Anilinopyrimidines (AP's) Working Group

Meeting on January 15, 2024, 1:30 pm - 5:15 pm
Protocol of the discussions and use recommendations of the AP's Working Group of the Fungicide Resistance Action Committee (FRAC)

Participants

BASF	Nadine Riediger Gerd Stammler
Bayer	Andreas Mehl Daniela Portz
K-I Chemical	Hidehiko Yamamoto Susumu Abe (excused)
Syngenta	Stefano Torriani Lorenzo Borghi James Fountaine

Venue:

Lindner Hotel & Residence Main Plaza

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Anti-Trust Guidelines (from FRAC Constitution) were shown before meetings started.

1.1 *Botrytis* results

Vineyards
(BASF, Bayer, K-I Chemical, Syngenta)

In 2023, sensitivity data from commercial vineyards and trial sites were presented for France, Italy, Portugal, Spain, Germany, Czech Republic, Austria, Hungary, and Croatia. Overall, 2023 data reflect a comparable sensitive situation as observed during the previous years. The frequencies of resistant strains were generally low and were varying in Europe from zero to moderate with regional variability.
These results still demonstrate an unchanged sensitivity across all studied European grape growing regions and confirm effective implementation of resistance management strategies over the past decade.

Historical background:
As in 2020, in 2021 and 2022, sensitivity data from commercial vineyards and trial sites were presented for France, Italy, and Spain in the major wine growing regions, as well as from Croatia, Germany, Hungary, Poland, Portugal, and Switzerland. Data from these studies show that frequencies of resistant strains was generally low and still varied in Europe from zero to moderate with regional variability.
These results still reflect a stable situation and are comparable to the observations made since more than a decade.

Frequencies of resistant strains varied in table grape samples from Chile (2018 data) from zero to high especially at trial sites, with regional variability.

Products, applied according to the FRAC-AP guidelines in grape spray programs, maintained good performance in the field.

Strawberries
(BASF, Bayer, Syngenta)

In 2023, sensitivity monitoring was carried out in Belgium, Netherlands, Greece, Italy, Poland, France, and Spain, from commercial locations and trial sites.
Data show that the frequency of resistant isolates is generally moderate, varying from field to field and from low to high.
Overall, the frequency of resistance detected in strawberries is higher than in grapes.

Historical background:
As in 2020, in 2021 and 2022, sensitivity monitoring was carried out in Belgium, Croatia, Finland, France, Germany, Italy, Poland, Slovenia, and Spain, from commercial locations and trial sites.
Data show that the frequency of resistant isolates is moderate, fluctuating from field to field, and still ranging from zero to high. Compared to data obtained a decade ago, the frequency of resistant isolates in the monitored populations remained stable.

Monitoring studies in 2017 and 2018 with samples originating from 8 Chinese provinces show mostly full sensitive isolates and only single resistant strains.

Products, applied according to the FRAC-AP guidelines in strawberry spray programs, provided good control in commercial situations.

Vegetables
(Syngenta, BASF)

2023: limited monitoring in bean samples originating from 4 locations from France showed full sensitivity with the exception of 1 isolate.

Historical background:
In 2022, limited sensitivity data for tomato samples collected in three locations in Greece, Italy, and the Netherlands show heterogeneous populations with varying frequencies of resistant isolates.

As in the last years, in 2020 and 2021, limited sensitivity data for tomato, lettuce, and cucumber showed a variable situation with sensitive and resistant isolates in samples originating from France and Spain.

In 2019, limited sensitivity data for tomato samples collected in a single location in Southern Italy indicated presence of resistant isolates.

In 2017 and 2018, limited sensitivity data for tomato samples collected in Belgium and the Netherlands showed no to moderate frequency of resistant isolates. Limited monitoring was also carried out in beans: one Spanish sample from 2018 showed resistance, while all samples from France were sensitive.
In 2016, European sensitivity monitoring in tomato, peas, and beans was carried out in the Netherlands, Belgium, Czech Republic, Italy, Serbia, France, and Poland with a limited number of samples obtained from commercial locations and trial sites.
Overall, the data show a low frequency of resistant isolates in tomato and beans.

Monitoring outside of Europe:
In 2018, samples originating from up to 6 Chinese provinces didn´t show occurrence of resistant isolates in tomato and cucumber.

In 2017, first monitoring studies with limited number of tomato and cucumber samples from China indicated, similar to the situation in strawberries, besides sensitive isolates also presence of resistant ones.

Evidence from field and laboratory trials has shown that there is a medium resistance risk of *Botrytis* to APs. Good agronomic practices and strict adherence to the FRAC AP use guidelines are crucial to ensure that APs remain effective due to the risk of increasing occurrence of multiple resistant strains and isolates with unspecific, increased efflux activity (often called `multidrug resistant´, MDR), particularly in soft fruits.

For more information on the different AP resistance types, refer to publications on AP related resistance research (e.g., Mosbach *et al*., 2017).

1.2. *Venturia* results
(BASF, Syngenta)

2022 monitoring data were presented, whereas monitoring programs of 2023 are still in progress.

Samples originating from France, Belgium, Bulgaria, Croatia, Germany, Romania, Italy, Netherlands, Portugal, Türkiye, Latvia, Lithuania, Austria, Hungary, Greece, Slovenia, and Spain were analysed.
As in the past years, the vast majority of all studied samples was sensitive.
These findings emphasize once more, that current resistance management strategies are effective.

Historical background:
In 2019, 2020 and 2021, a multitude of European samples were analysed. Based on dose-response to APs using *in vivo* biotests, populations are classified as either sensitive, moderately adapted, or resistant.
During all these years, most of all studied samples was sensitive, indicating that current resistance management strategies are efficient.

In 2016 and 2017, the trend for lower resistance frequencies at commercial and trial site locations, as already observed in 2015, was confirmed. This was linked to the detection of more sensitive and less moderately adapted populations in all apple growing areas monitored.

1.3. *Stemphylium vesicarium*
(Syngenta)

No monitoring carried out in 2022 and 2023.

Monitoring data has been presented for isolates originating from Portugal, UK, Croatia, Belgium, Germany, Spain, Greece, Italy, Netherlands, and Poland during 2015-2021, sampled in asparagus and pears.

In summary, the majority of all studied isolates were fully sensitive. However, single resistant isolates were detected in both crops.

1.4. *Alternaria solani* (potatoes)
(Bayer)

2022 monitoring data were presented, whereas monitoring programs of 2023 are still in progress.
Samples from Norway, Denmark, and Austria again showed full sensitivity.

Historical background:
2021 samples originating from the Netherlands, Austria, Germany, Denmark, and Sweden still showed high sensitivity.

In 2020, samples from the Netherlands, Austria, Germany, Norway, Denmark, Sweden, and Belgium were analysed. High sensitivity was reported.

First monitoring data has been generated in 2019 for European isolates originating from Belgium, Germany, Netherlands, Denmark, and Sweden.
All isolates showed high sensitivity in a narrow range.

1.5. *Monilinia spp.* (stone- and pome fruit)
(BASF, Syngenta)

In 2023, samples studied were originating from Hungary, France, Greece, Belgium, Bulgaria, Germany, Spain, Croatia, and Italy. As in the previous years, most of the isolates were fully sensitive, while again a small minority of strains showed lower sensitivity.

Historical background:
In 2021 and 2022, samples from Switzerland, Czech Republic, Germany, Spain, France, Croatia, Greece, Hungary, Italy, Poland, Portugal, and Romania were analysed. AP sensitivity was, overall, high with some variations in the baseline, dependent on the species (*M. laxa, M. fructicola, M. fructigena*), and especially with partly higher EC_{50} values for *M. fructigena*.

First and preliminary monitoring data have been generated in 2020 for European isolates originating from Portugal and Greece.
All isolates were sensitive and EC_{50} values showed a normal frequency distribution.

1.6. *Neofabraea spp.* (pome fruit)
(BASF)

2022 samples studied were originating from Belgium, Italy, Germany, France, and Poland. Most of the isolates were fully sensitive, however, some strains from Belgium showed lower sensitivity.

2. AP - Use Recommendations

The purpose of the use guidelines for AP containing products is to maintain the sensitivity in the target pathogens and to prevent crop losses due to resistant pathogen populations.

2.1 AP - Guidelines

For grey mold and apple scab control, specific guidelines have been developed. In general, where different AP-containing products are used in one season, the cumulative number of applications with cyprodinil-, pyrimethanil- or mepanipyrim-containing products must not exceed the maxima as mentioned below.
For sound resistance management, good agricultural practices, including phytosanitary measures and crop protection, should be followed not only in commercial practice, but also in nurseries.

The use recommendations were reviewed during the meeting on January 15th, 2024. The *Botrytis* and *Venturia* guidelines have not been changed.
For all other pathogens and crops, specific guidelines are not yet regarded to be needed. However, the maximum number of applications should be limited and should not exceed more than 50% of all treatments.

2.1.1 AP - *Botrytis* Guidelines

- Where up to three treatments are made per season, the number of applications of AP-containing products is limited to one.
- In situations where four to six Botrytis treatments are made per crop and season, a maximum of two applications with AP-containing products are recommended.
- In specific situations where seven or more Botrytis treatments are required per crop and season, a maximum of three applications with AP-containing products is recommended and not more than two consecutive applications.
- For specific crops and products, follow use recommendations of individual companies.

2.1.2 AP - *Venturia* Guidelines

- Apply a maximum of four AP-containing products per season.
- In locations where moderately adapted or resistant populations have been reported, use APs only in mixture with an effective non-cross-resistant scab fungicide.
- Individual products should always be used at recommended dose rates and during the period when they are most effective.
- Curative use only in conjunction with reliable scab warning systems.

The next AP FRAC Working Group meeting is scheduled for March 2025.

Literature

Mosbach *et al*., 2017: Anilinopyrimidine Resistance in *Botrytis cinerea* is linked to Mitochondrial Function, Front. Microbiol., https://doi.org/10.3389/fmicb.2017.02361