QoI Working Group

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

QoI WG Minutes 2006 – Print version

Cereal part: October 10th, 2006
Non-cereal part: November 28th, 2006
Non-cereal part: Updated May 29th, 2007 (blue text)

Organised by Bayer CropScience at Monheim, Germany

Membership

The working group is comprised of the following members:

Andy Leadbeater (Chair)	Syngenta
Pierre Begel	DuPont (non-cereals)
Robert Bird	DuPont (cereals)
Jean-Luc Genet	DuPont
Randall Gold	BASF (non-cereals)
Friedrich Kerz-Moehlendick	Bayer CropScience
Kristin Klappach	BASF
Karl-Heinz Kuck	Bayer CropScience
Andreas Mehl	Bayer CropScience
Ulrich Schöfl	BASF
Martin Semar	BASF (cereals)
Helge Sierotzki	Syngenta
Gerd Stammler	BASF
Paul Varney	Syngenta
Albert Witzenberger	Bayer CropScience (non-cereals)

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 and 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

2. Minutes of discussions

2.1. Review of sensitivity monitoring

2.1.1. Cereal diseases

Field experience in 2006 has confirmed, that, when used according to FRAC guidelines, the performance of QoI containing products within spray programmes was good. QoIs continue to contribute to overall disease management in cereals.

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

Bayer CropScience, Syngenta

Disease pressure was medium to high 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 2006 was similar to previous years . Single resistant isolates were detected in Italy and Austria. Low levels were found in Czech Republic, while low to medium levels were detected in Poland and Lithuania. Based on limited data, no resistance was found in Hungary, Belarus and Russia

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

Bayer CropScience

A stable situation was recorded compared to 2005.

High resistance levels were found in France, medium to high in 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 Austria, Czech Republic and Poland. No resistance was found in 2006 in Denmark, Sweden, Hungary, and Italy.

About Target site mutations

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 2006. As in previous years samples were taken in early spring and during summer.

Disease pressure in 2006 in Europe was generally heterogeneous but high in UK..

Frequency of resistance was slightly higher than in 2005 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 2006 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 medium 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), low to high resistance in the South (e.g. Bavaria, Baden-Wuerttemberg).

Poland, Latvia,: 2006 data show a very heterogeneous picture ranging from highly sensitive to highly resistant populations.

Austria, Switzerland, low to medium levels of resistance were detected in 2006

Czech Republic, 2006 data show generally no to low resistance levels.

Italy – no resistance was detected in Emilia Romagna in 2006

No data were available for Hungary and Lithuania from season 2006.

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

BASF, Bayer CropScience, Syngenta

Disease pressure was high in Belgium, Germany and UK, low to moderate in the rest of Europe.

Performance of QoI fungicides against brown rust was good. No resistant isolates were detected in widespread monitoring studies in Europe in 2006, confirming the fully sensitive picture already established.

Net blotch (*Pyrenophora teres*), barley

BASF, Bayer CropScience, Syngenta,

Disease pressure was moderate in Europe during 2006, Performance of QoI containing spray programmes against net blotch was good in 2006.

Extensive monitoring was carried out in 2006. 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 QoI mutations see also the respective FRAC document).

Frequency of F129L isolates increased in France compared to 2005, Levels were highly heterogenous, from none to high.

A few F129L containing - samples were detected in Ireland, UK Switzerland, Belgium, Czech Republic and Germany, none in Sweden, Austria, Denmark.

Leaf scald (*Rhynchosporium secalis*), barley

BASF, Bayer CropScience, Syngenta

Performance of QoI fungicides against leaf scald was good. Monitoring data from 2006 showed a fully sensitive picture for England, Scotland, Ireland, Germany and France.

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

Syngenta, BASF, Bayer Crop Science

Disease pressure was moderate to low in Europe. Performance of QoI containing spray programmes against tan spot was good in 2006.

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

More intensive sampling was carried out in 2006. As in 2005, in Denmark and Sweden, the F129L mutation was found more often than the G143A, whereas in northern / central Germany the G143A mutation was more frequent. Additional samples are being analysed.

Characterisation of F129L isolates has shown a clear dose response to QoI fungicides. (hyperlink to 143 / 129 document.)

A new mutation (G137R) mutation has been detected in a few isolates; the frequence of occurrence is low and only found in areas where the other known mutations have been detected. This confers weak resistance, lower than F129L and is considered to be of low practical relevance.

2.1.2. Vine diseases

Downy mildew (*Plasmopara viticola*)

BASF, Bayer CropScience, DuPont, Syngenta

In 2006, disease pressure was low to 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 were overall stable with some local increases.

All companies carried out major monitoring programmes in 2006. 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, Rheinhessen and Mosel areas of Germany, Switzerland, Northern Italy, Austria (Wachau).

Low to Moderate levels: Germany other areas, Austria (Burgenland), Central Italy, South – East France, Spain (Galicia).

Low levels: Hungary, Greece (limited data),, Portugal, North – East France (Alsace)

First cases of resistance were recorded in Bulgaria and Slovakia

No resistance was detected in Austria (Weinviertel),

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

Bayer CropScience, Syngenta, BASF

Disease pressure was moderate across Europe.

First cases of resistance in commercial vineyards were found in Virginia, USA during 2006. This was confirmed to be due to the G143A mutation.

In 2003 and 2004 no resistance was detected in Europe. In 2005 and 2006, intensive monitoring was carried out and no resistance was detected in the major commercial growing areas of Europe (France, Italy, Germany, Austria, Hungary, Switzerland, Spain, Greece and Portugal). However, in a few trial locations in Hungary resistance was found and confirmed to be due to the G143A mutation.

Additional late-season monitoring studies have shown a few cases of resistance in Eastern Austria. The practical relevance of these findings will be investigated during the 2007 season.

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

2.1.3 Pome fruit diseases

Apple scab (*Venturia inaequalis*)

BASF, Bayer CropScience

Disease pressure was moderate across Europe.

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

Intensive monitoring was carried out in Europe. The levels of resistance found were very heterogeneous in all countries, with values ranging from zero to high, even within individual orchards.. Frequencies of resistance reported below refer to the highest levels found per region:

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

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

Low - Italy (Trentino, Alto Adige)

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

First cases of resistance were detected in Denmark, Greece and Turkey.

USA - Resistance was detected in 2006 in the states of New York and Virginia. No resistance was detected in Michigan and Pennsylvania (limited data).

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

Pears (*Stemphylium vesicarium*)

BASF

A single sample with QoI resistance (G143A) was detected from a trial site in the Emilia Romagna area in Italy

Pear Scab (Venturia pirina)

BASF

First samples with QoI resistance (G143A mutation) were detected in California, USA.

2.1.4. Potato/tomato diseases

Late blight (*Phytophthora infestans*)

BASF, Bayer CropScience, DuPont

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

Early blight (*Alternaria solani*)

Syngenta

In the USA, isolates carrying the F129L mutation were confirmed in Oregon and Wyoming in 2005, but none were found in Washington and Idaho. Data from 2006 are not yet available.

Field performance was good for QoI containing fungicide programmes.

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

2.1.5. Soybean diseases

Asian Rust (*Phakopsora pachyrhiza*)

See the BRAZIL FRAC website for information

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

2.1.6. Other crops

Vegetables

Cucumber powdery mildew (*Sphaerotheca fuliginea*)

BASF

Monitoring was carried out in Southern France, samples were generally sensitive to QoIs.

Asparagus (*Stemphyllium vesicarium*)

BASF

First samples with QoI resistance (G143A) were detected in commercial locations in Germany

Further known cases of QoI resistance

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 and 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, 2007 season

Where the guidelines for the season 2006 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 2007 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, 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 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,

2.3. Communication plans

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

Next meeting

All crops: November 28th, 2007

Venue: TBA, hosted by BASF

Approved: June 2007