



STEROL BIOSYNTHESIS INHIBITOR (SBI) WORKING GROUP

**Annual Meeting 2017 on December 15, 2017, 08:00 –16:15
and Telephone Conference on March 28, 2018, 10:30-11:30
Protocol of the discussions and recommendations of the SBI
working group of the Fungicide Resistance Action Committee
(FRAC)**

Participants of the SBI WG Meeting on December 15, 2017
TelCo participation on March 28, 2018 indicated by TC

ADAMA	Martin Huttenlocher (excused)
BASF	Martin Semar (TC) Gerd Stammler (TC)
Bayer	Frank Goehlich (TC) Andreas Mehl (TC) Klaus Stenzel (TC)
DowDuPont	Greg Kemmitt
Sumitomo	Norio Kimura (excused) Yves Senechal Ippei Uemura
Syngenta	Steve Dale (TC) Stefano Torriani (TC) Birgit Forster (excused)
FRAC Brazil chairman (for soybean only)	Rogério Augusto Bortolan, Bayer; chairman (excused)
Venue of the meeting:	Lindner Congress Hotel, Frankfurt
Hosting organization:	FRAC/Crop Life International

Anti-Trust Guidelines (from FRAC Constitution) were shown before the Meeting started

1. DMI AND AMINES: CEREAL DISEASES

1. 1. WHEAT

1.1.1. Leaf spot (*Mycosphaerella graminicola* / *Septoria tritici*)

Presentation of monitoring data BASF, Bayer, Syngenta

- Disease pressure was moderate in most of the European countries but regionally variable in 2017.
- DMIs field performance was good when used according to the manufacturers and FRAC recommendations. No general field resistance has been reported.
- Monitoring was carried out in Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Italy, Ireland, Latvia, Lithuania, Netherlands, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, Ukraine, and United Kingdom.
- After the slight increase in the frequency of less sensitive isolates from 2002 to 2004, the situation had stabilised between 2005 and 2008. In 2009 a trend to slightly higher EC50 values was observed in important cereal growing areas (France, Germany, Ireland, United Kingdom), this trend has slowed down in 2010 to 2012 and was stable in 2013. 2014 sensitivity was in the same range as 2011.
- In 2015 depending on the individual active ingredient and regions slight shifts of sensitivity of populations have been observed. Highest EC50 values were observed in areas of elevated disease pressure and sub-optimal use of azoles in spray programs (e.g. reduction of rates in comparison to the manufacturer's recommended rate and inappropriate use of effective mix-partners).
- In 2016 and also in 2017 the sensitivity of the populations was overall stable on an European level with regional differences also based on different disease epidemics. In regions with lower sensitivity in 2015 the sensitivity of the populations was stable and in some areas even partially increased.
In regions with limited options in fungicides classes and/or a common practice of significantly reduced rates DMIs are at higher risk and performance might be impacted.

1.1.2. Powdery mildew (*Blumeria graminis* f.sp. *tritici* / *Erysiphe graminis* f.sp. *tritici*)

Disease pressure in 2017 was low to moderate across Europe.

DMIs

Presentation of monitoring data: Bayer

- DMI field performance was good.
- Monitoring was carried out in Belgium, Czech Republic, Denmark, France, Germany, Poland, Romania, Sweden, and United Kingdom.

- Sensitivity data presented for 2016 and 2017 confirmed that the situation was overall stable within the range of variability detected during the last 20 years. Differences in the sensitivity are a.i. and regionally dependent. Higher resistance factors were observed only for particular DMIs in Belgium, France, Germany, Poland and UK.

Amines

Presentation of monitoring data from 2016: Bayer

- Field performance of amine based products was good.
- In 2016 monitoring was carried out in Belgium, Czech Republic, France, Germany, Hungary, Italy, Poland, and United Kingdom.
- Sensitivity data presented from 2016 confirmed that the situation in 2016 was stable remaining in the range of variability seen over more than 25 years.
- Next monitoring will be carried out in 2018.

1.1.3. Wheat brown rust (*Puccinia triticina*)

Presentation of monitoring data in 2017: Bayer

- Brown rust disease pressure was moderate to high in most of the countries in Europe.
- Good field performance of DMIs against rust has been maintained.
- Monitoring in 2017 has been carried out in Belgium, Denmark, France, Germany, Sweden, and United Kingdom.
- Sensitivity data from 2017 for wheat brown rust showed that the sensitivities were in the range of those of the last 15 years.

1.1.4. Eyespot (*Tapesia* spp. *syn.* *Oculimacula* spp.)

For 2017 monitoring is still ongoing. Field performance was good.

Presentation of monitoring data for 2014: Bayer.

An analysis of samples from France, Germany, and UK from 2016 was presented by Bayer.

- Sensitivity data have been presented for W and R types. Between 2003 and 2012 there was no change in the sensitivity of both types, stable situation had been observed during the last 9 years. In 2013 some sensitivity change has been observed in the United Kingdom, but not in France or Germany. In 2014 further sensitivity decrease has been observed in the United Kingdom, and for the first time also in France and Germany. However, overall, resistance factors still remain low and performance was not affected. The 2016 data showed a homogenous and sensitive situation in all countries.

1.1.5. Tan spot (*Pyrenophora tritici-repentis*, syn. *Drechslera tritici-repentis*)

Monitoring was carried out for the first time in 2017: Syngenta

Monitoring data from 2017 showed a stable sensitivity range with no geographic variations.

1.1.6. Yellow rust (*Puccinia striiformis*)

Presentation of monitoring data from 2017: Bayer

Disease pressure was moderate.

Monitoring was carried out in Denmark, France, Germany, Latvia, and United Kingdom.

First monitoring in 2015 showed high sensitivity and low diversity, and for 2016 and 2017 a stable situation.

1.1.7. Snow Mould (*Microdochium nivale nivale* and *M. nivale majus*)

Presentation of monitoring data from 2014 to 2017: Syngenta

Monitoring was carried out in Belgium, Denmark, Finland, France, Germany, Italy, Latvia, Lithuania, Poland, Russia, Sweden, Ukraine, and United Kingdom.

In general a stable sensitivity situation has been reported for the past four years.

1.2. BARLEY

1.2.1. Powdery Mildew (*Blumeria graminis* f.sp. *hordei* / *Erysiphe graminis* f.sp. *hordei*)

No monitoring was carried out in 2017, next monitoring in 2018.

Data from 2016:

In 2016, disease pressure was low in Europe. Monitoring was carried out in Denmark, France, Germany, Sweden, and United Kingdom.

DMIs

Results from 2016 monitoring were presented by Bayer CropScience:

- DMI products performed well.
- The sensitivity of the populations stayed in the range observed for more than 15 years.

Reduced sensitivity was reported in barley powdery mildew in western and eastern Australia (ACNFP/Curtin University) in 2014.

Amines

Results from 2016 monitoring were presented by Bayer:

Monitoring was carried out in Czech Republic, France, Germany, Italy, Poland, and United Kingdom.

- Amine products performed well.
- The sensitivity of the populations stayed in the range observed for more than 15 years.

1.2.2. Scald (*Rhynchosporium secalis*)

Presentation of monitoring data: BASF, Bayer, Syngenta

- Disease pressure was low to moderate in Europe in 2017.
- Field performance of DMIs was good.
- Monitoring was carried out in Czech Republic, Denmark, France, Germany, Ireland, Italy, Latvia, Poland, Spain, and United Kingdom.
- Stable situation. The sensitivity of the populations stayed in the range observed in the previous 15 years.

1.2.3. Net blotch (*Pyrenophora teres* / *Drechslera teres*)

Presentation of first monitoring data for 2017: Bayer, Syngenta

- Disease pressure was moderate to high but regionally variable even within European countries in 2017
- Performance of SBI containing spray programmes was good.
- Monitoring was carried out in Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Latvia, Poland, Sweden, Spain, Ukraine, and United Kingdom.
- In 2017 in France significant shifts of sensitivity of populations have been observed. Highest EC50 values were observed in areas of elevated disease pressure, often coupled with a reported reduced variety-resistance at significant cultivation areas, and sub-optimal use of azoles in spray programs (e.g. reduction of rates in comparison to the manufacturer's recommended rate and inappropriate use of effective mix-partners).
- In general over the past years a significant fluctuation in sensitivity levels between the years was detected. In 2017 in single locations in Germany there have been seen some shifting which needs to be observed in the next season. The monitoring in the other countries showed a stable situation in 2017 within the regular fluctuation.

1.2.4. Ramularia leaf spot (*Ramularia collo-cygni*)

Presentation of monitoring data for 2016, 2017: Bayer. Some monitoring for 2017 is still ongoing.

Disease pressure was low to moderate in 2016.

Monitoring was carried out in Austria, Belgium, Denmark, Estonia, France, Germany, Ireland, Netherlands, Sweden, and United Kingdom.

- Field performance was regionally significantly affected.
- Isolates were detected showing significant loss of sensitivity. Relevant CYP51-mutations explaining the effects have been identified (I325T, I328L, Y403C/Y405H).
- 2016: broad sensitivity range has been identified with very high frequency of high resistant strains in southern Germany, with moderate frequency in Denmark, Ireland, Belgium, Northwestern Germany, and low frequency detected in France, Austria, Sweden, and United Kingdom. No detection of resistance in Estonia.
- First data showed high frequency of resistant strains in Denmark, Ireland, and United Kingdom, moderate frequency in Estonia, low to moderate frequency in Sweden, and no resistant strains were detected in Finland. In other countries the monitoring is still ongoing, the results will be reported later.
- Given that there already exist populations in Europe resistant to all main specific modes of actions it is recommended to add precautionary a multi-site to ensure robust disease control and an effective resistance management.

1.3. GENERAL RECOMMENDATIONS FOR CEREALS (DMIs AND AMINES)

The recommendations for the use of DMI and amine fungicides in mixture or alternation programmes with different mode of action fungicides remain unchanged. It needs to be emphasized that it is essential for resistance management purposes to follow strictly the manufacturer's and FRAC recommendations.

Repeated application of DMI or amine fungicides alone should not be used on the same crop in one season against risky pathogens (e.g. cereal powdery mildews, barley net blotch, scald) in areas of high disease pressure for that particular pathogen.

Reduced rates of DMIs can contribute to accelerate the shift to less sensitive populations. It is critical to use effective rates of DMIs in order to ensure robust disease control and effective resistance management. DMIs must provide effective disease control and be used at manufacturers recommended rates.

When used in mixture recommended effective rates of the SBI must be maintained. Split and reduced rate programmes, using multiple repeated applications at dose rates below manufacturer's recommendations, provide continuous selection pressure and accelerate the development of resistant populations, and therefore must not be used.

To ensure good performance and particularly resistance management in situations of even low disease pressure it is essential to adhere to dosages and spray timings as recommended by manufacturers. Curative applications should be avoided. Application timing has to be appropriate to all mix partners' characteristics. Mixing with a non-cross resistant fungicide at

effective dose rates contributes to a more effective disease control and resistance management.

The amine fungicides are effective non-cross-resistant partner fungicides for DMIs on cereals for the control of pathogens included in the label recommendation of each respective product.

2. DMI AND AMINES: INDUSTRIAL CROPS

2.1. SOYBEAN:

2.1.1. Asian soybean rust (*Phakopsora pachyrhizi*)

Presentation of monitoring data from season 2016/2017: BASF, Bayer, Syngenta

- A sensitivity baseline has been established in Brazil based on 2005/6 data. Extensive monitoring was carried out since 2007/8 across the country.
- Sensitivity shifts have been observed with a trend to stabilize in season 2010/11. This has to be seen in connection with the recommendation of an azole use in mixtures only and the introduction of a crop-free period. This trend continued in the following seasons until season 2013/14. In 2014/2015 slight shifts in sensitivity has been observed compared to 2013/14.
- In 2015/16 and 2016/17 the sensitivity level was on the same level as in previous years.
- Despite this situation it is recognized that a regional variability in performance of DMI mixtures has been observed which is under further investigations.

Recommendations for Asian soybean rust:

Refer to the general recommendations for SBI's.

In addition to ensure robust disease control and resistance management it is essential to

- Apply DMI fungicides always in mixtures with effective non-cross resistant fungicides. Refer to manufacturers recommendations for rates.
- Apply preventively or as early as possible in the disease cycle.
- Apply DMI fungicide containing products always at intervals recommended by the manufacturers and adjusted to the disease epidemics. Avoid extended spray intervals.
- 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.

2.1.2. Target Spot (*Corynespora cassiicola*)

First studies were carried out with isolates from season 2013/14 and 2014/15 by BASF. These initial studies showed high sensitivity to DMIs. Monitoring analysis in 2016/17 season is ongoing.

2.2. OILSEED RAPE

2.2.1. Phoma leaf spot and stem canker, blackleg (*Leptosphaeria maculans* / *L. biglobosa*)

Presentation of monitoring data: BASF (samples from season 2016/17). Further monitoring analysis for 2016/17 is still ongoing.

- Monitoring was carried out in Czech Republic, France, Poland, and United Kingdom.
- Monitoring data from 2006 to 2017 showed a stable sensitivity range as in the last years.
- For recommendations see General Recommendations.

2.2.2. Sclerotinia stem rot, white mould (*Sclerotinia sclerotiorum*)

Presentation of monitoring data for 2016: BASF, Bayer, Syngenta, for 2017: Bayer, Syngenta

- Monitoring was carried out in 2016 in: Czech Republic, France, Germany, Lithuania, Poland, Slovakia, and United Kingdom. Disease pressure was low to moderate.
- Monitoring was carried out in 2017 in Czech Republic, Denmark, France, Germany, Latvia, Poland, and United Kingdom. Disease pressure was low to moderate.
- Monitoring data from both years showed a stable sensitivity range as in the last years. Studies on further samples from 2017 are ongoing at BASF.
- For recommendations see General Recommendations.

2.3. SUGAR BEET

2.3.1. Leaf spot (*Cercospora beticola*)

Presentation of monitoring data for 2016: BASF, Bayer, and Syngenta.

Presentation of monitoring data for 2017: BASF, Bayer, Syngenta (DMI and Amines).

DMI

- Monitoring data for 2016 are available for Austria, Belgium, Czech Republic, France, Germany, Italy, Netherlands, Poland, Sweden, Switzerland, and United Kingdom. Based on this data a stable situation was observed as in the last years.

- Monitoring in 2017 was carried out in Austria, Czech Republic, France, Germany, Greece, Lithuania, Netherlands, Poland, Romania, Russia, Slovakia, Serbia, and United Kingdom. A stable situation was observed as in the last 5 years.
- Single isolates with slightly increased EC50 values were already detected 5 years ago in France and Germany but remain stable at a low frequency.

Field performance can be affected when solo DMI's are used.

The broad range of sensitivity leads to the assumption that a shift took place before routine monitoring was set up.

Amines

- Monitoring in 2017 was carried out in Austria, Czech Republic, France, Germany, Greece, Lithuania, Netherlands, Poland, Romania, Russia, Slovakia, Serbia, and United Kingdom.
- Monitoring showed a sensitive situation with a small range of sensitivity and without geographic variation.

For recommendations see General Recommendations.

2.4 RICE

2.4.1. Narrow brown spot (*Cercospora oryzae*)

Initial sensitivity studies performed 2017 by Syngenta with limited number of strains indicated high and homogenous sensitivity in Indonesia.

2.5 COTTON

2.5.1. Ramularia leaf blight (*Ramularia gossypii*, *R. areola*; *Mycosphaerella areola*)

Monitoring carried out 2017 by Syngenta in Brazil.

The data showed sensitivity within the known baseline generated in 2011.

3. DMI AND AMINES: OTHER CROPS

3.1. GRAPE VINE:

Powdery mildew (*Erysiphe necator*)

Monitoring data for **DMIs** were presented by Bayer (2017), Dow (2016), and Syngenta (2016, 2017). Monitoring analysis for 2017 is still ongoing.

- Disease pressure was moderate across Europe in 2017, moderate to high in 2016.
- Monitoring was carried out in 2016 in Austria, France, Germany, Italy, Portugal, Spain, and Switzerland
- Monitoring was carried out in 2017 in Austria, Croatia, Czech Republic, France, Germany, Hungary, Italy, Portugal, Romania, Slovakia, Spain, and Turkey.
- 2016 and 2017: Sensitivity for DMIs in Europe was stable and generally in the normal range of fluctuation as observed in the previous years.

Generally, population sensitivity can vary significantly between locations and years within individual countries. Exclusive frequency measurements of single *cyp51* mutations are not sufficient to describe the sensitivity situation in *Erysiphe necator* populations towards DMIs.

Monitoring data for amines for 2017 were presented by Bayer:

- Monitoring was carried out in France, Germany, Italy, Portugal, and Spain.
- Stable situation in the European countries with low resistance factors towards amines.

Recommendations:

- DMI's and amines should be used preventative and curative situations should be avoided.
- The existing strategy for effective disease control and resistance management continues to be successful and the use recommendation is a maximum of 4 applications per season per mode of action. The strategy includes the use of mixtures or alternation with non-cross resistant fungicides.
- To ensure that SBI's can remain the effective basis for control of *Erysiphe necator* in grape vine, their use should adhere to the full recommended rate (either alone or in mixture) at the recommended timing and application volume and an accurate treatment of each row.

3.2. STONE AND POME FRUIT

3.2.1. Scab on APPLE (*Venturia inaequalis*)

Presentation of monitoring data for 2017: Bayer, Syngenta.

- Disease pressure in 2017 was moderate across Europe.
- The performance of DMIs was good on this disease in 2017 when compounds were used according to the manufacturers' and FRAC recommendations within spraying programmes.

- Results from monitoring were available for Belgium, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Romania, Slovenia, Spain, and Switzerland.
- Sensitivity in European populations remains unchanged since 2011.

Recommendations:

- DMI fungicides are not recommended for season long use and a maximum of 4 DMI sprays either alone or in mixture is recommended.
- DMIs should be used in mixtures or (block) alternations with a non-cross resistant fungicide. Application of recommended label rates is important.
- Preventative applications should always be the first choice with DMIs. Curative applications are only recommended when accurate disease warning systems are available.

3.2.2. Powdery mildew (*Podosphaera leucotricha*) on APPLE

Presentation of monitoring data for 2017: Syngenta

- Performance of DMI was good.
- Monitoring was carried out in Belgium, Croatia, France, Hungary, Italy, and Poland.
- Monitoring was started in 2010 across Europe. No change in sensitivity comparing 2017 to 2010 was observed.
- See General Recommendations.

3.2.3. Brown rot on stonefruit (*Monilinia* spp.) – CHERRY, NECTARINE, PEACH, PLUM

Samples were analysed in 2017 by Syngenta.

- Monitoring was carried out in Croatia, Czech Republic, France, Germany, Italy, Poland, Romania, and Spain
- A narrow and homogenous distribution of sensitivity was detected across all crops and countries

3.2.4. Stemphylium on PEARS

Report by Syngenta for 2017 samples from Poland

- Homogenous and sensitive situation

3.3. TOMATO / POTATO

3.3.1. *Alternaria solani* and *Alternaria alternata*

Presentation of monitoring data for 2017: Syngenta

- Monitoring was carried out in Belgium, Czech Republic, France, Germany, Hungary, Italy, Netherlands, Poland, Romania, Slovakia, Spain, and Sweden.
- Homogenous sensitivity of both pathogens was observed in different countries across Europe and no change occurring in 2017.

3.4. CUCURBITS

3.4.1. *Podosphaera xanthii*/*Sphaerotheca fuliginea*

Presentation of monitoring data for 2017: Syngenta

- Monitoring was carried out in Belgium, France, Greece, Italy, Netherlands, Poland and Spain.
- No change of sensitivity has been observed from 2011 to 2017, and no variations between countries and samples collected from cucumber, melon or zucchini were reported.

3.5. OTHER VEGETABLES

3.5.1. *Alternaria* species on BROCCOLI, CABBAGE, CARROTS

Several crops and species were analysed in 2017 for the first time by Syngenta.

- This first monitoring was carried out in Bulgaria, Croatia, Denmark, France, Germany, Italy, Lithuania, Netherlands, Poland, Portugal, Spain, Sweden
- Monitored species were *Alternaria brassica*, *A. brassicola*, and *A. dauci* on broccoli, cabbage, and carrots
- There is no indication of a decreased sensitivity across all crops, countries, and species.

3.5.2. *Stemphylium* on ASPARAGUS

Monitoring was carried out in Germany over the last four years. Report for 2017 from Syngenta.

- Homogenous and sensitive situation

3.6. CITRUS, STRAWBERRY

3.6.1. Anthracnose (*Colletotrichum acutatum*)

Initial sensitivity studies performed 2017 by Syngenta with limited number of strains indicated high and homogenous sensitivity in USA.

3.6. BANANA

3.6.1. Black Sigatoka (*Mycosphaerella fijiensis*)

The conclusions and guidelines of the April 2016 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 end of April 2018.

4. SBI-CLASS III (KETO-REDUCTASE-INHIBITORS – KRI)

This group comprises of Fenhexamid and Fenpyrazamine as inhibitors of the Keto-Reductase (KRI). Both are cross-resistant.

4.1. Grey mould (*Botrytis cinerea*) on GRAPE VINE

- Presentation of monitoring data: Bayer (2016 and 2017), Sumitomo (2016)
- Disease pressure was moderate across Europe in 2017.
- Monitoring was carried out in Chile, France, Germany, Italy, and Spain
- High frequencies of resistant isolates were detected in Chile (2014, 2015, 2016), moderate to high frequencies in 2016 in Germany, low frequencies in France and very low in Italy and Spain.
- In 2017 the frequency of resistant isolates was low in France, moderate in Germany, and in Italy all strains analysed were fully sensitive.

Field performance of botryticides is most effective if embedded in sound spray programmes respecting the individual resistance management recommendations.

4.2. Grey mould (*Botrytis cinerea*) on STRAWBERRIES

- Presentation of monitoring data: Bayer (2017), Sumitomo (2016)
- Monitoring was carried out in 2016 in Austria, Italy, Spain, United Kingdom, Germany
- Monitoring was carried out in 2017 in Denmark, France, Germany, Poland, and United Kingdom

- 2016 and 2017 high presence of resistant strains in United Kingdom, moderate presence of resistant strains in Italy, low to moderate in Denmark and Germany, low presence in Austria, France, and Poland.

4.3. Grey mould (*Botrytis cinerea*) on RASPBERRIES

- No monitoring for 2016 and 2017.
- Presentation of monitoring data for 2014 and 2015: Bayer
- Limited monitoring in Norway in 2014 showed high frequency of resistant strains.
- Monitoring in 2015 in the Netherlands showed moderate frequency of resistance.

4.4 Recommendations for the use of KRIs:

- Use KRIs only protectively.
- Use KRIs only in strict alternation, no block application
- Solo product as part of alternation programmes:
 Spray programmes with a maximum of 3 treatments per season: max. 1 application with KRIs
 Spray programmes with 4-5 treatments/season: max. 2 applications with KRIs
 Spray programmes with 6 and more treatments: at the maximum one third of all Botryticide-applications
- Use in mixtures
 Both partners - if applied alone at the dose used in the mixture - must have sufficient activity against Botrytis. Not more than 50% of all Botryticide-treatments should be made with KRIs-containing mixtures.

For sound resistance management, good agricultural practices, including phytosanitary measures and crop protection, should be followed carefully.

5. NEXT MEETINGS

Next annual meeting is planned for December 14, 2018.
 Phone meeting will be arranged in March 2018 to review ongoing monitoring results.