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A bio-intensive insect pest management module for samba organic rice cultivation in new cauvery delta zone

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Abstract

Bio-intensive organic insect pest management module (BOIPM) and Farmers organic module (FOM) were compared for the pest intensity, natural enemy abundance and grain yield. In BOIPM, the interventions were incorporation of leaves of *Calotropis* + Neem into the nursery soil. Freshly prepared neem seed kernel extract 5% / *Pseudomonas fluorescens* 0.2% was used to manage insect pest / diseases respectively in nursery. While in the main field, *Daincha* was raised in situ; basal application of *Azospirillum* + Phosphobacteria + silica solubilizing bacteria + *Pseudomonas fluorescens* was done. During the last ploughing, neem cake was added to the soil. Seed treatment done with *Pseudomonas fluorescens* @ 10g/ kg of seed. Solar light trap was installed to monitor the insect pest activity. *Trichogramma japonicum* and *T. chilonis* were released at weekly interval thrice. Bird perches were set up at 2-3 ft height in vegetative stage. To enhance natural enemies' activity floral plants (cowpea, gingelly, sunflower, maize, black gram) were raised in the bunds all around the field. The FOM practices included incorporation of *Tephrosia purpurea* / *Calotropis* in nursery. Neem cake or crushed neem seed was added to the soil during the last ploughing. Panchagavya 3% was sprayed thrice during maximum tillering, panicle initiation and booting stage. The insect pest load was 2.05 to 2.15 times higher in the FOM as compared to the BOIPM. Population of the natural enemies was 1.96 to 2.88 times higher in the BOIPM as compared to the FOM. The mean pest defender ratio in BOIPM was 1: 2.46 compared to 1: 0.75 in the FOM. The profit earned from the BOIPM ranged from Rs. 70109/- to Rs. 77389/- per ha. There was a 10.38 per cent increased yield in *Samba*, 2018 over *Samba*, 2017 trial in BOIPM. Conversely, the profit earned form -FOM ranged from Rs. 68849/- to Rs. 56529/- per ha. There was a decreased yield trend of -17.89 per cent in *Samba*, 2018 over *Samba*, 2017 trial.

Key words: Bio-intensive organic insect pest management module, Farmers organic module, pest intensity, natural enemy abundance, pest defender ratio

Introduction

FAO/WHO defined "organic agriculture" as holistic food production management system, which promoted and enhanced agro-ecosystem health, including biodiversity, biological cycles and soil biological activity". The use of pesticides had led to enormous levels of chemical buildup in our environment, soil, water, air, animals and even in our own bodies. Fertilizers have a short-term effect on productivity but a long-term negative effect on the environment where they remain for years after leaching and run off, contaminating ground water and water bodies. The principal interventions included crop rotation, addition of green manures and compost, biological pest management and mechanical cultivation. These measures use the natural environment to enhance agricultural productivity; legumes were planted to fix nitrogen into the soil, natural insect predators were encouraged, crops were rotated to confuse pests and renew soil.

Owing to the water shrinkage in the New Cauvery Delta zone in the double cropped paddy area the alternative cropping system proposed particularly for organic rice cultivators was to go for green manure crop (*Dhaincha* / *Sunnhemp*) with the summer showers and in situ incorporation before the Samba paddy crop. Organic matter enrichment enhanced the association of above and below ground food

chains and augmented natural plant defense mechanism. Strengthening of the food webs and natural plant defense mechanism would naturally sustain the biological insect pest control and increase rice productivity over years. In this context, the present study was taken up "To develop a bio-intensive insect pest management module for Samba organic rice cultivation in New Cauvery Delta Zone" with a long term goal to enhance the pest defender ratio and sustain the productivity.

Materials and Methods

Field experiments were taken up in the organically maintained block for 10 years at Soil and Water Management Research Institute, Thanjavur, Tamil Nadu, India during Samba season (2017 and 2018) with cultivar Improved White Ponni. Two treatments viz., Bio-intensive organic insect pest management module and Farmers organic module were compared for the insect pest intensity, natural enemy abundance and grain yield.

In Bio-intensive organic insect pest management module, leaves of *Calotropis* @ 200 kg + Neem 300 kg/ 800 m^2 were incorporated into the nursery soil. Freshly prepared neem seed kernel extract 5% / *Pseudomonas fluorescens* 0.2% was used to manage insect pest / diseases respectively in nursery. In the main field, green manure *Daincha* @ 50 kg seed/ha was raised in situ and incorporated to a depth of 15 cm. Basal application of *Azospirillum* + Phosphobacteria + silica solubilizing bacteria @ each 2 kg/ha + *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha was done. Neem cake @ 1500 kg/ha was added to the soil during the last ploughing. Wet seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed. Solar light trap was installed to monitor the insect pest activity. When the stem borer and leaf folder moth activity was noticed, *Trichogramma japonicum* and *Trichogramma chilonis* @ 1,00,000 (5 cc) /ha each, were released thrice. Bird perches were set up at 2-3 ft height in vegetative stage @ 50 /ha. To enhance natural enemies' activity floral plants (cowpea, gingelly, sunflower, maize, black gram) were raised in the bunds all around the field. With regard to water management, alternate wetting and drying was maintained and submergence recommended during critical periods only. Need based application of freshly prepared Neem Seed Kernel Extract 5% as well as foliar spray of *Pseudomonas fluorescens* 0.2% if insect and disease incidence crossed ETL.

The farmers' organic module practices included incorporation of green leaf manure, Wild indigo (*Tephrosia purpurea*) / *Calotropis* in nursery @ 50 kg / 800 m^2. Neem cake or crushed neem seed @ 100 kg/ha was added to the soil during the last ploughing. Panchagavya 3 per cent was sprayed thrice during maximum tillering, panicle initiation and booting stage. Need based application of neem commercial formulation (Neem Azal/Achook) was done when insect and disease incidence crossed ETL. Each trial was taken up in one acre plot with Exploded block design (Rothamsted, 1974; Ramachander *et al.*, 1989). In each one acre plot, five micro-plots were maintained and observations were made at this point.

Profitability and sustainability of Bio-intensive organic insect pest management module and farmers organic module were determined in terms of net profit per ha and cost benefit ratio. A t-test carried out to know whether there was a significant difference between the Bio-intensive organic insect pest management module and farmer's organic module**.**

Results

Herbivore population in the rice field

During Samba the herbivores that affected the rice crop included yellow stem borer (YSB), *Scirpophaga incertulas* (Walker), Crambidae, Lepidoptera; green leafhopper (GLH), *Nephotettix* spp., Cicadellidae, Hemiptera; Short horned grasshopper, *Acrida exaltata* (Walker), Acrididae, Orthoptera; Stink bug, *Menida versicolor* (Gmelin) and Black bug, *Scotinophora lurida*, Pentatomidae, Hemiptera; Earhead bug, *Leptocorisa* spp., Alydidae, Hemiptera.

In *Samba* 2017 field trial, the yellow stem borer damage in bio-intensive organic insect pest management module averaged 0.83 per cent as against 3.18 per cent in the farmers' organic module. The damage level was 3.83 times higher in the farmers' organic module as compared to the bio-intensive organic insect pest management module. With regard to leaf folder damage, the bio-intensive organic insect pest management module had 1.13 times lesser leaf damage compared to farmer's organic module (Table 1). In *Samba* 2017 field trial, the total insect pests in bio-intensive organic insect pest management module averaged 1.78 nos./ 5 sweeps as against 3.83 nos./ 5 sweeps in the farmers organic module. The insect pest load was 2.15 times higher in the farmers' organic module as compared to the Bio-intensive organic insect pest management module.

In the *Samba* 2018 trial the total insect pests in bio-intensive organic insect pest management module averaged 3.37 nos./ 5 sweeps as against 6.91 nos./ 5 sweeps in the farmers organic module. In the second year trial also the insect pest load was 2.05 times higher in the farmers' organic module as compared to the Bio-intensive organic insect pest management module (Table 2).

Natural enemies' population in the rice field

Assassin bug, *Polytoxus* sp., Reduviidae, Hemiptera; Long horned grasshopper, *Conocephalus* sp., Tettigoniidae, Orthoptera; Tachinid fly, *Argyrophylax* sp., Tachinidae, Diptera; Rove beetle, *Paederus fuscipes*, Staphylinidae, Coleoptera; Ground beetle, *Ophionea nigrofasciata*, Carabidae, Coleoptera; Coccinellids, *Micraspis* sp., and *Menochilus sexmaculatus*, Coccinellidae Coleoptera; Damselfly, *Agriocnemis* sp., Coenagrionidae, Odonata; Dragonfly, *Diplacodes* sp., Libellulidae, Anisoptera, Odonata; Owl fly, Ascalaphidae, Neuroptera; Braconid wasps, *Stenobracon nicevillei* and *Macrocentrus* sp., Braconidae, Hymenoptera and Ichneumonids, *Trichomma cnaphalocrocis* and Xanthopimpla sp. lchneumonidae, Hymenoptera. Of the spiders, *Oxyopes* sp., Oxyopidae; *Argiope* sp., Araneidae; *Araneus* sp., Araneidae; *Tetragnatha* sp., Tetragnathidae and *Lycosa*, Lycosidae, Araneae were recorded.

Table 1: Insect pest and natural enemies in bio-intensive organic insect pest management module compared to farmers organic module, Samba season 2017

Period	YSB (% DH/WE)	Leaf folder (% LD)	Insect pests (no./5 sweeps)				Natural enemies (no./5 sweeps)				
			YSB moth	GLH	Namavandu	Total	Coccinellids	Damselfly	Spiders	Total	P:D ratio
	T1 – Bio-intensive organic insect pest management module										
I Oct, 2017	1.54	1.61	0.00	1.67	0.00	**1.67**	3.00	2.67	3.33	**9.00**	1: 5.40
II Oct 2017	1.00	1.51	0.00	2.00	0.00	**2.00**	2.00	2.67	3.00	**7.67**	1: 3.83
I Nov,2017	0.92	1.30	0.33	1.00	0.00	**1.33**	2.67	3.00	4.33	**10.00**	1: 7.50
IINov,2017	0.48	1.05	0.00	0.00	1.33	**1.33**	2.00	2.00	2.00	**6.00**	1: 4.50
I Dec, 2017	0.51	0.82	0.00	0.00	2.33	**2.33**	2.00	1.33	2.67	**6.00**	1: 2.57
II Dec, 2017	0.44	1.21	0.33	0.00	1.67	**2.00**	0.33	0.00	0.33	**0.66**	1: 0.33
I Jan, 2017	0.95	0.86	0.00	0.00	2.33	**2.33**	0.00	0.00	0.00	**0.00**	1: 0.00
Mean	**0.83**	**1.19**	**0.09**	**0.67**	**1.09**	**1.86**	**1.71**	**1.67**	**2.24**	**5.62**	
	T2 – Farmers organic module										
I Oct., 2017	3.19	2.07	1.00	2.33	0.33	**2.66**	1.67	1.67	2.67	**6.01**	1: 1.64
II Oct 2017	4.70	1.79	0.33	4.00	0.00	**4.00**	1.33	0.67	1.00	**3.00**	1: 0.69
I Nov, 2017	3.70	1.13	0.67	2.33	0.00	**2.33**	0.00	1.67	1.33	**3.00**	1: 1.00
II Nov, 2017	4.05	1.07	0.33	1.33	2.33	**3.66**	0.00	0.67	0.67	**1.34**	1: 0.33
I Dec, 2017	2.81	1.18	0.33	1.00	3.67	**4.67**	0.33	0.00	0.00	**0.33**	1: 0.07
II Dec, 2017	2.26	0.83	0.67	0.33	5.33	**5.66**	0.00	0.00	0.00	**0.00**	1: 0.00
I Jan, 2017	1.54	1.39	0.00	0.00	4.67	**4.67**	0.00	0.00	0.00	**0.00**	1: 0.00
Mean	**3.18**	**1.35**	**0.48**	**1.62**	**2.33**	**3.95**	**0.48**	**0.67**	**0.81**	**1.95**	
t value	-5.60	-1.22	-3.37	-3.70	-2.42		3.42	3.55	3.23		

** Mean of five replications t critical value (one-tail) - 1.94; t critical value (two-tail) - 2.45*

Table 2: Insect pests and natural enemies in bio-intensive organic insect pest management and farmer's organic module, Samba season 2018

Period	Insect pests (no./5 sweeps)						Natural enemies (no./5 sweeps)									P:D ratio
	Black bug	GLH	Earhead bug	SHG	Namavandu	Total	Coccinellids	Damselfly	Dragonfly	Dipteran	Ground beetle	Wasp	LHG	Spiders	Total	
Bio-intensive organic insect pest management module																
I Oct., 2018	1.00	1.67	0.00	0.00	3.00	**5.67**	7.67	1.00	0.33	0.33	2.67	0.33	0.33	6.00	**18.67**	**1:3.29**
II Oct., 2018	0.33	4.33	0.00	0.33	2.00	**7.00**	6.00	1.33	0.00	0.67	1.67	0.00	0.33	8.67	**18.67**	**1:2.67**
I Nov., 2018	0.00	3.00	0.00	0.00	3.33	**6.33**	4.33	3.00	0.33	1.00	2.00	1.33	0.00	4.00	**16.00**	**1:2.53**
II Nov., 2018	1.00	0.00	0.0	0.00	1.00	**2.00**	0.33	0.00	0.00	0.33	0.00	0.00	0.00	2.67	**3.33**	**1:1.67**
I Dec., 2018	0.00	0.00	2.67	0.00	2.00	**4.67**	4.33	5.00	0.33	0.00	2.33	2.00	0.00	7.33	**11.67**	**1:2.50**
II Dec., 2018	0.00	0.00	2.33	0.00	3.33	**5.67**	2.67	5.00	1.00	0.00	3.67	2.67	0.00	5.67	**12.00**	**1:2.12**
Farmers organic module																
I Oct., 2018	4.67	3.33	0.00	0.00	1.33	**9.33**	3.00	1.00	0.33	0.33	0.67	0.33	0.00	4.00	**9.67**	**1:1.04**
II Oct., 2018	0.00	10.67	0.00	0.00	1.00	**11.67**	3.67	0.33	0.33	0.00	1.67	0.67	0.00	4.00	**10.67**	**1:0.91**
I Nov., 2018	0.00	5.00	1.00	0.00	5.67	**11.67**	2.33	1.67	0.00	1.00	1.00	0.33	0.00	3.67	**10.00**	**1:0.86**
II Nov., 2018	0.00	3.67	0	1.33	2.33	**7.33**	1.67	0.00	0.00	0.00	0.67	0.00	0.00	1.00	**3.33**	**1:0.45**
I Dec., 2018	0.00	0.00	0.33	6.33	5.33	**12.00**	2.67	4.00	0.00	0.00	2.67	0.33	0.00	4.00	**7.00**	**1:0.58**
II Dec., 2018	0.00	0.00	0.00	4.67	6.33	**11.00**	1.33	3.33	0.33	0.00	2.33	0.33	0.00	5.00	**7.67**	**1:0.70**
	-0.58	-2.31	1.08	-1.74	-1.42		2.25	2.95	1.17	1.46	1.29	1.55	1.58	3.15		

**Mean of five replications t critical value (one-tail) – 2.02; t critical value (two-tail) – 2.57*

The mean natural enemies population in *Samba*, 2017 bio-intensive organic insect pest management module was 6.56 nos./ 5 sweeps as against 2.28 nos./ 5 sweeps in the farmers organic module. Population of the natural enemies was 2.88 times higher in the Bio-intensive organic insect pest management module as compared to the farmers' organic module. In *Samba* 2018, the mean natural enemies in Bio-intensive organic insect pest management module was 9.71 nos./ 5 sweeps as against 4.95 nos./ 5 sweeps in the farmers organic module. Population of the natural enemies was 1.96 times higher in the bio-intensive organic insect pest management module as compared to the farmers' organic module.

Pest defender ratio

In Bio-intensive organic insect pest management module, the pest-defender ratio was highest 1:7.50 during the first fortnight of November, 2017 as against 1:1.00 in the farmers' organic module during *Samba* 2017. The mean pest defender ratio in Bio-intensive organic insect pest management module was 1: 4.02 compared to 1: 1.24 in the farmers' organic module during *Samba*, 2017. In *Samba* 2018, Bio-intensive organic insect pest management module the highest pest-defender ratio was 1:3.29 during the first fortnight of October, 2018 compared to farmers' organic module (1:1.04). The mean pest defender ratio in Bio-intensive organic insect pest management module was 1: 2.46 compared to 1: 0.75 in the farmers' organic module during *Samba*, 2018.

Grain yield

In *Samba* 2017 field trial, the grain yield recorded was 4080 kg/ha in Bio-intensive organic insect pest management module as compared 3880 kg/ha in farmers' organic module. During Samba, 2018 grain yield recorded was 4340 kg/ha in Bio-intensive organic insect pest management module as compared 3440 kg/ha in farmers' organic module.

Profitability and sustainability

The total production cost for organic paddy accounted to Rs. 33041/- per ha in both Bio-intensive organic IPM module and farmers' organic module as uniformity was maintained in cultivation aspects. However with regard to the plant protection aspects it varied between Bio-intensive organic IPM module and farmers' organic module. The expenditure towards IPM (Rs.) was Rs. 11090/- per ha in bio-intensive organic IPM module as compared to Rs. 6750/- per ha in Farmers organic module. The profit earned form the bio-intensive organic IPM module was Rs. 70109/- during *Samba*, 2017 and Rs. 77389/- during *Samba*, 2018. There was a 10.38 per cent increased yield in *Samba*, 2018 over *Samba*, 2017 trial. Conversely, the profit earned form the Farmers organic module was Rs. 68849/- during *Samba*, 2017 and Rs. 56529/- during *Samba*, 2018. There was a decreased yield trend of -17.89 per cent in *Samba*, 2018 over *Samba*, 2017 trial.

Table 3: Profitability and sustainability of bio-intensive organic insect pest management module and farmers organic module

Parameter	Bio-intensive IPM module		Farmers organic module	
	2017-18	2018-19	2017-18	2018-19
Yield (kg/ha)	4080	4340	3880	3440
Net return (Rs./ha)	114240	121520	108640	96320
Total production cost (Rs./ha)	33041	33041	33041	33041
Expenditure towards Plant Protection (Rs./ha)	11090	11090	6750	6750
Profit (Rs./ha)	70109	77389	68849	56529
% increase yield over 2017 trial		10.38		-17.89
Cost benefit ratio	1:1.59	1:1.73	1:1.75	1:1.42

Discussion

Enhancing natural pest control in organic systems could help reduce costs, stabilize production, and increase the ability of organic practices to meet global demand. Decreased insect pests on long term organic farms have largely been attributed to practices that limit pest build-up, increase predator biodiversity, and increase the numbers of beneficial insects (Hole, 2005; Crowder *et al*., 2010, Garratt *et al*., 2011).

The green manure *Daincha* incorporated in the soil promoted soil microbes, the nutrient availability to plants and increased plant immunity against insect. Organic management strategies can increase microbial activity and biomass in soils, alter microbial communities, and in some cases enhance plant associations with beneficial microbes in the rhizosphere. Microorganisms that associate with plant roots play a critical role in resistance to abiotic and biotic stress (Vannette and Hunter, 2009).

In our study, the insect pest load was 2.15 times lesser in the bio-intensive organic insect pest management module as compared to the farmers' organic module. *Lyashenko et al*., 1982 reported that organic matter is mainly supplemented through Farm Yard Manure (FYM) in rice fields that increased levels of leucoanthocyanins, catechins, flavanol glycosides and phenol carboxylic acids in plants and this would be responsible for lesser incidence of many rice insect pests. Mohankumar *et al.* (1995) reported that organic manure application lowered gall midge incidence than inorganic fertilizer application. Basal application of *Azospirillum* + Phosphobacteria + silica solubilizing bacteria + *Pseudomonas fluorescens* (Pf 1) reduced the insect pest load. The total insect pests in Bio-intensive organic insect pest management module averaged 3.37 nos./ 5 sweeps as against 6.91 nos./ 5 sweeps in the farmers organic module. Earlier reports also revealed that incorporation of *Azospirillum* significantly decreased the incidence of BPH, GLH and leaf folder in rice (Anuradha, 1989). The combined application of *Azospirillum* with organic manure decreased the feeding rate of BPH and adversely affected its growth and development (Athisamy and Venugopal, 1995). Mohan *et al.* (1988) reported that *Azospirillum* would have favourably activated Phenyl Ammonia Lyase enzyme concerned in the biosynthesis of phenolics resulting in increased plant phenolics in plants which are responsible for lower damage. *Azospirillum* promotes growth of plant mainly by the production of phytohormornes viz., auxins, gibberlins and cytokinins in addition to biological nitrogen fixation (Cicciari *et al*., 1989). Neem cake soil application during the last ploughing increased the plant phenol contentwhich in turn had negative effect on the insect multiplication and development (Krishnaiah and Kalode,1985). The role of neem cake in reducing the incidence of planthoppers and leaf hoppers, gall midge, stem borer and leaf folder has been reported by Athisamy (1994) and Ambethgar (1996).

The mean natural enemies in Bio-intensive organic insect pest management module was 9.71 nos./ 5 sweeps as against 4.95 nos./ 5 sweeps in the farmers organic module. Population of the natural enemies was 1.96 times higher in the Bio-intensive organic insect pest management module as compared to the farmers' organic module. Ragini *et al*. (1995) observed that organic farming supported more *Ophionea*, *Paederus*, coccinellid beetles, mirids and spiders. In organic paddy ecosystem also the grain yield recorded was 4340 kg/ha in Bio-intensive organic insect pest management module as compared 3440 kg/ha in farmers' organic module.

In Bio-intensive organic insect pest management module there was a 10.38 per cent increased yield in *Samba*, 2018 over *Samba*, 2017 trial. Conversely, in farmers' organic module there was a decreased yield trend of -17.89 per cent in *Samba*, 2018 over *Samba*, 2017 trial. It could be concluded that organic matter enrichment and increased biocontrol agents activities in bio-intensive organic insect pest management module enhanced the association of above and below ground food chains and augmented natural plant defense mechanism furthermore would reflect in the increased rice productivity over years.

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