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Bio-efficacy evaluation of ready-mix insecticide (Diafenthiuron 30 + Pyriproxyfen 8% SE) against yellow mite, *Polyphagotarsonemus latus* (Banks) and whitefly, *Bemisia tabaci* (Gennadius) infesting in chilli in West Bengal

Suvash Ch. Bala

Abstract
The present studies were undertaken at District seed Farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during *Kharif*, 2020 and *Rabi*, 2020-21 to evaluate the bio-efficacy of the combine product Diafenthiuron 30% + Pyriproxyfen 8% SE against yellow mite and whitefly in chilli ecosystem. In case of yellow mite, maximum mortality was recorded from the treatment T_4 = Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha which was statistically at par with the treatment T_3 = Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1000ml/ha. The treatment T_5 = Diafenthiuron 50 WP @ 600 g/ha was recorded the next best result during the *kharif*, 2020 and *rabi*, 2020-21 seasons. However, in case of whitefly, maximum mortality was recorded from the treatment T_4 i.e., Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha followed by the treatment T_3=Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1000 ml/ha). The treatment T_2= (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 800 ml/ha) exhibited the next best option displayed good percentage of mortality during the period of investigation. However regarding yield is concern, maximum green chilli yield was obtained from the T_4 i.e., highest dose of Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha which was at par with treatment T_3.

Keywords: Bio-efficacy, Diafenthiuron 30% + Pyriproxyfen 8% SE, yellow mite, whitefly, chilli

Introduction
Chilli (*Capsicum annuum* L. and *Capsicum frutescens* L.) is being cultivated throughout the world as a major spice as well as a vegetable crop. India has emerged as the leading producer, consumer and exporter of chillies contributing almost one fourth of the total world's production (Anonymous, 2009) [1]. The area under chilli cultivation in India is about 1061 thousand ha with a production of 3592 thousand metric tons of green chilli and 2149 thousand metric tons of dried chilli during the year 2017-18. In West Bengal the area and production of chilli is about 65.12 thousand hectares and 100.34 thousand metric tons of dried chilli respectively (Anonymous, 2018) [2]. Chilli is used in all culinary preparations as a paste, powder and whole form for its pungency, colour, taste and flavour and it is one of the principal sources of vitamins A, B and C. Capsaicin is also used to prepare drugs in the pharmaceutical industry for medication of heart attack by dilating the blood vessels (Gill, 1989) [6]. However, due its extensive use and cultivation, this crop is infested by different pests and non-insect pest. Among them yellow mite, *Polyphagotarsonemus latus* (Banks) and whitefly, *Bemisia tabaci* (Gennadius) are the serious concern and considered as major pests of chilli (Berke and Sheih, 2000) [5]. Both the pests attack on top most leaves of the crop and cause huge economic loss every in year (Sarkar *et al.*, 2008) [12]. The yellow mite, *P. latus*, alone causes yield loss up to 60% (Srinivasan *et al.*, 2003) [11]. The mites attack young apical leaves, flower buds cause curling and crumpling of young developing plant parts, resulting in the shedding of flower buds, flowers and developing fruits (Bala *et al*., 2015) [4]. Another important pest of chilli is whitefly (*Bemisia tabaci*) which feeds by sucking on the lower leaves and caused damage symptom is more complicated because it is transmit to viruses (Jones, 2003) [10]. Several insecticides of different groups have been used to manage insects and non- insect pests for the last two decades, which evoke the resistance against insecticides and increased the residue level in the crops (Joia *et al*., 2001) [9].

Therefore, continuous efforts are needed to evaluate the bio-efficacy of certain newer insecticides that are comparatively safer for the environment and work effectively against insect and mite pests of chilli crop. However, Diafenthiuron and Pyriproxyfen are two newer insecticides with novel modes of action which inhibits oxidative phosphorylation and disrupts ATP formation whereas Pyriproxyfen (4-phenoxyphenyl (RS)-2- (2-pyridyloxy) propyl ether) is a juvenile hormone analogue that acts by suppressing embryogenesis, metamorphosis and inhibiting adult formation (Hugar *et al*., 2020) [8]. Therefore, congregate application of these insecticides provides a potential combination of two different modes of action against sucking pests which delay the development of resistance. Hence, the present study was undertaken to determine the effect of a combine product, Diafenthiuron 30% + Pyriproxyfen 8% SE against yellow mite and whitefly in chilli ecosystem.

Materials and Methods

The experiments were conducted at District seed farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal during *Kharif*, 2020 and *Rabi*, 2020-21 to evaluate the bio-efficacy of the combine product Diafenthiuron30% + Pyriproxyfen 8% against yellow mite and whitefly in chilli. Experiments were laid out in the randomized block design with 7 treatments including untreated control comprising of different doses of insecticides and used local chilli variety 'Bullet' with 3 replications. The plot size of each treatment was 20 m^2 and dibbled with a spacing 90 cm X 60 cm. The tested chemical, Diafenthiuron 30% + Pyriproxyfen 8% SE was evaluated at four different doses *viz*., 600, 800, 1000, 1200 ml/ha. Diafenthiuron 50% WP and Pyriproxyfen 10% EC were used as standard comparative checks @ 600 g/ha and 500 ml/ha respectively. There was one untreated control treatment for the comparison of all spray treatments. Two rounds of application were made at 15 days interval by using 500 litres of spray solution per hectare with high volume knapsack sprayer. All spray applications were made during early morning time.

Method of observation

The data of target pests were recorded from five randomly selected plants in each plot. First count was taken one day before first spray and post treatment counts were recorded after 3rd, 7th and 10th days after spray. Observation of total number of mite population was recorded from five top young leaves of selected plants of each replication per treatment. However, pre and post treatment observations on whitefly were recorded on 5 leaves selected from top, mid and bottom of selected plants in each plot. Based on these observations, mean insect population was worked out and the data were subjected to analysis after making necessary transformation and expressed on the basis of percent reduction of the pest population (Arivoli and Tennyson, 2013) [3].

$$\text{Percent mortality} = \frac{\text{No.of dead insects}}{\text{Total no.of insects}} \text{ X } 100$$

The data on pest management were analysed in RBD after making angular transformation to work out the critical difference (CD) at 5 percent level of significant.

The green chilli yield per plot of was considered as fresh weight basis after 3 rounds picking during the experimental period. The cumulative yield data thus obtained were expressed in q/ha which was analysed statistically and has been presented in table 3. The percent increase in yield over control was worked out by using the formula:

$$\frac{\text{yield in treatment} - \text{yield in control}}{\text{yield in control}} \text{ X } 100$$

Results and Discussion

The data recorded on mean of mortality percentage of the population of yellow mite and whitefly at 3, 7 and 10 days after first and second sprays have been presented in table 1 and 2. The population of targeted pests recorded before spray showed non-significant difference among different treatments indicated that its population was uniformly distributed in all the experimental plots in both the seasons. The data reveals that all the treatments were significantly superior to untreated control.

Table 1: Bio-efficacy evaluation of ready- mix insecticide (Diafenthiuron 30 + Pyriproxyfen 8% EC) against yellow mite, *Polyphagotarsonemus latus* (Banks)) infesting chilli during 2020-21

Treatment	Dosage g or ml/ha	*Kharif* season					*Rabi* season				
		PTP/leaf	% mortality of yellow mite *P. latus* (Mean of two round sprays)				PTP/leaf	% mortality of yellow mite *P. latus* (Mean of two round sprays)			
			3 DAS	7 DAS	10 DAS	Mean % of mortality		3 DAS	7 DAS	10 DAS	Mean % of mortality
T_1=Diafenthiuron 30% + Pyriproxyfen 8% SE	600	13.96	63.30 (53.01)*	59.21 (50.60)	53.84 (47.49)	58.78	8.93	65.66 (54.43)*	62.74 (52.68)	51.60 (46.20)	60.00
T_2=Diafenthiuron 30% + Pyriproxyfen 8% SE	800	13.31	67.73 (55.69)	63.90 (53.39)	56.53 (49.04)	62.72	8.27	67.46 (55.53)	66.24 (54.78)	62.39 (52.47)	65.36
T_3=Diafenthiuron 30% + Pyriproxyfen 8% SE	1000	14.62	75.01 (60.34)	70.49 (57.41)	65.20 (54.15)	70.23	7.93	79.02 (63.09)	69.46 (56.76)	64.70 (53.85)	71.06
T_4=Diafenthiuron 30% + Pyriproxyfen 8% SE	1200	13.36	76.56 (61.38)	73.11 (59.09)	67.78 (55.72)	72.48	8.31	84.45 (67.17)	76.20 (60.47)	69.83 (57.00)	76.82
T_5=Diafenthiuron 50%WP	600	14.33	72.06 (58.41)	70.83 (57.62)	62.62 (52.61)	68.50	9.27	74.31 (59.88)	67.77 (55.72)	60.79 (51.53)	67.62
T_6= Pyriproxyfen 10% EC	500	13.78	60.95 (51.62)	53.97 (47.56)	47.56 (43.89)	54.16	9.13	66.15 (54.73)	61.29 (51.82)	51.32 (46.04)	59.58
T_7= Untreated Control	--	14.82	0.0 (4.05)	0.0 (4.05)	0.0 (4.05)	0.0	8.67	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.0
CD (0.05)		NS	2.92	2.79	3.71	--	NS	13.85	11.53	9.32	--
S.Em. ±			0.95	0.91	1.21	--		4.49	3.74	3.02	--
CV %			0.45	0.48	0.68	--		2.05	1.92	1.69	--

* Values in the parentheses are angular transformed, DAS: Days after spray, PTP: Pre-treatment population

Table 2: Bio-efficacy evaluation of ready- mix insecticide (Diafenthiuron 30 + Pyriproxyfen 8% EC) against whitefly, *Bemisia tabaci* (Gennadius) infesting chilli during 2020-21

Treatment	Dosage g or ml/ha	Kharif season					Rabi season				
		PTP/ 15 leaf	% Mortality of Whitefly *Bemisia tabaci* (Mean of two round sprays)				PTP/ 15 leaf	% Mortality of Whitefly *Bemisia tabaci* (Mean of two round sprays)			
			3 DAS	7 DAS	10 DAS	Mean % of mortality		3 DAS	7 DAS	10 DAS	Mean % of mortality
T_1=Diafenthiuron 30% + Pyriproxyfen 8% SE	600	8.18	75.24 (60.49)*	67.60 (55.61)	65.96 (54.61)	69.60	6.60	65.29 (54.20)*	61.29 (51.82)	57.04 (49.34)	61.20
T_2=Diafenthiuron 30% + Pyriproxyfen 8% SE	800	7.93	80.14 (63.90)	70.89 (57.66)	67.89 (55.79)	72.97	6.69	71.35 (57.96)	67.10 (55.30)	60.86 (51.56)	66.43
T_3=Diafenthiuron 30% + Pyriproxyfen 8% SE	1000	8.51	82.64 (65.76)	79.71 (63.59)	70.22 (57.24)	77.52	6.51	74.03 (59.69)	70.23 (57.24)	60.16 (51.15)	68.14
T_4=Diafenthiuron 30% + Pyriproxyfen 8% SE	1200	8.04	84.79 (67.44)	79.47 (63.41)	75.21 (60.47)	79.82	6.66	75.52 (60.68)	72.06 (58.41)	64.93 (53.99)	70.83
T_5=Diafenthiuron 50%WP	600	7.73	70.71 (57.55)	63.11 (52.90)	55.07 (48.20)	62.96	6.24	69.68 (56.90)	67.28 (55.42)	58.09 (49.95)	65.01
T_6= Pyriproxyfen 10% EC	500	7.64	63.60 (53.19)	51.10 (45.92)	31.66 (34.55)	48.78	6.07	53.29 (47.17)	38.66 (38.74)	34.01 (35.98)	41.98
T_7= Untreated Control	--	8.62	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.0	6.38	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.0
CD (0.05)		NS	2.66	3.88	4.20	--	NS	8.06	5.67	6.35	--
S.Em. ±			0.86	1.26	1.37	--		2.61	1.85	2.10	--
CV %			0.38	0.64	0.78	--		1.22	1.10	1.23	--

* Values in the parentheses are angular transformed, DAS: Days after spray, PTC: Pre-treatment population

Table 3: Yield of green chilli recorded by using different formulations during 2020-21

Treatments	Formulation (ml /g/ha)	Yield (q/ha)		Mean yield (q/ha)	% increase in yield over control
		Kharif 2018	*Rabi* 2018-19		
T_1=Diafenthiuron 30% + Pyriproxyfen 8% SE	600	16.38	16.74	16.56	40.46
T_2=Diafenthiuron 30% + Pyriproxyfen 8% SE	800	17.98	17.44	17.71	50.21
T_3=Diafenthiuron 30% + Pyriproxyfen 8% SE	1000	19.91	20.03	19.97	69.38
T_4=Diafenthiuron 30% + Pyriproxyfen 8% SE	1200	20.03	19.95	19.99	69.55
T_5=Diafenthiuron 50%WP	600	16.00	17.05	16.73	40.16
T_6= Pyriproxyfen 10% EC	500	12.9	13.82	13.36	13.32
T_7= Untreated Control	--	11.18	12.4	11.79	--
CD (p=0.05)	--	2.56	2.46	2.32	--

Bio-efficacy of Diafenthiuron 30 + Pyriproxyfen 8% EC against chilli yellow mite (*Polyphagotarsonemus latus* in chilli

The efficacy of various formulations against yellow mite in chilli for first season has been depicted in the Table-1 which revealed that 54.16 to 72.48 percent mean mortality up to 10 days after spray in *Kharif* season experiment. However, maximum mortality (76.56%) was recorded from T_4 i.e., Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha which was statistically at par with T_3 (75.01%) at 3 days after spray. However, T_5 (Diafenthiuron 50 WP @ 600 g/ha) exhibited the next best result, recorded 72.06% mite mortality at 3 days after spray. After 7 days of spray, T_4 (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha) had given maximum mortality of 73.11% followed by T_5 (70.83%) and T_3 (70.49%) respectively, moreover those three treatments were statistically at par with each other. A minor decrease in the efficacy of these insecticides was observed at 10 days after treatment as compared to 3and 7 days. However, 10days after treatment 67.78% mortality of mite was noticed with T_4 (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha) which was statistically at par with T_3 (65.20%).

Similar trend of result has been found at *Rabi* season experiment, though in that case slightly higher percent of mean mortality was observed (Table1). The mean percent of mortality varied from 59.58% to 76.82% up to 10 days after spray. But, maximum mortality (84.45%) was recorded from T_4 (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha) which was statistically at par with T_3 and T_5 with mortality percentage 79.02% and 74.31% respectively during 3 days after spray. After 7 days of spray, T_4 (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha) had given maximum mortality of 73.11% followed by T_3 (69.46), T_5 (67.77), T_2 (66.24) respectively, though these treatments were statistically at par with each other. Similarly, 10 days after spray T_4 i.e., Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha was rendering maximum mortality of 69.83% followed by T_3 (64.70), T_2 (62.39), T_5 (60.79) respectively were statistically at par with each other. Lowest percent of mite mortality was recorded from the plot treated with Pyriproxyfen 10% EC @ 500 ml/ ha.

Bio-efficacy of Diafenthiuron 30 + Pyriproxyfen 8% EC against whitefly (*Bemisia tabaci*) in chilli

The experimental results showed that the initial population of whitefly was almost same in all the treatments in both seasons, which varying from 7.64 to 8.62 per 15 leaves during *Kharif* season and 6.07 to 6.69 per 15 leaves during *Rabi* season 2020-21. The efficacy of various formulations against whitefly in chilli for first season has been depicted in the Table-2 which revealed that 48.78 to 79.82 percent mean mortality up to 10 days after spray in *Kharif* season experiment. However, maximum mortality (84.79%) was recorded from T_4 i.e., Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha which was statistically at par with T_3 (82.64%) at 3 days after spray. The treatment T_2

(Diafenthiuron 30% + Pyriproxyfen 8% SE @ 800 ml/ha) exhibited the next best result, displayed 80.14% mortality at 3 days after spray. After 7 days of spray, the treatment T_3 = Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1000 ml/ha had registered maximum mortality of whitefly (79.71%) which was statistically at par with the treatment T_4 resulting in 79.47% mortality. A minor decrease in the efficacy of these insecticides was observed at 10 days after treatment as compared to 3 and 7 days. However, 10 days after treatment 75.21% mortality of whitefly was noted with the treatment T_4 (Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha) which recorded maximum among the tested formulations.

Similar trend of result has been found at *Rabi* season experiment, though in that case slightly higher percent of mean mortality was observed (Table 2). The mean percent of mortality varied from 41.98% to 68.14% up to 10 days after spray. However, maximum mortality (75.52%) was recorded from T_4 = Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha followed by T_3 (74.03%), T_2 (71.35%), T_5 (69.68%) respectively, those were statistically at par with each other. After 7 days of spray, the treatment T_4 had given maximum mortality of 72.06% followed by T_3 (70.23%), T_5 (67.28%), T_2 (67.10%) respectively, though these treatments were statistically at par with each other. Similarly, 10 days after spray T_4= Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha was rendering maximum mortality of 64.93% followed by T_2 (60.86) and T_3 (60.16) respectively. However, lowest percent of mite mortality was recorded from the plot treated with Pyriproxyfen 10% EC @ 500ml/ ha in both seasons.

Yield

The present study revealed that the maximum green chilli yield was obtained with the treatment T_4 = Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1200 ml/ha (19.99 q/ha) which was at par with the treatment T_3 i.e., Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1000 g/ha (19.97 q/ha) followed by T_2 (17.71 qt/ha), T_5 (16.73 qt/ha), T_1 (16.56 qt/ha), T_6 (13.36 q/ha) and untreated control (11.79 q/ha) (Table 3).

Conclusion

It was inferred that the combined insecticide treatment involving Diafenthiuron 30% + Pyriproxyfen 8% SE @1200 ml/ha was the most effective in controlling yellow mite and whitefly in chilli which was equally effective to lower dose @1000 ml/l. There was no adverse effect or mortality on natural enemies by application of Diafenthiuron 30% + Pyriproxyfen 8% SE which confirmed the eco-safety of formulation. Furthermore, phytotoxicity studies showed that there were no phytotoxic effects due to application of this combined formulation with different doses on chilli crop. Fruit yield of chilli also increased in the plots treated with this formulation. Therefore, Diafenthiuron 30% + Pyriproxyfen 8% SE @ 1000 ml/ha and 1200 ml/ha could be utilized for effective management against yellow mite and whitefly in chilli.

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