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Insect Genetic Resources – Innovations in Utilisation

Chandish R Ballal* **and Richa Varshney**
ICAR-National Bureau of Agricultural Insect Resources, Post Bag No. 2491, HA Farm Post, Bellary Road, Hebbal, Bengaluru–560024, Karnataka, India

Insects can be a problem or an opportunity. Though the proportion of useful and harmful insects is low within the class Insecta, it is now widely acknowledged that interactions in the insect community impact the density and diversity of economically important insects. Generally the emphasis is on economically important insects as they visibly and directly influence mankind, while the number of agriculturally important insects that need to be documented far outweighs the mere quantum of economically important insects. Insect biodiversity is instrumentally important not only for the production of food, but for other ecological services as well, including the recycling of nutrients, regulation of microclimate and suppression of undesirable organisms. In the United States alone, pollination by bees accounts for over US$9 billion of economic revenue and some estimates indicate that over ⅓ of the human diet can be traced directly or indirectly to bee pollination. There are two key gaps in understanding and utilizing the positive aspects of insect diversity: a general neglect of insects in biodiversity research and an overemphasis on their negative impacts in all other biological research areas.

Macrobials for Pest Management

ICAR-National Bureau of Agricultural Insect Resources, Bangalore is constantly in quest of potential natural enemies/biological control agents for tackling major pests which damage economically important cash, horticultural and polyhouse crops. With the current demand for organic, pesticide-residue free commodities, the search for bio-agents has become more intense. The pre-requisite of any bio-control programme is to have a large-scale supply of beneficial agents. Biological control has gained maximum acceptance in India through use of *Trichogramma* species against several lepidopteran pests. The egg parasitoid *Trichogramma chilonis* Ishii is generally mass produced on the eggs of rice moth *Corcyra cephalonica* (Stainton). Recent studies indicate that the production of *T. chilonis* on eri silkworm *Samia cynthia ricini* eggs is a farmer friendly system (Fig.1) and it could potentially yield trichogrammatids with superior biological attributes. The quality of *T. chilonis* mass produced on eri silkworm eggs was assessed in the field against early shoot and internode borers which attack sugarcane and their performance was recorded to be on par with those reared on rice moth eggs (Table 1). This mass production system proves to be economical and feasible to be adopted by farmers (Lalitha *et al.*, 2013).

Fig. 1. ***Trichogramma chilonis*** **parasitizing eri silkworm egg**

Predators are also effectively used in pest management. Augmentative releases of the Australian lady bird beetle, *Cryptolaemus montrouzieri* have led to successful suppression of mealybugs on grapevine, guava and custard apple. Chrysopid predators are used for effective management of aphids. *Amphiareus constrictus* (Stål), biology of which has been less studied, was successfully reared in the laboratory on the eggs of *C. cephalonica* without any plant substrate. The mass reared *A. constrictus* was evaluated against the tomato pinworm *Tuta absoluta* (Meyrick) and the brown plant hopper *Nilaparvata lugens* Stål and was found to be a

*Author for Correspondence: Email- chandishballal.nbaii@gmail.com, ballalchandish@gmail.com

Table 1. Percent pest incidence, Percent pest intensity, Infestation index and Percent parasitism by *T. chilonis* and yield in different treatments

Treatments	Pest incidence ** (%)	Pest intensity ** (%)	Infestation Index*	Parasitism ** (%)
Control plot	84.4 (71.4)b	9.7 (18.3)b	8.5 (2.9)b	0.65 (5.6)b
T. chilonis reared on Esw eggs released plot	60 (53.9)a	5.4 (13.0)a	4.5 (1.9)a	9.79 (16.4)a
T. chilonis reared on Corcyra eggs released plot	54.7 (48.3)a	6.6 (13.4)a	5.2 (2.1)ab	7.65 (15.3)a
LSD at 5%	16.88	4.26	0.8	4.79***

promising bioagent. Recent outbreak of the litchi stink bug, *Tessaratoma javanica* (Thunberg) (Hemiptera: Tessaratomidae), in Jharkhand has generated a pressing need for developing suitable mass rearing protocols for the parasitoids associated with this pest. *Anastatus acherontiae* Narayanan, Subba Rao & Ramachandra Rao (Hymenoptera: Eupelmidae) and *A. bangalorensis* Mani & Kurian, egg parasitoids of *T. javanica*, were reared successfully on eggs of eri silk worm.

Role of Endosymbionts in Improving Fitness Attributes and Insecticide Degradation

Insect health is strongly influenced by the composition and activities of resident endosymbionts. They alter the reproductive mode of their hosts and provide protection from natural enemies, including bacteria, viruses, protozoa, and parasitic insects and various other plant allelochemicals (Huang *et al*., 2012; Kikuchi *et al*., 2012; Werren, 2012). The symbiotic infection confers not only insecticide resistance but spread of the resistant trait in the insect populations. Role of endosymbionts in fitness attributes (enhanced adult longevity, fecundity, parasitism / predatory potential, temperature tolerance and insecticide degradation) of *Trichogramma*, *Chrysoperla* and *Cotesia plutellae* was established at NBAIR. DNA sequence data for the endosymbionts were also generated.

Chrysopids are found to harbour many endosymbiotic yeast and bacteria in the gut as well as in diverticulum. These yeasts may be commercially exploited for the mass rearing programmes. *Enterobacter asburiae* associated with the gut of larva of *Chrysoperla zastrowi sillemi* degrades the acephate and indoxacarb by imparting resistance to larvae against acephate and Indoxacarb.

Acephate-degrading bacterial isolates *Bacillus cereus* (PXBC.Or), *Enterobacter asburiae* (PXE), and *Pantoae agglomerans* (PX-Pt.ag.Jor) were isolated from the larval gut of diamondback moth. Apart from the insect esterases, bacterial carboxylesterase may aid in the degradation of insecticides in DBM. This information would be useful for ssynthesis of new molecule having different modes of action for suitable pest management strategies against DBM.

Bt as Insect Derived Resources for Pest Management

At NBAIR novel *Bacillus thuringiensis*-based formulations have been developed. Presently more than 300 *Bt* strains have been characterised for their cry gene profile. Strains of *Bt* for coleopteran and dipteran pests have been identified. Cloning, Expression and Bioassay of Vip3A Protein for broad spectrum activity has shown promising results against *Spodoptera litura* (Rangeshwaran *et al*., 2016). Further work on classification of the wide diversity of *Bt.* strains, characterisation of anti-Hemipteran strains of *Bt*, cry protein with cytocidal activity against specific human cancer cells, and deciphering the natural role of *Bt* in the environment are in progress.

Exploitation of Endophytism of Entomofungal Pathogens for Insect Pest Management

Entomofungal pathogens such as *Beauveria bassiana, Metarhizium anisopliae*, *Lecanicillium* sp., *Paecilomyces* sp. which are generally used as foliar spray are found to occur naturally as endophytes in plant tissues. Presently, these isolates are being tested for their ability to establish as endophytes in crop plants and to exploit their endophytism as a novel delivery mechanism for managing the insect pests especially borer pests.

Six indigenous strains of *Beauveria bassiana* (NBAIR-Bb-5a, 7, 14, 19, 23 and 45) which were established as endophytes in stem and leaf tissues of maize (Fig.2) (Renuka *et al.,* 2016) and sorghum (Anon, 2016) were evaluated and Bb-5a isolate was found to be most effective against stem borer *(Chilo partellus)* in maize and sorghum by significantly reducing the pest infestation (by 60-70%) and increasing yield by 20% (Anonymous 2016). Multi-locational field trials are being

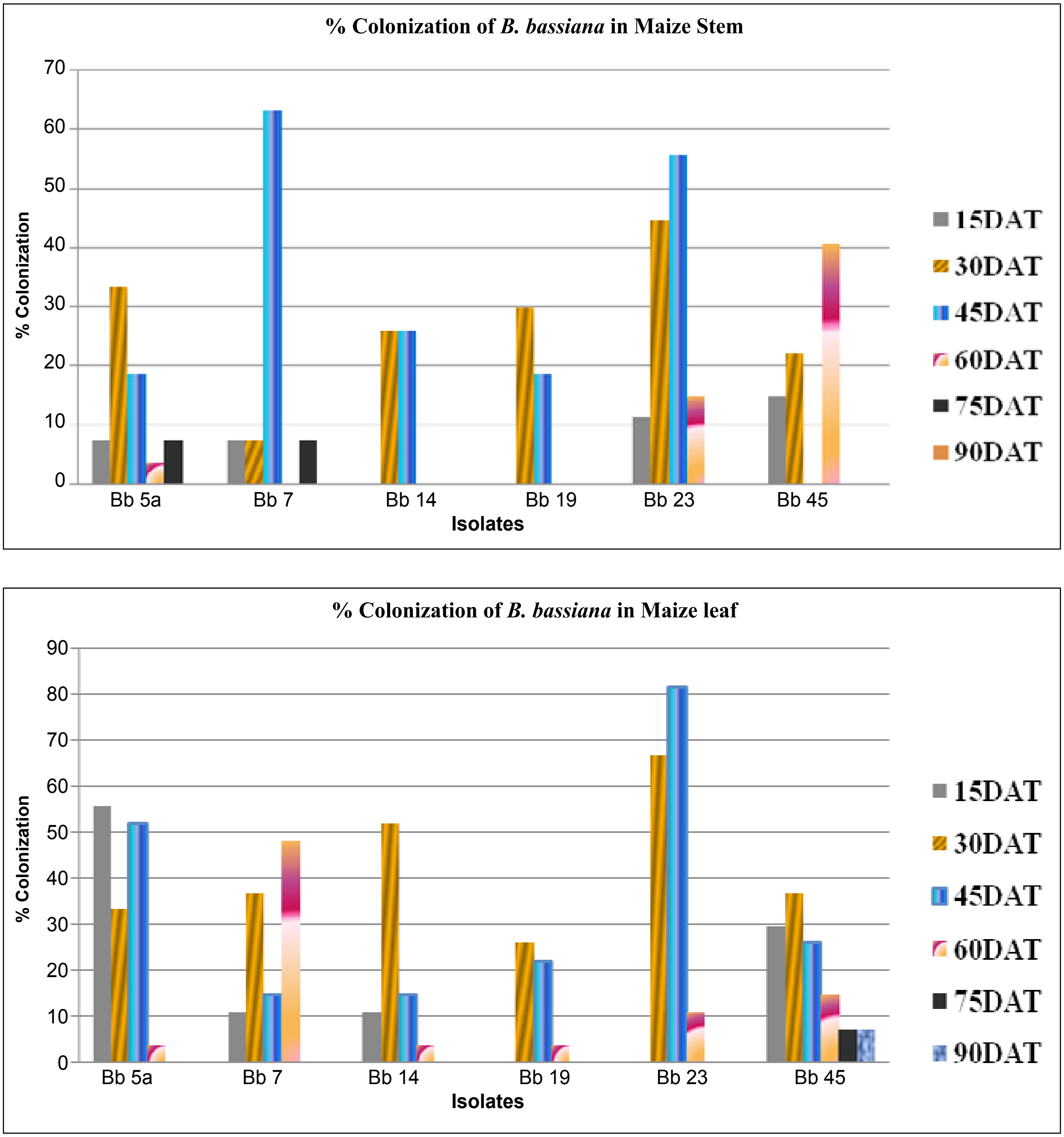

Fig. 2. Endophytic colonization of *B. bassiana* in Maize Stem and Leaf tissues (DAT: Days after treatment) (Renuka *et al.*, 2016)

attempted through AICRP Biocontrol & AICRP on maize. In cabbage and cauliflower, isolates of *B. bassiana* (Bb-5a, Bb-45 & Bb-68) and *M. anisopliae* (Ma-4, Ma-6 & Ma-35) have been established as endophytes and are being tested against *Plutella xylostella* (B. Ramanujam, Personal Communication).

Entomopathogenic Nematodes for Pest Management and Antagonists for Management of Plant Parasitic Nematodes

Diversity mapping and molecular identification have been done for 40 strains of EPNs (*Heterorhabditis* and *Steinernema* spp.). DNA barcoding has been done for 12 EPN strains (Nagesh *et al.*, 2013). Under pathogenomics of entomopathogenic nematodes against *G. mellonella*, NBAIR has sequenced whole genome & transcriptomes for four indigenous bacterial symbionts (*Photorhabdus indica, P. bacteriophora, H.* sp., and *Xenorhabdus* sp.) and identified some genes responsible for virulence through insecticidal, antibiotic and phase transmission properties. NBAIR has developed solid-state and diphasic fermentation and post-production technologies for contamination-free antagonistic fungi for the management of root-knot and cyst nematodes (Nagesh *et al*., 2007, 2013) and Indian patent rights have been granted to NBAIR on *A simple and novel design for small-scale solid state mass production unit for antagonistic fungi* (Indian Patent No. 275009).

Research efforts at NBAIR evolved *in vivo* production and formulation technologies for entomopathogenic nematodes with 10-12 months shelf-life, established their field efficacy against whitegrubs in arecanut, sugarcane, groundnut, maize, cardamom, redgram, ginger, eggplant etc. (Indian Patent application no. CHE/3490/2010). These technologies have been licensed to 14 commercial companies and currently in use over 20,000 ha across the country. Further, these technologies enabled win-win Private–Public Partnerships on EPN production and utilisation with a production of about 100 metric tonnes of WP formulation during 2015-16 alone.

Conclusion

Promising species/strains of macrobials and microbials have been identified for several of the notorious pests and diseases infesting crops. Simple and novel farmer friendly technologies have been standardised by NBAIR for the production of these potential bio-agents. At this juncture, armed with these technologies, focus should be on popularising the concept of biological control among farmers and motivating them to adopt this eco-friendly bio-approach as an important component of IPM.

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