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Effectiveness and economic evaluation of new generation insecto-acaricides against thrips and mites in green chilli

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ABSTRACT: Field experiments were conducted at ICAR-Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh, India during 2018-20 to evaluate the insecto-acaricidal activity of different newer molecules against yellow mite (*Polyphagotarsonemus latus* Banks) and thrips (*Scirtothrips dorsalis* Hood) infesting chilli revealed that maximum reduction in mite population was obtained in treatment with Chlorfenapyr 10% EC @ 1.5 mL L^{-1} (65.32%) followed by Fenpyroximate 5% EC @ 1 mL L^{-1} (62.13%) and Fenazaquin 10% EC@ 2.5 mL L^{-1} (58.94%). In case of thrips, maximum reduction was achieved with Fipronil 5% SC (78.63%) followed by Emamectin Benzoate 5% SG @@ 0.4 g L^{-1}(75.21%). Significantly higher green chilli yield (128.93 q ha^{-1}) was obtained from Chlorfenapyr treated plots followed by Spiromesifen (121.81 q ha^{-1}), and Fenpyroximate (113.22 q ha^{-1}) indicating superiority of these newer molecules over the conventional one. However, the maximum cost benefit ratio was recorded in Fenpyroximate 5% EC (1:14.01) followed by Chlorfenapyr 10% SC (1:8.64). Chlorfenapyr 10% SC was found to be the most effective and yielded the highest among all the treatments but showed comparatively lower C:B ratio due to its relatively high cost.

Keywords: Acaricide, insecticide, newer molecules, chilli, thrips, yellow mite, yield

INTRODUCTION

Chilli, *Capsicum annum* Linn., one of the important solanaceous vegetable and spice crops, is widely cultivated throughout the India. India is the largest producer, exporter and consumer of chillies in the world (Geetha and Selvarani, 2017). However, the average production and productivity of this 'wonder spice'is substantially low in comparison to that in other chilli producing countries. Insect and acarine pest problem is one of the major constraints for chilli production in Indian subcontinent. Among the recorded 57 species of insect and acarine pests of chilli (Reddy and Puttaswamy, 1984), yellow or broad mite (*Polyphagotarsonemus latus* Banks) and thrips (*Scirtothrips dorsalis* Hood) are noted to be causing serious yield loss to the tune of 25 - 50 per cent at national level (Ahmad *et al*., 1987; Desai *et al*., 2007). Damages by these sucking pests are distinctly visible in severe infestation. Thrips, being harbored in the upper side of the leaves, causes typical upward curling of leaves and whereas downward leaf curling along with elongated petiole was observed in yellow mite infestation (Rai *et al*., 2014). To manage these sucking pests, Indian farmers applied minimum of 12 to 15 rounds of the conventional pesticide sprays in a season (Halder *et al*., 2016). This not only increased the cost of cultivation but often caused the 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 effecton human health, and wide spread killing of non-target organisms (Halder *et al.* 2014, 2017). Pesticide residues in chilli are also of great concern from the point of domestic consumption and exports.

In general, most of the conventional insecticides/ acaricides are generally old generic, broad spectrum; require higher dose and many of them are toxic to the natural enemies of pests. Therefore, newer molecules having acaro-insecticidal activities against yellow mite and thrips of chilli have been evaluated and their efficacy was compared with conventional insecticides.

MATERIALS AND METHODS

Test chemicals

Seven newer molecules *viz*., Spiromesifen 22.9% SC @ 0.8 mL L^{-1}; Chlorfenapyr 10% SC @ 1.5 mL L^{-1}; Fenazaquin 10% EC @ 2.5 mL L^{-1}; Fenpyroximate 5% EC @ 1 mL L^{-1}; Emamectin Benzoate 5% SG @ 0.4 g L^{-1}; Fipronil 5% SC @ 2 mL L^{-1}were tested against the yellow mites and thrips in chilli and compared with conventional pesticide *i.e.,* Propargite 57% EC @ 2.5 mL L^{-1}.

Experimental layout

The experiment was carried out during the two consecutive *Rabi* seasons (August to March) of 2018-19 to 2019-20 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 three replications. The chilli seedlings of cv. Pusa Jwala were transplanted at

Table 1. Bioefficacy of some novel insecto-acaricidal molecules against yellow mites and thrips in chilli

Treatments	Dose (per lit)	Mites / leaf					Thrips / leaf					Spiders / plant	Yield (q/ha)
		Before spray	First year (2018-19)	Second year (2019-20)	Pooled mean	PROC	Before spray	First year (2018-19)	Second year (2019-20)	Pooled mean	PROC		
Spiromesifen 22.9% SC	0.8 ml	4.82	2.37^{ab}	1.69^{b}	2.03	56.81	2.36	0.72^{a}	0.69^{a}	0.71	69.66	1.33^{a}	121.81
Chlorfenapyr 10% SC	1.5 ml	4.69	1.89^{a}	1.37^{a}	1.63	65.32	2.49	0.69^{a}	0.78^{ab}	0.74	68.38	1.29^{a}	128.93
Fenazaquin 10 % EC	2.5 ml	5.07	2.19^{a}	1.67^{b}	1.93	58.94	2.18	0.89^{ab}	0.81^{b}	0.85	63.68	1.44^{a}	109.97
Fenpyroximate 5% EC	1 ml	4.69	2.08^{a}	1.47^{a}	1.78	62.13	2.69	1.11^{b}	0.95^{b}	1.03	55.98	1.24^{a}	113.22
Emamectin Benzoate 5% SG	0.5 g	4.37	2.52^{b}	1.96^{bc}	2.24	52.34	2.87	0.61^{a}	0.55^{a}	0.58	75.21	1.82^{a}	111.57
Fipronil 5% SC	2 ml	4.51	2.97^{c}	1.84^{b}	2.41	48.73	2.61	0.53^{a}	0.47^{a}	0.50	78.63	1.60^{a}	106.95
Propargite 57% EC	2.5 ml	5.03	2.59^{b}	1.75^{b}	2.17	53.83	2.50	1.46^{c}	1.23^{c}	1.35	42.31	1.22^{a}	98.74
Untreated control	--	4.82	5.13^{d}	4.27^{d}	4.70	--	2.68	2.18^{d}	2.49^{d}	2.34	--	3.59^{b}	89.35
SEm(±)	--	--	0.15	0.13	--	--	--	0.09	0.12	--	--	0.33	--
LSD(5%)	--	--	0.37	0.29	--	--	--	0.24	0.28		--	0.84	--

* Average of 15 observations over three sprays of different treatments at 15 days interval; In column, means followed by common letters are not significantly different at ($P \leq 0.05$).

spacing of 60 × 45 cm during second fortnight of Augustin a plot size of 3.6 × 4.5 m. Crop was raised following the recommended agronomic package of practices except any plant protection measures. The spray solutions were prepared using water just before their application and sprayed with the help of Knapsack power sprayer. These were sprayed thrice at 15 days interval. The first spray was initiated 35 days after transplanting (DAT).

Observations

The data were recorded from five tagged plants selected randomly. Three leaves were plucked from bottom, middle and top of each of the 5 tagged plants to count the number of mites and thrips per leaf. The leaves were brought to the laboratory and observations were taken under stereo zoom binocular microscope (Nikon SMZ 10A). Such observations were recorded on one day before and 1, 3, 5, 7 and 10 days after spray (DAS).

Data analysis

The data of two years trials were subjected to Analysis of Variance (ANOVA) with least significant difference (p=0.05) as test criterion and cost- benefit (C: B) was calculated using the following formula:

$$\text{Cost-benefit ratio} = \frac{\text{Net return (Rs. ha}^{-1})}{\text{Cost of treatment (Rs ha}^{-1})}$$

RESULTS AND DISCUSSION

Relative efficacy of different treatments

Yellow mites

From Table 1 it is evident that among all the tested molecules, Chlorfenapyr 10% SC at its recommended dose was significantly superior harbouring the average lowest yellow mite population (1.63 mites leaf^{-1}) followed by Fenpyroximate 5% EC (1.78) and Fenazaquin(1.93). Per cent mite reduction over control (proc) also followed the same trend and the highest reduction over control (65.32) was recorded in Chlorfenapyr followed by Fenpyroximate (62.13). From the two years data, it is apparent that these newer molecules had higher acaricidal activity against *P. latus* than the conventional old generic molecule like Propargite 57% EC. Chlorfenapyr, a pro-insecticide, hasunique mode of action as it acts as uncoupler 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, in case of Fenpyroximate and Fenazaquin, act on the energy metabolism of insects by blocking the mitochondrial complex-I electron transport inhibitors (IRAC, 2014, Kodandaram *et al*., 2010). This unique mode of action of these newer molecules might be responsible for the higher toxicity against this phytophagous tarsonemid mite. Another advantage of these newer molecules

Table 2. Economics of some novel insecto-acaricidal molecules against yellow mites and thrips in chilli

Treatments	Dose (per liter)	Yield of healthy fruits (q ha^{-1})	Increase in yield over control	Increase in yield (% over control)	Cost of increase yield (Rs ha^{-1})	Cost of treatment (Rs ha^{-1})	Net return (Rs ha^{-1})	Cost benefit ratio
Spiromesifen 22.9% SC	0.8 ml	121.81	32.46	26.65	64920	6780	58140	1:8.58
Chlorfenapyr 10% SC	1.5 ml	128.93	39.58	30.70	79160	8214	70946	1:8.64
Fenazaquin 10 % EC	2.5 ml	109.97	20.62	18.75	41240	11739	29501	1:2.51
Fenpyroximate 5% EC	1 ml	113.22	23.87	21.08	47740	3180	44560	1:14.01
Emamectin Benzoate 5% SG	0.4 g	111.57	22.22	19.92	44440	5100	39300	1:7.71
Fipronil 5% SC	2 ml	106.95	17.60	16.46	35200	5400	29800	1:5.52
Propargite 57% EC	2.5 ml	98.74	9.39	9.51	18780	6564	12216	1:1.86
Untreated control	--	89.35	--	--	--	--	--	--

Notes: Average cost of chilli @ Rs. 20 kg^{-1}

is that most of them required relatively lower doses than the conventional ones. Our earlier study revealed that Chlorfenapyr was highly effective against chilli mites (Halder *et al*., 2015). In another study, Smitha and Giraddi (2006) observed that Fenpyroximate 5% EC was most effective in controlling yellow mite (*P. latus*) infesting chillies. Recently, Samanta *et al.*(2017) identified Fenpyroximate 5% SC @ 25 g a.i. ha^{-1} was effective against chilli yellow mite. Aryl pyrroleacaro-insecticide Chlorfenapyr @ 100 and 125 g a.i. ha^{-1} were found to be most effective against the broad mite in chilli by registering significantly less infestation up to 15 days after treatment (Sarkar *et al*., 2013).

Thrips

From the two years data, it can be concluded that Fipronil 5% SC ranked first in controlling thrips as it harboured their lowest population (0.50 thrips leaf^{-1}) with the highest 78.63% reduction over control (ROC) followed by Emamectin Benzoate 5% SG (0.58 thrips leaf^{-1}, 75.21% ROC) and Spiromesifen 22.9% SC(0.71 thrips leaf^{-1}, 69.66% ROC). Fipronil is a strong nerve poison as itacts as GABA-gated chloride channel antagonist (Kodandaram *et al*., 2010). This unique mode of action might be responsible for its higher toxicity against this sucking pest. Emamectin benzoate is a novel group of insecticide and effective against lepidopteran pests and sucking pests like thrips and phytophagous mites (Rai *et al*., 2014; http://ppqs.gov.in/divisions/cib-rc/major-uses-of-pesticides). The mode of action of this new molecule is unique in the panorama of insecticides. It inhibits muscle contraction, causing a continuous flow of chlorine ions in the GABA and H-Glutamate receptor sites (Fanigliulo and Sacchetti, 2008). Verghese and Mathew (2013) from Kerala, India documented that Spiromesifen 45 SC were effective against chilli thrips. However, toxicity of an insecticide/acaricide also depends on crop architecture, environmental factors, chemical nature and its structure action relationship, target specificity, persistence, etc (Halder *et al*., 2011). From the present study, it is concluded that these newer molecules can be advantageous over other conventional insecticides like Propargite.

Green chilli yield

A marked difference in green chilli yield was observed among the different treatments. Chlorfenapyr 10% SC plots registered the highest yield (128.93 q ha^{-1}) as compared to other insecticides and/or acaricides. Amongst the other test molecules, Spiromesifen 22.9% SC (121.81 q ha^{-1}) and Fenpyroximate 5% EC (113.22 q ha^{-1}) are the next best molecules against these sucking pests and recorded significantly higher yield than the untreated control (89.35 q ha^{-1}).

Cost-benefit ratio

In terms of cost benefit ratio, Fenpyroximate5% EC ranked first followed by Chlorfenapyr 10% SC and Spiromesifen 22.9% SC (Table 2). The minimum C: B ratio 1:1.86 was recorded in Propargite 57% EC. Relatively low price of Fenpyroximate 5% EC could be the reason for its higher C: B ratio.

Spider population

In addition to major pests like thrips and mites population, predatory polyphagous spider population was also recorded. Lowest spider population (1.22 per plant) was observed in Propargite 57% EC treated plots and the untreated control plots harboured maximum number of spiders (3.59 plant^{-1}).

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