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Evaluation of different integrated pest management modules for the management of major pests of rice (*Oryza sativa*)

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ABSTRACT

Field experiments were conducted in farmers' rice fields at Karakkad village, Pattambi, Kerala during 2006–07 to 2008–2009 with 3 rice IPM modules (IPM I, IPM II and IPM III) in comparison with farmers' practices to validate and popularize the IPM modules in rice. The results showed that the IPM III module comprised alternate spraying with neem-based formulation and newer safe insecticides (cartap hydrochloride and spinosad) coupled with release of egg parasitoids against leaffolder and monitoring of stem borer with sex pheromone traps resulted in siginificant reduction of stem borer (3.88% dead heart, 1.95% white ear), whorlmaggot (4.10% damaged leaves), and leaf folder (2.73% damaged leaves). It has recorded highest grain yield (4 489 kg/ha) and C : B ratio (1: 1.30). Stem borer incidence was reduced by 61.6% in IPM III module as compared with farmers' practices. Leaf folder damage has showed a reduction of 64.8% and whorl maggot infestation indicated 61.03% reduction in IPM III module over farmers' practices which has also shown the lowest C: B ratio.

Key words: C:B ratio, IPM modules, Leaf folder, Stemborer, Whorlmaggot

The production of rice (*Oryza sativa* L.) was almost tripled from 30.4 million tonnes (milled rice) in 1966 to a record production of 93.3 million tonnes, with an average productivity of 2.08 tonnes/ha in 2001–02 (Rai 2006). Pests are one of the major constraints in achieving the desired level of rice production in India. Among the Indian states, Punjab stands first in pesticides consumption, followed by Uttar Pradesh and Haryana. The pesticide consumption in Kerala was reduced from 1 345 metric tonnes in 2001 to 360 metric tonnes in 2004 (Directorate of Plant Protection and Quarantine, Faridabad). However, the farmers still rely on chemical pesticides to a greater extend and the continuous usage of insecticides leads to an array of problems in humans and insects including development of resistance, pest resurgence and pest outbreaks. In this context, integrated pest management (IPM) is the best strategy to combat all these problems under diverse ecological conditions. The success of IPM strategies for ordinary and scented rice has been well documented (Garg *et al*. 2000). The IPM tactic including the application of neem-based products between chemical insecticides helps to delay the resistance development by the insects. The newer insecticides like cartaphydrochloride and spinosad with their higher bioefficacy against rice stem borer and leaf folder and safety towards natural enemies in rice ecosystem could be included in rice IPM (Karthikeyan *et al.* 2007, Karthikeyan *et al.* 2008). With a view to evaluate and popularize the IPM strategy in rice among the farmers, studies were carried out in farmers' fields with 3 IPM modules in comparison with farmers' conventional practices.

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MATERIALS AND METHODS

Experiments were conducted in the farmers' rice fields at Karakkad village, Pattambi, Kerala with 3 modules of rice IPM in comparison with farmers' practices in plots of 4 000 m^2 each, using the short-duration rice variety 'Kanchana' during 2006–07 to 2008–09. The IPM modules included: IPM I (insecticide module), spraying with chemical insecticides, chlorpyriphos 20% EC @ 500 g ai/ha, cartaphydrochloride 50% SP @ 500 g ai/ha, triazophos 40% EC @ 500 g ai/ha and methyl parathion 50% EC @ 500 g ai/ha at 25, 45, 60 and 75 days after transplanting; IPM II (non-insecticide module), spraying with neem-based formulation (eco-neem 1%) @ 2 ml/litre at 15, 30, 45, and 75 days after transplanting and *Bacillus thuringiensis* (Delfin) @ 500 g/ha at 60 days after transplanting with six releases of egg parasitoids *Trichogramma japonicum* against yellow stem borer and *T. chilonis* against leaf folder @ 100 000/ha along with the management of male moths of yellow stem borer with sex pheromone traps @ 20/ha; IPM III (insecticides + non-insecticides module), alternating sprays with neem-based formulation (eco-neem 1%) and newer chemical insecticides-eco-neem 1% at 15, 45 and 75 days after transplanting and eco-neem at 30 and 60 days with cartaphydrochloride 50% SP @ 500 g ai/ha and spinosad 45% SC @ 45 g ai/ha respectively with six releases of egg parasitoid *T. chilonis* against leaffolder @ 100 000/ha along with sex pheromone trapping of stem borer. All agronomic practices as per the package of practices recommendation of the Kerala Agricultural University were followed in all 3 IPM modules. The IPM modules were compared with farmers' practices of indiscriminate use of chemical fertilizers and insecticides.

Observations on the incidence of major pests were made diagonally across the field from 50 hills/plot after every spraying. Tiller damage was recorded for stem borer (dead hearts at vegetative stage and white ears at reproductive stage) and leaf damage was recorded for foliage pests like whorl maggot, caseworm and leaf folder. The grain yield at harvest, cost of cultivation and net profit were also recorded in each of the IPM module and calculated the C: B ratio. The data were analyzed statistically using Duncan Multiple Range Test (DMRT) (Duncan 1951).

RESULTS AND DISCUSSION

The results during 2006–07 (Table 1) showed that IPM module III was the best module with significant lowest incidence of dead hearts (13.4, 10.8 and 5.1% at 35, 45 and 60 days after transplanting, respectively) and white ears (3.30%). Similarly, the incidence of whorl maggot (5.2 and 11.8%) and leaf folder (11.3 and 3.5%) was also lowest in this module during the period. The grain yield was significantly higher (5 167 kg/ha) with a highest C : B ratio of 1: 3.01 in this module as compared to the lowest C : B ratio of 1: 1.56 in farmers' practices (Table 4). Conventional farmers practice resulted in highest pest incidence, lowest grain yield and C : B ratio. IPM module III reduced dead heart and white ears by 76.5 and 73.2% as compared to farmers' practices. Module III brought about 49.6 and 69.6% reduction of damage due to whorl maggot and leaf folder over the conventional farmers' practices. The yield was also found to be increased by 51.9% in IPM module III.

During 2007–08 also, the same trend was noticed although the pest incidence was less (Table 2). IPM module III was again found to be significantly effective in reducing stem borer, whorl maggot and leaf folder. The incidence of dead hearts in IPM module III was 0.4, 0.4 and 1.1% as against 1.5, 2.5 and 4.7% in farmers' practices at 35, 45 and 60 days after transplanting. The white ears caused by stem borer were also found to be significantly lower (0.30%) in IPM III module than that in conventional farmers' practices (2%).

Table 1 Incidence of rice pests in different IPM modules (2006–07)

Treatment	Stem borer (DH%)				Whorl maggot (%DL)		Leaf folder (% DL)	
	35 DAT	45 DAT	60 DAT	% WE	25 DAT	35 DAT	45 DAT	60 DAT
IPM I	20.30^{b}	18.60^{b}	21.30^{c}	12.00^{b}	8.70^{b}	21.40^{b}	21.10^{b}	7.70^{b}
IPM II	19.80^{b}	16.80^{b}	16.50^{b}	10.40^{b}	9.30^{b}	15.80^{a}	19.00^{b}	6.80^{b}
IPM III	13.40^{a}	10.80^{a}	5.10^{a}	3.30^{a}	5.20^{a}	11.80^{a}	11.30^{a}	3.50^{a}
FP	25.90^{c}	26.40^{c}	21.70^{c}	12.30^{b}	9.60^{b}	23.40^{b}	22.10^{b}	11.50^{c}
SEm±	2.56	3.22	3.87	2.11	1.02	2.65	2.45	1.64

• DAT, Days after transplanting; DH, dead heart; WE, white ear; DL, damaged leaves; FP, farmers' practice
• Mean value of 6 replicates: within columns, mean followed by common letter do not significantly differ at P=0.05

Table 2 Incidence of rice pests in different IPM modules (2007–08)

Treatment	Stem borer (DH%)				Whorl maggot (%DL)		Leaf folder (% DL)	
	35 DAT	45 DAT	60 DAT	% WE	25 DAT	35 DAT	45 DAT	60 DAT
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IPM I	0.80^{a}	2.10^{b}	4.30^{c}	1.10^{b}	14.10^{c}	6.10^{b}	4.30^{b}	2.30^{b}
IPM II	0.40^{a}	1.10^{b}	2.50^{b}	0.50^{ab}	7.30^{b}	4.80^{b}	4.00^{b}	0.00^{a}
IPM III	0.40^{a}	0.40^{a}	1.10^{a}	0.30^{a}	2.60^{a}	1.40^{a}	1.30^{a}	0.00^{a}
FP	1.50^{b}	2.50^{b}	4.70^{c}	2.00^{c}	18.70^{c}	7.00^{b}	4.75^{b}	5.60^{c}
SEm±	0.26	0.48	0.83	0.38	3.57	1.23	0.78	1.32

• DAT, Days after transplanting; DH, dead heart; WE, white ear; DL, damaged leaves; FP, farmers' practice
• Mean value of 6 replicates: within columns, mean followed by common letter do not significantly differ at P=0.05

The incidence of other pests such as whorl maggot and leaf folder was also reduced in this module with 2.6, 1.4 and 1.3, 0.0% respectively as against a higher damage of 18.7, 7.0 and 4.8 and 5.6% in farmers' practices. IPM III module also showed significantly highest grain yield (5 733 kg/ha), indicating 38.7% yield increase as compared to farmers' practices (Table 4). The C : B ratio was found to be doubled (1: 3.60) in IPM III module as compared to a lowest ratio (1: 1.80) in farmers' practices.

In 2008–09 also, the IPM III module was observed to be the best module with lowest stem borer incidence (0.23, 1.58 and 1.87% DH at 35, 45 and 60 DAT) (Table 3). The white ear incidence was significantly lower (2.25%) in the module III as compared to that in farmers' practices (2.72%). The whorl maggot and leaf folder incidence was also low with 0.6, 3.0% and 0.3, 0.0% in IPM III module. The field of farmers' practices showed the highest incidence of whorlmaggot (1.2 and 3.2%) and leaf folder (1.20 and 1.34%). The IPM III module also indicated a highest grain yield (2, 567 kg/ha) with a highest C : B ratio (Table 4). Lowest grain yield (1 933 kg/ha) and lowest C: B ratio (1: 1.62) was recorded in the conventional farmer's practices.

The overall results of 3 years experiments carried out from 2006 to 2008 revealed that the IPM module III (rotational spraying with neem-based formulation, newer chemical insecticides along with release of egg parasitoids and monitoring of yellow stem borer with sex pheromones) significantly reduced pest incidence by 67.4% reduction of dead hearts over farmers' practice. IPM module III brought about 52.6% dead heart reduction over IPM module I which comprised only insecticide sprays and 44.6% reduction of dead hearts over IPM module II (non-insecticide module). IPM module III reduced white ear incidence also to an extent of 65.6, 62.4 and 57.0% over FP, IPM I and IPM II modules, respectively. The present findings corroborates with the earlier study of Sharma *et al.* (2008) who reported that stem borer incidence was reduced in IPM fields with the release of egg parasitoids and monitoring the adult moths with sex pheromones.

In case of whorlmaggot, the incidence was lowest in IPM III module with an average incidence of 4.10% showing 61.0, 34.9 and 13.5% damage reduction over FP, IPM II and IPM I modules, respectively. The incidence of leaf folder was also significantly lowered in IPM III module with an overall mean of 2.73% revealing 64.8, 33.4 and 20.3% reduction of damage over FP, IPM II and IPM I modules, respectively. IPM III module indicated its superiority in grain yield also with a mean yield of 4 489 kg/ha leading to 29.7% yield increase over FP, 15.1% increase over IPM I module and 12.9% increase in IPM II module. Similarly, the IPM III module showed the highest C : B ratio of 1: 1.30, thus confirming the earlier study of Sharma *et al.* (2008) and Pathummalbeevi *et al.* (2002) who reported that IPM module with egg parasitoid release recorded higher grain yield with better C : B ratio.

It is conclusively proved that rice pests can be managed successfully and yield can be increased by adopting IPM tactics involving rotational sprays with neem-based

Table 3 Incidence of rice pests in different IPM modules (2008–09)

Treatment	Stem borer (DH%)				Whorl maggot (%DL)		Leaf folder (% DL)	
	35 DAT	45 DAT	60 DAT	% WE	25 DAT	35 DAT	45 DAT	60 DAT
IPM I	1.23[ab]	2.13[ab]	2.84 [ab]	2.43[a]	1.15[b]	3.17[ab]	0.83[b]	0.82[c]
IPM II	1.50[b]	1.73[a]	2.70[ab]	2.77[a]	0.75[ab]	3.12[ab]	0.75[b]	0.42[ab]
IPM III	0.23[a]	1.58[a]	1.87[a]	2.25[a]	0.60 [a]	3.02[a]	0.27[a]	0.00[a]
FP	1.97[b]	2.33[b]	3.57[b]	2.72[a]	1.23[b]	3.17[b]	1.20[c]	1.34[d]
SEm±	0.37	0.17	0.35	0.12	0.15	0.04	0.20	0.29

• DAT, Days after transplanting; DH, dead heart; WE, white ear; DL, damaged leaves; FP, farmers' practice
• Mean value of 6 replicates: within columns, mean followed by common letter do not significantly differ at P=0.05

Table 4 Cost of cultivation and cost : benefit ratio's in different IPM modules (2006–09)

Treatment	2006–07				2007–08				2008–09			
	Yield kg/ha	COC	NR	C: B	Yield kg/ha	COC	NR	C: B	Yield kg/ha	COC	NR	C: B
IPM 1	4 600[b]	8 888	16 412	1: 2.85	4 666[b]	9 488	18 508	1: 2.90	2 167[bc]	9 900	11 770	1: 2.19
IPM II	4 200[b]	9 112	13 988	1: 2.53	5 033[a]	9 612	20 586	1: 3.10	2 500[ab]	10 400	14 600	1: 2.40
IPM III	5 167[a]	9 425	18 993	1: 3.01	5 733[a]	9 612	24 786	1: 3.60	2 567[a]	10 800	14 870	1: 2.38
FP	3 400[c]	12 000	6 700	1: 1.56	4 133[b]	13 500	11 298	1: 1.80	1 933[c]	11 900	11 298	1: 1.62

• COC, Cost of cultivation; NR, net returns; C: B, cost : benefit ratio
• Mean value of 6 replicates: within columns, mean followed by common letter do not significantly different at P=0.05

formulation, newer safe insecticide molecules along with monitoring of yellow stem borer by sex pheromones and timely releases of egg parasitoids.

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