Proceedings of the

5th International Symposium on Biological Control of Arthropods

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10.2 A Practice of *Trichogramma*-based IPM of Rice Insect Pests

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Insect pests, particularly the striped stem borers *Chilo suppressalis* (Walker), the yellow stem borer *Scirpophaga incertulas* Walker, the leaf roller *Cnaphalocrocis medinalis* Guenée (Lepidoptera: Crambidae), the brown planthopper *Nilaparvata lugens* (Stål), and the white-backed planthopper *Sogatella furcifera* (Horváth) (Hemiptera: Delphacidae), are the most consistent constraining factors in rice production (Jena *et al.*, 2012). Potential *Trichogramma* (Hymenoptera: Trichogrammatidae) strains were collected from the Greater Mekong Subregion (GMS) (Liu *et al.*, 2017), and tested for their suitability for mass production, tolerance to high temperatures typically occurring in the GMS, and performance against the targeted pests to select for the best performing species/strains. To ensure compatibility of released *Trichogramma* with indispensable insecticide application for control of planthoppers, the toxicity and timing of application of insecticides were evaluated. On the basis of these laboratory and field tests, a *Trichogramma*-based IPM was established and demonstrated.

In the tests for suitability for mass production at 25ºC, life history traits differed significantly among the strains and the three *Trichogramma chilonis* Ishii strains and a *T. ostriniae* Pang and Chen strain were of high performance (Guo *et al.*, unpublished data).

When female wasps from the 25ºC cultures were exposed to 34 and 37ºC, the usual ambient air temperatures in the GMS, for a whole generation, negative effects were observed on key life history parameters. Effects on parental females and their offsprings were observed at 34ºC, and these became even more serious at 37ºC. In particular, the two *T. ostrinae* strains were not able to successfully develop to adulthood at all at 37ºC while the *T. chilonis* strains showed offspring adult emergence,but offspring female longevity was only around one day and no parasitism was observed. When the three *T. chilonis* strains were exposed to 37ºC for 4 to 12 h at prepupal and pupal stages, reflecting heat

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shocks that the released *Trichogramma* may experience in the field, adult emergence when the exposure was 12 h was lower than that at 25ºC. Despite this, the three *T. chilonis* strains showed relatively high potential for mass production and field release in the subtropical target region. Our results demonstrate that tests at both rearing and field temperatures are necessary in selection of potential *Trichogramma* strains for an inundative release program where there is significant difference between rearing and field temperatures (Guo et al., unpublished data).

Performance of potential *Trichogramma* strains against the target pests, *C. suppressalis* and *S. incertulas*, was tested in laboratory and field experiments. In laboratory vial tests against *C. suppressalis*, all the *Trichogramma* strains showed higher parasitism rates on 0-24-h eggs than on the two older age groups (24-48 and 48-72 h). Wasp emergence rate was also higher from parasitized 0-24-h *C. suppressalis* eggs. Parasitism rates differed among *Trichogramma* strains, with *T. chilonis* CJ strain showing a significantly higher parasitism rate than any other strains. In field tests, parasitism of sentinel *C. suppressalis* eggs by *Trichogramma* strains released at 50,000, 100,000, and 200,000 wasps per hectare was low, with marginal yet significant differences between strains. The highest parasitism was achieved by *T. chilonis* CJ strain at the high and medium release rates. Hence, it can be concluded that *T. chilonis* CJ strain released at 100,000 wasps per hectare may be a cost-effective control tactic for field releases targeting *C. suppressalis* (Ko *et al.*, 2014).

Against *S. incertulas*, *T. japonicum* and *T. chilonis* were tested for their performance. A laboratory cage test showed that the two species parasitized *S. incertulas* egg masses at 60.0 ±9.1% and 40.7 ±7.1%, respectively, with egg parasitism rates of 15.8 ±22.2% for *T. japonicum* and 2.8 ±5.0% for *T. chilonis*. Emergence rates from parasitized eggs were high for both species (> 95%). In paddy field trials with release rates at 50,000, 100,000 and 200,000 wasps/ha, egg mass parasitism was 9 ±7.7% for *T. japonicum* and 15 ±14.1% for *T. chilonis*, and again only a relatively small fraction of eggs was successfully parasitized. No clear conclusion could be drawn on the most efficient release rate for *S. incertulas* as no significant differences were found among the three release rates. A comparison of field collected and mass reared wasps showed significantly larger body size and ovipositor length in field collected wasps, suggesting potentially higher effectiveness of the released *Trichogramma* on *S. incertulas* eggs after at least one generation (Tang *et al.*, 2017).

Compatibility of released biocontrol agents with other management measures, especially pesticides, has to be considered in any IPM systems. Planthopper-targeting insecticides, pymetrozine, thiamethoxam, buprofezin and nitenpyram, were tested for toxicity to adults and immatures of *T. chilonis* using standard tests described by IOBC (Sterk *et al.*, 1999). In the dry film residue test, all insecticides resulted in more than 90% mortality in wasp adults and were ranked as moderately harmful. Persistent toxicity tests revealed that nitenpyram was short-lived and the other three insecticides were of slightly persistent toxicity to the wasp adults. Insecticides applied on egg, larval and prepupal stages of *T. chilonis* reduced the parasitism rate, but nitenpyram and pymetrozine applied at egg stage, buprofezin and nitenpyram at larval stage, and buprofezin and thiamethoxam at prepupal stage were ranked as harmless. Although insecticide treatment of the three wasp immature stages all reduced wasp emergence, only thiamethoxam applied at larval stage and buprofezin at prepupal stage were categorized as harmful. The data are of significance for IPM programs incorporating inundative release of *Trichogramma* for control of lepidopteran rice pests where there is heavy co-occurrence of planthoppers (Ko *et al.*, 2015).

A *Trichogramma*-based IPM was established and demonstrated, which included the such key elements as monitoring of pests as basis for decision making, release of *Trichogramma* at 3-4 times per season, reduction of chemical insecticide applications and use of bio-pesticides, growing nectar plants on bunds, balanced fertilization, and alternative wetting and drying. The demonstration showed that, while IPM plots received 1.5-2.5 times less pesticide applications than the control, pest incidence was generally similar between IPM and control plots with a trend towards lower numbers in IPM plots late in the season. Results also showed that numbers of natural enemies were higher in IPM plots compared to the control, 30-60% parasitism by *Trichogramma* on striped stem borer and leaf roller eggs were observed in IPM plots in contrast to about 5% in the control, 150-200 kg/ha extra rice was harvested from IPM plots, and pesticide input costs was reduced in IPM plots by about 230 USD/ha (excl. costs for *Trichogramma*) (Hou et al., unpublished data). These results indicate that a well-tuned *Trichogramma*-based IPM based on locally adapted strains of parasitoids, can achieve substantial control of rice insect pests while reducing pesticide use and costs for plant protection, and thus can contribute to the health of agro-ecosystem and sustainable development of rice production. With years of successive practice, a more promising expectation of the beneficial effects of the *Trichogramma*-based IPM can be expected.

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The 5th International Symposium on Biological Control of Arthropods, held in Langkawi, Malaysia, continues the series of international symposia on the biological control of arthropods organized every four years. The first meeting was in Honolulu, Hawaii, USA in January 2002, followed by the Davos, Switzerland meeting in September 2005, the Christchurch, New Zealand meeting in February 2009, and the Pucón, Chile meeting in March 2013. The goal of these symposia is to create a forum where biological control researchers and practitioners can meet and exchange information, to promote discussions of up-to-date issues affecting biological control, particularly pertaining to the use of parasitoids and predators as biological control agents. This includes all approaches to biological control: conservation, augmentation, and importation of natural enemy species for the control of arthropod targets, as well as other transversal issues related to its implementation.

Topics covered include:

- non-target impacts in biological control as the cornerstone of successful integrated pest management programmes;
- regulation and risk assessment methodology;
- implementing access and benefit sharing policies;
- assessing the impact of biological control programmes for both cost–benefit analyses and determining the socio-economic impact and effect on livelihoods;
- understanding the uptake of biological control solutions in low and lower middle income countries to replace the use of highly hazardous pesticides;
- the role of native and exotic natural enemies; and
- the importance of pre- and post-genetics in biological control.

Cover image: *Apechtis compunctor* (L.) attacking a pupa of *Cydalima perspectalis* (Walker). Photo by Tim Haye.