



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
Ulrich Schöfl	BASF
Martin Semar	BASF (cereals section)
Randall Gold	BASF (non-cereals section)

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
Cereals and non-cereals: November 27th and 28th, 2007
Organised by BASF at Schifferstadt, Germany**

2. Minutes of discussions

2.1. Review of sensitivity monitoring

2.1.1. Cereal diseases

Field experience in 2007 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

In 2007 the disease pressure was low to medium 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 2007 was similar to previous years. Single resistant isolates were detected in Hungary and Austria. Low levels were found in Czech Republic, while low to medium levels were detected in Poland.

In Southern France, heterogeneous levels of resistance from low to high were found.

No resistance was found in Italy,

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

Bayer CropScience

In 2007 the disease pressure was low to medium across Europe

An improved situation was recorded compared to 2006, with a tendency to lower levels of resistance in some countries (particularly Germany).

High resistance levels were found in France and parts of the UK. Medium levels in Belgium, Ireland and Northern Germany. Low to medium in other areas of Germany and UK. Low frequencies were detected in Czech Republic, Denmark and Poland. No resistance was found in 2007 in Austria, Hungary, Sweden and Italy.

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

BASF, Bayer CropScience, Syngenta, Du Pont

Extensive monitoring programmes were carried out throughout the wheat growing areas of Europe in 2007. As in previous years samples were taken in early spring and during summer.

Disease pressure in 2007 in Europe was low to moderate.

Frequency of resistance was slightly higher than in 2006 in wheat growing countries in Europe. Higher levels were found at sites where resistance has been previously detected.

Status at the end of the season 2007 is as follows:

UK, Belgium, The Netherlands, Austria, Switzerland, Sweden: 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), low to high resistance in the South (e.g. Bavaria, Baden-Wuerttemberg).

Poland, Latvia: 2007 data show a very heterogeneous picture ranging from low to highly resistant populations.

Czech Republic and first data from Finland 2007, show generally no to low resistance levels.

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

BASF, Bayer CropScience, Syngenta

Disease pressure was exceptionally high in most of the countries of Europe.

Performance of Qol fungicides against brown rust was good. No resistant isolates were detected in widespread monitoring studies in Europe in 2007, confirming the fully sensitive picture.

Net blotch (*Pyrenophora teres*), barley

BASF, Bayer CropScience, Syngenta, Du Pont

Disease pressure was moderate in Europe during 2007, Performance of Qol containing spray programmes against Net Blotch was good in 2007.

Extensive monitoring was carried out in 2007. Only the F129L mutation and not the G143A 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 Qol mutations see also the respective FRAC document).

Moderate to high levels of resistance were detected in Northern and Central France and the UK. Levels were highly heterogeneous, from none to high.

A few F129L containing - samples were detected in Ireland Belgium, Czech Republic, Denmark, and Germany, No resistance was found in Italy.

Leaf scald (*Rhynchosporium secalis*), barley

BASF, Bayer CropScience, Syngenta, Du Pont

Disease pressure was low in Europe during 2007

Performance of Qol fungicides against Leaf Scald was good. Monitoring data from 2007 showed a fully sensitive picture for all countries investigated (England, Scotland, Ireland, Germany, France and Poland).

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

Syngenta, BASF, Du Pont

Disease pressure was moderate to low in Europe. Performance of Qol containing spray programmes against tan spot was good in 2007.

Both point mutations known for Qols, G143A and F129L, have been detected, both mutations can occur in the same population, but rarely in the same isolate.

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

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

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

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



Mutations associated with QoI

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.

2.1.2. Vine diseases

Downy mildew (*Plasmopara viticola*)

BASF, Syngenta

In 2007, 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: Northern France, South-West France, Mosel area of Germany, , Northern Italy. Spain (Galicia).

Moderate levels: Germany other areas, Austria, Central Italy, South – East France, Switzerland

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

No resistance was detected in Greece,

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

Bayer CropScience, Syngenta, BASF

Disease pressure was low to moderate across Europe.

In 2007, intensive monitoring was carried out and no resistance was detected in major commercial growing areas of Europe (France, Italy, Germany, Switzerland, Spain and Portugal). Field performance of QoI containing spray programmes was good.

In 2006, monitoring detected resistance in a few trials locations in Hungary, and in airborne sampling in Eastern Austria.

In 2007, resistance was confirmed in commercial locations in Eastern Austria and also in Hungary. Cases of resistance were also detected for the first time in a few locations in the Czech Republic and Slovakia. Cases of resistance seem to be currently around a “hot-spot” situated in the region of the borders of Eastern AT, CZ, HU, SK. Further investigations are still underway.

FRAC guidelines have been widely followed 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 2007 - frequencies of resistance are reported below:

Moderate to High: Southern France, Northern Italy (Piemont and Po Valley), ,Poland and Eastern Germany.

Low to moderate: – Spain, Belgium and Western Germany.

Low - Italy (Trentino, Alto Adige), Northern France (Loire Valley)

No resistance was detected in UK, Portugal, the Lake Constance area of Germany, Canada, New Zealand

Resistance was confirmed in USA, South Africa and Greece (limited data)

Pears (*Stemphylium vesicarium*)

BASF

A single sample with QoI resistance (G143A) was detected in Italy

Pear Scab (*Venturia pirina*)

No monitoring was carried out in 2007

2.1.4. Potato/tomato diseases

Late blight (*Phytophthora infestans*)

BASF, Bayer CropScience, DuPont

Disease pressure was high in Northern Europe, low in Southern Europe.

No resistance was detected in all isolates collected from potato or tomato crops in France, Germany, Netherlands, Poland, UK, Belgium, Spain, Portugal and Italy,.. Performance remains good.

Early blight (*Alternaria solani*)

Syngenta

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

2.1.5. Soybean diseases

Asian Rust (*Phakopsora pachyrhiza*)

Syngenta, 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 and 2007. No resistant isolates have been detected.

2.1.6. Other crops

Vegetables

Cucumber powdery mildew (*Sphaerotheca fuliginea*)

BASF

Limited monitoring carried out in Netherlands confirmed resistance to be present. Limited monitoring carried out in Southern France showed a heterogeneous situation, samples were generally sensitive to QoIs with a few cases of resistance.

Grey Mold on Strawberries (*Botrytis cinerea*)

BASF

Monitoring was carried out in 2007. In UK and Italy samples were generally sensitive with a few cases of resistance at a low frequency. Low to moderate levels of resistance were detected in Germany at some sites. The G143A mutation was confirmed.

Adherence to FRAC guidelines must be stressed, especially in areas where resistance has been confirmed

Oilseed Rape (Canola)

Stem Rot (*Sclerotinia sclerotiorum*)

BASF

Disease pressure during 2007 was high in Europe.

Monitoring carried out in UK, France, Germany and Poland in 2007 showed a sensitive situation.



Pathogens with field resistance towards QoI fungicides

2.2. Review of global guidelines

2.2.1 Strategies and Guidelines for the 2007 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 straight 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 2007 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 with effective mixture partners from different cross-resistance groups.
3. For table grapes, a maximum of 4 QoI fungicide containing sprays per crop may be used when 12 or more fungicide applications are made.
4. Apply QoI fungicides preventively.
5. Apply QoI fungicides in single or block application in alternation with fungicides from a different cross-resistance group. In areas where resistance has been confirmed (areas of Hungary, Austria, Slovakia, Czech Republic), 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 QoI fungicide containing sprays per vine crop, only in mixture with effective partners from different cross-resistance groups.

4. Apply QoI 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 QoI fungicides on pomefruit

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

1. Apply QoI 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. QoI fungicides must be applied only in mixture with partners contributing to the effective control of the target pathogens.
3. Apply QoI fungicides preventatively. Under high disease pressure the spray interval should not exceed 7-10 days.
4. Apply a maximum of 3 QoI containing sprays per crop. A maximum of 4 QoI fungicide applications may be used where 12 or more applications are made per crop.
5. A maximum of 2 consecutive QoI fungicide sprays is preferred. Where field performance was adversely affected apply QoI 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 QoI fungicides on potatoes and tomatoes

Late blight (*Phytophthora infestans*)

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. Where QoI 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 QoI 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 QoI fungicide applications whichever is the lower. Do not use more than 3 consecutive QoI fungicide containing sprays.

Early blight (*Alternaria solani*)

1. Where QoI 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 QoI fungicide applications, whichever is the lower.

2.2.2.5 Guidelines for using QoI fungicides on soybean diseases

QoI 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 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 Qol fungicide sprays	1	1**	2**	2	2	2	2	3	3	3	3	4	*
Max. recommended Qol 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 Qol 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 Qol mixes in programs in which tank mixes or pre mixes of Qol with mixing partners of a different mode of action are utilized, the number of Qol containing applications should be no more than ½ (50%) of the total number of fungicide application per season.
- In programs in which applications of Qol are made with both solo products and mixtures, the number of Qol 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 Qol fungicides on banana

Please refer to the recommendations of the banana FRAC working group: The conclusions and guidelines of the Feb. 2006 meeting of the FRAC Banana Working Group are available on the FRAC Website (www.frac.info). The next meeting of the group is planned for February 2008.

2.3. Communication plans

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

Next meetings:

All crops: December 2nd and 3rd 2008.

Venue: TBA (probably Frankfurt), hosted by Syngenta