

MEMBERSHIP

The working group is comprised of the following members:

Andy Leadbeater (chair)	Syngenta
Helge Sierotzki	Syngenta
Paul Varney	Syngenta
Andreas Mehl	Bayer CropScience
Albert Witzemberger	Bayer CropScience
Friedrich Kerz-Moehlendick	Bayer CropScience
Robert Bird	DuPont
Jean-Luc Genet	DuPont
Gerd Stammler	BASF
Martin Semar	BASF (arable crops)
Randall Gold	BASF (speciality crops)

1. INTRODUCTION

The working group is responsible for global fungicide resistance strategies in the Qo inhibitor fungicides (QoI). The Qo inhibitor fungicides (QoI) all act at the Quinone 'outer' (Qo) binding site of the cytochrome bc1 complex.

The QoI fungicides are: azoxystrobin, dimoxystrobin, enestroburin, famoxadone, fenamidone, fluoxastrobin, kresoxim-methyl, metominostrobin, orysastrobin, picoxystrobin, pyraclostrobin, pyribencarb, trifloxystrobin

They are all in the same cross-resistance group and should be managed accordingly.

Companies participating in the meetings:

BASF, Bayer CropScience, DuPont, Syngenta

QoI working group of FRAC
Minutes of the meeting
All crops: December 2nd and 3rd, 2008
Organised by Syngenta in Frankfurt, Germany

2. Minutes of discussions

2.1. Review of sensitivity monitoring

2.1.1. Cereal diseases

Field experience in 2008 has confirmed that, when used according to FRAC guidelines, the performance of Qol containing products within spray programmes was good. Qols continue to contribute to overall disease management in cereals.

Powdery mildew (*Blumeria graminis* f. sp. *tritici* = *Erysiphe graminis* f.sp. *tritici*), wheat

Bayer CropScience

Disease pressure in 2008 was low to moderate across Europe.

No further monitoring was carried out in Northern and Western parts of Europe due to already established high levels of resistance as reported previously.

Overall in Eastern and Southern Europe the situation in 2008 was similar to previous years.

Low to medium resistance frequencies were found in Hungary Austria, Czech Republic and Poland.

No resistance was found in Italy.

Powdery mildew (*Blumeria graminis* f. sp. *hordei* = *Erysiphe graminis* f.sp. *hordei*), barley

Disease pressure in 2008 ranged from low to high across Europe.

Bayer CropScience

An improved situation was recorded compared to 2007, with lower levels of resistance in some countries (particularly Germany).

High resistance levels were found in France and the UK.

Low to medium frequencies were found in Germany, Denmark and Ireland.

No resistance was detected in Czech Republic, Austria, Hungary, Italy and Poland.

Septoria leaf spot (*Septoria tritici* = *Mycosphaerella graminicola*), wheat

BASF, Bayer CropScience, Syngenta, Du Pont

Disease pressure in 2008 in Europe was low to moderate.

Extensive monitoring programmes were carried out throughout the wheat growing areas of Europe in 2008.

Frequency of resistance was comparable to 2007 in wheat growing countries in Europe.

Status at the end of the season 2008 is as follows:

UK, Belgium, The Netherlands: widespread resistance all over these countries at high levels.

France: heterogeneous populations with decreasing gradient from North to South, i.e. high resistance levels in the North, variable from medium to high in the centre and low to medium in the South.

Germany: high resistance levels in the North (e.g. Schleswig-Holstein, Mecklenburg-Vorpommern, Niedersachsen), medium resistance frequencies in the South (e.g. Bavaria, Baden-Wuerttemberg).

Austria, Switzerland: 2008 data show a very heterogeneous picture ranging from low to highly resistant populations.

Czech Republic: 2008 data show generally no to medium resistance levels.

Poland: 2008 data show a very heterogeneous picture ranging from no to highly resistant populations.

Brown rust (*Puccinia recondita* = *Puccinia triticina*), wheat

BASF, Bayer CropScience.

Disease pressure was moderate in most of the countries of Europe in 2008.

Performance of QoI fungicides against brown rust was good. No resistant isolates were detected in widespread monitoring studies in Europe in 2008, confirming the fully sensitive picture.

Net blotch (*Pyrenophora teres*), barley

BASF, Bayer CropScience, Syngenta, Du Pont

Disease pressure was moderate in Europe during 2008. Performance of QoI containing spray programmes against Net Blotch was good in 2008.

Extensive monitoring was carried out in 2008. Only the F129L mutation (not the G143A or G137R mutations) was found. As already observed with other pathogens, resistance factors are significantly lower in comparison with the G143A mutation and field performance of products used according to FRAC and Manufacturers' recommendations remains good. (For differences between QoI mutations see also the respective FRAC document).

Frequency of the F129L mutation in 2008 was comparable to 2007 in barley growing countries in Europe.

The F129L mutation was found most frequently in populations in Central France and the UK, less frequently in Northern France, Ireland and Denmark.

A few F129L containing - samples were detected in Germany, Southern France, Sweden and Poland. No mutation was found in Czech Republic, Italy, Latvia and Lithuania.

Leaf scald (*Rhynchosporium secalis*), barley

BASF, Bayer CropScience, Syngenta

Disease pressure was moderate in Europe during 2008.

Performance of QoI fungicides against Leaf Scald was good.

Monitoring data from 2008 showed a fully sensitive picture for England, Scotland, Ireland, Germany, Poland.

Most of the samples collected from France were fully sensitive, but one sample from Northern France was found to contain the G143A mutation at low frequency. This is the first known case in *Rhynchosporium secalis*.

Tan spot (*Pyrenophora tritici-repentis*), wheat

BASF, Du Pont

Disease pressure was low in Europe. Performance of QoI containing spray programmes against tan spot was good in 2008.

All three point mutations known for QoIs, (G143A, F129L, G137R), have been detected, and can occur in the same population.

Resistance of Tan Spot to QoI fungicides has not spread rapidly (as compared with *M. graminicola*)

Samples containing the G143A mutation were found in Germany, France, Denmark, Latvia, Lithuania, Sweden, Czech Republic. However, levels were highly variable.

Samples containing the F129L mutation at lower frequency than the G143A mutation were found in Germany, France, Denmark, Latvia.

Characterisation of F129L isolates has shown a clear dose response to QoI fungicides.

→ Hyperlink to: Mutations Associated with QoI Resistance
http://frac.info/frac/meeting/2007/Mutations_associated_with_QoI_resistance.pdf

The G137R mutation, first detected in 2006, which confers weak resistance (lower than F129L) remains at low frequency. And only found in areas where the other known mutations have been detected. This is considered to be of low practical relevance.

Microdochium nivale and majus, wheat

BASF, Bayer CropScience, Du Pont, Syngenta

Disease pressure was high in 2008 in France.

Monitoring was carried out in 2008 on both species of *Microdochium* (*M. majus* and *M. nivale*).

A limited number of samples from several cereal growing areas in France were found to contain resistant isolates which were confirmed to contain the G143A mutation. The mutation was detected in both species.

Fusarium spp.

BASF

Monitoring was carried out in 2008 on *Fusarium culmorum* and *Fusarium graminearum* in France and Germany. A fully sensitive situation was found for both species.

2.1.2. Vine diseases

Downy mildew (*Plasmopara viticola*)

BASF, Bayer CropScience, Syngenta

In 2008, disease pressure was moderate to high (even severe) in the main grape growing areas of Europe. Disease management was challenging in many situations due to high disease pressure.

FRAC guidelines have been widely followed, and field performance of QoI containing spray programmes was good across Europe.

The levels of resistance found in monitoring programmes is summarised below:

High levels: France

Moderate levels: Germany, Austria, Spain, Switzerland, Northern Italy

Low levels: Spain (Rioja), Portugal, Germany (Baden)

In 2008 a decrease in frequency of the G143A mutation compared with 2007 was observed in several countries, particularly in Northern Italy.

Powdery mildew (*Uncinula necator* / *Erysiphe necator*)

Bayer CropScience, Syngenta, BASF

Disease pressure in 2008 was variable across Europe, with high levels reported in Italy, Switzerland, Austria, Hungary, Germany. Field performance of QoI containing spray programmes was good.

In 2008, intensive monitoring was carried out in Europe and no resistance was detected in Germany, Greece, Spain and most of France.

In 2008 resistance was found in commercial locations in Eastern Austria, Hungary and, for the first time, in Italy and the Armagnac region of France. In previous years resistance was found in Austria, Hungary, Slovakia and the Czech Republic.

Two samples were found in South Portugal in which there is a suspicion of the presence of the G143A mutation. However the significance of this finding is not clear and further investigations are needed.

FRAC guidelines have been widely communicated across Europe and field performance of QoI containing spray programmes was good. However, adherence to FRAC guidelines must be stressed, especially in areas where resistance has been confirmed.

2.1.3 Pome fruit diseases

Apple scab (*Venturia inaequalis*)

BASF, Bayer CropScience

Disease pressure was low to moderate across Europe.

FRAC guidelines have been widely followed, and field performance of QoI containing spray programmes was good across Europe.

Through intensive monitoring carried out in Europe it is known that in regions where resistance is present, the levels of resistance found are very heterogeneous, with values ranging from zero to high, even within individual orchards.

Intensive monitoring was carried out in 2008 - frequencies of resistance are reported below:

Moderate to High: Southern France, Northern Italy (except Alto Adige), Poland, Greece and Eastern Germany. Also South Africa.

Low to moderate: – Belgium and Western Germany.

Low - Italy (Trentino, Alto Adige), UK, Spain and Portugal.

No resistance was detected in Austria, Northern France (Loire Valley), and the Lake Constance area of Germany.

Pears (*Stemphylium vesicarium*)

No monitoring was carried out in 2008

2.1.4. Potato/tomato diseases

Late blight (*Phytophthora infestans*)

Bayer CropScience

No resistance was detected in all isolates collected from potato crops in France, Germany, Netherlands, Poland, UK, Ireland and Italy. Performance remains good.

Early blight (*Alternaria spp.*)

Syngenta

Monitoring has been carried out in *A. solani* in Brazil since 2000 (FRAC - Brazil) on tomatoes and potatoes. All samples tested were fully sensitive

In Europe in 2008, limited monitoring was carried out in *Alternaria* spp. from tomato and potato sampled in NL, DE and CH. All *A. solani* isolates were fully sensitive. The G143A mutation was found in some *A. alternata* isolates.

2.1.5. Soybean diseases

Asian Rust (*Phakopsora pachyrhiza*)

Bayer CropScience

See the BRAZIL FRAC website for information

Monitoring methods for baseline establishment and follow-up have been developed. Samples from commercial fields in the main soybean growing areas of Brazil were tested in 2006, 2007 and 2008. No resistant isolates have been detected.

2.1.6. Other crops

Vegetables

Cucumber powdery mildew (*Sphaerotheca fuliginea*)

No monitoring was carried out in 2008

Grey Mold on Strawberries (*Botrytis cinerea*)

No monitoring was carried out in 2008

Oilseed Rape (Canola)

Stem Rot (*Sclerotinia sclerotiorum*)

BASF

Disease pressure during 2008 was moderate in Europe.

Monitoring carried out in UK, France, in 2008 showed a sensitive situation.

Cotton (*Ramularia areola*)

Syngenta, FRAC – Brazil

Widespread sampling in Brazil in 2008 showed the occurrence of resistant isolates.

Studies are underway, being conducted by independent researchers sponsored by FRAC-Brazil. Conclusions are not yet available.

→ Hyperlink to: Pathogens with field resistance towards QoI fungicides
[http://frac.info/frac/meeting/2008/Pathogens with field resistance towards 2008.pdf](http://frac.info/frac/meeting/2008/Pathogens%20with%20field%20resistance%20towards%202008.pdf)

2.2. Review of global guidelines

2.2.1 Strategies and Guidelines for the 2009 season

Strategies for the management of QoI fungicide resistance, in all crops, are based on the statements listed below. These statements serve as a fundamental guide for the development of local resistance management programs.

Resistance management strategies have been further enhanced in order to be proactive and to prevent the occurrence of resistance to QoI fungicides developing in other areas and pathogens. Specific guidelines by crop follow the **general guidelines** given here.

A fundamental principle that must be adhered to when applying resistance management strategies for QoI fungicides is that:

The QoI fungicides (azoxystrobin, dimoxystrobin, enestroburin, famoxadone, fenamidone, fluoxastrobin, kresoxim-methyl, metominostrobin, orysastrobin, picoxystrobin, pyraclostrobin, pyribencarb, trifloxystrobin) are in the same cross-resistance group.

- Fungicide programs must deliver effective disease management. Apply QoI fungicide based products at effective rates and intervals according to manufacturers' recommendations. Effective disease management is a critical component to delay the build-up of resistant pathogen populations.
- The number of applications of QoI fungicide based products within a total disease management program must be limited whether applied solo or in mixtures with other fungicides. This limitation is inclusive to all QoI fungicides. Limitation of QoI fungicides within a spray programme provides time and space when the pathogen population is not influenced by QoI fungicide selection pressure.
- A consequence of limitation of QoI fungicide based products is the need to alternate them with effective fungicides from different cross-resistance groups.
- QoI fungicides, containing only the solo product, should be used in single or block applications in alternation with fungicides from a different cross-resistance group. Specific recommendation on size of blocks is given for specific crops.
- QoI fungicides, applied as tank mix or as a co-formulated mixture with an effective mixture partner, should be used in single or block applications in alternation with fungicides from a different cross-resistance group. Specific recommendations on size of blocks are given for specific crops.
- Mixture partners for QoI fungicides should be chosen carefully to contribute to effective control of the targeted pathogen(s). The mixture partner must have a different mode of action, and in addition it may increase spectrum of activity or provide needed curative activity. Use of mixtures containing only QoI fungicides must not be considered as an anti-resistance measure.
Where local regulations do not allow mixtures, then strict alternations with non-cross resistant fungicides (no block applications) are necessary.
- An effective partner for a QoI fungicide is one that provides satisfactory disease control when used alone on the target disease.
- QoI fungicides are very effective at preventing spore germination and should therefore be used at the early stages of disease development (preventive treatment).

2.2.2 Specific Crop/Pathogen guidelines

2.2.2.1. Strategies and Guidelines for cereals, 2008 season

Where the guidelines for the season 2008 were followed, field performance of QoI containing spray programmes was good. It continues to be essential to use non-cross resistant mixture partners (e.g. SBIs, multisites) to ensure robust disease management. This will also help to delay the evolution of resistance, especially in regions with no resistance or where resistance is at low levels.

Therefore the recommendations for the season 2008 remain unchanged.

Guidelines for using QoI fungicides on cereal crops

1. Apply QoI fungicides always in mixtures with non-cross resistant fungicides to control cereal pathogens. At the rate chosen the respective partner(s) on its/ their own has/ have to provide effective disease control. Refer to manufacturers recommendations for rates.
2. Apply a maximum of 2 QoI fungicide containing sprays per cereal crop. Limiting the number of sprays is an important factor in delaying the build-up of resistant pathogen populations.
3. Apply QoI fungicides according to manufacturers' recommendations for the target disease (or complex) at the specific crop growth stage indicated.
4. Apply the QoI fungicide preventively or as early as possible in the disease cycle. Do not rely only on the curative potential of QoI fungicides.
5. Split / reduced rate programmes, using repeated applications, which provide continuous selection pressure, accelerate the development of resistant populations and therefore must not be used.

2.2.2.2 Vine diseases

Guidelines for using QoI fungicides on vines

Powdery mildew (*Uncinula necator* / *Erysiphe necator*)

1. Apply QoI fungicides according to manufacturer's recommendations for the target disease at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Apply a maximum of 3 QoI fungicide containing sprays per vine crop, solo or in mixture (co-formulations or tank mixes) with effective mixture partners from different cross-resistance groups.
3. Apply QoI fungicides preventively.
4. QoI fungicides used solo should be used in strict alternation with fungicides from a different cross-resistance group.
5. Apply QoI fungicides used in mixture in a maximum of two consecutive applications in alternation with fungicides from a different cross-resistance group. In areas where resistance has been confirmed, apply QoI fungicides in strict alternation.

Downy mildew (*Plasmopara viticola*)

1. Apply QoI fungicides according to manufacturer's recommendations for the target disease at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Apply QoI fungicides preventively.

3. Apply a maximum of 3 Qol fungicide containing sprays per vine crop, only in mixture with effective partners from different cross-resistance groups.
4. Apply Qol fungicides in single or block application in alternation with fungicides from a different cross-resistance group.

2.2.2.3 Pome fruit diseases

Guidelines for using Qol fungicides on pomefruit

Scab (*Venturia inaequalis*, *Venturia pirina*)

1. Apply Qol fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stage indicated and adapted to size of trees. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Qol fungicides must be applied only in mixture with partners contributing to the effective control of the target pathogens.
3. Apply Qol fungicides preventatively. Under high disease pressure the spray interval should not exceed 7-10 days.
4. Apply a maximum of 3 Qol containing sprays per crop. A maximum of 4 Qol fungicide applications may be used where 12 or more applications are made per crop.
5. A maximum of 2 consecutive Qol fungicide sprays is preferred. Where field performance was adversely affected apply Qol containing fungicides in mixtures in strict alternation with fungicides from a different cross-resistant group.

2.2.2.4 Potato and tomato diseases

Guidelines for using Qol fungicides on potatoes and tomatoes

Late blight (*Phytophthora infestans*)

1. Apply Qol fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Where Qol fungicide products are applied alone do not exceed 1 spray out of 3 with a maximum of 3 sprays per crop. Do not use more than 2 consecutive applications.
3. Where Qol fungicide products are applied in mixtures (co-formulations or tank mixes) do not exceed 50% of the total number of sprays or a maximum 6 Qol fungicide applications whichever is the lower. Do not use more than 3 consecutive Qol fungicide containing sprays.

Early blight (*Alternaria solani*, *Alternaria alternata*)

1. Where Qol fungicide products are applied solo do not exceed 33% of the total number of sprays or a maximum of 4. Where mixtures (co-formulations or tank mixes) are used do not exceed 50% of the total number of sprays or a maximum of 6 Qol fungicide applications, whichever is the lower.

2.2.2.5 Guidelines for using Qol fungicides on soybean diseases

Qol fungicides effectively control soybean diseases including rust, which is a major disease in Latin America and has been detected recently in the USA. There is limited experience at this point in time in terms of resistance risk. Fungicide manufacturers have initiated baseline and monitoring studies.

In order to ensure sustainable use of QoIs the Working Group recommends:

1. Apply QoI fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Use QoIs preventatively or as early as possible in the disease cycle.
3. Use QoIs preferably in mixtures (co-formulations or tank mixes) with fungicides from a different cross-resistance group. At the rate chosen each partner on its own has to provide effective disease control. Refer to manufacturers' recommendations for rates.

2.2.2.6 Cucurbit diseases

Guidelines for using QoI fungicides on Cucurbit Vegetables

1. Apply QoI fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Apply a maximum of 3 QoI fungicide sprays per crop
3. Use a maximum of 1 QoI fungicide spray out of every three fungicide applications.
4. Do not use consecutive applications of QoI fungicides.
5. Apply QoI fungicides in alternation with fungicides from a different cross-resistance group with satisfactory efficacy against the targeted pathogen(s).
6. Continue QoI fungicide alternation between successive crops.

2.2.2.7 Guidelines for using QoI fungicides on greenhouse grown non-cucurbit vegetables

1. Apply QoI fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build-up of resistant pathogen populations.
2. Use a maximum of 1 QoI fungicide spray out of every 3 fungicide applications.
3. Do not use consecutive applications of QoI fungicides.
4. Apply QoI fungicides in alternation with fungicides from a different cross-resistance group with satisfactory efficacy against the targeted pathogen(s).
5. Continue QoI fungicide alternation between successive crops.

2.2.2.8 Guidelines for using QoI fungicides on other multiple spray crops (non-cucurbit field vegetables and ornamentals)

1. Apply QoI fungicides according to manufacturers' recommendations for the target disease (or complex) at the specific crop growth stage indicated. Effective disease management is a critical parameter in delaying the build up of resistant pathogen populations.
2. Observe spray limitations in the spray guideline table shown below for programmes utilising 12 or fewer fungicide sprays per crop.

Spray guideline table:

Total number of spray applications per crop	1	2	3	4	5	6	7	8	9	10	11	12	>12
Maximum recommended Solo QoI fungicide sprays	1	1**	2**	2	2	2	2	3	3	3	3	4	*
Max. recommended QoI fungicide sprays in mixture	1	2	2	2	2	3	3	4	4	5	5	6	*

* When more than 12 fungicide applications are made, observe the following guidelines:

- When using a QoI fungicide as a solo product, the number of applications should be no more than 1/3 (33%) of the total number of fungicide applications per season.
- For QoI mixes in programs in which tank mixes or pre mixes of QoI with mixing partners of a different mode of action are utilized, the number of QoI containing applications should be no more than ½ (50%) of the total number of fungicide application per season.
- In programs in which applications of QoI are made with both solo products and mixtures, the number of QoI containing applications should be no more than ½ (50%) of the total number of fungicide applied per season.

** Mixtures are preferred.

2.2.2.9 Banana

Guidelines for using QoI fungicides on banana

Please refer to the recommendations of the banana FRAC working group: The conclusions and guidelines of the Feb. 2008 meeting of the FRAC Banana Working Group are available on the FRAC Website (use following link):

 → [Hyperlink to Banana Working Group
 http://frac.info/frac/work/work_bana.htm](http://frac.info/frac/work/work_bana.htm)

The next meeting of the group is planned for February 2010.

2.3. Communication plans

The above Web Pages will serve as the main communication vehicle for the group.

Next meetings:

All crops: December 3rd 2009.

Venue: TBA (probably Frankfurt)