3 Park Place, Suite 307
Annapolis, MD 21401-3722 USA

Phone: 301-731-4535
Fax: 301-731-4538

esa@entsoc.org
www.entsoc.org

ESA Position Statement on Insect Resistance Management for Genetically Modified Crops

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Position:

Genetically modified (GM) crops have been grown for two decades, resulting in higher crop yields, a decrease in insecticide use, and an increase in farmer profitability, benefiting farmers, the environment, and society. Insect pest populations that develop resistance to GM crops have the potential to greatly diminish these benefits. Insect resistance management (IRM) programs to delay resistance frequently entail near-term individual and local costs for expected long-term societal benefits and require cooperation among researchers, educators, technology developers, farmers, governments, and other stakeholders. Successful IRM is an important component of integrated pest management (IPM) programs. Current IRM policies have prevented or delayed pest resistance to many GM crops; however, the threat remains. As of 2016, seven cases of resistance in five major insect pest species have been confirmed worldwide. These cases suggest that policies to improve and coordinate the adoption of IRM and IPM policies are needed to preserve the sustainable use of GM crops that possess these insect-resistant traits. Research into the economic and sociological implications of these policies is needed to ensure that costs and benefits are shared appropriately across society.

Recommendations:

Recognizing the potential for broad societal benefits from insect-protected GM crops, policies that will reduce the development and impact of insect resistance to the crops should include the following:

- Cooperation among private developers, public institutions, and regulators should emphasize collaboration in promoting practical, science-driven IRM practices within IPM programs based on near-term grower needs, and should support the use of GM crop technology for sustaining insect resistance over the long term. This should include coordination on monitoring programs that enable early detection and economically proportionate responses to emerging resistance situations.
- Education, incentives, and assistance for growers to implement IRM tactics within IPM programs. These require promoting a communication infrastructure that coordinates common messages about product stewardship and compels action towards long-term preservation of grower livelihood. This infrastructure should include strong public university research and extension networks, as well as locally driven outreach to farmers to encourage IRM programs in ways that are relevant for local conditions and culture.
- Predictable and reasonable regulatory requirements and review timelines for new GM crops that possess insect-resistant traits, and associated IRM programs that reduce the risk of resistance and promote sustainable use.

- Support for cross-disciplinary research into approaches to overcome the economic and sociological barriers to successful IRM and IPM.

Background:

Humans have been managing crops for thousands of years, often selecting plants with mechanisms to protect themselves from pests; in turn, pests evolve resistance mechanisms to overcome these defenses. Agriculturalists and entomologists need to manage crop defenses to counteract the evolution of resistance by insects. Genetically modified crops that possess insect resistant traits have been available to farmers since 1996 and present an opportunity to quickly introduce new plant defense mechanisms. The first generation of GM crops expressed insecticidal genes from the soil bacterium *Bacillus thuringiensis*, or Bt, which has been the source of a variety of manufactured microbial insecticides for the past 75+ years.

A recent global meta-analysis [1] found that insect-protection traits resulted in 22% higher crop yields, a 37% decrease in insecticide use, and a 68% increase in farmer profitability. In addition, GM crops have improved worker safety and enhanced simplicity and flexibility of farm management [2]. However, the eventual development of resistance in target pest populations can occur as a consequence of using any pest control tool. After 20 years of commercial use, seven cases of field-relevant resistance to specific Bt crops across five major pest species have been reported in India, South Africa, South America, and the US [3]. In at least one case, the resistance has remained even after withdrawal of the affected crop. The potential for future widespread insect resistance development is a major threat to the sustainability of the benefits of GM crops. Resistance management programs are therefore essential to extend and preserve the benefits.

Insect resistance management is one of the scientific approaches to long-term pest management to ensure that resistance does not interfere with the ability of all stakeholders to accomplish their goals [4]. By preserving the utility of GM insect protection traits over time, IRM programs for GM crops with these traits should be fully implemented to maintain incentives for technology developers to continue innovation (they improve return on investment), to benefit farmers (they realize cost savings, convenience, yield protection, reduced pesticide handling, and they implement sustainable pest management practices), to protect the environment (through reduced- or better-targeted insecticide applications), and to help consumers (lower pesticide residues, increased food security).

Key Concepts for Successful IRM:

<u>IRM is part of IPM</u>

IPM is the foundation of modern applied agricultural entomology. IPM emphasizes the integration of multiple tactics (cultural practices, breeding for host plant defenses, biological control using predators and pathogens, and chemical applications when necessary at economic thresholds) to manage pest populations at levels that are economically and socially acceptable. Many entomologists consider GM crops as a type of host plant defense, and thus one of the tactical pillars of IPM. Historically, the primary goal of IPM has been efficient management of a crop at the field level over a single season. Incorporating IRM into IPM broadens the program for area-wide, long-term pest management.

Like IPM, IRM uses multiple tactics to achieve its goal of slowing development of resistance in pest populations. IRM is based on four approaches: 1) diversification of control tactics, 2) reduction of selection pressure for each control tactic, 3) maintenance of a refuge for development of susceptible individuals and immigration to promote mixing with resistant individuals, and 4) evaluation of any development of resistance through the use of monitoring and models [5]. Summarily, combining multiple IPM tactics, reducing overall pest pressure, preserving beneficial parasitoids and predators, scouting, and applying insecticides at established thresholds reduces the likelihood of resistance developing in GM crops. Employing adequate non-insect-protected crop refuge is the backbone of IRM for GM crops, as it reduces the proportion of the pest population that is under active selection for resistance and, in the case of high-dose products, can greatly delay development of resistance to the GM crop.

IPM and IRM add operational and logistical complexities in managing crops and farms because farmers must closely monitor their fields, carefully select and plant crop seeds, and track season-long incidence and management of pests. In addition, the landscape scale of pest populations and resistant insects can create the impression that the actions of an individual farmer are not important as long as the neighbors are following the IPM and IRM recommendations. When the pests infest multiple crops in a landscape and are selected by multiple control tactics, IRM and IPM become even more complicated. While farmers are likely to recognize the threat that resistance poses to pest management, if delaying resistance becomes too burdensome in the short-term from either a time or financial perspective, they will be reluctant to adopt IRM techniques. For example, maintaining a refuge of vulnerable plants for susceptible pests is a foundational strategy, but if the pest population causes significant damage to refuge plants, producers are less likely to comply.

Policies and practices exist in other disciplines where short-term objectives and long-term goals need to be balanced. Economists and sociologists can partner with entomologists and regulators to find mechanisms to promote sound IRM strategies and behaviors by conveying the benefits.

<u>Coordination and Cooperation</u>

Because of the complexities and trade-offs associated with implementing effective IRM programs, coordination among individuals and across different sectors is needed. Resistance management strategies are only successful at the landscape level because this is where most pest populations exchange genes. Effective IRM thus requires cooperation of all producers in a given area. Pests move across agricultural landscapes, and resistance can affect multiple GM crops and insecticidal proteins at the same time. If some farmers practice IRM and others do not, the non-IRM farmers will benefit from the practices of the IRM farmers in the short-term, while the IRM farmers will not receive all of the benefits from their investments. In the long run, no one benefits because poor IRM hastens technology failure.

Diverse stakeholder groups – including farmers, crop consultants, grower associations, land-grant university researchers and extension scientists, crop consultants, seed companies, biotechnology companies, landowners, and government agencies – have responsibilities for different aspects of resistance management. This diversity reflects the societal benefits of effective IRM that preserves and promotes the economic, environmental, and food security gains enabled by GM crops.

To properly accomplish IRM, stakeholders must coordinate to recognize their different needs, and they should be encouraged to take responsibility for actions that will benefit most, if not all, over the long term. It is critical that entomologists in the public and private sectors, supported and enabled by government regulators and policymakers, and in partnership with technology developers, create and promote educational programs to teach farmers that IRM is essential to maintain effective insect control and that it is in their economic interests.

Summary:

Insect pests cause significant losses in agricultural production. GM crops that are protected from insect damage provide billions of dollars of economic benefit to farmers worldwide, reduce farm input and management costs, and ensure a more secure, environmentally sensitive, and profitable food supply. However, insect pests have a propensity to overcome control tactics, including GM crops. Given the importance of GM crops in meeting the demand for agricultural production, we must develop, implement, and support policies that maintain their efficacy and durability despite pest adaptability.

IRM programs require understanding multiple dynamics, including pest and crop biology, economics, social acceptance, and farmer behavior. Effective implementation requires coordination among developers, users, farm advisors, and regulators. Therefore, ESA advocates research that furthers our understanding of pest biology, GM crop efficacy, and the benefits and costs of insect-resistance management, as well as public and private sector education and training programs for end-users of IRM tactics.

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