Recommendations for cereal diseases as given by NORBARAG's fungicide group with respect to minimizing the risk of fungicide resistance.

- Promote non-chemical means that could reduce disease risks
- Reduce the fungicides selective pressure towards rising resistances
- Manage the efficacy of fungicides in situations of practical resistance

GENERAL RECOMMENDATIONS FOR 2012-13 BY NORBARAG

- Choose disease tolerant varieties, especially Septoria leaf blotch resistance, and avoid using susceptible wheat or barley cultivars over wide areas.

- Reduce disease risk and pressure, by limiting primary inoculums (for example adjust rotation, ploughing, sowing date, plant density, etc).

- **Treat only if necessary.** Use reliable observation methods, risk analysis or risk models based on information about climate, cultivation conditions, etc. Reflect and decide treatment times according to disease development.

- Limit the number of seasonal applications of active ingredients from the same chemical mode of action (usually characterized by a positive cross resistance).

- Alternate or use mixtures or co-formulations with different modes of action, in treatment programmes, to minimize the risk of resistance development or to deal with a practical resistance problem for a given family.

- Strobilurins (QoI) are not useful any longer on wheat for control of Septoria leaf blotch, powdery mildew, Glume blotch, Ramularia and DTR. . Widespread resistance to *M. nivale/majus* is now found in the NORBARAG region. QoIs remains effective on rust diseases in wheat. Strobilurins can still be applied for control of rust diseases in wheat

- Strobilurins are still active on *Rhynchosporium* and rust in barley. On net blotch the efficacy is reduced for some strobilurins compared to previous years in some regions of NORBARAG. For spring and winter barley strobilurins should be used in mixtures with compounds characterised by other modes of action and only once per season

- Reduced efficacy has been seen to some DMIs on Septoria leaf blotch and net blotch. It is recommended to choose the most efficient DMI products in situations of high risk. Their performances will be improved if they are mixed with compounds with different modes of actions.

- Generally economical and efficient dose rates should be recommended.

- As resistance to metrafenone in wheat powdery mildew has been in low level in Denmark and Sweden it is now recommended to treat only once per season with this active compound and preferable in mixtures..

FUNGICIDE RESISTANCES in the Nordic/Baltic regions
CEREAL DISEASES
Guidelines 2012-13

MAIN situation in 2011-12
SEPTORIA LEAF BLOTCH (*Mycosphaerella graminicola*) Resistance to QoIs (strobilurins) nowadays affects all the regions producing cereals. This resistance is especially widespread in the major wheat growing area. QoI resistance has been verified in Denmark, Sweden, Finland, Estonia, Latvia and Lithuania. So far only Norway has not been tested. In this context, the efficacy of all the strobilurins is strongly compromised. Concerning triazoles (main class of DMIs), the current *M. gramincola* strains show a low or moderate resistance to these compounds. The moderate resistant isolates have been found to be present to a different degree in the Nordic/Baltic region. A few wild types isolates are left. It is still an open question how widespread the strains with moderate resistance to DMIs are in the regions. Despite the fact that the efficacy in the field of some triazoles (e.g. tebuconazole) is decreasing, the most efficient ones (prothioconazole and epoxiconazole) are still providing good field performance. Furthermore, the efficacy of triazoles can be reinforced by some multisite fungicides and SDHI fungicides. Use of azole mixtures might also help to prolong the efficacy of this group of fungicides.
POWDERY MILDEW (*B. graminis f. sp. tritici*) Resistance to strobilurins is deeply established in the region. This family of QoI can no longer be considered as efficient on powdery mildew. Resistance to DMIs is widespread in the region, but several of these molecules are still quite effective. Fenpropimorph has been found to be less effective today compared to previous times. The resistance factor has for many years been approximately 10; however, fenpropidin is still found to give a very good field performance. Among the triazoles tebuconazole is still found to give reliable field control. Cyprodinil is used less for control of mildew, and it is unknown if changes in sensitivity has taken part. Changes have been found in other regions of Europe. New data with metrafenone, a new mode of action, have shown that this product is giving a high control of powdery mildew but some cases of resistance to this group have been seen in particular in France, the UK and Germany. Monitoring has been carried out in Denmark and Sweden and . only few isolates with major resistance has been found in Denmark. Low level of moderate resistance have been found in Deanmark and Sweden . . Due to a high resistance risk the product is only recommended once per season alone or in mixture with other mildew specific fungicides.
POWDERY MILDEW (*B.graminis f.s. sp. hordei*) Resistance to strobilurins is found to some extent in the region. QoIs can no longer be considered reliable as a solo product on powdery mildew in barley. Mixtures with effective mildewicides are recommended. Resistance to DMIs is widespread in the region, but several of these molecules are still quite effective. Fenpropimorph has been found to be less effective today compared to previous times: however, fenpropidin is still found to give a good field performance. Among the triazoles tebuconazole is still found to give reliable field control. Cyprodinil is used less for control of mildew and it is unknown if changes in sensitivity has taken part. Changes have been found in other regions of Europe. New data with metrafenone, a new mode of action, have shown that this product is giving a high control of powdery mildew. One isolate with resistance has been found in Scotland 2010. No monitoring has been carried out in the NORBARAG region.
EYESPOT (*Oculimacula spp*.) The main species is *Oculimacula (Tapesia) yallundae* and the strains are often still resistant to benzimidazoles. In other countries resistance has been seen to several DMIs, and especially to

prochloraz. Nevertheless, they remain sensitive to prothioconazole.
The sensitivity of eyespot to cyprodinil has not been investigated in the Nordic region, but low levels of resistant isolates have been found in e.g. France. This has, however, not been seen to have an impact on field performances as the level of resistant isolates remains low.
With the recent registration of boscalid and metrafenone, several actives are available for eyespot control. Due to the little importance of this disease few treatments are targeting this disease and low risk of resistance development is likely.

NET BLOTCH ON BARLEY (*Pyrenophora teres*)
In some regions in Europe, the resistance of *Pyrenophora teres* to QoI fungicides is well established. Unlike powdery mildew or Septoria leaf blotch, for this disease it is the mutation F129L which leads to low to moderate resistance. In the Nordic region occurrences of F129L has been verified in Denmark, Sweden and Finland, stable or decreasing levels in 2012The presence of F129L is to different degrees affecting the efficacies of strobilurins in the field. The field efficacy has been found to be influenced in Denmark but not specificly elsewhere in the region. The net blotch need to be further monitored in order to see how widespread the mutation is and how severely it influences field performance.
Different sensitivity to DMI is also known and reduced effectiveness has previously been found for several DMIs. The populations need to be characterized further in order to find out how sensitive the population is to different DMI's and what impact this has on field performances. Field trials from Finland showed a reduced control by propiconazole over the years (1998-2012). High sensitivity to imazalil has still been found in *in vitro tests*, although sometimes the field performances have been found to vary.

TAN SPOT IN WHEAT (*Pyrenophora tritici-repentis)*
Observations carried out in the Nordic region show the presence of 3 different mutations, either in position F129L, G137R or in position G143A. Approximately 50 % of the isolates in Sweden and Denmark have so far been seen to have mutations. Samples from Lithuania, Latvia and Norway have also shown occurrences of the mutation G143A, and low levels have also been found in Finland. Efficacy of strobilurins can be significantly affected by mutations. Tan spot shows relatively high tolerance to triazoles in bioassays. The practical implication of this is unclear and is another issue which needs further investigation. Benefits from mixes of triazoles and strobilurins are still seen in fields with QoI resistance.

EAR BLIGHT /SNOW MOULD (*Microdochium nivale/majus*)
This disease has previously been found to be resistant to benzimidazoles. QoI resistance /has been widely found in France and the UK. Screening from 2009 and 2010 in the Nordic/Baltic region for sensitivity to QoIs showed high levels of resistance. Data from 2011 shows high resistance levels in both Sweden and Denmark. Resistance seen in both wheat and barley. Impact from the use of strobilurins on this disease can no longer be counted on.

RAMULARIA LEAF SPOT (*Ramularia collo-cygni*)
Few isolates has been screened for sensitivity to QoI and resistance has been confirmed in the Danish and the Swedish population. Experience from France, UK, Sweden and Denmark show widespread resistance in field populations. It is recommended to use triazoles alone or mixed with carboxamides for control. Occurrences of strobilurin resistance in the other Baltic and Nordic countries need to be verified.

RHYNCHOSPORIUM *(Rhynchosporium secalis*)
This disease is known to shift in sensitivity to DMIs. Studies from the UK have shown that treatments with solo use prothioconazole shift the sensitivity more than mixtures. The sensitivity to DMIs in the Nordic/Baltic region has not been investigated. Only two cases of QoI resistance to this disease has been confirmed in France, one in 2008 and one in 2012.. Extensive monitoring in in 2009-2012 s in Denmark, Sweden, Finland, Norway and Latvia showed no signs of resistance. It is generally recommended to use mixtures of strobilurins and triazoles (or cyprodinil) for control.

RUST (*Puccinia spp*) No cases of QoI resistance or DMI resistance to these diseases have been confirmed.
GLUME BLOTCH *(Stagonospora nodorum)* This disease is getting quite rare in wheat in Denmark, but can still be found to be of importance in triticale. Glume blotch in wheat is more widespread in Norway, Finland, the Baltic region and some parts of Sweden. From Sweden QoI resistance has been confirmed in five fields (2003-2005), where G143A has been dominating in the populations. Testing in 2011 showed that G143A seems to be widespread in the region although the resistance situation to QoI needs to be investigated further.

Nordic/Baltic region

LIST 1 – Known cases of resistance in cereals (Practical resistance or detection of resistant strains)

Chemical group	Active ingredient	? Introduction year	Region	Scientific name	CROP	Practical resistance	Reference	First found
Benzimidazoles	Carbendazim Thiophanate-methyl	1968	DK	*Botrytis cinerea*	Peas strawberries	Yes	Schulz 1987	1983
Benzimidazoles	Carbendazim Thiophanate-methyl	1968	DK	*Microdochium nivale*	Cereals	Yes	Junker 1986	1986
Benzimidazoles*	Carbendazim Thiophanate-methyl	1968	DK	*Oculimacula spp*	Cereals	Yes	Nielsen & Jørgensen	1983
DMIs / Morpholines	Fenpropimorph Fenpropidin	1983	DK	*Blumeria graminis*	Cereals	No	Epilogic	1995
DMIs / Triazoles	Many	1983	DK	*Blumeria graminis*	Cereals	Yes for some DMIs	Jørgensen & Thygesen 2006	1990s
DMIs / Triazoles	Tebuconazole Propiconazole	1982 1999	DK	*Septoria tritici*	Wheat	Yes for some DMIs	Jørgensen et al 2006	2005
Phenylamides	Metalaxyl	1981	DK	*Phytophtora infestans*	Potato	Yes/no	Holm S 1987	1985
Strobilurins	Kresoxim-methyl Pyraclostrobin Picoxystrobin	1998	DK, S, Li, La	*Blumeria graminis*	Wheat	Yes	epilogic	1999
Strobilurins	Picoxystrobin Kresoxim methyl	1998	DK, S	*Blumeria graminis*	Barley	Yes	epilogic	2002
Strobilurins	Azoxystrobin (picoxystrobin ?)	1998	DK, S,	*Pyrenophora teres*	Barley	Yes, for some strobes	BASF, Syngenta	2008-2010
Strobilurins	Pyraclostrobin Picoxystrobin, Asoxystrobin	1998	DK, La, Li, S, F, N	*Pyrenophora tritici-repentis*	Wheat	Yes	Helge Sierotzki	2003-2010
Strobilurins	Pyraclostrobin Picoxystrobin, Azoxystrobin	1998	DK, S	*Ramularia collo-cygni*	Barley	Yes	Oxley, SAC	2007, 2009, 2010
Strobilurins	Pyraclostrobin	1998	DK, S, F,	*Septoria tritici*	Wheat	Yes	Syngenta, BASF,	2002-2010

	Picoxystrobin, Asoxystrobin		La, Li				DJF	
Strobilurins	strobilurins	1998	DK, F, S, La, Li, Es	*M. nivale/majus*	Wheat	Yes	Bayer, BASF, AU, Du Pont	2003
Strobilurins	Pyraclostrobin Picoxystrobin, Azoxystrobin	1998	S, DK, N, Fi	*Stagonospora nodorum*	Wheat	Yes	Eva Blixt, SLU Andrea Ficke Bioforsk	2007 2011
Strobilurins	Strobilurins	1998	DK	*M. nivale/majus*	Barley	Yes	AU	2007
	Metrafenone	2009	DK, S	Blumeria graminis	Wheat	No (few with moderate resistance)	BASF	2010, 2012