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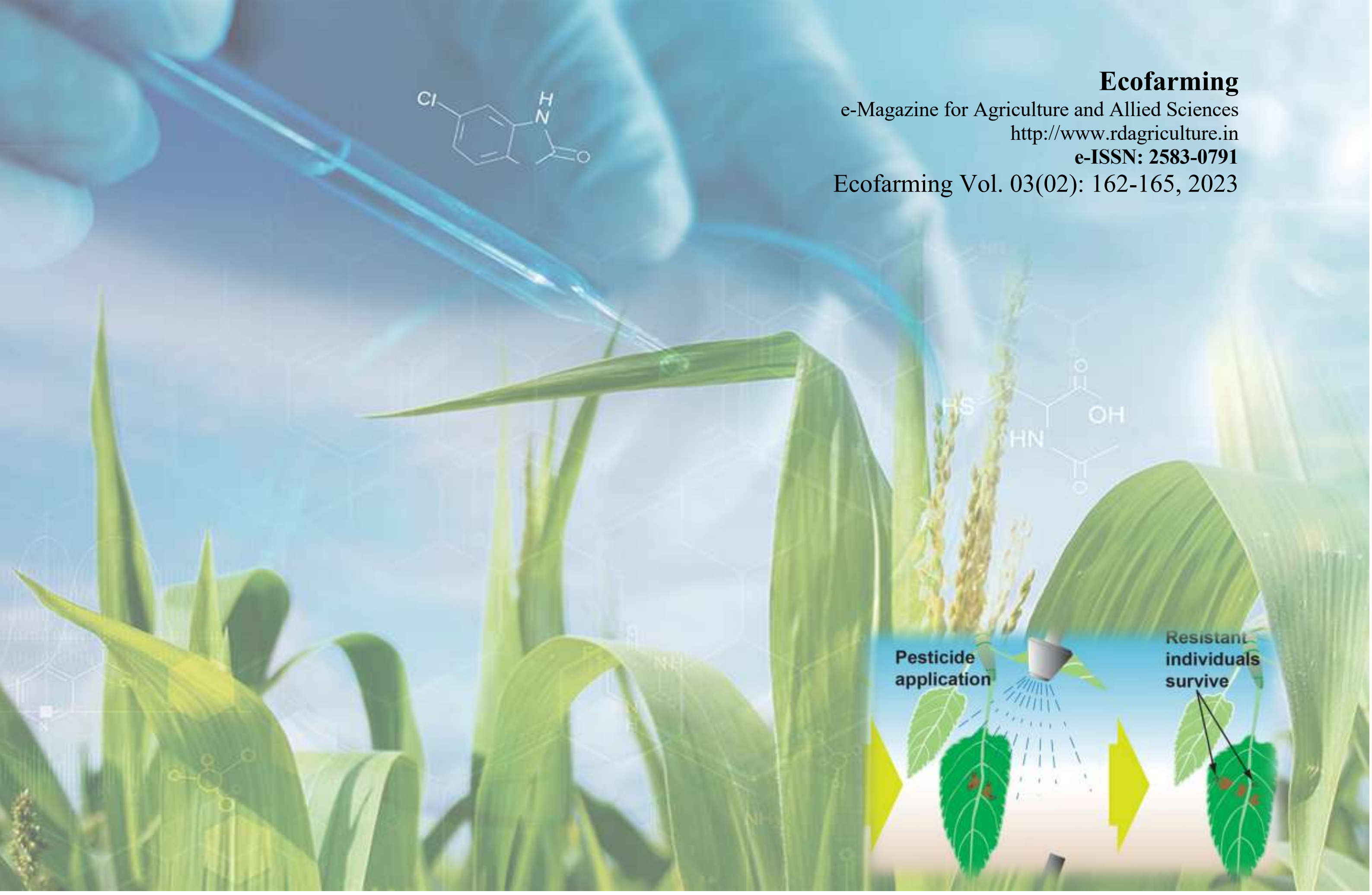

Insecticide Resistance Management Strategies in Transgenic Crops

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Introduction

World population have been increased fourfold during the last century, with current estimates placing it at 9.2 billion by 2050. We are facing situation where food demand is beginning to outstrip supply. This situation is combined by the fact that we may be at the limit of the existing genetic resources available in our major crops. Thus, new genetic resources must be found and only new technologies will enable this. GM crops are grown around the world by approximately 17 million farmers, most of them in developing countries. In total, more than 70 countries import or grow GMOs, and in 2019, 29 countries (five industrial and 24 developing) planted biotech crops. As of 2019, the top five countries growing GMOs in terms of crop area are the United States, Brazil, Argentina, Canada and India.

GM crops having insecticidal residues in their tissues have been cultivated for over two decades, resulting in higher crop yields, a decrease in insecticide use, and an increase in farm profitability. A global meta-analysis found that insect-protection traits resulted in 22 per cent higher crop yields, a 37 per cent decrease in insecticide use, and a 68 per cent increase in farm profitability. This benefits farmers, the environment, and society as a whole. However, widespread adoption and season-long expression of insecticidal substances in GM crops can apply strong selection pressure on the herbivorous insect populations that they target. Insect pest populations that develop resistance to GM crops have the potential to greatly diminish the benefits of this technology. Insect resistance management (IRM) programs to delay resistance frequently entail trade-offs between near-term individual and local costs and expected long-term societal benefits.

IRM in GM crops

Genetically modified crops having insect resistant traits have been accessible to farmers since 1996 and introduce new plant-defence mechanisms. The first generation of GM crops expressed insecticidal genes obtained from the soil bacterium *Bacillus thuringiensis*. It is the source of a variety of manufactured microbial insecticides for more than 75 years. IRM is approaches of long-term pest management to guarantee that resistance does not interfere.

- Environment protection (minimized or better application of targeted insecticide)
- Beneficial for farmers (economic, convenience, reduce pesticide applications)
- Sustain inspirations for technology developers to continue innovation
- Healthy for Consumers (via lower pesticide residues and increased food security)

Ideas for Successful IRM

IRM is part of IPM: IPM is a combination of multiple tactics *viz.;* cultural practices, host plant resistance, biological control using predators, parasitoids and pathogens and chemical insecticides. These approaches should apply at economic thresholds (ETL) to manage pest

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populations at levels that are economically and socially acceptable.

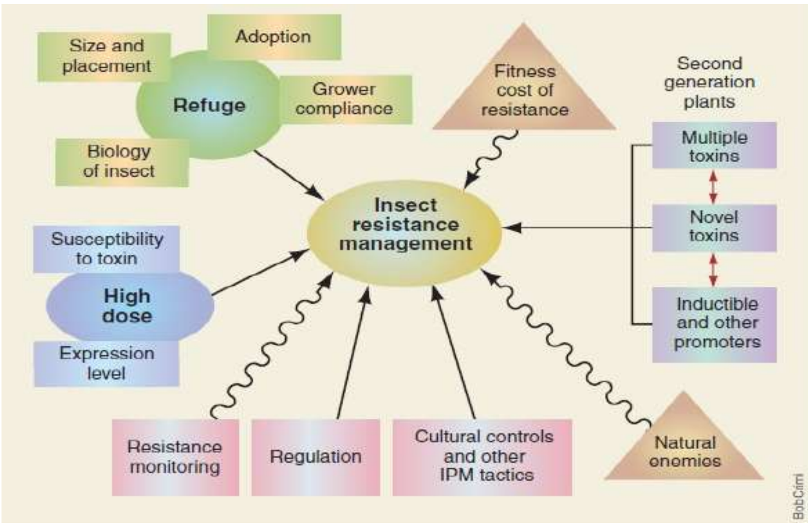
Like IPM, IRM uses multiple tactics to achieve its goal by developing resistance in pest populations. IRM is based on four approaches: diversity of control practices, minimize selection pressure for each control practices, maintenance of a refuge population for delaying resistance development.

Evaluation of any development of resistance through the use of monitoring and models.

The best solution depends on the insect species, crop, environment, farming practices. Ideally, combining multiple IPM practices, minimize overall pest pressure, conserving beneficial parasitoids and predators, survey and applying insecticides at ETL to reduces resistance developing in GM crops.

In many cases, IRM begins with sowing non-insect-protected crop refuge and more than one insecticidal trait active against the same pest which is known as pyramiding. Refuges reduce the pest population that is selection for resistance and in the case of high-dose, can significantly delay development of resistance to the GM crop. Pyramids provide control of insects that may carry resistance trait for one insecticide. Any IPM tactic, such as increase of non-GM host plant resistance, biological control, pest and resistance monitoring, use of pesticides, rotation among GM technologies and limitation in area of GM will play role to reduction of selection for resistance traits in a population.

While farmers recognize the threat that resistance for pest management, if delaying resistance becomes problematic in the short term due to inconvenience or financial loss or risk, they will be unwilling to incorporate with IRM techniques. For example, maintaining a refuge of weak plants for susceptible pests is a basic strategy, but if the pest population causes more damage to refuge plants, farmers are less likely to adopt. Essentially, novel efforts are desired to inspire the development sound IRM strategies and management approaches that can reduce the challenges of applying IPM and improve adoption of IRM.



[Fig.1 Factors affecting the efficacy of IRM strategies for insect-resistant GM crops]

Recommendations for Reducing the Threat of Pest Resistance to GM Crops

- Research that increases knowledge about biology and behaviour of different pest, factors that affect GM crop efficacy and the benefit-cost of insect-resistance management.
- Education, motivations, and assistance for farmers to implement IRM tactics within IPM programs (promoting a good communication infrastructure that coordinates common messages toward farmers).
- Understanding that private developers, public institutions and regulators should promote IRM practices within IPM programs, coordinate monitoring programs that permit early detection and economically balanced responses to emerging resistance, promote use of GM crops, which considers both short-term farmers need and efficient pest management.
- Predictable and reasonable regulatory requirements and review timelines for new GM crops that possess insect-resistant traits. The regulatory process and decision making should be transparent and enable IRM programs that reduce the risk of resistance and promote sustainable use while also considering other societal demands of agriculture.

Conclusion

Insect pests cause more losses in agricultural production. GM crops give protection from pest damage and provide financial benefit to farmers, reduction of farm input and reduce management cost, ecologically sensitive and profitable food supply. IRM strategies can do much to delay resistance to transgenic plants. However, the most effective use of transgenic crops will be as a component of overall IPM programs. For example, the use of Bt crops in combination with cultural or biological methods that have limited efficacy on their own may help increase the feasibility of large refuges or help suppress local pest populations in the near or long term. IRM require knowledge of pest and crop biology, economics, social acceptance and behavior of farmer. Effective implementation requires coordination among researchers, developers, users, farm advisors and regulators.

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