Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 1991-1996

Received: 11-01-2018
Accepted: 12-02-2018

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Evaluation of different IPM modules against pest complex of Chilli (cv. Byadgi dabbi)

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Abstract

Insect pest management has been dominated by the use of synthetic pesticides since its discovery. This awaken the world on dangers pose by the synthetic chemicals. Since then, the search for alternative pest control such that new molecules and bioagents, which is safe and effective, has been prioritized. An investigation on evaluation of different IPM modules for the management of pest complex in chilli (Cv. Byadgi dabbi) revealed that M-III was most effective module against thrips, mites and *Helicoverpa armigera* Hubner. Higher chilli yield 12.36 q/ha with 36.57 % increase over untreated control was observed in M-III (Root dip with imidacloprid 17.8 SL @ 0.5 ml/l for 30 min. at the time of transplanting + Acetamiprid 20 SP @ 0.2 g/l + Fenpropathrin 30 EC @ 0.5 ml/l + Diafenthiuron 50 WP @ 1.0 g/l + Spiromesifen 240 SC @ 1ml/l + Spinosad 45 SC @ 0.2 ml/l + Rynaxypyr 18.5 SC @ 0.2 ml/l) followed by M-II (Application of neem cake @ 2.5 q/ha at the time of sowing + Growing one row of marigold as a trap crop and two rows of maize as barrier crop + Root dip with imidacloprid 17.8 SL @ 0.5 ml/l for 30 min. at the time of transplanting + Azadirachtin 10,000 ppm @ 1.0 ml/l.+ *Lecanicillium lecanii* ($1x10^8$ CFU/g) @ 5 g/l + Diafenthiuron 50 WP @ 1.0 g/l @ 0.5 ml/l + Rynaxypyr 18.5 SC @ 0.2 ml/l) was equally effective in recording the yield of 11.84 q/ha with 33.78% increase in yield over control. Considering the result, M-I in comparison with M-III and M-II however appeared to be a quite promising strategy.

Keywords: integrated pest management, chilli, module, insect pests, natural enemies

1. Introduction

Chilli (*Capsicum annuum* L.) is one of the major vegetable and spice crop grown in the country. It is a important versatile spice as well as vegetable crop. Chilli is mainly used in culinary adding flavour, colour, pungency and rich source of vitamins like A, C, E, P and having medicinal properties. India is the largest consumer and exporter of chilli in the world with a production of 14.92 lakhs tonnes from an area of 7.75 lakh hectares [2]. In Karnataka, chilli occupies an area of 2.74 lakhs ha with a production of 1.44 lakhs tonne with the productivity of 4.85 quintals ha^{-1}. Byadgi chilli cultivars are known for their acceptable pungency and bright red colour value and considered as promising export varieties. India being the largest chilli producer, the number of limiting factors have been identified for the low productivity. A major bottle neck in the production is the pest complex of chilli with more than 293 insects and mite species debilitating the crop in the field as well as in storage [1]. The major insect pests that attack chilli are aphids (*Myzus persicae* Sulzer and *Aphis gossypii* Glover), mites (*Polyphagotarsonemus latus* Banks) and thrips (*Scirtothrips dorsalis* Hood). In Karnataka, thrips, mites and white flies have been identified as key sucking pests of chilli of which leaf curl caused by mite and thrips is serious [9]. In addition to these, pod borers also cause maximum damage to the crop both during vegetative and fruit formation stages. The crop loss by three major pests, where, 30-50% by thrips (*S. dorsalis*), 30-70% by mites (*P. latus*) and 30-40% by fruit borers *Helicoverpa armigera* and *Spodoptera litura* [6]. These pests cause serious damage to the chilli crop by direct feeding and transmitting deadly disease called "leaf curl disease" or "Murda complex". Continuous and indiscriminate use of chemical insecticides found to be ecologically unsafe and resulted in accumulation of pesticide residue on fruits. It is learnt that Byadgi chilli was rejected at the international ports of the importing countries very often due to maximum pesticide residues [10]. Therefore, it has become necessary to evaluate the new molecules for maximum reduction in sucking pests with least or no ill-effects on plant, consumer and environment, Selective toxicity to insects and safety to natural enemies have made the new class of insecticides more user and eco-friendly. Keeping this in back drop, an attempt was made to formulate a sound management programme with new molecules usage.

2. Materials and Methods

The experiment was laid out during *kharif* 2016 at the Horticulture research and extension centre, Haveri (Devihosur), University of Horticultural Sciences, Bagalkot. The plots were set out in a R.B.D. with four modules including an untreated check. Each IPM module was laid out in an area of 20 x 30 m with 2 m buffer zone in between each module. Each module was further demarcated in to five divisions to serve as replications for observations and statistical analysis. Marigold (variety African tall) was raised in the nursery before one week of planting of chilli in main field. Chilli seedlings of 30 days old were considered for transplanting. After 15 days of chilli planting, 20-25 days old marigold seedlings (two seedlings per hill) were planted in chilli plots with a spacing of 60 cm between each plant to synchronise the flowering of marigold and chilli with peak flowering and fruiting stage and approximately coinciding with the time of appearance of *H. armigera*. Two rows of maize (South African tall variety) was also maintained around each plot as a barrier crop. The population count of thrips (*S. dorsalis*) was taken at 5, 7, 9, 11 and 13 WAT (Weeks After Transplanting) and mean population was worked out. The number of thrips and mites were counted from each leaf by using 10x lens. Simultaneously, LCI (Leaf Curl Index) on thrips was also observed on 5, 7, 9, 11 and 13 WAT by following 0-4 scale [7]. Similarly, mite count as well as LCI was recorded at 13 and 15 WAT. For counting thrips and mites, ten plants were selected randomly in each plot and tagged. The mite along with the leaf were collected from top, middle and bottom and kept in the perforated polythene bag of size 16 x 18 cm and the samples were brought to laboratory and examined under 20x magnification binocular microscope. Total number of mites from each leaf were counted and expressed in terms of number of mites per leaf.

2.1 Leaf Curl Index (LCI): Upward curling due to thrips and downward curling due to mites were taken and later LCI due to thrips and mites were made separately based on the standard score [7]. Ten plants were selected randomly in each plot and scored for LCI.
The observation of larval population of chilli fruit borer, *H. armigera* was made on five randomly selected plants from each treatment at 16 and 18 WAT. Four different IPM modules were attempted.

Module I: Application of neem cake @ 2.5 q/ha at the time of sowing + growing one row of marigold as a trap crop (1:16) and two rows of maize as barrier crop + azadirachtin 10,000 ppm @ 1.0 ml/l.+ *Lecanicillium lecanii* ($1x10^8$ CFU/g) @ 5 g/l + diafenthiuron 50 WP @ 1.0g/l for mite management + azadirachtin 10,000 ppm @ 1.0 ml/l.+ *Lecanicillium lecanii* ($1x10^8$ CFU/g) @ 5 g/l.

Module II: Application of neem cake @ 2.5 q/ha at the time of sowing + growing one row of marigold as a trap crop (1:16) and two rows of maize as barrier crop + root dip with imidacloprid 17.8 SL @ 0.5 ml/l for 30 min. at the time of transplanting + azadirachtin 10,000 ppm @ 1.0 ml/l.+ *Lecanicillium lecanii* ($1x10^8$ CFU/g) @ 5 g/l + diafenthiuron 50 WP @ 1.0 g/l @ 0.5 ml/l + rynaxypyr 18.5 SC @ 0.2 ml/l.

Module III: Root dip with imidacloprid 17.8 SL @ 0.5 ml/l for 30 min. at the time of transplanting + acetamiprid 20 SP @ 0.2 g/l + fenpropathrin 30 EC @ 0.5 ml/l + diafenthiuron 50 WP @ 1.0 g/l + spiromesifen 240 SC @ 1 ml/l + spinosad 45 SC @ 0.2 ml/l + rynaxypyr 18.5 SC @ 0.2 ml/l.

Module IV: Untreated control

2.2 Dry chilli fruit yield

Totally two pickings of red chilli was done during 2016 *kharif* season. The total fruit yield from each plot was taken and expressed in terms of dry chilli fruit yield per hectare basis and subjected for statistical analysis.

2.3 Cost economics

The fruit yield per plot was recorded and computed to quintal per hectare. The data thus tabulated, pooled and ranked on the basis of their yield performance. The benefit cost ratio (B:C ratio) of different modules was worked out by estimating different cost of cultivation and return from fruit yield after converting them to one hectare of land. The average market price of dry chilli (Cv. Byadgi dabbi) was rupees 140 per Kg during the experimentation. The following formulae were used for calculation of B:C ratio.

1. Gross return = Yield x Market price of Byadgi dabbi (Rs. 14000/q)
2. Net Returns = Gross Return - Total Cost
3. B:C ratio = Gross Return / Total Cost

The data on mean population of sucking pests, natural enemies and fruit borer were transformed to $\sqrt{x+1}$ and per cent damage was transformed to arcsine transformation and then subjected to ANOVA using M-STATC ® software package. The treatment effect was compared by following Duncan's Multiple Range Test (DMRT).

3. Results

Consequent to sole reliance and continuous usage of synthetic insecticides, not only control measures have lost their efficacy but also becoming economically non-viable. In this background, the results for different modules involving eco-friendly tools with minimal toxicant usage were carefully designed and verified in comparison with untreated control are presented here.

3.1 Thrips

The mean thrips population from 5 WAT to 13 WAT was lowest in M3-Chemi-intensive module (0.71/leaf) which was statistically on par with M2-Adoptable module (0.91/leaf) indicating both are equally effective in reducing the thrips population. Whereas, M1-Biointensive module recorded higher thrips population (1.88/leaf) suggesting intermediate in its efficacy against thrips population. Correspondingly, the mean LCI from 5 WAT to 13 WAT was minimum in M3-Chemi-intensive module (0.17/plant) which was almost on par with M2-Adaptable module (0.22/plant) indicating both modules are superior in reducing the thrips population. Whereas, M1-Biointensive module recorded 0.91 LCI per plant suggesting moderate in its efficacy in suppressing the thrips population (Table 1).

3.2 Mites

By and large, the mean mite population from 13 WAT to 15 WAT (Weeks After Transplanting) was lowest in M3-Chemi-intensive module (0.17/leaf) which was almost on par with M2-Adaptable module (0.40/leaf) suggesting both are equally effective in reducing the mite population. Whereas, M1-Biointensive module recorded 1.16 mites per leaf indicating reasonable effect on thrips population. Similar trend was observed in mean data on LCI per plant where both M3-Chemi-intensive module (0.40/plant) and M2-Adaptable module (0.45/plant) suggesting both modules were found equally superior in reducing the mite population. Whereas, M1-Biointensive module recorded 0.85 LCI per plant indicating moderate in its efficacy against mite population (Table 2).

3.3 Fruit borer incidence, Fruit damage (%) and Yield (q/ha)

The mean data pertaining to fruit borer infestation indicated that significantly lower number of larvae noticed in M3-Chemi-intensive module (0.20/plant) which was on par with M2-Adaptable module (0.34/plant). However, M1-Biointensive module recorded relatively higher larval population (0.86/plant), but superior to untreated control (1.69/plant). Further results on fruit damage indicated that both M3-Chemi-intensive and M2-Adaptable modules recorded comparatively lowest fruit damage of 1.34 and 2.13 per cent with 90.13 and 84.32 per cent reduction over control, respectively. Whereas, M1-Biointensive Module was next best module in reducing the fruit damage (5.91%) with 56.48 per cent reduction over control. Undoubtedly, untreated control recorded highest fruit damage (13.58%). The results on fruit yield showed that M3-Chemi-intensive module registered significantly highest yield of 12.36 q/ha with 36.57% increase over untreated control. Further, M2-Adaptable module was equally effective in recording the yield of 11.84 q/ha with 33.78% increase over control. However, M1-Biointensive module was next best with 10.20 q/ha but superior to untreated control (7.84 q/ha) from (Table 3).

3.4 Natural enemies

The mean data indicated that M1-Biointensive module recorded higher number of coccinellids which is almost on par with M4-untreated control indicating bio-intensive module is ecofriendly and encouraged the coccinellid population. Next best module was M2-Adaptable Module. Least coccinellids were observed in M3-Chemi-intensive module (0.16/plant) indicating an adverse effect of insecticides. The mean data also indicated that chrysopid population was more in M1-Biointensive module (0.92/plant) which is followed by M2-Adaptable module (0.59/plant). However, M3-Chemi-intensive module registered lowest coccinellids indicating toxicity of insecticides on coccinellid population. Similar trend was observed in mean data on spider population where M1-Biointensive module (0.84/plant) encouraged the spider population followed by M2-Adaptable module (0.56/plant) and M3-Chemi-intensive module adversely affected the spider population (0.07/plant). The studies on efficacy of modules on natural enemies concluded that M1-Biointensive module recorded more number of natural enemies such as coccinellids, chrysopids and spiders as compared to M2-adoptable module and M3-chemintensive module. However, there was no statistical difference with untreated control indicating that there was no adverse effect of M1-biointensive module on natural enemies in chilli ecosystem (Table 4).

3.5 Cost economics

Among the modules, highest B:C ratio was obtained with M2-Adaptable module (3.29) with a net return of Rs. 115353. Although, M3-Chemi-intensive module bestowed with highest yield (12.36 q/ha) but resulted in lower B:C ratio (3.27) from (Table 5). Whereas, M1-Biointensive module offered less net returns (Rs. 93808) and B:C ratio (2.91) and superior over untreated control which recorded least net returns (Rs. 74760) and B:C ratio (3.13).

Bio-intensive and adoptable modules comprising of bio-agents has been considered to be a sound tool of IPM. Several successful instances have been recorded. These modules contain safest IPM components and there is a tremendous scope for their exploitation bio-agents such as *L. lecanii* and neem based insecticides. Fortunately, adoptable module comprising of growing one row of marigold as a trap crop and two rows of maize as barrier crop + application of neem cake @ 2.5 q/ha + root dip with imidacloprid 17.8 SL @ 0.5 ml/l for 30 min. at the time of transplanting + azadirachtin 10,000 ppm @ 1.0 ml/l.+ *L. lecanii* (1x10^8 CFU/g) @ 5 g/l + diafenthiuron 50 WP @ 1.0g/l + rynaxypyr 18.5 SC @ 0.2 ml/l proved to be quite effective hence it is most advisable to this module with a slight compromise on yield returns as compared to chemi-intensive module.

Table 1: Effect of IPM modules on chilli thrips and Leaf Curl Index (LCI)

IPM module	Mean number of thrips / leaf						Leaf Curl Index due to thrips					
	5 WAT	7 WAT	9 WAT	11 WAT	13 WAT	Mean	5 WAT	7 WAT	9 WAT	11 WAT	13 WAT	Mean
M1-Biointensive Module	0.54 (0.99) b	1.08 (1.21) b	4.33 (2.08) b	2.68 (1.69) b	0.76 (1.08) b	1.88 (1.47) b	0.21 (0.83) b	0.42 (0.93) b	1.68 (1.41) b	1.27 (1.27) b	0.95 (1.16) b	0.91 (1.14) b
M2-Adaptable Module	0.30 (0.87) a	0.60 (1.01) a	2.42 (1.60) a	1.06 (1.19) a	0.16 (0.80) a	0.91 (1.13) a	0.11 (0.77) a	0.12 (0.78) a	0.48 (0.96) a	0.25 (0.85) a	0.14 (0.79) a	0.22 (0.83) a
M3-Chemi-intensive Module	0.23 (0.84) a	0.46 (0.95) a	1.84 (1.45) a	0.90 (1.13) a	0.12 (0.78) a	0.71 (1.06) a	0.08 (0.76) a	0.09 (0.76) a	0.36 (0.90) a	0.20 (0.82) a	0.11 (0.77) a	0.17 (0.80) a
M4-Untreated Control	1.00 (1.17) c	1.99 (1.50) c	7.97 (2.74) c	4.44 (2.10) c	2.37 (1.61) c	3.55 (1.90) c	0.36 (0.91) c	0.73 (1.07) c	2.91 (1.75) c	2.38 (1.61) c	1.79 (1.44) c	1.63 (1.39) c
S.Em ±	0.03	0.05	0.12	0.08	0.05	0.07	0.02	0.02	0.06	0.05	0.04	0.04
C.D. at 5%	0.10	0.16	0.35	0.25	0.14	0.22	0.05	0.07	0.18	0.16	0.13	0.13

WAT: Weeks After Transplanting, Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values

In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 2: Effect of IPM modules on chilli mites and Leaf Curl Index (LCI)

IPM module	Mean number of mites / leaf			Leaf Curl Index due to mites		
	13 WAT	15 WAT	Mean	13 WAT	15 WAT	Mean
M1-Biointensive Module	1.58(1.38) c	0.74(1.08) b	1.16(1.23) b	1.26(1.27) b	0.43(0.94) b	0.85(1.12) b
M2-Adaptable Module	0.57(1.00) b	0.23(0.83) a	0.40(0.92) a	0.73(1.06) a	0.16(0.80) a	0.45(0.94) a

M3-Chemi-intensive Module	0.21(0.82) ^{a}	0.13(0.78) ^{a}	0.17(0.80) ^{a}	0.67(1.04) ^{a}	0.12(0.78) ^{a}	0.40(0.92) ^{a}
M4-Untreated Control	2.52(1.65) ^{d}	2.63(1.68) ^{c}	2.58(1.66) ^{c}	2.00(1.50) ^{c}	1.60(1.38) ^{c}	1.80(1.44) ^{c}
S.Em ±	0.06	0.05	0.05	0.06	0.04	0.05
C.D. at 5%	0.17	0.15	0.16	0.17	0.11	0.14

WAT: Weeks After Transplanting, Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 3: Effect of IPM modules on fruit borer, per cent fruit damage and yield of chilli

IPM module	Larvae/plant*			Fruit damage (%)**	% reduction over control	Yield (q/ha)	% increase in yield over control
	16 WAT	18 WAT	Mean				
M1-Biointensive Module	1.17(1.29) ^{b}	0.55(1.02) ^{b}	0.86(1.17) ^{b}	5.91(14.07) ^{b}	56.48	10.20	23.14
M2-Adaptable Module	0.45(0.97) ^{a}	0.23(0.85) ^{a}	0.34(0.92) ^{a}	2.13(8.39) ^{a}	84.32	11.84	33.78
M3-Chemi-intensive Module	0.25(0.87) ^{a}	0.14(0.80) ^{a}	0.20(0.83) ^{a}	1.34(6.65) ^{a}	90.13	12.36	36.57
M4-Untreated Control	1.84(1.52) ^{c}	1.53(1.36) ^{c}	1.69(1.41) ^{c}	13.58(21.62) ^{c}	00.00	7.84	00.00
S.Em ±	0.05	0.04	0.04	0.83		0.38	
C.D. at 5%	0.14	0.11	0.12	2.48		1.13	

WAT: Weeks After Transplanting, * Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values* * Figures in the parenthesis are arc sine transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 4: Effect of IPM modules on natural enemies

IPM module	Coccinellids / plant			Chrysopids / plant			Spiders /plant		
	11 WAT	15 WAT	Mean	11 WAT	15 WAT	Mean	11 WAT	15 WAT	Mean
M1-Biointensive Module	0.87(1.13) ^{b}	1.09(1.21) ^{c}	0.98(1.17) ^{c}	0.81(1.10) ^{b}	1.02(1.18) ^{c}	0.92(1.14) ^{c}	0.75(1.08) ^{b}	0.94(1.15) ^{c}	0.84(1.12) ^{c}
M2-Adaptable Module	0.74(1.07) ^{b}	0.58(1.00) ^{b}	0.66(1.03) ^{b}	0.63(1.02) ^{b}	0.54(0.98) ^{b}	0.59(1.00) ^{b}	0.66(1.03) ^{b}	0.45(0.94) ^{b}	0.56(0.99) ^{b}
M3-Chemi-intensive Module	0.14(0.79) ^{a}	0.17(0.81) ^{a}	0.16(0.80) ^{a}	0.07(0.75) ^{a}	0.09(0.76) ^{a}	0.08(0.75) ^{a}	0.05(0.74) ^{a}	0.09(0.76) ^{a}	0.07(0.75) ^{a}
M4-Untreated Control	0.95(1.15) ^{b}	1.18(1.24) ^{c}	1.06(1.20) ^{c}	0.96(1.15) ^{c}	1.08(1.30) ^{c}	1.02(1.18) ^{c}	0.88(1.13) ^{b}	1.10(1.21) ^{c}	0.99(1.17) ^{c}
S.Em ±	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.04	0.03
C.D. at 5%	0.11	0.13	0.12	0.10	0.12	0.11	0.10	0.11	0.10

Figures in the parenthesis are $\sqrt{x + 0.5}$ transformed values
In a column, means followed by same alphabet do not differ significantly (p= 0.05) by DMRT

Table 5: Cost economics of IPM modules against pests of chilli

IPM module	Yield (q/ha)	Cost of plant protection (Rs/ha)	Total cost of production (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C Ratio
M1-Biointensive Module	10.20	13992	48992	142800	93808	2.91
M2-Adaptable Module	11.84	15407	50407	165760	115353	3.29
M3-Chemi-intensive Module	12.36	17952	52952	173040	120088	3.27
M4-Untreated Control	7.84	00	35000	109760	74760	3.13

Gross return = Yield x Market price of Byadgi dabbi (Rs. 14000/q) Net Returns = Gross Return - Total Cost
B:C ratio = Gross Returns / Total Cost

4. Discussion

The overall mean thrips population from 5 WAT to 13 WAT was lowest in M3-Chemi-intensive module (0.71/leaf) which was statistically on par with M2-Adoptable module (0.91/leaf) indicating both are equally effective in reducing the thrips population (Fig. 1). The above findings are corroborated with the author of Venkatesh *et al*. (1998) [15] and Bagle (1998) [3] who reported that soil application of vermicompost (5 t ha^{-1}) with farm yard manure (2.5 t ha^{-1}) and half dose of NPK (75:25:25) recorded a minimum of thrips (9.96/leaf) and mite (4.98/leaf) population. Sunanda and Dethe (1998) [14] reported that seed dressing with 15 g of imidacloprid 70 WS per kg of seeds followed by a root dip of seedlings with 0.03 per cent imidacloprid 200 SL gave excellent control of sucking pests especially thrips and mites and also resulted in highest chilli yield. Further, seed treatment with imidacloprid 70 WS also had phytotonic effect on seedlings in nursery by showing maximum growth and higher total chlorophyll content of leaves. Ferers (2000) [4] reported that crop taller than main crop and planted in the border could act as a barrier crop and helps in reducing the incidence and better control of non-persistently transmitted aphid borne viruses. Patil *et al*. (2002) [8] reported that imidacloprid 200 SL @ 150 ml/ha recorded significantly highest chilli fruit yield.

By and large, the mean mite population from 13 WAT to 15 WAT (Weeks After Transplanting) was lowest in M3-Chemi-intensive module (0.17/leaf) which was almost on par with M2-Adaptable module (0.40/leaf) suggesting both are equally effective in reducing the mite population (Fig. 1). The results of the present investigation are in conformity with the findings of Gundannavar (2006) [5] who reported that, module M_1 comprising marigold as a trap crop, application of vermicompost @ 2.5 t/ha, neem cake 250 kg/ha (with no application of RDF), superimposed with neemazal 5 week after transplanting (WAT), diafenthiuron at 8 WAT, profenofos 11 WAT and neemazal 14 WAT was found to be most effective module against thrips, mites and fruit borer. Module $M_{3,}$ also recorded lowest fruit damage (1.34 %) with maximum net returns (Rs 120088/-) followed by M_2 and $M_{1.}$ The mean data pertaining to fruit borer infestation indicated that a significantly lower number of larvae noticed in M3-Chemi-intensive module (0.20/plant) which was on par with M2-Adaptable module (0.34/plant). The mean data indicated that M1-Biointensive module recorded higher number of natural enemies such as coccinellids, chrysopids and spiders which is almost on par with M4-untreated control indicating bio-intensive module is ecofriendly and encouraged the natural enemies (Fig. 3). Results of this investigation are

similar with findings of Smitha and Giraddi (2006) [12] who reported that by surrounding chilli with maize, intercropping of marigold, application of neem cake @ 500 kg/ha and neem based formulations and *Lecanicillium lecanii* enhanced the population of *Menochilus* spp, predatory green lace wing, *Chrysoperla carnea* and coccinellids resulting in reduced incidence of chilli thrips, mites and percent fruit damage as these biological pesticides are safer to natural enemies. It may be attributed that barrier crops prevented migration of thrips and mites and marigold acted as trap crop for fruit borer.
The highest B:C ratio was obtained with M2- Adaptable module (3.29) with net return of Rs. 115353. The dry chilli yield increase when maize and sorghum used as barrier crops as these crops enhanced the coccinellids, chrysopids and spider population which reduced sucking pests, leaf curl index, larval population of *H. armigera*, fruit damage and enhanced chilli yield with higher net returns and B:C ratio [11, 13] (Fig. 4).

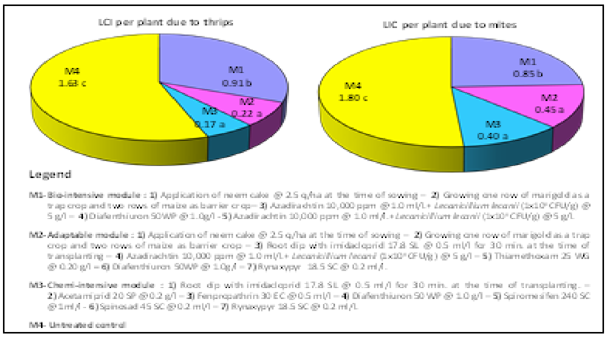

Fig 1: Effect of IPM modules on mean left Curl Index due to trips and mites

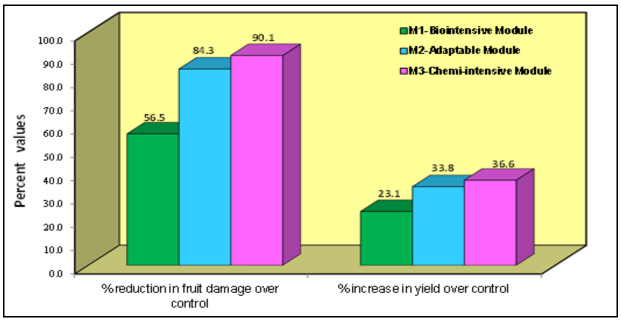

Fig 2: Effect of IPM modules on fruit damage and increase in yield of chili over countrol

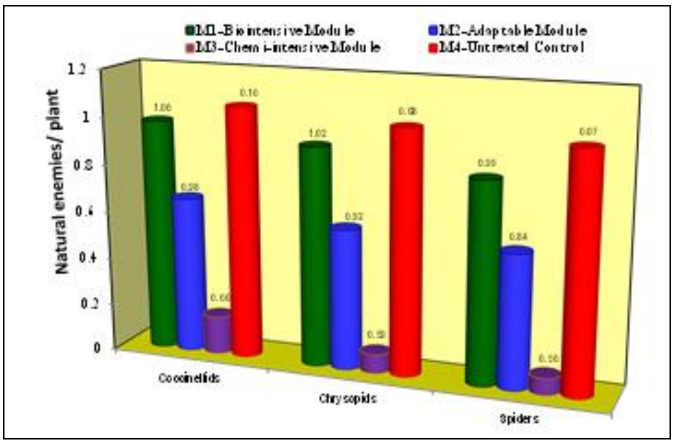

Fig 3: Effect of IPM modules on moon Pupation of confined: crisped and spied

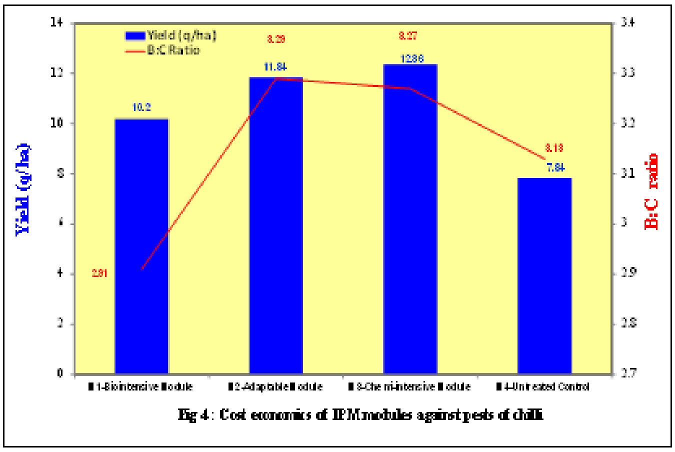

Fig 4: Cost economics of IPM mobiles ageing pest of chili

5. Conclusion

Conclusion that emerges from the foregoing facts is that integration of chemical insecticides with other environmentally compatible tools is mandatory. It is remembered that timing of application of either bio-agent or insecticides, based on ETL assumes greater importance than mere application at improper time. In the limelight of these studies, both bio-intensive and adoptable modules have been considered to be a sound tool of IPM. These modules contain safest IPM components and there is a tremendous scope for their exploitation bio-agents such as *Lecanicillium lecanii* and neem based insecticides. It can be concluded that integration of bioagents and green labelled insecticides is an eco-friendly approach, economically feasible and easily adoptable by the farmers. It is remembered that timing of application of either bio-agent or insecticides, based on ETL assumes greater importance than mere application at improper time. Thus, it is ideal to adopt either M2- Adaptable module or M1- Biointensive depending upon the convenience and availability of bio-agents.

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