
Workshop Report: Research and Development Perspectives

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Pest resistance has evolved against every form of pest control applied in agriculture to date. There are more than 600 species of insects resistant to insecticides, nearly 200 weed species resistant to herbicides, and more than 100 plant pathogens resistant to fungicides and bacteriocides. It is expected that pests will eventually evolve resistance to new transgenic technologies including plant pesticides (such as insect resistant, *Bacillus thuringiensis* [Bt] transgene crops now in use), herbicides combined with herbicide resistant crops, and transgenic crops with resistance to plant pathogens. Delaying the evolution of resistance will depend on carefully constructed and thoroughly implemented pest resistance management strategies. The US Environmental Protection Agency (EPA) has required such a plan for registration of plants and pesticides. The current approach is a combination of high doses of insecticidal protein and provision of refuge areas. (Note: A refuge is a set-aside part of a field that is planted to maintain a population of insects that is sensitive to Bt, i.e., non-Bt transgenic crops not protected against insects.) This plan, which marks the first such regulatory requirement in the pesticide registration process, appears to be working. However experience with the effectiveness of this plan is limited, and flexibility in modifying it may be required if resistance begins to evolve.

A similar situation may occur with the use of herbicide-resistant transgenic crops where increased herbicide use may accelerate the evolution of weeds with resistance to the herbicide. Transgenic plants resistant to attack by plant pathogens are under development. Proteins introduced via transgenes for this protective trait will be considered as plant pesticides, thereby requiring resistant pest management plans for EPA registration. Research experts and concerted efforts by professional societies will be needed to assist in developing these strategies. Such was the case for use of viral coat proteins to confer resistance to

viral pathogens where the EPA, with input from experts in the field, has granted an exemption from plant pesticide regulation.

In general, it is most important that transgenic tools be viewed as only one aspect in the overall scheme of integrated pest management in agriculture. Furthermore, it is important to continue to improve the transgenic approaches to pest management to maintain the benefits for the future.

ENVIRONMENTAL IMPACT OF GENE ESCAPE

The workshop groups were asked to discuss several issues concerning the long-term ramifications of gene escape, and the existing or potential natural and artificial barriers to gene escape. The first issue involved the potential benefits of transgenic technologies in plant systems. In general, this technology allows improved yields from a variety of crops with reduced environmental impact from use of toxic chemicals. Probably the best example is the use of transgenic Bt plants that provide resistance to insect pests with no toxicity to humans, wildlife, or most beneficial insects, while reducing the need for toxic and expensive chemical pesticides. A similar situation occurs for transgenic resistance to viruses that allow protection against devastating viral diseases and reduces the need for toxic-pesticides commonly used to eliminate the insect vectors of many viruses. Finally, the use of transgenic resistance to herbicides allows the use of relatively benign herbicides for weed reduction.

The second issue concerned the potential risks associated with this technology. Ironically, the first and perhaps the greatest, risk identified is the potential loss of the benefits conferred by the technology. For example, the potential loss of Bt insect resistance in plants and the development of Bt resistant pests due to misuse or overuse. Another potential risk is the possibility of escape of the transgene into non-target organisms, in particular wild relatives of the transgenic crop. An example is the acquisition of herbicide resistance by weeds or by non-weed plants that then become a weed.

Do the benefits of the technology justify the risks? Can the risks associated with this technology be reduced? The technology provides great benefits to society, to the economy, and to the environment. To preserve these benefits an effort should be made to reduce the risks (or perceived risks) associated with the technology.

A number of proposed strategies for risk reduction centered around an influx of money into research that would focus on attaining a basic understanding of the biology of the targeted plant/pest interactions. It is crucial that efforts to develop more sophisticated biocontrol begin immediately. This development depends on an understanding of the basic science of the particular system. For example, basic research into the nature of the interaction between Bt toxin and the insect receptor for the toxin could lead to designer toxins that provide better resistance. Thus, the second generation of transgenics could be in hand in time to supplement the expected failing resistance of first generation

transgenics. It is unfortunate for everyone involved that this type of innovative basic science is currently woefully under-funded, and that many opportunities to preserve this beneficial technology are being lost.

A second proposed method to reduce risks is the development of programs designed to educate the users of biotechnology. The education would focus on the importance of implementing current pest resistance management principles to slow down development of resistance in the pests, and on integration of transgenic technology with other management techniques.

RECOMMENDATIONS

- 1. Enhance basic research to develop effective resistance-management plans. The focus of the research should be towards development of a second (more sophisticated) generation of plant pesticides to supplement the first generation. An understanding of the molecular mechanisms that lead to transgenic resistance will facilitate the development of more sophisticated approaches.*
- 2. Take steps necessary to slow down the development of resistance to current biocontrol while developing the second generation of pesticides.*
 - Educate growers, crop consultants, extension agents, salespersons and international users on current pest-resistance management principles.*
 - Incorporate biocontrol strategies as a component of integrative pest management.*
- 3. There is a critical need to create a source of funding for research into innovative approaches for the safe and effective use of biotechnology in agriculture. It is important that these efforts take place in a timely manner so that the new transgenics become available before the first generation has failed. The group suggests an alliance between the private sector and the government to provide funding for a new government agency (National Institute for Agricultural Biotechnology?), or a free-standing research institute, co-funded by industry and government.*