



Carboxylic Acid Amides (CAA) Working Group

Annual Meeting 2015 on December 01st

Protocol of the discussions and recommendations of the CAA Working Group of the Fungicide Resistance Action Committee (FRAC)

Participants

Gerd Stammler (Chairman)	BASF SE, Limburgerhof, Germany
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Venue:

Lindner Congress Hotel, Frankfurt am Main, Germany

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, benthiavalicarb, mandipropamid, valifenalate and pyrimorph.

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	Cellulose synthesis	CAA-fungicides (Carboxylic acid amides)	cinnamic acid amides	dimethomorph flumorph pyrimorph	Low to medium risk. Resistance management required.
			valinamide carbamates	benthiavalicarb 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 is directly linked to the inhibition of cellulose synthesis in the Oomycete plant pathogen (Blum *et al.* 2010, Molecular Plant Pathology 11, 227-243). Uptake studies with ¹⁴C labeled mandipropamid (MPD) showed that this Oomycete control agent acts on the cell wall and does not enter the cell. Furthermore, ¹⁴C glucose incorporation into cellulose was perturbed in the presence of MPD. Gene sequence analysis of cellulose synthase genes in laboratory mutants, insensitive to MPD, revealed two point mutations in the *PiCesA3* gene, known to be involved in cellulose synthesis. Both mutations in the *PiCesA3* gene result in a change to the same amino acid (Glycine-1105) in the protein.

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.* 2007, Plant Pathology 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, benthiavalicarb 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 2015

2.1. *Plasmopara viticola* – Grape downy mildew

Disease incidence

In 2015, disease pressure was low to moderate in the main grape growing areas of Europe.

Monitoring results

(Results generated by ADAMA, BASF, Bayer, Belchim, Syngenta)

France

As in the years before, CAA resistant isolates have been detected consistently in most areas. High frequencies of resistance were detected in Cognac, moderate to high frequencies in Armagnac, Bordeaux, Val de Loire, Val de Rhone, Sud Ouest and Provence. Moderate frequencies were detected in Champagne, low to moderate frequencies in Bourgogne, Beaujolais and Languedoc, low values in Alsace, Lorraine and Savoie and no resistance was detected in Centre.

Germany

High frequencies of resistance were found in Mosel and Württemberg, moderate to high frequencies were observed in Baden and Pfalz, moderate values in Main-Franken and low to moderate values in Rheinhessen.

Switzerland

Moderate to high values were detected in Geneva, Zürich, and Graubünden, moderate values in Ticino and Neuchatel. Low resistance values were detected in Wallis.

Austria

No resistance was detected in Weinviertel, low frequencies of resistance were observed in Burgenland, moderate values in Wachau and high values in Steiermark.

Italy

High frequencies of resistance were observed in Alto Adige, Trentino, Toscana and Piemonte, moderate to high values in Friuli, Veneto and Emilia Romagna, moderate values in Marche and Campania, low to moderate values in Lombardia and no resistance was found in Abruzzi.

Spain:

High frequencies of resistance were found in Basque and no resistance was detected in Galicia.

Slovenia

Moderate to high frequencies of resistance were found in samples from Slovenia.

Portugal, Greece, Czech Republic

Sensitivity monitoring showed no CAA resistance in any sample from the above mentioned countries.

Field performance

Field performance of registered products was good in 2015.

2.2. *Phytophthora infestans* – Late blight of potatoes

Disease incidence

In 2015, disease pressure was low to moderate in the main potato growing areas of Europe.

Monitoring results

(Results generated by ADAMA, BASF, Belchim, KI Chemicals and Syngenta)

Sensitivity monitoring programs in 2015 did not detect less sensitive strains of *Phytophthora infestans* in potato in Europe (Belgium, Denmark, Estonia, France, Germany, Greece, Latvia, Netherlands, Spain, Sweden, Switzerland, UK). These studies document that populations of *Phytophthora infestans* are fully sensitive to CAA fungicides and confirm the observations of previous years.

Field performance

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

2.3. *Pseudoperonospora cubensis* - Downy mildew of cucurbits

(Results generated by BASF)

Sensitivity monitoring programs in 2015 were carried out in Europe. No resistance has been detected in France, Italy and Poland. A case of CAA resistance was observed in Spain.

2.4 *Bremia lactucae* – Downy mildew of lettuce

(Results generated by Syngenta)

First sensitivity studies were done with samples from 2013-2015 from France, Italy, Germany and Spain. All samples tested were sensitive.

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 CAA fungicides preferably in a preventive manner
- Apply a maximum of 50% of the total number of intended applications for disease control not exceeding a total of 4 CAA fungicide sprays during one crop cycle. In areas of high resistance the total number should not exceed a maximum of 3 applications 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 in 1993.

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:

- Apply CAA fungicides preferably in a preventive manner
- Apply a maximum of 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:

- Apply CAA fungicides preferably in a preventive manner
- Apply a maximum of 50 % of the total number of intended applications for disease control not exceeding a total of 4 CAA fungicide sprays during one crop cycle. In areas of high resistance the total number should not exceed a maximum of 3 applications 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 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:

- Apply CAA fungicides preferably in a preventive manner
- Apply a maximum of 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.

4. Next Meeting

Next annual meeting is planned for December 13th, 2016.

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