Eurowheat

-bringing information on disease management together across borders

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Background and Deliverables!

- www. EUROWheat.org
  - Tool for the support of disease management in wheat
  - Supporting disease control strategies based on an IPM concept
  - Added valued created when combining information from different countries
  - publicly available for end-users
    - plant breeders, agro-chemical companies, extension ,farmers

- Established groups exist on
  - Fungicide- and disease managements
  - Virulence surveys

Present content

- Fungicides
  - Efficacy, resistance, tradenames
- Pathogens
  - Names on pathogens in different languages
  - Yellow rust -Pathotypes and their distribution across years and countries
  - Fusarium risk and cultivar ranking
- Yield responses to fungicides
  - Fungicide input
  - Yield responses to fungicides in different countries
- IPM element
  - Links to other DSS platforms
  - How to monitor
  - Thresholds
  - Cultural practises

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14 October 2009
Welcome Lise Nistrup Jørgensen (LNJ)

Logout

2nd Workshop

Participants at the 2nd EuroWheat workshop at Julius Kuehn Institute, Berlin, Germany, 11th-12th March 2009.

Survey on the use of disease thresholds

New guideline on monitoring of diseases in wheat and a survey on control thresholds used in different countries

Read more ...

Welcome to EuroWheat

EuroWheat is an Internet based platform aiming at collating and displaying host - and pathogen characteristics, and pesticide efficacy on a European scale. Bringing together existing information from national programs and ensuring that these data are in a format, which can be readily understood trans-nationally, are expected to provide significant added value on a European scale. New disease - and resistance data will be published on the platform as soon as possible to support effective disease control, deployment of host resistances and breeding programs.

Present information available are:

- Virulences in the yellow rust population
- Ranking of wheat cultivars for susceptibility to Fusarium and different testing methods
- Disease names in six different languages
- Effectiveness of fungicides ranked in different countries
- Fungicides international trade names
- Fungicide resistance as present in Europe
- Survey on pesticide use and yield responses to fungicides in EU countries
- Yield level and yield losses from specific diseases in 8 EU countries
- Information on disease thresholds and DSSs used in Europe
- Cultural practices impact on disease development
- National documents on disease management

EuroWheat is funded by the ENDURE project and Aarhus University.

Contact

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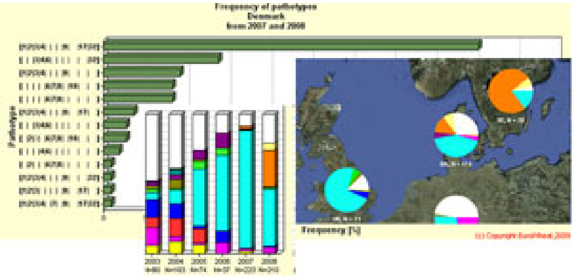
Web site provided by Aarhus University, Faculty of Agricultural Sciences, Department of Agroecology and Environment.
Report technical problems to webmaster: Poul Lassen.
Optimized for screen size 1024x768

Comparison of Fungicide efficacy across countries

Find information on the efficacy of the most important compounds against cereal diseases across countries in Europe. Read more ...

In 2009, information will be provided on fungicide resistance cases in specific pathogens by country.

Yellow rust pathotypes in Europe



New data for 2008 have been uploaded.

Most important pathotypes in Europe 1993-2008...

Evolution of pathotypes over years and countries

Pathotypes on Europe map

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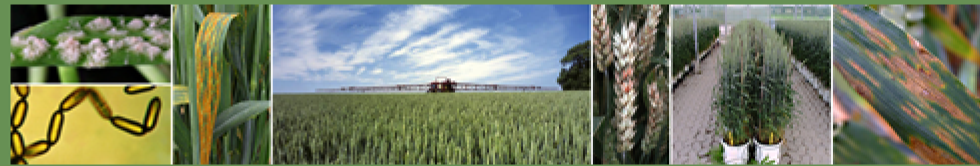

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People

Mail to listed people | Mail to selected people | Clear selection

Select group of people: All

Name	Institution	Select
Cristian Lannau	Institut national de la recherche agronomique, France	
Claude Pope	Institut national de la recherche agronomique, France	
Kerstin Flat	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Marga Jahn	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Bernd Rodemann	Julius Kuehn Institute - Federal Research Centre for Cultivated Plants, Germany	
Bill Clark	Rothamsted Research, United Kingdom	
Neal Evans	Rothamsted Research, United Kingdom	
Jerzy Czembor	Plant Breeding and Acclimatization Institute, Poland	
Tomasz Goral	Plant Breeding and Acclimatization Institute, Poland	
Jens Grønbech Hansen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Mogens S. Hovmøller	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Lise Nistrup Jørgensen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Poul Lassen	Aarhus University, Faculty of Agricultural Sciences, Denmark	
Ghita C. Nielsen	Danish Agricultural Advisory Service, Denmark	
Rosemary Bayles	National Institute of Agricultural Botany, United Kingdom	
Philippe du Cheyron	ARVALIS - Institut du végétal, France	
Claude Maumene	ARVALIS - Institut du végétal, France	

Name: Cristian Lannau
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Disease names

sp. tritici	Powdery Mildew	Echter Mehltau	Oïdium	Maczniak prawdziwy	Hvedemeldug	Vet
ale	Sharp Eyespot	Scharfer Augenfleck	Rhizoctone	Ostra plamistosc oczkowa	Skarp øjeplet	Ska
	Ergot	Mutterkorn	Ergot	Sporysz	Meldrøjer	Mjö
	Fusarium Head Blight	Partielle Weißährigkeit, Taubährigkeit	Fusariose	Fuzarioza k?osów	Aksfusarium	Axf
raminis var. tritici	Take-all	Schwarzbeinigkeit	Piétin-échaudage	Zgorzel podstawy zdzbla	Goldfodsyge	Rot
	Cephalosporium Leaf Stripe	Cephalosporium-Streifenkrankheit	Cephalosporium	Naczyniowa pasiastosc lisci	Hvedegulstribe	Gul
s	Snow Mould	Schneeschimmel	Fusariose	Plesn sniegowa	Sneskimmel	Snö
inicola	Septoria Leaf Blotch	Septoria-Blattdürre	Septoriose	Septorioza paskowana lisci	Hvedegråplet	Sva
	Eyespot	Halmbruchkrankheit	Piétin-verse	lamliwosc zdzbla	Knækkefodsyge	Str
um	Leaf and Glume Blotch	Stagonospora-Blatt- und Spelzenbräune	Septoriose (septoriose des épis)	Septorioza plew	Hvedebrunplet	Bru
p. tritici	Stem Rust	Schwarzrost	Rouille noire	Rdza zdzblowa	Hvedesortrust	Sva
	Yellow (Stripe) Rust	Gelbrost	Rouille jaune	Rdza zólta	Gulrust	Gul
	Leaf Rust	Braunrost	Rouille brune	Rdza brunatna	Brunrust	Bru
pentis	Tan Spot	Pyrenophora-Blattdürre	Helminthosporiose	Brunatna plamistosc lisci	hvedebladplet	Vet
	Dwarf Bunt	Zwergsteinbrand	Carie naine	sniec karlowa	Dværgbrand	Dvä
	Stinking Smut	Steinbrand	Carie commune	sniec cuchnaca	Stinkbrand	Stir
	Snow Rot	Typhula-Fäule		Palecznica zbóz	Trådkølle	Trå

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Ranking of wheat cultivars for susceptibility to Fusarium

Select ⓘ to change information in the right hand info box

- ⓘ Most resistant cultivars
- ⓘ Medium susceptible cultivars
- ⓘ Most susceptible cultivars

Fusarium resistance - Components and ways of measuring the feature

Resistance of wheat to Fusarium head blight is a complex trait. Five resistance components have been characterized. Type I and Type II are the most common ways of measuring Fusarium resistance.

Type I: Resistance to initial infection. Assessed using spray inoculation of heads with *Fusarium* spores or spreading *Fusarium* infected debris (or grain) on the soil and evaluating of number of infected spikes.

Type II: Resistance to spread of *Fusarium* fungus within the spike. Assessed by point inoculation of a middle spikelet in the head and evaluating of extent of symptoms spread from inoculation point. Inoculation methods for type I are also widely applied.

Type III: Resistance to mycotoxins (deoxynivalenol, nivalenol) i.e. nonaccumulation or ability to degrade (or inactivate) mycotoxins. Evaluated by analysis of mycotoxin amount in grain using ELISA tests or chromatographic techniques.

Type IV: Resistance to kernel infection. Assessed by counting of proportion of kernels visibly damaged by Fusarium or analysis of ergosterol amount in grain or *Fusarium* DNA quantity in grain.

Type V: Tolerance to *Fusarium* i.e. tolerant cultivars has lower yield loss than intolerant at the same FHB severity level.

Different testing methods

The screening for susceptibility to *Fusarium* is done differently depending on the country

Country	Metode used for ranking
Denmark	A mixture of spores of *Fusarium culmorun* and *Fusarium gramineirum* is applied 2-3 times during flowering with a densitiy of 10-x 106 spores pr ml. The degree of flowering is assessed for each variety at the time of inoculation.
Germany	**For official ranking:**Carrying out maize stubbles / residues of corn or silage maize in December with a density of 6-8 pieces per m²; **For selection of entries:**Spray inoculation of conidia with a mixture of *Fusarium culmorum* /

List of cultivars in selected countri

Most resistant cultivars

(DK) Skalmeje, Asano, Naturastar, Olivin, Skag
Petrus (resistant standard cultivar)

(UK) Panorama, Ketchum, Claire, Istabraq

(FR) Apache, Graindor, Galibier, Hymack, Epho
Hysun

(DE) Akratos; Astardo, Aszita, Atlantis, Batis, B
Butaro, Discus, Enorm, Esket, Hermann,
Impression, Lahertis, Lucius, Magister, Me
Mythos, Naturastar, Pamier, Petrus, Skaln
Sobi, Sokrates, Solitär, SW Maxi, Toras

(PL) Anthus, Dorota, Finezja, Fregata, Herman
Legenda, Mewa, Muza, Nutka, Olivin, Petru
Skalmeje*, Smuga, Solitär*, Turnia,
TonacjaEnorm*

Sources:

Mesterhazy A. 1995. Types and component
resistance to Fusarium head blight of wheat. P
Breeding 114: 377-386.
Mesterhazy A. Bartok T., Mirocha C.G., Komoroczy R. 1999. Nature of wheat resista
Fusarium head blight and the role of deoxyniva
for breeding. Plant Breeding 118: 97-110.
Miedaner T. 1997. Breeding wheat and rye f
resistance to Fusarium diseases. Plant Breedin
201-220.
Miller J.D., Young J.C., Sampson D.R. 1985
Deoxynivalenol and FHB resistance in spring c
Phytopath Z.113: 248-256.

Fusarium

Typical symptoms of infection by *Fusarium graminearum*. Copyright: Bill Clark, Rothamsted Research, UK.

Ploughing can significantly reduce the risk but also use of resistant cultivars is another important factor. No cultivar can give 100% control of Fusarium ear blight, but cultivar high levels of resistance are available. Several countries rank each year the relevant cultivars for susceptibility to Fusarium ear blight.

Several decision keys are made in different countries and can be used for evaluating risk level for DON (deoxynivalenol, one of the mycotoxins produced by Fusarium, Tab in a given field. The different risk assessments show that the right combination of agricultural practices can dramatically reduce the DON risk without the use of fungicid

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Updated April 2009, By Lise Nistrup Jørgensen

For fusarium good risk assessment systems have been developed, which can be used as a strategy tool and as a tactical tool for risk assessment during the season. The ma elements in the risk assessments are believed to be adoptable in most wheat growing regions in Europe.
Systems are available from:

- Sweden:
- France:
- UK:

Reducing the risks

There is a strong link between the risk from Fusarium and crop rotation and tillage methods. There is a particularly high risk in regions where maize is a widely grown crop in the rotation. Direct drilling and reduced tillage, which leave debris on the surface that can act as a source of inoculum, also increase the risk of Fusarium ear blight. In some countries growing wheat after wheat in combination with minimal tillage has also been found to increase the risk.

Mycotoxins

Fusarium head blight can reduce yields, but the fungi involved can also produce mycotoxins, dangerous to humans and livestock, and strict legal limits are in place for mycotoxins in grain destined for human consumption and animal feed.

Even though several species of Fusarium can affect wheat - not all of them produce mycotoxins. Microdochium species is one group giving head blight but not production of mycotoxins. The severity of attack depend mainly on weather conditions during flowering (warm and wet conditions are the worst) and a combination of agricultural factors.

Table 1. Fusarium toxin acronymes

Fusarium toxin acronyme	Chemical compound name
A-DON	acetyldeoxynivalenol
DON	deoxynivalenol

Table 2. Mycotoxins produced by different species of Fusarium

Species	Toxin production
F. avenaceum	MON, FUS C, BEAU
F. culmorum	DON, ZEA, NIV, FUS X, FUS C, A-DON
F. equiseti	DAS, ZEA, FUC
F. graminearum	DON, ZEA, A-DON, NIV, FUS X, FUS C
F. poae	DAS, MAS, NIV, FUS X, T-2, HT-2, FUS C, BEAU
F. sporotrichioides	T-2, HT-2, DAS, NEO, FUS C
F. tricinctum	FUS C
M. nivale	none

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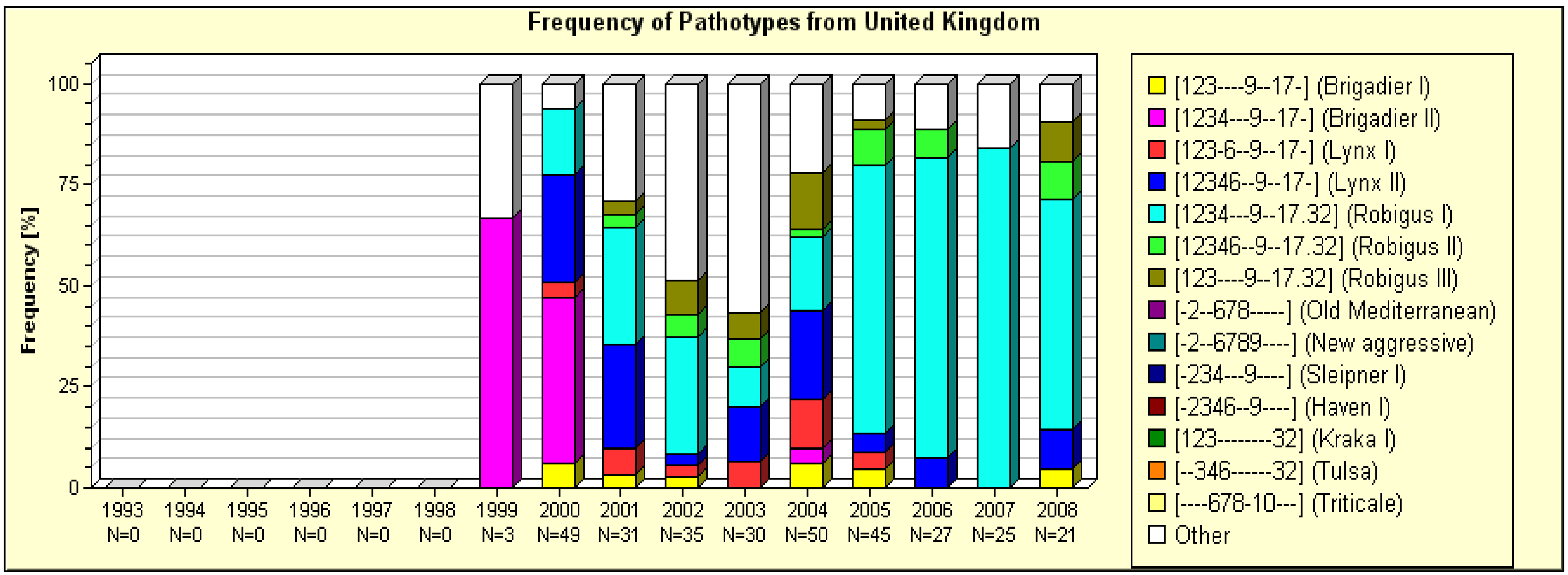
Frequency of pathotypes

Show Languages

Countries ☐ All ☐ ☐ Germany ☐ Denmark ☐ France ☐ Sweden ☑ United Kingdom

Year ☑ All ☑ 1993 ☑ 1994 ☑ 1995 ☑ 1996 ☑ 1997 ☑ 1998 ☑ 1999 ☑ 2000 ☑ 2001 ☑ 2002 ☑ 2003 ☑ 2004 ☑ 2005 ☑ 2006 ☑ 2007 ☑ 2008



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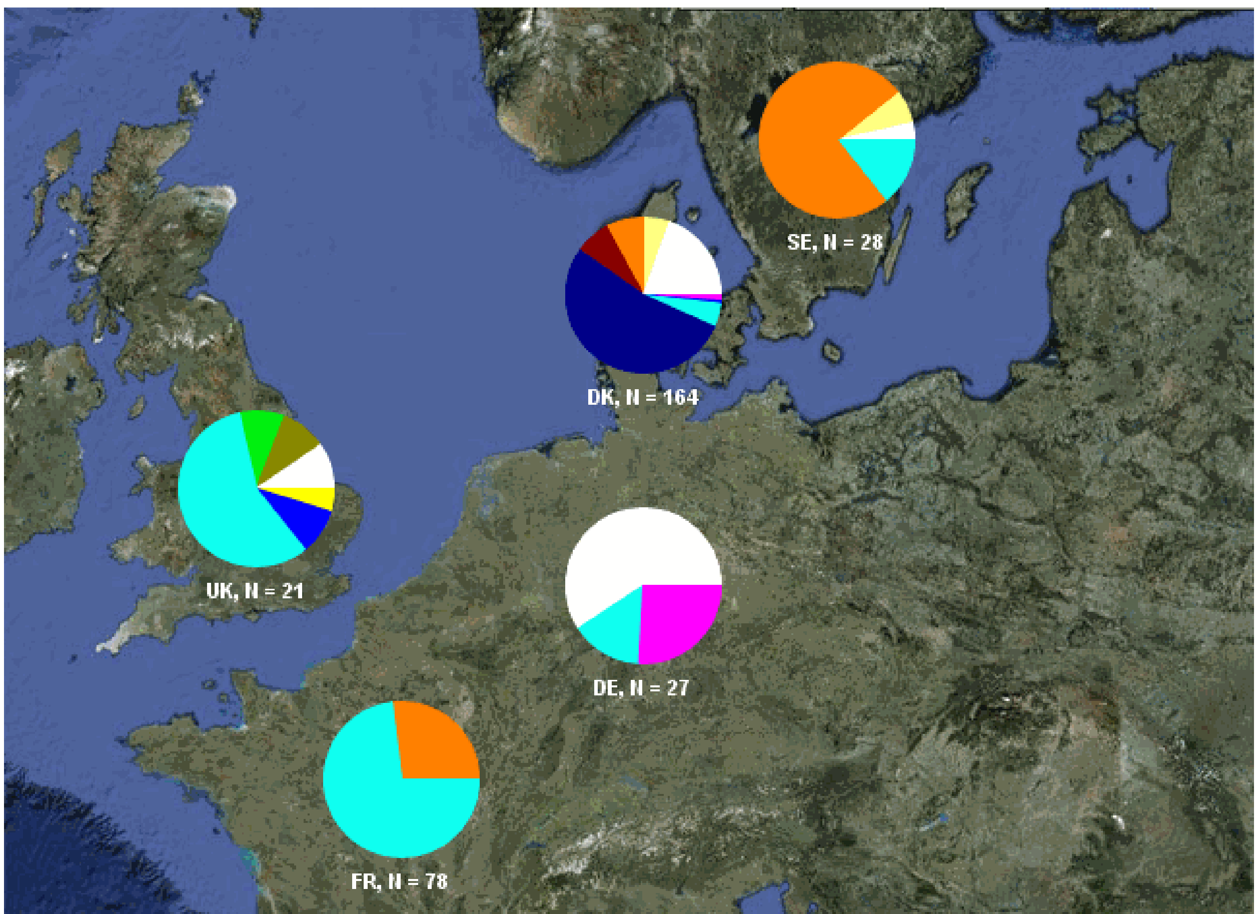
Frequency of pathotypes

Show | Languages

ar ☐ All ☐ 1993 ☑ 1994 ☐ 1995 ☐ 1996 ☐ 1997 ☐ 1998 ☐ 1999 ☐ 2000 ☐ 2001 ☐ 2002 ☐ 2003 ☐ 2004 ☐ 2005 ☐ 2006 ☐ 2007 ☑ 2008



Legend

- [123----9--17-] (Brigadier I)
- [1234---9--17-] (Brigadier II)
- [123-6--9--17-] (Lynx I)
- [12346--9--17-] (Lynx II)
- [1234---9--17.32] (Robigus I)
- [12346--9--17.32] (Robigus II)
- [123----9--17.32] (Robigus III)
- [-2--678-----] (Old Mediterranean)
- [-2--6789----] (New aggressive)
- [-234---9----] (Sleipner I)
- [-2346--9----] (Haven I)
- [123--------32] (Kraka I)
- [--346------32] (Tulsa)
- [----678-10---] (Triticale)
- Others

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DSSs for the control of wheat diseases in Europe

This list represents known DSSs used for chemical control of wheat diseases in Europe. The list was compliled via a DSS workshop in the EUDURE project. Plea
the links and find more detailed information about each DSS

Country, name of DSS and link	Target	Users	Contact/Owner
SIMONTO	Help to organize fieldwork and optimising disease control.	SIMONTO is provided to German farmers and advisers via an stabilished online infrastructure for agricultural extension. Requires meteological data. through the internet portal ISIP. Licence to other institutions is possible	Dr Benno Kleinhenz ISIP Rudesheimer strasse 6 Bad Kreuznach, DE kleinhenz@zepp.info
SIMCERC3	Forecast for risk for eyespot on a regional or field basic in order to assess if treatment is needed	SIMCERCO3 is provided to German farmers and advisers via an stabilished online infrastructure for agricultural extension. Requires meteological data. through the internet portal ISIP.Licence to other institutions is possible	Dr Benno Kleinhenz ISIP Rudesheimer strasse 6 Bad Kreuznach, DE kleinhenz@zepp.info
CRYPTO-LIS	Online system: Contains standard recommendations with fungicides according to regions and cultivars.	Dose response function, additive model for efficacy in mixture is used to compare fungicides. Variety susceptibility and region diseases pressure data are combined to estimate the disease risk at a regional level. Agronomic risk calculation is included for estimation of eyespot and fusarium risk at the field level.	Claude Maumene Arvalis Station Experimentale 91720 Boigneville c.maumene@arvalisinstitutd
CPOdiseases	Online system:Based on field registration recommendation can be given for control	System is developed for farmers and advisors. Based on information on cultivars, growth stages, weather data and disease levels specific recommendation for spraying or not is given. The system can be entered by UserID: DemoPVO Password: DemoPVO The system has been validated under Danish conditions. An English version is available.	Karen Eberhardt Henriksen Aarhus University Faculty of Agricultural Scien Inst. of Integrated Pest Man Flakkebjerg, DK-4200 Slage KarenE.Henriksen@agrsci.dk
SORTINFO	Online system with updated information on cultivar resistance, yield response to chemical control, predicted need for fungicides, etc	The system is developed for farmers and advisors. The system includes information on all relevant cultivars susceptibility to wheat diseases. The system is updated with information from yearly field trials. Cultivars yields and yield response to fungicides is included.	Morten Haastrup, Danish Agricultural Advisory Crop Production Udkærsvej 15, DK-8200 Årh MHS@Landscentret.dk
FUSAPROG	Online system to assess the risk of fusarium and toxin in wheat	The system is developed for farmers and advisors,The DON-model combines decision algorithms based on the cropping system with calculated weather risk values. Weather data and forecasted DON	Agroscope Reckenholz-Tänik Reckenholzstrasse 191 8046 Zürich

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Pesticide use

The input of pesticides measured as TFI (treatment frequence index) vary significantly between countries. Data in **Table 1** shows the level of input from 4 countries in EU, who have been calculating the input based of number of applications with full dose rates.

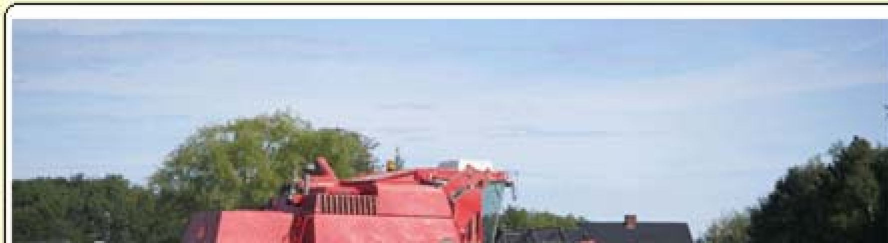
Table 1. Treatment Frequency Index in wheat in selected countries. Source: ENDURE

Pesticide group	UK (2006)	France (2006)	Germany (2007)	Denmark (2007)
Herbicides	2.4	1.4	1.9	1.3
Fungicides	2.4	1.6	1.9	0.6
Insecticides	1.7*	0.3	1.2	0.2
Plant Growth Regulators	1.1	0.7**	0.8	0.2
Total	7.6	4.0	5.8	2.4

* Incl. insecticides and molluscicides.
**Incl. Plant Growth Regulators and molluscicides

The term treatment frequency index (TFI) was introduced in DK in 1986 and is the theoretical number of pesticide treatments per hectare, calculated by dividing the amount of pesticides sold for agriculture by the standard approved dosages. The method is in DK based on standard dose rates of active ingredients, while it is based on standard products rates in other countries.

Updated May 2009, by Lise Nistrup Jørgensen



Yield responses to fungicides

The level of yield response to fungicides vary significantly from year to y
between countries (**Fig. 1**). The reasons for the different responses are
e.g. disease pressure, yield levels, climatic conditions and level of resista
grown cultivars

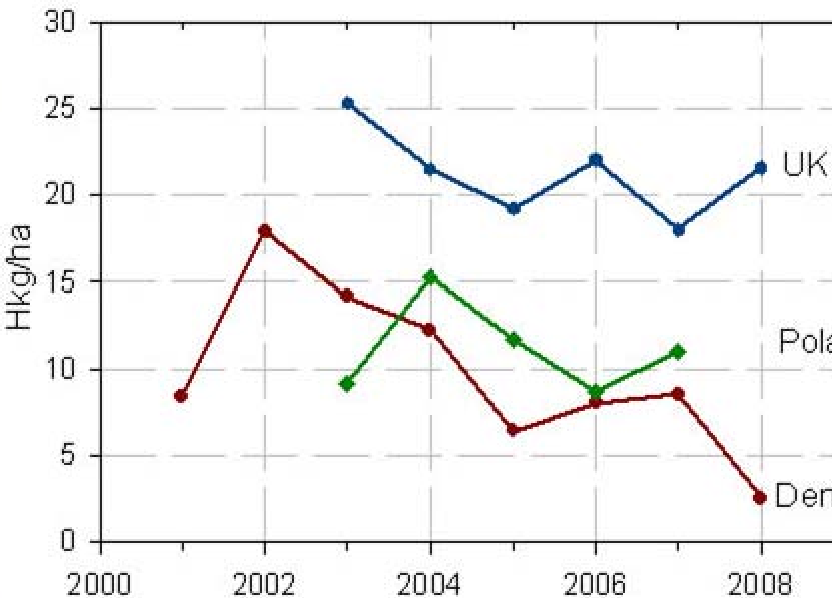


Fig. 1. Yield response to fungicides [Hkg/ha]. Source: ENDURE

When evaluating the yield response to fungicides, it is important for the f
consider several factors before deciding which input is needed. It is reco
to seek support from the following information:

- The individual cultivars susceptibility and risk for attack.
- Yield responses to fungicides in trials from previous seasons in or assess the potential loss.
- Relate the yield increase from fungicides to the cost of applying fu order to assess and optimize the economic return.
- Assess attack in the field during the season or follow national or r warning systems.

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Yield levels

Wheat is the most important cereal crop grown in EU. The yield levels and cropping conditions vary considerably between the different EU countries **(Fig. 1)**. In the countries most suitable for wheat production (Germany, the UK, France, Belgium, the Netherlands, Ireland, Denmark) average yields vary between 7 and 8 tonnes/ha, whereas in countries with more restricted cropping conditions (Hungary, Italy, Spain, Poland, Greece) yields vary between 2 and 4 tonnes/ha.

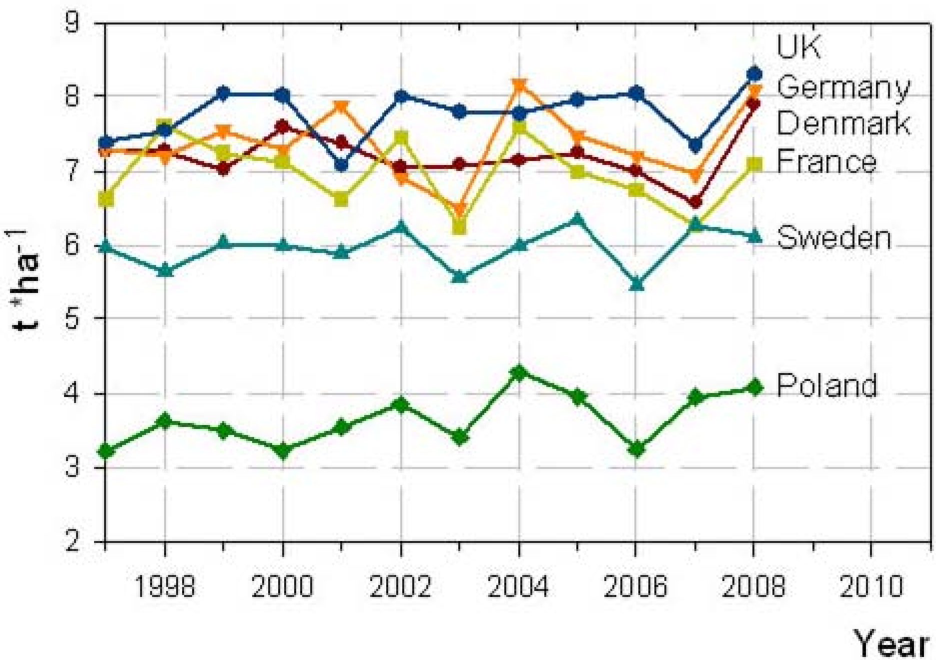

Fig. 1. Average wheat yields in individual years. Source: Eurostat.

Yield losses

Yield losses from specific diseases in the 8 countries involved in the ENDU were estimated, (**Table 1**). Based on these estimates septoria leaf blotch rust, take-all and fusarium head blight are considered as the most import in the main wheat growing countries with respect to yield loss and quality Yield losses between 5 and 15 dt/ha are common in many regions. Yellow powdery mildew, tan spot and eyespot are also regarded as important di however, their distribution is much more regional.

Table 1. Estimated yield losses [dt/ha] caused by specific diseases in dif countries. Source: ENDURE

Country	Tapesia	S. tritici	P. striiformis	P. triticina	Fusarium	Take all
FR	3	15	0	10	2	0-20
DE	-	3.2	2.5	2.7	0.4	-
UK	2	10	1	1	0.5	8
NL	1	5	1	1	2	1
PL	5	4	1	10	1	12
DK	2	8	1	1	1	3


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Fungicide efficacy
Legend: Not registrated: Problems with resistance: R Low efficacy: Moderate efficacy: Good efficacy:
Select
Powdery mildew (Blumeria graminis f. sp. tritici)
Septoria tritici Blotch (Mycosphaerella graminicola)
Brown Rust (Puccinia triticina)
Yellow rust (Puccinia striiformis)
bromuconazole
cyproconazole
difenoconazole
epoxiconazole
fenbuconazole
fluquinconazole
flusilazole
flutriafol
hexaconazole
metconazole
prochloraze
propiconazole
prothioconazole
tebuconazole
tetraconazole
triadimenol
azoxystrobin
fluoxastrobin
kresoxim-methyl
picoxystrobin
pyraclostrobin
trifloxystrobin
Internettet
Microsoft Office P...
Synkronisering
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Trade names for different fungicides in different countries											
						product rate					
Active ingredient	g/l	Active ingredient	g/l	Active ingredient	g/l	kg/l	Germany	France	Denmark	UK	Swed
Azoxystrobin	250					1	Amistar / PRIORI	Amistar	Amistar	Amistar	Amist
Azoxystrobin	80	Chlorthalonil	400			2,5	Amistar Opti			Amistar Opti	
Azoxystrobin	200	cyproconazole	80			1	Priori Xtra	Amistar Xtra/Priori Xtra		Priori Extra	
Azoxystrobin		Chlorthalonil		cyproconazole							
Azoxystrobin	100	fenpropimorph	280			2		Amistar Pro		Amistar pro	
bromuconazole	200					1,25				Jazz/Tote	
Chlorthalonil	750					1,4	Pugil 75 WG				
Chlorthalonil	500					2	Bravo 500/	Chlorthalonil		Joules/Bravo 500/Sonar	Bravo
Chlorthalonil		Cyproconazol		Propiconazole			Cherikee			Cherokee	
Cyflufenamid	50					0,25	Vegas	alto /caddy		Cyflamid	
cyproconazole	100					1		Mohawk			
Cyproconazol	240					0,4	Alto 240	Alto/Caddy/Mohawk		Centaur	
Cyproconazol	53	Cyprodinil	400			1,5	Radius WG	Iridia		Radius	
Cyproconazol	40	chlorothalonil	375			2		Citadelle		Alto Elite/Bravo Xtra	
Cyprodinil	750					1	Unix / PRIMA		Unix	Unix/Kayak	Unix/
difenoconazole	250	propiconazole	250			0,5	Taspa				
difenoconazole	250					0,3				Plover	
Dimoxystrobin	133	Epoxiconazol	50			1,5	Swing Gold			Swing Gold	Swing
Epoxiconazol	62,5	metrafenon	75	Fenpropimorph	200	2	Capalo			Capalo	
Epoxiconazol	100	Boscalid				1,5	Champion	Bell/Arolle	Bell	Tracker/Venture	
Epoxiconazol	43	Fenpropimorph	214	Pyraclostrobin	114	1,5	Diamant	Diamant		Diamant	
Epoxiconazol	125	kresoxim-methyl	125			1	JUWEL	Ogam	Opus Xtra	Allegro /Landmark	
Epoxiconazol	50	pyraclostrobin	133	kresoxim-methyl	67	1,5	OPTIMO	Opponent/Optimo		Opponent	
Epoxiconazol	125					1	Opus	Opus/Picarius	Opus/Rubric/Maredo	Opus	Opus
Epoxiconazol	84	Fenpropimorph	250			1,5	Opus Top	Opus Team	Opus Team	Opus Team/Eclipse	Opus
Epoxiconazol	41,6	metconazol	30			3	OSIRIS*			Brutus	
Epoxiconazol	83	metrafenon	100			1,5				Ceando	
Fenpropidin	750					0,75-1	Zenit M	Gardian	Tern	Patrol/Tern	Tern
Fenpropimorph	750					1	Corbel	Corbel BASF		Corbel	Forbe

Fungicide resistance

re has been gradual increase in the occurrence of fungicide resistance since the introduction of temic fungicides in the early 1970s. Such fungicides frequently have very specific modes of action, ke many older fungicides. Resistance can arise rapidly and completely so that disease control is totally or it can be a more gradual process resulting in partial loss of control. There are many cases of nplete failure of control due to resistance to the benzimidazols and stroblurins. A more gradual loss in trol has been found for the triazol group.

tors which affect the development of fungicides resistance include the type of fungicide, its frequency of , whether alone or in programme, the target pathogen and the ability of the resistant forms to survive.

ategies against resistance:

risk of pathogens developing resistance can be reduced by various means:

- Make full use of disease resistant varieties.
- Use varietal mixtures and other diversification strategies, which can decrease epidemic development should be considered.
- Use crop rotations to avoid the build up of soil born pathogens.
- Minimize the use of fungicides by avoiding unnecessary prophylactic treatments and particularly repeated applications of fungicides of the same group.
- Alternate applications of fungicides from different groups or use recommended formulated mixtures or tank-mixes designed to help combat resistance.
- Make full use of fungicides with a multi-site mode of action, which are less prone to fungicide resistance problems.

athogen	Benzimidazols	Triazoles DMI	Strobilurins (QoI)	Carboxamides
umeria aminis f. sp. tici	Yes, widespread. Mutation in ß-tubuline	Yes, widespread. Mutation in CYP 51 gen	Yes, widespread. G143A mutation	-
ptoria tritici	Yes, widespread. Mutation in ß-tubuline	Yes, widespread. Mutation in CYP 51 gen	Yes, widespread. G143A mutation	-
crodochium vale	-	Yes, widespread. Mutation in CYP 51 gen	Yes, widespread in France. G143A mutation	-
agonospora dorum	-	-	Yes, found in Sweden. G143A mutation	-
renophora tici-repentis	-	-	Yes, widespread. G143A, F129L and G137R. Mutations found	-

FRAC - Resistance action commitee

FRAC is the chemical companies resistance action commitee. The pages includes the lates updates on resistance development and recommendations to minimize the risk. The page also include methods for screening for resistance.

Reports and leaflets

Report from FRAG- UK (Fungicide Resistance Action Group)- Update from 2008.

The report contains general resistance management guidelines as well as specific recommendations in relation to individual diseases. For each disease a status of the resistance situation is given and recommendations with respect to specific fungicide groups are dealt with.

Leaflet from FRAG

The purpose of this publication is to provide information on fungicide resistance as it affects growers in the UK.

Collaboration note from INRA, SPV and Arvalis for cereal diseases resistance management - Update from 2008.

The report contains specific recommendations in relation to individual diseases. For each disease a status of the resistance situation is given and recommendations with respect to specific fungicide groups are dealt with.

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Fungicide resistance - general

There has been a gradual increase in the occurrence of fungicide resistance since the early 1970s. Resistance is usually first recognised when expected levels of disease control in the field are no longer achieved using commercial doses of the fungicide. Fungicide resistance can sometimes arise rapidly and disease control can be lost partially or completely. Sometimes it can be a gradual process resulting in a loss of control over many years. Examples of these types are common throughout Europe.

Many types of resistance mechanism are known. By far the commonest mechanism appears to be an alteration to the biochemical target site of the fungicide. This could explain why many of the older products, which have no specific target site, have not encountered resistance problems. In contrast, modern fungicides act primarily at single target sites, and are often referred to as 'single-site' fungicides. In this case, a single gene mutation can cause the target site to alter, so as to become much less affected by the fungicide. Different amino acid changes can cause different levels of resistance.

MBC fungicides
There are many instances of complete failure of control due to resistance to the MBC (e.g. carbendazim) fungicides. Resistance to the MBC fungicides in the eyespot fungus (*Oculimacula spp.*) occurred very quickly in the early 1980s. This was due to an alteration in the target site (ß-tubulin).

Strobilurin fungicides:
Resistance to the QoI fungicides (e.g. azoxystrobin) occurred very suddenly in the late 90s in powdery mildew (*Blumeria graminis*) and soon after many more diseases developed resistance. This development was due to changes in the target site protein (b-cytochrome). For example, the G143A mutation (causing glycine to be replaced by alanine) at amino acid position 143 in the b-cytochrome of mitochondrial Complex III, causes high levels of resistance to the QoIs, whereas the F129L mutation (replacing phenylalanine by leucine at position 129) results in only moderate levels of resistance to the QoIs

Triazole fungicides:
A more gradual loss of control has been found with the azole group (e.g. epoxiconazole). Resistance to the azole fungicides in Septoria (Mycosphaerella graminicola) is linked to several factors including altered target site in the CYP51 gene (e.g. V136A, Y137F, A379G, I381V), increased efflux (ABC transporters), and target-site over-production. This has resulted in a gradual loss of efficacy to azole fungicides since the mid 90s, which now appears to have stabilised.

Factors influencing resistance
Resistance to some groups of fungicides has occurred more frequently than to others. Similarly, some pathogens appear to be more likely than others to become resistant. Powdery mildew (Blumeria graminis) is particularly prone to resistance development). Factors which affect the development of fungicide resistance including the type of fungicide, its frequency of use, whether alone or in a mixture, the target pathogen and the ability of the resistant forms to survive.

Anti-resistance strategies:

Fungicide resistance groups in Eu

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

FRAC is the chemical companies r
action commitee. The pages inclu
lates updates on resistance develo
recommendations to minimize the
page also include methods for scr
resistance and links to regional FR
gruoups in Europe. more..

FRAG-UK interactive search facilit
Select on this page crop name an
information about fungicide group
tradenames etc.

Nordic Baltic Resistance Action Gr
(NORBARAG)
The group was initiated in 2008. N
meeting will be held in Lituania No
2009.

Reports and leaflets

Fungicide Resistance Management in Cere

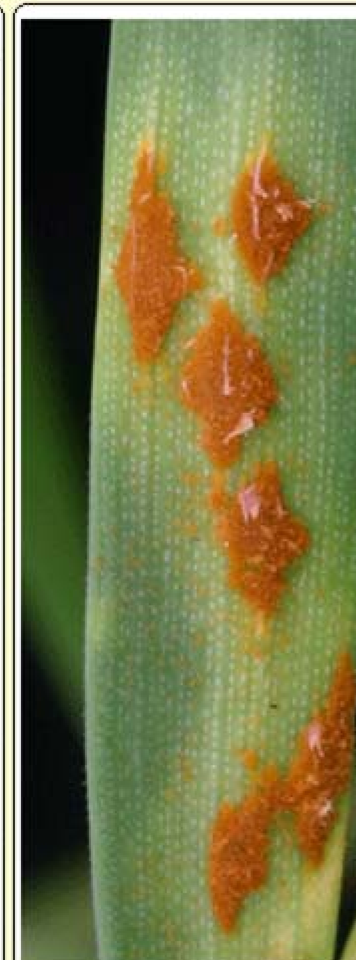
The document gives detailed examples of fungicid
in cereal pathogens, information about resistance
fungicide groups and new fungicides.

General Fungicide Resistance Guidelines

The leaflet contains general resistance manageme
guidelines as well as specific recommendations in
individual diseases. For each disease a status of th
resistance situation is given and recommendations
respect to specific fungicide groups are dealt with.

Fungicide Resistance Examples in Cereals

Fungicide Group	Comments
Azoles - Sterol demethylation inhibitors (DMIs) *E.g.: Tebuconazole, epoxiconazole, propiconazole, prothioconazole, cyproconazole*	There has been a significant shift towards reduced sensitivity to azoles in *Mycosphaerella graminicola* and *Blumeria graminis* but is now thought to have stabilised.
Strobilurins -Quinone outside inhibitors (QoIs) *E.g.: Azoxystrobin, pyraclostrobin, picoxystrobin, fluoxastrobin.*	Due to prevalence of the G143A mutation within several pathogen populations, resistant isolates of *Mycosphaerella graminicola, Blumeria graminis, Pyrenophora tritici-repentis* and *Phaeosphaeria nodorum* are widespread throughout Europe. Rusts do not carry the G143A mutation and so are not affected.
Chloronitriles *E.g.: Chlorothalonil*	There are no cases of resistance recorded to this group
Dithiocarbamates *E.g. Mancozeb, maneb*	There are no cases of resistance recorded to this group
Carboxamides (SDHIs) *E.g.: boscalid, penthiopyrad.*	There are no cases of resistance recorded to this group in cereals. However, resistance is known in other non-cereal pathogens (e.g. *Alternaria, Botrytis*).
Morpholines -Sterol reductase and isomerase inhibitors - pirimidines, morpholines and spiroketalamines *E.g.: Fenpropimorph, fenpropidin, spiroxamine*	A shift in sensitivity in *Blumeria spp.* was recorded in the 1990s, which led to a decline in field performance. The shift has remained stable since then.
Anilinopyrimidines *E.g.: Cyprodinil*	Low frequency of resistant strains in the eyespot population is found in France with little impact on practical use. Cyprodinil is no longer effective enough to be recommended for control of powdery mildew in France.
Quinolines *E.g.: Quinoxyfen*	Resistance to quinoxyfen in *Blumeria graminis* is established in parts of Europe.
Amidoxines *E.g.: Cyflufenamid*	There are no cases of resistance recorded to this group in cereals. However, resistance is known in other non-cereal pathogens (e.g. *Sphaerotheca*).
Quinazolinones *E.g.: proquinazid*	There are no cases of resistance recorded to this group. However, due to similarities in biological activity with the quinolines, the group may be at risk.
Benzophenones *E.g.: metrafenone*	There are no cases of resistance recorded to this group



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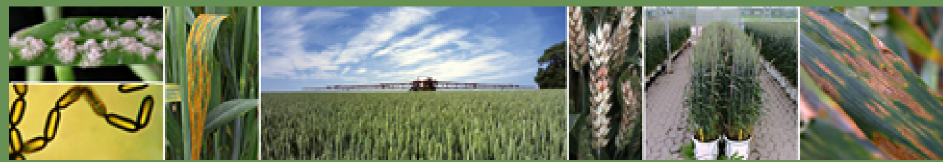

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Control thresholds

Monitoring for diseases in wheat

Select to change information in right hand info box

- Eyespot
- Yellow rust
- Brown rust
- Powdery mildew
- Septoria leaf blotch
- Tan spot

Field monitoring is an essential activity in order to optimize diseases management and apply IPM at farm level. Many countries have well-established control thresholds, which can be used as background for deciding whether or not to apply a fungicide. This guideline describes, how to do assessments and gives examples of thresholds recommended in different countries.

General principles for disease development

Following infection, the fungus develops for some time in the plant before symptoms appear. Latent period varies between the different diseases from 4-5 days to 3 weeks. Symptoms on lower leaves are generally less important compared with symptoms appearing on yield-forming upper leaves. Most control strategies aim at keeping the 3 upper leaves free from diseases.

Disease development is very complex and the severity of diseases in a season depends on the amount of disease inoculum, weather and the variety's genetic ability to 'resist' that pressure. A higher fungicide dose is needed when disease pressure is high and varietal resistance is low. Conversely, a resistant variety facing low disease pressure may not require any treatment.

Unfortunately disease forecasting is not a very precise discipline. Therefore risk assessment is often reduced to estimating, if risk of disease development is nil, low, moderate or high. Threshold is however still believed to be of good value, when the risk has to be decided.

General principles used for assessing diseases

Control thresholds used in different countries

Yellow rust(Puccinia striiformis)
HGCA photos

>1 % plants with attack. GS 29-60 (S). >10 % plants attacked after GS 61-71 (S)

>1 % plants with attack or foci (S) GS 29-59. >10 % plants with attack (R)

At first symptoms.

1-2 % severity or foci present

From GS 31: at first symptoms.Before GS 31: if spots are present and they are active

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Cultural Practices

Non-chemical control of wheat diseases

Select ⓘ to change information in the right hand info box

- Eyespot
- Yellow rust
- Brown rust
- Powdery mildew
- Septoria leaf blotch
- Tan spot
- Fusarium species
- Take-all

Integrated pest management (IPM) are closely linked to adaptation of cultural methods. This practise is often regarded as a sustainable and more enviromentally friendly method. Application of IPM can help to minimize the need for application of fungicides. IPM principles have been defined and promoted by several organisation like IOBC and FAO.

In relation to minimizing disease risk the following elements are known to be of major importance:

- Diversification of crop rotations.
- Use of resistant cultivars and/or variety mixture.
- Removal of debris.
- Reduced use of nitrogen.
- Optimal sowing conditions and timing.

Important links

HGCA:
The Encyclopaedia of Cereal Diseases

Wheat Disease Encyclopaedia

Cultural practices impact on disease development

Eyespot (Oculimacula spp.)
HGCA photos

Resistance genes	Varieties with moderate resistance genes are known, and help to reduce di levels. [25,33]
Previous crop	Wheat and other cereals increases the risk for attack. Non-cereal crops suc oilseed rape, etc reduce the risk. [38]
Sowing date	Early sowing is known to increase disease risk. Late sowing is seen to decr disease level as epidemic generally gets delayed. When wheat is sown afte is recommended if possible and practical to delay the sowing time to minim risk. [38]
Tillage	Ploughing can increase the risk - thought to be due to increased N-minerali coupled with deeper drilling. Direct drilling can reduce disease levels as pla more open habit with greater air movement. Ploughing can preserve crop d then increase the risk once it is brought back to the surface. [38]
Debris and volunteers	Debris may directly influence disease levels as disease as both ascospores condiospores are released from crop debris in the autumn.

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Cultural Practices

Non-chemical control of wheat diseases

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Important links

HGCA:
The Encyclopaedia of Cereal Diseases

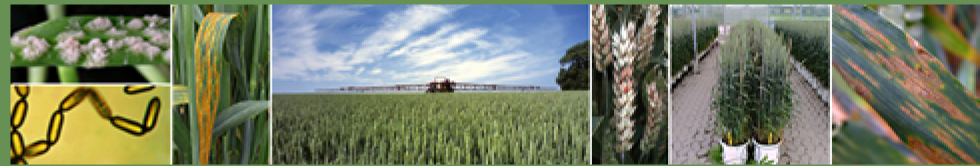
Wheat Disease Encyclopaedia

Cultural practices impact on disease development

Take-all (Gaeumannomyces graminis var. tritici)
HGCA photos

Resistance genes	There are no varieties with specific resistance genes. Different wheat varietie been found to build up different amounts of take-all inoculum in the soil, wher first cereal crop. [17]
Previous crop	The disease is usually most severe in second, third or fourth successive cerea but generally declines in importance in continuous cereals. Oats and broad le like oilseed rape as the previous crop will reduce the risk of take all. [13,17]
Sowing date	Early sowing is known to increase disease risk. Late sowing is seen to decrea disease level as the epidemic is delayed. When wheat is sown after wheat it is recommended to delay the sowing time to minimize the risk. A crop sown in i conditions is better than one where soil structure is poor. [9,19,37]
Tillage	Tillage is found sometimes to have a major impact on the disease developme Increased levels are sometimes seen following ploughing compared with non- tillage, but sometimes the opposite can take place. It relates to factors like so compaction, water content, etc. Light puffy seedbeds can encourage the deve the disease. In short sequences of cereals, ploughing generally has an advan [13,17]

EURO-wheat



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Disease resistance ranking
Yield response to fungicides
Diseases yield impact

ID	Reference
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Endure: Reports from wheat case study (2008)

Best control practices of diseases in winter wheat (85 pages)

The report contains a description of major disease problems and present wheat disease management in 7 different countries (UK, DE, DK, FR, It, Hu, Pl). It offers also examples of best disease practises, which can be used in order to minimize dependency on fungicides.

Using cultivar resistance to reduce fungicide input in wheat. Wheat Case Study- Guide no. 1. Autumn 2008 (preliminary)

The leaflet describes the benefits from growing cultivars with good resistance to major diseases, with focus on reduced dependency on fungicides.

Strategy to control Fusarium ear blight and mycotoxin production in wheat. Wheat case study- Guide no. 2. Autumn 2008 (preliminary)

The leaflet describes the risk for development of fusarium and toxins in grain. It gives recommendations to minimize the problems with focus on application of good agricultural practice.

Endure: Poster from 56th German Plant Protection Conference in Kiel:sept. 2008

The poster summarizes some of the results from the Wheat case study. With particularly emphasis on major disease problems and control strategies in the participating countries.

Endure: Abstract from 56th German Plant Protection Conference in Kiel:sept. 2008

The abstract summarizes some of the results from the Wheat case study. With particularly emphasis on major disease problems and control strategies in the participating countries.

Endure: Limiter les maladies sans avoir recours aux fongicides ?

Paper from France in Perspective Agricole on the wheat case study, with focus on how fungicides can be minimized.

National guidelines

The wheat disease management guide 2009, Spring 2009, 4th

This updated Wheat disease management guide brings together the lates information on controlling economically important wheat diseases. Foliar, root and ear diseases are covered. The guide now includes a section on good seed health - particularly relevant if you are home-saving seed.

UK-HGCA- Wheat seed health and seed born diseases. A guide 2004

The brochure describes the main disease problems in wheat with respect born diseases. Gives information on rules for certification of seed and for disease information on identification, life cycle, risk factors, economic im and control measures are given.

UK-HGCA. Managing the Fusarium mycotoxin risk in wheat. To 91/2007

Information on legislation, risk assessment and identification of fusarium given.

UK-Food standard agency: Code of Good Agricultural Practise reduction of mycotoxin in UK cereals.

The brochure describes agronomic and storage changes which can be ma minimize the risk of exceeding the EU-limits for fusarium toxin in cereals

Scientific papers

Jørgensen, LN. et al. (2008) Integrating disease control in wi - optimizing fungicide input. Outlook on Pest Management. Oct.

The paper describes how diseases are controlled in Denmark using moni thresholds and reduced fungicides rates.

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Kemisk bekæmpelse

Dyrkningsvejledninger

- Svampemidler i korn
- Bekæmpelsestærskler for svampesygdomme i korn

Udvalgte artikler:

Svampebekæmpelse i rug -
Effekttabel for svampemidler -
Effekt af aktivstoffer i korn - udenlandske data -
Svampebekæmpelse i triticale -
Svampebekæmpelse i alm. rajgræs -
Svampebekæmpelse i vinterhvede -
Svampemidlet Flexity godkendt -
Svampebekæmpelse i vinterraps -
Hold øje med gulrust i triticalesorterne Dinaro og Valentino -
Vækstregulering i vintersæd -
Svampebekæmelse i vinterbyg -
Svampebekæmpelse i hvede med forfrugt hvede og samtidig reduceret jordbearbejning -
Knækkefodsyge i vintersæd -
Valg af dyser og vandmængder -
Svampebekæmpelse i vårbyg -
Svampebekæmpelse i havre -

Artikler:

Vis: [10] eller [alle 356] artikler

► Forebyggelse af kartoffelskimmel
Kartoffelmarker bør nu behandles forebyggende mod kartoffelskimmel.
10. juni 2009 - Planteavl 738

Nye artikler

Forebyggelse af kartoffelskimmel 10/06

Registreringsnettet uge 24: Aktuelle sygdomme og skadedyr i korn 10/06

Manganmangel i havre 08/06

Udbyttetab ved gulrustangreb i triticale 05/06

Sidst opdateret kl. 16:40

Tabel 1. Relativ virkning af godkendte svampemidler i korn.

Vinterhvede	Aproach (picoxy-strobin)	Amistar (azoxy-strobin)	Acanto Prima (picoxy-strobin + cyprodinil)	Bell (epoxi-conazol + boscalid)	Comet (pyraclo-strobin)	Flexity (metra-fenon)	Folicur EC250/ Riza (tebuco-nazol)	Juventus 90 (metco-nazol)	Opera (pyraclo-strobin + epoxico-nazol)	Opus/ Rubric/ Maredo (epoxico-nazol)	Opus Team (epoxi-conazol + fenpro-pimorf)	Opus Xtra (epoxico-nazol + kresoxim-methyl)	Orius 200 EW (tebuco-nazol)
Knækkefodsyge	-	-	*	**	-	**	-	-	-	-	-	-	-
Hvedemeldug	*[2]	*[2]	**[2]	*(*)	*[2]	****(*)	***	**	**[2]	**	***	**[2]	***
Bygmeldug	**[2]	*[2]	***(*)[2]	**(*)	**[2]	****(*)	****	***	**(*)[2]	***	****	***[2]	****
Gulrust	**(*)	***(*)	**	*****	****(*)	-	****(*)	***	****(*)	*****	*****	*****	****(*)
Brunrust	***(*)	***(*)	***	****(*)	****	-	****(*)	***(*)	****(*)	****(*)	****(*)	****(*)	****(*)
Bygrust	****(*)	****(*)	***	****(*)	****(*)	-	*****	****	****(*)	****(*)	****(*)	****(*)	*****
Septoria	*[2]	*[2]	*[2]	****(*)	*[2]	-	**(*)	***(*)	***(*)[2]	****	****	****[2]	**(*)
Hvedebladplet	*[2]	*[2]	*[2]	**	*[2]	-	*	*	**[2]	**	**	**[2]	*
Skoldplet	***	**(*)	****	***(*)	***(*)		***	***	****	***(*)	****	***(*)	***
Bygbladplet	****(*)[3]	***[3]	****(*)[3]	****	****(*)[3]	-	***	***	****(*)[3]	***(*)	***(*)	***(*)[2]	***
Ramularia	*(*)	**	*(*)	****(*)	**		-	-	***(*)	***(*)	***(*)	***(*)	-
Aksfusarium	-	-	-	*	-	-	**	**	-	(*)	(*)	(*)	**
Sneskimmel	-	-	-	-	-		***	-	-	-	-	-	***
Trådkølle		-	-	-	-	-	****	-	-	-	-	-	****
Normaldosering, l/kg/ha	0,5[4]	1,0	1,5	1,5	1,0	0,5	1,0	1,0	1,5	1,0	1,5	1,0	1,25/1,9[5]
Pris pr. normaldosering inkl. afgift, ekskl. moms	212	440	396	561	388	325	266	340	596	420	482	440	313/475

\- = ikke aktuel, ikke godkendt eller ingen data.
* = svag effekt (under 40 %), ** = nogen effekt (40-50 %),
*** = middel til god effekt (51-70 %), **** = meget god effekt (71-90 %),
***** = specialmiddel (91-100 %), (*) = en halv stjerne.

[1] Efter brug af Proline må der først sås eller plantes bladgrøntsager 5 måneder efter.

[2] På grund af resistensudvikling hos svampe mod strobiluriner er effekten mod hvedemeldug, Septoria og hvedebladplet nu meget begrænset. Mod bygmeldug kan nu også

[3] Mod bygbladplet kan nu også forventes tilfælde af nedsat effekt med Amistar. En resistens som p.t kun forventes at berøre de øvrige strobiluriner i begrænset omfang. Der

[4] Effekt vurderet ud fra 1,0 l pr. ha.

[5] 1,9 liter pr. ha i byg og 1,25 liter i andet korn.

[6] 1,6 liter pr. ha i byg og 2,0 liter pr. ha i hvede og rug.

Effekt af aktivstoffer i korn - udenlandske data

Effekt af svampemidler i hvede
Klik på 'Opsætning'/'Resultater' for at vælge andre data

Vælg sprog:

Forklaring: : Ikke godkendt R: Problemer med resistens : Lav effekt : Moderat effekt : God effekt

Opsætning	Hvedemeldug (*Blumeria graminis f. sp. tritici*)					Hvedegråplet (*Mycosphaerella graminicola*)					Brunrust (*Puccinia triticina*)					Gulrust (*Puccinia striii*		
Triazoler																		
bromuconazole																		
cyproconazole																		
difenoconazole																		
epoxiconazole																		
fenbuconazole																		
fluquinconazole																		
flusilazole																		
flutriafol																		
hexaconazole																		
metconazole																		
prochloraze																		
propiconazole																		
prothioconazole																		
tebuconazole																		
tetraconazole																		
triadimenol																		
Strobiluriner																		
azoxystrobin	R	R	R	R	R	R	R	R	R	R								
fluoxastrobin					R					R								
kresoxim-methyl					R		R			R								
picoxystrobin	R		R	R	R	R	R	R	R	R								
pyraclostrobin	R				R	R	R	R		R								
trifloxystrobin			R	R	R		R	R	R	R								
Andre																		
boscalid																		
chlorothalonil																		
cyflufenamid																		
cyprodinil																		
fenpropidin																		

Conclusion

- It has been fun and interesting to collect information across borders
- Much more to come – if money and time allows!
- Not inventing the wheel again!!
- Links to many existing pages – HGCA – homepage etc
- Link to different relevant sites
- Plans for the near future
  - Update on existing elements
  - Thresholds for seed born diseases
  - Information on genetical resistance sources
- If we get the chance(!?)
  - Common monitoring data
  - Compare different models for risk assessments using weather data from different countries
- Platform future
  - Common databases with other platforms
  - Euroblight in potatoes
  - FAO rust database
  - Fusarium information