



## Membership

The Working Group is comprised of the following members:

Michael Merk (chairman)	BASF, Cesano Maderno, Italy
Randall Gold	BASF, Limburgerhof, Germany
Gerd Stammler	BASF, Limburgerhof, Germany
Dominique Steiger	Bayer CropScience, Monheim, Germany
Marie-Pascale Latorse	Bayer CropScience, Lyon, France
Luigi Burri	Isagro Ricerca S.r.l., Novara, Italy
Alessandro Bermano	Isagro SpA, Milano, Italy
Masaru Shibata	KI-Chemical, Brussels, Belgium
Satoshi Usami	KI-Chemical, Brussels, Belgium
Makiichi Takagaki	Kumiai Chemical Industry CO., LTD
Helge Sierotzki	Syngenta, Basel, Switzerland
Duncan McKenzie	Syngenta, Basel, Switzerland

### 1. Introduction

The FRAC CAA Working Group was set up in 2005 to generate common resistance management recommendations for the Oomycete fungicides dimethomorph, flumorph, iprovalicarb, bentiavalicarb, mandipropamid and valifenalate.

All of the above-mentioned fungicides exhibit cross resistance and are grouped under the FRAC Code No. 40 in the FRAC Code List.

CODE	TARGET SITE OF ACTION	GROUP NAME	CHEMICAL GROUP	COMMON NAME	COMMENTS
40	phospholipid biosynthesis and cell wall deposition (proposed)	CAA-fungicides (Carboxylic acid amides)	cinnamic acid amides	dimethomorph flumorph	Low to medium risk. Resistance management required.
			valinamide carbamates	benthiavdicarb iprovalicarb valifenalate	
			mandelic acid amides	mandipropamid	

As shown in the table, the group name **Carboxylic Acid Amides (CAA)** has been chosen. This name best represents compounds from three different chemical groups.

The mode of action of CAA compounds has not yet been fully elucidated. There are proposals for inhibition of phospholipid biosynthesis and for interference with cell wall deposition.

Sensitivity monitoring studies over several years revealed that in populations of the late blight pathogen, *Phytophthora infestans*, all isolates were fully sensitive to CAA fungicides. However, in populations of the grape downy mildew pathogen, *Plasmopara viticola*, isolates can be found in certain regions, which are resistant to all CAA fungicides.

Inheritance studies (Gisi et al., Plant Pathology, 2007, 56, 199-208) showed that sexual crosses between sensitive and CAA resistant isolates of *Plasmopara viticola* lead to a co-segregation of resistance to dimethomorph, iprovalicarb, benthiavdicarb and mandipropamid, but not to the phenylamide, mefenoxam, which was tested in parallel as an independent marker.

Further, the inheritance studies showed that the gene(s) for resistance to CAA fungicides are inherited in a recessive manner. Therefore, the entire F1 generation of crosses between sensitive and CAA resistant isolates was sensitive, and only in the F2 progeny did CAA resistance reappear in some isolates. These results suggest that the resistance risk can be classified as moderate (as compared to high for phenylamide and QoI fungicides) and that it can be managed by appropriate product use strategies (see below).

## 2. Resistance Monitoring 2009

### 2.1. *Plasmopara viticola* – Grape downy mildew

#### Disease incidence

In 2009, disease pressure was moderate to high in the main grape growing areas of Europe. Disease management was challenging in some locations due to high disease pressure.

#### Field performance

Field performance of registered products was good in 2009. No resistance-related complaints have been received.

#### Monitoring results

(Results generated by BASF, Bayer, KI-Chemical, Syngenta)

## **France**

As in the years before, CAA resistant isolates have been detected consistently in all areas. High frequency of resistance was detected in Cognac and Midi Pyrénées (Armagnac, Gascogne). In other areas there was a tendency for increased frequency of resistance compared to 2008, with large differences between vineyards due to disease and selection pressure.

## **Germany**

Resistant isolates have been detected in all major vine-growing regions. The highest level was observed in Mosel area and moderate frequencies were observed in Rheinhessen, Pfalz, Franken, Württemberg and Baden, similar to 2008

## **Italy**

High resistance levels were observed in Alto Adige, Trentino and Piedmont. Resistance was confirmed in Toscana at a low level and no resistance was found in other areas.

## **Spain, Portugal**

No resistance was detected in Galicia, Basque, Catalonia. Very low frequency of resistance at one location was observed in Rioja and Minho-Lima, respectively.

## **Switzerland**

As the years before the frequency of resistance was very low.

## **Austria**

Low frequency of resistance was observed.

## **2.2. *Phytophthora infestans* – Late blight of potatoes and tomatoes**

### **Field performance**

Field performance of CAA fungicides against late blight was very good.

### **Monitoring results**

(Results generated by BASF, KI Chemical and Syngenta)

Sensitivity monitoring programs in 2009 did not detect less sensitive strains of *Phytophthora infestans* in Europe. These studies document that populations of *Phytophthora infestans* are fully sensitive to CAA fungicides and confirm the observations of previous years.

## **2.3. Other Oomycete pathogens**

No sensitivity monitoring studies were conducted in 2009

## **3. Use Recommendations**

### **3.1. *Plasmopara viticola* – Grape downy mildew**

*Plasmopara viticola* is classified by FRAC as a high risk pathogen. Long-term experience with CAA fungicides demonstrates that the resistance risk of *Plasmopara viticola* to this fungicide group is moderate and can be managed through appropriate use strategies.

### **Use Recommendations:**

- Apply a maximum of 4 CAA fungicide sprays during one crop cycle
- Always apply CAA fungicides in mixture with effective partners such as multi-site or other non cross resistant fungicides
- An effective partner for a CAA fungicide is one that provides satisfactory disease control when used alone at the mixture rate
- Alternation with fungicides having other modes of action is recommended in spray programs

For more detailed product recommendations refer to the use guidelines published by the respective CAA manufacturers

### **3.2. *Phytophthora infestans* – Late blight of potato and tomato**

No resistant isolates from field populations have been found since the introduction of CAA fungicides over 15 years ago.

*Phytophthora infestans* is classified by FRAC as a medium risk pathogen. Long-term experience with CAA fungicides demonstrates that the resistance risk of *Phytophthora infestans* to this fungicide group is low to moderate. For effective resistance management a precautionary strategy has to be implemented.

### **Use Recommendations:**

- Maximum 50 % of the total number of intended applications for late blight control
- Alternation with fungicides having other modes of action is recommended in spray programs

For more detailed product recommendations refer to the use guidelines published by the respective CAA manufacturers.

### **3.3. *Pseudoperonospora cubensis* – Downy mildew of cucurbits**

*Pseudoperonospora cubensis* is classified by FRAC as a high risk pathogen.

### **Use Recommendations:**

- Maximum 50 % of the total number of intended applications for disease control
- Alternation with fungicides having other modes of action is recommended in spray programs; do not use more than 3 consecutive applications of CAA fungicides
- In areas where resistant strains have been detected in commercial fields, apply CAA fungicides only in mixture with effective partners such as multi-site or other non cross resistant fungicides

- An effective partner for a CAA fungicide is one that provides satisfactory disease control when used alone at the mixture rate

For product recommendations refer to the use guidelines published by the respective CAA manufacturers.

### **3.4. Other Oomycete pathogens**

Some of the downy mildew pathogens are classified by FRAC as moderate risk pathogens (e.g. *Bremia lactucae*). In spite of the use of CAA fungicides for more than 15 years against a range of such Oomycete pathogens, no reports on the occurrence of less sensitive field populations are available.

For effective resistance management a precautionary strategy has to be implemented.

#### **Use Recommendations:**

- Maximum 50 % of the total number of intended applications for disease control
- Alternation with fungicides having other modes of action is recommended in spray programs

For more detailed product recommendations refer to the use guidelines published by the respective CAA manufacturers.