

SDHI
Working Group

FRAC
FUNGICIDE RESISTANCE
ACTION COMMITTEE

Succinate Dehydrogenase Inhibitor (SDHI) Working Group

6th Meeting on December 5, 2012

Protocol of the discussions and use recommendations of the SDHI Working Group of the Fungicide Resistance Action Committee (FRAC)

Participants

BASF
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Venue:

Lindner Hotel & Conference Centre, Frankfurt/ Main, Germany

1. Monitoring Results 2011 (FRAC members)

1.1 Cereal diseases

Wheat – Septoria leaf blotch (*Mycosphaerella graminicola*)
(Bayer CropScience, Syngenta, BASF, DuPont)

Disease pressure was high in most of the European countries in 2012. Field performance of SDHI fungicides against Septoria was good.

Extensive monitoring programs were carried out since 2003. All isolates tested in routine monitoring programs were sensitive, within the baseline. The sensitivity of a single isolate from a trial site in North-France was outside of the baseline range. A target site mutation was identified in the SDH-C subunit at position 79 (T79N). However, the resistance factor was low and performance was not affected.

Wheat – brown rust (*Puccinia recondita*)
(BASF, Bayer CropScience, Syngenta)

Extensive monitoring programs were carried out since 2005. All isolates tested were sensitive, within the baseline.

Wheat – eye spot (*Oculi macula*, *O.yallundae*)
(Bayer CropScience)

Extensive monitoring programs were carried out since 2003. All isolates tested until 2011 were sensitive, within the baseline. 2012 monitoring program is still ongoing.

Snow mold (*Microdochium* spp.)
(Syngenta)

Monitoring programs carried out in 2011 showed full sensitivity of isolates from different European countries.

Powdery mildew (*Blumeria graminis*)
(BASF)

Monitoring programs carried out in 2012 showed full sensitivity of isolates from different European countries.

Barley – net blotch (*Pyrenophora teres*)
(Bayer CropScience, Syngenta, Du Pont, BASF)

Disease pressure in 2012 was moderate in Europe. Field performance of SDHI fungicides against net blotch was good.

Extensive monitoring programs were carried out since 2003. Monitoring is still ongoing. Until 2011, all tested isolates were sensitive, within the baseline. In 2012, the sensitivity of 2 isolates from North-Germany was outside of the baseline range. A target site mutation was identified in the SDH-B subunit at position 277 (H277Y). However, the resistance factor was low and performance was not affected.

Barley – scald (*Rhynchosporium secalis*)
(Bayer CropScience, Syngenta, BASF, DuPont)

Extensive monitoring programs were carried out since 2003. All isolates tested were sensitive, within the baseline.

Ramularia leaf spot (*Ramularia collo-cygni*)
(BASF, Bayer CropScience, Syngenta)

All isolates tested were sensitive, within the baseline.

1.2. Grape diseases

Grape grey mold (*Botrytis cinerea*)
(Bayer CropScience)

Extensive monitoring programs were carried out since 2003.
Monitoring is still ongoing.

See following table for detected mutations: ([Published and new cases of SDHI resistance in fungi](#)).

Grape powdery mildew (*Erysiphe necator*)
(Bayer CropScience, BASF)

Extensive monitoring programs were carried out since 2003. All isolates tested were sensitive, within the baseline (Austria, Czech Republic, France, Germany, Hungary, Italy, Portugal, Spain).

1.3 Pomefruit diseases

Apple scab (*Venturia inaequalis*)
(Syngenta, DuPont, BASF)

Extensive monitoring programs were carried out since 2005.
All isolates tested so far from 2011 and 2012 were sensitive, within the baseline (Austria, Belgium, Bulgaria, France, Germany, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Spain, Switzerland, UK).
2012 monitoring programs are ongoing.

Apple powdery mildew (*Podosphaera leucotricha*)
(BASF, Syngenta)

All isolates tested so far were sensitive, within the baseline (France, Germany, Italy).
Monitoring programs are ongoing.

1.4. Cucurbit diseases

Cucurbit powdery mildew (*Sphaerotheca fuliginea*, syn. *Podosphaera xanthii*, *Erysiphe cichoracearum*)
(Bayer CropScience, Syngenta, Mitsui)

Extensive monitoring programs were carried out since 2005.
Monitoring studies in 2012 were carried out in Belgium, France, Italy, Japan, Netherlands, Poland and Spain.
Full sensitivity was observed except for Belgium and Italy, where 1 resistant isolate was detected, resp.
Monitoring programs are still ongoing.

1.5 Other crops

Strawberries – grey mold (*Botrytis cinerea*)
(Bayer CropScience, BASF)

Extensive monitoring programs were carried out since 2003.
In 2012, resistance was detected in Denmark, Germany, Poland and Sweden.

See following table for detected mutations: ([Published and newer cases of SDHI resistance in fungi](#)).

When used according to manufacturers' recommendations, field performance of SDHI containing products is good.

Grey mold (*Botrytis cinerea*) on other vegetable crops (tomato, pepper, eggplant, lettuce, beans)
(Du Pont)

Monitoring programs on various vegetable crops were carried out in 2010 and 2011. Mutations at the target site were found in some isolates in Italy and Spain. No cases of reduced field performance were reported.

Oilseed rape – Sclerotinia (*Sclerotinia sclerotiorum*)
(BASF, Syngenta)

Extensive monitoring programs were carried out since 2006.
All sites tested in 2008 were sensitive, within the baseline with one exception: few isolates were found at one site (France) with sensitivity outside of the baseline. In 2009, no resistant isolates were detected (France, Germany, UK).
Single suspicious isolates were identified in FR in a routine monitoring program in 2010.
In 2011, no resistance was detected in Czech Republic, Denmark, Germany, Latvia, Lithuania, Poland and UK. Resistant isolates were detected in France and rarely in Germany.
In 2012, no resistance was detected in Czech Republic, Germany, Latvia Poland and UK.
Monitoring programs are still ongoing.

Oilseed rape (*Leptosphaeria maculans*, *L.biglobosa*)
(BASF)

All isolates tested were sensitive, within the baseline (France, Germany, UK).

Potato (*Alternaria solani*, *A.alternata*)

(Syngenta)

Monitoring studies are carried out since 2009.

No SDHI resistance was detected in *A.solani* in Austria, France, Germany, Italy, Netherlands, Poland, Slovakia and Sweden.

In *A.alternata*, mutations in the *sdh* genes were detected in Austria, Germany, France, Italy, Poland, Slovakia and Sweden. The practical relevance of these mutations and the role of *A.alternata* in the disease complex have to be clarified. Field performance was not affected.

Alternaria spp., other crops

(Syngenta)

Resistance was not found in other *Alternaria* species in cabbages and carrots.

Asparagus (Stemphylium botryosum)

(BASF)

Monitoring was carried out in 2010 in Germany. Most samples were sensitive. Some samples showed low to moderate frequencies of *sdh* mutations ([Published and newer cases of SDHI resistance in fungi](#)). In 2011, most samples (Germany) were sensitive. Few samples showed low frequencies of mutations conferring resistance.

No monitoring was carried out in 2012.

Soybean rust (*Phakopsora pachyrhizi*)

(Syngenta)

Baseline sensitivity was established in 2010/11 and 2011/12 in Brazil.

2. Detection of Resistance (other monitoring data sources, non-FRAC)

A complete overview on resistant plant pathogenic organisms, including published cases of SDHI resistance, can be viewed in the publications area of the FRAC website. See the [List of resistant plant pathogens - January 2013](#).

3. Use Recommendations

3.1 General SDHI Guidelines (all crops)

- Strategies and General Guidelines for the 2012 season
 - Strategies for the management of SDHI 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 designed in order to be proactive and to prevent or delay the development of resistance to SDHI fungicides.
 - A fundamental principle that must be adhered to when applying resistance management strategies for SDHI fungicides is that:

The SDHI fungicides (benodanil, benzovindiflupyr, bixafen, boscalid, carboxin, fenfuram, fluopyram, flutolanil, fluxapyroxad, furametpyr, isopyrazam, mepronil, oxycarboxin, penflufen, penthiopyrad, sedaxane, thifluzamide) are in the same cross-resistance group.

- Fungicide programs must deliver effective disease management. Apply SDHI 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 SDHI fungicide based products within a total disease management program must be limited.
- When mixtures are used for SDHI 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
 - must have a different mode of action
- Mixtures of two or more SDHI fungicides can be applied to provide good biological efficacy; however, they do not provide an antiresistance strategy and must be treated as a solo SDHI for resistance management. Each application of such a mixture when used in a spray program counts as one SDHI application.
- SDHI fungicides should be used preventively or at the early stages of disease development.

3.2 SDHI Guidelines – Grapes

- Apply SDHI fungicides according to manufacturers' recommendations.
- When mixtures are used for SDHI 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
 - must have a different mode of action
- Apply a max. of 3 SDHI-containing fungicides per year over all diseases, solo or in mixture with effective mixture partners from different cross-resistance groups but not more than 50% of the total number of applications.
- A maximum of 4 SDHI fungicide applications may be used where 12 or more fungicide applications are made per crop.
- If used solo, apply SDHI fungicides in strict alternation with fungicides from a different cross-resistance group.

- If used in mixture, apply SDHI fungicides in a maximum of 2 consecutive applications.
- Apply SDHI fungicides preventively.
- For SDHI fungicide applications specifically targeted against grey mold, *Botrytis cinerea*, refer to the table below.

Grey mold (*Botrytis cinerea*) spray table:

Total number of <i>Botrytis cinerea</i> spray applications per crop	1	2	3	4	5	6	>6
Maximum recommended Solo SDHI fungicide sprays (apply in strict alternation)	1	1	1	2	2	2	3
Max. recommended SDHI fungicide sprays in mixture (apply a max. of 2 consecutive applications)	1	1	2	2	2	3	3

3.3 SDHI Guidelines – Pomefruit

- Apply SDHI fungicides according to manufacturers' recommendations.
- When mixtures are used for SDHI 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
 - must have a different mode of action
- Apply SDHI fungicides using not more than 2 consecutive applications.
- Apply SDHI fungicides preventively.

The following spray table shall be used as a guideline irrespective of the targeted disease in pomefruits.

Total number of spray applications per crop	1	2	3	4	5	6	7	8	9	10	11	12	>12
Maximum recommended Solo SDHI fungicide sprays	1	1	1	1	2	2	2	3	3	3	3	4	4
Max. recommended SDHI fungicide sprays in mixture	1	1	2	2	2	3	3	3	3	3	3	4	4

3.4 SDHI Guidelines – Stone fruits

- Apply SDHI fungicides according to manufacturers' recommendations.
- When mixtures are used for SDHI 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
- must have a different mode of action
- Apply a max. of 3 SDHI-containing fungicides per year over all diseases, solo or in mixture with effective mixture partners.
- If used solo, apply SDHI fungicides in strict alternation with fungicides from a different cross-resistance group.
- If used in mixture, apply SDHI fungicides in a maximum of 2 consecutive applications.
- Apply SDHI fungicides preventively.

3.5 SDHI Guidelines – Other multi-spray crops (e.g. vegetables, including small berries and strawberries)

- When mixtures are used for SDHI 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
 - must have a different mode of action

The following spray table shall be used as a guideline irrespective of the targeted disease in the crops specified above.

	1	2	3	4	5	6	7	8	9	10	11	12	>12
Total number of spray applications per crop													
Maximum recommended Solo SDHI fungicide sprays (apply in strict alternation)	1	1	1	1	2	2	2	3	3	3	3	4	*
Max. recommended SDHI fungicide sprays in mixture (apply a max. of 2 consecutive applications)	1	1	1	2	2	3	3	3	3	3	4	4	*

* When more than 12 fungicide applications are made, observe the following guidelines:

- When using a SDHI 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 programs in which tank mixes or pre-mixes of SDHI are utilized, the number of SDHI containing applications should be no more than 1/2 (50%) of the total number of fungicide application per season.
- In programs where SDHIs are made with both solo products and mixtures, the number of SDHI containing applications should be no more than 1/2 (50%) of the total no. of fungicide applied per season.

3.6 SDHI Guidelines - Banana

Guidelines for the use of SDHI fungicides in banana are published by the Banana FRAC working group ([Summary of FRAC guidelines for banana in 2012](#)) (next meeting scheduled for 2014).

3.7 SDHI Guidelines – Cereals

3.7.1. Foliar applications

- Apply SDHI fungicides always in mixtures
- The mixture partner:
 - should provide satisfactory disease control when used alone on the target disease
 - must have a different mode of action
- Apply a maximum of 2 SDHI fungicide containing sprays per cereal crop.

Apply the SDHI fungicide preventively or as early as possible in the disease cycle. Do not rely only on the curative potential of SDHI fungicides. Strongly reduced rate programs including multiple applications must not be used. Refer to manufacturers' recommendations for rates.

3.7.2. Seed treatment applications

SDHIs 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 for the first time 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 SDHI fungicide is used as a seed treatment on autumn-sown cereals, there should be no implications regarding SDHI FRAC guidelines on the use of foliar SDHI fungicides on the same crop as long as the SDHI seed treatment is directed by rate and efficacy against seed and soil borne diseases or 'low risk' foliar pathogens ([FRAC pathogen risk list](#)).

In all other cases, the SDHI seed treatment is counted as one of the total number of recommended SDHI applications per crop - unless other modifiers are applied.

Potential Modifiers:

- Mixing partners in the seed treatment (i.e. as stated in the general recommendation: providing satisfactory disease control when used alone on the target disease and having a different MoA)
- Alternation (i.e. the first foliar spray following the seed treatment does not contain an SDHI)
- Dose rate in the seed treatment (i.e. dose rate adjusted to cover only seed/ soil borne diseases)

The listed modifiers represent equally valid alternatives and can be used either separately or in combination.

When an SDHI fungicide is used as a seed treatment on spring-sown cereals, there should be no implications regarding SDHI FRAC guidelines on the use of foliar SDHI fungicides on the same crop as long as the SDHI seed treatment is directed by rate and efficacy against seed and soil borne diseases or 'low risk' foliar pathogens

In all other cases, the SDHI ST is counted as one of the total number of recommended SDHI applications per crop.

3.8 All other crops

- Refer to the general guideline for the use of SDHI fungicides.

3.9. Seed treatment for other crops

FRAC will develop recommendations for other crops in upcoming meetings.