QoI Working Group

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

## MEMBERSHIP

The working group is comprised of the following members:

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| Helge Sierotzki (Chair) | Syngenta |
| Steve Dale | Syngenta |
| Stefano Torriani | Syngenta |
| Gina Swart | Syngenta |
| Andreas Mehl | Bayer |
| Frank Goehlich | Bayer |
| Jean-Luc Genet | Dow DuPont |
| Gerd Stammler | BASF SE |
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## 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, coumoxystrobin, dimoxystrobin, enoxastrobin, famoxadone, fenamidone, fenaminostrobin, fluoxastrobin, flufenoxystrobin, kresoxim-methyl, mandestrobin, metominostrobin, orysastrobin, pyraoxystrobin, picoxystrobin, pyraclostrobin, pyrametostrobin, pyribencarb, triclopyricarb, trifloxystrobin**

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

Companies participating in the meetings:

**BASF, Bayer, DowDuPont, Syngenta, Sumitomo**

**QoI working group of FRAC**
**Minutes of the meeting**
**All crops: December 14th, 2017**
**held in Frankfurt, Germany**
**and updated in March 2018**

Source: www.FRAC.info
December 2017 & March 2018

# 2. Minutes of discussions

## 2.1. Review of sensitivity monitoring

### 2.1.1. Cereal diseases

Field experience in 2017 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

Disease pressure in 2017 was low to moderate across Europe.

Monitoring has been carried out in Czech Republic, Poland and Romania

Medium to high frequencies of resistance were found in Poland.

Medium frequencies of resistance were found in Czech Republic.

Heterogeneous from no to high frequencies were found in Romania

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

Bayer

Disease pressure in 2016 was low across Europe.

Overall, where monitoring was carried out, there was a similar situation in 2016 as compared to 2015.

High resistance frequencies were found in Central France, Sweden and United Kingdom.

Low to medium frequencies were found in Czech Republic, Germany, Lithuania and Poland.

No resistance was detected based on limited number of strains in Belgium, Italy, Denmark, Austria and Western Russia

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

BASF, Syngenta

Disease pressure was moderate in most of the European countries but regionally variable in 2017.

The status at the end of the season 2017 is as follows:

In Belgium, Czech Republic, France, Germany, Ireland, New Zealand (2016), Netherlands, Sweden, Switzerland, and United Kingdom: widespread resistance over all these countries at high levels were detected.

Croatia, Latvia, Italy, Lithuania, Poland and Western Ukraine: populations were showing in average moderate levels of resistance with high variability.

Bulgaria, Romania, Russia, Slovakia, Spain, Tunisia (2016), and Eastern Ukraine: sampling in 2017 showed no to low levels of resistance.

Additional information for other countries is given in the 2016 minutes.

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

Bayer, Syngenta

In 2017, performance of QoI fungicides against brown rust was good. No resistant isolates were detected in widespread monitoring studies in Europe in 2016, confirming the fully sensitive picture (Belgium, Denmark, France, Germany, Hungary, Sweden, and United Kingdom).

These findings are consistent with the reported presence of a lethal intron in several fungi making the G143A mutation unlikely to occur (see FRAC QoI Intron Document).

**Brown rust / Dwarf rust (*Puccinia hordei*), barley**

Bayer

Next monitoring planned for 2018

During sensitivity studies with *Puccinia hordei* during 2010 to 2014, occasional isolates with slightly higher EC50 values to QoIs have been detected in Denmark, France, Germany, Sweden, and United Kingdom (in 2014 only in Denmark, France, and United Kingdom).

However, resistance factors are low and the mutations normally associated with QoI resistance were not found.

The practical relevance of these findings is not currently known. The mechanism is not known, no relevant mutations have been found.

Field performance in 2017 of QoI containing spray programmes was good.

**Net blotch (*Pyrenophora teres*), barley**

BASF, Bayer, Dow Du Pont, Syngenta

Disease pressure was moderate to high but regionally variable even within European countries in 2017. Field performance of QoI-containing fungicides against net blotch was generally good. However, control of net blotch, esp. in areas in France, was difficult in 2017 and potentially related to e.g. the high disease pressure, low varietal diversity, coupled to the reported break-down of variety-resistance (variety ETINCEL) at significant cultivation areas and higher frequencies of mutated strains.

Preliminary data from 2017 was shared. Only the F129L mutation 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 titled "Mutations associated with QoI resistance" available on the FRAC website under QoI fungicides →Quick references).

These findings are consistent with the reported presence of a lethal intron in several fungi making the G143A mutation unlikely to occur.

The situation in 2017 is as follows:

Moderate level: Denmark, Germany, United Kingdom

Low to moderate levels: Belgium, France, Netherlands and Sweden

No to low levels: Poland and Ukraine.

No detection of mutation: Bulgaria Czech Republic, Finland, Greece, Italy, Latvia, Lithuania Romania, Slovakia, Spain and Russia.

**Leaf scald (*Rhynchosporium secalis = Rhynchosporium commune*), barley**

BASF, Bayer, Syngenta

Performance of QoI fungicides against Leaf scald was good.

In 2017, all samples were sensitive in Belgium, Czech Republic, France, Germany, Ireland, Italy, Poland and United Kingdom.

However, in some years since 2008 (e. g., 2012 France, 2014 UK, 2015 Spain), occasionally isolates have been found containing the G143A mutation. The frequency is always very low.

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

BASF, Syngenta

Performance of QoI containing spray programmes against tan spot was good in 2017.

Samples containing the G143A mutation were found at the frequencies indicated below:

High: Denmark, Sweden

Moderate resistance frequencies were found in: Germany, Latvia and Poland.

Low to moderate frequencies were found in Ukraine, Lithuania.

No resistance was detected in Romania.

Although all three point mutations known for QoIs (G143A, F129L, G137R) have been detected in the past, and can occur in the same population, the G143A mutation is now dominant in this pathogen.

**Ramularia leaf spot *(Ramularia collo-cygni)*, barley**

Wide spread resistance was detected in the past in Western Europe; no further monitoring is conducted.

### 2.1.2. Vine diseases

**Downy mildew (*Plasmopara viticola*)**

BASF, Syngenta, Dow Du Pont

In 2017, disease pressure was low in the main grape growing areas of Europe.

The levels of resistance found in monitoring programmes **in 2016 and 2017** are summarised below:

High levels: Croatia, Germany (Mosel, Rheinhessen), France (Centre, Champagne, Franche Comte and Poitou Charentes), Spain (Basque), and Switzerland (Vaud)

Moderate levels: Bulgaria, Czech Republic, France (Aquitaine, Pay de la Loire), Germany (Baden Wuerttemberg, Franken), Hungary, Italy (Süd Tirol, Piemonte, Toscana, Emilia Romagna, Marche, Friuli, Veneto Abruzzo, Puglia), Portugal, Slovenia and Romania.

Low to Moderate levels: Austria, France (Languedoc Roussillon Lorraine Midi Pyrenees), Greece, Portugal, Spain (Galicia), Switzerland (Zürich) and Slovakia.

Low Levels: Italy (Trentino)

Resistance based on G143A mutation detection has been found in China in 2017.

In vine growing regions of Brazil the G143A mutation has been detected at moderate to high levels in 2017.

After numerous years of sensitivity monitoring carried out in Europe it has been observed the levels of resistance found are very heterogeneous, with values ranging from zero to high even between neighbouring vineyards.

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

BASF, Bayer, Syngenta

Disease pressure in 2017 was moderate across Europe.

The levels of resistance found in monitoring programmes in 2017 are summarised below:

High levels: Austria, Hungary, Italy (South Tirol, Trentino), Switzerland and Turkey.

Moderate to high: Germany.

Moderate levels: France, Greece (heterogeneous) and Italy (heterogeneous).

Low to Moderate levels: Italy (Emilia Romagna, Piemonte, Toscana, Veneto)

Low levels: Portugal and Spain.

Data from limited number of samples in 2016 from Romania and Switzerland showed presence of resistance allele.

Additional information for other countries is given in the 2016 minutes.

### 2.1.3 Pome fruit diseases

**Apple scab (*Venturia inaequalis*)**

BASF, Bayer

Disease pressure in 2017 was moderate across Europe.

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

Monitoring was carried out in 2017 indicating generally higher frequency of resistance as reported below:

High: Belgium, Germany, Hungary, Italy and Poland.

Moderate: France.

Heterogeneous situation found in Spain from zero to high levels.

Resistance based on the G143A mutation was detected in Japan, Aomori prefecture.

Samples from India (Kashmere) were all sensitive.

Additional information for other countries is given in the 2016 minutes.

**Apple Powdery Mildew (*Podosphaera leucotricha*)**

No data for 2017 were presented.

BASF

In 2016, resistance has still not been detected as in previous years in Czech Republic, France, Germany, Greece, Italy, Netherlands, Poland, Portugal and Spain. Field performance has been good.

These findings are most likely to be related to the reported presence of a lethal intron in several fungi making the G143A mutation unlikely to occur (see FRAC document titled “Impact of Intron at G143A on Qo resistance development” located on the FRAC website under QoI fungicides → Quick references).

Additional information for other countries is given in the 2016 minutes.

**Brown Rot in Stone Fruit (*Monilinia spp.*)**

BASF

Monitoring data for 2014 and 2015 showed all populations to be fully sensitive (France, Greece, Hungary, Italy, Poland and Spain) (BASF, Bayer).

In 2016:

Samples from France, Greece, Hungary, Italy and Poland were sensitive.

These findings are most likely to be related to the reported presence of a lethal intron in several fungi making the G143A mutation unlikely to occur (see FRAC document titled "Impact of Intron at G143A on Qo resistance development" located on the FRAC website under QoI fungicides → Quick references).

### 2.1.4. Potato/tomato diseases

**Late blight (*Phytophthora infestans*)**

BASF, Bayer, Dow Du Pont

No resistance was detected in all isolates collected in 2017 from potato crops in Belgium, Denmark, France, Germany, Ireland, Netherlands, Poland, Portugal, Sweden and United Kingdom.

Performance remains good.

**Early blight (*Alternaria* spp.)**

BASF, Syngenta

Monitoring was carried out in potatoes and tomatoes (*Alternaria solani*) in Europe in 2017.

*Alternaria solani*

**Tomato**

Single isolates collected in Italy, Poland and Slovakia showed decreased sensitivity.

**Potato**

Resistance to QoI is associated to the presence of the F129L mutation.

Less sensitive isolates were found at medium frequency in samples from Belgium, Denmark, Germany, Netherlands and at high frequency in Sweden. Less sensitive isolates were found at low frequency in samples from Czech Republic, France, Hungary, Poland, Romania and Spain.

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 titled "Mutations associated with QoI resistance" available on the FRAC website under QoI fungicides → Quick references).

*Alternaria alternata*

Data from 2016

(Syngenta, Dow Du Pont)

**Tomato**

Limited monitoring is carried out in 2016.

Resistance has been found in Bulgaria, Greece, Italy and Poland.

**Potato**

Resistant isolates (bearing the G143A mutation) were found in potato samples from Belgium, Bulgaria, France, Germany, Hungary, Netherlands, Poland, Romania, Slovakia, Sweden and United Kingdom.

No mutation was found in Spain.

**Sheath blight *(Rhizoctonia solani AG1.1A)***

Syngenta

In 2017 less sensitive isolates were detected in China (Inner Mongolia, Hebei, and Gansu) at low frequency.

## 2.1.5. Soybean diseases

**Asian Rust (*Phakopsora pachyrhizi*)**

BASF, Bayer, Dow Du Pont, FRAC Brasil, Syngenta

Intensive monitoring was carried out across Brazil during 2016/2017.

In 2014/15, isolates containing the F129L mutation were reported in a number of samples. However, sensitivity monitoring, based on bioassays, show that sensitivity has remained in the range of previous years.

(Analysis of historic samples showed that the F129L mutation was present at significant levels from at least 2012/13).

As already observed with other pathogens, resistance factors resulting from the F129L mutation are significantly lower in comparison with the G143A mutation.

(see FRAC document titled “Mutations associated with QoI resistance” available on the FRAC website under QoI fungicides →Quick references).

No samples containing the G143A mutation have been found in this pathogen. These findings are consistent with the reported presence of a lethal intron in several fungi making the G143A mutation unlikely to occur (see FRAC QoI Intron Document).

In 2014/15, the mutation F129L has been found in the majority of the samples throughout Brazil and Paraguay, which can lead to reduced sensitivity. High frequency of this mutation may affect field

performance, therefore QoI must be applied with a robust partner (the multi-sites/protectants, exclusively applied together with a QoI, provide control for a limited period and, after that, may leave the QoI unprotected and may endanger sound resistance management).

High frequency of F129L mutation has been observed in season 2016/17 as known from previous years and has been confirmed now also for Bolivia, Paraguay and on volunteer soybean plants.

**Target Spot (*Corynespora cassiicola*)**

BASF

Resistance due to the G143A mutation was detected in a significant number of samples from Brazil in 2015 and 2016

**Sheath blight *(Rhizoctonia solani AG1.1A)***

Syngenta

In 2016 a small number of fields in Louisiana, USA were found to contain less sensitive isolates.

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**2.1.6. Other crops**

**Vegetables**

**Cucumber powdery mildew (*Sphaerotheca fuliginea = Podosphora xanthii)***

Bayer

Testing of a few samples in 2017 confirmed presence of resistance in Italy and Spain from cucumber and zucchini.

No Monitoring was carried out in 2015 and 2016.

Monitoring was carried out in China during 2014. The frequency of resistance found was high (Syngenta).

**Cucumber downy mildew (*Pseudoperonospora cubensis*)**

No monitoring in 2016

Monitoring in the East Coast of USA showed widespread presence of resistance in 2013.

2014: Resistance was found in samples from cucumber in Spain, Greece and Italy (Sicilia). Samples from melons collected in Italy (Piemonte) were sensitive. (Bayer, Syngenta).

Dow Du Pont

A limited monitoring program was carried out in China in 2017. The resistance allele (G143A) has been detected in five different provinces.

**Alternaria spp**

BASF, Syngenta

Monitoring has been carried out on carrots, cabbage and broccoli in 2017.

Results showed that resistance in A. dauci from carrots is present in Bulgaria, Croatia, Germany, Italy, Netherlands and Portugal, but full sensitivity has been found in Denmark, France, Lithuania, Poland, Spain and Sweden.

Single resistant isolates has been detected in A. brassicicola from carrots in Germany. All isolates of A. brassicae were sensitive

**Soft fruits**

**Gray Mold (*Botrytis cinerea*)**

Bayer

Monitoring in 2017 has been carried out and showed high resistance frequencies in, Denmark, Germany, France, Poland, Sweden and United Kingdom.

**Grapes**

**Gray Mold (*Botrytis cinerea*)**

Bayer

2017 monitoring is ongoing, will be updated Q1 2018

Monitoring in 2015 and 2016 has been carried in Germany, Italy, France and Chile.

In 2015 high frequencies of resistance strains were found in Chile and Germany, moderate frequency in France and low in Italy.

In 2016 similar situation as in 2015 in Chile.

In Italy low levels and in Germany and France moderate resistance levels were detected in 2016.

Monitoring carried in 2017 showed low to moderate levels of resistance in Italy, remaining moderate levels in France and high levels in Germany.

QoI sensitive (cyt b wild type) strains often could be divided in isolates carrying or not carrying the intron int the cytochrome b gene. (Add link to intron (see FRAC document titled “Mutations associated with QoI resistance” available on the FRAC website under QoI fungicides → Quick references).

**Lettuce (*Bremia lactucae*)**

BASF

In 2016 genetic analysis showed that all samples from Spain and Germany did not contain any known mutations potentially causing QoI resistance and were therefore classified as sensitive to QoI.

**Onion (*Peronospora destructor*)**

BASF

In 2016 genetic analysis showed that samples from Germany did not contain any known mutations potentially causing QoI resistance and were therefore classified as sensitive to QoI.

**Oilseed Rape (Canola)**

**Stem Rot *(Sclerotinia sclerotiorum) OSR***

Syngenta, BASF, Bayer, Sumitomo

Preliminary monitoring in 2016/17 from , Czech Republic, Denmark, France, Germany, Latvia, Lithuania, Poland, Romania, Sweden, Ukraine and United Kingdom showed a fully sensitive situation with no target site mutations detected

Sporadic cases of reduced sensitivity observed in lab studies underlines the need to use inhibitors of the alternative oxidase (AOX), such as SHAM or propyl-gallate, in sensitivity tests. Relevance of the AOX in practice needs further elucidation.

**Blackleg (*Leptosphaeria maculans, L. biglobosa*)**

BASF

Monitoring carried out in 2016/17 in Czech Republic, France, Poland, Slovakia and United Kingdom showed a fully sensitive situation

Monitoring carried out in 2015/16 in France and Germany showed full sensitivity situation.

**Sunflower**

**White Mould *(Sclerotinia sclerotiorum)***

BASF, Dow Du Pont

Monitoring carried out in Hungary and Slovakia in 2016 showed a fully sensitive situation.

**Corn**

***Pythium* spp**

Syngenta

Single isolates showing reduced sensitivity belonging to *P. irregulare*, *P. paroecandrum* and *P. sylvaticum* were found in France and Germany in 2017. Full sensitivity was monitored in Belgium.

**Sugar Beet (*Cercospora beticola*)**

BASF, Bayer, Dow Du Pont, Syngenta

Intensive monitoring was carried out across Europe in 2017. The levels of resistance found were:

High levels;: Austria, Belgium, Czech Republic, France, Greece, Italy, Netherlands, Romania, Serbia, Slovakia, Switzerland, Ukraine and United Kingdom.

Moderate to high levels: France, Poland.

In Denmark, Germany, Russia a more heterogeneous situation across the country ranging from no to high levels were found.

Low to moderate levels: Lithuania

Information for previous years is given in the 2016 minutes.

**Rice**

***Blast (Pyricularia oryzae = Magnaporthe oryzae)***

BASF, Syngenta

Monitoring results from Japan between 2013 and 2016 showed a decrease of resistance frequency , following a reduced use of QoI. Resistance, based on G143A presence has been confirmed in Vietnam with heterogeneous frequency from zero to high in 2017 similar as observed as in 2016.

No resistance was detected in Indonesia (2016), China (2017), India (2015) and the Philippines (2016).

Monitoring was carried out in Spain and Italy in 2016 and showed full sensitivity. No resistance has been detected so far in Europe.

**Sheath blight *(Rhizoctonia solani AG1.1A)***

Syngenta

Full sensitivity was monitored in 2014 and 2015 in China.

In Japan no resistance has been detected in 2015.

Samples in 2011 from a small number of fields in Louisiana, USA were found to contain less sensitive isolates. Monitoring carried out between 2012 and 2017 showed a stable situation. Only the F129L mutation has been found in these isolates.

For further known cases of QoI resistance, see the document titled “Species with QoI Resistance (2012)” on the FRAC website located under QoI fungicides → Quick references.

## 2.2. Review of global guidelines

### 2.2.1 Strategies and Guidelines for the 2018 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, coumoxystrobin, dimoxystrobin, enoxastrobin, famoxadone, fenamidone, fenaminostrobin, fluoxastrobin, flufenoxystrobin, kresoxim-methyl, mandestrobin, metominostrobin, orysastrobin, pyraoxystrobin picoxystrobin, pyraclostrobin, pyrametastrobin, pyribencarb, triclopyricarb trifloxystrobin) are in the same cross-resistance group.

- Fungicide programmes 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 **(refer to the specific crop recommendations)**.
- 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,

Where the guidelines 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, multi-sites) 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 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 manufacturer's 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**

Apply a maximum of 4 QoI fungicide containing sprays against any disease per vine crop, and a maximum of 33% of the total number of applications.

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 2 QoI fungicide containing sprays targeted against powdery mildew per vine crop, preferably 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 and in mixture with an effective partner.

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 targeted against downy mildew 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 pome fruit**

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 of 6 QoI fungicide applications whichever is the lower. Do not use more than 3 consecutive QoI fungicide containing sprays.

Early blight (*Alternaria solani, Alternaria alternata*)

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. Where resistance has been confirmed, QoI fungicides must be applied only in mixture with partners contributing to the effective control of the target pathogens.

### 2.2.2.5 Guidelines for using QoI fungicides on soybean diseases

QoI fungicides control soybean diseases including rust, which is a major disease in Latin America and has been detected recently in the USA.

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

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.

1. Use QoIs preventatively or as early as possible in the disease cycle.
2. Use QoIs preferably in mixtures (co-formulations or, **where permitted**, 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. In regions where target site mutations in key target soybean pathogens are present mixtures are mandatory.
3. Limiting the number of sprays containing QoI fungicides is an important factor in delaying the build-up of resistant pathogen populations.

Good agricultural practices must be considered to reduce source of inoculum, disease pressure and resistance risk, e.g. no multiple cropping, implement and respect soybean-free periods, consider varietal tolerance, reduce the planting window, give preference to early-cycle varieties or endorse the destruction of volunteers.

### 2.2.2.6 Guidelines for using QoI fungicides on sugar beet

*Cercospora beticola*

1 Apply QoI fungicides according to manufacturer's recommendations for the target disease (or complex) at the specific crop growth stages indicated. 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 **from a different cross-resistance group**, contributing to the effective control of the target pathogens.
3. Apply QoI fungicides preventatively. Under high disease pressure the spray interval should not be extended.
4. Do not exceed 50% of the total number of sprays with QoI containing products. In low disease pressure situations where only 1 fungicide application is required for disease control then a QoI – containing mixture (as defined above) may be used.

Where QoI fungicides are used targeting other sugar beet diseases (e.g. rust, powdery mildew, Rhizoctonia, Ramularia and Stemphylium) then the potential impact of applications on the resistance management of *Cercospora beticola* should be considered. Where *Cercospora beticola* is not a disease of importance (e.g. in a certain geography) then the general guidelines for QoI fungicides apply.

### 2.2.2.7 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.

## 2.2.2.8 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.

## 2.2.2.9 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<br><br>Solo QoI fungicide sprays | 1 | 1** | 2** | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | * |
| Max. recommended<br><br>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.

## 2.2.2.10 Guidelines for using QoI fungicides on Rice

Rice Blast (*Pyricularia oryzae, Magnaporthe oryzae*)

1. Apply a maximum of 2 foliar treatments per season.
2. In situations where resistance has been detected or the risk is considered to be high always apply QoI fungicides in mixtures (where permitted) with non-cross resistant fungicides. At the chosen rate, the respective partner(s) on its/ their own has/ have to provide effective disease control. Refer to manufacturers recommendations for rates.

3. Apply QoI fungicides in programs with fungicides of different mode of actions.
4. Avoid QoI fungicides for seed production.
5. Apply QoI fungicide based products at effective rates and intervals according to manufactures'' recommendations.
6. To keep good field sanitation, avoid transplanting diseased seedlings, remove or destroy primary infection source e.g. left-over seedlings, infested straw and chaff.

Seed treatment applications

QoIs are and will be used as seed treatment products.

It is FRAC's objective to protect this fungicide group and integrate all uses into technical recommendations. These minutes contain a recommendation on seed treatments, including those which have efficacy on foliar pathogens.

These recommendations will be reviewed regularly and supported by monitoring. When an QoI fungicide is used as a seed treatment on rice, there should be no implications regarding QoI FRAC guidelines on the use of foliar QoI fungicides on the same crop as long as the QoI seed treatment is directed by rate and efficacy against seed and soil borne diseases or 'low risk' foliar pathogens (Link to FRAC pathogen risk classes).

QoIs used as a seed treatment in rice providing foliar efficacy against pathogens with moderate/ high resistance risk count against the total number of QoI applications.

If QoI seed treatment has been used, first foliar application have to be made with a different mode of action in the vegetative phase before subsequent QoI-based foliar sprays in the reproductive phase.

Please refer to the recommendations of Japan-FRAC www.jfrac.com link

#### 2.2.2.11 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 2016 meeting of the FRAC Banana Working Group are available on the FRAC Website (http://www.frac.info/frac/index.htm). The next meeting of the group is planned for spring 2018.

## 3. Communication plans

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

## 4. Next meetings:

All crops: December 13th 2018.

Venue: Frankfurt