QoI Working Group

FRAC
FUNGICIDE RESISTANCE ACTION COMMITTEE

MEMBERSHIP

The working group is comprised of the following members:

Helge Sierotzki (interim chair)	Syngenta
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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 CropScience, DuPont, Syngenta

QoI working group of FRAC
Minutes of the meeting
All crops: December 3th, 2015
held in Frankfurt, Germany

Source: www.frac.info
April 2016

2. Minutes of discussions

2.1. Review of sensitivity monitoring

2.1.1. Cereal diseases

Field experience in 2015 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

Disease pressure in 2015 was moderate across Europe.

Overall, where monitoring was carried out, there was a stable situation (Austria, Czech Republic, Denmark, Hungary, and Sweden) but also slight decrease of resistant isolates in Italy and Poland in 2015 compared with 2014.

High resistance frequencies were found in Denmark and Sweden.

Medium frequencies were found in Poland.

Low resistance frequencies were found in Austria, Czech Republic, Hungary, Italy, Ukraine, Bulgaria and Romania.

No resistance has been detected in Western Russia.

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

Bayer CropScience

Disease pressure in 2015 was moderate across Europe.

Overall, where monitoring was carried out, there was a similar situation in 2015 compared to 2014.

High resistance frequencies were found in Central Germany and United Kingdom.

Low to medium frequencies were found in Austria, Czech Republic, Denmark, Northern and Central France, Germany, Hungary, Poland, and Sweden.

No resistance was detected in Belgium and Italy.

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

BASF, Du Pont, Syngenta

Disease pressure in 2015 in Europe was moderate. Monitoring programmes were carried out throughout the wheat growing areas of Europe in 2015.

The status at the end of the season 2015 is as follows:

In Belgium, Denmark, France, Germany, Ireland, Netherlands, Sweden, Switzerland, and United Kingdom: widespread resistance over all these countries at high levels were detected.

Czech Republic, Hungary, Italy, Latvia, Lithuania, Poland, Slovenia Northern Spain, and Western Ukraine: populations were showing in average moderate levels of resistance with high variability

Austria, Bulgaria, Croatia, Romania, Russia, Slovakia, Southern Spain, and Eastern Ukraine: sampling in 2015 showed no to low levels of resistance.

Resistance to QoI fungicides in *Zymoseptoria tritici* was reported in USA in 2013 (Oregon). There were no reports of loss of field control from QoI-containing products and programmes.

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

BASF, Bayer CropScience

No monitoring in 2015.

In 2015, performance of QoI fungicides against brown rust was good. No resistant isolates were detected in widespread monitoring studies in Europe in 2014, confirming the fully sensitive picture (Austria, Belgium, France, Germany, Hungary, Italy, Poland, 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 CropScience

No monitoring in 2015.

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 2015 of QoI containing spray programmes was good.

Net blotch (*Pyrenophora teres*), barley

BASF, Bayer CropScience, Du Pont, Syngenta

Disease pressure was moderate in Europe during 2015. Performance of QoI containing spray programmes against Net Blotch was good.

Extensive monitoring was carried out in 2015. 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 2015 has improved compared to previous years and is as follows:

Belgium, France - moderate levels

Germany, Netherlands, and United Kingdom - low to moderate levels

Denmark, Italy, Poland, Sweden, and Ukraine - low levels

Croatia, Czech Republic, Finland, Hungary, Ireland Latvia, Romania, Russia, Slovakia, and Spain - no detection of mutations.

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

BASF, Bayer CropScience, Du Pont, Syngenta

Disease pressure was low in Europe during 2015.

Performance of QoI fungicides against Leaf Scald was good.

In 2015 all samples were sensitive in Denmark, Finland, France, Germany, Ireland, Latvia, Poland, Spain, Sweden, 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, Du Pont

Disease pressure was moderate in Europe in 2015.

Performance of QoI containing spray programmes against tan spot was good in 2015.

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

Moderate to high resistance frequencies were found in: Germany and Hungary.

Low to moderate frequencies were found in Czech Republic, Latvia, and Poland.

No to low resistance was detected in Romania and Ukraine.

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

Bayer CropScience, Syngenta

The levels of resistance found in monitoring programmes in 2014 are summarised below:

High Levels: Germany, Denmark and Sweden

No resistance: Estonia

2.1.2. Vine diseases

Downy mildew (*Plasmopara viticola*)

BASF, Bayer CropScience, Syngenta

In 2015, disease pressure was low to moderate in the main grape growing areas of Europe.

The levels of resistance found in monitoring programmes **in 2014** are summarised below:

High levels: Bulgaria, Croatia, France (Champagne, Ardenne), Germany (Bayern), Hungary, Italy (Umbria), Switzerland (Ticino, Graubuenden)

Moderate Levels: France (Pay de la Loire, Poitou Charentes, Aquitaine, Languedoc Rousillon, Bourgogne, Lorraine, Midi Pyrenees), Germany (Baden Wuerttemberg, Rheinland-Pfalz), Italy (Sud Tirol, Piemonte, Lombardia, Toscana, Emilia Romagna, Marche, Friuli, Veneto), Slovenia

Low to Moderate levels: Austria, Italy (Trentino), Portugal (none to moderate)

Low Levels: Southern Italy (Sicilia, Puglia, Abruzzo), Spain (Galicia), Romania

Heterogeneous level of resistance were found (from low to high) in Spain (Basque) and in Greece.

In 2015 limited monitoring was carried out in a small number of locations in France, Germany, Greece, Italy, Portugal, Slovakia, and Spain.

Low levels of resistance were found in France, Greece and Portugal, moderate in Italy, Slovakia and high in Germany and Spain (Basque).

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

BASF, Bayer CropScience, Syngenta

Disease pressure in 2015 was moderate to high across Europe.

In 2015, intensive monitoring studies show there was a general stability in the levels of resistance in Europe compared to 2014.

The levels of resistance found in monitoring programmes in 2015 is summarised below:

High levels: France (many regions), Germany (Pfalz, Baden-Württemberg, Neckar), Hungary, Italy (Trentino, Alto Adige, Veneto, Lazio), and Switzerland (Genf, Wallis)

Moderate levels: France (Languedoc, Loire Valley, Provence, Savoie, Champagne), Germany (Mosel, Rheinhessen), and Greece, Switzerland (Vaud), Italy (Marche)

Low levels: France (Cognac), Germany (Main-Franken), Spain (Jerez, Cadiz), Switzerland (Schaffhausen), and Italy (Toscana)

No resistance: Italy (Puglia, Piemonte, Emilia Romagna), Switzerland (Zürich)

Data from limited number of samples from Portugal and Slovakia showed presence of resistance allele.

Additional information for other countries is given in the 2014 minutes (Minutes of the 2014 QoI Meeting, Recommendations for 2015).

2.1.3 Pome fruit diseases

Apple scab (*Venturia inaequalis*)

Bayer CropScience

Disease pressure in 2015 was moderate 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 between neighbouring orchards.

Monitoring was carried out in 2015 - frequencies of resistance are reported below:

High: France (Southern), Germany (Eastern)

Low: North West France

Additional information for other regions is given in the 2014 minutes (Minutes of the 2014 QoI Meeting, Recommendations for 2015).

Apple Powdery Mildew (*Podosphaera leucotricha*)

No monitoring was carried out in 2014 and 2015

Resistance has not been detected until now and 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).

Information for previous years is given in the 2013 minutes (Minutes of the 2013 QoI Meeting, Recommendations for 2014).

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

BASF, Bayer CropScience

Monitoring data for 2014 showed all populations to be fully sensitive (France, Greece, Italy, Poland, Spain)

Monitoring for 2015:

Full sensitivity was detected in Belgium, France, Hungary, and Italy (Puglia)

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 CropScience

No resistance was detected in all isolates collected in 2014 from potato crops in Austria, Belgium, France, Germany, Netherlands, Poland, Spain and United Kingdom; and from tomatoes (Italy).

Performance remains good.

In 2015, again no resistance has been detected in Germany (potatoes).

Early blight (*Alternaria* spp.)

BASF, DuPont, Syngenta

Monitoring was carried out in potatoes and tomatoes (*Alternaria solani* and *Alternaria alternata*) in Europe in 2015.

Alternaria solani

Tomato

Limited monitoring showed no resistance in Bulgaria and Spain.

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 and Netherlands.

Low frequencies of the F129L mutation were confirmed in Austria, Hungary and Slovakia.

All samples tested from France, Greece, Italy, Spain, and United Kingdom were sensitive.

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

Tomato

Limited monitoring is carried out in 2015.

Resistance has been found in Bulgaria, Italy and Spain.

Potato

Resistant isolates (bearing the G143A mutation) were found in potato samples from Austria, Belgium, France, Germany, Greece, Hungary, Italy, Latvia, Netherlands and Slovakia.

In Czech Republic, United Kingdom, Poland, and Spain no G143A mutation was found.

The role of *A. alternata* in the disease complex remains under discussion.

2.1.5. Soybean diseases

Asian Rust (*Phakopsora pachyrhizi*)

BASF, Bayer CropScience, Du Pont, FRAC Brazil, Syngenta

Intensive monitoring was carried out across Brazil during 2014/2015.

In 2014, 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 2015, 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).

Target Spot (*Corynespora cassiicola*)

BASF

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

2.1.6. Other crops

Vegetables

Cucumber powdery mildew (*Sphaerotheca fuliginea*)

Syngenta

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

No monitoring has been carried out in 2015.

Cucumber downy mildew (*Pseudoperonospora cubensis*)

Bayer CropScience, Syngenta

First 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 (Sicily).
Samples from melons collected in Italy (Piemonte) were sensitive.

No monitoring was carried out in 2015.

Oilseed Rape (Canola)

Stem Rot *(Sclerotinia sclerotiorum) OSR*

Du Pont, Syngenta, BASF

Monitoring in 2015 from Czech Republic, France, Germany, Hungary, Latvia, Lithuania, Poland, Ukraine, and United Kingdom showed a fully sensitive situation.

Blackleg (*Leptosphaeria maculans, L. biglobosa*)

BASF, Du Pont

Monitoring carried out in 2015 in France, Germany, Hungary, Poland, and United Kingdom showed a fully sensitive situation.

Sunflower

White Mould *(Sclerotinia sclerotiorum)*

DuPont

Monitoring carried out in Hungary in 2014 showed a fully sensitive situation.

Peas and Beans

White Mould *(Sclerotinia sclerotiorum)*

BASF

All samples tested from Netherlands and Belgium were sensitive.

Corn

Grey Leaf Spot (Cercospora zeae-*maydis*)

BASF

Initial analysis confirmed the presence of the intron, preventing the G143A mutation. All studied strains from US in 2015 showed cyt b wild type sequence and were sensitive in bioassay.

Sugar Beet (*Cercospora beticola*)

BASF, Bayer CropScience, Du Pont, Syngenta

Intensive monitoring was carried out across Europe in 2014 and 2015. The levels of resistance found were:

High levels; Austria, Croatia, Hungary, Italy, Slovakia, and Slovenia

Medium to high levels: Denmark, France (heterogeneous situation)

No to low levels: Poland, Romania, Sweden

No resistance: Lithuania, Russia

Czech Republic - Overall moderate levels but rather heterogeneous, ranging from low to high resistance frequencies.

Belgium, Germany, Netherlands and Switzerland - Overall low levels but very heterogeneous across the country. Most isolates were fully sensitive but a low number were found with high frequencies of resistance.

Rice

Blast (Pyricularia oryzae = Magnaporthe oryzae)

BASF, Du Pont, Syngenta

Monitoring results from Japan in 2015 showed that resistance was found in 3 additional prefectures resulting in a total of 19:
Fukuoka Ohita, Saga, Yamaguchi, Kumamoto, Miyazaki, Kagoshima, Shimane, Tottori, Okayama, Hyogo, Ehime, Shiga, Gifu, Mie, Yamagata, Akita and Kochi. The presence of the G143A mutation was confirmed.

Resistance, based on G143A presence has been detected in 6 regions (An Giang, Can Tho, Soc Trang, Long an, Dong Thap Tien Giang) in Vietnam.

Monitoring carried out in India and China showed full sensitivity.

Currently, no resistance has been reported so far in Europe.

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

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 2014 showed a stable situation. Only the F129L mutation has been found in these isolates.

In Japan no resistance has been detected in 2015.

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

2.2. Review of global guidelines

2.2.1 Strategies and Guidelines for the 2015 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, 2015 season

Where the guidelines for the 2015 season 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 2016 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 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 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 effectively 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:

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

2. Use QoIs preventatively or as early as possible in the disease cycle.

3. Use QoIs preferably in mixtures (co-formulations or, **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.

4. 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 disease pressure and resistance risk, e.g. avoiding multiple cropping. Rotating products of the same mode of action group does not contribute to sound resistance management (see FRAC mixtures guidance document).

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, 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 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.

2.2.2.10 Rice

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

Based on the reported data, an additional recommendation will be suggested.

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 2014 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 April 2016, 17th to 19th.

3. Communication plans

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

4. Next meetings:

All crops: December 15th 2016.
Venue: Frankfurt