Reflections on Innovation in Plant Disease Control

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These are exciting times to be a plant scientist. Even though much remains to be accomplished, we derive satisfaction from the higher crop yields that have transformed many nations of hungry people into lands of food sufficiency. Advances in molecular genetics promise even more rapid mechanisms to lift crop yields, develop resistance to pests and diseases, and improve nutritional value in food crops. Spurred by these new developments, disease resistance and biological agents are being emphasized for control of many intractable plant disease problems. But as our research efforts move forward in these exciting areas, perhaps it is wise to consider some implications of increased emphasis on those methods of control.

Consider first some facts concerning chemical control of plant diseases. We have gone through a long period of reassessment both of chemicals used for control and of the strategies to utilize those materials. Now emerging are new fungicides and other chemicals that, because of careful scrutiny before registration, are much safer and more effective than those used a few decades ago. They are effective at lower rates than have been used in the past, many have after-infection activity, and most disappear rapidly in the environment. New strategies for use result in fewer applications and greater effectiveness. Responsible government regulation now requires exhaustive testing of new pesticides, and improved safety for pesticides can be expected to continue. Likewise, agricultural scientists will continue their research to utilize chemical pesticides in the most efficient manner possible and to integrate their use with other control practices.

In contrast, we know little about the potential of natural fungicides to affect human health. It is often assumed that genetic resistance is a safer means of plant disease control than is the use of chemical pesticides. Yet the basis for resistance often is the production of antimicrobial substances that permeate plant tissues. The inherent safety of these compounds is largely undetermined, even though they occur at much higher levels in plants and are consumed in larger quantities than are chemical pesticide residues (Ames, B. N., Magaw, R., and Gold, L. S. 1987. Ranking possible carcinogenic hazards. Science 236:271-280).

Bruce Ames, chairman of the Department of Biochemistry at the University of California, Berkeley, writing for the *Los Angeles Times*, made the point very well. He noted that all plants produce their own natural pesticides to protect against fungi, insects, and predators. These natural pesticides increase manyfold in response to pest attack, reaching hundreds or even thousands of parts per million. For example, psoralens, toxic compounds that occur naturally in carrots, parsnips, and celery, may reach very high levels in response to fungal infections (ibid.). Solanine, a constituent of Irish potatoes, can cause illness in consumers if care is not taken to eliminate cultivars containing large amounts of this compound. Other toxic substances occur in many plants, including peppers, cabbage, oranges, and pineapple.

The plants that man has selected for food throughout history have been screened for toxicity as well as for nutritional value. One consequence has been increased susceptibility of cultivated plants to diseases. Now that new sources of disease and pest resistance may be available through genetic engineering, perhaps it is necessary to reexamine the common assumption that genetic resistance is safer than the use of chemical pesticides. Do we need to refocus the priority for identifying the substances responsible for resistance and ascertain that the chemicals involved are safe for man and domestic animals? It seems unwise to promote the substitution of genetic resistance for chemical fungicides unless such resistance truly has greater safety.

A similar situation may apply in the concept of disease thresholds—meaning that we accept a certain subeconomic level of disease in plants. This is an underlying concept of integrated pest management. But infection may activate resistance mechanisms in plants and sometimes results in the formation of mycotoxins that may be harmful to health. What are the implications? Are we unwittingly promoting a small, but possibly significant, increase in harmful substances in our crops?

These remarks are not intended to imply that resistance or integrated pest management are unsafe practices for plant disease control. Plant breeders have performed outstanding services to humanity in the plentiful, varied food supply that is widely available, and pest management specialists have greatly improved efficiencies of pest and disease control. But the emphasis on reducing pesticide use should not obscure for plant scientists the need to maintain a multifaceted approach to disease and pest control, including chemical pesticides. The safest and most appropriate choices are easier to make when all of the facts are available. Novel sources of resistance made possible by genetic manipulation or induced by modification of organisms in the environment may be mixed blessings. And have pesticides really reached the limit of innovation? The modern tools of molecular biology might be well suited to initiate and guide the development of biorationally designed and highly specific inhibitors with novel properties. We might even find that new chemical pesticides carefully regulated by government agencies and applied by informed users may be among the safest of the mechanisms available to control many plant diseases and pests.