

## The Aims and Activities of Industry's Fungicide Resistance Action Committee

M. WADE, Shell Research Ltd., Sittingbourne Research Centre, Sittingbourne, Kent ME9 8AG, United Kingdom

The Fungicide Resistance Action Committee (FRAC) is a GIFAP (the international group of national associations of agrochemical manufacturers) intercompany committee dedicated to prolonging the effectiveness of fungicides liable to encounter resistance problems and to limiting crop damage during the emergence of resistance.

### How FRAC was formed

FRAC and the working groups it coordinates came from an impromptu meeting of industrial scientists held in August 1980 during the first of two excellent courses on fungicide resistance organized by J. Dekker and colleagues in Wageningen, Netherlands. This joint industry meeting proved to be a significant turning point in our approach to fungicide resistance. Hitherto, industry's response had been by individual companies isolated by traditional competitive patterns.

In the early 1970s, the intensive use of benomyl on many crops, of kasugamycin for the control of rice blast, and of the pyrimidine fungicides for the control of powdery mildews of cucurbits and cereals led to the first major field resistance problems with fungicides. Consequently, there was a need to change some usage recommendations. The response was an immediate allocation of research and development resources by individual companies marketing a particular product. The companies also sponsored and worked closely with government and academic investigations to determine the scope of the problem and the risks from various strategies. Subsequently, appropriate measures were formulated to minimize risks and retain maximum benefits where possible. This meant recommending less benomyl or kasugamycin, etc., and more complex treatment schedules. This, in turn, required education through advisory services to promote these strategies, which would reduce immediate sales but extend the life of the product.

Individual attempts by companies were only partially successful. It became clear at Wageningen that the problems associated with fungicide resistance were of such a nature that they could be effectively dealt with only through collaboration. Of particular concern were issues relating to cross-resistance. One company's efforts to safeguard the effectiveness of a product by promoting sensible usage could be nullified by the abuse of a related product through cross-resistance.

Other concerns included the lack of education or awareness of the causes and consequences of resistance on the part of users, distributors, marketing managers, and registration officials, even after a decade of resistance problems. This lack of awareness was a major stumbling block to the adoption of antiresistance strategies in practice. Some growers were unwilling to adopt more expensive and more complicated methods to restrict the use of a product at risk in order to prolong its effectiveness. Marketing managers were often reluctant to forego competitive marketing strategies. Registration officials, particularly those in the United States, were reluctant to consider the merits of mixtures or the retention of older products having different modes of action for use in resistance strategies. New products were considered for registration in some countries solely on efficacy without reference to their mode of action.

The handling of resistance reports in the press and in scientific journals was frequently fraught with emotion and

often confusing or inaccurate. Rumors spread rapidly, and speculation from laboratory studies sometimes sounded like widespread field resistance problems. There was a need to standardize definitions of resistance and monitoring methods so as to avoid confusion and unnecessary alarm and problems for growers, advisors, and manufacturers.

With these thoughts in mind, a steering committee (later to become FRAC) organized an industry seminar to define the problems and discuss possible action. The seminar was sponsored by GIFAP and held at their headquarters in Brussels, May 1981. At the meeting it was apparent that there was an urgent need for collaboration on these vital issues, and plans were formulated for cooperative industrial efforts to be coordinated by FRAC.

### Objectives and functions

FRAC was set up to:

1. Identify existing and potential resistance problems;
2. Establish a working group for each fungicide type considered to be at risk, including phenylamides, benzimidazoles, demethylation inhibitors (DMIs), and dicarboximides;
3. Collect existing information and generate new information; and
4. Communicate the results of the information to those involved in fungicide research, distribution, and use.

The principal functions of FRAC were defined as:

1. To initiate, stimulate, and monitor the working groups;
2. To provide guidelines and coordinate the efforts of the working groups;
3. To help the working groups communicate their conclusions;
4. To publicize guidelines on procedures/definitions of resistance research;
5. To provide technical counsel for resistance courses and research studies;
6. To liaise with universities, advisory services, farmers, distributors, and government; and
7. In general, to be alert to broad issues related to fungicide resistance and act as a focal point and clearinghouse for ideas, discussions, and actions.

FRAC established working groups for each of the major fungicide classes at risk and provided the following guidelines for their operation:

1. Each group should comprise technical representatives from two or more companies having "at risk" fungicides with similar modes of action and/or cross-resistance potential;
2. The contact person from each company should be a senior scientist with the technical expertise and authority to represent the company;
3. Members should establish mutual trust, pool all relevant information, define the problems, and assess the risks;
4. Members should agree on common monitoring methodology, establish baseline sensitivity data, and jointly interpret results;
5. Members should verify reports of resistance, statements, investigations, remedies, etc.;
6. Members should encourage resistance research and help guide its direction;
7. Members should encourage the dissemination of information on resistance; and most important
8. Members should recommend *technical* strategies aimed at

prolonging the useful life of the group of compounds at risk and encourage their implementation.

These are very ambitious objectives. It is not easy to establish trust among traditionally competitive companies or to select mutually acceptable monitoring or evaluation methods. The acceptance of sound technical strategies that inhibit or complicate marketing requires vision. Strategies might well not be beneficial to the short-term interests of marketing managers, distributors, and even growers. Nevertheless, as there is an increasing number of situations where the effectiveness of all related products will be lost if agreement and action are not possible, such objectives are worth striving for. If we do not, everyone will ultimately lose.

I am the current chairman of FRAC. P. Urech of Ciba-Geigy, Basel, Switzerland, is vice-chairman of FRAC and chairman of the phenylamide working group, and C. M. Smith of DuPont, Wilmington, Delaware, is secretary of FRAC and chairman of the benzimidazole working group. H. Scheinflug of Bayer, Monheim, West Germany, is chairman of the DMI working group, and F. Löcher of BASF, Limburgerhof, West Germany, is chairman of the dicarboximide working group. Other members of FRAC are T. Kato of Sumitomo, Hyogo, Japan; A. M. Skidmore of ICI, Jealott's Hill, United Kingdom; and H. Laufersweiler of Schering, West Berlin.

## The working groups

**Phenylamide (formerly acylalanine) working group.** This group consists of five companies (Ciba-Geigy, Chevron, Farmoplant, Schering, and Sandoz) that market or develop phenylamide fungicides. The group set about in a very determined way to come to grips with the problems. The members agreed that all chemicals in question (metalaxyl, ofurace, benalaxyl, cyprofuram, and oxadixyl), despite differing chemical structures, have similar modes of action and require the same attention and use pattern to avoid or delay the onset of resistance.

The group maintains, in association with advisory services and universities, a very extensive monitoring program that has proved invaluable in assessing the scope of the problem and in helping to define strategies. The main elements of a use strategy the group conceived and advocates are: 1) only prepackaged mixtures for foliar use, 2) no more than four sprays per season, 3) no curative use, and 4) no soil treatments for control of airborne pathogens. The prepackaged mixtures of phenylamides and residual fungicides gave encouraging results during 1983–1986. Monitoring studies continue, and the results will be assessed to see if recommendations need revising.

**Benzimidazole working group.** Although benzimidazole field resistance problems arose in the early 1970s on several crops as a result of intensive use of these fungicides, cooperation among companies marketing the products only began through FRAC. The group (currently DuPont, Nippon Soda, BASF, Hoechst, Pennwalt, and Kumiai) agreed to focus activities on studying the use of benzimidazoles for *Pseudocercospora herpotrichoides*, the cereal eyespot pathogen. Again, extensive field-monitoring programs in France, Germany, and the United Kingdom, conducted in conjunction with advisory officers and universities, led to agreement that cereal growers may gain cost-effective yield improvements from benzimidazole treatments for eyespot control even in fields with resistance or poor eyespot control. Benefits are particularly marked in fields where control has been satisfactory. In fields with a high risk from eyespot disease or where a benzimidazole has been used for several years, a mixture of a benzimidazole and a nonbenzimidazole fungicide is recommended. A benzimidazole should not be used where disease control failed as the result of resistant strains. The situation is reviewed regularly.

**DMI working group.** Because so many effective sterol-inhibiting fungicides used for the control of powdery mildews of cereals and cucurbits, etc., have resistance potential, there are grave implications for their abuse. It is possible that improper use of one will result in a resistance problem for several others.

This working group, therefore, has a tremendous responsibility to anticipate resistance problems, to avoid abuse, and to implement preventive strategies.

The group (currently Bayer, Ciba-Geigy, ICI, Celamerck, Eli Lilly, Schering, and DuPont) is organized into geographic subcommittees and has set up an extensive monitoring effort throughout Europe and the Middle East. The group has enjoyed the close cooperation of university and government scientists and has commissioned many special studies through them. As a result, the group recommends the use of mixtures of DMIs and fungicides with a different site of action. Efforts devoted to monitoring and special studies remain very high. The group keeps alert to changes in the sensitivity of pathogen populations in different areas.

**Dicarboximide working group.** After extensive monitoring studies in France, Germany, and Switzerland, again with outside help, this group (Agroplant, Ciba-Geigy, Dr. R. Maag AG, Rhone-Poulenc, Sandoz, Siegfried, BASF, Bayer, Hoechst, Spiess and Sohn, and Sumitomo) agreed on usage recommendations on vines. Dicarboximides should be limited to two applications (at bunch-closing and maturing of berries) and preferably be sprayed in combination with downy mildew fungicides having an additional *Botrytis* effect. Such measures have proved to be effective in controlling resistance onset. In areas where intensive and exclusive use of dicarboximides has led to severe problems, abstinence is allowing the proportion of resistant strains in the pathogen population to decrease.

## Other activities

FRAC meets regularly to review the activities of the working groups and to deal with the wider aspects of resistance. FRAC has been active in publishing definitions of resistance, guidelines on the handling and movement of resistant strains, conclusions and recommendations of working groups, minutes of FRAC meetings, and articles, posters, and talks on industry's response to resistance. In addition, individual members write articles on resistance studies and on its management.

FRAC is also committed to a broad-based educational program designed to reach all persons who influence decisions concerning the manufacture, distribution, sale, regulation, and use of fungicides. FRAC aims to change people's attitudes to accepting a more responsible and rational approach to fungicide use. To supplement the courses, papers, discussions, and articles, FRAC (with IRAC, its insecticide counterpart) is producing a video and slide series on pesticide resistance as a teaching aid.

FRAC also provides advice and funds for practical resistance research. It cooperates with the FAO and ISPP in running practical courses on resistance (Malaysia in 1984, Costa Rica and Chile in 1986, North America in 1987, East and West Africa in 1988) and in providing financial and practical expertise for such courses. FRAC encourages and supports workshops and seminars on resistance.

## Challenges for the future

FRAC has made an impressive beginning, but there is still much to do to maintain the impetus of the working groups, to continue to educate in all areas (as well as within our own companies), and to build closer working relationships with authorities, advisory services, and university and government scientists. Their support is vital. We must convince the legislative authorities of the importance of mixtures and compounds of different modes of action, etc., in resistance strategies, and we must stay alert to developments and issues relevant to fungicide resistance.

FRAC's continued success depends on maintaining credibility in an increasingly complex world and on the active support of our friends and colleagues in universities, advisory services, and government in promulgating sound technical strategies. Together, we believe we can continue to make real progress toward preserving the invaluable option of chemical disease control for our crops.