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Research Article

Impact of bio-intensive integrated pest management practices on insect pests and grain yield in *basmati* rice

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ABSTRACT: Bio-intensive pest management practices were compared with farmer's practices and untreated control in *basmati* rice at village *Sahauli* (Punjab). BIPM practices involved green manuring; seed treatment; alternate wetting and drying of the field; installation of pheromone traps and bird perches; augmentative releases of *Trichogramma* spp.; spray of Neem oil 1%. The farmer's practices comprised the applications of chemical insecticides. The mean leaffolder damage was 3.12, 1.90 and 5.41 per cent in BIPM, farmer's practice and untreated control, respectively. The dead heart incidence was 2.49 per cent in BIPM, 1.16 per cent in farmer's practice and 4.30 per cent in untreated control. Similarly, the mean incidence of white earheads was 3.31, 1.78 and 5.06 per cent in BIPM, farmer's practice and untreated control, respectively. Highest grain yield was recorded in farmer's practice fields (30.63 q/ha) followed by yield in BIPM fields (28.07 q/ha). These yields were significantly better than untreated control (25.18 q/ha).The population of natural enemies was higher in BIPM fields as compared to farmer's practiced fields.

KEY WORDS: *Basmati,* bio-Intensive pest management, leaf folder, natural enemies, stem borer

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INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than half of the world's population, covering approximately 11 per cent of the world's arable land (IRRI, 2011). It is cultivated in more than 80 countries across Asia, Africa, Europe, Oceania, North America, Latin America and the Caribbean regions over an area of about 162 million ha (GRiSP, 2013). Thus, the formulation and implementation of research technologies in rice have the potential to influence the world population and environment substantially. India is the largest rice growing country accounting for about one-third of the world's acreage under the crop. The country ranks second in the world's rice producers with milled rice production to the tune of 106.50 million metric tonnes, accounting for about 20 per cent of global rice exports, particularly *basmati* rice (USDA-FAS, 2016). India produces more than 70 per cent of the total world *basmati* rice with Punjab, Haryana, U.P and Jammu and Kashmir as major growing states (Singh, 2011). The country exported about 4.05 million metric tonnes of *basmati* rice to the world, worth 3.47 billion US dollars, during the year 2015–16 (APEDA, 2017). However, in respect of productivity, India (3.59 MT/ha) ranks below many rice producing countries of the world like USA (8.49 MT/ha), China (6.81 MT/ha), Japan (6.71 MT/ha), Vietnam (5.76 MT/ha), Brazil (5.42 MT/ha), Indonesia (4.73 MT/ha) and Philippines (4.02 MT/ha) (USDA-FAS, 2016). Damage by the insect pests is considered to be one of the major causes of low yields in rice (Matteson, 2000). The major insect pests of rice include yellow stem borer, *Scirpophaga incertulas* (Walker), leaf folder, *Cnaphalocrocis medinalis* (Guenée), and plant hoppers; brown planthopper, *Nilaparvata lugens* (Stal) and whitebacked planthopper, *Sogatella furcifera* (Horváth). The use of synthetic chemicals is the most preferred strategy for the control of these insect pests. However, excessive and indiscriminate use of pesticides has not only polluted the environment, but also affected the health of non-target organisms including human beings. Enhanced awareness about ecologically safe food has provided impetus to organic farming and area under organically grown crops is continuously rising in India (Sharma and Aggarwal, 2014). Keeping in view the growing demand for organic food, a Bio-Intensive Integrated Pest Management (BIPM) module was compared with farmer's practices and untreated control in *basmati* rice at village Sahauli (Patiala, Punjab).

MATERIALS AND METHODS

Experiment plan

Field experiment was conducted on *basmati* rice variety *Pusa* 1121 during *Kharif* season of 2015 at village Sahauli, district Patiala, Punjab, India. The BIPM practices involving regular pest surveillance and monitoring, cultural control, biological control and bio-rational approaches were compared with farmer's practices (chemical control) and untreated control (Table 1). The area was divided into three blocks representing three treatments, i.e., T1 - BIPM (1 ha), T2 - farmer's practice (1 ha) and T3 - untreated control (500 m^2). These fields were further divided into four blocks representing replicates. All the observations were recorded from randomly selected 20 hills from each block. BIPM practices included green manuring with *Sesbania aculeata* (Willd.) Pers.; seed treatment with *Trichoderma harzianum* @ 15 g/kg seed; optimum plant population (33 hills/m^2); alleyways of 30 cm after every 2 m; alternate wetting and drying for plant hoppers; installation of yellow stemborer pheromone traps (PCI, India) and bird perches each @ 20/ha; six releases of *Trichogramma chilonis and T. japonicum* each @ 1,00,000/ha at weekly interval starting from 30 days after transplanting (DAT); spray of Neem oil 1% @ 1250 ml/ha at ETH level (2% dead hearts). The farmer's practices comprised of applications of cartap hydrochloride 4G @ 25 kg/ha, acephate 75 SP @ 1.25 kg/ha, bifenthrin 500 ml/ha, imidacloprid 17.8 SL @ 250 ml/ha at different vegetative and reproductive stages of the crop.

Table 1. Treatments followed in different modules

Particular	BIPM	Farmer's practices
Cultural control		
• Fertilizers	Green manuring with *dhaincha*	Excessive use of chemical fertilizers
• Plant Population	Optimum plant spacing (33 hills / m^2)	20-22 hills /m^2
• Water Management	Alternate wetting and drying for plant hoppers	Continuous flooding
• Alleyways	Alleyways of 30 cm after every 2 m	-
Bio-rational approach		
• Pheromone traps	Installation of pheromone traps for yellow stem borer @ 20 / ha	-
Biological control		
• Augmentative releases	Six releases of *Trichogramma chilonis and T. japonicum* each @ 1,00,000/ha at weekly intervals starting from 30 DAT	-
• Predation	Bird perches @ 10/ha	
Monitoring and Surveillance	For insect pests at regular intervals to determine ETH level	-
Chemical control		
• Seed treatment	Seed treatment with fungicide (*Trichoderma harzianum* @ 15 g/ kg seed)	No seed treatment
• Insecticidal Sprays	Spray on basis of ETH level (Neem oil 1% @ 1250 ml/ha)	Blanket application (Padan @ 15 kg/ ha, Acephate 75 SP @ 1.25 kg/ha, Bifenthrin 500 ml/ha, Imidacloprid 17.8 SL @ 250 ml/ha)

Data collection

The observations on stem borers infestation (dead hearts), leaf folder damaged leaves (at least $1/3^{rd}$ leaf area damaged) and plant hopper population were recorded at weekly intervals starting from 30 DAT. White ears incidence by stem borers was recorded one week before the harvest of the crop. The population of predators like spiders, coccinellids, dragonflies and damselflies was also recorded from 50 hills selected at random from each block at weekly interval during the entire crop season. The grain yield was recorded on whole plot basis.

Statistical analysis

The data pertaining to Dead Hearts (DH), White Earheads (WE) due to stem borer and Damaged Leaves (DL) 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

Insect pests

Significantly lower incidence of leaf folder (1.90% DL) was observed in farmer's practice (1.90% DL) than in BIPM practices (3.12% DL) during 2015 (Table 2). Both the treatments were significantly better than untreated control (5.41% DL). The per cent reduction in incidence over control was 42.33 and 64.88 in BIPM and farmer's

Table 2. Impact of different management practices on the incidence of major insect pests and grain yield in *basmati* rice during 2015

Treatments	Leaffolder		Stemborer				Plant hoppers (No./hill)
	Damaged Leaves# (%)	% reduction over control	Dead hearts# (%)	% reduction over control	White ears (%)	% reduction over control	
BIPM	3.12[b] (10.16)	42.33	2.49[b] (9.06)	42.09	3.31[b] (10.48)	34.58	0.00 (1.00)
Farmer's practice	1.90[a] (7.91)	64.88	1.16[a] (6.18)	73.02	1.78[a] (7.66)	64.82	0.00 (1.00)
Untreated control	5.41[c] (13.44)	-	4.30[c] (11.96)	-	5.06[c] (12.99)	-	1.08 (1.44)
LSD (p = 0.05)	(0.50)		(0.40)		(0.29)		(0.03)

Means in a column followed by the same letters are not significantly different at p = 0.05. Data in parentheses are arcsine transformed values for dead hearts, damaged leaves and white ears and square root transformed values for plant hoppers
#Mean of 8 observations starting at 30 DAT

practice, respectively. The mean dead heart incidence in farmer's practice plots was significantly lesser (2.49% DH) than BIPM plots (1.16% DH). Untreated control plots recorded the highest stemborer incidence, wherein the dead heart incidence was 4.30 per cent. The per cent reduction in stemborer incidence over control was 42.09 and 73.02 in BIPM and farmer's practice, respectively. Similarly, significantly lower white ear incidence was recorded in farmer's practice (1.78% WE) as compared to BIPM plots where the incidence was 3.31 per cent. The highest incidence of white earheads was recorded in untreated control (5.06% WE). The mean reduction in white earheads incidence over control was 34.58 and 64.82 per cent in BIPM and farmer's practice, respectively. No plant hoppers' population was recorded in BIPM as well as farmer's practice plots. However, their population in untreated control was also not very high and it was recorded as 1.08 hoppers per hill.

Pheromone trap catch

The data on pheromone trap catches for rice yellow stemborer revealed moth population ranging from 1.00 to 14.75 moths per trap per week during the entire season (Fig. 1). As the season progressed, the moth population gradually increased, with maximum population (14.75 moths/trap/week) during 38th SMW (3rd week of September), thereafter it decreased. The lowest moth population (3.13 moths/trap/week) was recorded during 40th SMW (1st week of October).

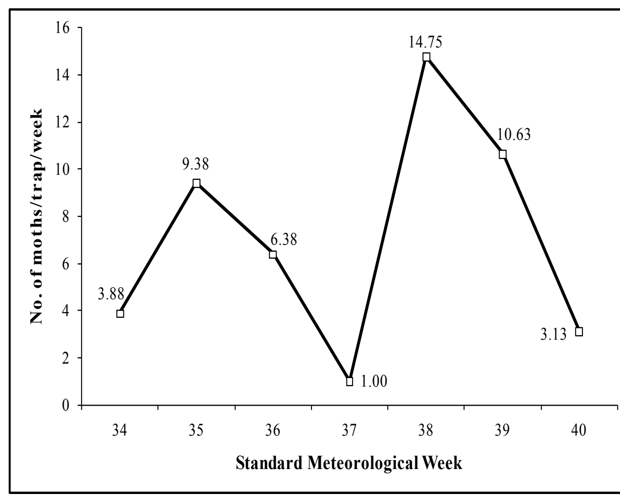

Fig. 1. Moth catch of rice yellow stem borer from sex pheromone traps in BIPM plots at village Sahauli during 2015.

Natural enemies

Higher populations of natural enemies were observed in BIPM plots than farmer's practice fields (Table 3). The mean population of spiders (4.25/plot), dragonflies (0.75/plot) and damselflies (4.50/plot) was significantly higher in BIPM practiced plots. In farmer's practice plots, the mean population of spiders, dragonflies and damselflies was 3.63, 0.38 and 3.88 per plot, respectively. The corresponding figures for the untreated control were 4.35, 0.73 and 4.60 per plot, respectively.

Table 3. Impact of different management practices on the natural enemies and grain yield in *basmati* rice

Treatments	Mean* no. of natural enemies/plot			Paddy yield (q/ha)	% increase in yield over control
	Spiders	Dragonflies	Damselflies		
BIPM	4.25[a] (2.29)	0.75[a] (1.32)	4.50[a] (2.34)	28.07[b]	11.48
Farmer's practice	3.63[b] (2.15)	0.38[b] (1.17)	3.88[b] (2.21)	30.63[a]	21.64
Untreated control	4.35[a] (2.31)	0.73[a] (1.32)	4.60[a] (2.37)	25.18[c]	-
LSD (p = 0.05)	(0.12)	(0.04)	(0.09)	0.47	

Means in a column followed by the same letters are not significantly different at p = 0.05. Data in parentheses are square root transformed values
*Mean of 8 observations starting at 30 DAT

Grain yield and economic returns

The observations on the grain yield revealed significantly higher yield in farmer's practiced fields (30.63 q/ha) followed by BIPM fields (28.07 q/ha). However, yield in both treatments was significantly better than untreated control (25.18 q/ha). The mean increase in yield over control in farmer's practice and BIPM plots was 21.64 and 11.48 per cent, respectively (Table 3). The analysis of cost effectiveness of the different treatments revealed gross returns of Rs 73683/-, 64323/- and 52878/- per ha in BIPM, farmer's practice and untreated control, respectively (Table 4). The net returns were higher in BIPM practice plots (Rs 69008/- per ha) as compared to farmer's practice (Rs 59238/- per ha) and untreated control (Rs 52878/- per ha).

Table 4. Economics of various management practices in *basmati* rice

Treatments	Yield (q/ha)	Gross returns (Rs/ha)	Cost of treatment* (Rs/ha)	Net returns (Rs/ha)
BIPM	28.07	73683	4675	69008
Farmer's practice	30.63	64323	5085	59238
Untreated control	25.18	52878	-	52878

Price of *basmati* rice Rs. 2100/- and Rs. 2625/- per quintal for conventional and organic produce, respectively; *include trichocard/pheromone traps/insecticide + labour cost

A successful management strategy depends on the farmers' understanding of insect free crop that is achieved through a particular control tactic, without disturbing the natural balance. BIPM provides an ecologically acceptable way for residue free crop production by resource poor farmers. The present study corroborates with the findings of Kumar *et al.* (2007) who reported maximum paddy yield in the plots wherein, BIPM practices were followed. Kaur *et al.* (2007) evaluated BIPM practices against leaffolder and stemborer in *Basmati* rice and reported reduction in incidence that was at par with chemical control. Likewise, Khan *et al.* (2005) during their studies on the response of different *basmati* rice varieties to the chemical and biological control of lepidopteran pests, reported positive effect of BIPM tactics on paddy yield with significant increase over control.

Egg parasitoids belonging to number of genera play a significant role in the management of key insects of many crops and have been well documented in rice (Garg *et al.*, 2002; Karthikeyan *et al.*, 2007). In the present study, the augmentative releases of Trichogrammatids helped in reducing stemborer and leaffolder incidence. Similar results have been reported by Sharma *et al.* (2008) where reduced leaffolder incidence in IPM fields was recorded with the release of egg parasitoids. Kumar and Khan (2005) also reported reduction in damaged leaves to the extent of 81.8 per cent where, egg parasitoids were released at 100,000 per ha. The present study ascertains the fact that these parasitoids can be well integrated with the application of biopesticides/botanicals for successful management of rice insect pests at field level. This is in line with the findings of Sagheer *et al.* (2008), who reported that *Trichogramma* releases @100000 and 125000 could be integrated with bio-pesticides (Neem and *Bt*) for the sustainable management of leaf folder. Karthikeyan *et al.* (2010) also reported similar results where management module comprising alternate spraying with neem-based formulation coupled with release of egg parasitoids against leaffolder and monitoring of stem borer with sex pheromone traps significantly reduce incidence of dead hearts, white earheads and damaged leaves. Present study also documents the augmented population of natural enemies like spiders, dragonflies and damselflies in BIPM practiced plots in comparison to farmer's practice. It got support from the earlier study of Aggarwal *et al.* (2016) wherein, validation of large scale BIPM practices strategies in aromatic rice recorded higher population of natural enemies in BIPM fields in comparison to conventional plots.

The present work substantiates the fact that bio-intensive integrated pest management technologies provide a sustainable system for the ecofriendly management of insect pests in rice. Through BIPM, the crop was managed by alternative eco-friendly pest management methods. In contrast, under farmer's practice, the blanket application of insecticides affected natural enemies' population. Though crop yields in

BIPM fields were lower than in conventional fields, but at the same time, higher remunerative price compensated for low yields, resulting in higher net returns and promoted habitat for avian predators and conservation of natural enemies.

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REFERENCES

Aggarwal N, Sharma S, Jalali SK. 2016. On-farm impact of biocontrol technology against rice stem borer, *Scircophaga incertu*las (Walker) and rice leaf folder *Cnaphalocrocis medinalis* (Guenee) in aromatic rice. *Entomol Gen*. **36**: 137–148. https://doi.org/10.1127/entomologia/2016/0135

APEDA. 2017. Agricultural and Processed Food Products Export Development Authority. Available at: http: //agriexchange. apeda.gov.in/product_profile/prodintro/Basmati_Rice.aspx

Garg DK, Kumar P, Singh RN, Pathak M. 2002. Role of parasitoid *Trichogramma japonicum* and other natural enemies in the management of yellow stemborer and leaffolder in basmati rice. *Indian J Entomol.* **64**:117–123.

Gomez KA, Gomez AA. 1984. *Statistical procedures for agricultural research,* 2nd ed. John Wiley and Sons Inc, New York, USA, 704 p.

GRiSP. 2013. Global Rice Science Partnership – Rice Almanac, 4th edition. International Rice Research Institute, Los Ba-os, Philippines, 283 p.

IRRI. 2011. Opportunities for global rice research in a changing World, Technical Bulletin No. 15, International Rice Research Institute, Los Ba-os, Philippines, 25 p.

Karthikeyan K, Jacob S, Beevi P, Purushothaman SM. 2010. Evaluation of different integrated pest management modules for the management of major pests of rice (*Oryza sativa*). *Indian J Agric Sci.*: **80**: 59–62.

Karthikeyan K, Jacob S, Purushothaman SM. 2007. Field evaluation of egg parasitoids, *Trichogramma japonicum* Ashmead and *Trichogramma chilonis* Ishii, against rice yellow stemborer and leaffolder. *J Biol Control* **21**: 145–148.

Kaur R, Brar KS, Singh J, Shenhmar M. 2007. Large scale evaluation of bio-intensive management for leaf folder and stem borer on basmati rice. *J Biol Control* **21**: 255–259.

Khan RA, Khan JA, Jamil FF, Hamed M. 2005. Resistance of different Basmati rice varieties to stem borers under different control tactics of BIPM and evaluation of yield. *Pak J Bot.* **37**: 319–324.

Kumar S, Khan MA. 2005. Bio-efficacy of *Trichogramma* spp against yellow stem borer and leaf folder in rice ecosystem. *Ann Plant Protect Sci.* **13**: 97–99.

Kumar S, Maurya RP, Khan MA. 2007. Impact of biointensive pest management strategies on yellow stem borer and leaf folder in rice and their effect on the economics of production. *J Entomol Res.* **31**:11–13.

Matteson PC. 2000. Insect pest management in tropical Asian irrigated rice. *Ann Rev Entomol.* **45**: 549–574. https://doi.org/10.1146/annurev.ento.45.1.549

Sagheer M, Ashfaq M, Mansoor-ul-Hasan, Rana SA. 2008. Integration of some biopesticides and *Trichogramma chilonis* for the sustainable management of rice leaffolder, *Cnaphalocrocis medinalis* (Guenee) (Lepidoptera: Pyralidae). *Pak J Agri Sci.* **45**: 69–74.

Sharma OP, Garg DK, Trivedi TP, Satpal C, Singh SP. 2008. Evaluation of pest management strategies in organic and conventional Taraori Basmati Rice (*Oryza Sativa* L) farming system. *Indian J Agric Sci.* **78**: 862–867.

Sharma S, Aggarwal N. 2014. Time-linked dosage appraisal of Trichogrammatids against *Cnaphalocrocis medinalis* (Guenée) and *Scirpophaga incertulas* (Walker) in organic aromatic rice. *Eco Environ Conserv.* **20**: 111–118.

Singh J. 2011. Impact Assessment study of IPM Basmati Project for Boosting Diversification Process in Punjab. Navajbai Rata Tata Trust, Mumbai, India, 43 p.

USDA-FAS. 2016. World Agricultural Production. Available at: http://usda.mannlib.cornell.edu/usda/current/worldag-production/worldag-production-12-09-2016.pdf