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BIO-EFFECTIVENESS OF DINOTEFURAN AGAINST TEA MOSQUITO BUG, *HELOPELTIS THEIVORA* WATERHOUSE, IN TEA PLANTATIONS OF WEST BENGAL, INDIA

L. MAITY* AND P. K. SARKAR
Department of Agricultural Entomology,
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur -741 252, Nadia, West Bengal
e-mail: labanimaity1990@gmail.com

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***Corresponding author**

ABSTRACT

Field bio-effectiveness and the most effective rate of application of dinotefuran 20% SG was tested against tea mosquito bug, *Helopeltis theivora* Waterhouse (Heteroptera: Miridae) along with its phytotoxicity and effect on natural enemies in tea ecosystem in the present study. The field trial was conducted at the Sukhna Tea Estate, Terai, Darjeeling where the results exhibited that a single spray of dinotefuran 20% SG at the rate of 300 ml/ha provided persistent (upto 28 days) and most effective reduction of infestation (0.34% mean twig infestation and 98.69% reduction tea mosquito bug population over control) with substantial increase in yield (2.20 q/acre respectively with 85.45% increase in yield over control). At 300 and 350 ml/ha the test insecticide was found to be soft to prevailing coccinellids (3.85 and 3.95 nos. of *Stethorus* sp., 5.20 and 5.00 Cheilomenes sp. and 8.10 and 7.95 *Micraspis discolor* per 10 leaves respectively) and predatory mite species (16.80 and 16.60 nos respectively/ 10 leaves) in the tea ecosystem. Further it was observed that, the chemical did not produce any phytotoxic symptom on tea bushes. Therefore, dinotefuran 20% SG @ 300 can be recommended to tea growers for successful management of this pest.

INTRODUCTION

India secures the second position in production of tea after China and the fourth largest exporter in the world. The cultivation of the tea, *Camellia sinensis,* is carried out as a monoculture, which provides a sustainable niche to over 230 species of insect and mite pests causing 11% to 55% loss in yield (Chakraborty *et al.*, 2015) worth U.S. $500 million to $1 billion.

Tea mosquito bug, *Helopeltis theivora* Waterhouse (Family: Miridae) is one of the most dreaded polyphagous pest. This pest has emerged as a commonly occurring major pest of cashew (Srikumar and Bhat, 2013, Vanitha *et al.,* 2014) and large cardamom plants by sucking the sap from the leaves developing dark brown streak stains (Kalitha *et al.*, 2016). In tea it causes damage to the tune of 10 -50% followed by subsequent crop loss (Bora *et al.*, 2007). This pest recently is causing severe economic loss to the North Bengal tea plantations due to environmental changes (Mukhopadhyay and Roy 2009).

Nymphs and adults both suck the sap from pluckable buds, young leaves and tender stems and in addition inject toxic substances (Roy *et al.,* 2009 a) which results in appearance of reddish brown sunken spots which eventually turns dark curl up and deform. Severe infestation may cause shoots to produce dieback symptoms (Roy *et al.,* 2015). Moreover, this pest causes ovipositional damages to the tender tissues. It attacks only the young shoots which are the actual crop of tea (Rahman *et al.,* 2005). Therefore, cause considerable economic losses.

Chemical control would continue to be the first line of defense against this pest. However, control failures due to pesticide resistance have increased the difficulty in economic tea production (Gurusubramanian *et al.,* 2008 and Saha *et al.,* 2013). To combat the damage there has been a rise in pesticide use every passing year which further aggravated the problem and has led to significant rise in cost of management (Sannigrahi and Talukdar, 2003). Hence, as traditional and cultural practices alone cannot give satisfactory control over the pest menace (Vanlaldiki *et al.*, 2013), small and marginal farmers are compelled to use chemical insecticides in order to cultivate lucratively.

In order to address the aforesaid problems new insecticides can be thought as alternative and effective new bio-rational and eco-friendly molecules that are safe to natural enemies and non-target organisms and also to human health and environment (Chakraborty *et al.,* 2010, Reddy *et al.,* 2014).

Dinotefuran is a new furanicotinyl class of chemistry representing the third generation of neonicotinoid group acts as an agonist of insect nicotinic acetylcholine receptors. It has translaminar systemic action acting through both contact and ingestion, resulting in the cessation of feeding within several hours of contact and death shortly after. Due to its high effectivity against sucking pests (Bernhardt, 2009) and selective nature (Elbert *et al.,* 2008) , the test molecule may be a good fit in integrated pest management programs of tea, as it is likely to keep the pest population in check while have little impact on the predatory fauna.

Keeping these views in mind, the present investigation was dealt on-field bio-effectiveness of dinotefuran with safety evaluation against natural enemies and phytotoxic effect on tea bushes with an objective to evaluate its suitability in IPM programs of the tea gardens.

MATERIALS AND METHODS

The experiment was laid out in Randomized Block Design with six treatments & four to ten replications depending on the type of experiments in the Sukhna Tea Estate, Terai, Darjeeling, West Bengal for the period from February-April of 2014 and 2015.

A plot size of 50 bushes/replication having clone TV_9 (15 & 16 yrs old bushes) was selected for the experiment. Sprays with dinotefuran 20% SG (TOKEN) @ 200 ml/ha, 250 ml/ha, 300 ml/ha, 350 ml/ha, thiamethoxam 25% WG @ 100 ml/ha and profenofos 50% EC @ 800 ml/ha were imposed coinciding ETL of pests. Sticker i.e. Sandovit @ 1.0 % was added with spray solution due to waxy nature of tea leaves. The application of sprays was scheduled at an interval of 10 days.

For evaluation of bio-efficacy the data of population of Helopeltis sp. was taken as number of pest on 10 bushes / plot previously selected at random. Observations on pest incidence were taken on 3rd, 7th, 15 th, 21 st and 28 th days after spraying (DAS). The percentage reduction in tea mosquito bug population was assessed by adopting the following formula (Henderson and Tilton, 1955). Percentage reduction = {1 - (Ta x Cb / Tb x Ca)} X 100%

Where-

Ta = TMB (tea mosquito bug) population in treated plant after treatment.

Tb = TMB population in treated plant before treatment.

Ca = TMB population in control plants after treatment.

Cb = TMB population in control plant before treatment.

The data collected were subjected to transformation before statistical analysis to test the treatment significance following Gomez and Gomez, (1984). The data were then subjected to Analysis of Variance (ANOVA) after making angular transformation by $\sin^{-1}$ p (where p is % mortality / 100). The data on yield was also transformed ($\sqrt{x+0.5}$) (where x is the yield of green leaves in quintal/acre) and subjected to further analysis.

Ten randomly selected plants of 15 years old were sprayed with the chemical by a high volume knapsack sprayer to observe phytotoxicity on 0-10 scale as per CIB and RC (Central insecticide board and registration committee, Govt.of India) guide lines. Phytotoxic symptoms included yellowing, chlorosis, leaf tip injury, wilting, hyponasty, epinasty. Observations were taken at 1, 3, 7, 10 & 14 days after application.

The predatory population (*Amblyseius ovalis,* Stethorus sp Cheilomenes *sexmacculata* & *Micraspis discolor*) was worked out based on their number on 10 leaves selected randomly from each of the ten bushes previously selected at random. Observations on the incidence of predators were taken 15 days after application (Chakraborty *et al.*, 2015).

RESULTS AND DISCUSSION

Effect on *H. theivora*

The pooled data on the efficacy of different treatment schedules of Dinotefuran 20%SG along with standard checks Thiamethoxam 25% WG and Profenofos 50% EC against *Helopeltis theivora* of tea during February-April 2014 has been represented in Table I. It appeared that all the plots treated with chemicals provided significant reduction of tea mosquito bug infestation. However, dinotefuran 20% SG @ 300 & 350 ml./ha gave excellent control of tea mosquito bug keeping the plots almost free from pest upto 28 days after application & as far as yield is concerned (2.20 and 2.78q/acre respectively with 85.45 and 88.49 % increase in yield over control). The yield increase commensurate with the performance of the treatments and the optimum yield was obtained in plots treated with Dinotefuran 20% SG @ 300 & 350 ml/ha.

The same trend was also observed in the next year (February-April 2015) also (Table II). During this year the initial shoot infestation percentage was found to be little low. However, the efficacy of Dinotefuran 20% SG @ 300 & 350 ml/ha was found to prove the best treatment once again with zero population of pest (100% reduction over control) upto 28 days after application. The yield of green tea leaves was found to be 2.90 and 3.05 q/acre which was higher than previous year with 84.13 and 84.91% increase in yield over control. The standard check thiamethoxam 25% WG @ 100ml/ha and profenofos 50% EC @ 800ml/ha were also moderately effective in suppressing tea mosquito bug population (50.43-65.67%) and (22.98-36.45% reduction respectively) over untreated control over 2 seasons. A perusal of available literature revealed that no work has been done on the field bio-effectiveness of dinotefuran 20%SG against tea sucking pest. Bernhardt (2009) reported that dinotefuran 20%SG is excellent and having contact mortality and significantly better residual activity than historically provided from the commonly used pyrethroid and organophosphate insecticides. However, the results found were in conformity with that of Roy *et al.* (2009b). Chowdhury *et al.* (2013) reported that application of thiamethoxam gave 85.90% reduction of tea mosquito bug over untreated control in Bi-lashcherra Experimental Farm of Bangladesh Tea Research Institute (BTRI). Smitha and Puspalatha (2014) reported that thiamethoxam can be a promising molecule in the tea mosquito bug management package.

Phytotoxicity

No phytotoxic symptoms were observed in any of the treated plots with dinotefuran 20% SG (Table III) even up to 15 days after application.

Effect on natural enemies

Natural enemies profile in tea eco-syatem at terai in association with *Helopeltis theivora* mainly consisted of predatory mite *Amblyseius ovalis* and insect predators like *Stethorus* sp. Chielomenes sexmaculata & *Micraspis discolor*. It was observed that Dinotefuran 20% SG (TOKEN at 300 and 350

Table I: Effect of different treatment schedules of Dinotefuran 20% SG in control of Tea Mosquito Bug of Tea during (February-April 2014) at Sukhna Tea Estate, Terai, Darjeeling,West Bengal [First season]

Sl.No.	Treatment	Dose (ml/ha)	Pre-treatment observation (%shoot infestation)	% new shoot infestation at different daysafter 3	7	15	21	28	Mean % shoot infestation	% reduction over control	Yield of Green leaves q/acre	% increase in yield over control
1.	Dinotefuran 20% SG	200	25.68	8.87* (17.33)#	3.52 (10.81)	10.61 (19.01)	14.64 (22.50)	20.27 (26.76)	11.58	55.43	1.25 (1.62)	59.20
2.	Dinotefuran 20% SG	250	30.83	2.48 (9.06)	0.83 (5.23)	3.52 (10.81)	7.58 (15.98)	11.29 (19.63)	5.14	80.22	2.15 (1.97)	85.12
3.	Dinotefuran 20% SG	300	28.41	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.66 (7.40)	0.34	98.69	2.20 (1.98)	85.45
4.	Dinotefuran 20% SG	350	26.25	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00	100	2.78 (2.17)	88.49
5.	Thiamethoxam 25% WG	100	31.64	0.00 (0.00)	0.83 (5.23)	9.84 (18.28)	13.48 (21.54)	20.48 (26.91)	8.92	65.67	1.80 (1.84)	82.23
6.	Profenofos 50% EC	800	26.89	4.86 (12.74)	6.42 (9.33)	12.42 (20.64)	20.27 (26.76)	38.62 (38.42)	16.51	36.45	0.95 (1.48)	66.31
	Untreated control	-	25.98	28.41 (32.21)	35.40 (36.51)	45.64 (42.50)	53.55 (47.04)	63.87 (53.05)	45.37	-	0.32 (1.07)	-
	C.D.at 5%		NS	0.02	0.89	2.51	1.24	2.03			0.15	

*Original value , # Transformed (sin^{-1}"x), ##Transformed ("x+0.5) value for analysis

Table II: Effect of different treatment schedules of Dinotefuran 20% SG in control of Tea Mosquito Bug of Tea during (February-April 2015) at Sukhna Tea Estate, Terai, Darjeeling,West Bengal [Second season]

Sl.No.	Treatment	Dose(ml /ha)	Pre-treatment observation (% shoot infestation)	% new shoot infestation after different days of treatment 3	7	15	21	28	Mean % shoot infestation	% reduction over control	Yield of Green leavesq/acre	% increase in yield over control
1.	Dinotefuran 20% SG	200	20.55	10.35*(18.76)#	8.00(16.42)	13.50(21.56)	18.25(25.29)	25.00(30.00)	13.22	43.75	2.20* (1.98)##	79.09
2.	Dinotefuran 20% SG	250	22.50	7.25(15.62)	0.75(4.97)	6.50(14.77)	8.25(16.69)	14.50(22.38)	7.45	68.30	2.75 (2.16)	83.27
3.	Dinotefuran 20% SG	300	19.75	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00	100	2.90 (2.20)	84.13
4.	Dinotefuran 20% SG	350	20.00	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00	100	3.05 (2.25)	84.91
5.	Thiamethoxam 25% WG	100	22.80	0.00(0.00)	3.25(10.39)	13.25(21.35)	18.00(25.10)	23.75(29.17)	11.65	50.43	2.40 (2.05)	80.84
6.	Profenofos 50% EC	800	23.00	7.00(15.34)	9.25(17.71)	15.00(22.79)	24.25(29.50)	35.00(36.27)	18.10	22.98	0.70 (1.34)	34.28
	Untreated control	-	23.50	18.25(25.29)	30.75(33.68)	35.50(36.57)	45.50(42.42)	60.75(51.21)	38.15	-	0.46 (1.18)	-
	C.D.at 5%		NS	0.25	0.78	1.58	1.56	1.54			0.19	

*Original value , # Transformed (sin^{-1}"x), ##Transformed ("x+0.5) value for analysis

Table III: Evaluation of Dinotefuran 20% for phytotoxicity on tea during (February-April 2015) at Sukhna Tea Estate, Terai, Darjeeling,West Bengal (based on one application and ten replications)

Sl.No	Treatment	Dose (ml/ha)	Visual rating (phytotoxicity) in 0-10 scale of grading 0 0- 0.0%	1 1-10%	2 11-20%	3 21-30%	4 31-40%	5 41-50%	6 51-60%	7 61-70%	8 71-80%	9 81-90%	10 91-100%
1.	Dinotefuran 20% SG (TOKEN)	250	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
2.	Dinotefuran 20% SG (TOKEN)	300	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
3.	Dinotefuran 20% SG (TOKEN)	350	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP
4.	Untreated control	-	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP	NP

N.B.:- NP = No phytotoxicity; Observation taken for fifteen days on necrosis, epinasty, hyponasty, leaf tip injury, leaf surface injury, wilting, vein clearing etc; on 15 years' old tea bush.

Table IV: Effect of different treatment schedules of Dinotefuran 20% SG on some important natural enemies at Sukhna Tea Estate, Terai, Darjeeling,West Bengal (mean of one application & three replications). [Mean of 2 Seasons]

SlNo	Treatment	Dose(ml /ha)	No. of natural enemies 15th day after application *Amblyseius ovalis*	*Stethorus* sp	*Chielomenes sexmacculata*	*Micraspis discolor*
1	Dinotefuran 20% SG	200	16.55 (4.13)	4.00 (2.12)	5.75 (2.50)	8.00 (2.92)
2	Dinotefuran 20% SG	250	16.70 (4.15)	4.00 (2.12)	5.85 (2.52)	7.80 (2.88)
3	Dinotefuran 20% SG	300	16.80 (4.16)	3.85 (2.09)	5.20 (2.39)	8.10 (2.93)
4	Dinotefuran 20% SG	350	16.60 (4.14)	3.95 (2.11)	5.00 (2.35)	7.95 (2.91)
5	Profenofos 50% EC	800	16.45 (4.12)	3.70 (2.05)	5.60 (2.47)	7.60 (2.85)
6	Thiamethoxam 25% WG	100	19.95 (4.52)	5.05 (2.36)	7.75 (2.87)	12.35 (3.58)
	CD (p=0.05)	NS	NS	NS	NS	

*Original value , # Transformed (“x+0.5) value for analysis

ml/ha was safe to all the natural enemies as results on all the treatment were at par (Table IV). Szczepaniec et al., (2013) reported that dinotefuran was safe to predatory mites. Wakita (2009) reported dinotefuran to be selective in nature because of its unique mode of action.

Hence, it is evident from the present investigation, that single application of Dinotefuran 20% SG @ 300 ml/ha is the optimum dose for the effective control of *Helopeltis theivora* in Tea, as this dose was equally same in effectiveness with that of higher doses and also showed significant effectiveness after 1, 3, 5 and 7 days after treatment in comparison to check followed by commendable yield. The test chemistry was also found to be safe to the prevailing predatory fauna in tea plucking tables and non phytotoxic to tea canopy. Thus, dinotefuran 20% SG @ 300ml/ha can be recommended for widespread application for successful management of tea mosquito bug as it can be placed in sustainable management of *Helopeltis theivora*.

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