prothioconazole (90 ppm) was introduced.

Year	EC_{50} epoxiconazole	RF	EC_{50} prothioconazole	RF
2005	0.12 (47)	2	-	
2006	0.57 (180)	10	-	
2007	0.77 (140)	13	-	
2008	0.17 (88)	3	-	
2009	0.70 (96)	12	0.70 (96)	7
2010	1.40 (54)	23	4.40 (54)	29
2011	1.33 (85)	22	11.20 (85)	74
2012	0.30 (40)	15	10.90 (40)	72
2013	0.36 (133)	18	11.70 (98)	78
2014	0.50 (290)	25	9.90 (290)*	66
2015	0.45 (262)	17	11.27 (192)*	75
2016	1.39 (220)	66	22.12 (145)*	124
Average wild type IPO323	0.02-0.03	1	0.15-0.30	1

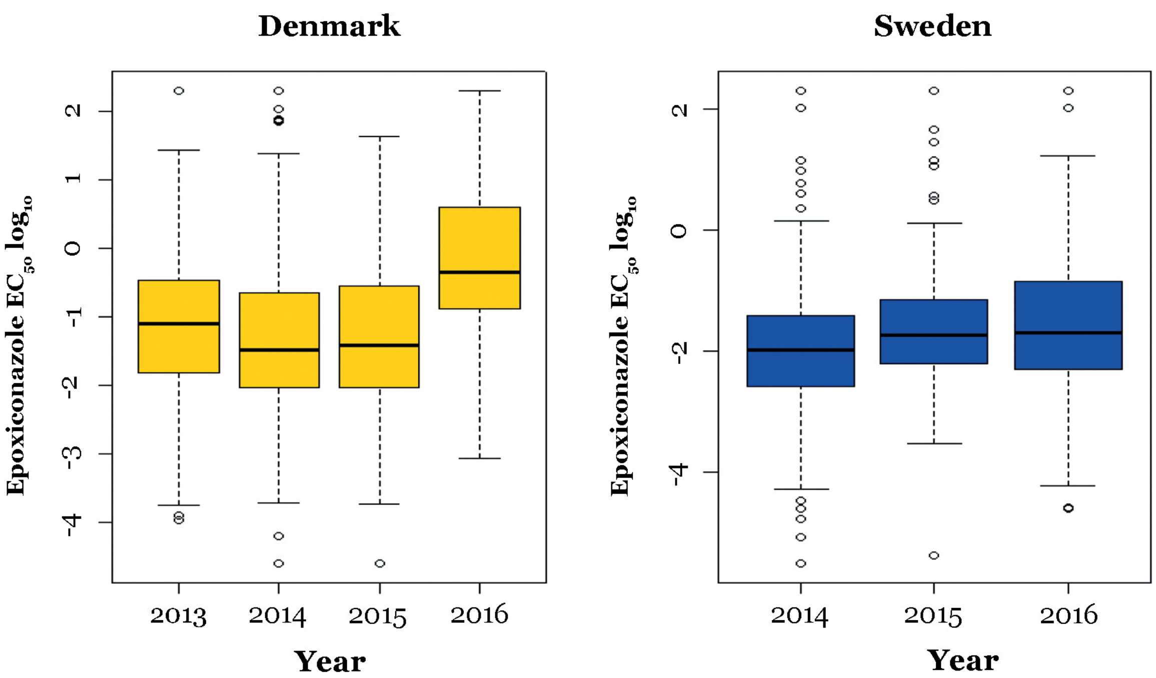


Figure 1. Box plot of EC_{50} (ppm) values for epoxiconazole (logit transformed) for *Z. tritici* in Denmark and Sweden. Danish EC_{50} values were significantly higher in 2016 than in the years 2013-2015, indicating a sudden shift in sensitivity towards epoxiconazole. Swedish EC_{50} values for 2016 were significantly higher compared to 2014; the development in Sweden appears to be more gradual than in Denmark.

Table 2. Results from single localities in Denmark with data from sensitivity testing for *Zymoseptoria tritici* screened on epoxiconazole and prothioconazole using approximately 10 isolates per locality.

Location		Number of isolates	Epoxiconazole		Prothioconazole	
			RF	Average	RF	
16-ST-DK-03	Flakkebjerg	3	0.44	21	12.74	72
16-ST-DK-04	Sorø	10	0.98	46	19.94	113
16-ST-DK-08	Brønderslev	10	2.48	117	25.40	144
16-ST-DK-09	Brønderslev	10	0.63	29	22.11	125
16-ST-DK-10	Åbenrå	9	2.24	108	23.33	132
16-ST-DK-11	Åbenrå	10	0.72	34	12.76	72
16-ST-DK-13	Nr. Åby, Funen	3	0.47	22	18.62	106
16-ST-DK-14	Sejet	2	0.57	27	16.81	95
16-ST-DK-16	Flakkebjerg	4	0.23	11	13.23	75
16-ST-DK-17	Flakkebjerg	2	0.30	14	12.74	72
16-ST-DK-18	Vissenbjerg	5	0.92	43	26.76	152
16-ST-DK-19	Ullerslev	8	1.32	62	23.01	130
16-ST-DK-23	Sorø	9	0.46	22	18.16	103
16-ST-DK-24	Sorø	10	0.81	38	20.92	119
16-ST-DK-26	Hjerm	10	2.57	121	22.76	129
16-ST-DK-27	Horsens	4	0.95	45	18.72	106
16-ST-DK-28	Flakkebjerg	4	0.76	36	26.71	151
16-ST-DK-29	Flakkebjerg	5	1.84	86	31.72	180
16-ST-DK-30	Flakkebjerg	2	1.13	53	20.92	119
16-ST-DK-32	Rønde	10	3.21	151	30.97	176
16-ST-DK-33	Rønde	10	4.49	212	41.20	233
16-ST-DK-35	Østermarie	5	3.31	156	27.17	154
16328-1	Flakkebjerg	34	0.94	44	-	-
16328-2	Horsens	41	1.50	71	-	-
Reference IPO323		-	*0.02*	-	*0.18*	-
Total		220	-	-	-	-
Average		-	1.39	65	22.12	125

Results - Sweden

In 2016, a gradual shift in sensitivity towards epoxiconazole and prothioconazole of *Z. tritici* was observed (Table 3), though not as pronounced as in Denmark. The average EC_{50} values for epoxiconazole and prothioconazole were 0.52 ppm and 12.31 ppm, respectively. Compared to results from 2014, EC_{50} values were significantly higher in 2016. More isolates with EC_{50} values above 1 ppm for epoxiconazole and 10 ppm for prothioconazole were detected in 2016. Results from 2016 confirmed the great variation in EC_{50} values in Sweden (Table 4); more sensitive isolates in the middle part of the country and less sensitive isolates in the south. These results might suggest the existence of two quite separate *Z. tritici* populations in Sweden.

Table 3. Summary of measured EC_{50} (ppm) values and resistance factors (RF) for epoxiconazole and prothioconazole assessed for *Z. tritici* in Sweden. Total numbers of tested isolates are given in brackets. * indicates the years in which an additional concentration for prothioconazole (90 ppm) was introduced.

Year	EC_{50} epoxiconazole	RF	EC_{50} prothioconazole	RF
2008	-		1.5 (55)	11
2009	-		3.6 (101)	24
2010	0.63 (131)	13	6.6 (131)	44
2011	1.00 (166)	16	7.8 (166)	52
2012	0.36 (211)	18	13.3 (211)	89
2013	0.65 (170)	33	19.0 (170)	63
2014	0.27 (337)	35	7.76 (337)*	89
2015	0.33 (227)	12	10.68 (225)*	70
2016	0.52 (212)	24	12.70 (173)*	72
Average wild type IPO323	0.02-0.03	1	0.15-0.30	1

Table 4. Results from single localities in Sweden with data from sensitivity testing for *Z. tritici* screened on epoxiconazole and prothioconazole using approximately 10 isolates per locality.

Location		Number of isolates	Epoxiconazole		Prothioconazole	
			RF	Average	RF	
16-ST-SW-01	Tierp	10	0.04	2	0.48	3
16-ST-SW-02	Hallfreda, Visby	10	0.01	5	1.57	9
16-ST-SW-03	Kråkerum, Mönsterås	10	1.24	58	16.24	92
16-ST-SW-04	Skänninge	10	2.11	99	9.76	55
16-ST-SW-05	Ödeshög	10	0.19	9	-	-
16-ST-SW-06	Sönderköping	10	0.12	5	-	-
16-ST-SW-07	Skänninge	10	0.18	8	-	-
16-ST-SW-08	Uppsala	4	0.72	34	-	-
16-ST-SW-09	Uppsala	5	0.24	11	-	-
16-ST-SW-10	Uppsala	10	0.11	5	4.37	25
16-ST-SW-11	Köping	8	0.21	10	17.59	100
16-ST-SW-12	Vesterås	10	0.21	10	8.26	47
16-ST-SW-13	Önnestad , Kristianstad	8	0.51	24	29.80	169
16-ST-SW-14	Gliminge, Simrishamn	9	0.64	30	19.00	108
16-ST-SW-15	Ingelstorp, Åstorp	10	0.97	46	11.37	64
16-ST-SW-16	Sandby gård, Borrby	6	0.57	25	11.62	66
16-ST-SW-17	Klagstorp 1	6	0.54	25	16.16	92
16-ST-SW-18	Klagstorp 2	4	0.35	16	20.83	118
16-ST-SW-19	Gislöv, Trelleborg	9	0.88	42	14.27	81
16-ST-SW-20	Ö. Vemmenhög	9	0.41	19	17.19	97
16-ST-SW-21	Ö. Vemmenhög	8	0.93	44	19.19	109
16-ST-SW-22	Kattarp; Helsingborg	10	0.30	14	10.85	61
16-ST-SW-23	Lundsbrunn	9	0.95	45	7.01	40
16-ST-SW-24	Grästorp	1	0.13	6	4.52	26
16-ST-SW-25	Skövde	9	0.42	20	11.77	67
16-ST-SW-26	Skara	7	0.40	19	14.90	84
Reference IPO323		-	*0.02*	-	*0.18*	-
Total		212	-	-	-	-
Average		-	0.52	24	12.70	72

CYP51 mutations in the *Z. tritici* populations in the Baltic region 2016

The decline of triazoles has been associated with molecular changes in the fungus (Cools & Fraaije, 2013). Among those changes, the main focus has been on mutations in the CYP51 target gene of the triazoles. In 2016, bulked leaf samples from diseased leaf samples from Denmark, Sweden, Norway, Latvia, Lithuania, Estonia and Northern Germany (Schleswig-Holstein) were analysed by pyrosequencing and qPCR (performed at BASF) for the frequency of the most important CYP51 mutations in Z. tritici: D134G, V136A/C, I381V and S524T (Table 5). As seen in previous years, mutation I381V was present throughout the region at frequencies of 90%-100%. The frequencies for mutations D134G, V136A/C and S524T, all of which have only recently emerged in the Northern European *Z. tritici* population, varied greatly. Those mutations are now found to a great extent (up to 68%) in Denmark, Southern Sweden, Northern Germany and Norway, but only in frequencies of 0%-21% in the Baltic region and Central Sweden, suggesting a west-east and perhaps a south-north gradient. Compared to previous years, a general trend towards higher frequencies of CYP51 mutations is seen, indicating that the rapid development of less triazole-sensitive *Z. tritici* strains in Northern Europe.

In addition, the presence of mutation G143A was investigated by qPCR; a mutation known to confer resistance to QoI fungicides. This mutation has been established at high levels for many years and continues to be present in Northern Europe. Results for this mutation indicate a gradient from west to east. The same samples were also analysed for SDHI mutations and fortunately none of the known mutations were found in samples from the Northern Zone.

From Denmark 10 different localities were specifically tested for their CYP51 mutations (Table 6). The data showed a major variation in the composition of mutations, which might reflect different control strategies applied in different fields.

Table 5. CYP51 mutation and G143A frequencies (%) in bulked *Z. tritici* samples from Denmark, Sweden, Norway, Northern Germany, Latvia, Lithuania and Estonia in 2016.

Baltic Sea Area 2016	CYP51					QoI
	D134G	V136A	V136C	I381V	S524T	G143A
Denmark - Southern Jutland	60%	68%	5%	100%	9%	98%
Denmark 2 - Northern Jutland	45%	53%	6%	96%	12%	97%
Denmark 3 - Eastern Denmark	36%	51%	7%	90%	7%	98%
Sweden (South)	49%	64%	5%	91%	12%	96%
Sweden (Central)	3%	11%	6%	96%	3%	85%
Norway	55%	49%	5%	97%	13%	99%
Lithuania	2%	9%	21%	100%	18%	79%
Latvia	1%	8%	10%	96%	2%	31%
Estonia	0%	15%	3%	99%	5%	43%
Northern Germany (Schleswig-Holstein)	51%	61%	7%	100%	19%	89%

Table 6. CYP51 mutation in *Z. tritici* samples from Danish localities collected in 2016.

Denmark 2016	CYP51 (%)				
	D134G	V136A	V136C	I381V	S524T
Askov	34%	49%	9%	91%	6%
Ålborg	44%	51%	7%	100%	6%
Rønde, Djursland	54%	48%	13%	100%	16%
Bornholm	3%	28%	29%	N.A.	29%
Ytteborg, Hjerm	42%	56%	3%	N.A.	38%
Vojens	55%	76%	8%	90%	12%
Tølløse	34%	46%	6%	92%	8%
Flakkebjerg	22%	39%	3%	90%	4%
Horsens	32%	53%	11%	98%	9%

N.A. = not available

Strobilurin resistance to net blotch

In 2016, a total of 20 samples with net blotch were investigated for the distribution of the QoI resistance mutation F129L. The samples were collected from field trials by AU Flakkebjerg, SEGES and Tystofte Foundation and originate mainly from untreated plots in field trials.

Similarly to previous years, the investigation for mutations was carried out by BASF. The data from 2016 showed that the level of F129 in the population of *Drechslera teres* is quite stable and not changing dramatically. F129L is known to be a mutation which only partly influences the field performances of strobilurins.

Data showed that F129L could be found in 55% of the tested Danish samples. Data from the last 9 years' monitoring are given in Table 7. The localities with resistance have been found in Zealand, Funen, Bornholm, Central Jutland and Northern Jutland. Field data from Flakkebjerg where the level of F129L is quite high have shown that the different strobilurins perform differently. Amistar has been seen to be more influenced by F129L than Comet and Aproach/Acanto. Although the number of positive samples is moderate, it can unfortunately not be verified which fields are affected with F129L mutations before treatments, so farmers generally have to go for the most effective products.

Table 7. Summing up of results from the strobilurin resistance investigation, F129L incidence in the net blotch fungus (*Drechslera teres*) in Denmark.

Year	No. of samples	No. without F129L	No. with 1-20%	No. with >20-61%	No. with >60%	% samples with F129L
2008	20	9	5	3	3	55
2009	44	18	7	13	6	59
2010	16	5	3	7	1	69
2011	34	13	4	12	5	62
2012	19	14	1	2	2	24
2013	25	17	2	4	2	32
2014	20	13	2	3	2	35
2015	8	3	0	3	0	38
2016	20	9	3	8	0	55

From Sweden 10 samples were investigated and F129L mutations were found in 2 of the 10 samples. A few samples from Estonia and Lithuania were also investigated; none of these samples showed signs of F129L.

References

Cools, H. J. and B. A. Fraaije (2013). Update on mechanisms of azole resistance in *Mycosphaerella graminicola* and implications for future control. Pest Management Science 69, 150-5.

VIII Testing different *Septoria* models (MS project)

Lise Nistrup Jørgensen, Anne-Marie Fejer Justesen, Thies Heick, Niels Matzen & Birgitte Boyer Frederiksen

In a project financed by Miljøstyrelsen (Danish EPA) new models for control of *Septoria* are being developed and tested. The decision support system Crop Protection Online (CPO) has for many years been recommending treatments for control of *Septoria* based on days with precipitation. Treatments are recommended if 4 days with rain (> 1 mm) have occurred starting at GS 32. If the crop has been treated, the crop is seen as protected for 10 days before a new risk period is initiated. A new model based on leaf wetness and periods with high relative humidity is being investigated as an alternative to the existing model along with a more complex growth model. In order to test the new models trials have been carried out at 3 localities in 2016. One trial was located at Flakkebjerg, one near Horsens (LMO) and one at Holeby (Lolland). Disease data from the trials are given in Table 1 and yield data in Table 3. The treatment using the complex growth model recommended an early treatment at all localities in April at GS 31-32. In Jutland a second treatment was recommended using Model 1. The humidity model (Model 2) recommended a treatment at all 3 localities following an event with 20 hours with 85% relative humidity. Finally CPO was recommending 1 treatment in Jutland and Flakkebjerg but none at Lolland (Table 2). Different treatments were used in comparison with the different models, using Bell at 3 different timings.

The conclusion from this year's trials are that the humidity model and CPO recommended very similar input at two sites (Horsens and Flakkebjerg) but in Lolland where the season was very dry CPO did not recommend a treatment, which was the right choice based on yield data from this season. Model 1 probably missed the best timing at Flakkebjerg and Lolland. But at Horsens the two timings gave a good gross yield, but a less good net yield (Table 3).

Table 1. Detailed yield data from the 3 validation trials carried out in 2016.

Treatments l/ha				% *Septoria*			Yield and yield	TGW
	GS 32-33	GS 37-39	GS 55	GS 71 leaf 2	GS 75 leaf 2	GS 77 leaf 1	hkg/ha	ghkg/ha
1. Untreated				2.6	29.3	27.9	86.7	43.0
2.	Bell 0.5	Bell 0.5	Bell 0.5	1.2	12.9	14.5	4.4	44.9
3.		Bell 0.5		1.4	12.0	17.1	4.1	44.4
4.		Bell 0.5	Bell 0.5	1.4	12.0	14.7	5.0	44.5
5.	Bell 0.5	Bell 0.5	Bell 0.5	1.3	10.6	12.7	4.7	45.8
6. Model SIM				1.6	22.2	15.0	2.6	44.0
7. Humidity model				2.1	16.4	19.7	3.7	44.8
8. CPO				1.8	12.4	18.4	3.6	44.3
				3	3	3	3	3
LSD_{95}				0.9	5.5	4.1	3.2	

The validation trials will continue in 2017. The platform used for organising the humidity platform is shown in Figure 1 and made available through Landbrugsinfo.

Table 2. Detailed dates for application in models.

	Flakkebjerg	LMO	Holeby
SIM model	10 May	10 May + 7 June	4 May
Humidity model	26 May	26 May	27 May
PVO	24 May	26 May	None

Table 3. Detailed yield data from the 3 validation trials carried out in 2016.

				16300-1			16300-2			16300-2		
	GS 32-33	GS 37-39	GS 55	Yied and increase dt/ha	Cost dt/ha	Net yield dt/ha	Yied and increase dt/ha	Cost dt/ha	Net yield dt/ha	Yied and increase dt/ha	Cost dt/ha	Net yield dt/ha
1. Untreated				80.6			90.4			89.3		
2.	Bell 0.5	Bell 0.5	Bell 0.5	9.5	5.8	3.7	5.0	5.8	-0.8	-1.3	5.8	-7.1
3.		Bell 0.5		2.9	2.9	6.0	4.9	2.9	2.0	-1.4	2.9	-4.3
4.		Bell 0.5	Bell 0.5	10.5	5.8	4.7	4.3	5.8	-1.5	0.1	5.8	-5.7
5.	Bell 0.5	Bell 0.5	Bell 0.5	10.8	8.7	2.1	4.8	8.7	-3.9	-1.4	8.7	-10.1
6. Model SIM				3.7	2.9	0.8	6.3	5.8	0.5	-2.1	2.9	-5.0
7. Humidity model				7.3	2.9	4.4	3.9	2.9	1.0	0	2.9	-2.9
8. CPO				8.2	2.9	5.3	4.5	2.9	1.6	-1.9	0	-1.9
LSD_{95}				5.9			3.6			NS		

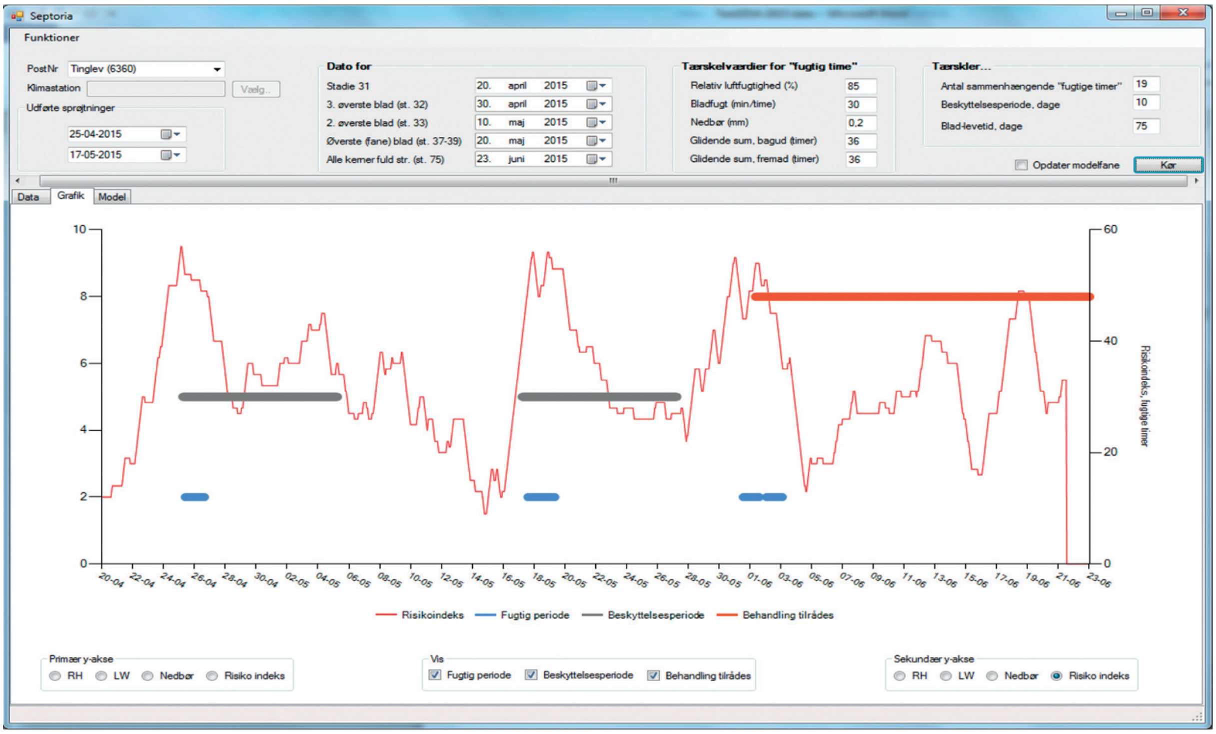
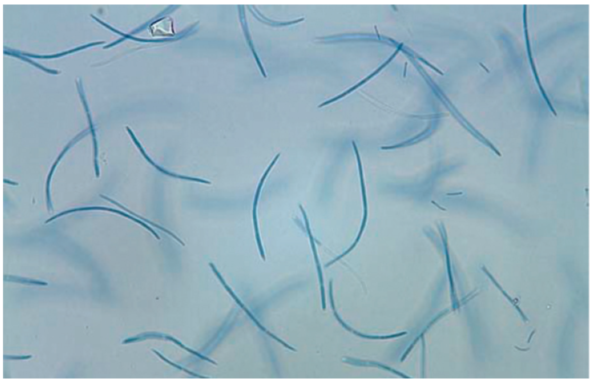


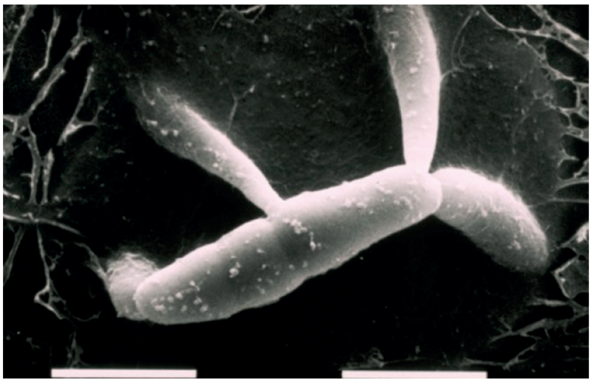
Figure 1. Measurements from a climate station are included on a prototype platform with the aim of developing a new *Septoria* risk model. The project is financed by the Danish Environmental Protection Agency. The platform helps to optimise the timing of spraying against *Septoria* and visualise when spraying is needed or when the crop can be expected to be protected.

Collecting spores of *Septoria*

During the season spores were trapped in 4 Burkard spore traps placed at 3 different sites. One near Holeby – Lolland, 1 near Gedsergaard, 1 at the trial site at Horsens and 2 at Flakkebjerg – 1 outside and 1 in the crop (Table 4). The sampler collects airborne particles by impaction onto a sticky tape, which is fixed onto a rotating drum. Every week the tapes were changed and cut into pieces, which each represent one day. For each day a QPCR test was run to measure the quantity of *Septoria* spores collected on the tape. This provides a picture of the spore concentration released during the season, which again might have an impact on the disease epidemic. Two types of spores are produced – ascospores and pycnidia spores. Ascospores are windspread while pycnidia spores are mainly splashborne. The QPCR method cannot separate the two spore types, but from other studies the majority of spores are known to be ascospores.



Pycnidia spores from *Zymoseptoria tritici*.



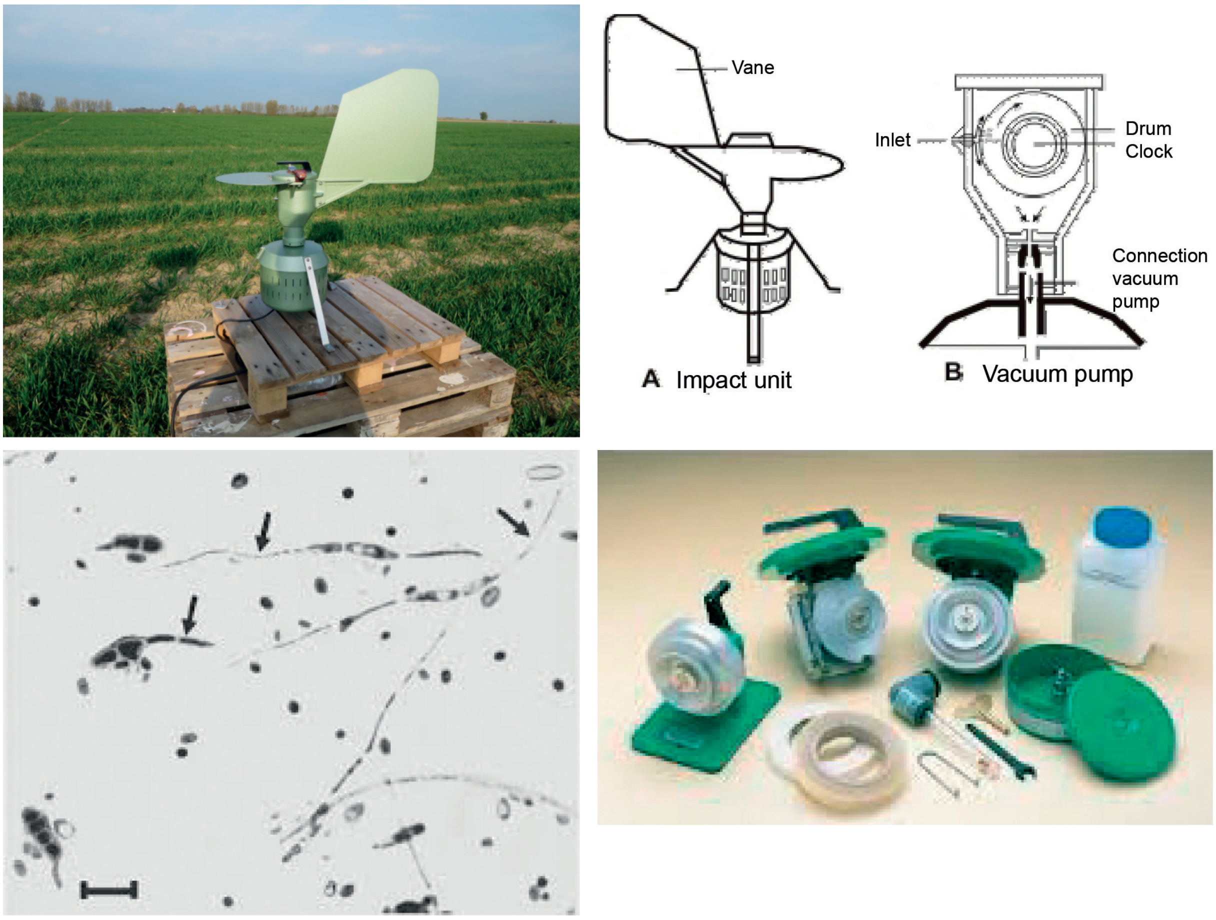
Ascospore from *Zymoseptoria tritici*.

Table 4. Localities and periods at which spores have been collected.

	Start of collection	End of collection
Flakkebjerg 1 near wheat crop	21 April	10 November
Flakkebjerg 2 placed in a wheat crop	21 April	10 November
LMO placed close to a wheat field	22 April	12 July
Gedsergaard – Gedser. Used for collection of beet pathogens – but used similarly for *Septoria*	29 June	30 September
Holeby - Lolland. Used for collection of beet pathogens – but used similarly for *Septoria*	8 April	21October

The analysis and graphs indicate that minor release of spores takes place during most of the season (Figures 2-5). In certain intervals major peaks of release has taken place. This is particularly seen in August at Flakkebjerg (Figures 2 + 3). Higher numbers are seen from the spore trap placed in the field compared with the one placed outside the field. But both follow the same pattern.

From literature increases in spore release have been linked to periods with wet conditions few days prior to releases. Negative correlations have been found to sun radiation and high temperatures, which inhibit spore releases. In agreement with other investigations this investigation also showed small releases of spores throughout the season. Peaks of spores occurring in late summer and autumn are known to be of major importance for the carryover effect of *Septoria* from one season to the next.



Photoes and illustration of a Burkard 7-day volumetric spore trap located in the field. The trap is linked to a vacuum pump and airborne particles are impacted onto a sticky tape, which rotates at a speed equivalent to 1 week. Bottom left shows a collection of spores caught on the tape.

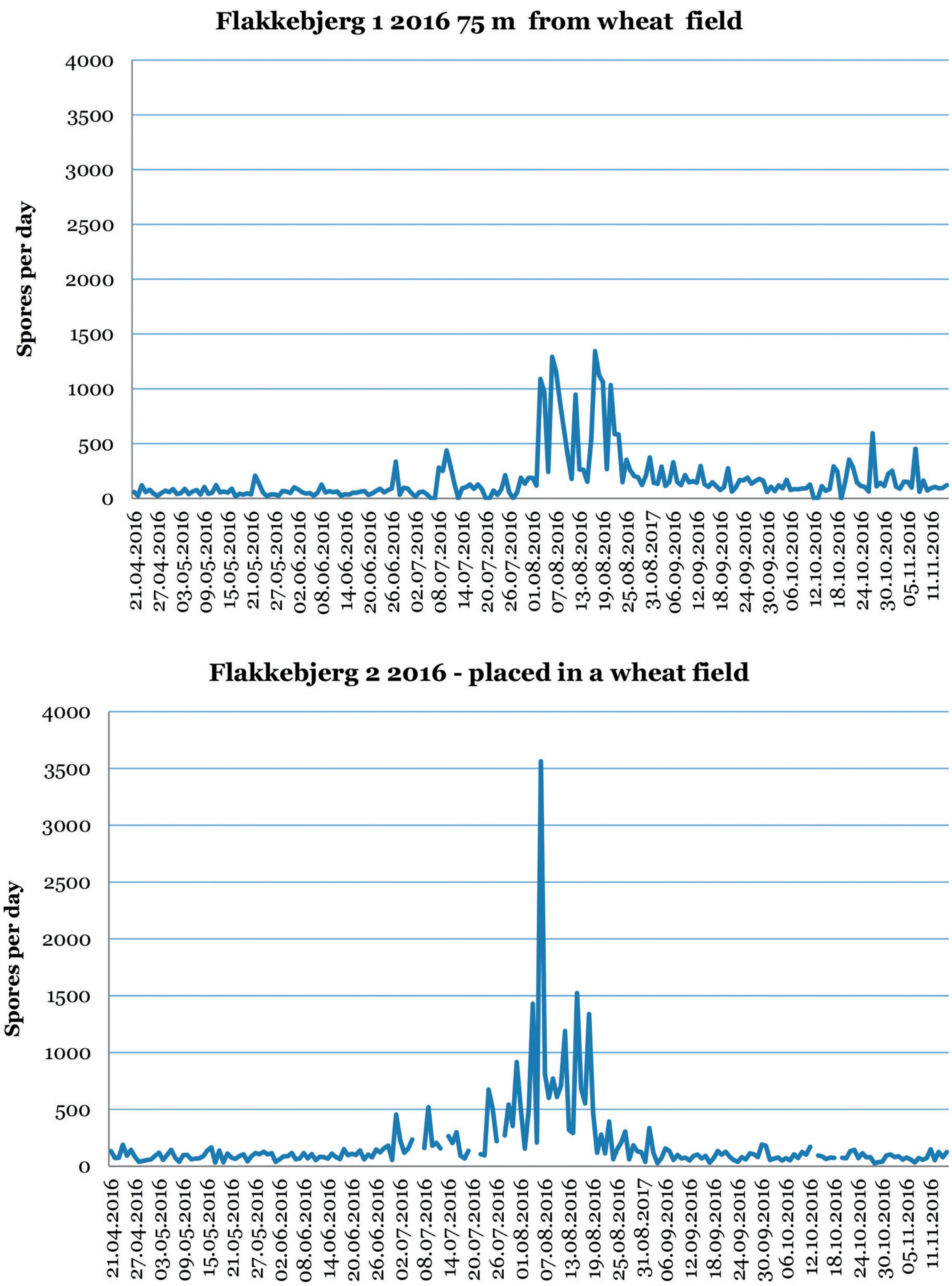
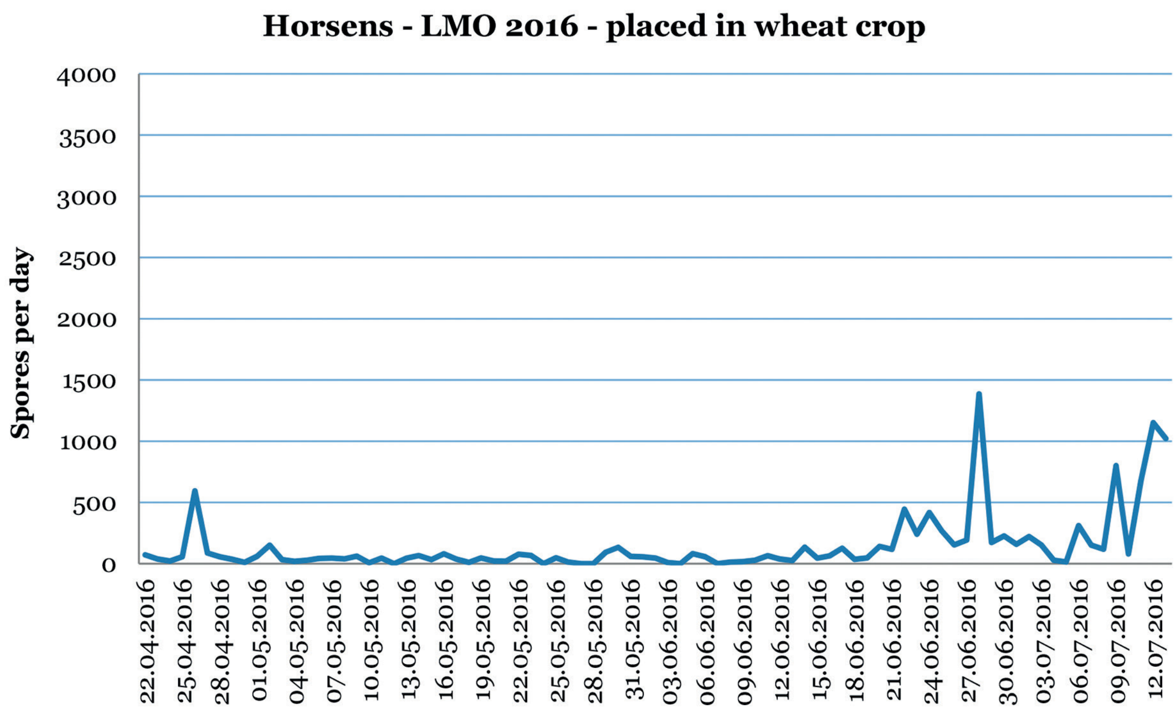


Figure 2. Spores collected by 2 spore traps placed at Flakkebjerg during the growing season 2016.



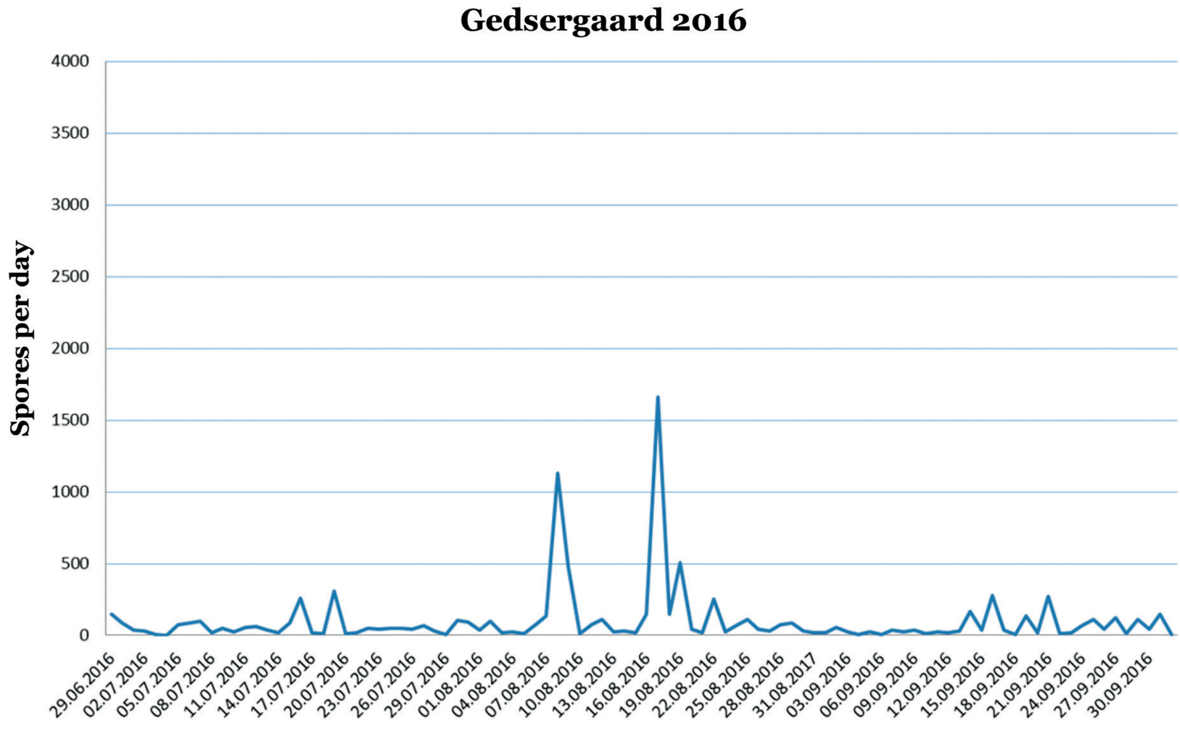


Figure 3. Spores collected by 2 spore traps placed near Horsens and at Gedsergaard in Falster during the growing season 2016.

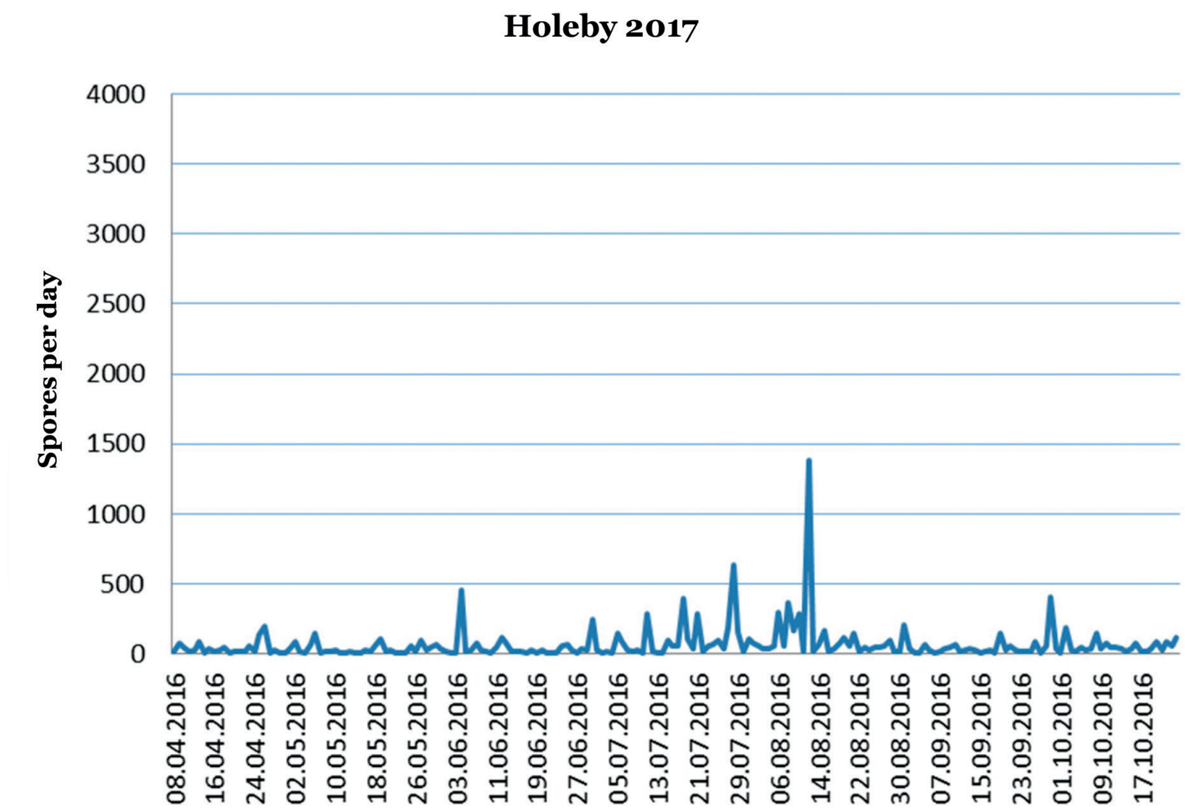


Figure 4. Spores collected by 2 spore traps placed near Holeby in Lolland during the growing season 2016.

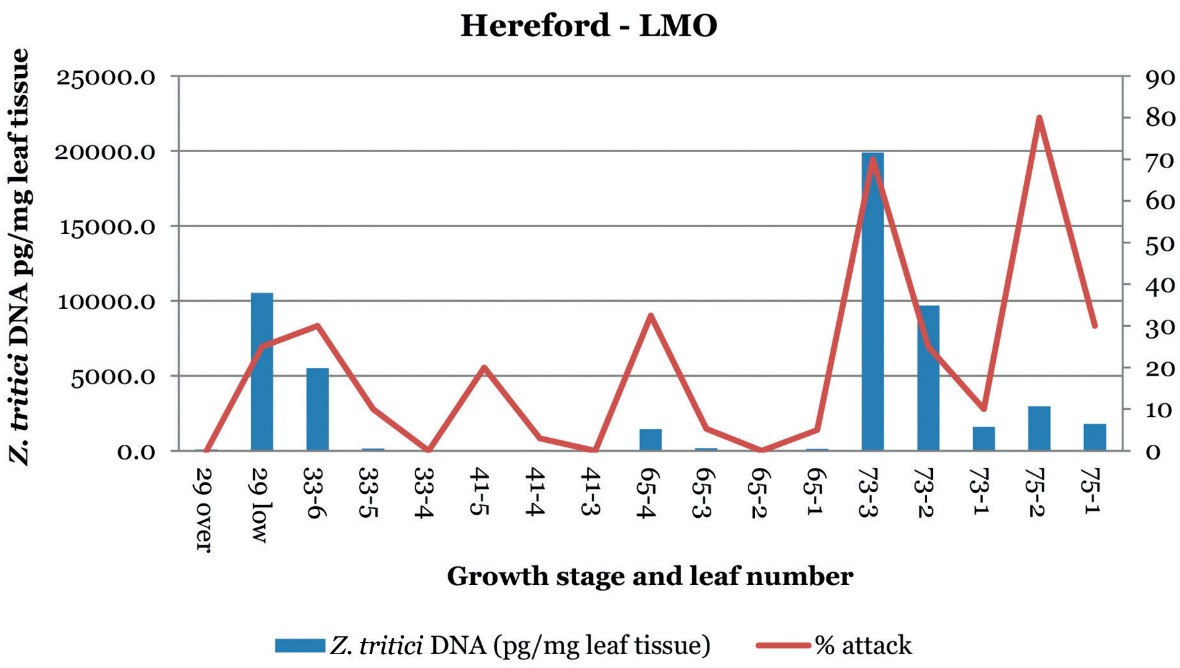
Different levels of *Septoria* attack. Slight levels of attack can be accepted at GS 75, without major losses.

3-5% *Septoria* is regarded as acceptable. (Photo: Ghita C. Nielsen).

10% *Septoria* is seen as slightly too much. (Photo: Ghita C. Nielsen).

50% *Septoria* – assessed at GS 75 is considered to clearly reduce yield.

Quantification of *Septoria* (*Zymoseptoria tritici*) DNA in wheat leaves
During the season leaves were collected with regular intervals and leaves were divided into leaves with visible attack and leaves without visible attack. At each sampling time growth stage and the level of *Septoria* was assessed on each of the leaf layers.



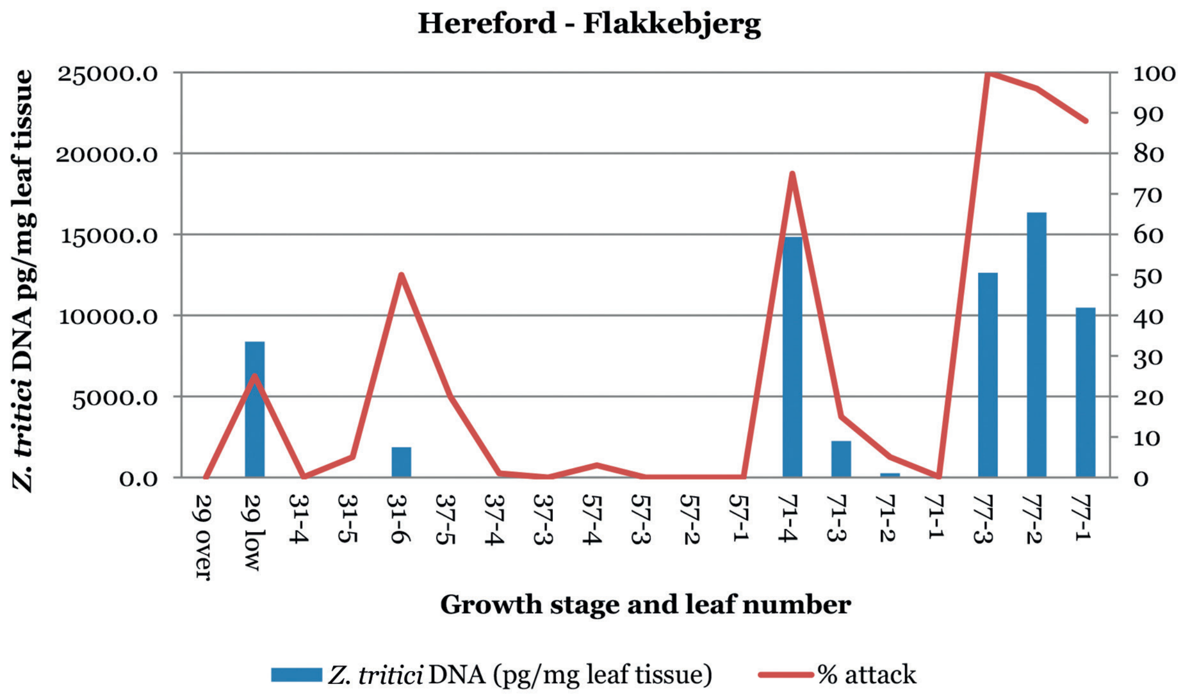


Figure 5. Link between DNA and % attack of *Septoria*. Data from Flakkebjerg and LMO in the cultivar Hereford. Low = Lower leaves with attack; Over = top leaves without attack.

DNA was extracted from the leaf samples, and by using QPCR the level of *Zymoseptoria tritici* was measured. A clear gradient across the canopy indicates a higher level of attack on the lower leaves than on the upper leaves. The DNA analysis gave 18 cases of pre-symptomatic readings – based on readings from leaves which still had no visible attack, indicating that the DNA method can detect latent attack.

Generally a good link between disease severity and DNA measurement was seen as shown in Figures 5-8 from specific cultivars and localities. In a few cases for the late growth stages only moderate DNA content was seen despite assessments of severe attack. Part of this poor correlation might be due to the leaves being very dry and senescent for this very late assessment.

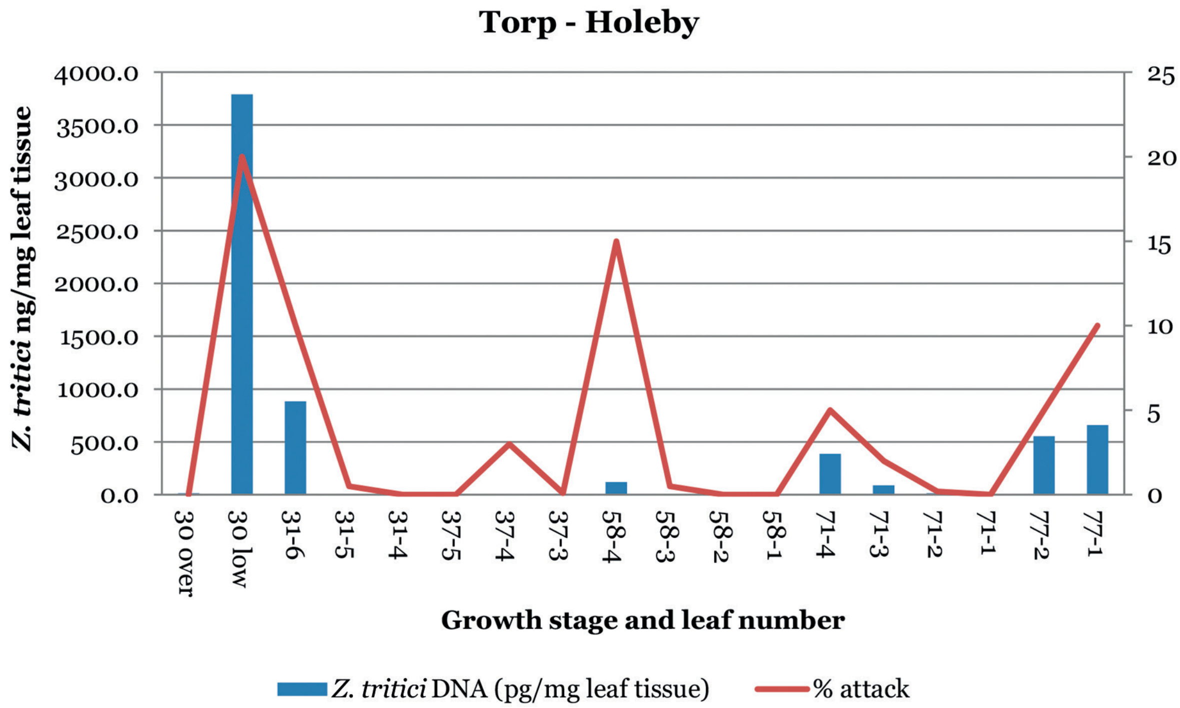
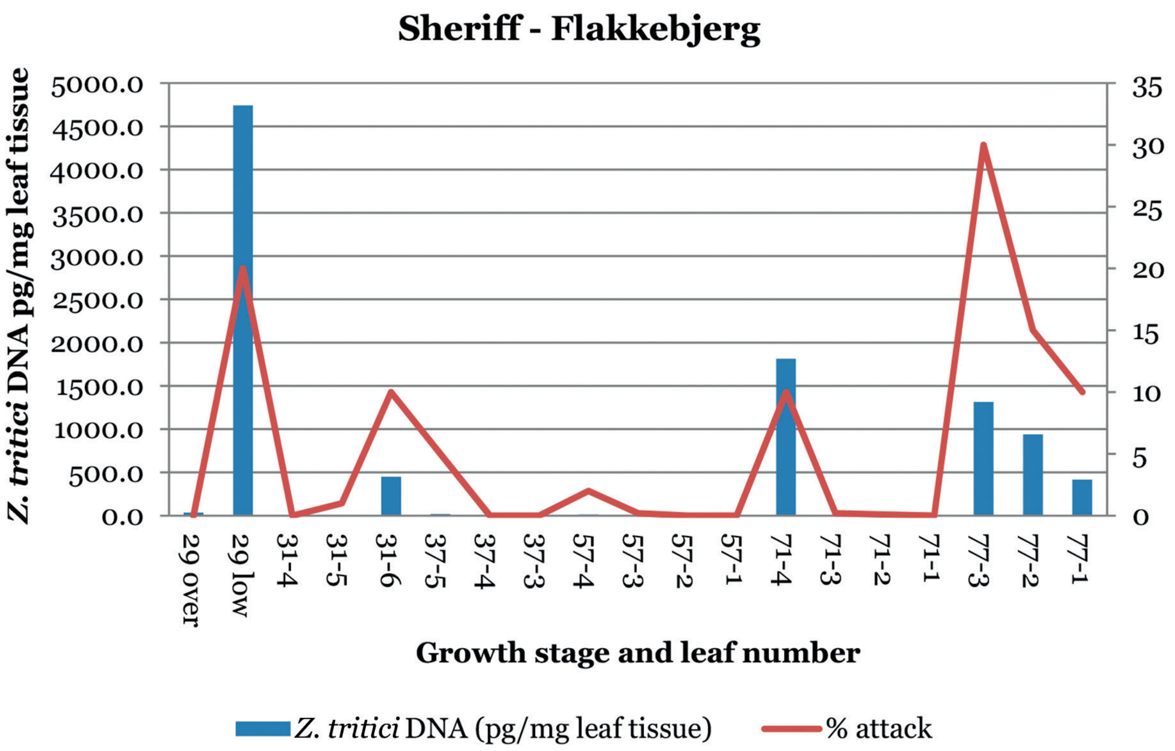


Figure 6. Link between DNA and % attack of *Septoria* in Torp. Data from Holeby from a locality with low levels of diseases. Low = Lower leaves with attack; Over = top leaves without attack.



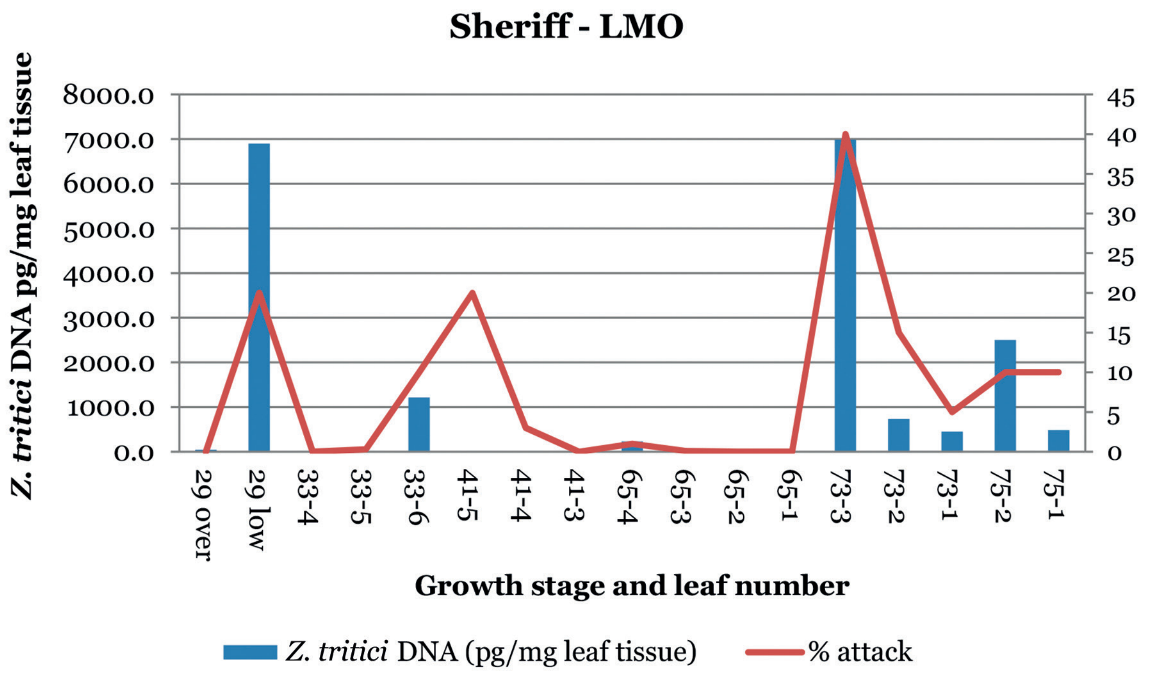


Figure 7. Link between DNA of *Z. tritici* and % attack of *Septoria* in the cultivar Sheriff. Data from Flakkebjerg and LMO. Sheriff is much less susceptible than Hereford. Low = Lower leaves with attack; Over = top leaves without attack.

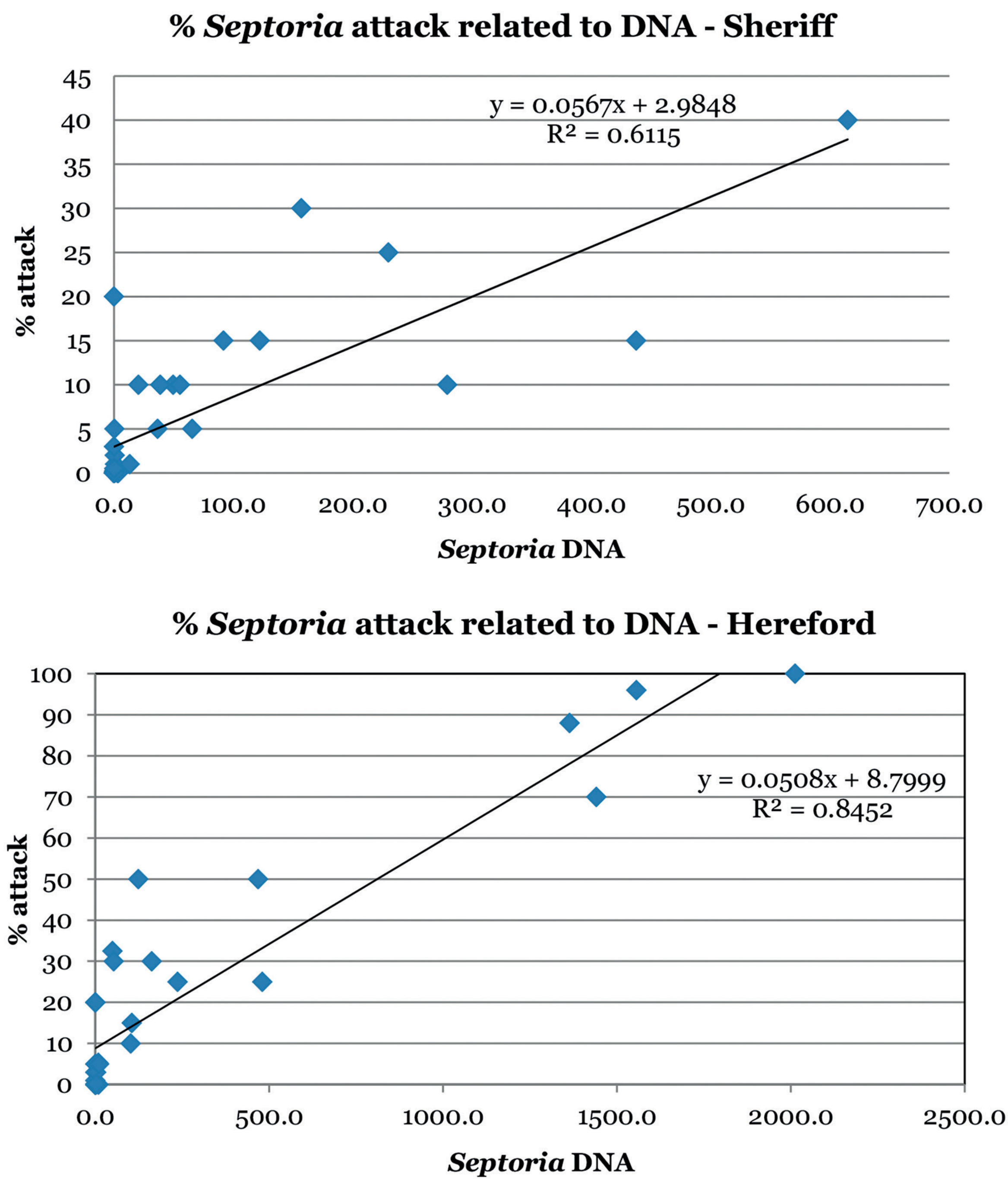


Figure 8. Correlation between DNA and visual assessments of *Septoria* in two cultivars (DNA 1). Link between two DNA measurements.

IX Control of late blight (*Phytophthora infestans*) and early blight (*Alternaria solani* & *A. alternata*) in potatoes

Bent J. Nielsen & Isaac Kwesi Abuley

Abstract

Due to low infection pressure of late blight (*Phytophthora infestans*) in the second half of July 2016 there was in general a slow disease development of late blight at Aarhus University (AU) Flakkebjerg and it was not until mid-August that severe attacks were seen in most of the trials. Spraying with Banjo Forte, Vendetta, Revus or Carial Flex at 7-day or 14-day intervals had a very high impact on late blight with overall 97-99% control with no significant differences between products or spray intervals (7 days and 14 days). In order to test the effect of Proxanil and Cymbal on established lesions of late blight, a trial was set up almost in the same way as in 2014 and 2015. The trial demonstrated that applying a curative spray at the right time (low level of attack) can reduce the development of late blight significantly when followed up by weekly sprayings at full dose. Trials were also carried out to investigate different spray strategies to control early blight (*Alternaria solani*). The trials with early blight were inoculated *in late June. The development of early blight was slow in the month of July, mainly because of dry weather. However, from the beginning of August, favourable weather conditions coupled with the potatoes reaching a very susceptible age accounted for an increase in early blight attack. Spray strategies with Revus Top, Amistar, Vendetta, Signum and Narita (+ additive) had a high impact on *Alternaria* with overall 85-91% control. The only significant difference was the lower effect (75% control) after delaying the start of spraying by 15 days in the 2 x Revus Top + 2 x Amistar strategy. The spraying was done on 19 July when the attack of *Alternaria* was approximately 0.1-2% in the plots of this treatment. In a spray programme testing anti-resistance strategies spraying was carried out three times with different products. Amistar, Signum WG and Vendetta each had a high impact on *Alternaria* with overall 85-88% control. Spraying with Revus Top had a significantly lower effect (65% control). Dithane NT had, as expected, an effect of 47% control, which was significantly lower than the effect of the other products. From the level of control by using Amistar it can be seen that the *Alternaria* population at Flakkebjerg was susceptible to strobilurin fungicides. Spraying with Revus Top – Amistar – Signum WG resulted in a very high level of control (89% control), at the level of Amistar, Signum WG or Vendetta. However, the strategy Dithane NT – Revus Top – Signum WG had a significantly lower effect (72% control). A trial was set up in order to evaluate the effect on *Alternaria* of Revus Top, Amistar, Signum WG, Vendetta and Narita in combinations with either Ranman Top or Revus. Spraying was done two times at 14-day spray intervals. The first spraying was done before first symptoms were recorded. There was a high level of control of two sprayings early in the season with Amistar and Vendetta (susceptible population) with overall 90% control and 81% control respectively. The effect of Signum WG at two sprayings was a little lower (68% control). Spraying with difenoconazole products two times early in the season had in general a less long-lasting effect (Narita 0.4 l/ha + Ranman Top 0.5 l/ha: 58% control and Revus Top: 51% control). Combining Narita 0.4 l/ha with either Ranman Top or Revus showed best effect for the combination with Ranman Top (58% control) compared with the combination with Revus (45% control). There was a clear dose response using 0.4 l/ha and 0.6 l/ha of Revus Top sprayed two times early in the season. Yield increase after spraying against *Alternaria* was in the different trials 2-12% for tuber yield and 2-15% for starch yield.

Materials and methods

The potato trials were carried out at AU Flakkebjerg on sandy clay loam (JB 5-6) with a randomised complete block design and 4 replicates in the starch varieties Kuras and Eurogrande. Plot size was 3.75 x

9 m (*Alternaria*) or 3.75 x 8 m (late blight) with net yield plots of 15.75 m² or 14.6 m². The potatoes were planted in the last days of April and emerged on 1 June. The late blight trials were artificially inoculated on 9 July by spraying a sporangial suspension of *P. infestans* (1000 sporangia/ml) over spreader rows between the blocks. The *Alternaria* trials were artificially inoculated on 29 June with autoclaved barley seeds inoculated with *A. solani* and *A. alternata* placed in the furrow between the plants.

Spraying was begun according to the protocols, and the spray technique was 300 l water/ha, Hardi ISO MD 025 nozzle and 3 bar. During the season the plots were assessed at weekly intervals for the extent of potato late blight (*P. infestans*) and early blight (*Alternaria solani* & *A. alternata*). Each plot was scored as a whole for % disease severity (percentage coverage of all green leaves; EPPO guideline PP 1/2 (4), 2012). All plots were assessed during the whole season or until 100% disease in the specific plot.

After harvest the starch content was determined by measuring weight under water of dry matter (% starch = dry weight – 5.75). Tuber blight was assessed as percentage of tubers affected by tuber blight on minimum 100 tubers per plot after at least 2 weeks and up to 8 weeks of storage under normal conditions. The trial site was irrigated 4 times (20 mm water) from mid-June to the end of September.

The trials were performed according to EPPO guidelines PP 1/2(4), PP 1/135(3), PP 1/152(3), PP 1/181(3) and PP 1/263(1). The data were subjected to analysis of variance and treatment means were separated at the 95% probability level using Fisher protected LSD.

Infection pressure for potato late blight (www.skimmelstyring.dk)

The infection pressure for late blight is a running sum of sporulation hours during a 5-day window including current date, 2-day weather forecast and two days of historic weather (Figure 1). Sporulation hours for potato late blight (HSPO) are defined as the number of hours in periods of 10 or more hours when Rh>88% and the temperature at the same time is between 10°C and 24°C. HSPO is 5 if there are 10 consecutive hours of Rh>88% and the temperature in 5 of those humid hours is above 10°C. During a high infection pressure it is expected that there is a risk of both sporulation and infection. Infection pressure: < 20 is regarded as low; 20-40 is regarded as moderate risk and > 40 is regarded as high risk.

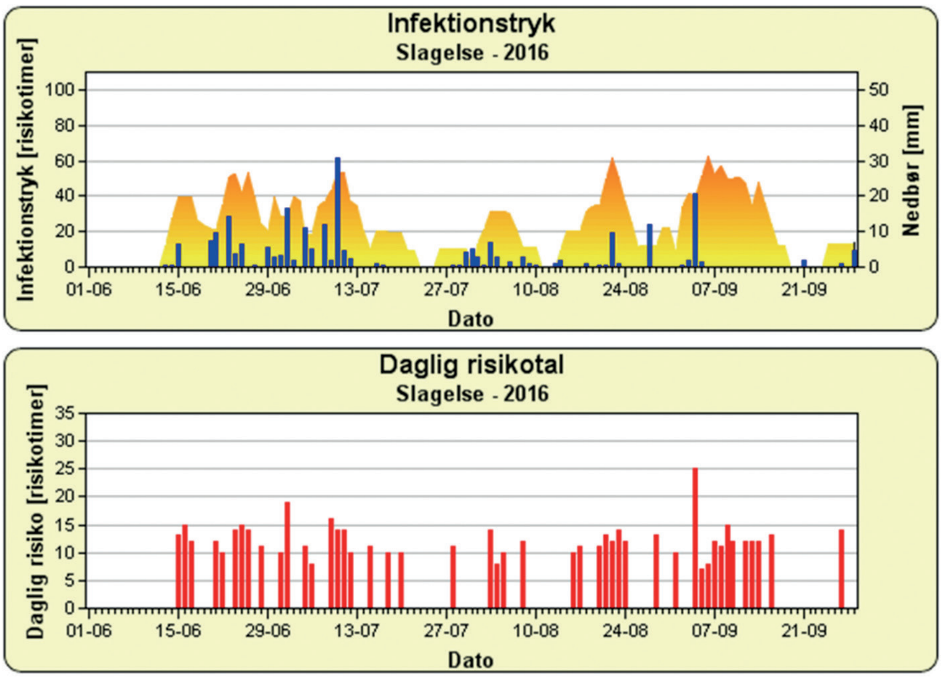


Figure 1. Infection pressure ("Infektionstryk", 5 days running mean), sporulation hours, daily risk values DRV ("Daglig risikotal") for potato late blight, temperature and relative humidity (%) for Slagelse 2016 (10 km north-west of Flakkebjerg).

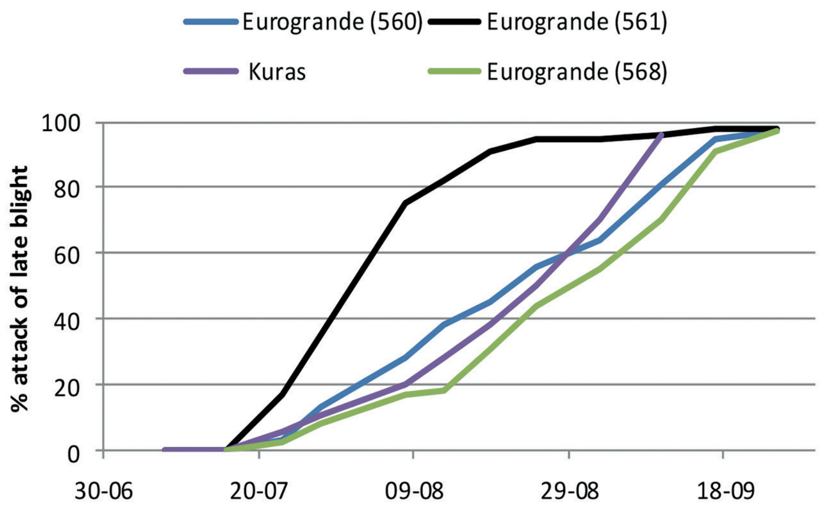


Figure 2. Development of late blight (*Phytophthora infestans*) in untreated plots at Flakkebjerg 2016. Different trials with varieties Kuras and Eurogrande. Artificial inoculation on 9 July.

Potato late blight (*Phytophthora infestans*) 2016

The trials at Flakkebjerg were artificially inoculated on 9 July 2016 by spraying a sporangial suspension of *P. infestans* (1000 sporangia/ml) over infector plants in the spreader rows between the blocks. The first attacks were seen in the spreader rows on 11 July and in the untreated plots of the trials on 14 July. Due to low infection pressure of late blight in the second half of July (Figure 1) there was in general a slow disease development and it was not until mid-August that severe attacks were seen in most of the trials (Figure 2). In 2016 there were differences in the disease development between the different trial sites at Flakkebjerg, and in some trials in the variety Eurogrande the disease development was rapid from July onwards (Eurogrande 561 in Figure 2).

The disease development in 2016 began almost at the same time (first weeks of July) as in previous years apart from the late (and dry) year 2013 (Figure 3). The first symptoms of late blight were observed in untreated plots at Flakkebjerg on 22 July 2009, 20 July 2010, 15 July 2011, 9 July 2012, 22 July 2013, 16 July 2014, 31 July 2015 and 13 July 2016. However, in 2016 the progress curve for late blight was more linear and did not follow the usual sigmoid curve (Figure 3).

Conditions for development of infection of the tubers were slight to moderate in 2016.

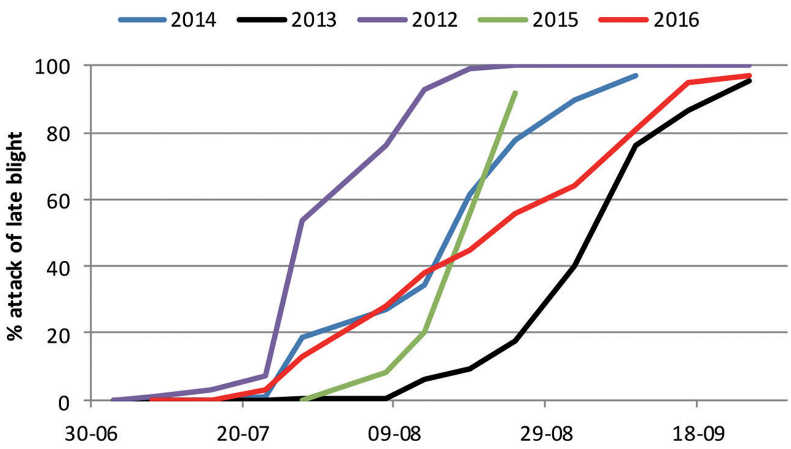


Figure 3. Development of late blight (*Phytophthora infestans*) in untreated plots of varieties Dianella (2012-2014) and Eurogrande (2015-2016) at Flakkebjerg 2012-2016. Artificial inoculation during the first 10 days of July.

Potato early blight (*Alternari solani* & *A. alternata*) 2016

Overview of the field trials

The trials to investigate different strategies to control early blight were carried out at Flakkebjerg, Sunds (Western Jutland) and Billund (Central Jutland). The trials in Flakkebjerg were artificially inoculated on 29 June 2016 with autoclaved barley seeds inoculated with *A. solani* and *A. alternata* with seeds placed in the furrow between the plants. The first attacks on the lower leaves were observed between 11 and 15 July (Figure 4). The weather conditions during the season were generally favourable for early blight development, but the occurrence of dry weather on several days in the last two weeks in July restricted the development of early blight after the onset. It was during the month of August that we observed an increase in early blight attack. Due to severe desiccation it was difficult to record the attack of *Alternaria* accurately at the last assessment in September.

The trials at Sunds and Billund were not inoculated. The first attacks at Sunds (2 years potato free) were observed on 21 July. The first early blight attacks were observed on 22 July on the potatoes at Billund where potatoes were last grown 8 years ago. The development of *Alternaria* did not start until early August (Figure 4). Development in *Alternaria* in untreated plots at Sunds in the years 2012-2016 can be seen in Figure 6.

Early blight development and the weather

We used the TOMCAST model (Tomato forecaster) (Gleason et al., 1995) to predict how favourable the weather would be for early blight attack during the season using leaf wetness and average temperature during the leaf wetness hours in a day. We also used the physiological age model (Pdays) (Sands et al., 1979) to measure the age of the potatoes using minimum and maximum daily temperatures. The age of potatoes is important in determining the epidemic rate of early blight on potatoes. The output of the Pdays and TOMCAST models are presented in Figures 7 and 8 respectively.

The 330 Pdays, which predict the first occurrence of symptoms, were reached on 11 July, 19 July and 21 July at Flakkebjerg, Sunds and Billund respectively (Figure 7). At Flakkebjerg, the Pdays predicted exactly when the first symptoms occurred on most of the potatoes in the untreated plots (i.e. 11 July) (Figure 4 for the disease progress and Figure 7 for the Pdays output).

At Sunds, the Pdays predicted the first symptoms to occur on 21 July (Figure 7) and the actual symptoms occurred on 21 July (Figure 4). Thus Pdays predicted the exact day that the first symptoms occurred.

At Billund, the Pdays model predicted the first symptoms to occur on 22 July and the first symptoms were observed the same day (22 July) (Figure 4).

In general, the disease progress after the onset of the disease was slow at the 3 locations until the beginning of August. The increase in early blight attack from the month of August onwards was because the potatoes reached the critical age (500 physiological age) at the beginning of August (Figure 7). Again the TOMCAST model showed that the threshold favourable for significant early blight attack was reached in August. July was generally less favourable for early blight attack even though some days with moisture and favourable temperatures occurred.

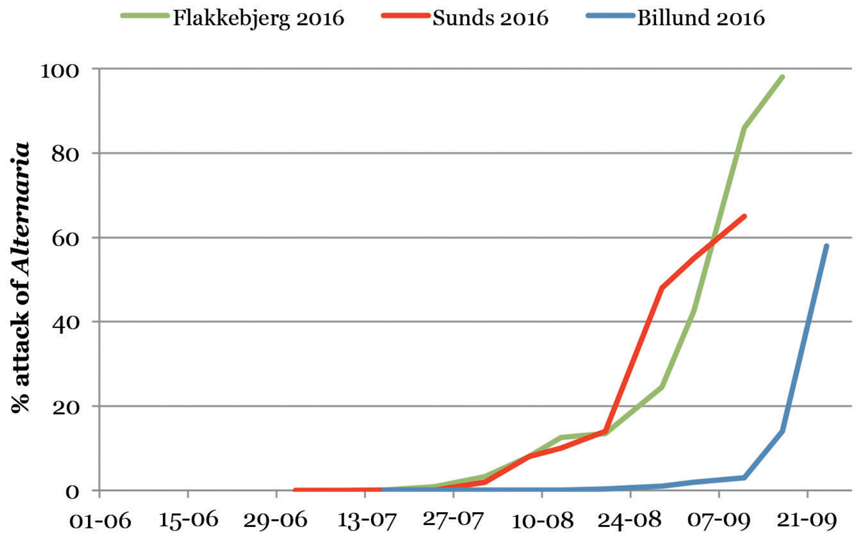


Figure 4. Development of *Alternaria* 2016 in untreated plots at Flakkebjerg, Sunds (Western Jutland) and Billund (Central Jutland). Artificial inoculation at Flakkebjerg, natural infestations at Sunds and Dronninglund. Variety Kuras.

The development in early blight at Flakkebjerg in 2016 started almost at the same time as in 2012-2015 (Figure 5).

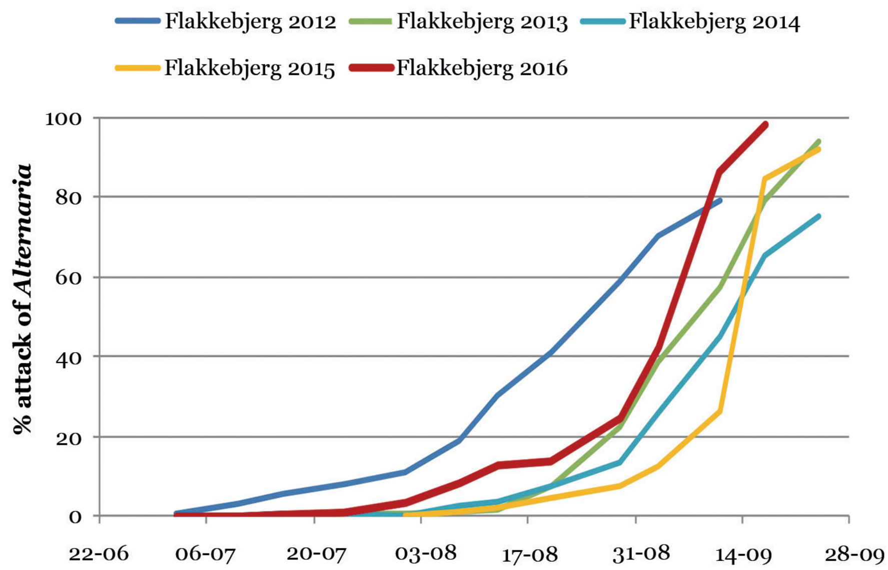


Figure 5. Development of *Alternaria* in untreated plots at Flakkebjerg 2012-2016. Artificial inoculation by inoculated barley seeds at the end of June. Varieties Kuras and Kardal (2015).

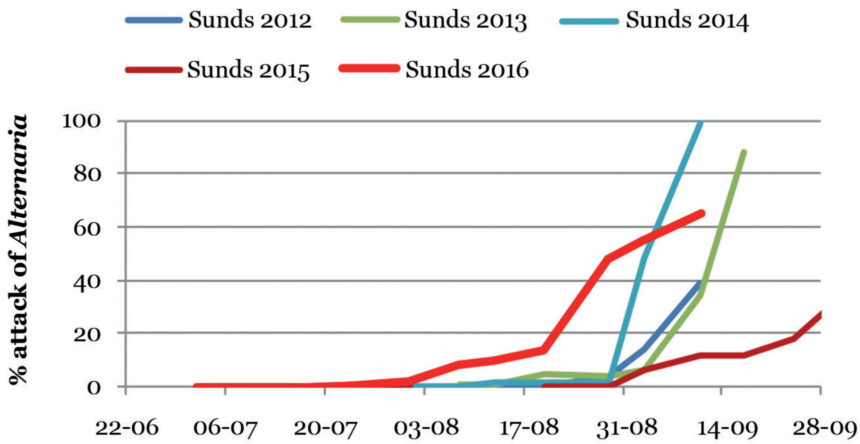


Figure 6. Development of *Alternaria* in untreated plots at Sunds (Jutland) 2012-2016. Natural infestations. Varieties Kuras and Kardal (2015).

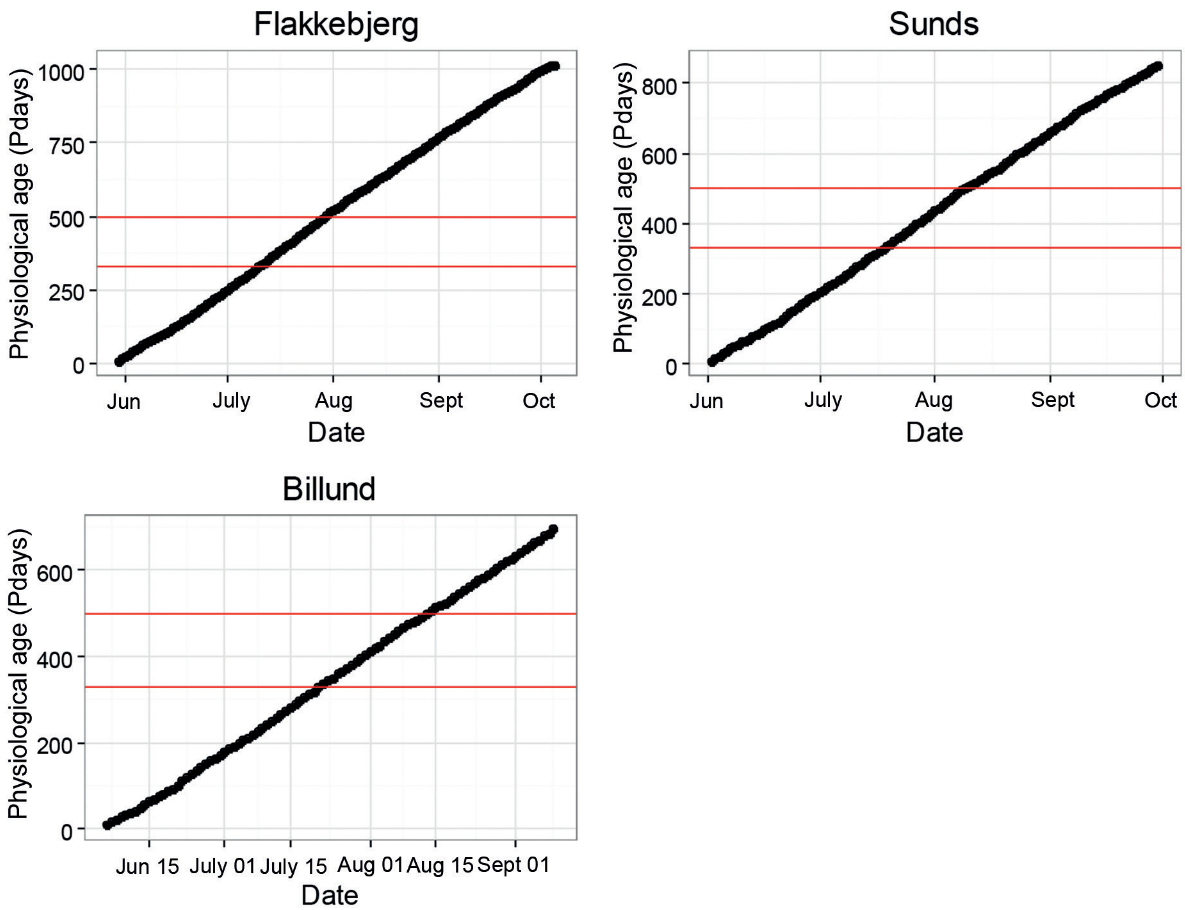


Figure 7. The age of the potatoes (variety Kuras) expressed as physiological age (Pdays) from 50% emergence at Flakkebjerg, Sunds and Billund. The lower and upper red lines represent the 330 and 500 Pdays thresholds respectively. The 330 Pdays were reached on 11 July, 19 July and 21 July in Flakkebjerg, Sunds and Billund respectively. The 500 Pdays were reached on 1 August, 9 August and 15 August in Flakkebjerg, Sunds and Billund respectively.

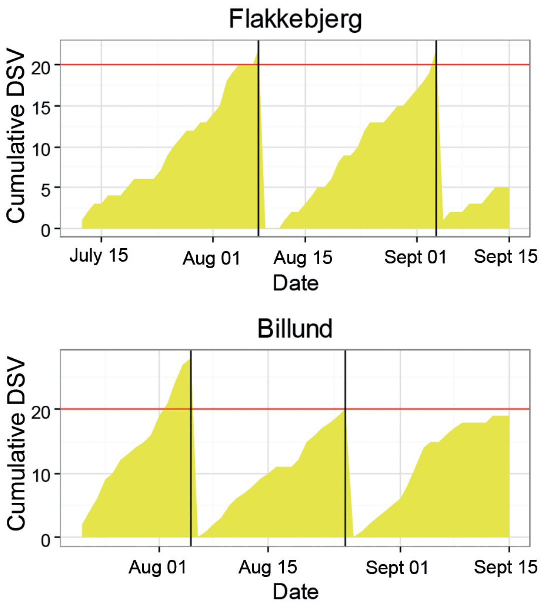


Figure 8. Model output of TOMCAST DSV (Disease Severity Values) used for the modified TOMCAST model during the season at Flakkebjerg, Sunds and Billund trial sites. TOMCAST DSV is calculated according to the dew model from the FAST model (Forecasting *Alternaria* of Tomatoes) (Madden et al., 1978). The horizontal red and black vertical lines represent the 20 DSV thresholds and the day actual spraying was done respectively.

Results from field trials 2016

Comparing strategies

The trial was performed in Eurogrande in order to evaluate the efficacy of spray strategies with four sprays of Banjo Forte (1.0 l/ha), Vendetta (0.5 l/ha), Revus (0.6 l/ha) or Carial Flex (0.6 l/ha) at 7-day intervals or 14-day intervals (Table 1). The sprayings were started on 13 July at the first high risk period for potato late blight (infection pressure for late blight > 40 and late blight present in the region (Figure 1). In the period before the high risk period (starting 30 June) and after the sprayings with the test products the plots were sprayed with Revus (0.3 l/ha) or Ranman Top (0.25 l/ha) alternating with two sprayings of each product. Last spraying was on 31 August. Reference treatment (Treatment 2) was Revus (0.6 l/ha) and Ranman Top (0.5 l/ha).

Spraying with Banjo Forte (1.0 l/ha), Vendetta (0.5 l/ha), Revus (0.6 l/ha) or Carial Flex (0.6 l/ha) at 7-day or 14-day intervals had a very high impact on late blight with overall 97-99% control with no significant differences between products, spray intervals (7 days and 14 days) or Revus/Ranman Top sprayed at weekly intervals throughout the season (Figures 9-10). There was a trend that Carial Flex had a little better effect compared with Banjo Forte, Vendetta or Revus when compared at 7- and 14-day intervals (Figure 10).

Late blight attacks on stems were assessed on 2 August by counting the number of stem lesions in the two middle rows of the trial. There was a high level of attack of stem blight in the untreated plots (405 lesions in total on 18 row m of plants). Since the assessments were done on 2 August only the effect after the first 3 sprayings at 7-day intervals and after the first 2 sprayings at 14-day intervals can be evaluated. There was a high level of control of the attacks on stems after spraying with the different products with a trend that the highest effect was obtained after spraying with Carial Flex, Banjo Forte and Revus/Ranman Top (Figure 11). Tuber yield in untreated was 329.4 dt/ha tubers and 64.5 dt/ha starch with an increase in tuber yield of 61% to 73% (tubers) and 79% to 91%% (starch) after spraying with Banjo Forte, Vendetta, Revus or Carial Flex (Figure 12).

Table 1. Trial plan for testing spray strategies against late blight (*Phytophthora infestans*) in potato. Spraying with Banjo Forte (BF), Vendetta, Revus (RE) and Carial Flex (C Flex) was started at the first high risk period of late blight and continued at 7-day or 14-day intervals. Actual dates for the sprayings are shown in the table. Variety Eurogrande, Flakkebjerg 2016

	30-06	07-07	13-07	20-07	28-07	03-08	11-08	18-08	25-08	31-08
	3	4	5	6	7	8	9	10	11	12
1	Untreated									
2	0.6 RE	0.6 RE	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT
3	0.3 RE	0.3 RE	1.0 BF	1.0 BF	1.0 BF	1.0 BF	0.3 RE	0.3 RE	0.25 RANT	0.25 RANT
4	0.3 RE	0.3 RE	0.5 Vendetta	0.5 Vendetta	0.5 Vendetta	0.5 Vendetta	0.3 RE	0.3 RE	0.25 RANT	0.25 RANT
5	0.3 RE	0.3 RE	0.6 RE	0.6 RE	0.6 RE	0.6 RE	0.3 RE	0.3 RE	0.25 RANT	0.25 RANT
6	0.3 RE	0.3 RE	0.6 C Flex	0.6 C Flex	0.6 C Flex	0.6 C Flex	0.3 RE	0.3 RE	0.25 RANT	0.25 RANT
7	0.3 RE	0.3 RE	1.0 BF	0.3 RE	1.0 BF	0.25 RANT	1.0 BF	0.3 RE	1.0 BF	0.25 RANT
8	0.3 RE	0.3 RE	0.5 Vendetta	0.3 RE	0.5 Vendetta	0.25 RANT	0.5 Vendetta	0.3 RE	0.5 Vendetta	0.25 RANT
9	0.3 RE	0.3 RE	0.6 RE	0.3 RE	0.6 RE	0.25 RANT	0.6 RE	0.3 RE	0.6 RE	0.25 RANT
10	0.3 RE	0.3 RE	0.6 C Flex	0.3 RE	0.6 C Flex	0.25 RANT	0.6 C Flex	0.3 RE	0.6 C Flex	0.25 RANT

RE: Revus (mandipropamid) at 0.6 l/ha or 0.3 l/ha. RanT: Ranman Top (cyazofamid) at 0.5 l/ha or 0.25 l/ha. BF: Banjo Forte (fluazinam + dimethomorph) 1.0 l/ha. Vendetta (fluazinam + azoxystrobin) 0.5 l/ha. C Flex (mandipropamid + cymoxanil) 0.6 l/ha.

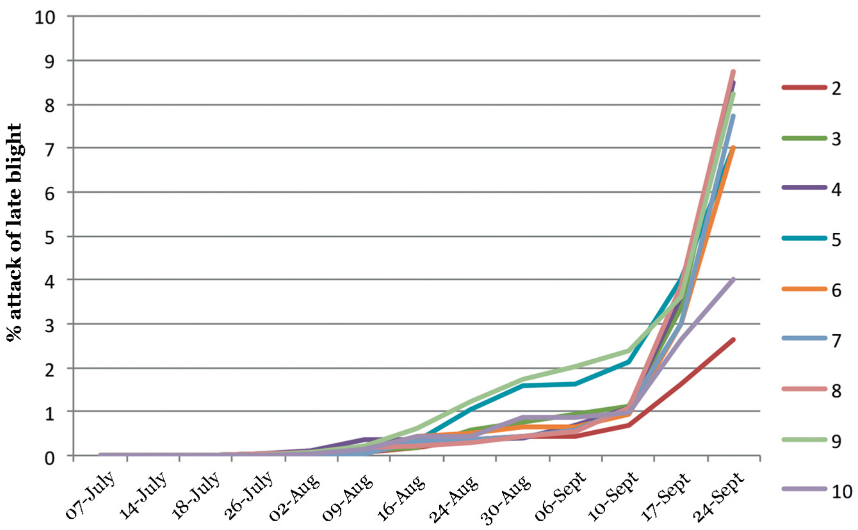


Figure 9. Development of late blight (*P. infestans*) in plots with different treatments. Explanation of treatment numbers is shown in Table 1. Untreated is not shown here. Variety Eurogrande. Flakkebjerg 2016.

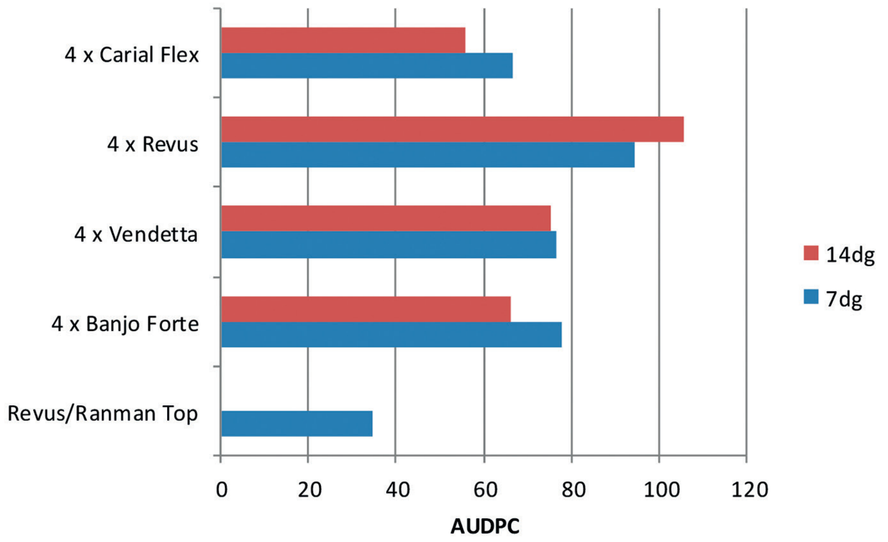


Figure 10. Area under disease progress curve for late blight (AUDPC) for treatments with Revus (0.6 l/ha) or Ranman Top (0.5 l/ha), Banjo Forte 4 x 1.0 l/ha, Vendetta 4 x 0.5 l/ha, Revus 4 x 0.6 l/ha and Carial Flex 4 x 0.6 l/ha at 7-day intervals (7dg) or 14-day intervals (14dg) starting on 13 July (Table 1). AUDPC for untreated = 3425, not shown. Variety Eurogrande, Flakkebjerg 2016.

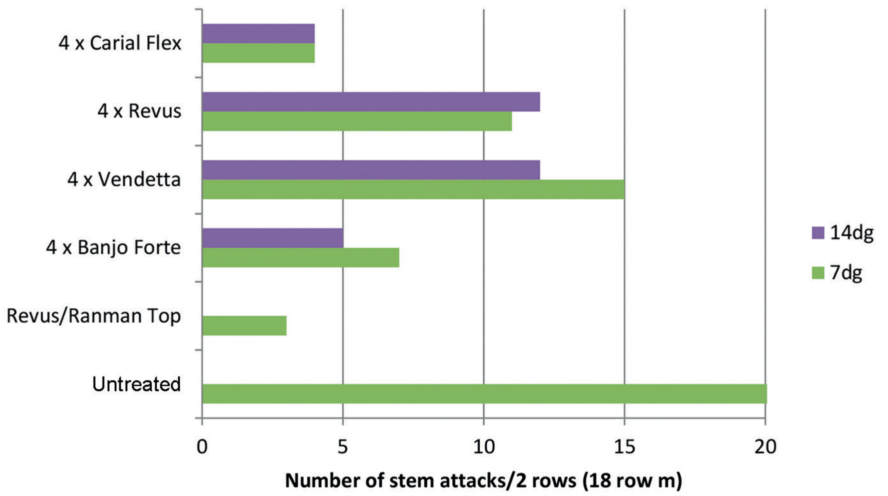


Figure 11. Attacks of late blight on stems measured as number of stem lesions in two middle rows (18 row m) 2 August in treatments with Revus (0.6 l/ha) or Ranman Top (0.5 l/ha), Banjo Forte 4 x 1.0 l/ha, Vendetta 4 x 0.5 l/ha, Revus 4 x 0.6 l/ha and Carial Flex 4 x 0.6 l/ha at 7-day intervals (7dg) or 14-day intervals (14dg) starting on 13 July (Table 1). Number of stem lesions in untreated = 405, not shown. Variety Eurogrande, Flakkebjerg 2016.

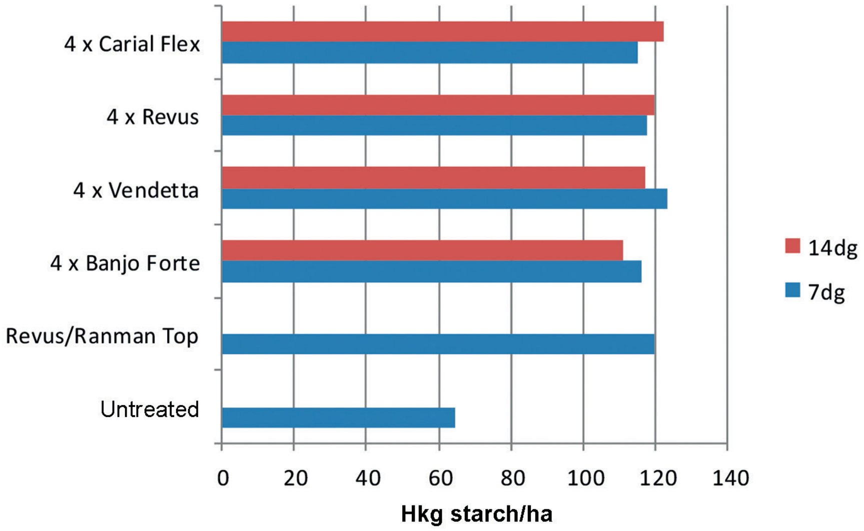


Figure 12. Starch yield (hkg/ha or dt/ha) after treatments with Revus (0.6 l/ha) or Ranman Top (0.5 l/ha), Banjo Forte 4 x 1.0 l/ha, Vendetta 4 x 0.5 l/ha, Revus 4 x 0.6 l/ha and Carial Flex 4 x 0.6 l/ha at 7-day intervals (7dg) or 14-day intervals (14dg) starting on 13 July (Table 1). Variety Eurogrande, Flakkebjerg 2016.

Curative control under field conditions

In order to test the effect of curative products on established lesions of late blight, a trial was set up in almost the same way as in 2014 and 2015 (explanation in Table 2). Spraying was started on 18 July with Proxanil (2.0 l/ha) + Ranman Top (0.25 l/ha) as Treatment 4 and Cymbal (0.25 kg/ha) + Ranman Top (0.5 l/ha) as Treatment 5 at a very low level of attack of late blight (0.01-0.05%). In the following week there was no development in late blight. It was not until 28 July that more widespread attacks of late blight were seen in the plots. The level of attacks across the plots was 0.01% to 0.3% when treatments were started on 28 July by spraying *within the same week* (Table 2). After the sprayings within the week all plots in Treatments 1-5 were sprayed with Ranman Top (0.5 l/ha) or Revus (0.6 l/ha) at weekly intervals (Table 2).

The first small attack was seen on 18 July. Later there were a development in the attacks in untreated plots with a moderate development late August to September reaching approximately 30% attack on 17 September. Spraying with Proxanil at low level of attack (0.01% to 0.3%) in Treatments 2-3 had a very high impact on late blight. The effect of these single sprayings could be seen throughout the season (overall 92% and 94% control respectively) with a trend to higher effect of Treatment 2 (Cymbal in the mid-week). Early spraying (18 July) at very low level of attacks (0.01-0.05%, no real development in late blight) had (slightly) less effect (overall 82-83% control in Treatments 4-5) but still relatively good compared with only contact fungicide sprayings in Treatment 1 with Ranman Top (68% control). The effect of Treatment 3 was significantly different from Treatments 1, 4 and 5 (Figure 13).

Late blight attacks on stems were assessed on 1 August by counting the number of stem lesions in the two middle rows of the trial. There was a low level of attack of stem blight in the untreated plots (18 lesions in total on 18 row m of plants). The assessments were done 14 days after the start of sprayings in Treatments 4-5 and 4 days after the start of sprayings in Treatments 1-3. A clear effect could be seen of the early sprayings with Proxanil + Ranman Top in Treatment 4 and a relatively smaller effect of the other sprayings. There were no statistical significant differences between the treatments.

The trial demonstrated that applying a curative spray at the right time (low level of attack) can reduce the development of late blight significantly when followed up by weekly sprayings at full dose.

Table 2. Trial plan for testing effect of curative control on established lesions of late blight under field conditions. Variety Eurogrande, Flakkebjerg, 2016.

	0.01% attack. No development	0.03-0.3% attack. Active sporulation								
		Within the same week								
	D	E	F	G	H	I	J	K	L	M
	18-07	28-07	02-08	04-08						
1		0.5 RanT		0.5 RanT	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT
2		2.5 PROX + 0.25 RanT	0.25 CYMB + 0.6 RE	0.5 RanT	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT
3		2.5 PROX + 0.25 RanT	0.6 RE	2.5 PROX + 0.25 RanT	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT
4	2.0 PROX + 0.25 RanT	0.5 RanT		0.5 RanT	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT
5	0.25 CYMB + 0.5 Ran T	0.25 CYMB + 0.5 Ran T		0.25 CYMB + 0.5 Ran T	0.5 RanT	0.5 RanT	0.6 RE	0.6 RE	0.5 RanT	0.5 RanT

Attack of late blight: 18 July: 0.01-0.03%. 28 July: 0.03-0.3% attack. RE: Revus 0.6 l/ha, PROX: Proxanil 2.0 l/ha or 2.5 l/ha, RanT: Ranman Top 0.25 l/ha or 0.5 l/ha. Cymb: Cymbal 0.25 kg/ha. Sprayings E-G were within the same week. From 11 August (H) the sprayings in plots 1-5 were full dose of either Ranman Top or Revus.

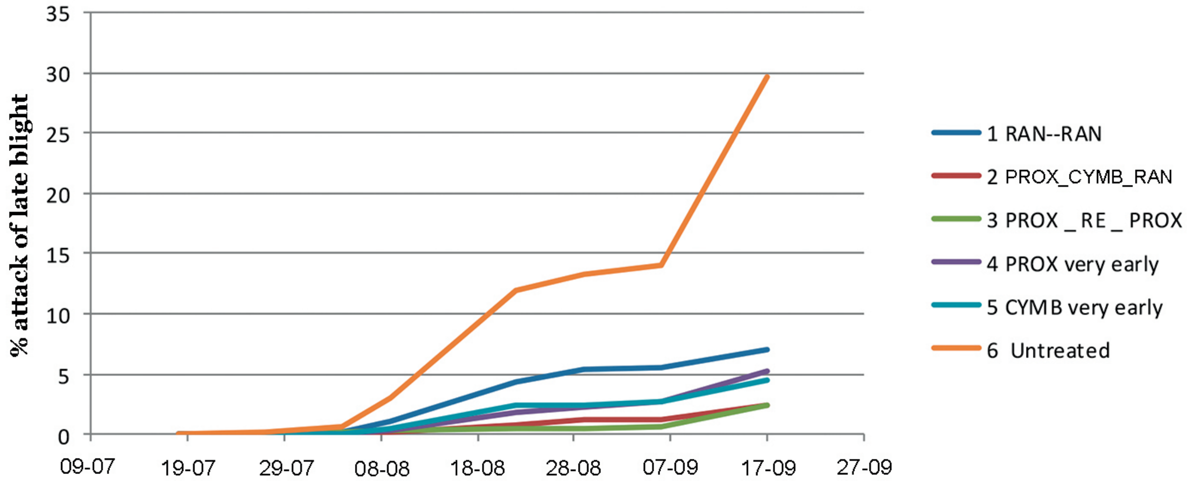


Figure 13. Development of late blight in plots with curative treatments. Explanation of treatment numbers is shown in Table 2. Treatments 4-5 were started on 18 July at a very low level of attack of late blight (0.01-0.05%). Treatments 1-3 were started on 28 July where late blight was seen to be more widespread in the plots. Variety Eurogrande, Flakkebjerg 2016.

Trial with curative control under field conditions at Flakkebjerg 2016. Untreated plots and plots with low disease control can be seen. (Photo: Uffe Pilegård Larsen).

Control of early blight (*Alternaria alternata* & *A. solani*)

Field trials with control of early blight were carried out in 2016 in cooperation with SEGES at three locations (Flakkebjerg, Sunds and Billund). Summary of the trials and conclusions from previous years trials can be seen in "Oversigt over landsforsøgene 2016" (Forsøg og undersøgelser i Dansk Landbrugs-rådgivning, SEGES). Below only the trial at AU Flakkebjerg will be commented.

Table 3. Trial plan for testing different control strategies against early blight (*Alternaria solani*). Variety Kuras, 2016. Actual dates for the sprayings are indicated for the trial at Flakkebjerg. Set-up and the weekly spraying was almost the same in the trials at Billund and Sunds.

			04-07		19-07		02-08		16-08		30-08	
	1	2	3	4	5	6	7	8	9	10	11	12
1												
2			0.6 RT		0.6 RT		0.5 A		0.5 A			
3					0.6 RT		0.6 RT		0.5 A		0.5 A	
4			0.5 VEN		0.5 VEN		0.5 VEN		0.6 RT			
5			0.25 S		0.4 NA		0.25 S		0.4 NA		0.4 NA	
6			0.4 NA		0.4 NA		0.25 S		0.4 NA		0.25 S	
7			0.4 NA		0.25 S		0.4 NA		0.25 S			
8			0.25 S		0.25 S		0.25 S		0.25 S			
NA: Narita 0.5 l/ha, VEN: Vendetta 0.5 l/ha. RT: Revus Top 0.6 l/ha. A: Amistar 0.5 l/ha. S: Signum WG 0.25 kg/ha.												

The trial was performed in the variety Kuras in order to evaluate the effect of spraying with different strategies as explained in Table 3. All strategies were started at the same time as the first small symptoms (4 July). In order to test the effect of delaying the start, spraying with 2 x Revus Top (0.6 l/ha) + 2 x Amistar (0.5 l/ha) was also delayed for 15 days (19 July). Narita was in all sprayings mixed with an additive (additive to Ranman). Spraying with the different strategies had a high impact on *Alternaria* with overall 85-91% control (Figure 14 and Table 4). The only significant difference was the lower effect (75% control) after delaying the start of spraying by 15 days in the 2 x Revus Top + 2 x Amistar strategy. The spraying was done on 19 July and the attack of *Alternaria* was approximately 0.08-2% in the plots of the treatment (at the assessment on 21 July). The lower effect (e.g. compared with the same treatment starting two weeks earlier, Treatment 2) could already be seen 2-3 weeks after the first spraying (Table 4).

The tuber yield in untreated was 556 hkg/ha tubers and 110.1 t/ha starch with an average increase in tuber yield from all the treatments of 28.1 hkg/ha (5.1%, range 2-12%) and 7.8 hkg starch/ha (7%, range 2%-15%) (Table 4).

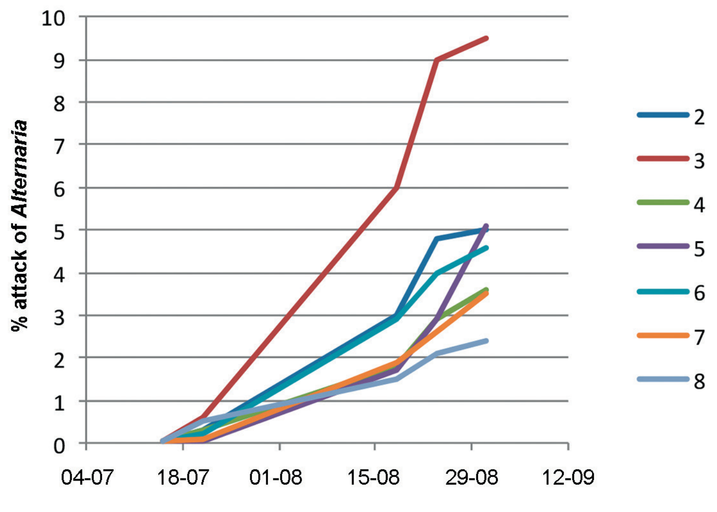


Figure 14. % attack of early blight (*Alternaria solani*) and the development of the disease in plots with different spray strategies. The different treatment numbers are explained in Table 3. Variety Kuras, Flakkebjerg 2016.

Trial with control of *Alternaria* at Flakkebjerg 2016 with untreated plots. 6 September 2016. (Photo: Uffe Pilegård Larsen).

Table 4. Field trials testing different control strategies against early blight (*Alternaria solani* & *A. alternata*). % attack of early blight (*Alternaria solani*) and yield. Variety Kuras, Flakkebjerg 2016. Details of the spray plan are mentioned in Table 3.

	% attacks of *Alternaria*. Flakkebjerg 2016								Yield and yield increase hkg/ha	
	15-Jul	21-Jul	18-Aug	24-Aug	31-Aug	8-Sep	17-Sep	AUDPC	Tubers	Starch
1	0.05	0.8	13.5	24.5	42.5	85.5	98.0	1029.3	556	110.1
2	0.05	0.3	3	4.8	5	7.75	55.0	150.6	47.8	8.4
3	0.04	0.6	6	9	9.5	9.5	37.5	258.7	16.7	9.7
4	0.04	0.3	1.8	2.9	3.6	9.5	52.5	112.7	13.2	6.2
5	0.03	0.06	1.7	2.9	5.1	7.5	25.0	107	20.6	2.1
6	0.04	0.2	2.9	4	4.6	7.5	28.8	130.8	66.2	16.8
7	0.04	0.1	1.9	2.6	3.5	6.75	45.0	96.4	23.3	5
8	0.04	0.5	1.5	2.1	2.4	6.25	46.3	89	8.9	6.1
					LSD 3.6			LSD 76.2	n.s. between treatments	

Spray strategies and fungicide resistance

The trial was performed in the variety Kuras in order to evaluate the effect spraying with 3 x Dithane NT (2.0 kg/ha), 3 x Signum WG (0.25 kg/ha), 3 x Revus Top (0.6 l/ha), 3 x Vendetta (0.5 l/ha), 3 x Amistar (0.5 l/ha), Revus Top (0.6 l/ha) – Amistar (0.5 l/ha) – Signum WG (0.25 kg/ha) and Dithane NT (2.0 kg/ha) – Revus Top (0.6 l/ha) – Signum WG (0.25 kg/ha) (Table 5). Spraying against *Alternaria* was started on 13 July (A) and the level of attack was approximately 0.05%. The spray interval was 2 weeks with following sprays on 26 July (B) and 9 August (C).

Spraying three times with Amistar (0.5 l/ha), Signum WG (0.25 kg/ha) or Vendetta (0.5 l/ha) had a high impact on *Alternaria* with overall 85-88% control (Figure 15). Spraying with Revus Top had a significantly lower effect (65% control). Dithane NT had, as expected, an effect of 47% control, which was significantly lower than the effect of the other products. From the level of control of Amistar it can be seen that the *Alternaria* population was susceptible to strobilurin fungicides. Spraying with Revus Top

– Amistar – Signum WG resulted in a very high level of control (89%) at the level of Amistar, Signum WG or Vendetta. However, the strategy Dithane NT – Revus Top – Signum WG resulted in a significantly lower effect (72% control) (Figure 15).

The yield in untreated was 483 hkg/ha tubers and 90.7 hkg/ha starch with an average increase in tuber yield from the treatments with Amistar, Signum, Vendetta or Revus Top of 42 hkg/ha (8.7%, range 5-12%) and 10 hkg starch/ha (11%, range 6-15%) (Figure 16).

Table 5. Trial plan for testing different control strategies against early blight (*Alternaria solani*). Variety Kuras, 2016. Actual dates for the sprayings are indicated for the trial at Flakkebjerg. Set-up and the weekly spraying was almost the same in the trials at Billund and Sunds.

			13-07		26-07		09-08	
	1	2	3	4	5	6	7	8
2			Dithane		Dithane		Dithane	
3			0.25 S		0.25 S		0.25 S	
4			0.6 RT		0.6 RT		0.6 RT	
5			0.5 VEN		0.5 VEN		0.5 VEN	
6			0.5 A		0.5 A		0.5 A	
7			0.6 RT		0.5 A		0.25 S	
8			Dithane		0.6 RT		0.25 S	
Dithane: Dithane NT 2.0 kg/ha, VEN: Vendetta 0.5 l/ha. RT: Revus Top (0.6 l/ha). A: Amistar 0.5 l/ha. S: Signum WG 0.25 kg/ha.								

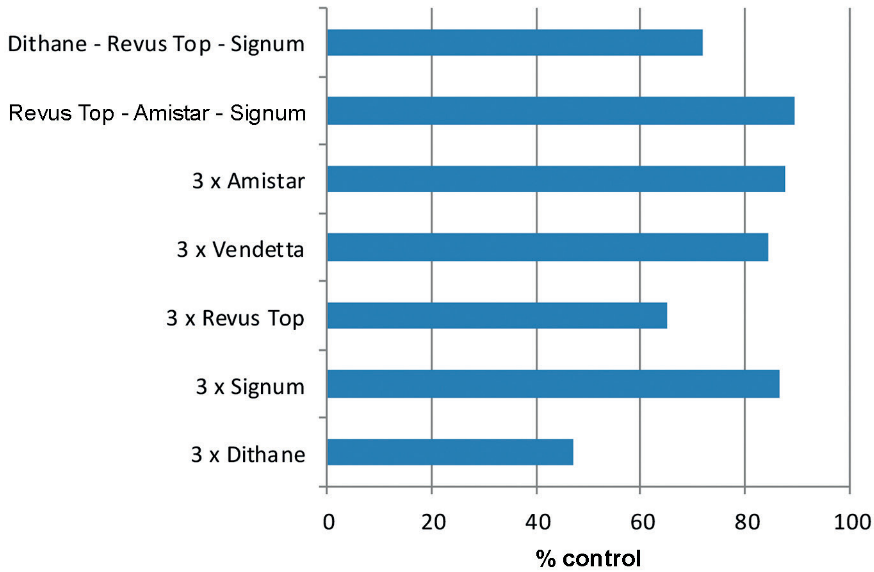


Figure 15. % control (based on AUDPC) of early blight (*Alternaria solani*) after the different spray strategies starting on 13 July (Table 5). Variety Kuras, Flakkebjerg 2016.

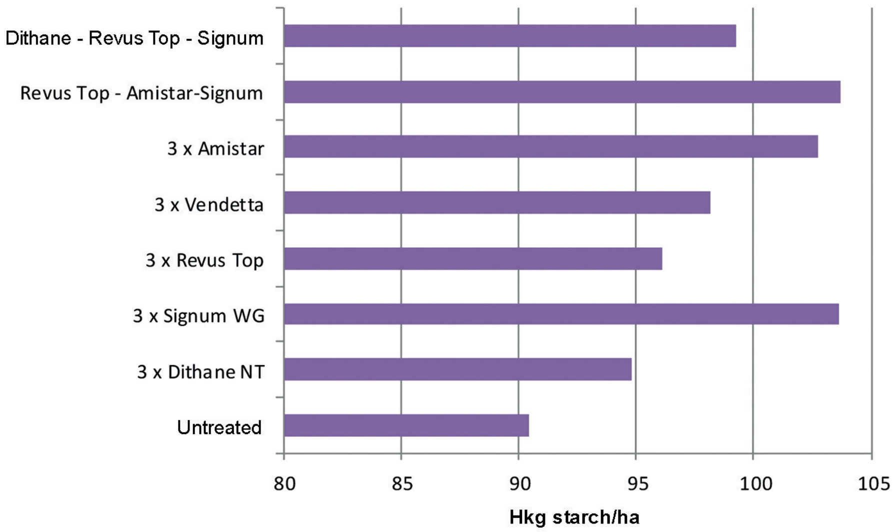


Figure 16. Starch yield (hkg/ha or dt/ha) after the different treatments (Table 5). Variety Kuras, Flakkebjerg 2016.

Comparing *Alternaria* fungicides

The trial was carried out in order to evaluate the effect of Revus Top, Amistar, Signum WG, Vendetta and Narita in combinations with either Ranman Top or Revus (Table 6). Spraying was done two times A: 4 July and B: 18 July at 14-day spray intervals. The first spraying was done before the first symptoms were recorded. Treatment 7 (Narita 0.5 l/ha + Ranman Top 0.5 l/ha) was deleted due to a spraying error.

There was a high impact of two sprayings early in the season with Amistar (0.5 l/ha) and Vendetta (0.5 l/ha) with overall 90% control and 81% control respectively (based on AUDPC values) (Figures 17-19). The effect of Signum WG at two sprayings was a little lower (68% control, Figure 17). In general spraying with difenoconazole products two times early in the season resulted in less long-lasting effect with Narita 0.4 l/ha + Ranman Top 0.5 l/ha 58% control and Revus Top 0.6 l/ha 51% control. Combining Narita 0.4 l/ha with either Ranman Top or Revus showed best effect for the combination with Ranman Top (58% control) compared with the combination with Revus (45% control). There was a clear dose response using 0.4 l/ha and 0.6 l/ha of Revus Top sprayed two times early in the season (Figure 19).

Table 6. Trial plan for comparing *Alternaria* fungicides. Variety Kuras, 2016. Actual dates for the sprayings are indicated for the trial at Flakkebjerg.

				04-07		18-07	
	1	2	3	4	5	6	7
1							
2				0.6 RT		0.6 RT	
3				0.4 RT		0.4 RT	
4				0.5 A		0.5 A	
5				0.25 S		0.25 S	
6				0.5 VEN		0.5 VEN	
7				0.5 NA+RANT		0.5 NA+RANT	
8				0.4 NA+RANT		0.4 NA+RANT	
9				0.5 NA+RE		0.5 NA+RE	
10				0.4 NA+RE		0.4 NA+RE	
				Beginning minor attacks			
NA: Narita 0.5 l/ha mixed with either RANT: Ranman Top 0.5 l/ha or RE: Revus 0.6 l/ha. VEN: Vendetta 0.5 l/ha. RT: Revus Top (0.6 l/ha). A: Amistar 0.5 l/ha. S: Signum WG 0.25 kg/ha.							

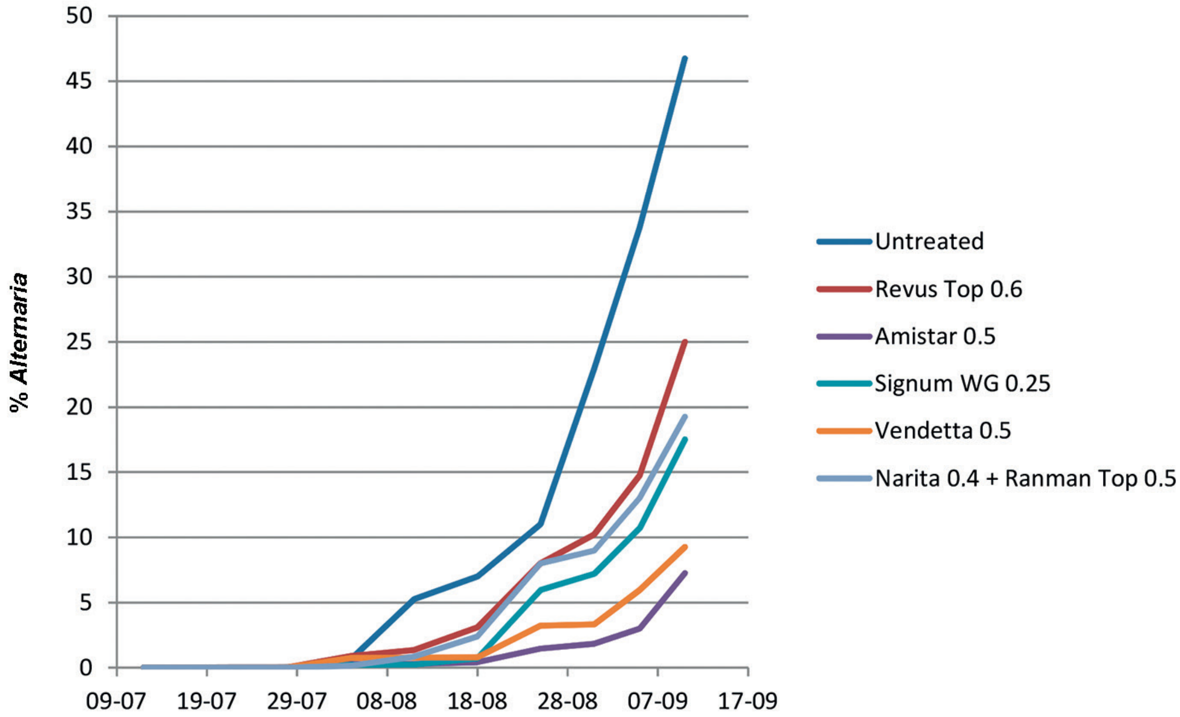


Figure 17. % attack of early blight (*Alternaria solani*) and the development of the disease in plots with different spray strategies. The different treatment numbers are explained in Table 6. Variety Kuras, Flakkebjerg 2016.

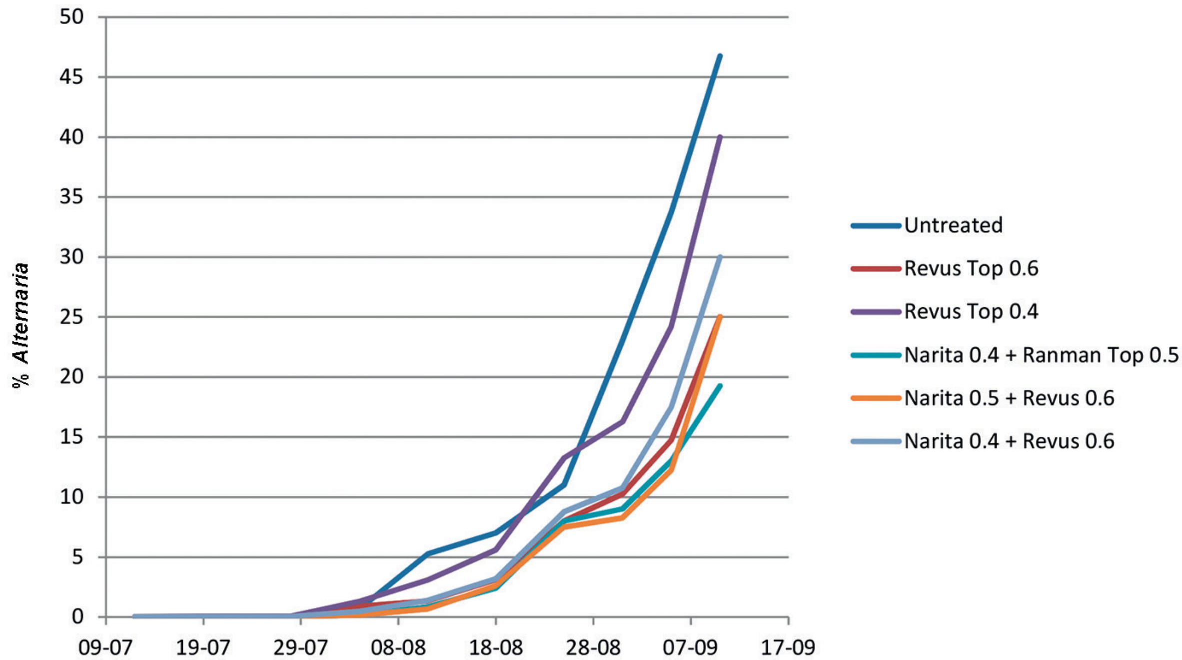


Figure 18. % attack of early blight (*Alternaria solani*) and the development of the disease in plots with different spray strategies (Narita combinations). The different treatment numbers are explained in Table 6. Variety Kuras, Flakkebjerg 2016.

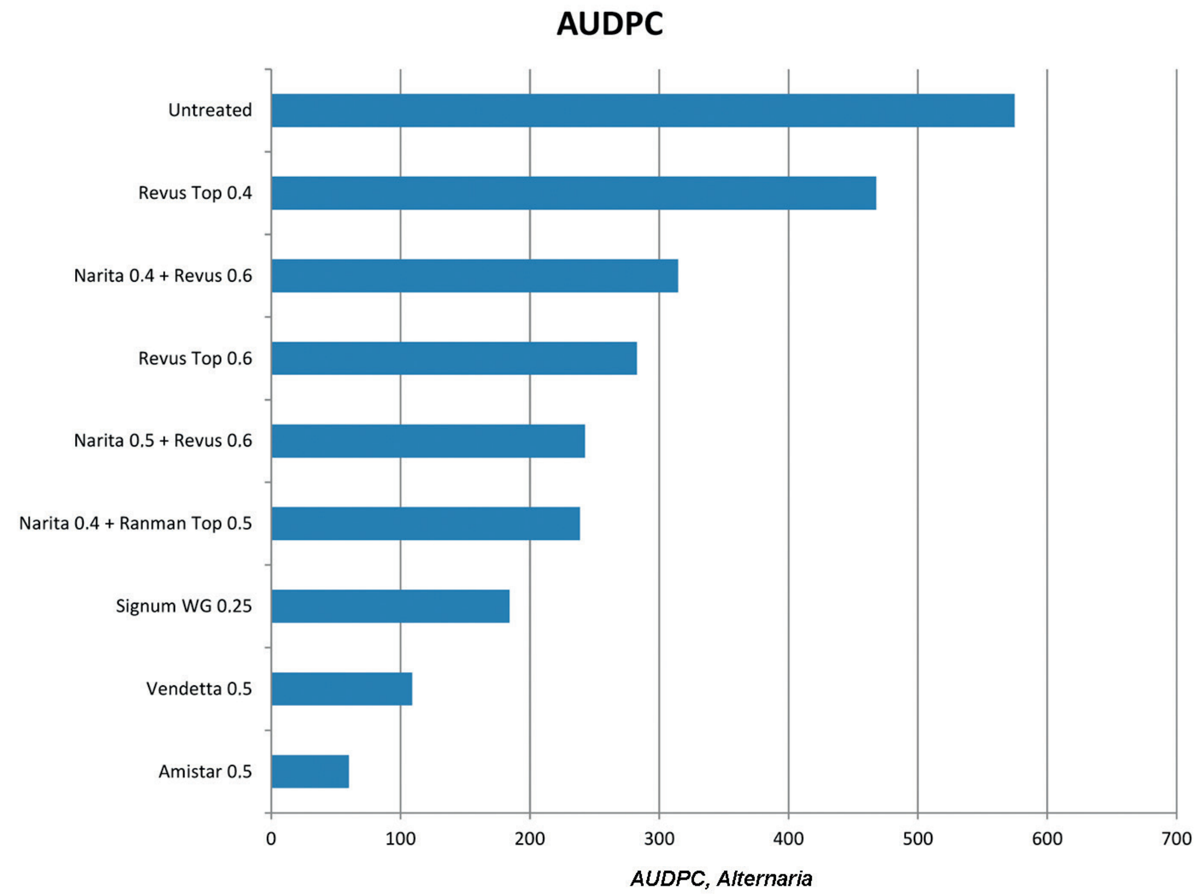


Figure 19. Area under disease progress curve (AUDPC) for early blight (*Alternaria solani*) for the different spray strategies (Table 6). Variety Kuras, Flakkebjerg 2016.

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X Longevity of seeds of Italian rye-grass following different stubble cultivation treatments

Peter Kryger Jensen

Italian rye-grass (*Lolium multiflorum*) is in some areas considered a troublesome weed. The purpose of the present experiment was to test the influence of different stubble treatments on the longevity of newly shed seeds of Italian rye-grass. Two types of experiments were conducted, a field experiment using normal tillage implements and a small plot field experiment simulating the influence of various tillage treatments on placement of seeds in the soil profile. In the experiment simulating tillage treatments, samples of seeds were placed at distinct soil depths and the longevity of the seed samples following these treatments was assessed. In the field experiment using relevant tillage implements the working depth of the implement was controlled, but the influence on the placement of the seeds in the soil profile following the treatment was not assessed. However, assessing Italian rye-grass seedling emergence and longevity in the two types of studies gives an indication of how seed incorporation in the soil profile is influenced by the tillage implements. Both trials were repeated twice in 2015 and 2016. In both experiments newly harvested seeds of Italian rye-grass (cultivar Fox) were used.

The field experiment was in both years carried out in a stubble field after harvest of winter barley and removal of the straw. Treatments, assessments and applications are shown in Table 1.

Table 1. Treatments, assessments and applications in the field experiment.

Activity	2015	2016
Harvest of winter barley and removal of straw	3 August	18 July
Distribution of Italian rye-grass seeds on stubble	4 August	1 August
1st stubble treatment	4 August	1 August
2nd stubble treatment	24 August	23 August
1st count of germinated rye-grass seedlings	14 September	14 September
Control of germinated rye-grass seedlings with glyphosate before seedbed preparation	16 September	15 September
Seedbed preparation	30 September	27 September
2nd count of germinated Italian rye-grass	19 December	14 December

Italian rye-grass was sown in the stubble at a rate corresponding to 235 seeds per m2 in 2015 and 80 seeds per m^2 in 2016. The different stubble treatments included in the field trial are shown in Table 2. The implements used for stubble treatment and seedbed harrowing are shown in photos 1-3. The seedbed treatment in late September included driving with a seedbed harrow or a direct drilling machine but without sowing of a crop. Seedlings of Italian rye-grass were counted two times in the autumn (Tables 3 & 4). The first assessment shows the influence of the stubble cultivation treatments on the establishment of Italian rye-grass seedlings and the late assessment in December is taken as an indicator of the effect of the stubble cultivation treatments on longevity of rye-grass seeds. On the first assessment date in 2015 (Table 3) there was a reduced number of plants in treatments with stubble harrowing to 5 and 10 cm depth compared with treatments with no cultivation at all and the shallow treatments with the flex-tine weeder. The number of seedlings was lowest in treatments with stubble harrowing to 5 and 10 cm depth 3 weeks after harvest. This is probably due to a control of a proportion of the emerged seedlings using this intensive treatment. Using the flex-tine weeder there was no difference in Italian rye-grass seedling density as affected by timing. This indicates that the second treatment with the flex-tine weeder did not control emerged seedlings. The results of the first assessments also show that emergence and establishment of Italian rye-grass seedlings in the stubble were unaffected of whether the stubble was left undisturbed or a shallow soil disturbance was made using the flex-tine weeder. The results of the early assessment in 2016 (Table 4) followed the same trend with a lower number of Italian rye-grass seedlings following the two stubble cultivation treatments to 5 or 10 cm depth. Following the first assessment emerged seedlings was controlled with a glyphosate application and later in the month a seedbed was prepared using the treatments described in Table 2. Seedlings of Italian rye-grass following the seedbed preparation were counted in December (Tables 3 and 4). The density of seedlings at this assessment date is taken as an indication of the longevity of seeds of Italian rye-grass following the different stubble treatments. The density was, however, generally very low in both years, and therefore no significant differences between stubble treatments were found. It cannot be precluded that some dormant seeds are remaining in the soil, and this would especially be expected following the two deeper stubble cultivations to 5 and 10 cm depth.

Flex-tine weeder.

Horsch direct drill.

Seedbed harrow.

Stubble harrow.

Table 2. Stubble treatment – timing, implement and tillage depth.

Treatment number	Immediately after harvest (4 August)	Approximately 3 weeks after harvest (24 August)	Seedbed late September (30 September)
1.	None	None	2 x seedbed harrowing 2-4 cm
2.	2 x flex-tine weeder 1-2 cm		2 x seedbed harrowing 2-4 cm
3.	2 x flex-tine weeder 2-4 cm		2 x seedbed harrowing 2-4 cm
4.	2 x stubble harrowing 5 cm		2 x seedbed harrowing 2-4 cm
5.	2 x stubble harrowing 10 cm		2 x seedbed harrowing 2-4 cm
6.		2 x flex-tine weeder 1-2 cm	2 x seedbed harrowing 2-4 cm
7.		2 x flex-tine weeder 2-4 cm	2 x seedbed harrowing 2-4 cm
8.		2 x stubble harrowing 5 cm	2 x seedbed harrowing 2-4 cm
9.		2 x stubble harrowing 10 cm	2 x seedbed harrowing 2-4 cm
10.	2 x flex-tine weeder 1-2 cm	2 x flex-tine weeder 1-2 cm	2 x seedbed harrowing 2-4 cm
11.	None	None	No-till drilling
12.	2 x flex-tine weeder 1-2 cm		No-till drilling
13.	2 x flex-tine weeder 2-4 cm		No-till drilling
14.	2 x stubble harrowing 5 cm		No-till drilling
15.	2 x stubble harrowing 10 cm		No-till drilling
16.	2 x flex-tine weeder 1-2 cm	2 x flex-tine weeder 1-2 cm	No-till drilling

Table 3. Density of Italian rye-grass seedlings following different stubble cultivations in 2015.

Immediately after harvest (4 August)	Approximately 3 weeks after harvest (24 August)	Seedbed late September (30 September)	No. of rye-grass seedlings per m^2 (14 September)	No. of rye-grass seedlings per m^2 (19 December)
None	None	Seedbed harrow 2-4 cm	52	0.25
Flex-tine weeder 1-2 cm		Seedbed harrow 2-4 cm	71	0
Flex-tine weeder 2-4 cm		Seedbed harrow 2-4 cm	73	0
Stubble harrow 5 cm		Seedbed harrow 2-4 cm	38	0.25
Stubble harrow 10 cm		Seedbed harrow 2-4 cm	28	0.5
	Flex-tine weeder 1-2 cm	Seedbed harrow 2-4 cm	55	0.5
	Flex-tine weeder 2-4 cm	Seedbed harrow 2-4 cm	46	0
	Stubble harrow 5 cm	Seedbed harrow 2-4 cm	16	0.75
	Stubble harrow 10 cm	Seedbed harrow 2-4 cm	9	0.25
Flex-tine weeder 1-2 cm	Flex-tine weeder 1-2 cm	Seedbed harrow 2-4 cm	71	0
None	None	No-till drilling	72	0
Flex-tine weeder 1-2 cm		No-till drilling	73	0
Flex-tine weeder 2-4 cm		No-till drilling	79	0.25
Stubble harrow 5 cm		No-till drilling	36	0.5
Stubble harrow 10 cm		No-till drilling	27	0
Flex-tine weeder 1-2 cm	Flex-tine weeder 1-2 cm	No-till drilling	60	0.25
LSD (p=0.05)			17	NS

Table 4. Density of Italian rye-grass seedlings following different stubble cultivations in 2016.

Immediately after harvest (4 August)	Approximately 3 weeks after harvest (24 August)	Seedbed late September (30 September)	No. of rye-grass seedlings per m^2 (14 September)	No. of rye-grass seedlings per m^2 (14 December)
None	None	Seedbed harrow 2-4 cm	6	0.75
Flex-tine weeder 1-2 cm		Seedbed harrow 2-4 cm	8	0.75
Flex-tine weeder 2-4 cm		Seedbed harrow 2-4 cm	7	0.5
Stubble harrow 5 cm		Seedbed harrow 2-4 cm	6	1.5
Stubble harrow 10 cm		Seedbed harrow 2-4 cm	6	0.75
	Flex-tine weeder 1-2 cm	Seedbed harrow 2-4 cm	5	0.5
	Flex-tine weeder 2-4 cm	Seedbed harrow 2-4 cm	5	0.75
	Stubble harrow 5 cm	Seedbed harrow 2-4 cm	2	0.0
	Stubble harrow 10 cm	Seedbed harrow 2-4 cm	3	0.25
Flex-tine weeder 1-2 cm	Flex-tine weeder 1-2 cm	Seedbed harrow 2-4 cm	9	0.25
None	None	No-till drilling	8	0.5
Flex-tine weeder 1-2 cm		No-till drilling	9	0.75
Flex-tine weeder 2-4 cm		No-till drilling	9	0.5
Stubble harrow 5 cm		No-till drilling	4	0.25
Stubble harrow 10 cm		No-till drilling	4	0.25
Flex-tine weeder 1-2 cm	Flex-tine weeder 1-2 cm	No-till drilling	7	0.25
LSD (p=0.05)			3	NS
* NS = not significant				

The small plot field experiment was carried out using seeds from the same seed lot. Samples of 400 seeds were counted and placed either at the soil surface or buried at different depths in the first week of August. Two treatments included placement of the seeds at the soil surface. In the first treatment seeds were left directly at the soil surface, whereas in the second treatment a shallow harrowing was carried out with the fingers to mimic shallow soil tillage. The treatments with placement of seeds at the soil surface was carried out in small pots, whereas the treatments including burial at different depths were carried out using samples with seeds mixed with soil and placed in fabric mesh bags. By the end of September all samples were collected from the field and a germination test was carried out in the laboratory. During the germination test soil samples were kept moist to ensure optimal conditions for germination. The number of germinated seedlings was counted when emergence ceased, and this figure (Figures 1 and 2) is taken as an indication of the influence of the various field treatments on the longevity of Italian rye-grass seeds. The result varied between the two years. In 2015 (Figure 1) the lowest viability was found in seeds left at the surface, and there was no influence of finger harrowing. With increasing depth increasing viability was generally found this year. Obviously it seems that the “finger harrowing” had a limited influence on seed placement and hence longevity. In 2016 there was no significant difference between seeds left at the surface and seeds incorporated to 5 cm depth. A larger viability was, however, also seen in 2016 for seed samples incorporated to 10 and 25 cm depth.

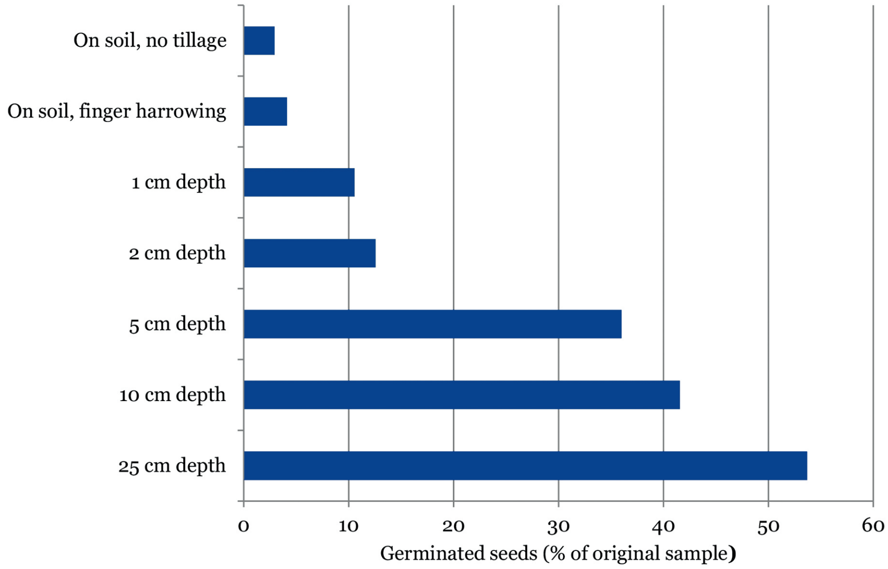

Figure 1. Germination of seeds of Italian rye-grass from samples kept at different soil depths in the field from beginning of August to the end of September 2015. The figures show the number of plants in the germination test as a percentage of the original seed sample. LSD =4.75.

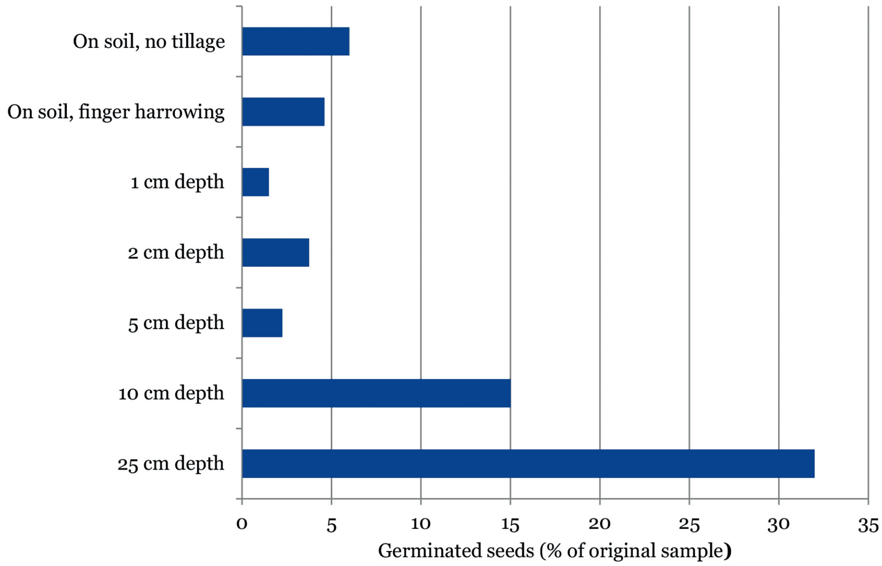

Figure 2. Germination of seeds of Italian rye-grass from samples kept at different soil depths in the field from beginning of August to the end of September 2016. The figure shows the number of plants in the germination test as a percentage of the original seed sample. LSD=5.6.

Conclusion

The results of the two experiments are parallel and support the general conclusion that stubble treatment strategy can have a large influence on the persistence of newly shed seeds. The longevity of Italian rye-grass seeds was very limited at the soil surface. When seeds were incorporated, a much higher percentage of the seeds survived, and this percentage increased with increasing burial depth. An important question is how superficial stubble treatments influence incorporation of seeds and hence longevity. The experiment with full-scale tillage implements as well as the experiment with simulated "finger harrowing" showed that there was no negative influence of a shallow tillage probably because neither the "finger harrowing" nor the flex-tine weeder incorporates the seeds.

XI Effects of new adjuvants, N32 and pH of the spray solution on herbicide efficacy

Solvejg K. Mathiassen

This chapter reports the results of pot experiments conducted to study the effect of new adjuvants, a liquid nitrogen fertiliser (N32) and pH of the spray liquid on herbicide activity. Each experiment was only conducted once and should be replicated or followed up by additional experiments.

Influence of pH and adjuvants on the efficacy of MaisTer

MaisTer is authorised for the control of broadleaved and grass weeds in forage maize. MaisTer contains foramsulfuron and iodosulfuron (300 + 10 g/kg) and is recommended applied in mixture with MaisOil. In this experiment we compared the efficacy of MaisTer + MaisOil (1.33 L/ha) with two new adjuvants – Fieldor Max (0.15%) and Gondor (0.15%). Fieldor Max is a penetration oil and Gondor is a non-ionic surfactant. Gondor is claimed to reduce drift and increase the rainfastness. We also examined the influence of pH of the spray solution on MaisTer efficacy. Previous studies have shown that the biological efficacy of some sulfonylureas is affected by pH (Green & Cahill, 2003). High pH increases the solubility of the sulfonylureas but is also expected to reduce uptake. In this experiment we reduced pH of spray solutions of MaisTer + MaisOil from 7.8 to 5 using K_2HPO_4 and enhanced pH to 9 using K_3PO_4. We also tested MaisTer + MaisOil (1.3 L/ha) in mixture with pH Fix 5 (0.2%), which is an adjuvant adjusting pH to 5.

All spray solutions were prepared in tap water with a hardness of 18. Each treatment was applied at six MaisTer doses to pot-grown *Setaria viridis* at the 4-leaf stage. Adjustment of pH was made before MaisTer was added to the water. Plants were harvested 4 weeks after herbicide application and fresh and dry weights were recorded. A dose-response model was fitted to the data and ED_{50} doses were estimated.

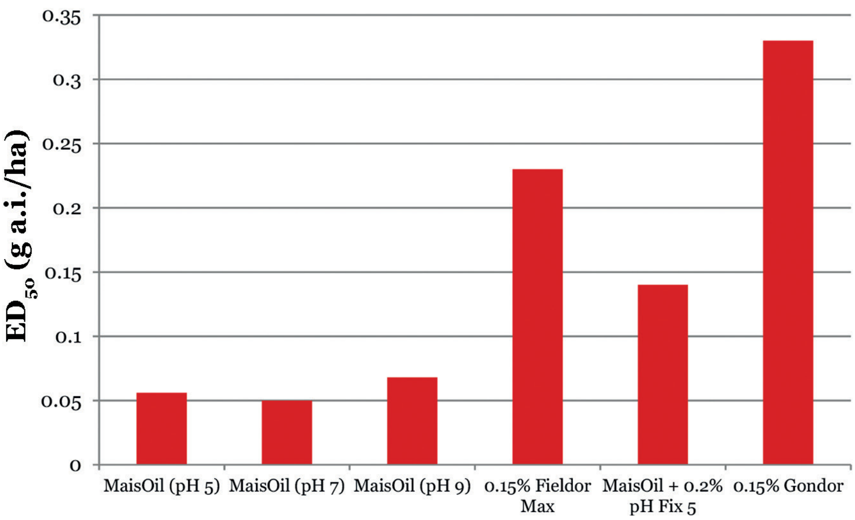

Figure 1. Activity of MaisTer (300 g/kg foramsulfuron + 10 g/kg iodosulfuron) on *S. viridis*. The columns show the dose of MaisTer (g a.i./ha) that was required to reduce fresh weight by 50% (ED_{50}). MaisOil was applied at 1.33 L/ha.

Adjustments of pH of spray solutions of MaisTer + Maisoil had no effect on herbicide activity (Figure 1). Significantly higher effects of MaisTer were obtained in mixture with MaisOil compared with pH Fix 5, Fieldor Max and Gondor.

Influence of pH and adjuvants on the efficacy of Monitor

Monitor contains 800 g/kg sulfosulfuron and is authorised for control of broadleaved and grass weed species, specifically *Bromus* species, *Apera spica-venti* and *Poa trivialis*. Currently, the maximum dose is 2 x 12.5 g/ha or 1 x 18.75 g/ha. However, these doses will most likely be reduced in future due to changes in the risk envelope. It is recommended to apply Monitor in mixture with 0.2% non-ionic surfactant. In this study we examined the effect of Monitor + 0.2% Agropol at different pH of the spray solution. In addition the effect of adding pH Fix 5 (0.2%) and NovaBalance (0.1%) to the spray water was examined. Both of these adjuvants reduce pH of the spray solutions to 5. Finally the effect of Gondor (0.15%) was tested.

All spray solutions were prepared in tap water with a hardness of 18. The pH of the spray solutions was reduced to 5 using K_2HPO_4 and increased to 9 using K_3PO_4. Each treatment was applied at six Monitor doses to *A. spica-venti*. Adjustment of the pH of the water (including pH Fix 5 and NovaBalance) was made before Monitor was added to the water. Plants were harvested 4 weeks after herbicide application and fresh and dry weights were recorded. A dose-response model was fitted to the data and ED_{50} doses were estimated.

Overall, no significant differences in activity of the different treatments were obtained. Under the conditions tested neither adjustment of pH of the spray solutions nor addition of NovaBalance or pH Fix 5 had any significant effect on the activity of Monitor + Agropol (Figure 2). The activity of Monitor was similar in mixture with Gondor and Agropol.

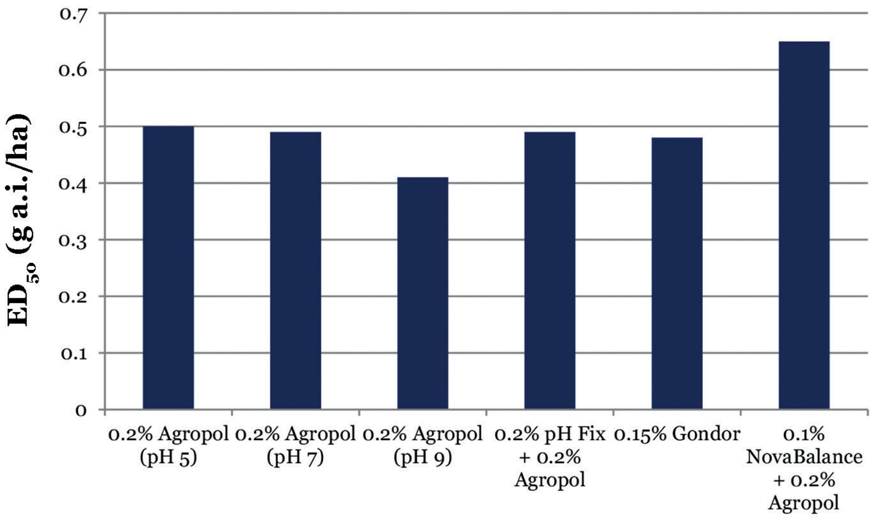

Figure 2. The effect of different adjuvants and pH of spray solutions on the activity of Monitor (800 g/kg sulfosulfuron) on *A. spica-venti*. The columns show the dose of Monitor (g a.i./ha) that is required for reducing fresh weight of plants by 50% (ED_{50}).

Influence of adjuvants on the activity of glyphosate formulations

The efficacy of Glyphogan (360 g/L glyphosate), Glyfonova 480 (480 g/L glyphosate) and Roundup Flex (480 g/L glyphosate) applied alone and in mixture with ammonium sulphate (AMS) + Contact (2 kg/ha + 0.2%) or NovaBalance + Contact (0.2 L/ha + 0.2%) was examined on *Elytrigia repens*. The plants were established in the spring 2015 by planting three one-node rhizomes in 2-L pots. The plants were grown outdoors until late autumn when they were moved to a cold glasshouse (min. temperature 2°C). In spring 2016 the plants were moved outdoors again. In June above-ground plant material was cut and removed. Herbicide treatments were applied in mid-July when the plants had 4 leaves. Each treatment was applied at 4 glyphosate doses (135, 270, 540 and 1080 g/ha glyphosate). Spray solutions were prepared in tap water with a hardness of 18 and a pH of 7.8. Plants were cut at soil surface 4 weeks after treatments and the efficacy was assessed by recording leaf regrowth from the rhizomes.

Results of fresh weights of regrowth are shown in Figure 3. No significant differences in efficacy were found between formulations applied without adjuvants. The effects of all formulations were significantly increased in mixture with AMS + Contact and NovaBalance + Contact with no significant differences between the adjuvants.

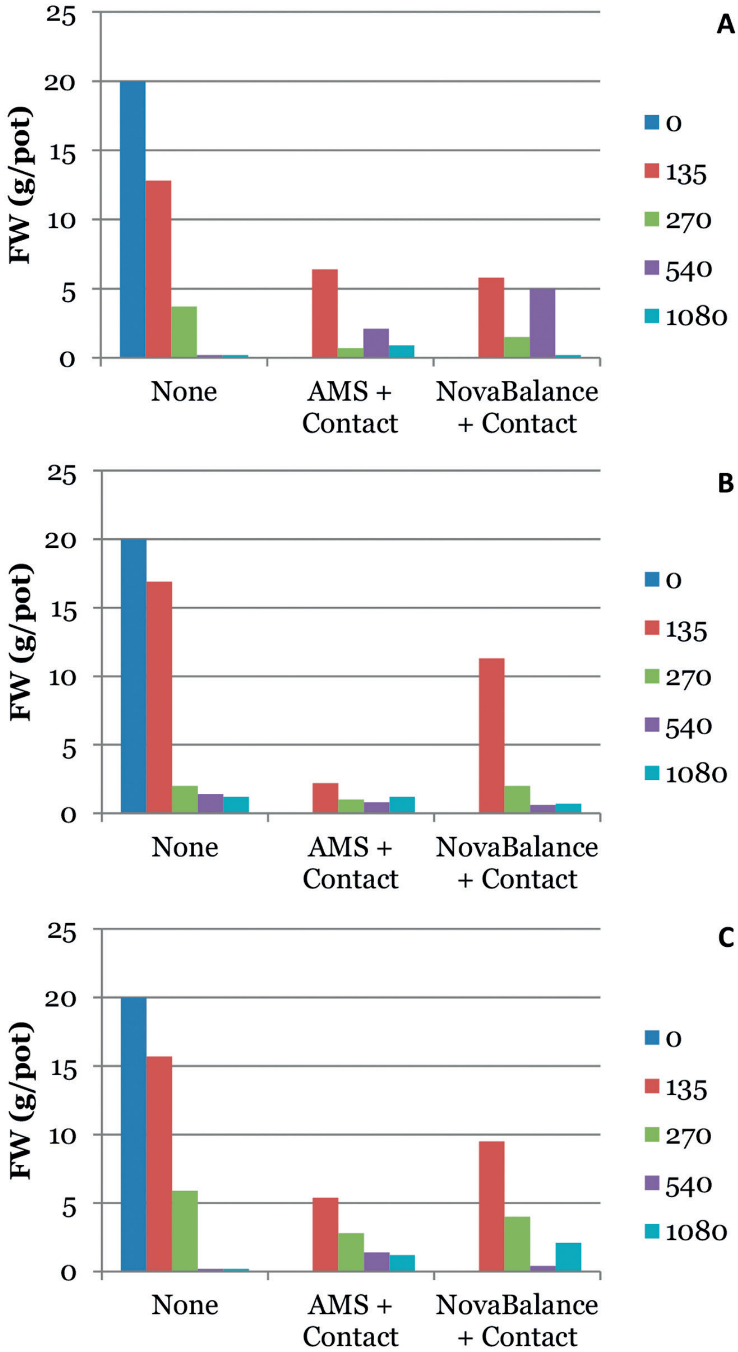

Figure 3. The efficacy of Glyphogan (A), Glyfonova 480 (B) and Roundup Flex (C) alone and in mixture with ammonium sulphate (AMS) + Contact (2 kg/ha + 0.2%) or NovaBalance + Contact (0.2 L/ha + 0.2%) on regrowth of *E. repens*.

Effect of Support Kip-R on the activity of Boxer and Kerb

Support Kip-R is specifically recommended as an adjuvant to herbicides with soil activity. According to the manufacturer Support Kip-R encapsulates the herbicide and induces an electrical charge at the herbicide surface, which prolongs the time that the active ingredient spends in the root zone. Support Kip-R is recommended at a dose of 0.2-0.4 L/ha.

We tested the effect of Boxer (800 g/L prosulfocarb) and Kerb (400 g/L propyzamide) alone and in mixture with 0.3 L/ha Support Kip-R on *Poa annua* and *Stellaria media*. Six doses of each herbicide were applied alone and in mixture with Support Kip-R two days after sowing. In order to distribute the herbicides evenly in the upper soil layer, 25 mL of water was added to the soil surface after spraying. The pots were placed in a glasshouse at a temperature of 10-15°C. The plants were harvested 8 weeks after herbicide application.

Support Kip-R had no significant effect on the activity of Kerb and Boxer on *P. annua* and *S. media* (Table 1).

Table 1. Influence of Support Kip-R on the effect of Boxer (800 g/L prosulfocarb) and Kerb (400 g/L propyzamide) on *P. annua* and *S. media*. ED_{50} is the dose required for reducing fresh weight of the weed species by 50%.

Herbicide	Weed species	Adjuvant	ED_{50} (g a.i./ha)
Kerb	*P. annua*	None	5.1
		Support Kip-R	5.0
	S. media	None	43.7
		Support Kip-R	42.8
Boxer	*P. annua*	None	142.3
		Support Kip-R	145.2
	S. media	None	57.0
		Support Kip-R	53.6

Effect of N32 on herbicide efficacy on *Vulpia myuros*

N32 is a liquid fertiliser containing 7.9% nitrogen as N-ammonium, 7.9% as N-nitrate and 15.9% as N-amide. The effect of applying Boxer (800 g/L prosulfocarb), Broadway (68.3 g/kg pyroxsulam + 22.8 g/kg florasulam) and Glyphomax (360 g/L glyphosate) in mixture with N32 was examined in a pot experiment using *Vulpia myuros* as test plant. The plants were grown outdoors.

Boxer was applied at the 3-4 leaf stage while Broadway and Glyphomax were applied at two growth stages - the 3-4 leaf stage and when plants had 6 leaves and 2 tillers. Each herbicide was applied at 5 doses. Boxer was applied alone and in mixture with N32 (30 L/ha). Glyphomax was applied in mixture with N32 (30 or 60 L/ha) and ammonium sulphate (AMS) + Contact (2 kg/ha + 0.1%). Broadway was applied in mixture with the recommended adjuvant PG26N (0.5 L/ha) and PG26N + N32 (0.5 L/ha + 30 L/ha).

The plants were harvested 4 weeks after treatment. Fresh and dry weight was recorded. A dose-response model was fitted to the data and ED_{50} doses were estimated.

Table 2. Influence of N32 on the activity of Boxer (800 g/L prosulfocarb), Broadway (68.3 g/kg pyroxsulam + 22.8 g/kg florasulam) and Glyphomax (360 g/L glyphosate) on *Vulpia myuros*. ED_{50} is the dose required for reducing fresh weight of *V. myuros* by 50%.

Herbicide	Growth stage	Adjuvant	ED_{50} (g a.i./ha)
Boxer	3-4 leaves	None	354
		30 L/ha N32	515
Broadway	3-4 leaves	0.5 L/ha PG26N	11.9
		0.5 L/ha PG26N + 30 L/ha N32	7.0
	2 tillers	0.5 L/ha PG26N	19.9
		0.5 L/ha PG26N + 30 L/ha N32	11.1
Glyphomax	3-4 leaves	None	65
		30 L/ha N32	47
		60 L/ha N32	34
		2 kg/ha AMS + 0.1% Contact	< 30
	2 tillers	None	< 30
		30 L/ha N32	< 30
		60 L/ha N32	< 30
		2 kg/ha AMS + 0.1% Contact	< 30

N32 had no effect on the activity of Boxer but improved the efficacy of Broadway and Glyphomax (Table 2). For Broadway + PG26N the ED_{50} dose was reduced by 40% when N32 was added to the spray solution. The efficacy of Broadway was higher at the 3-4 leaf stage compared with the tillering stage. At the 3-4 leaf stage of *V. myuros* the effect of Glyphomax was significantly increased in mixture with N32. However, the efficacy in mixture with AMS + Contact was similar to the efficacy in the tank mix with 60 L/ha N32. Generally the efficacy of Glyphomax was higher at the tillering stage compared with the 3-4 leaf stage. The high efficacy in the mixture with N32 and AMS + Contact is suggested to be caused by a higher retention of spray liquid on the waxy leaves of *V. myuros* and/or increased uptake. *Vulpia myuros* is difficult to control and the possibility to improve the efficacy on this species is interesting. Additional trials are planned to examine crop selectivity of tank mixtures of herbicides and N32 and to study the effect on other weed species.

Field treated with 0.2 L/ha Cossack (10 g/L mesosulfuron + 2 g/L iodosulfuron) + 80 g/ha Broadway (68.3 g/kg pyroxsulam + 22.8 g/kg florasulam) around 1 April. Two weeks later the field border was treated with 50 g/ha Broadway + 100 L/ha N32. (Photo: Lars Albrecht Karr).

References

Green, J. M. and W. R. Cahill (2003). Enhancing the Biological Activity of Nicosulfuron with pH Adjusters. Weed Technology 17: 338-345.

XII Results from trials with herbicides and growth regulators in agricultural crops in 2016

Verner Lindberg, Henrik Jespersen & Steen Sørensen

During the 2015–2016 season 65 trials with herbicides and growth regulators were conducted in agricultural crops. Most trials were conducted in winter and spring cereals (43); of these 24 were autumn treatments in winter cereals; the remaining trials were conducted in winter oilseed rape, maize and seed grass; of these 6 were growth regulation trials in seed grass. As the majority of the trials are confidential, only results from the growth regulation trials in seed grass will be shown below.

Materials and methods

All testing trials are conducted as field trials. Most are located at farmers' fields in Zealand in order to meet specific demands regarding cultivar, soil and composition of the weed flora, but a few trials are located at AU Flakkebjerg.

All trials are conducted as GEP trials in accordance with EPPO guidelines and the trial protocol. Applications are made with a self-propelled sprayer, in which the spray pressure is achieved with atmospheric air. As standard the applications are conducted with a Hardi low drift nozzle LD-015-110 with 150 litres of water/ha, a nozzle pressure of 2.6 bar and a boom speed of 4.5 km/h.

In the growth regulation trials in seed grass the assessments of crop damage and lodging were made from treatment until harvest and the height of the crop was measured. The yield was also measured in the growth regulation trials.

Introduction and purpose

In 2016 6 growth regulation trials were conducted with Medax Max and Medax Top + ammonium sulphate, 2 trials in red fescue and 1 trial in rye-grass, tall fescue, cock's-foot and smooth meadow-grass, respectively. The purpose of the trials was to study tolerance and the effect of the products Medax Max and Medax Top + ammonium sulphate, which were compared with Moddus. The treatments were conducted in seed grass in the spring of 2016 when the seed grass was at stage 32-37 BBCH (2-6 May); in rye-grass a treatment was also made at stage 40-49 BBCH (18 May).

Results

In smooth meadow-grass, red fescue, rye-grass and tall fescue no damage was seen. In cock's-foot some inexplicable damage was seen; this was probably caused by drought. In smooth meadow-grass, cock's-foot and tall fescue the time of full earing was delayed in comparison with untreated. In red fescue and rye-grass there was no such delay.

In all trials the measuring of height, which was conducted at stage 59 and stage 75 BBCH, showed significantly lower plants at increasing rates in comparison with untreated (Figures 1-6).

The assessment of lodging showed that the treatment with Medax Max delayed the time and extent of lodging depending on rate; this also applied to Medax Top + ammonium sulphate. In red fescue and rye-grass there was 100% lodging at harvest, in cock's-foot there was no lodging at harvest. In tall fescue and smooth meadow-grass there was 98% lodging in untreated at the time of swathing; in the treated plots there was less lodging at increasing rates (Table 1).

The seed yield following the treatment with Medax Max increased in most trials with the rate, most at double rate; only in one red fescue trial and in the cock's-foot trial did the yield peak at normal rate, which probably was due to drought occurring after the treatment. The seed yield following the treatment with Medax Top + ammonium sulphate was in all trials at the same level as that of normal dose rate of Medax Max. The seed yield following treatment with the standard product Moddus was at the same level as that of Medax Max seen in relation to rate (Table 2).

Figures 1- 8. Testing of Medax Max and Medax Top + ammonium sulphate.

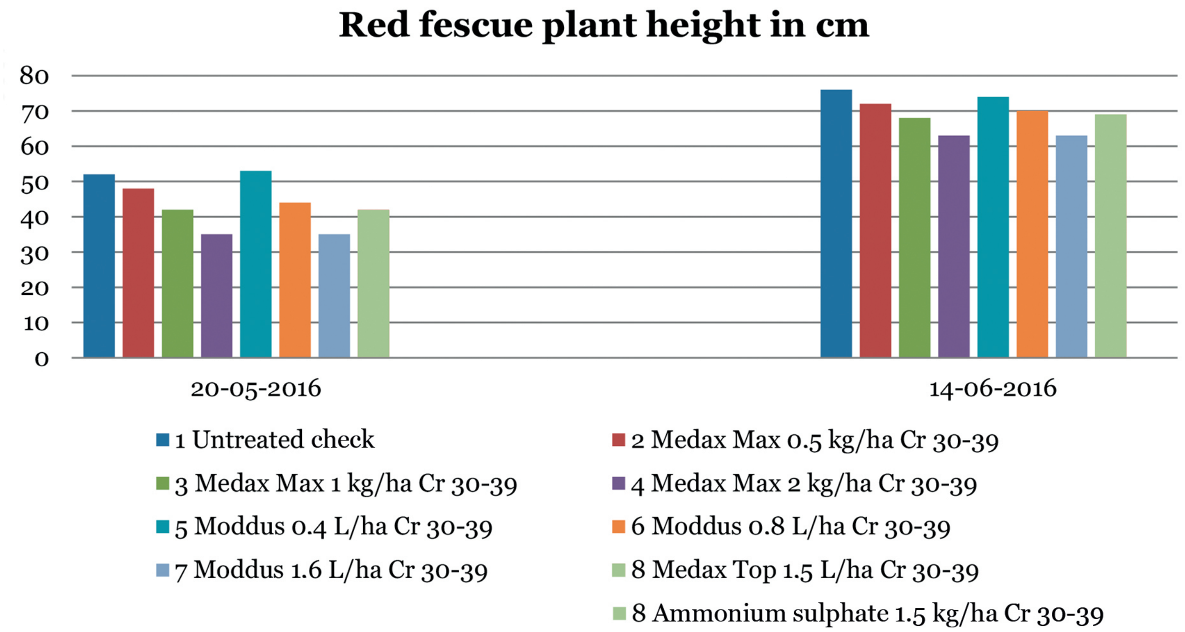

Figure 1. Red fescue plant height in cm (Trial 1).

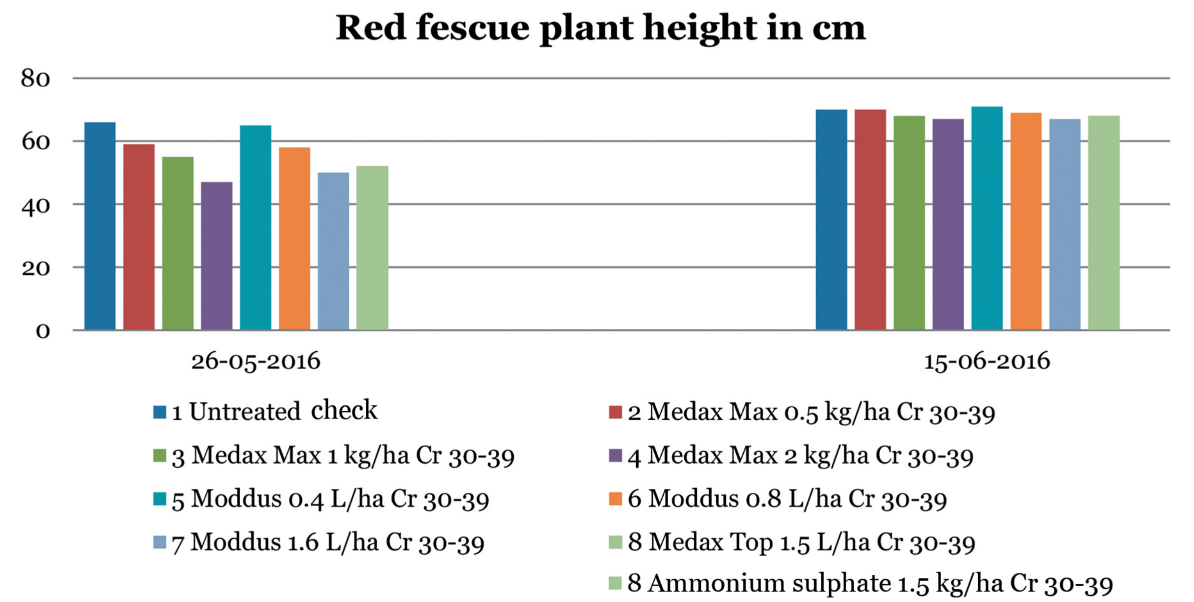

Figure 2. Red fescue plant height in cm (Trial 2).

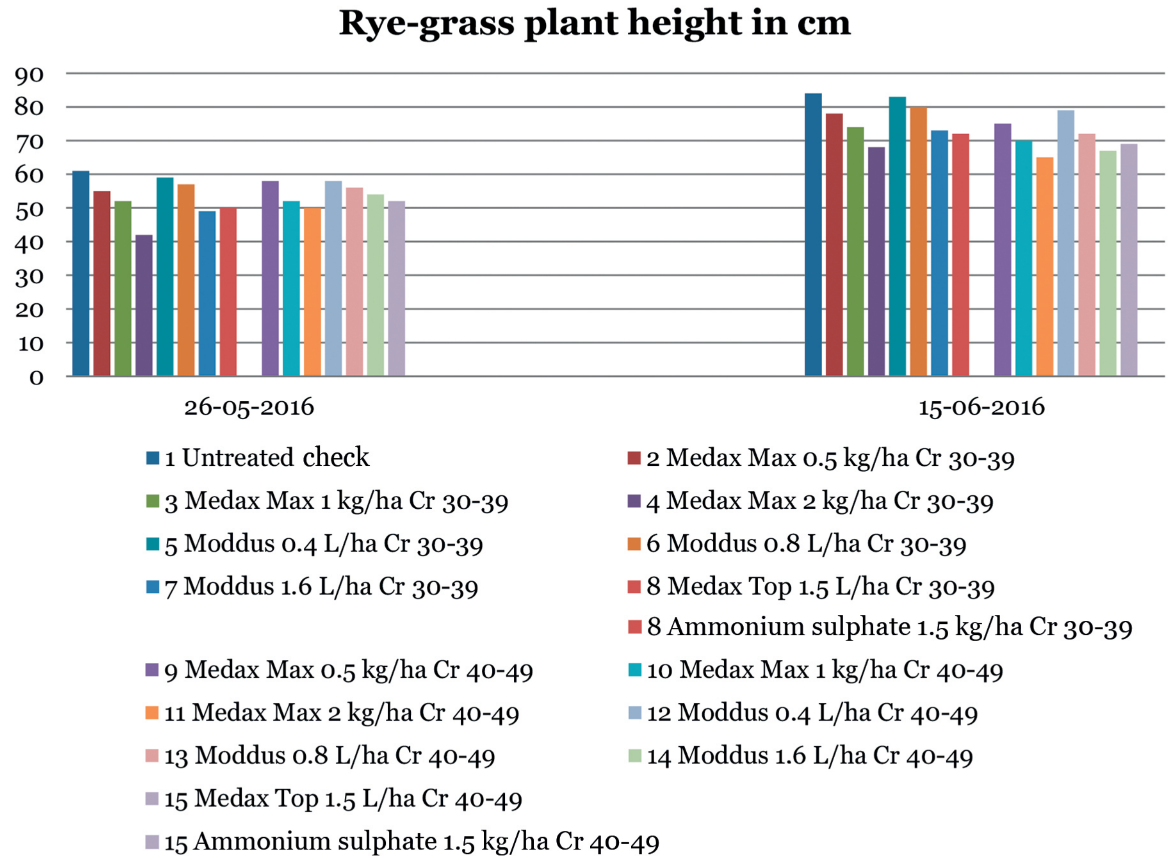

Figure 3. Rye-grass plant height in cm.

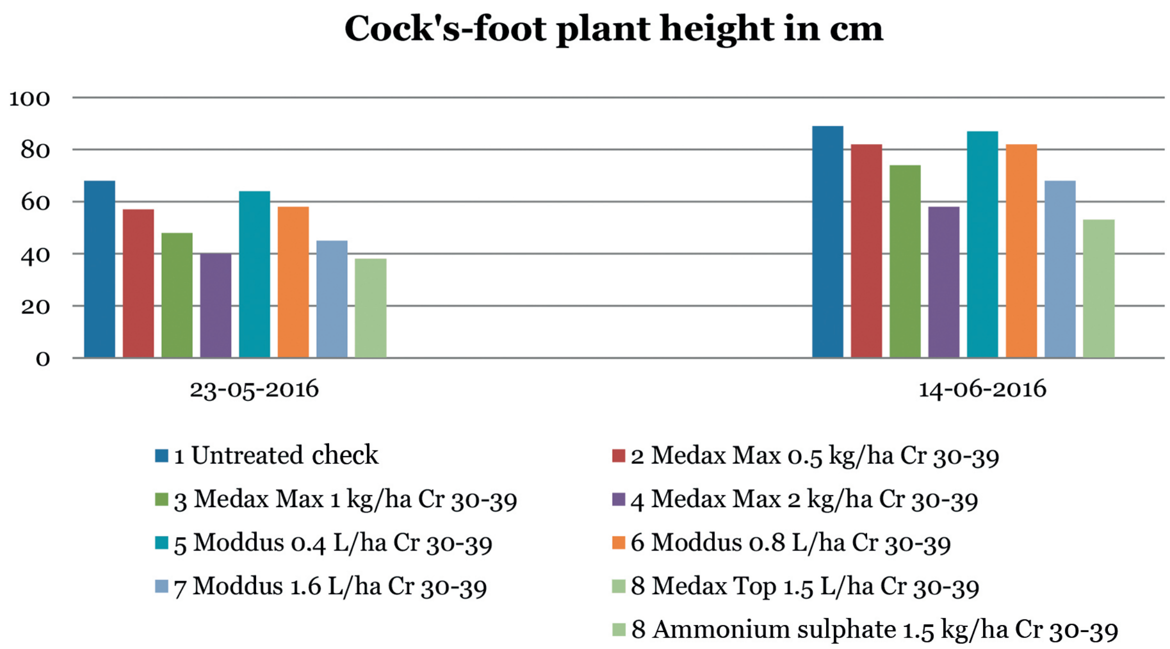

Figure4. Cock's-foot plant height in cm.

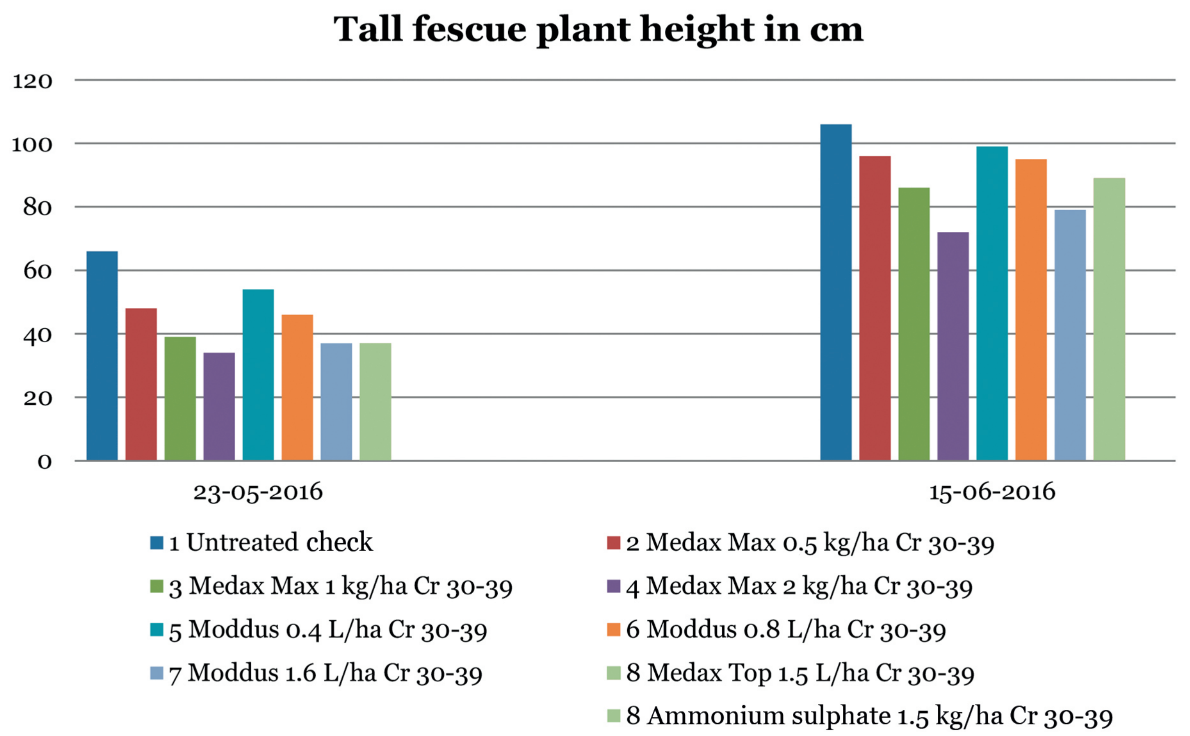

Figure 5. Tall fescue plant height in cm.

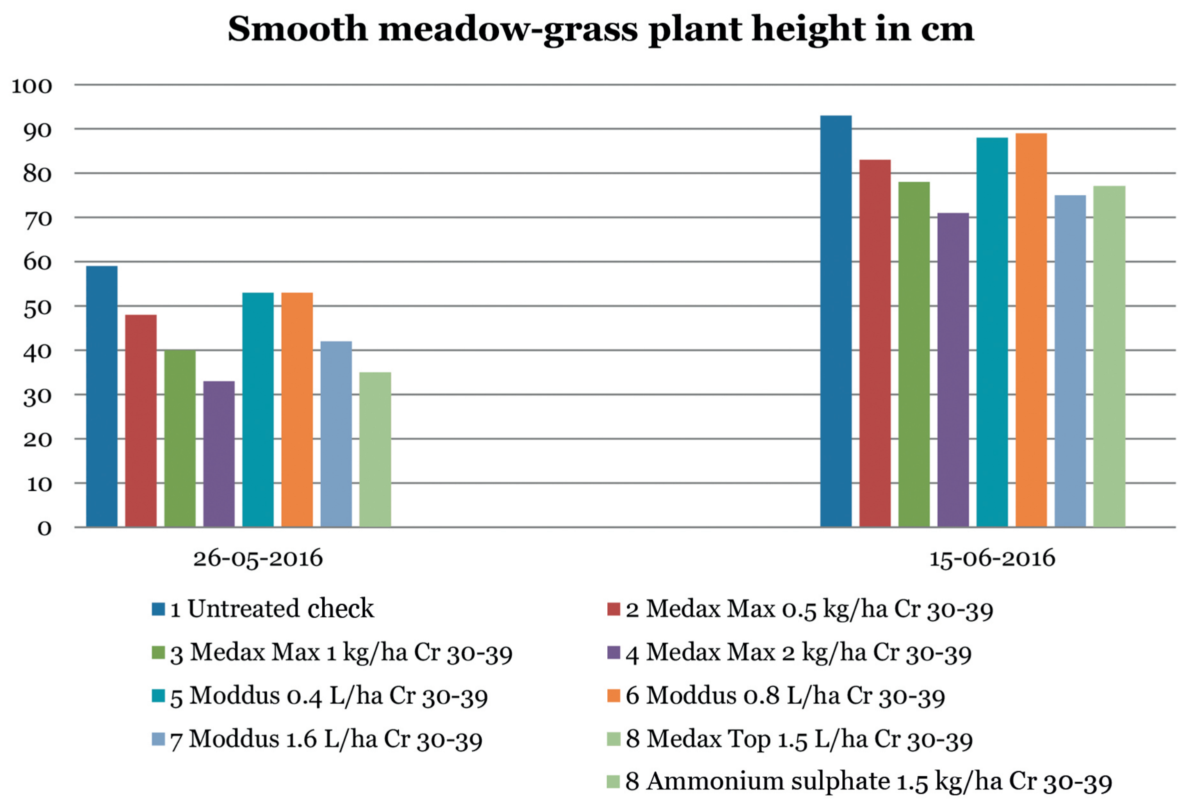

Figure 6. Smooth meadow-grass plant height in cm.

Table 1. Assessment of lodging from full earing to end of flowering. (FESRU average of 2 trials).

	Treatment name						Assessment of lodging 0 = no lodging, 100 = lodging in the plot								
				CROP	FESRU	LOLPE	DACGL	FESAR	POAPR	FESRU	LOLPE	DACGL	FESAR	POAPR
				Date	23-05	26-05	23-05	23-05	26-05	15-06	15-06	14-06	15-06	15-06
				BBCH	59	55	58	58	58	75	68-73	69-73	68-75	73-75
1	Untreated check				24	83	0	0	0	99	100	0	0	80
2	Medax Max	Crop 30-39	0.5	kg/ha	3	11	0	0	0	93	95	0	0	18
3	Medax Max	Crop 30-39	1	kg/ha	0	0	0	0	0	72	91	0	0	1
4	Medax Max	Crop 30-39	2	kg/ha	0	0	0	0	0	20	8	0	0	0
5	Moddus	Crop 30-39	0.4	L/ha	13	33	0	0	0	97	100	0	0	35
6	Moddus	Crop 30-39	0.8	L/ha	3	6	0	0	0	88	100	0	0	16
7	Moddus	Crop 30-39	1.6	L/ha	0	0	0	0	0	15	75	0	0	0
8	Medax Top+amm. sulphate	Crop 30-39	1.5+1.5	L/ha	0	0	0	0	0	73	91	0	0	0
9	Medax Max	Crop 40-49	0.5	kg/ha		18					99			
10	Medax Max	Crop 40-49	1	kg/ha		4					78			
11	Medax Max	Crop 40-49	2	kg/ha		0					51			
12	Moddus	Crop 40-49	0.4	L/ha		49					100			
13	Moddus	Crop 40-49	0.8	L/ha		8					98			
14	Moddus	Crop 40-49	1.6	L/ha		3					90			
15	Medax Top+amm. sulphate	Crop 40-49	1.5+1.5	L/ha		3					89			

Table 2. Seed yield in kg/ha.

							Yield kg/ha			
	Treatment name			CROP	FESRU	FESRU	LOLPE	DACGL	FESAR	POAPR
				Date	07-07	22-07	20-07	14-07	20-07	14-07
1	Untreated check				1254	1277	1620	365	1501	957
2	Medax Max	Crop 30-39	0.5	kg/ha	1398	1403	1895	559	1561	920
3	Medax Max	Crop 30-39	1	kg/ha	1403	1627	2038	602	1399	1087
4	Medax Max	Crop 30-39	2	kg/ha	1246	1709	2330	662	1397	1058
5	Moddus	Crop 30-39	0.4	L/ha	1379	1343	1749	448	1490	882
6	Moddus	Crop 30-39	0.8	L/ha	1331	1517	1872	569	1381	944
7	Moddus	Crop 30-39	1.6	L/ha	1308	1581	2176	644	1436	930
8	Medax Top+amm. sulphate	Crop 30-39	1.5+1.5	L/ha	1374	1631	2000	570	1458	1073
9	Medax Max	Crop 40-49	0.5	kg/ha			1836			
10	Medax Max	Crop 40-49	1	kg/ha			2006			
11	Medax Max	Crop 40-49	2	kg/ha			2101			
12	Moddus	Crop 40-49	0.4	L/ha			1646			
13	Moddus	Crop 40-49	0.8	L/ha			1889			
14	Moddus	Crop 40-49	1.6	L/ha			2007			
15	Medax Top+amm. sulphate	Crop 40-49	1.5+1.5	L/ha			2121			
				LSD_{95}	99.2	114.9	153.7	70.0	323.0	91.4

XIII List of chemicals

Name	Active ingredients	G active per l or kg	Standard dosis l/ha
Fungicides			
Acanto	Picoxystrobin	250	0.5
Adexar	Epoxiconazole + fluxapyroxad	62.5 + 62.5	2.0
Amistar	Azoxystrobin	250	1.0
Aproach	Picoxystrobin	250	0.5
Armure	Difenoconazole + propiconazole	150 + 150	0.8
Aviator Xpro	Bixafen + prothioconazole	75 + 160	1.25
Banjo Forte	Dimethomorph + fluazinam	200 + 200	1.0
Bell	Boscalid + epoxiconazole	233 + 67	1.5
Bell Super	Boscalid + epoxiconazole	140 + 50	2.5
Bravo 500 SC	Chlorothalonil	500	1.5
Bumper 25 EC	Propiconazole	250	0.5
Caramba 90	Metconazole	90	1.0
Ceando	Epoxiconazole + metrafenon	83 + 100	1.5
Comet	Pyraclostrobin	250	1.0
Comet Pro/Comet 200	Pyraclostrobin	200	1.25
Cymbal	Cymoxanil	450	0.25
Dithane NT	Mancozeb	750	2.0
Flexity	Metrafenon	300	0.5
Folicur EC 250	Tebuconazole	250	1.0
Folicur EW 250	Tebuconazole	250	1.0
Folicur Xpert	Prothioconazole + tebuconazole	80 + 160	0.5
Folpan 500 SC	Folpet	500	1.5
Ignite	Epoxiconazole	83	1.25
GF 3303	Inatreq + prothioconazole	Xx + xx	2.0
GF 3308	Inatreq	xx	2.0
GF 3309	Inatreq+ pyraclostrobin	Xx + xx	2.0
Imtrex	Fluxapyroxad	62.5	2.0
Juventus 90	Metconazole	90	1.0
Kayak	Cyprodinil	300	1.5
Leander	Fenpropimorph	750	0.5
Maredo 125 EC	Epoxiconazole	125	1.0
Narita	Difenoconazole	250	0.2
Opera	Pyraclostrobine + epoxiconazole	133 + 50	1.5
Option	Cymoxanil	600	0.2
Opus	Epoxiconazole	125	1.0
Opus Max	Epoxiconazole	83	1.25
Osiris	Epoxiconazole + metconazole	37.5 + 27.5	2.0
Osiris Star	Epoxiconazole + metconazole	56.3 + 41.3	1.33

Name	Active ingredients	G active per l or kg	Standard dosis l/ha
Proline 275	Prothioconazole	275	0.72
Proline EC 250	Prothioconazole	250	0.8
Proline Xpert	Tebuconazole + prothioconazole	80 + 160	0.75
Propulse SE 250	Fluopyram + prothioconazole	125 + 125	1.0
Prosaro EC 250	Prothioconazole + tebuconazole	125 + 125	1.0
Proxanil	Propamocarb + cymoxanil	333.6 + 50	2.0
Ranman Top	Cyazofamid	160	0.5
Revus	Mandipropamid	250	0.6
Revus Top	Mandipropamid + difenoconazole	250 + 250	0.6
Rubric	Epoxiconazole	125	1.0
Shirlan	Fluazinam	500	0.4
Signum	Pyraclostrobin + boscalid	67 + 267	0.25
Siltra EC 260	Bixafen + prothioconazole	60 + 200	1.0
Talius	Proquinazid	200	0.25
Tilt 250 EC	Propiconazole	250	0.5
Tridex	Mancozeb	750	2.0
Vendetta	Fluazinam + azoxystrobin	375 + 150	0.5
Viverda	Epoxiconazole + pyraclostrobin + boscalid	50 + 60 + 140	1.25-2.5
Zignal	Fluazinam	500	0.4
Herbicides			
Boxer	Prosulfocarb	800	5.0
Broadway	Pyroxsulam + florasulam	68.3 + 22.8	165 g
Glyphogan	Glyphosate	360	3
Glyphomax	Glyphosate	360	3
Glyfonova 480	Glyphosate	480	2.25
Roundup Flex	Glyphosate	480	2.25
Kerb 400 SC	Propyzamid	400	1.25
MaisTer	Foramsulfuron + iodosulfuron	300 + 10	100
Monitor	Sulfosulfuron	800	18.75 g
Growth regulators			
Medax Max	Trinexapac-ethyl + prohexadion-calcium	75 + 50	0.75
Moddus M	Trinexapac-ethyl	250	0.4
Medax Top	Mepiquat-chlorid + prohexadion-calcium	210 + 30	1.5

DCA - National Centre for Food and Agriculture is the entrance to research in food and agriculture at Aarhus University (AU). The main tasks of the centre are knowledge exchange, advisory service and interaction with authorities, organisations and businesses.

The centre coordinates knowledge exchange and advice with regard to the departments that are heavily involved in food and agricultural science. They are:

Department of Animal Science
Department of Food Science
Department of Agroecology
Department of Engineering
Department of Molecular Biology and Genetics

DCA can also involve other units at AU that carry out research in the relevant areas.

SUMMARY

This publication contains results from crop protection trials which were carried out at the Department of Agroecology within the area of agricultural crops. Most of the results come from field trials, but results from greenhouse and semi-field trials are also included. The report contains results that throw light upon:

- Effects of new pesticides
- Results of different control strategies, including how to control specific pests, as part of an integrated control strategy involving both cultivars and control thresholds
- Results with pesticide resistance
- Trial results from different cropping systems

APPLIED CROP PROTECTION 2016
DCA REPORT NO. 094 • APRIL 2017