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Exploitation of Biocontrol Agents, *Trichogramma chilonis* and *Tetrastichus howardi* on Yield Improvement in Sugarcane at EID Parry (India) Ltd., Sugar Mill Command Areas

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Abstract:
Insect pests are one of the major causes for reduction in sugarcane yield. In particular, borer's damage in sugarcane crop is a subject of concern in Tamil Nadu. Though the general pest control measures recommended is the use of chemical pesticides, this is difficult in sugarcane due to environmental hazard, canopy structure and resistance. The concept of biological control is the only effective and eco friendly approach for internode borer management in sugarcane cultivation. E.I.D Parry (India) Ltd., is committed to safe environment and sustainable agriculture. Since 1997, Parry Mills to manage a major pest of sugarcane internode borer, Chilo Sacchariphagus indicus (INB) by releasing biocontrol agent, Trichogramma chilonis (egg parasitoid), later, 2007 onwards added another biocontrol agent such as, Tetrastichus howardi (pupal parasitoid). However, these two biocontrol agents are also taking care of cane damages from other borer pests of Sugarcane early shoot borer, Chilo infuscatellus, and sugarcane top shoot borer, Scirpophaga excerptalis.

Keywords*: biocontrol agents, sugarcane internode borer, trichogramma chilonis, tetrastichus howardi.*

1. Introduction

Sugarcane is one of the major industrial crops in India, cultivated under diverse agro climatic conditions. Cane yield is markedly influenced by many factors like soil fertility, climate, variety, and cultural practices, prevalence of pests and diseases and environmental stress. Insect pests are known to inflict considerable losses both in cane yield and sugar output. The loss due to pest has been estimated from 15-20% in cane yield and 15% in sugar recovery. Although pests are generally more devastating in the subtropics, tropical region of India and also experiences seriousness of some pests in specific situations is necessitating evolution of strategies to maintain them below damaging level.

1.1. Pest Problems

More than 200 species of insects and non-insects pests that infest sugarcane crop are economically important. In tropical India, borers and sucking pest are the major aerial pests while termites and white grubs constitute subterranean pests. Among the borer's in sugarcane, an early shoot borer (ESB) and sugarcane internode borers (INB) are the economically important pests and the losses caused by these borer pests varied in different sugarcane-growing regions. Biological control methods have been made available for almost all major insect pests infesting sugarcane in our EID Parry (I) Ltd 4 Mill command areas *viz.*, Nellikuppam, Pugalur, Pettavaithalai and Pondicherry. Our earlier unpublished record shows that an excellent control of sugarcane top shoot borer has been achieved in tropical India by making inoculative releases of an indigenous parasitic wasp insect, *Isotima javensis* which keeps the top shoot borer incidence below 5-10% in Tamil Nadu and Pondicherry region.

The term pest management as opposed to pest control, in itself contains the inherent suggestion that pests are to be managed and not completely controlled or eradicated. Pest control, in fact is the earliest concept and remained valid for a considerable period ie. As long as the methods of the earlier times delivered goods, with the realization of pests to hit back the concept of their management or

containment within some tolerable levels called economic injury level (EIL) and economic threshold level (ETL) emerged. In pest management any single method followed for pest suppression had its own limitations and inadequacies; hence more than one method was integrated for pest management and thus the concept of integrated pest management evolved. Our Parry Mills command cane areas are following the concept of IPM (The integrated use of all available methods and strategies to manage the pest population below the EIL with least ecological or environment disturbance and greatest socio-economic acceptance).

1.2. Exploitation of Biocontrol agents

The bio control agent used *Trichogramma chilonis*, an egg parasite to control Inter node borer (INB). *Trichogramma* cards are produced and distributed to farmers through rural entrepreneur- model (Jaigeetha *et al*., 2014). Another biocontrol agent, *Tetrastichus howardi*, developed in our lab and released to the cane command area since 2007. The objectives of this study was to determine the effect of different biocontrol agents controlling borer pests in sugarcane and total cane yield compared from biocontrol agents released and non released fields among the 4 Mills to asses the yield parameter to non released plots (Sankar *et al*., 2014).

2. Materials and Methods

2.1. Production of Biocontrol agents: Trichogramma chilonis (egg parasitoid)

An egg parasitoid, *Trichogramma chilonis* was mass produced by using rice moth, *Corcyra cephalonica* eggs and this host insect larva were mass reared in the biocontrol labs located at Pugalur and Nellikuppam Sugar Mills in partially grained cumbu grains sub suited with yeast and groundnut powder mixed media. The host insect eggs were collected from the ovipositor cage and sterilized for 20 minutes in a Ultra Violet (UV) chamber. The sterilized eggs were pasted on the yellow cards with help of gum and allowed the freshly emerged *Trichogramma chilonis* adult insects for 48h to parasitize at room temperature 27^0c in a hygienic condition. The Trichogramma adults parasitized egg cards *i.e.* tricho cards were initially mass produced and distributed to farmers from our R&D laboratories. Later, the standardized technology was commercially made successful; the Tricho card production facility was expanded and increased through rural entrepreneur model. In this model the innovative and entrepreneurship cane growing farmers were encouraged, extended financial and technical assistance from the company. These rural entrepreneurs were developed as a successful business model. This gave options for some of the farmers for additional income and also easier way of controlling INB.

2.2. Production of Biocontrol agents: Tetrastichus howardi (Pupal parasitoid)

The biocontrol agent, *Tetrastichus howardi* was initially mass reared using pupae of tobacco cut worm, *Spodoptera litura* in our biocontrol lab at Pugalur and Nellikuppam Sugar Mills. The host insect, *S. litura* young stage larvae from 1^{st} to 3^{rd} instars were fed with castor leaves in a group and the later stages 4^{th} and 5^{th} instars were reared separately on artificial diet prepared by using basin flour, yeast, and multivitamins sub suiting agar as a wetting agent to the media. The fully grown pupa of *S. litura* was used to mass produce the parasitic insect, *Tetrastichus howardi*.

Later, the works have initiate in search of an another host insect to alter the existing host insect, tobacco cut worm, *S. litura* to mass produce *T. howardi* to increase the percentage of cane area to cover from 80 to 100%. Ultimately it is an urgent need of finding new host insect which is bigger in size and rich nutrients supporting the growth and production of more offspring. *Tetrastichus sp* is a pupal parasitoid for all the lepidopteron insects which needs particularly pupal stage to continue its life cycle and its progeny development.

In the study, initially we have tried few locally available lepidopteron insects pupa like; cotton boll worm, *Helicoverpa armigera,* Pink boll worm, *Sesamia inference* reared in artificial diet and eri silkworm, *Philosamia ricini* and Mulberry silk worm, *Bombyx mori* reared on castor leaves as referred by Priyadarshini (2013) in the biocontrol laboratory at Pugalur Sugar Mill. Pupa of *Bombyx mori and Philosamia ricini* was able to parasitize by the tetrastichus insects and its progeny was recorded more than the progeny produced by *S. litura.* The pupal size of *B. mori and P. ricini* was more than the other insects which was varying from 2.0 to 2.5 g wt, however the percent parasitization by Tetrastichus insects of pupa of *Bombyx mori* recorded only 10% and it was noticed that the most of the pupae infecting with microorganisms however the larva and pupal cultures of *Philosamia ricini* could able to multiply in the laboratory at temp., vary from 25 to 27^0c without any mortality. Pupae of *Philosamia ricini* showed parasitizing more than 50% by Tetrastichus insects and considerable number of progeny was developed in the laboratory. Hence the Tetrastichus is being multiplied by using pupae of *Philosamia ricini* the same is being released to our cane command areas for the management of sugarcane internode borer at pupal stage.

To make this model more sustainable, the tricho card distribution to farmers is done through unique distribution system and the payment is routed through company once in fortnight interval. Due to sustained income and hassle free marketing, currently 14 *Trichogramma* rural entrepreneur production centers are functioning in all four EID Parry mill command areas in Tamil nadu and Pondicherry. Parry is pioneer organization to introduce this rural entrepreneur model for bio control agent production which is now been followed by other sugar mills in India and the same is also introduced in foreign countries. We also have ambitious plans of expanding this entrepreneur base to cover the entire Parry command area for a sustainable pest control.

2.3. Biocontrol agents release plan

The biocontrol agents such as; egg parasitised tricho cards are released 2 cards/month @ 1 cc/ac fortnight interval and the total of 6 cc/ac for 3 months continuous release on 4^{th}, 5^{th} and 6^{th} month aged cane. The pupal parasitoid, *Tetrastichus howardi* were released

500 insects/month on 5th, 6th and 7th month aged cane for 3 months and the total of 1500 insects/ac. Both the biocontrol agents were released on the cane var., Co-86032 of both plant & ratoon crops in our Parry mill command areas of Nellikuppam, Puducherry, Pugalur and Pettavaithalai Units. Data on total percent cane yield (MT/ac) of sugarcane var., Co-86032 with biocontrol agents released and non-released plots and individual data of trichogramma and tetrastichus released data was obtained from our net based Cane Management system (CMS) for the sugar year 2012-13 in all the sugar Mills and was statistically analyzed with One Way ANOVA to draw the conclusion.

3. Results and Discussion

Trichogramma, an egg parasitoid can be used in controlling many lepidopteran pests. Therefore, it is necessary to demonstrate the capacity of these natural enemies in controlling the pest population so as to use them in biological control programs against the pest. Biological control agents have been considered a viable alternative for pest control and new research is being carried out constantly to find new natural enemies or improve the efficiency of known ones. Since 2007, we are concentrating of releasing the egg parasitoid, *Trichogramma chilonis* and the pupal parasitoid, *Tetrastichus howardi* are being used in controlling many lepidopteran pests Therefore, it is necessary to demonstrate the capacity of these natural enemies in controlling the pest population so as to use them in biological control programs against the pest. EID Parry (I) Ltd., have challenge in controlling the major pest of Internode borer (INB), *Chilo sacchariphagus indica* releasing only biocontrol agents promoting through entrepreneur model to save the crop from the borer pests complex avoiding pesticides and its residual effect with an ecofriendly approach. The results of present study and data obtained for the sugar year 2012-13 showed that the effectiveness of the biocontrol agents *T. chilonis* and *T. howardi* managing pest control with an percent yield increases was varied differently among two climatic zones *viz.*, East coat and Peninsular zone in our Mill command areas.

Based on the percent yield of cane per acreage, the egg parasitoid, *T. chilonis* has a better control over the pupal parasitoid, *T. howardi* in the sugar command areas of Nellikuppam and Puducherry. An average % cane yield of 38.96% and 36.71% was recorded Nellikuppam and Puducherry mill areas against the non biocontrol agents release plot average yield of 32.61% and 33.85% respectively (Fig.1) which come under East Coast zone having hot & humid climate (Table-1). Among the mill command area, the percent cane yield increases data shows that the sugarcane internode borer is being managed by trichogramma insects increasing its parasitization rate in the field under this favorable condition which come under East Coast zone having hot & humid climate. Earlier Sing and Jalali (1994) reported that trichogrammatids are one of the most important groups of biotic agents for the suppression of many lepidopterous pests under favorable condition in India. Host preference is also one of role of increasing the rate of parasitization by trichogramma, recently Puneeth and Vijayan (2013) reported that the parasitization rate of *T. chilonis* was found to be 61% on *Corcyra cephalonica* eggs and 80 % on the eggs of *Spodoptera litura*.

The pupal parasitoid, *T. howardi* is a common of attacking an economically important pests in agricultural. Tawar *et al* (1996) reported that the pupal parasitoid, *Tetrastichus howardi* was identified as a hyperparasitoid of the Tachinids, *Goniophthalmus halli* and *Senometopia illota* and *Helicoverpa armigera* pupae in pigeon pea fields in southern India and they have also recorded 59% of parasitization on *G. halli* and *S. illota* pupae however, *T. howardi* was not a primary parasitoid of *H. armigera* and the percent parasitization was recorded below 10%. Coincidence of the above reports, in our study, the pupal parasitoid, *T. howardi* showed better control of sugarcane inter node borer (INB), *Chilo sacchariphagus indica* in our mill areas of Pugalur and Pettavaithalai which was recording more yield of 26.3 % and 22.98 % respectively against non biocontrol agents released plots (22.9% and 22.54%) (Fig.2) which come under Peninsular Zone having hot & dry Cauvery basin. Elizangela *et al*., (2011) also confirmed that *Diatraea* sp. (sugarcane INB) pupae parasitized by *T. howardi* were naturally collected in sugarcane fields in Dourados, Mato Grosso do Sul State, Brazil. Baitha *et al*., (2004) also given an evidence of his report that they recorded pupal parasitoid *T. howardi* is increasing the parasitizing efficiency of *Chilo partellus* (Swinhoe) which is coming under the same species of *Chilo sacchariphagus indica*. Fig. 3 shows among the sugar Mills command areas, the difference in % yield of cane (MT/ac) increased by the way of reducing INB damages by exploring these two biocontrol agents and its individual percent variation are shown very clearly on sugarcane *var*., Co-86032 in plant and ratoon crops.

4. Conclusion

Effectiveness of *Trichogramma chilonis* (egg parasitoid) and *Tetrastichus howardi* (pupal parasitoid) on different climatic zones: *T. chilonis* has a better control over *T. howardi* in the sugar command areas of Nellikuppam and Puducherry which come under East coast zone having hot & humid climate whereas *T. howardi* has a better control in the mill areas of Pugalur and Pettavaithalai which come under Peninsular Zone having hot & dry Cauvery basin controlling sugarcane internode borer, *Chilo sacchariphagus indicus.*

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Average yield (MT/ac)			
Mill	**% of increase**	**Yield of plot With Activity***	**Yield of plot Without Activity**
Nellikuppam	19.47%	38.96	32.61
Pugalur	10.56%	25.54	23.1
Pettavaithalai	0.53%	22.7	22.58
Puducherry	8.45%	36.71	33.85

Table 1: Percentage yield increase with the egg parasitoid, T. chilonis released plots in EID Parry command areas
** Biocontrol agent egg parasitoid, Trichogramma chilonis (tricho card) released.*

Average yield (MT/ac)			
Mill	**% of increase**	**Yield of plot With Activity***	**Yield of plot Without Activity**
Nellikuppam	19.01%	38.44	32.3
Pugalur	14.93%	26.32	22.9
Pettavaithalai	1.95%	22.98	22.54
Puducherry	5.92%	35.81	33.81

Table 2: Yield of Co-86032 in the biocontrol released and non-released plots in Parry command area.
** Biocontrol agent, pupal parasitoid, Tetrastichus howardi released*

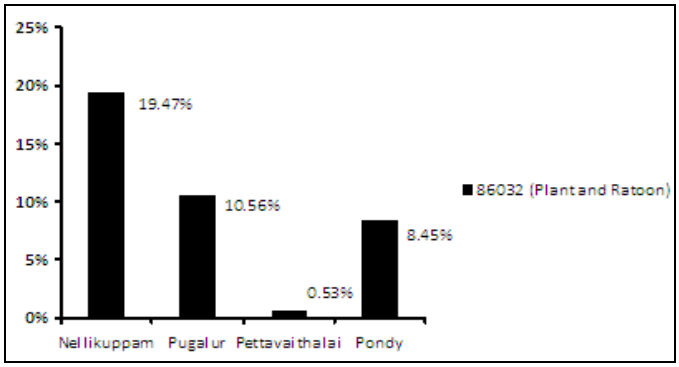

Figure 1: Cane % yield increases with the impact of egg parasitoid, Trichogramma chilonis released plots in the Parry command areas

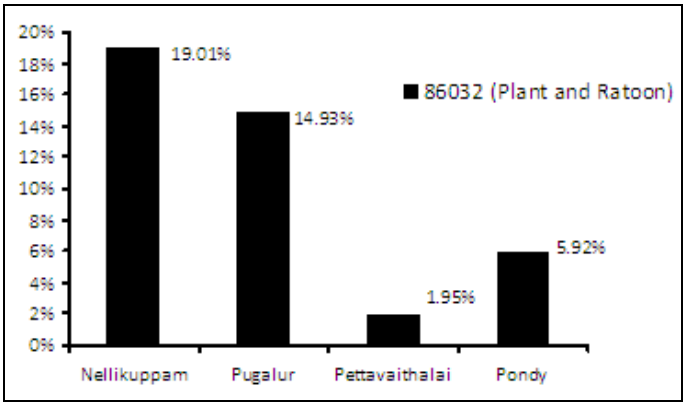

Figure 2: Percent (%) yield increase with the impact of pupal parasitoid, T. howardi released plots in the Parry command areas

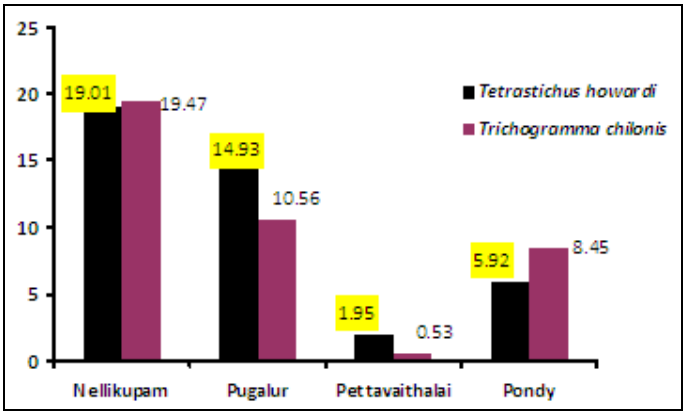

Figure 3: Percentage increases on average yield/ac of trichogramma and tetrastichus releases plots in the Parry command areas

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