



Impact of paddy growth stages on the parasitoid community of yellow stem borer (*Scirpophaga incertulas*)

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ABSTRACT

The yellow stem borer (YSB) (*Scirpophaga incertulas*) (Pyralidae: Lepidoptera) is a conundrum pest of paddy in India. One of the best ways to overcome the attack of this pest is to control the initial stage of its life cycle by parasitoids. Per cent infestation of yellow stem borer and extent of parasitization was assessed in organic and conventional paddy fields at ICAR-Indian Agricultural Research Institute, New Delhi. Results revealed that stem borer infestation was more (0.59%) in conventional rice than organic rice (0.47%). Larval parasitoids, viz., *Myosoma chinensis* (Szepligeti), *Trathala flavoorbitalis*, *Temelucha philippinensis* and pupal parasitoids *Xanthopimpla punctata* emerged from both conventional and organic cropping systems. *Myosoma chinensis* was the most dominant among all the parasitoids recorded and all are new records to Delhi region. This study indicated that organic cultivation practices supported more to beneficial insects. Overall per cent parasitization under organic ecosystem was higher (34.6%) to conventional ecosystem (13.3%).

Key words: Beneficial insects, *Myosoma chinensis*, Organic ecosystem, Parasitization

Rice (*Oryza sativa* L.) is one of the world's most important food crops, a staple food for nearly half of the global population (Prasad *et al.* 2017). There are more than 800 insect species damaging rice but in tropical Asia about 20 species are of major importance and of regular occurrence (Dale 1994). Adoption of modern technologies of crop production had aggravated the insect pest problem. Rice production experiences approximately 25% yield loss every season due to insect pests in India (Dhaliwal *et al.* 2010). Among them stem borer (*Scirpophaga incertulas*), is the most widespread and serious insect pest of rice, regularly infesting rice plants from seedling stage to maturity. Other stem borer species like *S. fusciflua* and *S. virginia* were also recorded from India on rice crop (Saini *et al.* 2017a;). Symptoms of infestation for measuring stem borer incidence are percentage of dead hearts during vegetative stage and percentage of white heads at flowering and maturity stages. Host plant resistance to yellow stem borer is ambiguous. Cultural, mechanical and chemical control methods have been employed to minimize the losses due to stem borer but the control measures are often not successful as the larvae remain concealed inside. Hence, biological control is the

most logical, economical, and environmentally sound pest management strategy. However, activity of the parasitoid occurs only during specific stages of the crop, coinciding with the developmental stages of the pest. On the other hand organic agriculture promotes a natural environment and sustains the health of the soil ecosystem and people. It also keeps the soil strong and fertile to maintain the diversity of the entomophagous insects that suppresses pest population thus maintains the ecological balance. Conventional method of growing rice requires the use of synthetic fertilizer and pesticides for higher productivity. Conventional production system is believed to enhance soil degradation, pollution and chemical residues in food and loss in diversity of useful fauna. It also intensifies the farm household's actual and physiological burden on high-cash capital expenses. In India, during *kharif* season, *S. incertulas* causes damage to all the developmental stages of paddy causing heavy losses. Therefore, there is need to study the per cent infestation and to explore the potential parasitoids with the activity of developmental stages of pest. The knowledge on the incidence of larval and pupal parasitoids will certainly be helpful in formulating the insect pest management strategies for *S. incertulas*. Therefore, an attempt has been made to understand the effect of conventional and organic cultivation practices on the stem borer infestation and per cent parasitism at larval and pupal developmental stages. So far no such field observation even of preliminary nature has been carried out in the rice growing areas of India under organic rice production.

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MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of 2019 at Research Farm of ICAR–Indian Agricultural Research Institute, New Delhi located at the latitude of 28°38' N, longitude of 77°10' E and altitude of 228.6 m above the mean sea level. The climate of Delhi is of sub-tropical and semi-arid type with hot and dry summer and cold winter and falls under the agro-climatic zone 'Trans-Gangetic plains'. The mean annual normal rainfall was 650 mm and annual mean pan evaporation was about 850 mm. The soil of experimental field was sandy clay loam in texture having pH 7.6, organic carbon (0.54%) and available N, P, K and DTPA-extractable Zn of 200.3 kg/ha, 23.3 kg/ha, 284.6 kg/ha and 0.87 mg/kg, respectively (Prasad *et al.* 2006). The rice variety Pusa Basmati 1 was grown in 4.8 m × 4.8 m plot size under long term field experiment of organic basmati production system. Management of organic and conventional rice ecosystem difference was made by using fertilizers, pesticide and plant refuge. The quantity of inorganic fertilizers applied in the conventional field was 120 kg N, 60 kg P₂O₅ and 50 kg K₂O/ha, respectively. All quantity of P₂O₅, K₂O was applied as basal application at the time of puddling, whereas N was applied in three split doses at 10, 30 and 50 days after transplanting (DAT), respectively. The nutrient inputs for the organic rice field included well decomposed farmyard manure (FYM) @ 10 t/ha. Other standard agronomic packages of practices were followed to raise the rice crop under both the production

system, i.e. conventional and organic.

The percentage infestation of yellow stem borer at different growth stages like tillering, boot leaf, flag leaf and panicle initiation stage was studied based on number of infested hills. Similarly effect of crop growth stages on the per cent parasitisation of larval and pupal parasitoids under conventional and organic production system was carried out. The fifteen dead hearts caused by *S. incertulas* were collected randomly at different crop growth stages from both the production system. The collected dead hearts were brought to the laboratory and kept individually till the emergence of adult parasitoids. Observations were recorded on number of adult parasitoids emerged from parasitized larvae and pupae and percent parasitisation was calculated. Further, the parasitoid spp were preserved and processed for taxonomic studies.

RESULTS AND DISCUSSION

Estimates of the percentage of dead hearts and white heads at different developmental stages indicated that stem borer infestation was more (0.30% to 0.43%) in conventional rice at initial developmental stages of paddy. Before harvesting white ear incidence was more in organic rice (1.56%) compared to conventional rice (1.34%) (Fig 1). In the present study per cent parasitization by larval and larval pupal parasitoids of stem borer in both the systems was studied (Table 1 & 2). Population of the natural enemies fluctuated depending upon the developmental

Table 1 Parasitization of *S. incertulas* by various parasitoids in organic rice ecosystem during *kharif*, 2019

Stage of crop growth	<i>Myosoma chinensis</i>		<i>Trathala flavoorbitalis</i>		<i>Xanthopimpla punctata</i>		<i>Temelucha philippinensis</i>	
	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism
Tillering stage	2	13.3	0	0	0	0	0	0
Boot leaf stage	3	20	0	0	1	6.7	1	6.7
Flag leaf stage	5	33.3	1	6.7	2	13.3	2	13.3
Panicle initiation stage	4	26.7	1	6.7	1	6.7	1	6.7
Harvesting stage	2	13.3	0	0	2	6.7	1	6.7
Mean		17.3		2.6		8		6.6

Table 2 Parasitization of *S. incertulas* by various parasitoids in conventional rice ecosystem during *kharif*, 2019

Stage of crop growth	<i>Myosoma chinensis</i>		<i>Trathala flavoorbitalis</i>		<i>Xanthopimpla punctata</i>		<i>Temelucha philippinensis</i>	
	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism	No. of parasitized larvae	% parasitism
Tillering stage	1	6.7	0	0	0	0	0	0
Boot leaf stage	0	0	0	0	0	0	1	6.7
Flag leaf stage	0	0	0	0	1	6.7	1	6.7
Panicle initiation stage	2	13.3	0	0	0	0	0	0
Harvesting stage	1	6.7	0	0	1	6.7	1	6.7
Mean		6.6		0		2.6		4

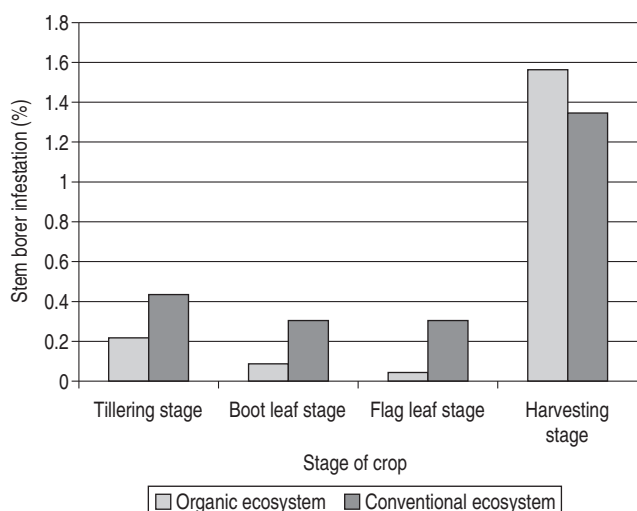


Fig 1 Per cent infestation of *S. incertulas* in organic and conventional rice ecosystem

stage of the borers. Recorded parasitoids belong to two families of Hymenoptera, viz. Ichneumonidae and Braconidae. Ichneumonidae is an important parasitoid group in terrestrial ecosystems having two families like Ichneumonidae and Braconidae and can be used to evaluate variable patterns of habitat disturbance and modification (Samways 1993, Delfon and Burgos 2000). Maintaining high parasitoid diversity is very important in preserving and sustaining the unpaid natural control services provided by agro ecosystems (Buchori *et al.* 2008). Natural enemies, especially parasitoids and predators, are always present in annual paddy fields (Laba 2001). During the present study the parasitoids emerging from *S. incertulas* larvae were identified as *Myosoma chinensis* (Szepligeti), *Trathala flavaorbitalis*, *Temelucha philippinensis* and pupal parasitoids like *Xanthopimpla punctata* belongs to the families Braconidae and Ichneumonidae, respectively. Overall per cent parasitization under organic ecosystem was higher (34.6%) when compared to the conventional ecosystem (13.3 %). This study was supported by Yaharwandi and Hidrayani (2014) who reported that a total of 717 individuals of hymenopteran parasitoids were collected consisting of 21 families and 131 species from both organic and conventional agro ecosystems. In organic agro ecosystems 533 individuals were collected consisting of 20 families and 85 species, whereas in conventional ones 184 individuals were collected, consisting of 13 families and 46 species.

Per cent parasitization by *Myosoma chinensis*:

Many species of Braconidae have been used successfully in pest management programs to control lepidopterous pests. Most members of Braconinae are koinobiont parasitoids of lepidopteran larvae. The species are easy to recognize with identification marks like Head reddish-testaceous, Metasoma (abdomen) smooth and shiny, petiole (tergum 1) with median tergite black, posterior margin with a narrow white band.

Ovipositor prominent, but shorter than body. In our study mean parasitism by *Myosoma chinensis* on larvae of *S. incertulas* was 17.3% in organic rice. However parasitism was higher (20%) at tillering and harvesting stages compared to the other stages. Further under conventional farming system mean parasitism by *B. chinensis* was quite low (6.7%), although it was 13.6% at panicle initiation stage (Table 1 & 2). This parasitoid commonly found in association with graminaceous stem borers on rice, sorghum, maize, and sugarcane, particularly, *Chilo partellus* (Swinhoe), and other *Chilo* spp., *Scirpophaga excerptalis* and *Sesamia inferens*. Ovruski *et al.* (2015) reported that parasitoid populations were found to dwindle during the rainy season. Further insecticide spray areas many parasitoids enter diapauses to overcome adverse conditions. Also during emergence of panicle, the use of pesticides affected chalcid populations seriously (Menon *et al.* 2016).

Per cent parasitization by *Trathala flavaorbitalis*

Trathala flavaorbitalis Cameron (Hymenoptera: Ichneumonidae), is a larval parasitoid of stem borer recognizable by its orange colour with yellow scutellum, unique metasomal coloration with tergites 1 and 2 black brown (Rousse *et al.* 2011). No parasitism by *Trathala flavaorbitalis* was observed in the conventional rice ecosystem. Although the overall mean parasitism by *Trathala flavaorbitalis* was low (2.6%) in the organic fields (Table 1 & 2). It was supported by FAO (1979) and Greathead (1979), reported that when little or no insecticide is used, tropical irrigated rice fields possess a rich arthropod community including many different kinds of natural enemies. The present results support a management strategy that promotes the conservation of existing natural biological control agents through a major reduction in insecticide use and a corresponding increase in habitat heterogeneity.

Per cent parasitization of *Xanthopimpla punctata* in paddy crop

The species of *Xanthopimpla* are important parasitoids of lepidopterous stem borers of cereals, sugarcane, and sometimes, other crops. The species are easy to recognise and almost all known species are more or less bright yellow in colour, with or without black spots on various parts of the body. *X. punctata* was recorded in both ecosystems. In the present study under organic condition, the overall mean parasitism by *X. punctata* on larvae of *S. incertulas* was recorded as 8% and 13.3% during flag leaf and harvesting stages, respectively. The per cent parasitisation of *X. punctata* recorded in conventional ecosystem on larvae of *S. incertulas* much lower at 2.6% (Table 1 & 2). During initial growth stages, no parasitism was recorded. The intensification and simplification of conventional agricultural systems have been characterized by a reduction in non-crop habitat, which leads to decrease in natural enemy populations and subsequent increase in pest abundance (Miles *et al.* 2011). *Xanthopimpla* species are endo parasitoids of lepidopteran pupae and its choice

of preferred hosts varies according to species. They are important due to their abundance and role as biological control agent (Townes 1970).

Per cent parasitization by Temelucha philippinensis

Parasitisation by *T. philippinensis* was recorded in both the systems. *Temelucha* is medium-sized fast flier. The adult wasp is orange brown and looks like *Macrocentrus*, except that it has a flattened abdomen and shorter antennae. It is a larval parasitoid attack stem borer larvae when it moves from one tiller to another before they can rebore into the rice stem. In the present study, results reveal that in organic ecosystem overall mean parasitism by *T. philippinensis* on *S. incertulas* larvae was 6.6%. The highest parasitism of 13.0 % was recorded during flag leaf stage, whereas in the conventional ecosystem the per cent parasitisation by *T. philippinensis* revealed that, the overall mean parasitism by *T. philippinensis* on *S. incertulas* larvae was 4.0%.. (Table 1 & 2). As parasitoids are natural regulators, exercising control over the populations of many phytophagous groups of insects it is essential to understand parasitoid diversity patterns (LaSalle and Gauld 1993). Overcoming these impediments future studies should focus on species (not higher taxonomic categories) within parasitoid complexes. Bhattacharyya *et al.* (2006) recorded 30 species of parasitoids belonging to 10 families of Hymenoptera, viz. Braconidae, Ichneumonidae, Scelionidae, Trichogrammatidae, Bethyridae, Eulophidae, Chalcididae, Pteromalidae, Ceraphronidae and Vespidae from rice fields during 1999-2000 at three locations in Jorhat, Assam. However, in our study no host associations were made and also host and host range associations were recorded. Overall per cent parasitization under organic ecosystem was more (34.6%) compared to conventional ecosystem (13.3%).

During the present study it was observed that population of natural enemies fluctuated depending upon the developmental stage of *S. incertulas*. In our study among the parasitoids, most abundant species was *Bracon* which was observed during the cropping season in both organic and conventional ecosystems. All the parasitoids were new records to Delhi region as per the compiled checklist of the biodiversity of hymenopterous parasitoids associated with rice ecosystem by Dey *et al.* (1999). Important larval and pupal parasitoid percentage under organic farming system was up to 34.6%, whereas under conventional ecosystem it was 13.3%. Organic farming is reported to increase the population of natural enemies, such as carabid beetles (Pfinner *et al.* 1996). Organic rice ecosystems increased the biodiversity of useful insects (parasitoids). It was further observed during the present study that natural enemies in rice ecosystem keep the population of borers at natural equilibrium. Hence, there is a need to conserve these natural enemies by conservation practices. For example, rice cultivation system using conventional methods causes low biodiversity (Loreau *et al.* 2002), however, organic farming used more environmental friendly materials for fertilizers and pesticides, which can reduce the leaching

of nutrients, store more carbon (Drinkwater *et al.* 1995) and reduce pesticide in the irrigation system. The present investigation results would benefit lower and marginal farming community through adaptation of organic farming practices as it splendidly enhance activity of parasitoids and thereby influencing natural control of early instars of *S. incertulas* under field condition.

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