

MEMBERSHIP

The working group is comprised of the following members:

Andy Leadbeater (chair)	Syngenta
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Karl-Heinz Kuck	BayerCropScience
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Gerd Stammmer	BASF
Kristin Klappach	BASF
Ulrich Schöfl	BASF
Martin Semar	BASF (cereals)
Randall Gold	BASF (non-cereals)

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, famoxadone, fenamidone, kresoxim-methyl, picoxystrobin, pyraclostrobin, trifloxystrobin, fluoxastrobin, metominostrobin, orysastrobin, dimoxystrobin and enestroburin.

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 meetings
Cereal part: on October 11th, 2005
Non-cereal part: on November 29th, 2005
Organised by Du Pont at Bad Homburg/ Germany**

1. Agenda
 - 1.1. Review of sensitivity monitoring
 - Cereals
 - Vines
 - Pome fruit
 - Potato/tomato
 - Other crops
 - 1.2. Review of global guidelines
 - 1.2. Communication plans

2. Minutes of discussions

2.1. Review of sensitivity monitoring

2.1.1. Cereal diseases

Field experience in 2005 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 (*Erysiphe graminis* f.sp. *tritici*), wheat

Bayer CropScience

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

In Southern and Eastern parts of Europe no further increase of resistance was detected compared to 2004. No resistance was detected in Italy and Austria. Low levels have been found in Czech Republic and Hungary while higher levels were detected in Poland.

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

Bayer CropScience

A stable situation was recorded compared to 2004.

High resistance levels were found in France, Belgium and North-Eastern Germany. Medium and heterogeneous levels have been found in the UK and in all other parts of Germany. Low frequencies were detected in Denmark, Czech Republic and Poland. No resistance was found in 2005 in Hungary, Austria, and Italy.

Septoria leaf spot (*Septoria tritici*), wheat

BASF, Bayer CropScience, Syngenta

Extensive monitoring programmes were carried out throughout the wheat growing areas of Europe in 2005. As in previous years samples were taken in early spring and during summer.

Disease pressure in 2005 in Europe was generally heterogeneous but high in Northern France.

Frequency of resistance has further increased in wheat growing countries in Europe. Higher levels were found at sites where resistance has been previously detected and new locations were added.

Status at the end of the season 2005 is as follows:

Ireland, UK, Belgium, The Netherlands, Denmark, 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 low to high in the centre and no to low in the South.

Germany: high resistance levels in the North (e.g. Schleswig-Holstein, Mecklenburg-Vorpommern, Niedersachsen), no to medium resistance in the South (e.g. Bavaria, Baden-Wuerttemberg).

Poland, Hungary: 2005 data show a very heterogeneous picture ranging from highly sensitive to highly resistant populations.

Austria, Switzerland, Czech Republic, Lithuania, Latvia: 2005 data show generally no to low resistance levels.

Brown rust (*Puccinia recondita*), wheat

BASF, Bayer CropScience, Syngenta

Performance of QoI fungicides against brown rust was good. No resistant isolates were detected in intensified widespread monitoring studies in Europe in 2005, confirming the fully sensitive picture already established.

Net blotch (*Pyrenophora teres*), barley

BASF, Bayer CropScience, Syngenta, Du Pont

Disease pressure was high in some parts of Europe, e.g. in Northern France and parts of the UK. Performance of QoI containing spray programmes against net blotch was good in 2005.

Widespread monitoring was carried out in 2005. Reduced sensitivity was detected only in laboratory studies. 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 (for differences between QoI mutations see also the respective FRAC document). Further characterisation of F129L isolates confirmed a clear dose response to QoI fungicides. Frequency of F129L isolates increased slightly at some sites in the UK and France and remains at low to moderate levels. Single F129L isolates were detected in Ireland, Switzerland and Germany, none in Belgium. As field performance of QoI containing mixtures was good in 2005, their use will remain essential in the future.

Leaf scald (*Rhynchosporium secalis*), barley

BASF, Bayer CropScience, Syngenta

Performance of QoI fungicides against leaf scald was good. Monitoring data from 2004 and 2005 showed a fully sensitive picture for England, Scotland, Ireland, Germany, the Netherlands, Denmark and France.

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

Syngenta

Disease pressure was moderate in Europe. Performance of QoI containing spray programmes against tan spot was good in 2005.

As reported in June 2005, both point mutations known for QoIs, G143A and F129L, have been detected.

Based on limited data from 2004 and 2005 in Denmark and Sweden, the F129L mutation was found more often, whereas in northern Germany the G143A mutation was more frequent. Additional samples are being analysed. Further characterisation on F129L isolates confirmed a clear dose response to QoI fungicides.

***Microdochium nivale*, wheat**

No monitoring data was available for the meeting.

2.1.2. Vine diseases

Downy mildew (*Plasmopara viticola*)

BASF, DuPont, Syngenta

In 2005, disease pressure was moderate in the main grape growing areas of Europe.

FRAC guidelines have been widely followed, and field performance of QoI containing spray programmes was good across Europe. Compared to previous years resistance levels have further stabilised. No performance complaints were received.

All companies carried out major monitoring programmes in 2005. Both bioassay and PCR techniques were used to generate data.

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

Moderate to High levels: Northern France, South-West France, Switzerland, Northern Italy, Austria

Low to Moderate levels: Germany, Southern Italy, South – East France, Serbia,

Low levels: Hungary, Greece, Spain,

No resistance was detected in Bulgaria

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

Bayer CropScience, Syngenta, BASF

Disease pressure was moderate across Europe. For information on the USA situation refer to the [NAFRAC pages](#).

FRAC guidelines have been widely followed, and field performance of QoI containing spray programmes was good across Europe. No complaints were received.

In 2003 and 2004 no resistance was detected. In 2005 full sensitivity was reported based on available monitoring data including samples from France, Italy, Germany, Austria, Switzerland, Spain, Greece and Portugal.

2.1.3 Pome fruit diseases

Apple scab (*Venturia inaequalis*)

BASF, Bayer CropScience

Disease pressure was moderate to high across Europe.

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

Monitoring was carried out in Germany, France, Italy, UK, Netherlands, Belgium, the Czech Republic, Poland, Hungary, Spain, Portugal, Greece, and Chile. Methods used included QPCR and pyrosequencing.

Intensive monitoring was carried out in Europe. The levels of resistance found were very heterogeneous, with values ranging from zero to high, even within individual orchards. Some patterns were observed, **maximum** levels of resistance are reported below:

Moderate to High: Southern France, Northern Italy, Eastern and Northern Germany, Czech Republic, Hungary, Poland

Low to moderate: – Netherlands, Spain, Belgium, Southern and Western Germany, Chile

No resistance was detected in UK, Portugal, Greece and in the Lake Constance area of Germany.

It is important to state that resistant populations are still locally restricted to certain orchards in affected apple growing regions.

2.1.4. Potato/tomato diseases

Late blight (*Phytophthora infestans*)

Bayer CropScience, DuPont

No resistance was detected in all isolates collected from potato crops in France, Germany, Netherlands, UK, Eire, Belgium, Denmark, Finland and Poland. Performance remains good.

Early blight (*Alternaria solani*)

Syngenta

In the USA, isolates carrying the F129L mutation were confirmed in Oregon and Wyoming, but none were found in Washington and Idaho. More data will be available in early 2006.

Field performance was good for QoI containing fungicide programmes.

2.1.5. Soybean diseases

Asian Rust (*Phakopsora pachyrhiza*)

See the BRAZIL FRAC website for information

Monitoring methods for baseline establishment and follow-up are being developed. No resistant isolates have been detected.

2.1.6. Other crops

Tree crops

In almonds resistance in *Alternaria alternata* was confirmed in 2004 in California / USA, leading to reduced performance of solo QoIs. Resistance is based on the G143A mutation. It is recommended to follow the FRAC recommendations for multi-spray crops.

Further known cases of [QoI resistance](#)

2.2. Review of global guidelines

2.2.1 Strategies and Guidelines for the 2006 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, famoxadone, fenamidone, kresoxim-methyl, picoxystrobin, pyraclostrobin, trifloxystrobin, fluoxastrobin, dimoxystrobin, metominostrobin, orysastrobin and enestroburin) 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 manufacturer's 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, 2006 season

Where the guidelines for the season 2005 were followed, field performance of QoI containing spray programmes was good. It continues to be essential to use non-crossresistant 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 2006 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.

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

Apple scab (*Venturia inaequalis*)

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 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*)

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 Qols the Working Group recommends:

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. Use Qols preventatively or as early as possible in the disease cycle.
3. Use Qols 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 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 $\frac{1}{2}$ (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 $\frac{1}{2}$ (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](#)

2.3. Communication plans

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

Next meeting

Cereal crops: October 10th, 2006,
Non-cereal crops: November 28th, 2006

Venue: TBA, hosted by Bayer CropScience