Succinate Dehydrogenase Inhibitor (SDHI) Working Group

10th Meeting on December 14, 2016
Telephone conference on March 7, 2017
Meeting on Soybean on June 19, 2017
Protocol of the discussions and use recommendations of the SDHI Working Group of the Fungicide Resistance Action Committee (FRAC)

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Venue:

Lindner Hotel & Conference Centre, Frankfurt/ Main, Germany

Source: www.frac.info

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1. Monitoring Results 2016 (FRAC members)

1.1 Cereal diseases

Wheat – Septoria leaf blotch (*Mycosphaerella graminicola*)
(Bayer, Syngenta, BASF, Du Pont, Isagro/ FMC)

Disease pressure in 2016 was moderate to high but regionally variable, even within European countries. Field performance of SDHI fungicides against Septoria was good.
As in 2015, single isolates with moderate resistance factors and bearing the mutation H152R (SDH subunit C) were detected in 2016 in Ireland and the United Kingdom. The mutation was detected for the first time in Italy and the Netherlands. The overall frequency of this mutation remains at a low level and has not increased at the European level.
The following new mutations with low resistance factors were reported for the first time: B-T268A, B-N225I, C-T79I, C-R151S, C-N86A. The following mutations were also reported for the first time but are not associated with any sensitivity change: C-N33T, C-N34T.

Historical background:
Extensive monitoring programs were carried out since 2003. Most isolates tested in routine monitoring programs were sensitive, within the baseline. Since 2012, few isolates with reduced sensitivity were detected in Germany, France, Ireland and the United Kingdom (SDH subunit C: T79N, W80S, N86S, SDH subunit B: N225T, T268I). The resistance factors were low and field performance was not affected.

Wheat – Brown rust (*Puccinia recondita*)
(BASF, Syngenta)

Extensive monitoring programs were carried out since 2005. Samples from the following countries were tested in 2016: the United Kingdom, Belgium, France, Germany and Hungary. All tested isolates were sensitive, within the baseline.

Wheat – Yellow rust (*Puccinia striiformis*)
(Bayer, Syngenta)

In 2016, samples from Switzerland, Spain, France, the Netherlands, Sweden, Germany and the United Kingdom were tested and showed full sensitivity, within the baseline.

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

No data for 2016 samples are available. Monitoring programs carried out in 2015 showed full sensitivity of isolates from Germany, France, the United Kingdom, Slovakia and Italy confirming the results from 2014.

Wheat – Powdery mildew (*Blumeria graminis*)
(BASF)

Monitoring programs carried out in 2016 confirmed the results from 2015 and showed full sensitivity of isolates originating from the United Kingdom, France, Belgium, Germany and Denmark.

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

Disease pressure was low to moderate but regionally variable even within European countries in 2016. Field performance of SDHI-containing fungicides against net blotch was good.
The sensitivity situation was similar to 2015. The frequency of mutations was low in the United Kingdom, Czech Republic, Poland, Italy, Southern France, Southern Germany and Denmark. Moderate frequencies were observed in Northern France and Northern Germany. Among the mutations with moderately decreased sensitivity, CG79R and C-H134R are the most frequently detected mutations. While in France, C-G79R is the predominating mutation, in Germany, C-H134R is observed to be the more frequent mutation.
No mutations were detected in Estonia, Ireland, Hungary, Latvia, Lithuania, Slovakia, Spain, Bulgaria, Romania, Ukraine, Finland, Sweden and Russia.
These findings emphasize the importance of adhering to FRAC guidelines.

Historical background:
Extensive monitoring programs were carried out since 2003. 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 (B-H277Y). In 2013 and 2014, more isolates were detected with reduced sensitivity, carrying different mutations (link to mutations table) in France, Italy, Germany and the United Kingdom. The predominant mutation was C-G79R. The resistance factors were low for B-H277Y, D-D124E, D-D145G and moderate for C-G79R, C-H134R, C-S135R, C-N75S, C-R64K, D-H134R, C-K49E.
The mutation D-G138V was detected for the first time in 2015 and found to be associated to very low resistance factors.

Barley – Scald (*Rhynchosporium secalis*)
(Bayer, BASF)

Extensive monitoring programs were carried out since 2003. Isolates were tested from France, the United Kingdom, Germany, Ireland and Poland and were sensitive, within the baseline.

Barley - Ramularia leaf spot (*Ramularia collo-cygni*)
(BASF, Bayer, Syngenta, Isagro/ FMC)

Disease pressure was very high in 2016.
No mutations were detected in Sweden, Denmark, Estonia, Slovakia, France and Greece.
Samples carrying the mutations C-H146R or C-H153R associated with significantly decreased sensitivity were detected in Germany, Ireland, the Netherlands and the UK.
For single monitoring programs, results are not yet available and will be reported at the next working group meeting in December 2017.
Observations in trial sites confirmed the results from 2015. A decreased dose response was observed in field trial sites in Germany and the UK with high proportions of SDHIs in spray programs. Samples taken from the untreated plots at the same sites showed baseline level sensitivity. Confirmation of these results with molecular-biological studies will be reported at a later point.

Historical background:
In 2014, single isolates with slightly decreased sensitivity were detected from France and Germany. Retesting of 2014 isolates showed full sensitivity. Isolates sampled in 2014 from the Czech Republic were sensitive, within the baseline.
In 2015, extensive monitoring in Germany showed particularly in trial-sites for the first time occurrence of strains with strongly decreased dose-response in bioassays, carrying the mutation C-H146R or C-H153R. Another mutation, C-N87S, which was found to be associated with low

resistance factors, was monitored in Germany, Ireland and Slovenia in single isolates. No mutations were detected in Austria and Croatia.

Barley – Rust (*Puccinia hordei*)
(Bayer)

Monitoring programs were carried out since 2006. All isolates tested until 2014 were sensitive, within the baseline.
No monitoring was carried out in 2015 and 2016.

1.2. Grape diseases

Grape grey mold (*Botrytis cinerea*)
(Bayer, BASF)

Samples were tested coming from Spain, France, Germany, Austria, Hungary, Italy and Greece.
New mutations were detected at the following positions: C-P80H and C-P80L in single isolates in Germany and France. The resistance factor of these mutations was very low.
Depending on the regions, the overall frequency of mutation B-H272Y, /R and B-N230I remains at a moderate to high level in Chile and Germany, resp. The mutation B-P225H /L /F remains overall at a low level.
In France, low levels of resistance were found.

Historical background:
Extensive monitoring programs were carried out since 2003.
In 2012, few isolates with resistance to SDHIs were detected in France and Germany. An increasing frequency was observed in Germany in 2013. No new mutations have been identified in 2014 and the percentage of less sensitive isolates remained stable compared to 2013.
In 2015, resistant isolates were detected in Germany, France, Italy, Portugal and Chile at low frequency.

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

In 2016, the mutation B-H242R was detected in Czech Republic, Slovakia and in Hungary and at very low levels in France. The mutation C-G169D was not detected in 2016 studies.
Full sensitivity was observed in Greece, Portugal, Germany, Italy, Spain and Austria.
Field performance reductions were not reported. These findings emphasize the importance of adhering to FRAC guidelines.

Historical background:
Extensive monitoring programs were carried out since 2003. All isolates tested were sensitive, within the baseline (Austria, France, Germany, Hungary, Portugal, Spain, Switzerland). Single strains carrying a mutation (SDH subunit C-G169D) with moderate resistance factors were detected in single fields in Italy (retrospective investigations from 2014 samples, no detection in 2015), Slovenia and Greece (both from 2015 samples), resp.

1.3 Pomefruit and stonefruit diseases

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

Samples analysed so far showed full sensitivity, coming from the United Kingdom, Germany, Italy, Portugal, Spain, France, Belgium, the Netherlands and Poland.

At this point of (March 2017), sensitivity data for 2016 are not yet complete and will be reported in Dec. 2017 at the next working group meeting.

Historical background:
Extensive monitoring programs were carried out since 2005.
Data from commercial sites in 2015 show full sensitivity in Bulgaria, Belgium, Switzerland, Germany, Spain, France, Greece, Hungary, Croatia, Ireland, Italy, Latvia, Lithuania, Netherland, Romania, Portugal, Poland, the United Kingdom and Serbia.
Single isolates from trial sites with slightly reduced sensitivity were found in Bulgaria, Italy and Spain. Product performance was not affected.
For resistant isolates originating from trial sites in Italy, the mutations B-T253I and C-H151R were detected.

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

In 2016, all isolates tested showed full sensitivity. Samples originated from Belgium, Bulgaria, Switzerland, Germany, Spain, France, Portugal, Greece, the Netherlands, Czech Republic, Hungary, Italy, Lithuania, Poland and Romania.

Historical background:
All isolates tested in 2014 were sensitive, within the baseline (France, Spain, Austria, Hungary, Germany, Romania, Bulgaria).
All isolates tested in 2015 coming from Belgium, Switzerland, Germany, Spain, France, Italy, Latvia, the Netherlands, Portugal and Poland were sensitive, within the baseline.

Stonefruit - Brown rot (*Monilinia* spp.)
(BASF, Syngenta)

In 2015, samples from Italy, France and Spain were studied (confirmation of species still open). Single isolates with reduced sensitivity were detected at 3 trial sites in France. Only sensitive phenotypes were reported from Italy and Spain.

Historical background:
Sensitivity of samples from Spain, France, Italy, Germany and Poland was analysed and showed full sensitivity in 2014.
In 2015, samples originating from Belgium, France and Hungary were all sensitive, within the baseline.

1.4. Cucurbit diseases

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

P.xanthii samples were analysed originating from zucchini, cucumber, melon and water melon.
Single samples showed resistance and were found in Belgium, France and Greece. Decreased sensitivity was reported in a few samples from China. No resistance was detected in Spain, Italy, the Netherlands.

Historical background:
Extensive monitoring programs were carried out since 2005.

Monitoring studies in 2014 were carried out in France, Italy, Greece, Germany, Switzerland, China and Spain. Full sensitivity was observed except for Spain, Italy and China, where single resistant isolates were detected.
In 2015, full sensitivity was observed in Belgium, Bulgaria, Spain and the Netherlands. Resistant isolates were detected in Germany, Czech Republic, Italy, Poland, Greece and France.

1.5 Other crops

Strawberries – Grey mold (*Botrytis cinerea*)
(Bayer, DuPont)

In 2016, the majority of isolates showed full sensitivity, originating from Germany, France and the United Kingdom.
In all countries mentioned, the mutations B-H272R and B-H272Y were detected at moderate levels and B-N230I was detected at low levels.

Historical background:
Extensive monitoring programs were carried out since 2003.
In 2015, monitoring was carried out in Germany, Belgium, Hungary, Italy, France, Denmark, Poland, Sweden, the Netherlands (raspberry) and the United Kingdom. Some resistant isolates were detected in Germany, Poland, Belgium and the United Kingdom.
When used according to manufacturers' recommendations, field performance of SDHI containing products is good.

Grey mold (*Botrytis cinerea*) on other vegetable crops (tomato, lettuce, zucchini, cucumber)
(Du Pont)

No monitoring was carried out in 2016.

Historical background:
Monitoring data were reported from 2013 (France, Italy, Portugal, Greece).
Resistant isolates were found in Italy, Greece and Portugal. No cases of reduced field performance were reported.
No monitoring was carried out in 2015.

Vegetables – *Alternaria* spp. (cabbage, broccoli, carrot)
(Syngenta)

No data were reported for 2016.
Resistance was detected in 2014 at low frequency in *A. brassicae* and *A. brassicicola* isolated from cabbage in Germany and *A. alternata* sampled from broccoli in Spain.
In 2015, a single isolate with resistance was detected in *A.alternata* from broccoli in Spain.

Peas, beans – White mold (*Sclerotinia sclerotiorum*)
(Bayer)

No monitoring was carried out in 2016.

In 2015, samples from the Netherlands and Belgium were all sensitive, within the baseline.

Oilseed rape – White mold (*Sclerotinia sclerotiorum*)
(BASF, Bayer, Syngenta, Isagro/ FMC)

Disease pressure in 2016 was very high.

In the season 2016, samples were tested from Germany, France, the United Kingdom, Czech Republic, Lithuania, Denmark and Poland.
No to low frequency of resistance was detected in France and Germany.
Analysis of samples including mutations is not yet completed and will be reported at the next working group meeting.

Historical background:
Extensive monitoring programs were carried out since 2006.
In 2014 and 2015, single resistant isolates were detected in France. No resistant isolates were detected in 2014 in Czech Republic, Germany, the United Kingdom and Poland.
In 2015, no resistance was detected in the Netherlands, Belgium, France, Poland, Czech Republic, Croatia and Germany.
For information on previously detected mutations please refer to "Link to mutations table".
Field performance was not affected.

Oilseed rape - Blackleg (*Leptosphaeria maculans, L.biglobosa)*
(BASF, DuPont, Bayer)

Samples coming from France and Germany were all sensitive, within the baseline.

Historical background:
All isolates tested were sensitive, within the baseline (France, Germany, Poland, United Kingdom and Hungary).

Potato – Early blight, Alternaria leaf spot (*Alternaria solani, A.alternata*)
(Syngenta, BASF)

In *A.alternata*, no resistance was detected in Bulgaria, Romania, Sweden, France, the United Kingdom and Slovakia in 2016.
Low frequency of resistance was detected in Hungary and Poland. Low to moderate frequency of resistance was detected in Switzerland and Germany, and moderate levels in Belgium.

In *A.solani*, no resistance was detected in Czech Republic, Spain, Finland, Greece, Hungary and Slovakia. Low frequency of resistant isolates was detected in Poland, Denmark, Italy, Romania and the United Kingdom. Moderate frequency was detected in Belgium, Germany, the Netherlands and Sweden.

Historical background:
Monitoring studies are carried out since 2009.
In 2015, no SDHI resistance was detected in *A.solani* in Austria, France, Greece, Hungary, Italy, Slovakia and Spain. Isolates with reduced sensitivity were detected in Europe in Belgium, Germany, the Netherlands and Denmark.
In *A.alternata*, isolates with reduced sensitivity were detected in Austria, Belgium, Germany, Hungary, Italy, Slovakia and the Netherlands. Full sensitivity was found in Finland, France, Greece, Latvia and Spain.
For information on previously detected mutations please refer to "Link to mutations table".
The practical relevance of these mutations and the role of *A.alternata* in the disease complex are still under discussion by the research community.

Potato – Silver scurf (*Helminthosporium solani*)
(Syngenta)

No monitoring was carried out in 2016.

In 2014, single resistant isolates were detected in Belgium and the Netherlands. No resistant isolates were detected in the United Kingdom, France and Germany.

Potato – Stem canker/ Black scurf *(Rhizoctonia solani*)
(Syngenta)

No monitoring was carried out in 2016.

All samples analysed from the United Kingdom, the Netherlands, France and Germany in 2014 showed full sensitivity.

Tomato – Early blight, Alternaria leaf spot (*Alternaria solani, A.alternata*)
(Syngenta)

In A.solani, no resistance was detected in Poland and Italy in 2016.

In A.alternata, few isolates showing reduced sensitivity were detected in Poland, Italy and Greece.

Historical background:
In 2015, no SDHI resistance was detected in *A.solani* in Poland, Bulgaria and Spain. In *A. alternata*, a single isolate from Italy showed reduced sensitivity. No SDHI resistance was reported from Spain and Bulgaria.
For information on previously detected mutations please refer to "Link to mutations table".

Tomato – Powdery mildew (Oidium neolycopersici)
(Syngenta)

All samples originating from Belgium, Spain, France and the Netherlands showed full sensitivity.

Soybean – Asian soybean rust (*Phakopsora pachyrhizi*)
(Syngenta, Bayer, BASF, DuPont, Isagro/ FMC)

Soybean rust samples have been tested for sensitivity to SDHI fungicides since 2007.
Field efficacy of SDHI-containing fungicides remains generally good and in many hundreds of trials as well as in commercial fields analyzed throughout Brazil in 2016/2017 season performance was as expected based on experience from previous years.
For the first time in the season 2015/16 and more frequently in 2016/17 at sites with a history of intensive SDHI-use and very high disease pressure, cases of reduced performance have been detected.
Further analyses of populations from 2016/17 have shown reduced sensitivity to varying degrees.
No to high frequencies of less sensitive populations were observed in the South of Brazil (Rio Grande do Sul, Parana, Mato Grosso do Sul).
A low proportion of less sensitive populations was found in Goias, Minas Gerais, Sao Paulo and Mato Grosso.
No to very low frequency of less sensitive populations was found in Bahia, Maranhao and Tocantins.

Currently, the resistance mechanisms are not fully understood.
The initial characterization of populations collected 2015/16 indicated a mutation in the C-subunit at position I86F. The relevance and distribution of this mutation for the reduced SDHI sensitivity partly observed as well in 2016/17 samples is currently under investigation.
Other mutations or resistance mechanisms cannot be excluded.

Intensive monitoring programs are running to investigate the magnitude and relevance of the findings.

Soybean – Target spot (*Corynespora cassiicola*)
(BASF)

2016 monitoring is still ongoing and will be reported at the next working group meeting.
All samples analysed from Brasil in 2014/15 showed full sensitivity.

Banana – Black sigatoka (*Mycosphaerella fijiensis*)
(Syngenta, Bayer, BASF)

In vitro monitoring studies have revealed first isolates with reduced sensitivity in Ecuador and Costa Rica. No information on target site mutations is available at this point in time. Field performance was not affected.
More details are published by the Banana FRAC working group (Link).

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.

See following table for detected mutations: (mutations table).

3. Use Recommendations

3.1 General SDHI Guidelines (all crops)

- Strategies and General Guidelines for the 2017 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 (adepidyn, benodanil, benzovindiflupyr, bixafen, boscalid, carboxin, fenfuram, fluindapyr, 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 anti-resistance 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.
    - Please refer to the "mixture document" for more information on fungicide mixtures for resistance management.
    - Species can carry different mutations which affect SDHIs. A few mutations can lead to different sensitivities depending on the chemical structure of the active ingredient.
    - As SDHIs are cross-resistant, resistance management must be the same for all SDHIs.
    - All monitoring and guideline related statements refer to the entire group of SDHIs.

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 *Botrytis cinerea* 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	2	2	3	3	3	3
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.

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 **(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.
- 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.

3.6 SDHI Guidelines - Banana

Guidelines for the use of SDHI fungicides in banana are published by the Banana FRAC working group (link) (next meeting scheduled for 2016).

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.

Source: www.frac.info

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 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 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 (Link to FRAC pathogen risk list).

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

3.8 Soybeans

Species can carry different mutations which affect SDHIs. A few mutations can lead to different sensitivities depending on the chemical structure of the active ingredient.
As all SDHIs are cross-resistant, resistance management must be the same for all SDHIs. All monitoring and guideline related statements refer to the entire group of SDHIs.

- Apply SDHI fungicides always in mixtures
  - The mixture partner(s):
  - should provide satisfactory disease control when used alone on the target disease
  - must have a different mode of action
  - The use of additional, non-crossresistant modes of action should also be considered (ready-mixtures and tankmixtures where legally possible).
- Apply a maximum of 2 SDHI fungicide containing sprays per soybean crop (no soy after soy/ double cropping).
- Apply SDHI-containing fungicides preventively or as early as possible in the disease cycle. Do not rely only on the curative properties of SDHIs, or SDHI-containing mixtures
- Strongly reduced rate programs including multiple applications must not be used. Refer to manufacturers' recommendations for rates.
- Respect the spray intervals according to the manufacturers' guidelines.

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 partially resistant soybean varieties, reduce the planting window, give preference to early-cycle varieties and endorse the destruction of volunteers.

3.9 All other crops

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

Oilseed rape

Extensive monitoring programs have been carried out. Reduced sensitivity has been detected in *S.sclerotiorum*.

Further monitoring programs will continue and clarify the necessity for a specific crop guideline. The general guidelines for the use of SDHIs are currently considered to be sufficient because current data shows sporadic detection, no consistent increase and spread of resistant mutations. In addition, the life cycle of the pathogen, its distribution and rotation with non-host crops confirm that *Sclerotinia* in OSR justify the classification as a low risk pathogen (Link pathogen risk list).

3.10 Seed treatment for other crops

There are no guidelines for additional crops because currently the relevant pathogens are not considered as high risk pathogens. Monitoring programs will continue to be carried out and serve as basis for regular reviews of the need for specific guidelines.