



Impact of different pest management modules against the major sucking pests complex of chilli (*Capsicum annuum*)

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ABSTRACT

Three different pest management modules were tested against major sucking pests complex of chilli (*Capsicum annuum* L.) (thrips, yellow mites) and occurrence of *Pepper leaf curl virus* transmitted by whitefly [*Bemisia tabaci* (Gem.)] and compared with the untreated control. Two promising varieties (Kashi Anmol and Kashi Gaurav) were sown at experimental plots of IIVR and three pest management modules, viz. biointensive module (M1), integrated module (M2) and chemical module (M3) were examined for two consecutive years (2011-12 and 2012-13). All the tested modules were found significantly applicable over the control in terms of pest and disease management. Among these, integrated module (M₂) comprising seedling dip with Imidacloprid 17.8% SL@ 1 ml/ l of water, spraying of Buprofezin 25%SC @ 1 ml/l at 25 DAT, Fipronil 5% SC@ 2 ml/l at 35 DAT, *Lecanicillium* (= *Verticillium*) *lecanii* @ 5 g/l at 45 DAT, Chlorfenapyr 10% SC@ 1.5 ml/l at 55 DAT, neem oil 1% at 65 DAT and their need based rotation was most effective in reducing the thrips and mite population in chilli and significantly enhancing the yield over control. Reduced yellow mite population was observed in both the varieties, i.e. Kashi Anmol (79.16%) and Kashi Gaurav (73.59%). Likewise, reduction in thrips population was also recorded in Kashi Anmol (58.09%) and in Kashi Gaurav (48.16%) varieties. However, occurrence of *Pepper leaf curl virus* was lowest in chemical module (M₃), viz. 7.04% and 11.18% lower leaf curl infestation was observed, respectively in Kashi Anmol and Kashi Gaurav varieties followed by integrated module (M2) with 8.36% and 12.64% less leaf curl infestation. In terms of cost benefit ratio, integrated module (M2) was found applicable for both the varieties, i.e. 1:2.26 and 1:6.66 cost benefit ratios were recorded respectively in Kashi Anmol and Kashi Gaurav. Thus, integrated module (M2) may be adopted to get rid of these sucking pests menace.

Key words: Chilli, *PeLCV*, Pest management modules, Thrips, Yellow mite

Chilli (*Capsicum annuum*) is one of the most important vegetable and spice crop in India cultivated for its pungent and non-pungent fruits is almost all parts of the country. Apart from its traditional use of chilli as vegetables, spices, condiments, sauces and pickles it is also being used in pharmaceuticals, cosmetics and beverages (Tiwarly *et al.* 2005, Rai *et al.* 2010). India is the largest producer, exporter and consumer of chillies in the world. This chilli is also ravaged by a large number of insect and acarine pests throughout its growth period and considered as one of the most important constraints for chilli production. Among 57 species of insect and mite pests on record damaging chilli (Reddy and Puttaswamy 1984), yellow mite (*Polyphagotarsonemus latus* Banks) (Acarina: Tarsonemidae) and thrips (*Scirtothrips dorsalis* Hood) (Thripidae: Thysanoptera) are noted to be of much devastating causing yield loss to the tune of 12 to

90% at national level (Ahamd *et al.* 1887, Desai *et al.* 2007, Rai *et al.* 2014). In severe infestation, damage caused by thrips and mites are distinctly visible as the former causes typical upward leaf curling, whereas downward leaf curling visible in case of mites. In addition to these, whitefly [*Bemisia tabaci* (Gennadius)] (Hemiptera: Aleyrodidae) is also causing serious damage by sucking the sap as well as serve as a vector for *Pepper leaf curl virus* (PeLCV). To manage these sucking pests, Indian farmers used to apply minimum of 25 to 30 rounds of pesticide sprays. This not only increases the cost of cultivation but often causes problems like resistance to insecticides, resurgence of target insects and secondary pest outbreak in addition to these residues to food and beverages, contamination of groundwater, adverse effect on human health and wide spread killing of non-target organisms (Halder *et al.* 2013, 2014). Considering this, different pest management modules comprising seedling dip, botanicals, microbial and novel molecules along with conventional acaroinsecticide molecules were tested against these nefarious pests of chilli basically aimed at to reduce the synthetic insecticides usage and safety of environment.

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MATERIALS AND METHODS

The experiment was conducted during the two consecutive *rabi* seasons of 2011-12 to 2012-13 at the experimental farm of ICAR-Indian Institute Vegetable Research, Varanasi (82°52' E longitude and 25°12' N latitude), Uttar Pradesh, India in randomized block design with five replications. Following three pest management modules were developed and evaluated against yellow mites and thrips in chilli (cv. Kashi Anmol and Kashi Gaurav).

Biointensive module (M_1): Seedling dip with Imidacloprid 17.8% SL @ 1 ml/l of water; Spraying of Abamectin 1.8% EC @ 0.75 ml/l at 25 days after transplanting (DAT); Spraying of *Lecanicillium* (=Verticillium) *lecanii* (1×10^8 cfu/g) @ 5 g/l at 35 DAT; Spraying of Pongamia oil @ 1% at 45 DAT; Spraying of Buprofezin 25% SC @ 1 ml/l at 55 DAT; Spraying of neem oil @ 1% at 65 DAT; and subsequent rotation.

Integrated module (M_2): Seedling dip with Imidacloprid 17.8% SL @ 1 ml/l of water; Spraying of Buprofezin 25% S @ 1 ml/l at 25 DAT; Spraying of Fipronil 5% SC @ 2ml/l at 35 DAT; Spraying of *Lecanicillium* (=Verticillium) *lecanii* (1×10^8 cfu/g) @ 5 g/l at 45 DAT; Spraying of Chlorfenapyr 10% SC @ 1.5 ml/l at 55 DAT; Spraying of neem oil 1% at 65 DAT; and subsequent rotation

Chemical module (M_3): Seedling dip with Imidacloprid 17.8% SL @ 1 ml/l of water; Spraying of Dicofol 18.5%EC @ 2.5 ml/l at 25 DAT; Spraying of Propargite 57%EC @ 2.5 ml/l at 35 DAT; Spraying of Spiromesifen 22.9%SC @ 0.8 ml/l at 45 DAT; Spraying of Fenazaquin 10%EC @ 2.5 ml/l at 55 DAT; Spraying of Quinalphos 25%EC @ 2 ml/l at 65 DAT; and subsequent rotation).

Untreated control (M_4): Reasons for selecting these duo varieties was as the former is recommended for cultivation in the states of Punjab, Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Karnataka, Tamil Nadu and Kerala, whereas the later, i.e. Kashi Gaurav for West Bengal and Asom.

The chilli seedlings of these varieties were transplanted at spacing at 60×45 cm during second fortnight of August in a large plot size of 20×15 m² for each module. As such four such plots were prepared. From each plot five spots were selected randomly for pest counts. The spray solutions were prepared just before the application and the spray was done with the help of Knap Sack Power Sprayer and sprayed as per mentioned schedules during evening hour. The data were recoded from five randomly selected plants from each spot. Since, thrips and mites are mostly congregated towards terminal parts of the plant; three leaves were sampled from each of 5 random plants and the number of mites and thrips per leaf were counted under stereo zoom binocular microscope. Such observations were recorded at weekly interval in each plot of different modules including untreated control. In case of whitefly, number of *PeLCV* infected chilli plants at the end of crop season in each plot were counted and expressed in terms of per cent. As regards to yield, different pickings made separately from each of 60 m² spot from each module

were clubbed together and converted on per hectare basis. The data of two year trials were subjected to Analysis of Variance (ANOVA) with least significant difference (P=0.05) as test criterion was converted to hectare basis and then, economics were calculated. Benefit-cost analysis was expressed in terms of benefit cost ratio by using the following formula:

$$\text{Cost benefit ratio} = \frac{\text{Net return (₹/ha)}}{\text{Cost of treatment (₹/ha)}}$$

RESULTS AND DISCUSSION

From the Table 1 it is evident that amongst the four tested pest management modules, the integrated module (M_2) was found significantly effective in controlling sucking pests population and thereby crop damage in both the varieties. In case of Kashi Anmol, integrated module registered lowest mite population of 2.18 and 1.98 per terminal leaf during 2011-12 and 2012-13, respectively, with average of 2.08 mites/terminal leaves which is lowest than any other pest management modules. Similar observation was also noted in case of thrips population. Minimum thrips population in variety Kashi Anmol was noted in both the years, viz. 2011-12 (2.77 / terminal leaves) and 2012-13 (1.17) with average of 1.97 thrips/terminal leaves in case of M_2 . Per cent mite and thrips reduction over control (79.16 and 58.06, respectively), was also highest in module-2 in this variety. The same trend was also observed in variety of Kashi Gaurav. Lowest mites population per terminal leaves was recorded by integrated module and the corresponding values were 2.91 and 6.39 for the year 2011-12 and 2012-13, respectively, with average of 4.65. In case of thrips, it was 3.79 (2011-12) and 2.12 (2012-13) with average of 2.96. M_2 was an effective IPM module because of reduced incidence of duo sucking pests which might be due to the effectiveness of its individual components.

In addition, integrated module (M_2) also registered highest yield in both the varieties. In case of Kashi Anmol, integrated module yielded significantly highest yield (3 277 kg/ha) followed by chemical module (2 669 kg/ha), whereas untreated control plots had lowest yield (2 004 kg/ha). Similar trend was also followed in case of variety Kashi Gaurav where integrated module registered maximum yield of 6 162 kg/ha, whereas lowest yield (3 176 kg/ha) was in untreated control. The higher incidence of *PeLCV* in case of farmers' practice could be the non-practicing of seedling dip with Imidacloprid. Local farmers are generally do not follow the seed treatment with any systemic insecticide resulting higher level of whitefly incidence at early stage synchronizing with the higher incidence of *PeLCV*. Reasons for lower pest pressure accompanied with higher yield in integrated module might be the using of different pest management inputs of diverse origin, viz. synthetic newer molecules (Imidacloprid, Fipronil and Chlorfenapyr), plant origin pesticides (neem oil), entomopathogenic fungus (*Lecanicillium* (=Verticillium) *lecanii*), insect growth regulator (Buprofezin) and with their different mode of action.

Table 1 Efficacy of different pest management modules against yellow mites, thrips and *PeLCV* disease in chilli

Modules	Number of yellow mite/terminal leaves [#]				Number of thrips/terminal leaves [#]				<i>PeLCV</i> infected plants (%)	Yield (kg/ha)		
	First year (2011-12)	Second year (2012-13)	Pooled mean	% ROC* (Avg)	First year (2011-12)	Second year (2012-13)	Pooled mean	% ROC* (Avg)		First year (2011-12)	Second year (2012-13)	Pooled mean (kg/ha)
<i>Variety – Kashi Anmol</i>												
M1	3.26 ^a	4.41 ^b	3.84 ^{ab}	61.57	3.67 ^a	1.97 ^a	2.82 ^a	40	14.75 ^b	1750 ^c	2857 ^c	2304 ^c
M2	2.18 ^a	1.98 ^a	2.08 ^a	79.16	2.77 ^a	1.17 ^a	1.97 ^a	58.09	8.36 ^a	3160 ^a	3393 ^a	3277 ^a
M3	3.53 ^a	3.48 ^{ab}	3.51 ^a	64.88	2.95 ^a	1.52 ^a	2.24 ^a	52.45	7.04 ^a	2313 ^b	3024 ^b	2669 ^b
M4	8.89 ^b	11.07 ^c	9.98 ^c		6.83 ^b	2.57 ^a	4.70 ^b		17.41 ^b	1460 ^d	2548 ^d	2004 ^d
SEm(±)	0.42	0.76	0.57		0.57	0.31	0.52		1.05	16.07	6.48	10.82
LSD (P=0.05)	1.29	2.34	1.76		1.76	0.95	1.60		3.23	39.69	19.89	33.22
<i>Variety – Kashi Gaurav</i>												
M1	3.68 ^a	11.27 ^a	7.48 ^a	57.57	4.96 ^b	3.25 ^a	4.11 ^a	27.98	13.82 ^a	6320 ^c	3917 ^c	5119 ^c
M2	2.91 ^a	6.39 ^a	4.65 ^a	73.59	3.79 ^a	2.12 ^a	2.96 ^a	48.16	12.64 ^a	7110 ^a	5214 ^a	6162 ^a
M3	4.29 ^a	8.25 ^a	6.27 ^a	64.39	4.56 ^b	2.88 ^a	3.76 ^a	34.74	11.18 ^a	6984 ^b	5167 ^b	6076 ^d
M4	10.73 ^b	24.48 ^b	17.61 ^b		6.64 ^c	4.76 ^a	5.70 ^{ab}		25.12 ^b	3114 ^d	3238 ^d	3176 ^d
SEm(±)	0.75	1.03	1.15		0.34	0.62	0.57		1.61	24.48	14.68	19.39
LSD (P=0.05)	2.31	3.17	3.54		1.05	1.91	1.76		4.95	75.40	45.21	59.72

* ROC = Reduction over control. #Average of 7 observations of different treatments at 10 days interval. Means followed by same letter in a column do not differ significantly by DMRT (P=0.05).

Chlorfenapyr, a pro-insecticide, has unique mode of action as it acts as uncouplers of oxidative phosphorylation via disruption of the proton gradient (IRAC 2014) in the mitochondria, resulting in disruption of production of ATP, cellular death and ultimately organism mortality. Similarly, Fipronil is a strong nerve poison as it acts as GABA-gated chloride channel antagonists (IRAC 2014), whereas Buprofezin acts as inhibitor of chitin biosynthesis of the insect. Other inputs like *L. lecanii* killed the insects due to mycosis as well as produce the toxins, whereas neem oil known for its multicide actions. This diverse site of actions could be the reason for integrated module to become most effective. Reddy *et al.* (2007) recorded that amongst the 17 test insecticides, Fipronil 5% SC @ 0.01% was most

effective in controlling chilli thrips. Our earlier study also revealed that amongst the newer molecules tested, Fipronil 80% WG was found effective against chilli yellow mites and thrips and per cent reduction over control was 57.29 and 75.41, respectively (Halder *et al.* 2015). In another study, Sarkar *et al.* (2013) reported that Chlorfenapyr 10% SC@ 100 and 125 g a.i./ha were found to be most effective against the chilli thrips and yellow mite up to 15 days after treatment. Chlorfenapyr 10% SC@ 1 000 ml/ha showed mean 50.22% yellow mite mortality in chilli in Andhra Pradesh Pathipati *et al.* (2012). Incorporation of these newer acaro-insecticide molecules in integrated module might be responsible for its effectiveness than the other molecules. However, Nandini *et al.* (2011) observed that chemical

Table 2 Economics of different pest management modules against major sucking pests of chilli

Treatment	Yield of healthy fruits (kg/ha)	Increase in yield over control (kg/ha)	Increase in yield per cent over control	Cost of increase yield (₹/ha)	Cost of treatment (₹/ha)	Net profit (₹/ha)	Cost benefit ratio
<i>Kashi Anmol</i>							
M1	2304	300	14.97	6000	5982	18	1:0.004
M2	3277	1273	63.52	25460	7800	17660	1:2.26
M3	2669	665	33.18	13300	10857	2443	1:0.23
M4	2004						
<i>Kashi Gaurav</i>							
M1	5119	1943	61.18	38860	5982	32878	1:5.5
M2	6162	2986	94.02	59720	7800	51920	1:6.66
M3	6076	2900	91.31	58000	10857	47143	1:4.34
M4	3176						

Spray volume – 600 l/ha; Average cost of chilli was ₹ 20/kg

intensive module comprising sequential application of Imidacloprid, Dimethoate, Abamectin, Fenazaquin, Dicofol and Acephate were significantly effective than biorational and IIHR modules in controlling yellow mite, thrips and leaf curl damage in *C. annuum* grown under shade house condition.

In terms of cost benefit ratio, integrated module (M₂) only recorded highest cost benefit ratio in both the varieties. In case of Kashi Anmol, Module 2 registered cost benefit ratio of 1:2.26 followed by chemical module (1:0.23). However, when these modules were tested against Kashi Gaurav, M₂ had also highest cost benefit ratio (1:6.66) followed by the biointensive module (1:5.5). Significantly lower green chilli yield in Kashi Anmol could be the reason for non-effectiveness of most of the pest management modules where this is compensated by the higher yield of the Kashi Gaurav.

From the above study it can be concluded that integrated pest management module (M₂) comprising seedling dip with Imidacloprid 1 ml/l of water, sequential spraying of Buprofezin @ 1 ml/l, Fipronil @ 2 ml/l, *L. lecanii* @ 5 g/l, Chlorfenapyr @ 1.5 ml/l, neem oil 1% each at 10 days intervals from 25 DAT onwards was found most effective in reducing the thrips and mite population in both the varieties of chilli (Kashi Anmol and Kashi Gaurav) and significantly enhancing the yield over control apart from registering highest cost benefit ratio.

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