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Research Article

On-farm impact of egg parasitoid, *Trichogramma* spp. against lepidopteran pests in organic *basmati* rice

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ABSTRACT: On farm impact of Trichogrammatids was studied against lepidopteran pests, i.e., yellow stem borer, *Scirpophaga incertulas* (Walker) and leaf folder, *Cnaphalocrocis medinalis* (Guenee) in organic *basmati* rice (var. Pusa 1121) over an area of 20 and 60 hectares during 2014 and 2015, respectively. Six augmentative releases of *Trichogramma chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha were made starting from 30 days after transplanting (DAT) and was compared with untreated control. Based on the overall mean, the biocontrol treatment (1.74% DH) was significantly effective in reducing the dead heart incidence as compared to untreated control (4.52% DH). The reduction in dead hearts was 61.50 per cent in biocontrol over untreated control. The mean incidence of white ears was also significantly lower in biocontrol field (2.05%) as against untreated control (4.89%) resulting in a reduction of 58.08 per cent. Similarly, leaf folder damage in biocontrol (2.04% LFDL) resulted in 62.50 per cent reduction over untreated control (5.44% LFDL). Grain yield in biocontrol fields (29.81 q/ha) was 18.76 per cent more than the untreated control (25.10 q/ha). The increase in yield due to control of stem borers and leaf folder in biocontrol fields resulted in an additional benefit of INR 16332/- and INR 9818/- during 2014 and 2015, respectively. Conclusively, 6 releases of *T. chilonis* and *T. japonicum* each @ 1,00,000/ha resulted in lower incidence of rice insect pests and higher grain yield in organic *basmati* rice with an additional benefit over untreated control.

KEY WORDS: Biocontrol, *Cnaphalocrocis medinalis, Scircophaga incertulas, Trichogramma* augmentation

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INTRODUCTION

Rice is the most important cereal food crop of India, ranking second in the world's rice producers, with production of 106.50 million metric tons (USDA-FAS, 2016). *Basmati* rice occupies a special status in rice cultivation for its excellent cooking attributes. India produces more than 70 per cent of the total world *basmati* rice with Punjab, Haryana, Uttar Pradesh and Jammu and Kashmir as major growing states (Singh, 2011). In Punjab state, area under *basmati* rice was 8.63 and 7.63 lakh hectares during 2014-15 and 2015-16, respectively predominantly occupied by variety Pusa *Basmati* 1121 (83.65%). Rice is essentially crop of warm and humid environment conducive to survival and proliferation of many insect pests. More than 100 species of insects have been reported to ravage the rice crop, of these 15-20 are considered to be economically important (Kalode, 2005). The overall losses due to insect damage in rice have been estimated to be 25 per cent (Dhaliwal *et al*., 2010). Among these, rice stem borers *viz*. yellow stem borer, *Scirpophaga incertulas* (Walker); white stem borer, *S. innotata* (Walker) and pink stem borer, *Sesamia inferens* (Walker) and leaf folder, *Cnaphalocrocis medinalis* (Guenee) are of utmost importance in Punjab causing huge reductions in yield (Singh *et al*., 2002). The larval feeding of all three borer species results in 'dead hearts' during vegetative stage and sterile panicles or 'white ears' during reproductive stage. Leaf folder larvae fasten the edges of leaves together, fold them longitudinally and feed on green matter from inside the fold, leaving behind the whitish membranes. In the absence of genetic resistance against these pests, farmers have relied heavily on insecticides for their effective management. However, indiscriminate use of insecticides has led to many ecological backlashes like environmental pollution, resistance to pesticides and pest resurgence besides lethal effect to non target organisms and health hazards to users. The awareness for the consumption of ecologically safe food has provided impetus to organic farming in India and intensive efforts have been made to find out alternate methods of pest control (Nathan *et al*., 2004).

Among management practices, biological control through use of natural enemies provides an environmental friendly and effective method of minimizing the pest damage. Egg parasitoids in the genus *Trichogramma* (Hymenoptera: Trichogrammatidae) have been widely used for biological control of Lepidopteran insect pests (Garg *et al.,* 2002; Bueno *et al.,* 2010; Shawer *et al*., 2013; Ko *et al*., 2014). In Punjab, augmentative releases of *Trichogramma chilonis* Ishii and *T. japonicum* Ashmead @ 1,00,000 each have been found effective for the biological suppression of yellow stem borer, *S. incertulas* and leaf folder, *C. medinalis* in organic rice (Brar *et al.,* 1999; Kaur and Brar, 2008). The present study was, therefore conducted to validate and promote this technology in organic farming for large scale adoption at farmers' fields in the Punjab state.

MATERIALS AND METHODS

Large scale demonstrations for the management of rice stemborers and leaffolder using egg parasitoids were conducted at farmers' fields in organic *basmati* rice (var. Pusa 1121) over an area of 20 and 60 hectares during 2014 and 2015, respectively. Six augmentative releases of *T. chilonis* and *T. japonicum* each @ 1,00,000 parasitoids/ha were made starting from 30 Days After Transplanting (DAT) and was compared with untreated control. The culture of *T. chilonis* was maintained in the Biological Control Laboratory, Department of Entomology, Punjab Agricultural University (PAU), Ludhiana. Tricho-cards each having approximately 1000 parasitized eggs were cut into 100 strips and were stapled uniformly to the underside of the leaves in biocontrol treatment. The observations on stem borers infestation (dead hearts), leaf folder damage leaves (at least 1/3rd leaf area damaged) were recorded from randomly selected 20 hills at vegetative stage, i.e., 45 and 60 DAT. White ears incidence by stem borers was recorded one week prior to harvest of the crop. Grain yield was recorded on plot basis and economics was worked out. The data pertaining to per cent Dead Hearts (DH), per cent White Ear (WE) due to stemborer and per cent damaged leaves (LFDL) due to leaf folder were subjected to arc sine transformations prior to statistical analysis. The data of different parameters were analyzed using ANOVA. The different treatment means were separated by Least Significant Difference test (LSD) at $p = 0.05$ (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Stem borers infestation

The mean incidence of stem borers in terms of dead hearts during vegetative stage and white ears during reproductive stage of the rice crop was significantly lower in biocontrol fields as compared to untreated control during the years, 2014 and 2015.

Dead hearts: In the year 2014 (Table 1), the dead heart incidence at 45 DAT was 1.45 and 4.48 per cent in biocontrol field and untreated control, respectively. The corresponding figures at 60 DAT were 1.92 and 5.72 per cent. The mean dead hearts during 2015 in biocontrol fields was 1.54 and 2.00 per cent as against 3.63 and 4.96 per cent in untreated control at 45 and 60 DAT, respectively (Table 1). Based on the overall mean, the biocontrol treatment (1.74%) involving augmentative releases of *T. chilonis* and *T. japonicum* was significantly effective in reducing the dead heart incidence as compared to untreated control (4.52%). The reduction in dead hearts (pooled over two years) was 61.50 per cent in biocontrol over untreated control (Fig. 1).

Table 1. Effect of biocontrol practices on dead heart incidence due to stem borers in organic *basmati* rice

Treatments	Dead hearts (%)						
	45 DAT			60 DAT			Over all Mean
	2014	2015	Mean	2014	2015	Mean	
Biocontrol*	1.45^{a}	1.54^{a}	1.51^{a}	1.92^{a}	2.00^{a}	1.98^{a}	1.74^{a}
Untreated control	4.48^{b}	3.63^{b}	3.87^{b}	5.72^{b}	4.96^{b}	5.18^{b}	4.52^{b}
t value	6.20	8.22	9.71	8.07	11.74	13.62	13.06
p value	0.0008	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001

DAT – days after transplanting; *6 releases of *Trichogramma chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

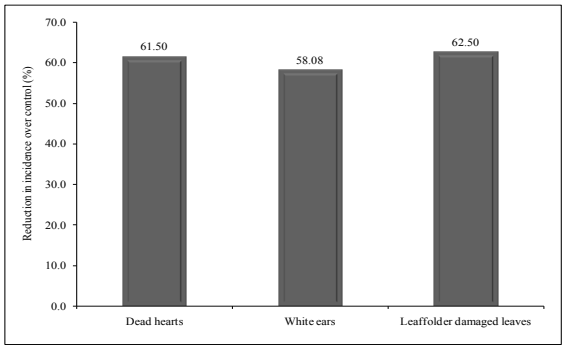

Fig. 1. Effect of biocontrol practices on per cent reduction in incidence over control in organic *basmati* rice (pooled mean of two years).

White ears: During 2014 (Table 2), the white ear incidence in biocontrol fields (2.02%) was significantly effective in reducing the stem borer damage as compared to untreated control (6.60%). Similar trend was observed in 2015 also. The mean white ears in biocontrol and untreated control were 2.07 and 4.16 per cent, respectively. Based on the overall mean, the biocontrol treatment (2.05% WE) resulted in 58.08 per cent reduction (Fig. 1) in white ear incidence over untreated control (4.89% WE).

The present results on rice stem borer corroborate with the findings of Kaur and Brar who reported that the seven releases of *T. chilonis* and *T. japonicum* @ 1,00,000 per ha effectively controlled yellow stem borer in *basmati* rice. The study also finds support from the findings of Kumar and Khan who reported that innundative releases of *T. chilonis* and *T. japonicum* @100000/ha reduced the tiller damage by 78.1 to 81.6 per cent over control.

Leaf folder infestation

The mean leaf folder damage observed during vegetative stage at 45 and 60 DAT was significantly lower in biocontrol fields as against untreated control during both the years, 2014 and 2015. The damaged leaves during 2014 in biocontrol fields were 1.20 and 1.78 per cent as against 5.09 and 6.45 per cent in untreated control at 45 and 60 DAT, respectively (Table 3). During 2015, the leaf folder damaged leaves at 45 DAT was 2.04 and 4.61 per cent in biocontrol field and untreated control, respectively. The corresponding figures at 60 DAT were 2.47 and 6.01 per cent (Table 3). Based on the overall mean, the biocontrol treatment (2.04% LFDL) resulted in 62.50 per cent reduction of leaf folder damage over untreated control (5.44% LFDL). The present study is in consonance with Sagheer *et al*., who confirmed the efficacy of egg releases of *Trichogramma* sp. @ 100000 and 1250000 per hectare in reducing per cent infestation of the leaf folder. Similarly, Kumar and Khan reported that parasitoid releases at 100000/ha significantly reduced leaf folder damage up to 72.6 to 81.8 per cent.

Table 2. Effect of biocontrol practices on white ears due to stem borers and yield in organic *basmati* rice

Treatments	White ears (%)			Paddy yield (q/ha)			
	2014	2015	Mean	2014	2015	Mean	% increase over control
Biocontrol*	2.02[a]	2.07[a]	2.05[a]	32.00[a]	28.93[a]	29.81[a]	18.76
Untreated control	6.60[b]	4.16[b]	4.89[b]	26.88[b]	24.39[b]	25.10[b]	–
t value	4.40	5.36	6.90	4.17	6.52	6.16	
p value	0.0046	<0.0001	<0.0001	0.0059	<0.0001	<0.0001	

DAT – days after transplanting; *6 releases of *Trichogramma chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

Table 3. Effect of biocontrol practices on leaf folder damaged leaves in organic *basmati* rice

Treatments	Leaf folder damaged leaves (%)						
	45 DAT			60 DAT			Over all Mean
	2014	2015	Mean	2014	2015	Mean	
Biocontrol*	1.20[a]	2.04[a]	1.80[a]	1.78[a]	2.47[a]	2.27[a]	2.04[a]
Untreated control	5.09[b]	4.61[b]	4.75[b]	6.45[b]	6.01[b]	6.14[b]	5.44[b]
t value	21.40	12.26	15.00	15.72	22.00	22.63	17.89
p value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

DAT – days after transplanting; *6 releases of *Trichogramma chilonis* and *T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 DAT

Table 4. Effect of *Trichogramma chilonis* releases for the management of lepidopteran pests on economic returns in organic *basmati* rice

Treatments	Yield (q/ha)	Additional yield over control (q/ha)	Gross returns (Rs)	Cost of treatment* (Rs/ha)	Net return over control (Rs/ha)
2014					
Biocontrol*	32.00[a]	5.12	18432.00	2100	16332.00
Untreated control	26.88[b]	-	-	-	-
2015					
Biocontrol*	28.93[a]	4.54	11917.50	2100	9817.50
Untreated control	24.39[b]	-	-	-	-

Market price of *organic* basmati rice @ Rs 3600/- and 2625/- per quintal in 2014 and 2015, respectively; include cost of tricho-cards

Paddy yield and economic returns

During 2014 (Table 2), paddy yield in biocontrol fields (32.00 q/ha) was significantly better as compared to untreated control (26.88 q/ha). The paddy yield in biocontrol and untreated control were 28.93 q/ha and 24.39 q/ha, respectively during 2015. Based on the mean of two years, yield increase in the biocontrol treatment (29.81 q/ha) was 18.76 per cent more than untreated control (25.10 q/ha). The increase in yield due to control of stem borers and leaf folder infesting rice crop in biocontrol fields resulted in net profit of INR 16332/- over untreated control during 2014. During 2015 also, an additional benefit of INR 9818/- was obtained in biocontrol fields with augmentative releases of *Trichogramma chilonis* and *T. japonicum* as compared untreated control (Table 4). Karthikeyan *et al.* also reported similar results wherein, releases of *T. japonicum* and *T. chilonis* @ 1,00,000 per ha resulted in increased paddy yields by 25.79−45.13 per cent over insecticide treated plots, with a C : B ratio of 1 : 2.6 and 1 : 1.9 in parasitoid released and insecticide treated plots, respectively.

Conclusively, biocontrol package involving six releases of *Trichogramma chilonis* and *T. japonicum* each @ 1,00,000/ha resulted in lower incidence of stem borers and leaf folder and higher grain yield with an additional benefit in terms of monetary returns in organic *basmati* rice. It could be a viable option for the ecofriendly management of key rice pests under organic farming.

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