



Membership

The Working Group is comprised of the following members:

Karl-Heinz Kuck (leaving chairman)	Bayer CropScience, Monheim, Germany
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1. Introduction

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

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	bentiavalicarb iprovalicarb	
			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 the populations of the late blight pathogen, *Phytophthora infestans*, all isolates were fully sensitive to CAA fungicides. However, in the populations of the grape downy mildew pathogen, *Plasmopara viticola*, isolates can be found in certain regions, which are simultaneously 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, in press) showed that sexual crosses between sensitive and CAA resistant isolates of *Plasmopara viticola* lead to a co-segregation of resistance to dimethomorph, iprovalicarb, bentiavalicarb 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 a few 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

2.1. *Plasmopara viticola* – Grape downy mildew

2.1.1. Sensitivity Situation before 2005

Shortly after the introduction of dimethomorph, Albert et al. (1994) published that less sensitive populations towards dimethomorph had been detected in France. In 1998, iprovalicarb was introduced to the market. Long-term monitoring experience is therefore available for *Plasmopara viticola* and these two fungicides.

Monitoring studies for two developmental compounds, bentiavalicarb and mandipropamid, have been initiated during the last years and generated further information.

France

Less sensitive populations could be detected consistently in the department Gers in South-Western France (known as part of the Armagnac region) and in the South-East (lower Rhone valley). In all other French wine-growing areas, such as Bordeaux, Loire, Champagne and in the upper Rhone valley, less sensitive populations have also been detected, but less frequently and less regularly. In addition, in these regions the percentage of resistant strains fluctuated largely from year to year. Analyzing the resistance frequency over the years, a consistent trend for either an increase or a decrease of resistant *Plasmopara* populations could not be detected.

Germany

Less sensitive populations have been detected in some wine-growing regions of Germany, including Rheinhessen, Palatinate, Mosel and Franconia. As in most parts of France, a consistent trend for increase or decrease of resistance has not been detected over the years.

Other countries

Systematic monitoring has also been performed in the past in Italy, Spain and Portugal. Since 2000, only fully sensitive populations have been detected. In Switzerland, apart from isolates coming from trial sites, all isolates were fully sensitive.

2.1.2 Monitoring 2006

Disease incidence

In major vine growing areas of Europe disease onset was late and disease pressure remained low in the Mediterranean regions, Portugal and North-West Spain. In France a heterogeneous situation could be found, whereas in Germany a very high infection pressure could be found in the second half of the season.

Field performance

Field performance of registered products was good in 2006. No resistance-related complaints have been received.

Monitoring results

France

As in the years before, CAA resistant isolates have been detected consistently in the department Gers and the lower Rhone valley. In other regions generally a stable situation was observed compared to 2005.

Germany

Resistant isolates have been detected in all major vine-growing regions except in Baden. An increase compared to 2005 was observed.

Italy, Spain

Only fully sensitive strains were detected.

Portugal, Switzerland

Resistant isolates were detected at a very low level.

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

2.2.1 Monitoring 2006

Disease Incidence

Disease onset was rather late all over Europe. High disease pressure was observed in Northern Europe in the second part of the season.

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

Sensitivity monitoring run by all member companies of the CAA Working Group has never detected less sensitive strains of *Phytophthora infestans*. These studies, covering many years and all major potato and tomato growing areas, document that populations of *Phytophthora infestans* are fully sensitive to CAA fungicides. This general statement was confirmed again in the 2006 season with a large number of isolates collected across Europe.

3. Use Recommendations

3.1. *Plasmopara viticola* – Grape downy mildew

Plasmopara viticola is regarded as a high risk pathogen as classified by FRAC. 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 again in 2006 season and is supported by the fact

- that resistance related complaints never became known with CAA fungicides as long as mixtures with multi-site fungicides have been used
- that the resistance frequency in the affected regions is mostly fluctuating with no clear progression over years and regions
- that resistance genes are inherited in a recessive manner

Use Recommendations:

- Apply a maximum of 4 CAA sprays during one crop cycle
- Apply CAA fungicides always in mixture with effective partners such as multi-sites 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

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

No less sensitive isolates from field populations have been found since the introduction of CAA fungicides.

Phytophthora infestans is regarded as a medium risk pathogen as classified by FRAC. 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 precaution strategy has to be implemented:

- Maximum 50 % out of all applications for *Phytophthora*-control with CAA fungicides
- Alternation with other modes of action should be considered

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

3.3. Other Oomycete (Peronosporomycete) Pathogens

In single trial sites it was possible to detect resistant isolates of *Pseudoperonospora cubensis*. There are no complaints on the performance of CAA products from commercial fields.

Some of the downy mildew pathogens are regarded as high risk pathogens as classified by FRAC. In spite of the intensive use of some 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 precaution strategy has to be implemented:

- Maximum 50 % out of all applications for disease control with CAA fungicides
- Alternation with other modes of action should be considered

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

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