



Membership

The Working Group is comprised of the following members:

Michael Merk (chairman)	BASF, Cesano Maderno, Italy
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Albert Schirring	Bayer CropScience, Monheim, Germany
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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.

Concurrently the above-mentioned fungicides have been re-grouped under the new FRAC Code No. 40 in the revised 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 iprovaldicarb 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 phospholipids 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. Therefore, in the case of *Plasmopara viticola*, a positive cross resistance among all CAA fungicides is obvious for the vast majority of isolates. The degree of sensitivity covers a wide range of EC50 values with isolates being sensitive, moderately resistant and fully resistant.

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, iprovaldicarb, 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).

Overall, these results explain some characteristics of CAA resistance, especially the limited spread and propagation of resistant isolates in field populations.

2. Resistance Monitoring 2008

2.1. *Plasmopara viticola* – Grape downy mildew

Disease incidence

In 2008, disease pressure was moderate to high (even severe) in the main grape growing areas of Europe. Disease management was challenging in many situations due to high disease pressure.

Field performance

Field performance of registered products was good in 2008. No resistance-related complaints have been received.

Monitoring results

(results generated by BASF, Bayer, Isagro SpA, KI-Chemical, Syngenta)

France

As in the years before, CAA resistant isolates have been detected consistently in all areas. High frequency of resistance was confirmed in South East and Midi Pyrenees (Armagnac, Gascogne). Minor variations at low to moderate frequencies were observed in the other regions compared to 2007.

Germany

Resistant isolates have been detected in all major vine-growing regions, similar to 2007. The highest level was observed in Mosel area and moderate frequencies were observed in Rheinhessen, Pfalz, Franken, Württemberg and Baden.

Italy

Resistance levels increased in Alto Adige and Trentino. First resistant isolates were detected in Piedmont, Veneto (Venezia) and Tuscany (Chianti). No resistance was found in other areas.

Spain

No resistance was detected in areas monitored, except in the Basque area where the frequency of resistance was moderate. In comparison to 2007, no resistant isolates were found in Galicia.

Portugal, Switzerland

As in 2007 the frequency of resistance was very low.

Greece, Austria, Hungary

No resistant isolates were detected.

China

No resistant isolates were detected in 2007.

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

Field performance

Field performance of CAA fungicides against late blight was good and fulfilled grower expectations. No resistance-related complaints have been received for the registered compounds.

Monitoring results

(results generated by BASF, Isagro SpA and Syngenta)

Sensitivity monitoring programs in 2008 did not detect less sensitive strains of *Phytophthora infestans* in Europe and South Africa. These studies document that populations of *Phytophthora infestans* are fully sensitive to CAA fungicides and confirm the observations of previous years.

2.3. *Pseudoperonospora cubensis* – Downy mildew of cucurbits

There were no complaints on the performance of CAA products from commercial fields.

In China, a sensitivity monitoring program did not detect any resistance.

In a few trial sites in the USA it was possible to detect resistant isolates of *Pseudoperonospora cubensis* following intensive use of CAA fungicides (used solo without mixing partner).

2.4. Other Oomycete pathogens

Sensitivity monitoring programs on *Phytophthora capsici* (USA and China) and *Peronophythora litchi* (China) did not detect any resistance.

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. This experience has been confirmed in the 2008 season and is supported by the fact that:

- resistance related complaints have not been reported with CAA fungicides as long as mixtures with multi-site fungicides have been used
- the resistance frequency in the affected regions generally fluctuates over years and regions
- resistance genes are inherited in a recessive manner

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

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 10 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

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; 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 10 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

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