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Impact of different IPM Modules of Brinjal (*Solanum melongena* L.) on coccinellid Beetles

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ABSTRACT: The contribution and safety of the natural enemies is often neglected whenever a module is developed to manage major pest of the crop. So, field experiments were conducted to evaluate the different IPM modules for the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* along with their safety towards predatory coccinellids during *Rabi* 2020-21 and *Kharif* 2021-22 at Zonal Agricultural and Horticultural Research Station (ZAHRS), Shivamogga. The results revealed that the Bio Intensive Pest Management (BIPM) module was ultimately the most promising and recorded higher number of coccinellids compared to IPM module, chemical intensive Farmers practice module and untreated control during both seasons recording mean number of 1.96 adult coccinellids/plant. This highlights the scope to augment the natural enemies and maintain their population under BIPM module through which the infestation of *L. orbonalis* could be much more reduced.

Keywords: *Leucinodes orbonalis*, coccinellids, BIPM, Modules.

INTRODUCTION

Brinjal, *Solanum melongena* L. is a prominent vegetable crop cultivated across South East Asia. In India it is cultivated over an area of 7.43 lakh hectares with a production of 127.7 lakh tonnes with a productivity of 17.17 MT/ha (Anon., 2022). Brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee is a significant constraint in brinjal cultivation which damages the crop by boring into the most economic part *i.e.,* fruit and also lead to drooping of shoots. This pest is reported to cause yield losses up to 20-93 per cent (Mall *et al*., 1992; Raju *et al*., 2007; Srinivasan, 2008; Jagginavar *et al*., 2009; Kodandaram *et al*., 2017). Due to cryptic nature of this pest farmers generally prefer to apply the insecticides as a paraphyletic measure (Mishra and Dash 2007). This has led to numerous sprays of insecticides within a cropping season (Latif *et al*., 2010). Recent reports have revealed development of insecticidal resistance in this pest (Kodandaram *et al*., 2015). Indiscriminate use of broad-spectrum insecticides resulted in development of resurgence in secondary pests such as whitefly, mites and thrips (Krishnakumar and Krishnamoorthy 2001). Insecticides also affect the non-target organisms (including natural enemies), and also cause many diseases in humans (Ahmad e*t al*., 2007; Lu *et al*., 2012; Decourtye *et al*., 2013; Passos *et al*., 2018; Taning *et al*., 2019). This has given rise to development of Integrated Pest Management (IPM) strategies. IPM has received more attention as a potential strategy for lowering reliance on chemical pest management and it helps proliferation of local natural enemies to encourage the pest suppression (Srinivasan, 2008). Coccinellid beetles are voracious predators of soft bodied insects like scales, aphids and psyllids (Sundararaj and Sharma 2012). So, there is need to develop ecologically and environmentally sound pest management modules that help in conserving these charismatic group of insects. However, the impacts of different modules on safety of natural enemies often neglected as more focus is given to the target pest of the crop. So, keeping these things in mind present investigation was undertaken in order to evaluate different IPM modules on their safety towards predatory coccinellids occurring in brinjal cropping ecosystem.

MATERIAL AND METHODS

Field experiments were conducted to evaluate the different Integrated Pest Management (IPM) modules for the management of brinjal shoot and fruit borer, *L. orbonalis* along with their safety towards predatory coccinellids during *Rabi* 2020-21 and *Kharif* 2021-22 at Zonal Agricultural and

Horticultural Research Station (ZAHRS), Shivamogga using the brinjal F_1 hybrid Lalit, which is the predominant hybrid grown in and around Shivamogga and Davanagere districts of Karnataka. The twenty-five days seedlings were transplanted with the spacing of 90 × 60 cm in a plot size of 250 m^2 for each IPM module. All the recommended dose of fertilizers and FYM were followed as per package of practices except recommended plant protection measures. Each module was considered as treatments and these treatments were divided into six plots (six replications). The observations on total numbers of adult coccinellids present in different modules were recorded at fortnight intervals from 5 weeks After Transplanting (WAT) on ten randomly selected plants from each plot. The various treatments applied in the modules are mentioned in Table 1.

Statistical analysis. The number of adult coccinellids recorded were subjected to square root transformation using SPSS software. The transformed values were represented in parenthesis. Significant difference between treatment means were depicted by different letters based on Tukey's HSD. Graphical representation was done using Graph Pad Prism 8.0.2 software.

Table 1: Treatment details of various modules used in the study.

Module - I	
Treatment details	**Biointensive module**
1	Installation of pheromone traps (10/ha) 30 DAT
2	4 releases of *Trichogramma pretiosum* at 50000 egg/ha from flowering stage at 10 days interval
3	Spraying of NSKE 5% at 4^{th}, 8^{th}, 12^{th} and 16^{th} week after trap installation
4	Spraying of *Beauveria bassiana* at 2g/lit at 3^{rd}, 7^{th} and 15^{th} week after trap installation as larvicidal biopesticide
Module – II IPM module	
1	Installation of pheromone traps (25/ha) 30 DAT for mass trapping
2	Removal and destruction of infested shoots and fruits
3	Spraying of azadirachtin 1% (10000 ppm) at 4^{th}, 5^{th} and 6^{th} weeks after trap installation
4	Spraying of *Bacillus thuringiensis* var *kurstaki* at 2g/lit at 7^{th} and 8^{th} week after trap installation
5	Spraying of chlorantraniliprole 18.5% SC at 0.3ml/lit 12^{th}, 13^{th} and 15^{th} week after trap installation
Module – III Farmers practice module	
1	Spraying of emamectin benzoate 5% SG at 0.4g/lit
2	Spraying of chlorantraniliprole 18.5% SC at 0.3 ml/lit
3	Spraying of lambda-cyhalothrin 5%EC at 0.5ml/lit
The above-mentioned insecticides were sprayed alternatively at weekly intervals	
Untreated control	No plant protection measures were taken, served as an untreated control

RESULTS AND DISCUSSION

Adult ladybird beetle populations were recorded based on their numbers in different modules during *Rabi* 2020-21 and *Kharif* 2021-22. Different species of coccinellids *viz*., *Coccinella transversalis, Menochilus sexmaculatus* and *Propylea dissecta* were recorded during the study. During *Rabi* 2020-21, significantly higher number of coccinellids was recorded in bio-intensive module (2.10/plant) followed by untreated control (1.15/plant) and IPM module (1.10/plant) which were on par with each other at 5 Weeks After Transplanting (WAT). Then, decreasing trend was noticed in the population of coccinellids in different modules during 7 and 9 WAT, again in which the population of coccinellid adults were significantly higher in Bio-Intensive module. However, there was no significant difference in the population of coccinellids among bio-intensive module (1.35/plant), IPM module (1.08/plant) and untreated control (1.08/plant) during 11 wat and similar trend was noticed during 13 WAT. Observations at 15 WAT revealed that significantly higher number of coccinellids were recorded in bio-intensive module (1.75/plant) followed by untreated control (1.27/plant) and IPM module (0.98/plant), which were on par with each other. Significantly lower numbers were recorded in farmers practice module (0.17/plant). However, significant difference was noticed between untreated control and IPM module which recorded 1.32 coccinellids numbers/plant and 0.88/plant, respectively, at 17 WAT (Table 2). During *Kharif* 2021-22, Significantly higher number of adult coccinellids were noticed in Bio-intensive module (1.90/plant) followed by IPM module (1.25/plant) and Farmers practice module (0.70/plant) which were on par with each other during 5 WAT. Significantly higher number of ladybird beetles were recorded in bio-intensive module (2.15/plant) during 7 WAT followed by untreated control (1.17/plant) and significantly lower population was recorded in farmers practice module (0.42/plant). Similar trend was noticed during 9 WAT. Like previous weeks, significant difference was noticed in the populations of coccinellids among bio-intensive module (1.35/plant) which recorded highest number followed by IPM module (1.08/plant) and untreated control (1.08/plant)at 11 WAT. The same trend was noticed at 13 WAT. During 15 WAT significantly higher number of coccinellids was noticed in bio-intensive module (2.48/plant) followed by untreated control (1.87/plant) and IPM module (1.23/plant).. However, there was no significant difference between Bio-intensive module and untreated control which recorded 2.20 coccinellids numbers/plant and 1.32/plant, respectively, at 17 WAT (Table 3).

Table 2: Population of coccinellids on brinjal under different modules during *Rabi* 2020-21.

Module	Mean number of adult coccinellids/plant							
	5 WAT	7 WAT	9 WAT	11 WAT	13 WAT	15 WAT	17 WAT	Mean coccinellids/plant
Module – I (Biointensive)	2.10 ± 0.34 (1.61)[a**]	1.83 ± 0.32 (1.52)[a]	1.18 ± 0.26 (1.29)[a]	1.35 ± 0.19 (1.36)[a]	1.53 ± 0.39 (1.42)[a]	1.75 ± 0.33 (1.50)[a]	1.70 ± 0.25 (1.48)[a]	1.64± 0.43
Module – II (IPM)	1.10 ± 0.19 (1.26)[b]	0.88 ± 0.23 (1.17)[b]	0.92 ± 0.23 (1.19)[a]	1.08 ± 0.28 (1.25)[a]	1.18 ± 0.12 (1.30)[a]	0.98 ± 0.15 (1.22)[b]	0.88 ± 0.12 (1.18)[c]	1.00± 0.28
Module – III (Farmers practice)	0.52 ± 0.21 (1.00)[c]	0.42 ± 0.17 (0.95)[c]	0.37 ± 0.19 (0.93)[b]	0.25 ± 0.16 (0.86)[b]	0.22 ± 0.08 (0.85)[b]	0.17 ± 0.08 (0.82) [c]	0.13 ± 0.08 (0.79)[d]	0.30± 0.16
Untreated control	1.15 ± 0.40 (1.28)[b]	1.00 ± 0.30 (1.22)[b]	0.92 ± 0.29 (1.18)[a]	1.08 ± 0.31 (1.25)[a]	1.20 ± 0.20 (1.30)[a]	1.27 ± 0.31 (1.32)[b]	1.32 ± 0.26 (1.35)[b]	1.13± 0.37
F $_{(3,15)}$	35.00	48.92	14.03	24.61	45.15	65.03	106.03	
P (α=0.05)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	

*Mean ± SE (values in parentheses are √x + 0.5 transformed values)

**Mean followed by different letters are significantly different at α = 0.05 (p-value < 0.05) according to Tukey's HSD. NS = Non-significant at P > 0.05

Table 3: Population of coccinellids on brinjal under different modules during *Kharif* 2021-22.

Module	Mean number of adult coccinellids/plant							
	5 WAT	7 WAT	9 WAT	11 WAT	13 WAT	15 WAT	17 WAT	Mean coccinellids/plant
Module – I (Biointensive)	1.90 ± 0.37 (1.55)[a]	2.15 ± 0.16 (1.63)[a]	2.05 ± 0.40 (1.59)[a]	2.55 ± 0.55 (1.74)[a]	2.63 ± 0.37 (1.77)[a]	2.48 ± 0.36 (1.72)[a]	2.20 ± 0.51 (1.64)[a]	2.28± 0.48
Module – II (IPM)	1.25 ± 0.10 (1.32)[b]	1.12 ± 0.26 (1.27)[b]	0.98 ± 0.12 (1.22)[b]	1.37 ± 0.25 (1.36)[b]	1.42 ± 0.31 (1.38)[b]	1.23 ± 0.27 (1.31)[c]	0.90 ± 0.18 (1.18)[b]	1.18± 0.36
Module – III (Farmers practice)	0.70 ± 0.17 (1.09)[c]	0.42 ± 0.12 (0.96)[c]	0.30 ± 0.09 (0.89)[c]	0.15 ± 0.08 (0.80)[c]	0.20 ± 0.11 (0.83)[c]	0.27 ± 0.14 (0.87)[d]	0.10 ± 0.06 (0.77)[c]	0.30± 0.18
Untreated control	1.12 ± 0.23 (1.27)[b]	1.17 ± 0.34 (1.29)[b]	1.07 ± 0.27 (1.25)[b]	1.60 ± 0.17 (1.45)[b]	1.77 ± 0.34 (1.50)[b]	1.87 ± 0.15 (1.54)[b]	1.68 ± 0.30 (1.47)[a]	1.47± 0.24
F $_{(3,15)}$	27.87	61.80	58.26	90.17	72.94	95.94	78.99	
P (α=0.05)	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	

*Mean ± SE (values in parentheses are √x + 0.5 transformed values)

*Mean followed by different letters are significantly different at α = 0.05 (p-value < 0.05) according to Tukey's HSD. NS = Non-significant at P > 0.05

Pooled data (*Rabi* 2020-21 and *Kharif* 2021-22) on mean number of coccinellids revealed that Bio-intensive module (1.96/plant) recorded a higher number of ladybird beetles, followed by the Untreated control (1.30/plant) and IPM module (1.09/plant). The Farmers practice module recorded the least population density of coccinellids (0.30/plant) (Fig. 1).

The coccinellids are the most important predators and prey upon large numbers of sucking pests like aphids, leafhoppers, white flies and lepidopteran eggs and neonate larvae(Singh and Brar, 2004). Our results are in conformity with those of Sardana *et al*. (2006) who reported significantly higher populations of coccinellids, predatory spiders and *Chrysoperla* in IPM fields. Tamoghna *et al*. (2014) indicated that that IPM module was safer to the predators by recording 5.20 to 7.80 coccinellids/ plant followed by organic module (4.20 to 6.60 coccinellids/ plant). Niranjana *et al*. (2019) recorded 5.75 natural enemies per 10 plants in untreated control which was on par with BIPM module which recorded 5.25 nos./10 plant, majorly dominated by coccinellids. Similarly, Naik *et al.* (2019) recorded higher number of coccinellids in control plot (2.36/plant) followed by IPM module (2.33/plant) and least number of coccinellids were recorded in chemical control module (0.67/plant). Divya *et al*. (2020) recorded significantly higher number of coccinellids (10.5/plant) compared to chemical intensive farmers practice module (5.58/plant). Kavyashree *et al*. (2022) also recorded significantly higher number of adult coccinellids in bio-intensive module (1.73/plant) compared to chemical intensive module (0.22/plant) in maize. Farmers practice module was chemical intensive comprising the insecticides *viz*., chlorantraniliprole, emamectin benzoate and spinetoram, which are preferred by farmers to manage *L. orbonalis* in brinjal. These insecticides might have caused negative impact on the coccinellids population. Chlorantraniliprole was proved to be moderately toxic to first and second instars and slightly harmful to adults of coccinellid, *Adalia bipunctata* (Depalo *et al*., 2017). However, in the field, larvae are more likely to contact residues than adults, since they walk on treated surfaces and do not fly and adults frequently disperse from one field to another (Dinter *et al*., 2008; Jalali *et al*., 2009). Lower mortality rates were observed in a previous study conducted using first instar larvae of *Coccinella transversalis* and second instar grubs and adults of *Menochilus sexmaculatus* to the chlorantraniliprole (Cole *et al*., 2010). Whereas, emamectin benzoate hindered the rapid colonization of *C. transversalis* (Depalo *et al*., 2008).As per the previous study, very low concentrations of lambda-cyhalothrin led to significant developmental and reproductive dysfunction in *Coccinella* sp (Tengfei *et al*., 2019). This indicated that different insecticides are known to affect certain specific stages of the coccinellids. This has to be taken into consideration and modules can be planned accordingly to take up the insecticides based on the persisting life stages of coccinellids in the field.

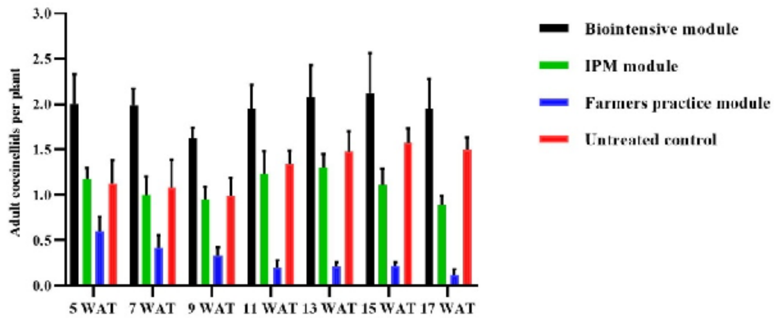

Fig. 1. Population of adult coccinellids (Mean ± SE) on brinjal under different modules during *Rabi* 2020-21 and *Kharif* 2021-22 (Pooled).

CONCLUSION

Our study highlighted the negative impacts of chemical intensive modules on the coccinellid beetles which keep the sucking pest's population under check. Bio-intensive module, untreated control and also IPM plots maintain significantly higher activity of coccinellids compared to chemical intensive farmers practice module.

FUTURE WORK

There is need to evaluate efficacy of different IPM modules in maintaining egg, larval and larval-pupal parasitoids of brinjal shoot and fruit borer. Also, region-specific IPM modules can be developed against *L. orbonalis* keeping concern on safety of natural enemies.

Conflict of Interest. None.

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