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Conference Report

Systemic Acquired Resistance (SAR): A Meeting Organized by the Pesticide Group of the Society of the Chemical Industry, March 10, 1998, London, UK

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GENERAL REMARKS

The use of chemical activators in the defense systems of the plant in order to induce resistance against pathogens and insect infestation represents a third alternative in the development of effective plant protection in addition to the application of conventional synthetic pesticides and the recently introduced method of integrating and expressing resistance-promoting genes in the plant genome. A central element in this induced defense reaction is the development of systemic acquired resistance (SAR), i.e. the establishment of a lasting resistance which persists in the case of subsequent infections by the same or even unrelated pathogens (viruses, bacteria or fungi). SAR can be induced when there is an incompatible interaction between pathogen and plant. At the same time signal substances, so-called elicitors, are released which regulate a number of local or systemic defensive responses of the plant. The elicitor effect of salicylic acid (SA) has been particularly well investigated. This substance is at the same time an important link in the SAR signal chain and brings about the development of a resistance by stimulation and expression of certain defense-associated genes. Benzothiadiazol (BTH), a synthetic compound which imitates the natural inductive properties of SA, is already being used in agriculture and thus belongs to a new generation of indirectly active agrochemicals.

The Society of the Chemical Industry organized a meeting which was held in London on 10th March 1998 to discuss current findings on the molecular mechanisms of SAR induction, their commercial uses and experience with SAR inducing compounds in agriculture. Papers were presented and round-table discussions with experts from the industry and from public and private research institutes were held to this effect. Approximately 70 participants attended the meeting which demonstrated the future significance of employing chemical activators of the plant's defense systems as a possible alternative to pesticides which work directly. Particular interest was shown by the agrochemical manufacturers.

ORAL PRESENTATIONS

A retrospective overview of the discovery of important molecular mechanisms and the laborious process of elucidating them was presented by J.A. LUCAS (Bristol University) under the title *"Plant Immunization from Myth to SAR"*. His contribution revealed that a large part of present-day knowledge about systemic acquired resistance in plants was obtained through basic research on the tobacco plant. For example, an SAR reaction was observed for the first time during infection in *Nicotiana tabacum* with blue mould in 1960, while the development of resistance in TMV-infected tobacco was documented just one year later. This was followed by a period of intensive research aimed at decoding the biochemical and molecular reactions involved in SAR during signal transmission. Finally, salicylic acid (SA) was

identified as a central element of SAR signal transmission. As a result of this decisive discovery, several pesticide manufacturers carried out intensive research to develop new compounds with properties similar to SA which would allow their use on crops, providing full protection from pests through induction of the plant's defense systems. The first commercially available plant activator was presented in public by Novartis in 1995. This benzothiadiazol compound (BTH, marketed under the brand name Bion, Actigard) offers effective protection against numerous diseases caused by fungi, bacteria or viruses through activation of the SAR signal chain and the resulting expression of certain defense-associated genes. In the course of his presentation, J.A. LUCAS also addressed unclarified issues concerning biotechnological applications based on SAR induction. Thus the use of transgenic plants with a modified SAR signal chain to obtain a stronger expression of resistance-promoting genes was one of the points under discussion.

In the following presentation entitled *"Cytological Analysis of the SAR Response of Cereals to the Powdery Mildew Fungus"*, K.H. KOGEL (University of Gießen) reported on the role of reactive oxygen species (e. g. hydrogen peroxide) in the development of the SAR. Many scientists ascribe a dual function to hydrogen peroxide which e g accumulates locally at the infection site during penetration of fungi into the plant tissue. While elevated H_2O_2 concentrations can promote cross-linking of the plant cell wall, thus making it more difficult for fungi to penetrate, it is thought that hydrogen peroxide could also be an important component of the SAR signal transduction. However, the study presented by K.H. KOGEL comparing BTH and H_2O_2 with respect to their inductive effect on marker genes of SAR did not determine any gene-stimulating effect for hydrogen peroxide. K.H. KOGEL therefore concludes that H_2O_2 did not have any function as signal substance in SAR.

With his paper entitled *"Molecular Basis of SAR"*, U. NEUENSCHWANDER (Novartis Crop Protection AG) provided an insight into the molecular mechanisms of an SAR induction and development of resistance in the plant tissue following interaction with a pathogen, or through exogenous SA application. He emphasized that the development of SAR is closely related to the expression of certain SAR-associated genes which code for the so-called pathogenesis-related proteins (PRP). Consequently, research has been able to identify potential chemical plant activators on the basis of their inductive effect on PRP accumulation. Furthermore it became clear that a rise in SA content in the tissue seems to be essential to the development of SAR. Tobacco plants which express a bacterial, SA-catabolizing salicylate hydroxylase gene are thus not capable of developing resistance following attack by a pathogen. The presenter also stressed that development of an effective resistance against pathogens in the plant requires a systemic signal to spread from the site of primary infection into remote, still unaffected tissue parts of the plant. However grafting tests with tobacco plants have shown that SA is probably not identical with the "long-distance signal" which researchers are looking for. The findings presented by U. NEUENSCHWANDER from a study comparing the Bion effect and conventional fungicides clearly show that the plant activator has no direct influence on the pathogen, but exerts a protective effect by stimulating the plant's defense mechanism. Another characteristic of Bion is the activation period between application and protective effect. Generally, it takes a few days after the Bion application before the plant develops effective resistance. In contrast, conventional pesticides have a direct effect on the pathogen which consequently requires considerably higher doses than is the case for Bion.

In his contribution entitled *"Signaling in SAR"*, J. DRAPER (University of Wales, Aberystwyth) dealt with characterization and purpose of the signaling molecules thus far identified in SAR. He ascribes a reinforcing effect on the intensity of the SAR reaction to the SA accumulation in plant cells. In his opinion, an increase in SA content following contact with a pathogen decisively affects the extent of production of reactive oxygen species at the lesion site.

In his presentation *"Field Experience with CGA 245704 in a Wide Range of Crops"*, W. RUESS (Novartis Crop Protection AG) reported on experience gained with the plant activator Bion on a series of crops. He also made reference to results obtained in field studies with *Nicotiana tabacum*. According to these studies, application of Bion on tobacco at low doses of 12–25 g ai*/ha will stimulate resistance mechanisms against a number of pathogens of the tobacco plant (e.g. *Peronospora tabacina, Pseudomonas* sp. and PVY). In the case of blue mould it can afford up to 95 % protection, achieving somewhat lower resistance to PVY (approx. 60 %) and 79 % protection against *Pseudomonas tabaci* (Angular leaf spot). A mixture of Bion and the conventional fungicide Metalaxyl has proved particularly effective in inducing resistance against pathogens. Thus, any damage causes by blue mould infection can be considerably reduced by using this combined preparation. The fact that Bion has already been registered in Germany as a plant protection preparation for use on crops suggests that it could also be used in tobacco cultivation, due to its beneficial properties and its effectiveness. However, application for a specific type of crop is, in each case, subject to the manufacturer's recommendations.

* ai = active ingredients