Workshop Report: Industrial and Economic Perspectives

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The workshop on Industrial and Economic Perspectives was highly diverse in membership and included representatives from industry, academe, government, farmers, and others. Most of the discussion focused on transgenic crops containing the gene for biopesticidal toxin from Bt (*Bacillus thuringiensis*.) A major concern discussed in the plenary sessions, as well as in the workshops of the NABC conference, was the potential for insects to develop resistance to the Bt toxin. Although at the time of the workshop no cases of insect resistance to transgenic crops containing the Bt gene had been documented, there was great concern expressed about this possibility.

What Potential Risks Do Resistant Pests Pose to the Environment and Society?

The loss of the ability to control a plant pest via a biopesticide produced in a transgenic crop could result in crop losses to growers and the return to reliance on the use of chemical pesticides. However, this type of risk is not new. Resistant pests have always developed in response to conventional hybrid resistant varieties or use of chemical pesticides. Over the years various weeds, insects, and fungi have become resistant to a variety of chemicals. Yet with management plans that include cultural practices, alternative chemistries, and crop rotations, the pests have been controlled.

If pest resistance occurs with transgenic pesticidal plants, regulatory hurdles could be increased (especially with Bt) and become a liability in both the domestic and global arena. Even if the pest is ubiquitous in many crops (e.g. lepidopteran) and the gene for resistance is also in those crops, pest resistance may not develop if the exposure of the pest to the gene is seasonal and appropriate refuges are used.

Because Bt is a natural resource, care must be taken to ensure its usefulness is maintained. Resistance to Bt could lead to a negative perception of Bt crops by consumers and have a negative economic impact on producers and manufacturers. Meanwhile, industry (seed, agricultural, chemical, and biotechnology companies) is working to identify new genes as alternatives to Bt that target pests not controlled by Bt. Academic institutions and other credible groups can play a role in educating the public.

How is Development of Resistance Monitored and Who Is Responsible for Monitoring?

Both the companies that have commercialized the technology and the US Department of Agriculture (USDA) are monitoring for the development of pest resistance to transgenic Bt plants. However, the effectiveness of monitoring techniques is not yet clear. The US Environmental Protection Agency (EPA) requires that companies monitor for pest resistance. Industry has a vested interest in resistance and the proper use of its products. Concern was expressed that industry may be seen as 'the fox guarding the chicken house' and it was suggested that a third party should be involved. Such an approach could use universities, extension services, or private consultants under contracts to verify industry's findings.

A European suggestion is to put in place an organization comprised of university and government personnel to oversee and monitor pest resistance in transgenic plants. There is a need to find a credible source for monitoring, for public disclosure, and for educating the legislature and all parties involved.

Is There an Acceptable Level of Resistance?

Pest resistance to control measures, per se, is not new. Future generations of transgenic plants will come with new variants of the Bt genes or other genes for insect control. There will also be new synthetic chemical pesticides to complement and assist the effectiveness of the transgenics. Resistance to a pest control agent is almost inevitable when the agent's mode of action targets a single site. However, due to the effectiveness of the transgenics, the benefits to the growers, and the investment of industry, the goal is to minimize and/or delay pest resistance to biopesticides produced by transgenic plants by following recommendations for refuges and alternative chemistries. Guidelines should be developed with the following questions in mind:

- Breadth of pest resistance (e.g., is the resistance confined to a specific insect or many insects?)
- Alternatives (e.g., do safe and economic alternate methods of pest control exist?)

Responsibility for Enforcement and Penalties

Questions about the responsibility for enforcement and use and size of penalties for non-compliance have not been resolved. For example, what is the penalty to the grower who does not follow the guidelines? What should the size and location of the refuge be? How can this be implemented in third world countries where there are many farmers with very small acreage? Much more research is needed to generate real data to answer these questions. Matching grants from industry and government may provide the funds needed to conduct such research.

What Are the Potential Benefits of Transgenic Technology in Plant Systems?

There are many benefits projected from the use of transgenic crops:

- Decrease in the amount of crop protection chemicals used, which is better for the environment, water quality, and overall health and safety.
- Increase in food production in third world countries.
- Value-added crops for growers.
- Increase quality traits such as oils, proteins, etc.
- Allows crop yield to approach its potential.
- Less capital.

In addition, society may benefit from the use of transgenic plants in phytoremediation, and in the production of bio-based products such as plant vaccines, nutraceuticals, and industrial products.

What Are the Potential Risks of Transgenic Technology in Plant Systems?

While there are many benefits, there are also some risks that need to be managed. One threat is the potential for gene escape. For example, the pest resistance gene(s) may be transferred from the transgenic host plant to a native relative (weedy) plant in the field area. Further investigations need to be done on the probability of this happening. As with failures with conventional products, companies are liable when the product fails or causes a side effect. From an industry perspective, there is concern that the transgenic biopesticide product life will be shorter than that of a chemical product. In addition, inventory control is more difficult since the seeds for the next year's crop are grown during the current year. The demand for a mix of traits (e.g., Bt plus high oil) also make inventory management more difficult. With transgenic plants there is also the problem of increased regulation and trade barriers. The major consolidation in the agrochemical/biotechnology/seed industry suggests that there will be less diversity in the research of a few consolidated companies

than the primary companies that pre-existed consolidation. Furthermore, large consolidated companies will have larger market share and more control of germplasm, and may have a monopoly in some markets.

To Decrease the Risks of Gene Escape:

- Develop technologies so that the transgene is not expressed in next generation.
- Avoid planting transgenic crops in their evolutionary center of crop origin where there may be wild and weedy relatives.
- Rotate crops so that other types of chemical or cultural pest control measures can be used.

How Should Responsibility for the Future of Plant Biotech Be Decided and How Does the Public Participate?

The EPA currently has regulations governing the registration of transgenic plants. Should there be additional standards for safety and efficacy? Should there be an equivalent of the Centers for Disease Control to oversee the use of transgenics? Industry might argue that the current regulations suffice and it is in their own best interest to ensure compliance with guidelines so their plant biotechnology products have a long life. Others could argue that a tool such as Bt should not be ruined by overuse for the sake of immediate rewards. While Bt is widely used by home gardeners and organic growers, other transgenic plants for pest management (herbicide- and virus-resistant) are more like conventional products and have similar regulatory and management issues. There is still a gap in research on the best way to avoid/delay development of pest resistance. In the end, the transgenic plant is just another tool for the grower to use in the quest for maximum yield and economic return.

While educating the public seems logical, we must be realistic about who is really interested and who is influencing public opinion. The land grant universities should take the lead in developing methods to deliver the information about biotechnology, genetically altered organisms and transgenics in “plain” language. This information should be presented to (but not limited to):

- Service groups (e.g. Kiwanis, Rotary).
- Influencers of public opinion (Note: the influencer is not always the leader but may have the leader's ear and trust).
- Classrooms.

RECOMMENDATIONS

1) To decrease the risk of development of pest resistance:

- *Maintain an integrated approach to pest management with diverse options.*
- *Maintain strong public and private research infrastructure to ensure diverse options.*
- *Encourage shared funding between industry and government.*

2) Resistance monitoring:

- *Registrant (industry) should conduct baseline monitoring starting with field trials and through commercialization.*
- *The strategy needs to be part of the registration package.*

3) Enforcing resistance management strategies:

- *Research is needed on how to delay/avoid pest resistance, and test such theories.*
- *Use existing groups (e.g. Crop Improvement Association) or new non-industry groups to monitor development of resistance and compliance with management strategies.*
- *Industry and universities need to develop "certified" methods for monitoring.*
- *Growers should keep crop records, including the field location of transgenic and non-transgenic crops.*
- *Penalty for non-compliance should be the same as for misuse of a chemical.*
- *Monitoring and penalties must be standardized across regions.*

4) To reduce the risk of gene escape into the environment:

- *Identify areas of particular concern (centers of origin).*
- *Develop a management plan (e.g., crop rotation).*
- *Express transgenes only in the current crop, not in the next generation.*
- *Create an oversight committee.*
- *Set standards for efficacy and safety.*
- *Identify needed research.*

5) To communicate/educate the public:

- *Land grant universities should take the lead to develop a plain language delivery method of information.*
- *Education is needed for influential leaders and policymakers, media, service groups (Rotary, Kiwanis, etc.), and teachers.*