Ecofarming
e-Magazine for Agriculture and Allied Sciences
http://www.rdagriculture.in
e-ISSN: 2583-0791
Ecofarming Vol. 03(02): 157-161, 2023

Genetic Improvement of Natural Enemies

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Received: **January, 2023;** ***Revised:*** **February, 2023** ***Accepted:*** **February, 2023**

Introduction

Using natural enemies (predator, parasitoid and pathogen) to control insect pests is called biological control. A predator is an animal that preys upon other animals which are either smaller or weaker than itself. A parasitoid is a special kind of parasite which is often about the same size as its host, kills its host and requires only one host (prey) to develop into a free-living adult and the use of microorganisms like viruses, bacteria, protozoa, fungi, rickettsia and nematodes, which kill their host or debilitate future generations is called microbial control. The biological control industry in India is well organized. NBAIR act as a nodal agency for the collection, characterization, documentation, conservation, exchange, research and utilization of agriculturally important insect resources (including mites, spiders and related arthropods) and insect-derived resources for sustainable agriculture. Nowadays, the application of different pesticides may depress populations of beneficial insects and also there are serious constraints to the establishment and success of biological control protocols due to environmental conditions, adaptation to crops, compatibility with pesticides, etc. Recent research has shown that, like any other system, there is scope for improvement of biocontrol agents also. Both laboratory-selected or genetically engineered natural enemies can be established in the field and enhance the efficiency of IPM programs by reduction of pesticide use.

Potential traits to increase the performance of natural enemies

Pesticide resistance, acceptance of food supplementation, resistance to plant defence mechanisms, starvation resistance microbiome, tolerance to relative humidity range, tolerance to extreme temperatures, resistance to desiccation, improved synchronization with the host and non-diapause are the traits to be incorporated to increase the performance of the natural enemies (Bielza *et al*., 2020).

Successful improvements of natural enemies through different methods

1. Artificial selection

Trichogramma chilonis strain TcT1E tolerant to endosulfan (resistance factor 9.55) and an insecticide tolerant strain PTS-8 of *Chrysoperla zastrowi sillemi*, having tolerance to different groups of pesticides, viz. organophosphate, organochlorine and synthetic pyrethroid was developed (NAIP, 2012). Multiple insecticide-tolerant strains of *Trichogramma chilonis* (MITS-TC), tolerant to endosulfan, monocrotophos and fenvalerate were developed by NBAIR. Patel and Yadav, (1995) reported the monocrotophos-resistant strain of *Chrysoperla carnea.* The same strain has shown cross-resistance to other insecticides such as dimethoate, acephate, phosphamidon and methyl-o-demeton (Patel and Yadav, 2000).

2. Hybridization

Interspecific hybrids of *Chrysoperla* with increased fertility were developed by crossing *C. carnea* and *C. nipponensis* (Naka *et al*., 2005). Mukuka *et al.* (2010) developed intraspecific hybrid strains of *Heterorhabditis bacteriophora* which were heat-tolerant up to 40-42 ºC and desiccation tolerant. Venkatesan and Jalali (2015) developed *T. chilonis* which can tolerate high temperatures (32-38ºC) and chemical insecticides *viz*., endosulfan, monocrotophos and fenvalerate.

3. Mutagenesis

The production of the delta-endotoxin and Vip3Aa16 toxin by *B. thuringiensis* was enhanced through the mutagenesis of vegetative cells (Ghribi *et al*., 2004; Hmani *et al*., 2018). Thermotolerant mutants of *Beauveria bassiana* and *Lecanicillium lecanii* were developed using physical mutagens *viz.*, moist heat stress (35°C) and UV (Avanti *et al*., 2014). *Isaria fumosorosea* with enhanced resistance against the broad-spectrum fungicide, benomyl was developed (Shinohara *et al*., 2013). The strains BB22 and BB24 with tolerance to the broad-spectrum fungicide benomyl were developed by exposing these to ion beams and gamma rays (Fitriana *et al*., 2015). Mutants of *Heterorhabditis bacteriophora* with high longevity were also developed.

4. Recombinant DNA Technology

Gene	Source	Natural Enemy	Use	Reference
Insect cuticle degrading protease (PR1)	*Metarhizium anisopliae*	*Metarhizium anisopliae*	25 per cent reduction in time of kill in *Manduca sexta*	Leger *et al.* (1996)
Insect-specific scorpion neurotoxin AaIT	*Androctonus australis*	*B. bassiana*	Reduce the Median Lethal Times against *Dendrolimus punctatus* and *Galleria mellonella*	Lu *et al.* (2008)
PR1A	*M. anisopliae*			
Carbendazim tolerant gene (mrt)	*Botrytis cinerea*	*L. lecanii*	380-fold resistance to the fungicide	Zhang *et al.* (2014)

Other techniques

Strains of *M. anisopliae* and *B. bassiana* with fast mycelia growth and abundant sporulation were developed by protoplast fusion (Sirisha *et al*. 2010). Development of herbicide-tolerant strains of *L. lecanii*, with tolerance to phosphinothricin herbicide with a broad spectrum of action was developed using electroporation (Timofeev *et al*., 2019). Presnail and Hoy, (1992) transformed the predatory mite, *M. occidentalis*, with a heat shock protein (HSP 70) from Drosophila and Bar gene from *Streptomyces hygroscopicus* (Jensen) was transferred into *M. anisopliae* var. *acridum* to offer resistance against herbicides like bialaphos and glufosinate ammonium (Inglis *et al.,* 2000) using microinjection and microprojectile methods respectively.

	
Trichogramma sp Source: Arve *et al.* (2014)	*Chrysoperla* sp Source: https://entomology.ca.uky.edu/ef708

Conclusions

Natural enemies have no hazardous environmental impact, but their efficacy under various conditions limits their usage. The improvement of their potency can boost their uses over the chemical mode of pest control. The impact of genetically modified organisms in farmers' fields must be assessed, considering the ecological input of different organisms. Different biological attributes such as pesticide tolerance, extending temperature and relative humidity tolerances and altering host or habitat preferences could enhance the effectiveness of natural enemies. Hence, we should utilize these techniques to manipulate natural enemies to help our farmers.

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