Research Article

COMPARATIVE EFFECTIVENESS OF NEW INSECTICIDES AGAINST *SPODOPTERA LITURA* IN TOBACCO NURSERIES

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ABSTRACT

Tobacco caterpillar, *Spodoptera litura* F. is the key pest of tobacco nurseries and it is one of the major problems in successful production of healthy tobacco seedlings required to realise optimum yield and quality tobacco leaf. Insecticides chlorfenapyr 10 SC @ 0.01%, metaflumizone 22 SC @ 0.04%, spinosad 48 SC 0.01% and IGRs novoluron 10 EC @ 0.01% & lufenuron 5 EC @ 0.006% were evaluated against *S. litura* in tobacco seed beds in a replicated experiment in comparison with emamectin benzoate 5 SG @ 0.0025% and untreated control for two seasons. Emamectin benzoate 0.0025% recorded least seedling damage followed by chlorfenapyr 10 SC @ 0.01%. The seedling damage in the treatments of emamectin benzoate and chlorfenapyr was on á par with each other. The studies on persistent residual toxicity of the insecticides showed cent per cent mortality up to 8 days in emamectin benzoate @ 0.0025% and 6 DAS in chlorfenapyr @ 0.01%. The period of persistency was 20 days in emamectin benzoate and 16 days in chlorfenapyr treatment. The mean persistent toxicity and persistent toxicity index were 62.84 & 1256.80 for emamectin benzoate 5 SG @ 0.0025% and 71.95 & 1151.20 for chlorfenapyr 10 SC @ 0.01%. Chlorfenapyr 10 SC @ 0.01% can be used for management of *S. litura* in tobacco seed beds along with emamectin benzoate 5 SG @ 0.0025%.

INTRODUCTION

Tobacco caterpillar, *Spodoptera litura* is the key pest of tobacco nurseries in India. The damage due to this pest in unprotected nurseries was as high as 80 -100 per cent in the years of severe incidence (Chari, 1987). The registered insecticides that provide adequate control of the pest continued to decrease. The guidance residue levels (GRLs) of the recommended insecticides have been revised to a lower level by CORESTA (CORESTA, 2016). Repeated application of insecticides to control the pest is a common practice among nursery growers. Adverse effects of indiscriminate use of insecticides are well documented. In order to overcome the problems, there is a need to replace the conventional insecticides with selective insecticides effective at low dose in tobacco. Search for safer alternatives for pest control, which are less aggressive for the environment has brought a significant development in identification and deployment of new insecticides, with possibilities of use in pest management and contributing to a safer and more efficient way of pest management. Emamectin benzoate is a semi-synthetic derivative of the avermectin family of naturally-derived products and quite effective against lepidopteran insects and is used in several crops including tobacco for management of *S. litura* (Sreedhar, 2010; Hegde and Gadad, 2017; Babu *et al*., 2018; Ghosal *et al*., 2018). The extensive use of emamectin benzoate against *S. litura* may provide an ideal environment for development of resistance (Ahmad *et al*., 2008; Hong Tong *et al*., 2013). In order to postpone the development of resistance, a resistance management strategy of decreased selection pressure could be achieved by certain methods. Using insecticides with different mode of action is considered as one of the possible alternatives.

Chlorfenapyr is a pesticide, and specifically a pro-insecticide (meaning it is metabolized into an active insecticide after entering the host), derived from a class of microbially produced compounds known as halogenated pyrroles. Chlorfenapyr uncouples oxidative phosphorylation at the mitochondria resulting in disruption of adenosine triphosphate (ATP), cellular death, and ultimately mortality of the insect. It is good candidate due its low toxicity to mammals and aquatic life. Metaflumizone is a novel semi carbazone insecticide with greatly improved mammalian safety and it works by blocking sodium channels in target insects, resulting in flaccid paralysis (Takagi *et al*., 2007). Metaflumizone blocks sodium channels by binding selectively to the slow-inactivated state. Novaluron is a benzoylphenyl urea IGR with good activity against lepidopetrous pests with and low mammalian toxicity pests (Ishaaya *et al*., 2002). Novaluron has been reported to be effective against *S.litura* on various crops (Dhawan *et al*., 2008; Krishna *et al*., 2008; Bhushan *et al*., 2010; Panwar and Ghugali, 2015). Lufenuron, a benzoylurea pesticide is basically a chitin synthesis inhibitor specifically acts on the incorporation of N-acetyl glucosamine monomer into chitin in the integument, resulting in the formation of abnormal new cuticle and death of the insect. It has also been reported that lufenuron has the properties of juvenile hormone (JH) as well as ecdysteroid agonists (Tunaz, 2004). Lufenuron inhibits the production of chitin in insects. Without chitin, a larva will never develop a hard outer shell (exoskeleton). With its inner organs exposed to air, the insect dies from dehydration soon after hatching or molting (shedding its old, smaller shell). Because of their desirable characteristics, such as low toxicity, less environmental pollution, high selectivity, and low impact on natural enemies and people, IGRs are used to control various insects. Spinosad is a novel mode-of-action insecticide derived from a family of natural products obtained by fermentation of *Saccharopolyspora spinosa*. Spinosad contains a mix of two spinosoids, spinosyn A, and spinosyn D. Spinosad is highly active, by both contact and ingestion, in numerous insect species. It has a novel mode of action, primarily targeting binding sites on nicotinic acetylcholine receptors (nAChRs) of the insect nervous system that are distinct from those at which other insecticides have their activity. Spinosoid binding leads to disruption of acetylcholine neurotransmission. It kills insects by hyper excitation of the insect nervous system. Spinosad so far has proven not to cause cross-resistance to any other known insecticide. Spinosad has high efficacy, a broad insect pest spectrum, low mammalian toxicity, and a good environmental profile, a unique feature of the insecticide compared to others (Orr *et al*., 2009). Hence, experiments were conducted with the objective of evaluating the bio-efficacy of certain new insecticides against *S. litura* in tobacco seed beds.

MATERIALS AND METHODS

Tobacco nursery was raised with *Nicotiana tabacum* cv. Siri and the 400 seedlings were reset on m^2 beds. When the seedlings were six weeks old, 30 laboratory reared third instar (10 days old) *S. litura* larvae/bed were released. Spraying with the respective treatments was carried out with a high-volume knapsack sprayer. The insecticides viz. Chlorfenapyr 10 SC @ 0.01%, metaflumizone 22 SC @ 0.04%, novoluron 10 EC @ 0.01%, spinosad 48 SC 0.01%, lufenuron 5 EC @ 0.006% were evaluated in a replicated trial in comparison with emamectin benzoate 5 SG @ 0.0025% and untreated control in a replicated experiment for two seasons. Observations on per cent seedlings damaged were recorded at 2, 4, and 8 days after spraying. The data were subjected to analysis of variance after transforming the values.

Table 1: Efficacy of new insecticides against *S. litura* in tobacco seedbeds-2013 & 2014

Treatments	Per cent seedlings damaged								
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
		2DAS			4DAS			8DAS	
Novoluron 10 EC 0.01%	7.56 (1.75)	7.76 (1.83))	7.66	7.19 (1.58)	7.56 (1.75)	7.37	7.19 (1.58)	6.60 (1.33)	7.10
Emamectin benzoate 5 SG 0.0025%	6.19 (1.17)	5.63 (1.00)	6.06	5.17 (0.83)	4.92 (0.75)	5.04	4.66 (0.67)	4.36 (0.58)	4.51
Metaflumizone 22 SC 0.04%	7.19 (1.58)	7.56 (1.75)	7.37	7.01 (1.50)	7.19 (1.58)	7.10	6.39 (1.25)	6.19 (1.17)	6.29
Chlorfenapyr 10 SC 0.01%	6.60 (1.33)	6.39 (1.24)	6.49	6.19 (1.17)	5.96 (1.08)	6.07	5.48 (0.92)	5.14 (0.83)	5.31
Spinosad 48 SC 0.01%	10.49 (3.33)	10.62 (3.40	10.55	9.06 (2.50)	9.65 (2.83)	9.35	9.95 (3.00)	10.08 (3.08)	10.01
Lufenuron 5 EC 0.006%	9.50 (2.75)	9.67 (3.42)	9.58	8.08 (2.00)	8.45 (2.17)	8.26	7.56 (1.75)	7.76 (1.83)	7.66
Untreated control	32.14 (28.33)	32.97 (29.66)	32.55	32.59 (29.08)	33.29 (30.17)	32.94	33.13 (29.92)	31.81 (27.83)	32.47
S.Em±	0.49	0.63	0.32	0.65	0.49	0.41	0.52	0.59	0.40
CD at 5%	1.50	1.94	1.31	1.99	1.52	1.19	1.61	1.82	1.18

Figures in parentheses are retransformed means

Persistence Studies

An experiment was conducted to know the persistent residual toxicity of chlorfenapyr 10 SC @ 0.01%, metaflumizone 22 SC @ 0.04%, novoluron 10 EC @ 0.01%, spinosad 48 SC 0.01%, lufenuron 5 EC @ 0.006% on tobacco in comparison with emamectin benzoate 5 SG 0.0025%. Leaves from the treated nursery beds were offered daily to 10 days old *S.litura* larvae in plastic jars till the mortality dropped to zero. Persistent toxicity index was calculated following Pradhan (1967) and as used by Sarup *et al*. (1970) subsequently.

RESULTS AND DISCUSSION

All the treatments were significantly superior to control during 2013 as shown by less seedlings damaged at 2, 4 and 8 DAS (Table 1). At 2 DAS emamectin benzoate 5 SG @ 0.0025% recorded least (6.19%) seedling damage followed by chlorfenapyr 10 SC @ 0.01% (6.60%), metaflumizone 22 SC @ 0.04% (7.19%) and novaluron 10 EC @ 0.01% (7.56%) and were on a par with one another. At 4 DAS the treatments of emamectin benzoate, chlorfenapyr and metaflumizone were found to be at par with each other. At 8 DAS, only emamectin benzoate (4.66%) and chlorfenapyr (5.48%) were on a par with each other while metaflumizone recorded significantly higher (6.39%) seedling damage. Among all the treatments highest damage was recorded in the treatment of spinosad 48 SC 0.01%, lufenuron 5 EC @ 0.006% at all the observations though it was significantly less than untreated control. During 2014 emamectin benzoate recorded least (5.63%) seedling damage followed by chlorfenapyr (6.39%), metaflumizone 22 SC @ 0.04% (7.56%) which was on a par with each other at 2 DAS. At 4 DAS only emamectin benzoate (4.92%) and chlorfenapyr (5.96%) were on a par with each other while metaflumizone recorded higher (7.19%) seedling damage. At 8 DAS similar trend was observed. The highest damage was recorded in the treatment of spinosad 48 SC 0.01%, lufenuron 5 EC @ 0.006% at all the observations though it was significantly less than untreated control.

Pooled data of two seasons showed that emamectin benzoate (6.06%), chlorfenapyr (6.49%) and metaflumizone (7.37%) were on a par with each other at 2 DAS, while chlorfenapyr and metaflumizone were found to be on a par with novaluron (7.66%). Among the treatments, spinosad treatment showed the highest seedling damage (10.55). At 4 DAS only emamectin benzoate (5.04%) and chlorfenapyr (6.07%) were on a par with each other while metaflumizone recorded higher (7.10%) seedling damage. Metaflumizone remained on a par with the IGR novaluron (7.37%). Bothe the IGRs novaluron and lufenuron (7.37 & 8.26%) recorded more or less similar damage. Spinosad while remaining on a par with lufenuron recorded the highest seedling damage (9.35%) among the treatments, though it was significantly less than that in untreated control (32.94%). Similar trend was observed at 8 DAS.

Table 2: Persistent residual toxicity of insecticides against *S. litura*

Treatment	Percent mortality (Days after application)											Period of persistency (P)	Mean persistent Toxicity (PT)	Persistent toxicity index (PTI)
	0	2	4	6	8	10	12	14	16	18	20			
Novoluron 10 EC 0.01%	100	100	100	90.6	50.8	20.2	6.6	-	-	-	-	12	66.88	802.56
Emamectin benzoate 5 SG 0.0025%	100	100	100	100	100	77.2	52.8	38.0	14.2	6.8	2.2	20	62.84	1256.80
Metaflumizone 22 SC 0.04%	100	100	100	90.8	88.2	60.2	40.6	20.2	2.8	-	-	16	66.98	1071.68
Chlorfenapyr 10 SC 0.01%	100	100	100	100	92.2	72.4	49.2	26.0	7.8	-	-	16	71.95	1151.20
Spinosad 48 SC 0.01%	100	100	90.8	70.6	52.2	28.2	10.8	-	-	-	-	12	64.57	774.84
Lufenuron 5 EC 0.006%	100	100	100	90.4	48.6	18.8	6.2	-	-	-	-	12	66.28	795.36

Effectiveness of emamectin benzoate against *S. litura* is well established (Sreedhar, 2010; Hegde and Gadad, 2017; Babu *et al*., 2018; Ghosal *et al.*, 2018). Novaluron was reported to be effective against *S. litura* on various crop viz., cotton (Dhawan *et al.*, 2008), groundnut (Krishna *et al*., 2008), potato (Bhushan *et al*., 2010) and soybean (Panwar and Ghugali, 2015). The effectiveness of chlorfenapyr against *S. litura* on various crops was reported (Krishna *et* al., 2010; Bhushan *et al*., 2010; Chatterji and Mondal, 2012; Patra *et al*., 2016; Kambrekar, 2018). Effectiveness of metaflumizone against army worms, *Spodoptera Spp*. was reported by Seal *et al*, 2007. However, recently metaflumizone and lufenuron were found to be inferior to emamectin benzoate against *S. litura* on groundnut (Ghadiya *et al.*, 2014). Similarly inferior efficacy of spinosad against *S. litura* was reported (Rame Gouda and Basavana Goud, 2001). The present studies are in conformity with these studies.

Persistent Residual Toxicity

The data presented (Table 2) show that emamectin benzoate 5 SG @ 0.0025% and chlorfenapyr 10 SC @ 0.01% were the most persistent insecticides, which gave cent per cent mortality of *S. litura* till 8 and 6 DAS respectively. Among others cent per cent mortality was observed up to 4 days in metaflumizone 22 SC @ 0.04% and novaluron 10 EC 0.01%. More than 90 per cent mortality was recorded up to 6 DAS in novaluron, metaflumizone and lufenuron. The period of persistency was longest (20 days) in case of emamectin benzoate 5 SG @ 0.0025% followed by chlorfenapyr 10 SC @ 0.01% and metaflumizone 22 SC @ 0.04% (16 Days) where as it was 12 days for novaluron 10 EC @ 0.01%, lufenuron 5 EC @ 0.006% and spinosad 48 SC @ 0.01%. The mean persistent toxicity was highest (71.95) in chlorfenapyr followed by metaflumizone (66.98). However, the persistent toxicity index was highest (1256.80) in emamectin benzoate followed by chlorfenapyr (1151.20) and metaflumizone (1071.68). The persistent toxicity index (PTI) was 802.56 for novaluron and 795.36 for lufenuron. The reduction in effectiveness started from 10 DAS in emamectin benzoate (22.8%), and 8 DAS for chlorfenapyr (7.8%); 6 DAS in metaflumizone (9.2%), novaluron (9.4%) and lufenuron (9.6). Based on the results the order of persistency was found to be emamectin benzoate 0.0025% > chlorfenapyr 0.01% > metaflumizone 0.04% > novaluron 0.01% > lufenuron 0.006% > spinosad 0.01%.

Based on the bio- efficacy data for two seasons and studies on persistent residual toxicity, it is evident that emamectin benzoate 5 SG @ 0.0025% recorded least seedling damage followed by chlorfenapyr 10 SC @ 0.01%. It is concluded that chlorfenapyr 10 SC @ 0.01% can be used along with emamectin benzoate 5 SG @ 0.0025 % for management of tobacco leaf eating caterpillar *S. litura* in tobacco nurseries.

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