Minutes of the FRAC QiI (Quinone inside Inhibitors) Working Group Meeting

26 March 2026 – 09.30 to 12:30

Frankfurt, Germany

Protocol of the discussions and use recommendations of the QiI (Quinone inside inhibitors) Working Group of the Fungicide Resistance Action Committee (FRAC)

Participants

Andy Leader (QiI Chair)	Corteva
Helge Sierotzki (Qo Chair)	Syngenta
Mamadou Mboup	Corteva
Amandine Picard	Corteva
Lorenzo Borghi	Syngenta
Stefan Dragos	Syngenta
David Ranner	Syngenta
Andreas Mehl	Bayer
Chris Cooksley	Bayer (arable crops)
Gerd Stammler	BASF SE
Michael Merk	BASF
Raffaello Zito	BASF SE
Yuichi Matsuzaki	Sumitomo
Gaelle Huet	FMC
Yutaka Sakinaga	ISK Biosciences Europe
Yoshitake Desaki	Ishihara Sangyo Kaisha
Victor de Amorin	ISK Biosciences Europe
Yasuhiro Fukami	Nissan Chemical Corporation
Hiroyuki Ito	Nissan Chemical Europe

Companies participating in the QiI meeting:
BASF, Bayer, FMC, Corteva, Syngenta, Sumitomo, ISK, Nissan

Disclaimer

The technical information contained in the global guidelines/the website/the publication/the minutes is provided to CropLife International/RAC members, non-members, the scientific community and a broader public audience.

While CropLife International and the RACs make every effort to present accurate and reliable information in the guidelines, CropLife International and the RACs do not guarantee the accuracy, completeness, efficacy, timeliness, or correct sequencing of such information. CropLife International and the RACs assume no responsibility for consequences resulting from the use of their information, or in any respect for the content of such information, including but not limited to errors or omissions, the accuracy or reasonableness of factual or scientific assumptions, studies, or conclusions.

Inclusion of active ingredients and products on the RAC Code Lists is based on scientific evaluation of their modes of action; it does not provide any kind of testimonial for the use of a product or a judgment on efficacy. CropLife International and the RACs are not responsible for, and expressly disclaim all liability for, damages of any kind arising out of use, reference to, or reliance on information provided in the guidelines.

Listing of chemical classes or modes of action in any of the CropLife International/RAC recommendations must not be interpreted as approval for use of a compound in a given country. Prior to implementation, each user must determine the current registration status in the country of use and strictly adhere to the uses and instructions approved in that country.

Introduction

The FRAC QiI (Quinone **i**nside **I**nhibitors) Working Group was formed in 2025 and the first meeting took place in March 2025. In previous FRAC meetings, companies presented introductions to QiI molecules including baseline data and resistance management recommendations. Some QiI molecules have been available for use by growers for several years. All QiI molecules share the same FRAC Group 21 and target site C4 - Quinone 'inside' (Qi) binding site of the cytochrome bc1 (ubiquinone reductase) which inhibits fungal cell respiration in the mitochondria. However, Oomycete QiI molecules amisulbrom and cyazofamid have different crops and disease spectrum from non-oomycete compounds fenpicoxamid and florylpicoxamid. Amisulbrom and cyazofamid are effective against Oomycete pathogens (late blight and downy mildews) in associated target crops (potatoes, tomato, grape vine and leafy vegetables) whereas Non-Oomycete QiI molecules (fenpicoxamid, florylpicoxamid) are active against ascomycete and basidiomycete fungi in row crops (cereals, oilseeds, sugar beet), banana, ornamentals and fruit and vegetable crops with no activity on Oomycete pathogens. The lack of commonality in disease spectrum requires separate resistance management recommendations for Oomycete and Non-Oomycete QiI compounds.

The objective of the Working Group is to generate common resistance management recommendations for the fungicides amisulbrom and cyazofamid active against predominantly oomycete pathogens in potato, grape vines and leafy fruiting vegetable crops. Additionally, to generate common resistance management recommendations for the Non-Oomycete QiI fungicides (fenpicoxamid and florylpicoxamid) active against ascomycete and basidiomycete diseases.

QiI fungicides have been classified under the FRAC Code 21 C4. The resistance risk is medium to high.

FRAC Code	Target site and code	Group name	QiI Disease Spectrum	Chemical group	Common name	Comments
21	C4 - Quinone 'inside' (Qi) binding site of the cytochrome bc1 (ubiquinone reductase)	QiI fungicides (Quinone inside Inhibitors)	**Oomycete**	Sulfonamide Cyanoimidazole	Amisulbrom, Cyazofamid,	Resistance risk assumed to be medium to high (single site inhibitor). Resistance management required. Picolinamides show no spectrum overlap with Oomycete compounds amisulbrom and cyazofamid
			Non Oomycete Actinomycete Basidiomycete	Picolinamides	Fenpicoxamid, Florylpicoxamid	

QiI Minutes of the 2025 discussions
Review of sensitivity monitoring 2024 and earlier

1. Introduction

The working group is responsible for global fungicide resistance strategies in the Qi inhibitor fungicides (QiI). The Qi inhibitor fungicides (QiI) all act at the Quinone 'inside' (Qi) binding site of the cytochrome bc1 complex, separated into one subgroup (FRAC code 21 C4) reflecting different binding properties from other QI fungicides (QoI and QioSI (FRAC codes 11, 11A (C3) and 45 (C8)).

The QiI FRAC code 21 C4 fungicides are: fenpicoxamid, florylpicoxamid, amisulbrom and cyazofamid. The resistance risk is classified as medium to high depending on the pathogen. As Oomycete QiI molecules amisulbrom, cyazofamid have a different crop and disease spectrum from non-oomycete compounds fenpicoxamid, florylpicoxamid, separate resistance management recommendations are required.

Fungicides in the code group 21 are not cross-resistant to fungicides in the FRAC code group 11A and 11.

2. Minutes of discussions

2.1. Review of sensitivity monitoring

In the text below the categorisation of the findings ranging from “high” to “no resistance” are based on agreed frequency of resistant or adapted isolates in collections of samples from the respective countries or regions mentioned (no, no to low, low, low to medium, medium, medium to high, high, low to high, no to high resistance). Please refer to the wording in each category for more specific information.

Fungicides in FRAC code 21:

2.1.1. Cereal diseases

Field experience since first use in 2020 has confirmed that, when used according to FRAC guidelines, the performance of QiI Non-Oomycete containing products within spray programmes was good. QiIs continue to contribute to overall disease management in cereals.

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

Companies: Corteva, Bayer

Sensitivity baseline data generated by Corteva across seven years (2011, 2013, 2014, 2016, 2017, 2018 and 2019) from Belgium, Czechia, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Poland, Spain, Sweden and United Kingdom showed a very narrow EC50 range and full sensitivity.

Sensitivity monitoring has continued to be conducted in 2021, 2022 and 2023 with samples from Belgium, France, Germany, Hungary, Ireland, Italy, Netherlands, Spain and United Kingdom where no changes in sensitivity were observed.

2024: Companies: Corteva, Bayer

In 2024, extensive monitoring based on bioassay in Austria, Belgium, Denmark, Czechia, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Spain, Sweden and United Kingdom showed full sensitivity within the established base line range. No resistant isolates observed.

2025: Companies: Corteva, Bayer, Syngenta

In 2025, extensive monitoring based on bioassay in Austria, Belgium, Denmark, Czechia, France, Germany, Ireland, Italy, Estonia, Hungary, Latvia, Lithuania, Netherlands, Norway, Poland, Slovakia, Spain, Sweden and United Kingdom showed full sensitivity within the established base line range. No resistant isolates observed.

Samples from New Zealand with isolates tested from 2020 to 2024 showed full sensitivity within the established base line range. No resistant isolates observed.

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

Companies: Corteva, Bayer

Sensitivity baseline data generated by Corteva across three years (2015, 2016 and 2018) in Austria, Belgium, Czechia, Denmark, France, Germany, Hungary, Italy, Netherlands, Poland, Sweden and United Kingdom showed a narrow EC50 and full sensitivity.

2024: Companies: Bayer

In 2024, sensitivity monitoring based on bioassay in France, Germany, Ireland and United Kingdom, showed full sensitivity. No resistant isolates observed.

2025: Companies: Bayer, Corteva

In 2025, sensitivity monitoring based on bioassay in Czechia, France, Germany, Hungary, Ireland, Poland, Sweden, and United Kingdom showed full sensitivity. No resistant isolates observed.

Yellow rust (*Puccinia striiformis*), wheat

No data presented

Net blotch (*Pyrenophora teres*), barley

Companies: Corteva, Bayer,

Sensitivity baseline data was generated by Corteva across two years (2018 and 2019) with samples from Belgium, Czechia, Denmark, France, Germany, Hungary, Italy, Poland, Sweden and United Kingdom showed a narrow EC50 and therefore full sensitivity.

2024: Companies: Bayer

In 2024, sensitivity monitoring based on bioassay in Austria, Belgium, Czechia, Denmark, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Sweden, Netherlands and United Kingdom showed full sensitivity. No resistant isolates observed.

2025: Companies: Bayer

In 2025, sensitivity monitoring based on bioassay in Austria, Belgium, Czechia, Denmark, Estonia, France, Finland Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Poland, Sweden, Netherlands and United Kingdom, UA showed full sensitivity. No resistant isolates observed.

Ramularia (*Ramularia collo-cygni*), barley

Companies: Corteva,

Sensitivity baseline data generated by Corteva across four years (2018, 2019, 2020 and 2021) in Czechia, Denmark, France, Germany, Hungary, Ireland and Italy showed a narrow EC50 and therefore full sensitivity. No resistant isolates observed.

No testing in 2024 and 2025

2.1.2 Sugar Beet

Cercospora Leaf Spot *(Cercospora betecola)*

Companies: Corteva

Sensitivity baseline data generated across two years (2023 and 2024) in Austria (2023), Belgium, Czechia, Germany, France, Hungary, Italy, Netherlands, Poland, Romania, Spain. showed a narrow EC50 and therefore full sensitivity.

2.1.3 Ornamentals

Grey Mold (*Botrytis cinerea*) in ornamentals

Companies: Corteva
Sensitivity baseline data generated in 2023 and 2024 from Colombia showed full sensitivity.

No monitoring in 2025

2.1.4 Cotton

Ramularia leaf spot (*Ramulariopsis* pseudoglycines syn Ramularia areola) cotton

Companies: Corteva,

Sensitivity baseline data based on bioassay was generated across two years (2023, 2024) in Brazil. Samples were collected from different regions with a narrow sensitivity baseline observed.

2.1.5 Bananas

Black Sigatoka (Pseudocercospora fijiensis)

See most recent FRAC banana WG

2.1.6 Potatoes /Tomatoes

Potato/tomato late blight (*Phytophthora infestans*)

Companies: Nissan, Corteva and Syngenta

In 2024, samples from potato crops in Austria, Belgium, Czechia, Croatia, Denmark, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Slovenia, Switzerland, and United Kingdom were fully sensitive. No resistant isolates were observed.

Sensitivity samples were generated across multiple years (2016 and 2023) from Belgium, Czechia, Denmark, France, Germany, Hungary, Italy, Netherlands, Poland, Sweden and United Kingdom which were fully sensitive.

Since QiI fungicides were introduced over a decade ago, no resistant isolates have been found in field populations. *Phytophthora infestans* is classified by FRAC as a medium risk pathogen. Long-term experience with Oomycete QiI fungicides demonstrates that the resistance risk of *P. infestans* is moderate.

Companies: ISK, Corteva and Syngenta

In 2025, samples from potato crops in Austria, Belgium, Czechia, Croatia, Denmark, Estonia, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and United Kingdom were fully sensitive. No resistant isolates were observed.

2.1.7 Grape Vine

Grape downy mildew (*Plasmopara viticola*)

Companies: ISK, Nissan, Corteva and Syngenta

2019-2022
Companies: ISK and Nissan

Historical sensitivity samples baseline and monitoring were generated by companies across multiple years (2008 and 2022) from Austria, France, Germany, Greece, Italy, Spain and Portugal with 2019-2022 data reporting some different resistance mechanisms based on target site mutations and non-specific resistance mechanisms mediated by overexpression of alternative oxidase (AOX) with variability of occurrence by country and regions.

2024: Companies: ISK, Nissan, Corteva, Syngenta

In 2024 and 2023 extensive sensitivity monitoring of Oomycete QiI compounds in grape vine was carried out by bioassay or molecular methods in Austria, Croatia, France, Germany, Hungary, Italy, Portugal (only 2023), Romania (only 2023) and Spain.

Different resistance mechanisms based on target site mutations (insertions after Amino acid (AA) positions 203 \ 204, respectively, and L201S (the latter one found in single populations and low frequency)) have been reported. These mutations can impact the

activity of QiI compounds to varying degrees. Overall frequency of resistance is highly variable across Europe depending on countries, regions and even across years.
France: Low to Moderate
Germany: Low, regionally moderate
Austria: Low to Moderate
Italy: Low, regionally moderate

Overexpression of alternative oxidase (AOX) is also widely encountered but considered of lower practical relevance.

Future research should evaluate in more depth the relationship between mutation frequency and sensitivity, and their distribution regionally within countries.

2025: Companies: ISK, Nissan, Corteva, Syngenta

In 2025, extensive sensitivity monitoring of Oomycete QiI compounds in grape vine was carried out by bioassay or molecular methods in Austria, Croatia, France, Germany, Greece, Hungary, Italy, Portugal, Spain and Switzerland.

Different resistance mechanisms based on target site mutations (insertions after Amino acid (AA) positions 203 / 204, respectively, and L201S (the latter one found single cases in a few countries at low frequency)) have been reported. These mutations can impact the activity of QiI compounds to varying degrees. Overall frequency of mutations is highly variable across Europe depending on countries and regions in 2025 monitoring.

- France: Low to Moderate frequency of mutations, higher incidence primarily in South and Southwest France based mainly on insertion 203/204 DE.
- Austria, Germany, Switzerland: moderate and regionally high, mainly based on insertion 203/204 DE and 203/204 VE and single cases associated with L201S.
- Spain: No to regionally high (Basque region), mainly based on insertion 203/204 DE.
- Italy: Low, to regionally moderate, mainly based on insertion 203/204 VE
- Hungary, Greece, Portugal: Low, mainly based on insertion 203/204 VE and a limited data set.
- Croatia: low to high: mainly based on insertion 203/204 VE and a limited data set.

Plasmopara viticola is a high-risk pathogen. Overexpression of alternative oxidase (AOX) is also widely encountered but considered of limited practical relevance in an effective field program where rotation of modes of action is recommended.

2.1.4 Cucurbits

Cucurbit downy mildew (*Pseudoperonospora cubensis*)

No data presented

Recommendations for Use

General recommendations for Non-Oomycete QiI Compounds

- Apply QiI's preventatively.
- Use QiI's as part of an Integrated Crop Management (ICM) strategy incorporating other methods of control.
- Always follow product specific label recommendations for resistance management.
- When mixtures are used for QiI fungicide resistance management, applied as tank mix or as a co-formulated mixture, the mixture partner should provide satisfactory disease control when used alone on the target disease and must have a different mode of action.

Recommendations for cereals

- Apply a maximum of 1 QiI containing spray per crop.
- QiI fungicides should always be applied in mixture (co-formulation or tank mix) with a partner(s) from a different cross-resistance group which provide(s) robust control.

Recommendations for bananas

- See most recent FRAC banana WG use recommendations - summary table.
- QiI-fungicides should always be applied in mixtures with effective fungicides from different cross-resistance groups. The mixture partner should give effective control of black sigatoka at the rate selected.
- Make no consecutive applications of QiI fungicides.
- Apply QiI-fungicides for no more than three (3) applications or maximum 33% of the total period of protection needed per crop, whichever is more restrictive.

Recommendations for ornamentals

- Apply a maximum of 5 QiI containing sprays per year or a maximum of 33% of total sprays (1/3 of spray program) whichever is lower.

Recommendations for cotton

- Apply a maximum of 2 QiI containing sprays per crop.

Recommendations for sugar beet

- Apply a maximum of 2 QiI containing sprays per season or a maximum of 33% of total sprays (1/3 of spray program) whichever is lower. In case of the use of solo QiI fungicides, no more than one application per year.
- Apply QiI fungicides in strict alternation with fungicides from a different cross-resistance group. No consecutive applications.

General recommendations for Oomycete QiI Compounds

Recommendations for Grape Vines: *Plasmopara viticola* – Grape downy mildew
Plasmopara viticola is classified by FRAC as a high risk pathogen. The resistance risk of *P.viticola* to QiI fungicides is moderate to high and can be managed through appropriate use strategies.

- Always apply QiI fungicides in mixture with effective partners such as multi-site or other non-cross resistant fungicides in high risk areas/regions.
- Apply QiI fungicides preferably in a preventive manner.
- Apply a maximum of 50 % of the total number of intended applications for disease control not exceeding a total of 4 QiI fungicides sprays during one crop cycle. In areas of high resistance, the total number should not exceed a maximum of 3 applications during one crop cycle.
- Alternation with fungicides having other modes of action is recommended in spray programs.
- Apply QiI fungicides according to manufacturers' instructions.

Recommendations for Potatoes: *Phytophthora infestans* – Potato late blight

For effective resistance management a precautionary strategy has to be implemented.

- Apply QiI fungicides preferably in a preventive manner.
- Apply a maximum of 50 % of the total number of intended applications for late blight control during one crop cycle.
- Alternation with fungicides having other modes of action is recommended in spray programs.
- Apply QiI fungicides according to manufacturers' instructions.

3.0 Interim meeting in September 2026

Next Annual Meeting 18 March 2027

New cases of resistance: none reported in 2025