FUNGICIDE RESISTANCE ACTION COMMITTEE (FRAC)

P E Russell, Secretary of FRAC tells of the work undertaken by the International Steering Committee, the way forward and the success that has been achieved

This article was published in April (pages 90-2), but contained errors. It is republished here with those errors corrected. Apologies for any inconvenience that this might have caused.

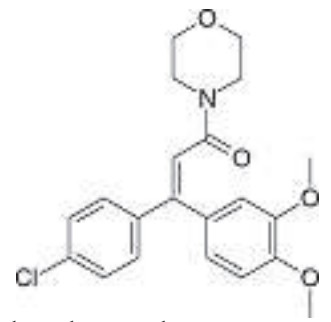
It was not so many years ago that people were saying to me that as far as they were concerned the need for more advice and information on how to manage fungicide resistance was not needed. The basic principles of restricting solo product use and using tank mixtures and coformulated mixtures had been laid down by experiences with the then dominant chemical groups (benzimidazoles, dicarboximides, phenylamides, SBIs) and all that had to be done was to adapt these principles to the disease control programme as appropriate. This was also at a time when there was some despondency, mostly from outside the industry I might add, on whether or not the industry could keep on generating new fungicide molecules with differing modes of action.

If we look at recent history we can see that this despondency was not warranted. The industry has been very successful in discovering new molecules with new modes of action... QoI fungicides (previously known as strobilurins), anilinopyrimidines, quinoxyfen, dimethomorph, fenhexamid (incidentally a new class of SBI fungicide), zoxamide, iprovalicarb and silthiofam to name a few. Discovery and marketing of these new molecules has generated an ongoing need for more information on resistance management and, very importantly, a need for consistent advice on how best to use the new molecules in order to prolong their active lives. Alongside this requirement has been the influence of the European registration directives which require resistance management information to be provided as part of the registration procedure of new molecules. Taken together the current position is that the need for FRAC, rather than remaining static, has increased tremendously.

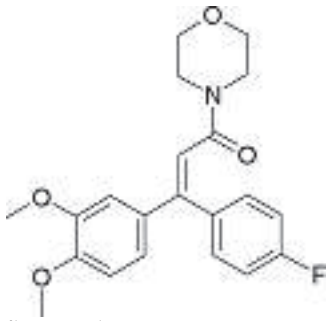
One of the key functions of FRAC is to gather and disseminate information on the current resistance situation for key molecules and offer advice on their use. Such information and advice is the responsibility of specific chemical Working Groups and they publish their findings on the FRAC webpage (www.frac.info). Current established Working Groups are those devoted to the SBIs, anilinopyrimidines, the QoI fungicides and a new group, the carboxylic acid amides (see later). A further crop specific group exists for bananas. Working Groups for the benzimidazoles, dicarboximides and phenylamides have been replaced by 'Expert Fora' as the resistance management guidelines for such chemistry are now well established and there is little, if any, industrial resistance monitoring carried out. The Expert Fora are thus provided by FRAC as a contact point for advice and information concerning any matters pertaining to resistance occurrence and management for these chemical groups. We are pleased to report that much use is being made of these fora, indicating that there is still much interest in the use of this older chemistry.

A New Working Group: CAA; Carboxylic Acid Amides

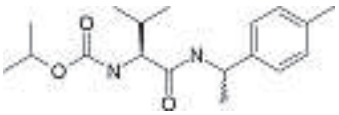
The generation of a new Working Group is triggered by the need for co-ordinated co-operation between two or more companies marketing molecules with common modes of action and/or cross resistance patterns into the same market segment. The reason for this is clear: in order to safeguard the life of molecules that could be affected by cross resistance to another molecule it is essential to co-ordinate resistance management strategies for all molecules affected so that the use pattern of one molecule does not adversely affect resistance risk for the group as a whole. The newest Working Group to be generated by FRAC is the CAA Group (carboxylic acid amides, Dr Karl-Heinz Kuck, Bayer CropScience, as Chairman) which includes dimethomorph (BASF) and flumorph (Shenyang) (cinnamic acid amides), iprovalicarb (Bayer CropScience) and benthiavalicarb-isopropyl (Ihara/Kumiai) (valinamides; the latter still in development) and mandipropamid (Syngenta), a mandelic acid derivative still in development.



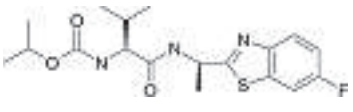
dimethomorph



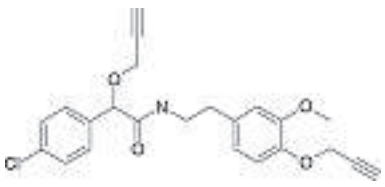
flumorph



iprovalicarb



benthiavalicarb



mandipropamid

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Extensive research conducted by the parent companies has demonstrated that cross resistance is present between these chemicals. The resistance is inherited as a recessive trait such that only homozygous recessive progeny show resistance. F1 progeny are all sensitive with resistance only segregating at the F2 generation. The key pathogen of interest is *Plasmopara viticola*, the cause of downy mildew of grapevine. Dimethomorph and iprovalicarb have been on the market for several years and are still effective. Recent monitoring data indicate that resistance in *P. viticola* can be consistently found in the Gers department (Armagnac region of France) and in the lower Rhone valley, but is much less common with levels fluctuating widely from year to year in other regions of France such as Bordeaux, Loire, Champagne and Rhone valley. Similar fluctuations are found in Germany. Monitoring continues for Italy, Spain, Portugal and Switzerland where no resistant populations were detected during the last five years in commercial fields.

No field resistance has been detected in *Phytophthora infestans* since 1994, and no cases of field resistance in other Oomycetes have been validated.

For resistance management, mixtures with non cross resistant fungicides are being recommended with a maximum of 4 applications in any one crop cycle for vines. The mixture partner must be used at a rate capable of giving good control if used alone at that rate. Specific recommendations for other crops are being finalised.

Vine downy mildew on a vine leaf *(Plasmopara viticola)*
Courtesy of BASF

Potato blight (*Phytophthora infestans*) Courtesy of BASF

Current Areas of Key Interest.

The past few years have seen much research being devoted to the QoI fungicides. This group, formerly referred to as strobilurins, promised to provide an extremely valuable, highly active group of fungicides with a very broad spectrum of activity covering all fungal classes. Risks of resistance development were largely estimated from experiences with the individual pathogen history of development to other fungicide classes. Pathogens such as *Erysiphe graminis (Blumeria graminis*, wheat powdery mildew*)* and *P. viticola* were accepted as being particularly at risk and, despite management recommendations being made, resistance was not long in developing. In the case of wheat powdery mildew the speed that resistance developed and spread from Northern Europe southwards was a very serious matter and has led to a situation that QoI fungicides cannot be recommended as powdery mildew fungicides any more in the badly affected regions. For *P. viticola* the situation was not so serious. Resistance was widespread, but as the use of comprehensive resistance management strategies was common, the QoI fungicides retained a role in disease control. That position remains today with indications that resistance has stabilised and is, possibly, decreasing, although this latter point needs more data to confirm.

What was not predicted was the appearance and rapid rise in occurrence of resistance in *Septoria tritici* to QoI fungicides. Septoria had always been regarded as a low – moderate risk pathogen based on its previous history, but that view had to be changed as resistance developed throughout Europe. Why it happened is not known for certain, although various theories have been put forward, mostly based on a consideration of applied dose rates and the epidemiology of the pathogen, particularly the role of the sexual phase. Whatever the reason, the rise in resistance was real and did lead to speculation that QoI fungicides would no longer have a role to play in cereal disease control. Happily, this latter worry has not been demonstrated. Latest information does indicate that resistance is widespread; but it is variable in extent and effect. Where QoI mixture based products are used as recommended field performance is very good.

During the past decade, major advances have been made in the detection of resistant strains by the use of molecular techniques. For the QoI fungicides the major breakthrough was the widespread development and adoption of techniques based on detection of the G143A mutation that leads to resistance in the pathogen. Virtually all QoI monitoring of known resistance cases is now carried out using this method, but questions remain as to how to use the results of such techniques in predicting the effects of the resistance on field control accurately. The G143A mutation is also clearly not the only one responsible for resistance. The F129L mutation, initially found to be responsible for low level resistance in *Alternaria solani* on potatoes is now known to operate in *P viticola, Helminthosporium tritici-repentis* (spot blotch, tan spot) on wheat and in barley net blotch *Pyrenophora teres*. For *H. tritici-repentis*, reduced sensitivity has been found associated with F129L in Sweden while G143A is prevalent and can be found alongside F129L in Germany and Denmark.

Excellent news is that *P. infestans* remains fully sensitive to QoI fungicides.

Tan spot on wheat *(Helminthosporium (Pyrenophora) tritici-repentis)* Courtesy of BASF

Local FRAC and FRAG Groups

Effective dissemination of information and implementation of resistance management strategies is made much easier by the presence of local organisations. FRAC local groups, consisting of expert industry representatives, are already very active in North America, Japan, Brazil and Spain. Complementary FRAG organisations e.g. FRAG-UK consist of experts from academia, research institutes, government agencies and industry. Such groups are very active in the UK, Netherlands and Australia (as Avcare). Information is exchanged freely between all organisations in order to ensure consistency of approach to management strategies.

FRAC as an Educational Resource

Anyone with an interest in fungicide resistance management is encouraged to visit the FRAC webpage (www.frac.info). The page is regularly updated with current monitoring data and recommendations for use information (see the Working Group pages) and contains pdf files for the three FRAC monographs on fungicide resistance. Also present are the FRAC code lists and Mode of Action information for the vast majority of fungicides currently used. The FRAC code list is a particularly valuable document as these codes are being increasingly adopted as the international standard for identifying chemical groups and modes of action. Full information on how to contact FRAC experts is included throughout the pages.

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