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Integrated management of insect and mite pests of chilli under hill zone of Karnataka

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Abstract
The study was carried out on integrated management of chilli pest during March of 2015. The results revealed that chilli crop was bordered by double layered shade net with one sprays of all chemicals *viz.*, imidacloprid 17.8 SL @ 0.3 ml/l @ two WAT, clorantraniliprole 18.5 SC @ 0.25 ml/l @ five WAT, flubendiamide 48 SC @ 0.2 ml/l @ seven WAT, spiromesifin 30 SC @ 2ml/l @ nine WAT, spinosad 45 SC @ 0.25 ml/l @ 11 WAT were found to be better and which were on par with seed treatment of imidachloprid 70 WS @ 7g/kg, neem cake @ 250 kg/ha. seedling dip with imidacloprid 17.8 SL @ 0.3 ml/l at the time of transplanting and one sprays of all chemicals *viz.*, azadirachtin 10000 ppm @ 2ml/l @ two, cyantraniliprole 10% OD @1.2 ml/l @ five, *L. leacanii* @ 2g/l + spinosad 45 SC @ 0.25 ml/l @ seven, *M. anisoplea* @ 2g/l + spiromesifin 2 ml/l @ nine and flubendiamide 48 SC @ 0.2 ml/l @ 11 WAT.

Keywords: integrated pest management, chilli, insect and mite pests

1. Introduction
Chilli (*Capsicum annuum* L.) is an important spice as well as vegetable crop grown all over India and essential ingredient of Indian curry, which is characterized by tempting colour and titillating pungency by Reddy and Puttaswamy (1988) [8]. Although, the crop has got great export potential besides huge domestic requirement, a number of limiting factors have been attributed for low productivity. Among them occurrence of viral diseases as well as ravages caused by insect pests are significant ones with Solanki and Rai (2006) [14]. The pest spectrum of chilli crop is complex with more than 293 insects and mite species debilitating the crop in the field as well as in storage (Anon, 1987) [1]. Amongst these, aphids, *Myzus persicae* Sulzer., *Aphis gossypii* Glover., thrips, *Scirtothrips dorsalis* Hood., yellow mite, *Polyphagotarsonemus latus* Banks and fruit borer, *Helicoverpa armigera* Hubner are the most vital production constraints (Puttarudraiah, 1959, Solanki and Rai, 2006) [7, 14]. A total of 39 and 57 insect pests were recorded in Karnataka in chillies on nursery and field crop respectively (Reddy and Puttaswamy, 1988) [8]. During the last two decades insecticidal control of chilli pests in general and especially in irrigated crop characterized by high pesticide usage.

Over use of pesticides have often leads to the development of undesirable problems like destruction of natural enemies, pest resurgence and failure of control strategies results in outbreak of leaf curl in chilli. In addition, the presence of pesticide residues in chillies (Joia *et al.*, 2001) [4] has been more concerned for export of chillies to developed countries. In this context, it is therefore necessary to develop effective non-chemical pest management strategies against sucking pests for sustained crop management and production of healthy food. In view of this indiscriminate use of chemical pesticides and public concerns, the rise of new generation insecticides provides an alternative to reduce the ill effects of conventional insecticides (Joia *et al.*, 2001) [4]. The new insecticides are more tissue-specific, activated in unique ways inside the target cells of insects resulting in reduced threat to other organism. Selective toxicity to insects and safety to natural enemies have made the new class of insecticides more user and eco-friendly. In order to prevent the infestation of the insect pests and to produce a quality crop, it is essential to manage the pest population at appropriate time with suitable measures (Gundannavar *et al.*, 2006) [3]. Since, Chikmagalur is located under hill zone of Karnataka, usually many farmers' takes up chilli/capsicum cultivation throughout the year. Due to high humidity and temperature during summer season, pests especially, thrips, whitefly and mites build up is common leads to murda complex and farmers have to resort to minimum of 3 to 4 chemical sprays in this area. Keeping these points in view, the present study was undertaken to evolve the eco-friendly management strategy against major sucking insect pests of chilli with special reference to integrated pest management approaches.

2. Material and Methods

The present study experiment was carried out in open field with drip irrigated conditions during March of 2015 at Karkipette, Chikmagalur district, Karnataka. The seeds of chilli variety Priyanka were sown in the pro trays in nursery and 35 day old seedlings were transplanted in the field with 60 cm × 30 cm. Experiment was carried out with randomized complete block design with five treatments (modules) and five replications with main plot of size 10 m × 15 m. During experimentation the modules *viz.,* CBM, BIM and IPM modules were established with double layered shade net (4m ht.) around each treatments (modules) to avoid the movement of entomopathogenic fungal spores from one module to other modules. Further, from each replication five chilli plants were selected randomly to record the insect and mite pest of chilli. Both adults and nymphs of thrips, *Scirtothrips dorsalis* (Hood) were counted from half to fully opened young top three leaves in five randomly selected and tagged plants were counted with the help of magnifying lens and later converted into per leaf. Whereas, mites *Polyphagotarsonemus latus* (Bank) were recorded (no's/leaf) on top, middle and bottom leaves on five selected and tagged plants were kept in the perforated polythene bag size 16×18 cm and were brought to laboratory and examined under 20 X magnification binocular microscope.

2.1 Leaf curl index (LCI/plant)

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 given by Niles (1980) (Table 1).

2.2 Treatment details

Farmers Practice (FP): one sprays of dimethoate 30 EC @ 1.7 ml/l @ five WAT, two sprays of flubendiamide 48 SC @ 0.2 & 0.3 ml/l @ seven @ nineWAT).

Recommended Plant Protection (RPP): Two sprays of dimethoate 30 EC @1.7 ml/l @ two & five WAT, two sprays of profenophos 50 EC @ 1ml/l @ seven & 11 WAT, one sprays of dicofol 18.5 EC @ 2.5 ml/l @ nine WAT).

Chemical Based Module (CBM): One sprays of imidacloprid 17.8 SL @ 0.3 ml/l @ two WAT, one sprays of clorantraniliprole 18.5 SC @ 0.25 ml/l @ five WAT, one sprays of flubendiamide 48 SC @ 0.2 ml/l @ seven WAT, spiromesifin 30 SC @ 2 ml/ l @ nine WAT, one sprays of spinosad 45 SC @ 0.25 ml/l @ 11 WAT).

Bio-Intensive Module (BIM): Seed treatment with imidachloprid 70 WS @ 7g/kg, neem cake @ 250 kg/ha. at the time of sowing, one sprays of azadirachtin 10000 ppm @ 2 ml/l @ two WAT, two sprays of *Lecanicillium leacanii* (Zimm.) @ 2 g/l @ five & nine WAT, one sprays of *Beauveria bassiana* (Balsamo) @ 2 g/l @ seven WAT, one sprays of *M. anisopleae* @ 2 g/l @ 11 WAT).

Integrated Pest Management (IPM): Seed treatment with imidachloprid 70 WS @ 7 g/kg, neem cake @ 250 kg/ha. seedling dip with imidacloprid 17.8 SL @ 0.3 ml/l at the time of transplanting, one sprays of azadirachtin 10000 ppm @ 2ml/l @ two WAT, one sprays of cyantraniliprole 10% OD @1.2 ml/l @ five WAT, one sprays of *L. leacanii* @ 2g/ l + spinosad 45 SC @ 0.25 ml/l @ seven WAT, one sprays of *Metarhizium anisoplea* (Metschn.)
@ 2g/l + spiromesifin 30 SC 2 ml/l @ nineWAT, one sprays of flubendiamide 20 WG @ 0.2 ml/l @ 11 WAT).

The fruit borer populations were recorded on five randomly selected and tagged plant. Further, the observations were recorded day before and after every two weeks starting from 9 WAT to 13 WAT (mean of three weeks data was presented). Further, per cent fruit damage was calculated using the formula (Obodji *et al.,* 2015) [6].

$$\text{Per cent fruit damage (\%)} = \frac{\text{Number of infested fruits/plant}}{\text{Total number of fruits/plant}} \text{ x 100 at each treatment}$$

The population of natural enemies includes coccinellid beetles, chrysopids and spiders. They were recorded by visual observation on five randomly selected plants in each treatment. Later, the observations on number of natural enemies per plant were recorded.

Cost effectiveness of each treatment was assessed based on net returns. Net returns of each treatment were worked out by deducting total cost of the treatment from the gross returns. Total cost of production includes both cultivation as well as plant protection charges.

Table 1: Standard procedure for scoring Leaf Curl Index (LCI)

LCI/Grade (0-4)	Category	Symptoms
0.	Immune (I)	No symptom (No curling, completely healthy plant)
1.	Resistant (R)	1-25 per cent leaves/plant show curling, less damage
2.	Moderately Resistant (MR)	26-50 per cent leaves/ plant show curling, moderately damaged
3.	Susceptible (S)	51-75 per cent leaves/plant show curling, heavily damaged, malformation of growing points and reduction in plant height
4.	Highly Susceptible (HS)	> 76 per cent leaves/ plant show curling, severe and complete destruction of growing points, and drastic reduction in plant height, defoliation and severe malformation.

3. Results and Discussion

The results pertaining to populations of thrips, mites and fruit borers were significantly different among the treatments. The treatment chemical based module (CBM) recorded significantly lower populations of thrips and mites (0.04 thrips/leaf and 0.28 mites/leaf, respectively) per leaf. Further, leaf curl index due to thrips and mites (0.55 LCI/pl. and 0.32 LCI/pl., respectively) were also significantly lower in CBM. With regards to fruit borers, again CBM recorded significantly lower larval population/plant and per cent fruit damage (0.18 larvae/pl. and 8.16 per cent, respectively). Further, IPM recorded significantly lower populations thrips and mites (0.06 thrips/leaf, and 0.31 mites/leaf, respectively) per leaf. Leaf curl index due to thrips and mites (0.58 LCI/pl. and 0.34 LCI/pl. respectively) were also lower in IPM (Table 2). The present findings are also line with Tatagar *et al.* (2009) [15] who indicated that lower insect and mite population with highest fruit yield of 7.48 q/ha., could be obtained from the plots treated with flubendiamide 20 WG @ 60 g a.i./ha. followed by flubendiamide 20 WG @ 40 g a.i./ha. (6.72 q/ha.), emamectin benzoate 5 SG @ 11 g a.i./ha. (7.22 q/ha.) and spinosad 45 SC @ 75 g a.i./ha. (7.32q/ha.). Similarly, Samota (2016) reported that lower insect and mite population with highest fruit yield of 105.11 q/ha. was recorded in the plots treated with imidacloprid, followed by thiamethoxam (103.18 q/ha.), acetamiprid (99.99 q/ha.), dimethoate (99.69 q/ha.) and fipronil (97.65 q/ha.).The minimum fruit borer population and per cent fruit damage was (0.24 larvae/pl. and 12.28 per cent, respectively). Further, the maximum fruit yield was obtained by CBM (12,890 kg/ha.) and they were on par with IPM (11,870 kg/ha.). In the present study CBM were found very effective in decreasing the insect and mite pest populations mainly because of new molecules. Further, these insects and mites were not developed resistance to these newer molecules. Hence CBM is very effective than other treatments. However, IPM was also found effective mainly because of newer molecules along with different IPM components compared to FP and RPP. The present findings are in agreement with Roopa and Kumar (2014) [10] also indicated that among different chemicals, spinosad 45 SC @ 0.01% emerged as the best treatment by recording highest per cent reduction in fruit damage of 76.53 with a highest yield of 30050 kg/ha. in capsicum. However, Singh (2014) [12] reported that spinosad (29.67 larvae/plant) and emamectin benzoate (27.67 larvae/plant) were most efficient in reducing *H. armigera* larval population in Bell pepper and per cent fruit infestation with highest number of healthy fruits. It may be opinioned that it is due to spinosad having rapid contact and ingestion activity in insects, causing excitation of the nervous system, leading to cessation of feeding and paralysis supports the present findings. As evident from table 3, IPM and BIM treated plots which were superimposed with safer molecules were significantly superior over FP in having maximum number of coccinellids, chrysopids and spiders. Another probable reason may be that chilli crop bordered by thick double layered shade net acted as barrier for migration and hence contributed significantly in conserving and enhancing natural enemy population in these plots. These results confirm the findings of Gosh *et al.* (2010) [2] who reported that spinosad at 73 to 84 g a.i./ha were very safe to natural enemies. Spinosad is one of such new chemical which is derived from fermentation broth of soil actinomycetes, *Saccharopolyspora spinosa* (Mertz and Yao), containing a naturally occurring mixture of spinosyn A and spinosyn D. It is safe to nymphs and adults of the natural enemies in tomato. The present findings also agree with the findings of Varghese and Mathew (2013) [17] where they reported that spiromesifen 45 SC at 100 g a.i./ha. was safest insecticide against natural enemies *viz.*, predatory mites, coccinellid beetles and spiders in chilli. Similarly, Tatagar *et al.* (2011b) [16] revealed that chilli plots surrounded by two rows of maize all along the border (untreated) recorded significantly more number of coccinellids (2.56 no/pl.) at 15 WAT also supports the present findings. As evident from table 4, highest gross return, net return and C: B ratio was obtained in CBM (2,19,130 Rs/ha., 1,62,909 Rs/ha. and 1:2.90, respectively) followed by IPM (2,01,790 Rs./ha., 1,47,519 Rs/ha. and 1:2.72, respectively), RPP (1,54,700 Rs/ha., 1,10,242 Rs/ha. and 1: 2.48, respectively) and BIM (1,48,920 Rs/ha., 1,05,222 Rs/ha. and 1: 2.41, respectively). However, lowest gross return, net return and C: B ratio was recorded in FP (1,39,400 Rs/ha., 95,060 Rs/ha. and 1: 2.14, respectively).

The present findings are in accordance with the findings of Roopa (2013) [9] who reported that spinosad 45 SC @ 0.01% was found to be the best insecticide in getting highest net profit and cost benefit ratio (Rs. 7,40,661; 1:4.60, respectively). Similarly, Singh (2014) [12] reported that highest marketable fruit yield and B: C ratio was recorded in plots treated with spinosad (44.86 t/ha.;1:2.78, respectively) and emamectin benzoate (42.96 t/ha.; 1:2.69, respectively).

Table 2: Effect of Integrated pest management modules on chilli thrips, mites Leaf Curl Index (LCI), fruit borers and fruit yield

Sl. No	Treatments (Modules)	Mean no. thrips and mites/leaf		LCI/pl.		*No. of larvae/plant (*H. armigera* & *S. litura*)	**% Fruit damage	Fruit yield (Kg/ha)
		Thrips	Mites	Thrips	Mites			
1.	FP	0.12(0.85)	0.34(1.08)	0.68	0.38	0.42(1.15)	25.00(30.00)	7800.00
2.	RPP	0.16(0.90)	0.32(1.07)	0.72	0.42	0.34(1.08)	19.50(26.20)	9100.00
3.	CBM	0.04(0.70)	0.28(1.03)	0.55	0.32	0.18(0.92)	8.16(16.53)	12890.00
4.	BIM	0.42(1.15)	0.46(1.18)	1.07	0.56	0.30(1.05)	17.20(24.50)	8760.00
5.	IPM	0.06(0.74)	0.31(1.06)	0.58	0.34	0.24(0.99)	12.28(20.51)	11870.00
S. Em ±		0.01	0.01	-	-	0.03	0.99	703.55
CD @ 5%		0.04	0.04	-	-	0.11	2.97	2109.26

* -Values in parenthesis are square root + 0.5 transformed; **- Values in parenthesis are angular transformed.

Table 3: Effect of treatments on natural enemies of chilli

Sl. No.	Treatments	Coccinellids/pl.	*Chrysopids*/pl.	Spiders/pl.
1.	FP	0.33 (1.07)	0.24(0.99)	0.22(0.97)
2.	RPP	0.36(1.10)	0.27(1.02)	0.24(0.99)
3.	CBM	0.34(1.08)	0.26(1.01)	0.24(0.99)
4.	BIM	1.08(1.54)	0.52(1.22)	0.58(1.26)
5.	IPM	1.12(1.56)	0.54(1.23)	0.62(1.29)
S.Em ±		0.04	0.06	0.03
CD @ 5%		0.13	0.18	0.09

Note: Values in parenthesis are $\sqrt{x}$ +0.5 transformed.

Table 4: Cost economics of treatments in the management of insect and mite pests of chilli

Sl. No.	Treatments	Yield (Kg/ha)	Cost of plant protection (Rs/ha)	Total cost of production (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	C:B ratio
1.	FP	8,200.00	4,340.00	44,340.00	1,39,400.00	95,060.00	1:2.14
2.	RPP	9,100.00	4,458.00	44,458.00	1,54,700.00	1,10,242.00	1:2.48
3.	CBM	12,890.00	16,221.00	56,221.00	2,19,130.00	1,62,909.00	1:2.90
4.	BIM	8,760.00	3,698.00	43,698.00	1,48,920.00	1,05,222.00	1:2.41
5.	IPM	11,870.00	14,271.00	54,271.00	2,01,790.00	1,47,519.00	1:2.72
S.Em ±		703.55	-	-	-	-	-
CD @ 5%		2109.26	-	-	-	-	-

Gross returns = Yield × Market price (Rs. 17/Kg) Net returns = Gross returns - Total cost

4. Conclusion

Chemical based module (CBM) with one sprays of imidacloprid 17.85 SL 0.3 ml/l @ two WAT, one sprays of clorantraniliprole 18.5 SC @ 0.25 ml/l @ five WAT, one sprays of flubendiamide 48 SC @ 0.2 ml/l @ seven WAT, spiromesifen 30 SC @ 2ml/l @ nine WAT, one sprays of spinosad 45 SC @ 0.25 ml/l @ 11 WAT was found very effective in the management of chilli insect and mite pest with higher chilli fruit yield and highest gross return, net returns and C:B ratio. Further, integrated pest management (IPM) module also found better in reducing the insect and mite pests of chilli and was on par with CBM.

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