



Succinate Dehydrogenase Inhibitor (SDHI) Working Group

5th Meeting on December 6, 2011

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

Participants

BASF Kristin Klappach (Chairwoman)
Randall Gold (partially)
Gerd Stammler
Martin Semar

Bayer CropScience Helene Lachaise
Andreas Mehl
Dominique Steiger
Andreas Goertz

Du Pont Robert Bird
Jean-Luc Genet

LKC Matthew Kane
(repres. Mitsui)

Syngenta Tyler Harp
Andy Leadbeater
Helge Sierotzki
Steve Dale

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)

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

Wheat – brown rust (*Puccinia recondita*)
(Syngenta)

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

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

Extensive monitoring programmes were carried out since 2003. All isolates tested in 2011 were sensitive, within the baseline.

Barley – rust (*Puccinia hordei*)
(Bayer CropScience)

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

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

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

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

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

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

All isolates tested were sensitive, within the baseline.

1.2. Grape diseases

Grape grey mould (*Botrytis cinerea*)
(BASF)

Extensive monitoring programmes were carried out since 2003.
Monitoring was carried out in France, Germany, Austria and Spain. No resistance was detected in Spain, low levels in France and Austria while moderate to high levels were detected in Germany.

In general, the levels of frequency are similar to 2010.

[See following table for detected mutations:](#)

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

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

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

1.3 Pomefruit diseases

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

Extensive monitoring programmes were carried out since 2005 with all tested isolates being sensitive, within the baseline.

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

All isolates tested were sensitive, within the baseline (UK, Belgium, Netherlands, Germany, France, Spain, Lithuania, Portugal, Austria, Switzerland, Poland).

1.4. Cucurbit diseases

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

Extensive monitoring programmes were carried out since 2005. No resistance was detected in monitoring studies in 2011 in France, Belgium, Netherlands, Italy and Spain.

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

Monitoring programmes on various vegetable crops were carried out since 2010. No shift in sensitivity was detected in Spain, Italy, France, Portugal and Greece.

1.5 Other crops

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

Extensive monitoring programmes were carried out since 2003. In 2011, resistance was detected in Germany, Spain, Belgium, Denmark, Poland and in the UK.

[See following table for detected mutations:](#)

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

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

Extensive monitoring programmes 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 programme in 2010. In France and Eastern Germany a few suspicious isolates were detected in 2011. Field performance was not affected. Full sensitivity was observed in UK, PL, CZ, DK, LT, LA. First *in vitro* studies in microtiter plate assays indicate that SDHI still contribute to Sclerotinia control under field conditions. Nevertheless, further studies on mechanisms, stability, sensitivity and impact on field performance are necessary to characterise further the relevance of these strains.

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

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

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

Monitoring studies are carried out since 2009. No SDHI resistance was detected in *A. solani* in France, Belgium, Netherlands, Germany and Poland. In monitoring studies carried out in Idaho/ USA, few *A. solani* isolates with *sdh* mutations have been detected. In *A. alternata* mutations in the *sdh* genes were detected in Netherlands, Belgium, Poland, Switzerland, Czech Republic and Serbia. The practical relevance of these mutations and the role of in the disease complex have to be clarified. Field performance was not affected.

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.](#) *Sdh* mutations were detected at very low frequency levels in 2011, even below the 2010 level.

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](#).

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
- 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 mould, *Botrytis cinerea*, refer to the table below.

Grey mould (*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 – Stonefruits

- 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](#) (next meeting scheduled for 2012).

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.

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 (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
- Dose rate

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.