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Research Article

Field evaluation of bio-intensive IPM modules against important insect pests of mustard under North Coastal Plain Zone of Odisha

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ABSTRACT: Studies on the efficacy on some biocontrol based IPM modules against the important insect pests of mustard were carried out at the farmers' field of Balasore district of Odisha during the rabi seasons of 2011-12 and 2012-13. A significantly lower incidence of mustard aphid, saw fly, painted bug and cabbage webber were observed in all the IPM modules in comparison to the farmers' practice of scheduled based insecticide application. However, the minimum population of aphid (13.56/10 cm twig of plant), saw fly (3.93 larvae/10 plants), cabbage webber (4.20 caterpillar/10 plants) and painted bug (4.86 bugs/10 plants) were recorded in the module M_1 comprising of two foliar spray of neem based pesticides (300 ppm azadirachitin) @ 5 ml/l of water at 40 and 55 days after sowing (DAS), twice release of two-days old first instar larvae of *Chrysoperla zastrowii sillemi* @ 20000/ha at 50 and 60 DAS and installation of yellow sticky traps (@ 25/ha. Besides, the population of natural enemies like lace wing bugs, coccinellid beetles, syrphid flies and pollinators like honey bees was significantly higher in all the IPM plots in comparison with farmers practice indicating that the IPM modules were comparatively less harmful to these beneficial insects. The yield obtained in the IPM modules were found to be significantly higher than the farmers practice (7.95 q/ha) and the maximum yield was recorded in M_1 (11.17 q/ha) with highest net return (18628.00), B: C ratio (1.96) and incremental B:C ratio (2.37).

KEY WORDS: Insect pest of mustard, Biocontrol, IPM modules

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INTRODUCTION

Mustard is an important oilseed crop in India and is cultivated in an area of about 6.8 million ha with average productivity of 11.51 q/ha. It contributes about 28.6% of total oilseeds production in the country and is the second most important edible oilseed after groundnut (Shekhawat *et al*., 2012). Among the various production constraints, high incidence of insect pests is the major limiting factors responsible for low yield in mustard. About 43 insect species have been recorded infesting this crop (Khan *et al*., 2013) and among these mustard aphid *Lipaphis erysimi* Kalt. is the most important one contributing towards the yield loss ranging from 9 to 96% (Singh and Sharma, 2002) and 15% oil reduction (Verma and Singh, 1987) in India. Both the nymphs and adults suck sap from leaves, twigs, buds, inflorescence, developing pods and causes damage by poor plant growth, curling of leaves, delayed flowering, flower abortion, reduced pod formation and poor seed setting. Delayed sowing and excessive application of nitrogenous fertilizers by the farmers aggravates the aphid incidence and maximize the yield loss in mustard. Besides, other insect pests like cabbage webber (*Crocidolomia binotalis*), saw fly (*Athalia lugens proxima*) and painted bug (*Bagrada hiliaris*) also infest the crop and increase the yield loss in mustard. Application of chemical insecticides is still regarded as the most preferred pest management strategy among the farmers and their indiscriminate application have serious adverse effect on beneficial insects, human health and surrounding environment. Some of the insecticides are not yielding the desired level protection against aphids due to the development of insecticide resistance. Considering the adverse effect of insecticides, management of the insect pests of mustard through IPM strategies is gaining importance in the recent years. Keeping this in view some bio-intensive IPM modules comprising the release bio-control agent (*Chrysoperla zastrowii sillemi*), foliar application of botanicals and biopesticides along with some cultural and mechanical methods of were evaluated in the present investigation for the sustainable reduction of insect pest incidence in mustard crop.

MATERIAL AND METHODS

Experiments were carried out in the farmers' field of Balasore district of Odisha during rabi seasons of the year 2011-12 and 2012-13 for evaluating the efficacy of three bio-intensive IPM modules (Table 1) in mustard against the existing insecticide application based farmers' practice. Field trials were conducted in a complete randomized block design with four treatments (3 IPM modules and farmers' practice) and five replications having plot size of 10 cent (400 m^2) each. The seeds of mustard variety Pusa Bold were sown on first week of December in the well prepared experimental plots with standard agronomic package of practices and intercultural operations. All the three IPM modules had similar cultural practices like timely sowing and balanced fertilizer application (60:30:30 kg NPK/ha). However, in the farmers' practice, sowing was done on last week of December and the crop production and protection practices were followed as per the farmers' will.

The bio-control agent *C. zastrowi sillemi* obtained from the bio-control laboratory of Department of Entomology, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar were released twice at fortnightly interval @ 20,000 first instar larvae per hectare. The neem based pesticides and myco-insecticides were applied on the crop during the afternoon hours in the form of foliar spray with the help of knapsack hand sprayer using 500 liter of spray solution per hectare. Treatment and replication wise periodic observations of aphids were recorded with their appearance in the field and continued till harvesting of the crop. The aphid population was counted on weekly interval from top 10 cm of central shoot of 10 randomly selected tagged plants from each replication and cumulative numbers of observations were considered to work out the mean aphid population over the crop period. The effect of different modules on other insect pests like cabbage webber, saw fly and painted bug was also assessed by recording their population from the 10 tagged plants per replication and expressed as average insect population/plant. The safety of IPM modules to the beneficial insects was evaluated by recording the population of predators and pollinators in each treatment. The data on aphids, other insect pest of mustard and the beneficial insects after necessary transformation were subjected to statistical analysis to find out the efficacy of the IPM modules. The effect of various IPM modules on the seed yield was also analyzed and the net return and benefit: cost ratio was worked out for assessing the economic efficiency.

Table 1. Bio-intensive IPM Modules tested against mustard aphid during 2011-12 and 2012-13

IPM Modules	Details of IPM modules
Module 1	Two foliar spray of neem based pesticides (300 ppm azadirachitin) @ 5 ml/l of water at 40 and 55 DAS + Twice release of *Chrysoperla zastrowi sillemi* @ 20000/ha at 50 and 60 DAS + Installation of yellow sticky traps (@ 25/ha).
Module 2	Two foliar spray of *Verticillium lecanii* formulations @ 2 ml/l of water at 40 and 55 DAS + Twice release of *Chrysoperla zastrowi sillemi* @ 20000/ha at 50 and 60 DAS + Sprinkling of wood ash @ 10 kg/ ha
Module 3	Two foliar spray of *Beauveria bassiana* formulations (Mycozal) @ 2 ml/l of water at 50 and 60 DAS + Twice release of *Chrysoperla zastrowi sillemi* @ 20000/ha at 50 and 60 DAS + Topping of aphid infested twigs
Farmers' practice	Three round spraying with insecticides like dimethoate, acetamiprid and triazophos at 12-18 days interval starting from 30 to 35DAS.

RESULTS AND DISCUSSION

Relative efficacy of IPM modules against aphids and other insect pests in mustard

The pooled mean value of both the years of experiment indicated that there has been a significant reduction in aphid population in all the IPM modules (Table 2.) in comparison to the farmers' practice. Among the different modules evaluated, the module M_1 was found to be the most effective in reducing aphid population with an average 13.46 aphids/10 cm terminal twig. The aphid population was also significantly lower in M_3 (17.57 aphids/10 cm twig) and M_2 (19.52 aphids/10 cm twig). In contrast maximum aphid population was found in the farmers' practice (23.94 aphids/10 cm twig) despite of scheduled based application of insecticides. The IPM modules evaluated for the management of mustard aphid were also evaluated for their efficacy against other insect pests which appeared in the mustard experimental plots. The IPM module M_1 retained its superiority in minimizing the incidence of cabbage webber (4.20 caterpillars/10 plants) and is closely followed by M3 with 4.54 caterpillars/10 plants. Both these modules were found to be statistically at par with each other and remained significantly different from M_2 (5.42 caterpillars/10 plant) and farmers' practice (6.33 caterpillars/10 plant). A similar trend was also observed in the comparative efficacy

of different IPM modules on the incidence of mustard saw fly and M_1 registered the lowest incidence with an average 3.93 larvae/10 plants. The module M_3 was considered to be the next effective treatment with 4.25 larvae/ 10 plants and had statistically similar effect with M_1. The module M_2 also offered a good control of saw fly (5.03 larvae/10 plants) and registered significantly superior control over the farmers' practice (5.81 larvae/10 plants). Similarly, the population of painted bug was suppressed in all the IPM plots compared to farmers' practice and a significant difference in their population was observed among the different modules under study. Among the IPM modules, M_1 afforded maximum control of painted bug with an average of 4.86 insects/10 plants and was closely followed by M_3 (5.18 insects/10 plants) and both these modules were statistically comparable with each other. The next lower bug incidence was observed in the module M_2 (5.97 insects/10 plants) and found to be significantly better than the farmers' practice (6.79 insects/10 plants).

Effect of IPM modules on the predators and pollinators in mustard

It was evident from the pooled mean data of 2011-12 and 2012-13 (Table 3.) that all the IPM modules retained significantly higher population of predatory insects in comparison to the farmers' practice of indicating the toxic effect of chemical insecticides on their population build up and activity. Higher population of green lace wing bugs was recorded in the IPM plots (11.24 to 12.19 larvae per 10 plants) compared to only 4.64 larvae/10 plant in the farmers' practice. However, the highest chrysopid population was observed in M_1 (12.19 larvae per 10 plants) followed by M_2 (11.34 larvae/10 plants) and M_3 (11.24/10 plants). No significant difference in the lace wing population was observed among the IPM plots. The IPM modules also harboured encouraging number of ladybird beetle population ranging from 8.73 to 9.09 insects/10 plants as against an average 4.07 insects/10 plants in the farmers' practice.

Table 2. Relative efficacy of IPM modules against aphids and other insect pests in mustard

IPM Module	Mustard aphid (Population/10 cm twig of plant)			Cabbage webber (Average caterpillar/10 plant)			Mustard saw fly (Average larvae/10 plant)			Painted Bug (Average insects/10 plant)		
	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean
M1	14.54 (3.88)	12.38 (3.58)	13.46 (3.73)	4.51 (2.23)	3.88 (2.09)	4.20 (2.16)	3.68 (2.04)	4.18 (2.16)	3.93 (2.10)	4.78 (2.30)	4.93 (2.33)	4.86 (2.31)
M2	21.07 (4.64)	17.97 (4.29)	19.52 (4.47)	5.72 (2.49)	5.07 (2.36)	5.42 (2.43)	4.84 (2.31)	5.22 (2.39)	5.03 (2.35)	5.90 (2.53)	6.03 (2.55)	5.97 (2.54)
M3	19.11 (4.43)	16.02 (4.06)	17.57 (4.25)	4.93 (2.33)	4.14 (2.15)	4.54 (2.24)	4.03 (2.13)	4.46 (2.23)	4.25 (2.18)	5.17 (2.38)	5.20 (2.39)	5.18 (2.38)
Farmers' practice	26.82 (5.22)	21.06 (4.64)	23.94 (4.94)	6.63 (2.67)	4.95 |(2.33)	6.33 (2.61)	4.69 (2.49)	5.93 (2.53)	5.81 (2.51)	6.74 (2.69)	6.84 (2.71)	6.79 (2.60)
SE(m) ±	0.09	0.09	0.07	0.05	0.06	0.04	0.05	0.04	0.03	0.04	0.04	0.03
CD (*P*> 0.05)	0.26	0.28	0.21	0.15	0.19	0.13	0.14	0.12	0.10	0.13	0.14	0.10

* Figures in the parenthesis are the √ x+0.5 transformed values

Table 3. Effect of IPM modules on the predators and pollinators in mustard

IPM Module	Chrysoperla larvae / 10 plants			Lady bird beetle population (Average numbers of adult and grub/10 plant)			Syrphid fly population (Average larvae 10 / plant)			Honey bee population (Bee visits/plant / 5 minutes)			Other pollinators (Insect visits / plant / 5 minutes)		
	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean	2011-12	2012-13	Pooled mean
M1	11.70 (3.49)	12.67 (3.62)	12.19 (3.56)	9.28 (3.13)	8.91 (3.06)	9.09 (3.10)	6.65 (2.67)	7.15 (2.76)	6.90 (2.72)	2.71 (1.79)	2.87 (1.83)	2.79 (1.81)	1.91 (1.55)	2.02 (1.59)	1.97 (1.57)
M2	11.14 (3.41)	11.54 (3.47)	11.34 (3.44)	9.05 (3.09)	8.40 (2.98)	8.73 (3.04)	6.36 (2.61)	6.62 (2.66)	6.49 (2.64)	2.46 (1.71)	2.62 (1.76)	2.54 (1.74)	1.78 (1.50)	1.93 (1.55)	1.85 (1.53)
M3	10.81 (3.36)	11.68 (3.49)	11.24 (3.42)	8.94 (3.07)	8.62 (3.02)	8.78 (3.04)	6.19 (2.58)	6.31 (2.61)	6.25 (2.60)	2.55 (1.74)	2.59 (1.75)	2.57 (1.75)	1.71 (1.48)	1.86 (1.53)	1.79 (1.51)
Farmers' practice	4.55 2.24)	4.73 (2.28)	4.64 (2.26)	4.19 (2.16)	3.94 (2.10)	4.07 (2.13)	3.21 (1.92)	3.36 (1.96)	3.28 (1.94)	1.18 (1.29)	1.24 (1.32)	1.21 (1.31)	1.02 (1.23)	1.07 (1.25)	1.04 (1.24)
SE(m) ±	0.09	0.08	0.07	0.05	0.07	0.06	0.07	0.06	0.06	0.05	0.06	0.05	0.05	0.06	0.04
CD (P> 0.05)	0.29	0.24	0.21	0.15	0.23	0.17	0.20	0.19	0.19	0.16	0.17	0.14	0.16	0.17	0.12

*Figures in the parenthesis are the √ x+0.5 transformed values

The highest ladybird beetle population was observed in M_1 (9.09 insects per 10 plants) followed by M_3 (8.78 insects/10 plants) and M_2 (8.73 insects/10 plants) without having any statistical difference among themselves. Similarly, all the bio-intensive modules encouraged significantly higher population of syrphid flies (6.25 to 6.90 larvae per 10 plants) compared to 3.28 larvae per 10 plants in farmers' practice and the module M_1 retained the maximum population of this predatory flies. It was observed in this experiment that all the IPM modules had favorable effect on honey bees and other the pollinators like bumble bees and butterflies. The population of honey bees was found to be invariably higher in all the modules (2.54 to 2.79 bee visits/plant/5 minutes) as against only 1.21 bee visits/plant/5 minutes in the farmers' practice. Similarly, a proportionately higher population of other pollinators was recorded in the IPM modules (1.79 to 1.97 insect visits/plant/5 minutes) in comparison to the farmers' practice (1.04 97 insect visits/plant/5 minutes). A large population build up of natural enemies and pollinators in the IPM plots indicated that IPM practices augments biodiversity of beneficial faunas in the mustard eco-system and hence, can ensure its sustainable production.

Effect of IPM modules on the yield and economics of mustard production

The effect of IPM on seed yield was studied during the experiment which revealed that mustard yield has increased significantly in all the IPM plots over farmers practice (Table 4). However, the highest yield of 11.17 q/ha was registered with the module M_1 followed by M_3 (10.71 q/ha) and these modules were statistically at par with each other. The module M_2 with seed yield of 9.95 q/ha was the next effective IPM module and found to be significantly superior to the farmers' practice (7.95 q/ha). Economic effectiveness of various pest management modules based on net returns gained and B:C ratio were evaluated and it was observed that the highest net return per ha was recorded in the module M_1 (Rs. 18628.00) owing to the yield advantage over other modules. The modules M_3 and M_2 with net return of Rs. 16614.00 and Rs. 14230.00, respectively were also found to be more profitable in comparison to the farmers' practice (Rs. 11230.00). When the economics of different modules were studied in terms of benefit: cost ratio (B:C ratio), it was found that the module M_1 with the highest B:C ratio of 1.96 considered to be the most economical. The modules M_3 and M_2 with B:C ratio of 1.84 and 1.73 were the next economical IPM modules and farmers' practice proved to be least economical with B:C ratio (1.71). Besides, the incremental B:C ratio (IBCR) among the different modules under study was also estimated on the basis of additional return over the additional cost incurred and it was observed that maximum IBCR was obtained in the module M_1 (2.37). This module had the highest additional return of Rs. 7698.00 with additional expenditure of Rs. 3250.00 over the farmers' practice. However, the lowest ICBR was estimated in the module M_2 (0.94) owing to less additional return over the additional cost.

The results of the present investigation got ample support from the findings of Pandey and Singh (2008) who reported that the module consisting of foliar spray of 5 % NSKE and release of *C. zastrowi sillemi* (two-days old first instar larvae @ 150 000/ha) significantly reduced the aphid population to 17.19/ 10 cm central shoot in comparison to the untreated control (84.62/10 cm twig). This module also increased the seed yield to 10.81 q/ha over the untreated control (3.45 q/ha) and registered higher additional return of Rs. 13768.65/ha. Patel *et al*. (2009) also observed the rich activity of bio-agents i.e. syrphid fly, coccinellids and *D. rapae* in mustard when they used neem oil based formulation @ 0.3% for the control of aphids. Dhaka *et al*., (2011) reported that biopesticides like Neem oil (neemarin), NSKE and *Beauveria bassiana* performed better against sawflies as compared to untreated plots. Khan (2013) observed that among the different treatments tested against canola aphid, module consisting of neem oil 2% + *C. zastrowi sillemi* proved the most effective in reducing the aphid incidence. He also suggested that neem oil was very effective and compatible with predator, *C. zastrowi sillemi* for the management of aphids in canola. Meena *et al.* (2013) also re-

Table 4. Effect of IPM modules on the yield and economics of mustard production

IPM Modules	Seed Yield (q/ha)			Gross return (Rs.)	Cost of production (Rs.)	Net return (Rs.)	B:C ratio	Additional Cost over F.P (Rs.)	Additional Return over F.P (Rs.)	Incremental B:C ratio
	2011-12	2012-13	Pooled mean							
M 1	10.86	11.48	11.17	37978	19350	18628	1.96	3250	7698	2.37
M 2	9.74	10.15	9.95	33830	19600	14230	1.73	3500	3300	0.94
M 3	10.47	10.94	10.71	36414	19800	16614	1.84	3700	5684	1.54
F.P	7.76	8.14	7.95	27030	15800	11230	1.71			
SE(m) ±	0.22	0.24	0.15	-	-	-	-			
CD (0.05)	0.68	0.74	0.47	-	-	-	-			

vealed that after 10 days of spray 5 % NSKE resulted 83.20 % reduction in aphid population followed by *B. bassiana* @ 5 g per litre of water (78.00%) and *V. lecanii* @ 5 g per litre of water (75.0%). He also reveled that significantly higher mustard seed yield (2017-2460 kg/ha) was recorded in all treatments over the untreated control and a higher yield of 2358 kg/ha was attained in the NSKE treated plots.

Therefore, the present study revealed that all the IPM modules have been found to be highly effective against mustard aphid and their efficacy was due to the cumulative effect of all the components of IPM i.e. early sowing, balanced fertilizer dose, mechanical control (yellow sticky trap/topping of leaves), release of bio-agents and timely application of biopesticides or botanicals. The bio-intensive modules have been proved to be safer to the beneficial insects and resulted in higher yield and profit of mustard.

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REFERENCES

Dhaka SS, Prajapati CR, Singh DV, Singh R. 2011. Efficacy of insecticides and biopesticides against *Athalia Proxima* on Indian mustard. *Ann Plant Protect Sci.* 19(2): 333–335.

Khan MH, Nazir A, Shah Rashdi SMM, Ismail M, Rauf I, mad Tofique M. 2013. Studies on the compatibility of neem oil with predator, *Chrysoperla carnea* for the management of aphids (Homoptera: Aphididae) in canola (*Brassica napus L*). *J Cereals Oilseeds* **4(6)**: 85–88.

Meena H, Singh SP, Nagar R. 2013. Evaluation of microbial agents and bio-products for the management of mustard aphid, *Lipaphis erysimi* (Kalt). *The Bioscan*. **8(3)**: 747–750.

Pandey R, Singh NN. 2008. Effectiveness of biocontrol based IPM modules against *Lipaphis erysimi* Kaltenbach (Hemiptera: Aphididae). *J Plant Prot Res.* **48**(1): 1–7.

Patel BS, Patel IS, Patel GM. 2009. Evaluation of different eco-friendly modules for the management of mustard aphid, *Lipaphis erysimi* (Kalt) in North Gujarat. *J Oilseed Res*. **26**: 679–680.

Shekhawat K, Rathore SS, Premi OP, Kandpal BK and Chauhan JS. 2012. Advances in agronomic management of Indian mustard *Brassica juncea* (L.) Czernj Cosson: An overview. *Int J Agronomy.*

Singh YP, Sharma KC. 2002. Integrated approach to manage the mustard aphid, *Lipaphis erysimi* (Kalt) (Homoptera: Aphididae) in oil seed Brassica crops-A review. *J Aphidology*. **16**: 77–88.

Verma SN, Singh OP. 1987. Estimation of avoidable losses to mustard by aphid, *Lipaphis erysimi* in Madhya Pradesh. *Indian J Plant Protect*. **15**: 87–89.