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Identification of Extensive Insecticide Usage Areas through Insecticide Usage Pattern Survey for Exploration of Insecticide Tolerant Strains of Entomophages in Major Vegetable Growing Districts of Tamil Nadu

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ABSTRACT

Insecticide usage pattern survey revealed that 82.86% of respondents were dependent on pesticide dealers for their recommendations. About 64.76% of the respondents using power operated mist blower for spraying. The respondents (70.95%) were using insecticides solely with a least gap between two sprays was 7.57 days in Coimbatore district with 2.82 days of waiting period and long gap was (15.65 days) in Namakkal district with 6.71 days of waiting period. The highest frequency of application of insecticides observed was 7.2 times in Coimbatore district and lowest was in Namakkal (5.38) per season per crop. Only 2.38% of the respondents were known about deleterious effects of the insecticide residues and using masks (2.90%) while spraying. None of the respondents mixing the spray fluid using bare hand. Few respondents (16.7%) from Coimbatore district adopting ecofriendly measures using pheromone traps, sticky traps and biopesticides. The use of chlorantraniliprole 18.5 SC was found maximum (75.71%) followed by Dimethoate 30EC (60.48%); Imidacloprid 17.8SL (57.62%); Acephate 75SP (42.86%) and the least was Bio fit (0.95%). Among the respondents, 41.19% were using older molecules and 57.86% were novel insecticides. Based on the survey, the order of insecticide usage was Coimbatore with 19.79% followed by Dharmapuri (15.63%) and Dindigul (15.53%). These areas may be considered as extensive insecticide usage areas and may be selected for exploration and development of insecticide tolerant strains of entomophages.

Keywords Survey, Insecticide usage, Safety, Awareness, Tolerant strains.

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INTRODUCTION

The major cultivable vegetables are Tomato, Brinjal and Okra in southern parts of India. India is the world's second largest producer of vegetables next to China with 197.23 million tonnes in 10,966 thousand hectares. Among the vegetables, Tomato contributes 10.67%, brinjal (6.43%) and okra (3.29%) of total vegetable production in our country (Horticulture Database 2021). The pest complex (sucking pests, defoliators and borers) of these vegetables varies from region to region and number of recorded species ranges from 13 to 72 depending on the agro-climatic conditions (Meenambigai *et al*. 2017).

Farmers rely solely on the synthetic insecticides for the management of insects pests in different vegetable ecosystems because of easy adaptability, immediate and spectacular knockdown effects of pesticides (Pawar *et al*. 1988, Verma 1989, Adjrah *et al*. 2013 and Sanjaykumar 2021). Despite these credentials, continuous usage of synthetic insecticides has been found ecologically unsafe and indiscriminate use of insecticides has resulted in the development of resistance by insects, resurgence of primary and secondary pests, inimical to predators and parasitoids, accumulation of pesticide residues in/on fruits (Mitra *et al*. 1999), break-down of food web in natural ecosystem and finally environmental pollution (Mahapatro and Gupta 1998). Meenambigai *et al*. (2017) and Anjali *et al*. (2018) also reported that okra and exotic vegetable growing farmers were dependent on the highly toxic novel group of insecticides for pest management which develop resistance in insects.

Jalali *et al*. (2006), Venkatesan *et al*. (2009), Venkatesan and Jalali (2015) and Srinivasnaik *et al*. (2018) stated that resistance development also takes place in natural enemies associated with the insect pests in extensive insecticide usage areas. Development of insecticide tolerant strains of entomophages is one of important pest management strategy in extensive insecticide usage areas. This will prevent development of resistance in target insect pests and enhance the potential of natural enemy in integrated pest management programs.

With this background and considering the importance of developing insecticide tolerant strains in IPM programs identification of extensive insecticide usage areas is important in major vegetable ecosystems in Tamil Nadu for exploration and development of insecticide tolerant strains of entomophages (Parasitoids/Predators).

MATERIALS AND METHODS

An insecticide usage pattern survey was conducted in 7 vegetable growing districts of Tamil Nadu during January 2018 to 2020 using well structured questionnaire. The districts selected based on the vegetable cultivation and information obtained from the Department of Horticulture, Government of Tamil Nadu and Horticulture Database (2021)

The main objective of the study is to identify extensive insecticide usage areas in different districts (Coimbatore, Dharmapuri, Dindigul, Karur, Namakkal, Salem and Villipuram) for generation of baseline data for collection of insecticide tolerant strains of entomophages. The information regarding the insecticide usage profile was collected from 30 farmers from each district and a total of 210 respondents randomly selected. The data was collected by personal interaction by visiting their farm field (Table1). The

Table 1. Survey areas for characterization of insecticide usage pattern.

Sl. No.	District	Blocks/ Villages	No.of respondents	Total respondents	Vegetable ecosystems
1.	Coimbatore	Thondamuthur	10		
		Karamadai	10		
		Annur	10		
2.	Dharmapuri	Pauparapatty	10		
		Dharmapuri	10		
		Pallipatty	10		
3.	Dindigul	Oddanchatram	10		
		Attur	10		
		Dindigul	10		Tomato,
4.	Karur	Karur	10	210	Brinjal
		Aravakurichi	10		and
		Krishnarayapuram	10		Okra
5.	Namakkal	Namakkal	10		
		Pallipalayam	10		
		Sendamangalam	10		
6.	Salem	Salem	15		
		Thalaivasal	15		
7.	Villipuram	Kanai	15		
		Koliyanur	15		

questionnaire consists of the following categories under which information was collected and analyzed.

Category 1: General information on farmers socio economic conditions (Name, education, age, address, family type, crops and acreage)

Category 2: Insecticide usage pattern (Source of information, spraying appliances, mixing of insecticides, safety measures, waiting period, volume of spray fluid, handling and disposal of insecticide containers, awareness on insecticide residues, frequency of spraying and information on ecofriendly techniques)

Category 3: Range of insecticides used (Insecticides, chemical name, trade name, dosage, company, target insect pests and stage of the crop)

The data collected from different vegetable growing districts of Tamil Nadu using well structured questionnaire was analyzed using descriptive statistics and based on the % usage of different insecticides, extensive insecticide usage areas were selected. These areas will be explored for collection of insecticide tolerant strains of entomophages.

RESULTS AND DISCUSSION

Survey on socio economic conditions of the vegetable growing farmers revealed that 92.38% of the respondents in the surveyed districts were males and only 7.62% were females cultivating vegetables. About 83.33% of the respondents were in nuclear family. Among the respondents only 27.62% had the opportunity to pursue primary education and only

Table 2. Characterization of socio economic conditions of vegetable growing farmers in different districts of Tamil Nadu. No Number of respondents, %: Percentage of respondents, CBE: Coimbatore, DMI: Dharmapuri; DNL: Dindigul, KR: Karur, NKL: Namakkal, SA: Salem, VLM: Villipuram.

Character/District		CBE		DMI		DNL		KR	
		No.	%	No.	%	No.	%	No.	%
Gender	Male	24	80.0	29	96.7	27	90.0	28	93.3
	Female	6	20.0	1	3.3	3	10.0	2	6.7
Family	Nuclear	22	73.3	28	93.3	26	86.7	23	76.7
	Joint	8	26.7	2	6.7	4	13.3	7	23.3
Education	Illiterate	6	20.0	5	16.7	3	10.0	11	36.7
	Primary	4	13.3	13	43.3	1	3.3	5	16.7
	Middle	12	40.0	5	16.7	5	16.7	2	6.7
	Secondary	2	6.7	3	10.0	15	50.0	3	10.0
	Collegiate	6	20.0	4	13.3	6	20.0	10	33.3
Occupation	Agriculture	22	73.3	24	80.0	25	83.3	25	83.3
	Other	8	26.7	6	20.0	5	16.7	5	16.7
Landholding	Avg(acres)	4.6		1.0		5.1		3.5	

Table 2. Continued.

Character/District		NML		SA		VLM		Average % respondents
		No.	%	No.	%	No.	%	
Gender	Male	30	100.0	29	96.7	27	90.00	92.38
	Female	0	0.0	1	3.3	3	10.00	7.62
Family	Nuclear	26	86.7	26	86.7	24	80.00	83.33
	Joint	4	13.3	4	13.3	6	20.00	16.67
Education	Illiterate	10	33.3	10	33.3	12	40.00	27.14
	Primary	7	23.3	12	40.0	16	53.33	27.62
	Middle	4	13.3	5	16.7	1	3.33	16.19
	Secondary	6	20.0	2	6.7	1	3.33	15.24
	Collegiate	3	10.0	1	3.3	0	0.00	14.29
Occupation	Agriculture	25	83.3	24	80.0	24	80.00	80.48
	Other	5	16.7	6	20.0	6	20.00	19.52
Landholding	Avg(acres)	2.2		3.1		4.2		3.38

14.29% were collegiate. The main occupation of the respondents was agriculture (80.48%) with the average land holding of 3.38 acres (Table 2). These results are in line with the findings of the Srinivasnaik *et al*. (2015) who also reported that 85% respondents were males between the age of 25-75 with medium level of education (32%) with average farm size was 4.86 acres of okra growing farmers in Coimbatore district.

The knowledge level of vegetable growing farmers on insecticide usage pattern (Table 3) revealed that in order to get information on pesticide recommendation 82.86% of respondents approached pesticide dealers. This might be due to mutual relationship with the dealer and credit based purchase of insecticides. These findings are in line with the Srinivasnaik *et al*. (2015) and Meenambigai *et al*. (2017) who also reported that 80% and 75.83% of the farmers in surveyed areas are dependent on pesticide dealers for the recommendations respectively.

The pre-existing assumption was that the farmers are dependent on hand sprayer for spraying, but very few % of the respondents were dependent on the former equipment and most of them using power operated mist blower (64.76%). They revealed that as the power sprayer is easy to use and cover more area in less time. The respondents revealed that they (70.95%) dependent on the insecticides only, but a few on insecticide + insecticide (16.67%) and insecticide + Fungicide (12.38%). But, the chemical names of the mixtures were not known. The least gap between two sprays was 7.57 days in Coimbatore district with 2.82 days of waiting period and long gap was (15.65 days) in Namakkal district with 6.71 days of waiting period. This less gap might be due to tenderness/ perishability of the vegetables. If they follow exact waiting period, the vegetables loose their tenderness and unfit for consumption. The highest frequency of application of insecticides observed was 7.2 times in Coimbatore district and lowest was in 5.38 per season

Table 3. Characterization of insecticide usage pattern of vegetable growing farmers. No.: Number of respondents; %: Percentage of respondents, CBE: Coimbatore, DMI: Dharmapuri, DNL: Dindigul, KR: Karur, NKL: Namakkal, SA: Salem, VLM: Villipuram.

Sl.No.	Character/District	CBE		DMI		DNL		KR	
		No.	%	No.	%	No.	%	No.	%
1.	Source of information								
	Agri. Dept.	4.0	13.3	7.0	23.3	2.0	6.7	0.0	0.0
	Pesticide Dealer	22.0	73.3	19.0	63.3	26.0	86.7	30.0	100.0
	Neighbour	4.0	13.3	4.0	13.3	2.0	6.7	0.0	0.0
2.	Spraying appliance								
	Hand sprayer	12.0	40.0	5.0	16.7	9.0	30.0	4.0	13.3
	Power sprayer	18.0	60.0	25.0	83.3	21.0	70.0	26.0	86.7
3.	Pesticide mixtures								
	Insecticide +Fungicide	0.0	0.0	17.0	56.7	1.0	3.3	0.0	0.0
	Insecticide+Insecticide	6.0	20.0	7.0	23.3	5.0	16.7	3.0	10.0
	Insecticide only	24.0	80.0	6.0	20.0	24.0	80.0	27.0	90.0
4.	Avg. gap (days)	7.57		12.8		11.75		11.90	
5.	Waiting period	2.82		6.34		3.51		6.47	
6.	Vol. of spray fluid	100.9		165.9		97.5		184.2	
7.	Avg. No. of Applns.	7.2		6.40		6.7		5.57	
8.	Awareness on residues								
	Yes	3.0	10.0	0.0	0.0	0.0	0.0	2.0	6.7
	No	27.0	90.0	30.0	100.0	30.0	10.0	28.0	93.3
9.	Mixing: Stick	30	100	30	100	30	100	30	100
	Bare hand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10.	Safety: Mask	2.0	6.7	1.0	3.3	1.0	0.3	2.0	6.7
	Gloves	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	No	28.0	93.3	29.0	96.7	29.0	9.7	28.0	93.3
11.	Pheromone traps	5	16.7	0	0	0	0	0	0
12.	Light traps	5	16.7	0	0	0	0	0	0
13.	Biopesticides	0	0	0	0	0	0	0	0
14.	Entomophages	0	0	0	0	0	0	0	0

Table 3. Continued.

Sl.No.	Character/District	NML		SA		VLM		Avg.%
		No.	%	No.	%	No.	%	
1.	Source of information							
	Agri. Dept.	2.0	6.7	1.0	3.3	0.0	0.0	7.62
	Pesticide Dealer	25.0	83.3	24.0	80.0	28.0	93.3	82.86
	Neighbour	3.0	10.0	5.0	16.7	2.0	6.7	9.52
2.	Spraying appliance							
	Hand sprayer	15.0	50.0	13.0	43.3	16.0	53.3	35.24
	Power sprayer	15.0	50.0	17.0	56.7	14.0	46.7	64.76
3.	Pesticide mixtures							
	Insecticide +Fungicide	3.0	10.0	1.0	3.3	4.0	13.3	12.38
	Insecticide+Insecticide	2.0	6.7	7.0	23.3	5.0	16.7	16.67
	Insecticide only	25.0	83.3	22.0	73.3	21.0	70.0	70.95
4.	Avg. gap (days)	15.65		13.0		14.1		12.40
5.	Waiting period	6.71		6.22		4.76		5.26
6.	Vol. of spray fluid	175.3		164.0		202.1		155.70
7.	Avg. No. of Applns.	5.38		6.64		5.50		6.20
8.	Awareness on residues							
	Yes	0.0	0.0	0.0	0.0	0.0	0.0	2.38
	No	30.0	100.0	30.0	100.0	30.0	100.0	84.76
9.	Mixing: Stick	30	100	30	100	30	100	100.00
	Bare hand	0.0	0.0	0.0	0.0	0.0	0.0	0.00
10.	Safety: Mask	1.0	3.3	0.0	0.0	0.0	0.0	2.90
	Gloves	0.0	0.0	0.0	0.0	0.0	0.0	0.00
	No	29.0	96.7	30.0	100.0	30.0	100.0	84.24
11.	Pheromone traps	0	0	0	0	0	0	16.70
12.	Light traps	0	0	0	0	0	0	16.70
13.	Biopesticides	0	0	0	0	0	0	0.00
14.	Entomophages	0	0	0	0	0	0	0.00

per crop. The results are in compliance with Anjali *et al*. (2018) who also reported that 65% of the farmers in Nilgiris district followed 5 days interval in Iceberg lettuce, 6 days in Broccoli and Red cabbage. Tyagi *et al*. (2015) who found that not less than 70% of farmers sprayed more than 4 times on cauliflower and tomato grown in India. In Ghana, Ntow *et al*. (2006) observed that farmers had sprayed the pesticides 6 to 12 times with an interval of 7 days in tomato and 12 times with 7 days interval in brinjal. The awareness on the pesticides residues was in order to minimize the application of the insecticides revealed that only 2.38% of the respondents were known about the deleterious effects of the insecticides. The knowledge on preparation of spray fluid observed that none of the respondents mixing spray fluid with bare hand at the time of spraying. These findings are in agreement with Meenambigai *et al*. (2017) who also reported that 100% respondnets were mixing the spray fluid using stick only. Safety measures of the insecticide applicator was found that only 2.90% of the respondents were using masks. The large % of the respondents were not using either gloves or masks or any other safety measure. This might be due to lack awareness on deleterious and chronic effects of insecticides on their health. These findings are in contrast with Boateng and Amuzu (2013) and Singh *et al*. (2016) reported that 39.33% of farmers used mask or hand gloves while spraying in Himachal Pradesh. Knowledge levels on the ecofriendly approaches revealed that none of the respondents using pheromone traps, light traps, yellow sticky/blue sticky traps, biopesticides and entomophages (Parasitoids and predators), but few respondents (16.67%) from Coimbatore district adopting ecofriendly measures (Table 3).These results are inline with the Anjali *et al*. (2018) who also reported that none of the farmer using biopesticides and insect traps in exotic vegetables in Nilgiris district.

The insecticide usage profile of the vegetable growing farmers depicts that use of chlorantraniliprole 18.5SC was maximum (75.71%) followed by

Table 4. Range of insecticides usage by the vegetable growing farmers. ET: Extremely Toxic; HT: Highly Toxic; MT: Moderately Toxic; LT: Less Toxic; OP: Organophosphate; PP: Phenyl pyrazoles; SP: Synthetic pyrethroids; CBE:Coimbatore, DMI:Dharmapuri; DNL:Dindigul; KR:Karur; NKL: Namakkal; SA:Salem; VLM:Villipuram .

S. No	Insecticide	Toxicity class	Category	No. of farmers spraying insecticide							Total	Percent	Molecule
				CBE	DMI	DNL	KR	NKL	SA	VLM			
1	Dimethoate 30EC	HT	OP	25.0	23.0	22.0	15.0	10.0	14.0	18.0	127	60.48	
2	Oxydemeton methyl 25EC	HT	OP	10.0	5.0	5.0	3.0	2.0	1.0	0.0	26	12.38	
3	Profenophos 50EC	HT	OP	3.0	2.0	4.0	5.0	6.0	5.0	3.0	28	13.33	Older
4	Quinalphos 25EC	HT	OP	30.0	5.0	2.0	6.0	5.0	3.0	4.0	55	26.19	Mole-
5	Monocrotophos 36SL	ET	OP	2.0	2.0	4.0	2.0	0.0	1.0	2.0	13	6.19	cules
6	Acephate 75SP	MT	OP	15.0	10.0	17.0	10.0	12.0	16.0	10.0	90	42.86	(435-4
7	Triazophos 40EC	HT	OP	3.0	5.0	12.0	10.0	6.0	3.0	2.0	41	19.52	1.19
8	Phosphamidon 40SL	ET	OP	3.0	2.0	0.0	0.0	0.0	0.0	0.0	5	2.38	%)
9	Cypermethrin 10 EC	HT	SP	4.0	12.0	12.0	10.0	2.0	3.0	7.0	50	23.81	
10	Imidacloprid 17.8SL	HT	Nicot-inoid	25.0	20.0	15.0	17.0	15.0	12.0	17.0	121	57.62	
11	Chlorantranili-prole 18.5EC	LT	Diam-ides	28.0	23.0	28.0	24.0	24.0	18.0	14.0	159	75.71	Novel
12	Indoxacarb 14.5SC	HT	Oxad-iazine	5.0	8.0	7.0	10.0	5.0	6.0	12.0	53	25.24	mole-
13	Fipronil 5 SC	HT	PP	5.0	6.0	2.0	4.0	3.0	7.0	4.0	31	14.76	cules
14	Thiacloprid 21.7 SC	HT	Nicot-inoid	5.0	6.0	2.0	3.0	4.0	6.0	4.0	30	14.29	(611-5
15	Acetamiprid 20 SP	HT	Nicot-inoid	5.0	8.0	9.0	7.0	4.0	5.0	6.0	44	20.95	7.86
16	Diafenthiuron 50 WP	MT	Thio-urea	5.0	3.0	2.0	1.0	1.0	1.0	3.0	16	7.62	%)
17	Thiomethoxam 25 WG	MT	Nicot-inoid	6.0	7.0	6.0	4.0	3.0	7.0	6.0	39	18.57	
18	Flubendiamide 39.35 SC	LT	Diam-ides	20.0	18.0	15.0	16.0	14.0	18.0	17.0	118	56.19	
19	Encounter	Unkn-own	Unk-nown	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5	2.38	Unkn-
20	Bio fit	Unkn-own	Unk-nown	2.0	0.0	0.0	0.0	0.0	0.0	0.0	2	0.95	own
21	Eco mite	Unkn own	Unk-nown	3.0	0.0	0.0	0.0	0.0	0.0	0.0	3	1.43	(10-0. 9%)
	Total respondents	-	-	209.0 19.79	165.0 15.63	164.0 15.53	147.0 13.92	116.0 10.98	126.0 11.93	129.0 12.22	1056		

Dimethoate 30 EC (60.48%); Imidacloprid 17.8SL (57.62%), Acephate 75SP (42.86%) and the least was Bio fit (0.95%) for the management of sucking pests, defoliators and borer complex in the tomato, brinjal and okra ecosystems. Among the respondents, 41.19% were using older molecules and 57.86% were novel insecticides and least was bio product (0.9%) (Table 4). These results are in agreement with Anjali *et al*. (2018) who also reported that 65-75% respondents were using Flubendiamide 39.35% SC, Spinosad 2.5%SC, Chlorantraniliprole 18.5%SC, Imidacloprid 70%WG and Acetamiprid 20%SP for

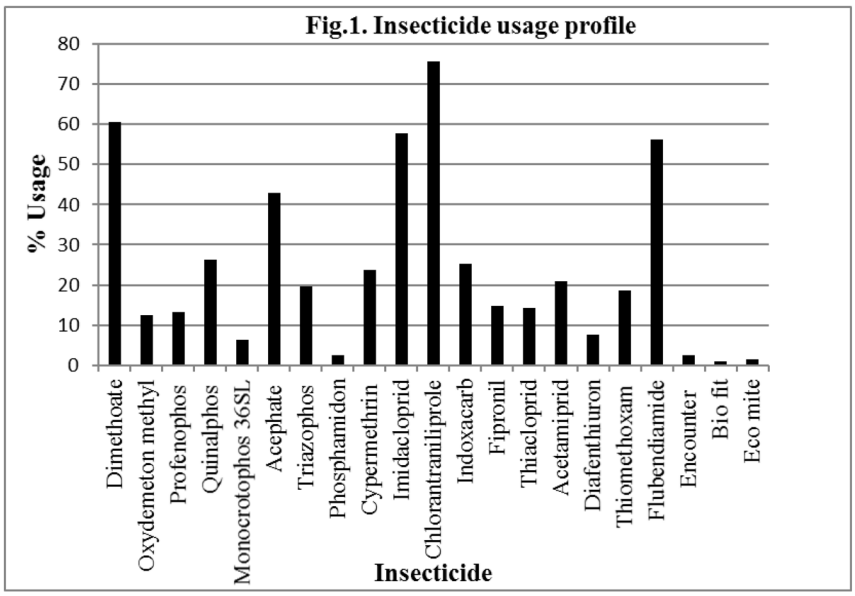

Fig. 1. Insecticide usage profile.

different insect pest management in different exotic vegetables (Table 4 and Fig. 1).

Based on the survey and usage of insecticides in 7 vegetable growing districts of Tamil Nadu, the order of insecticide usage was observed as Coimbatore with 19.79% followed by Dharmapuri (15.63%) and Dindigul (15.53%). These areas may be considered as extensive insecticide usage areas and may be selected for exploration and development of insecticide tolerant strains of entomophages (Table 4 and Fig. 2).

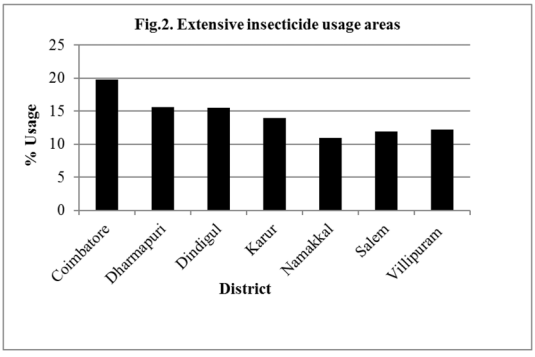

Fig. 2. Extensive insecticide usage areas.

CONCLUSION

The tomato, brinjal and okra were the major vegetable ecosystems cultivated in the study area. The respondents depend on the newer molecules (Imidacloprid 17.8SL Chlorantraniliprole 18.5EC, Indoxacarb 14.5SC, Acetamiprid 20SP, Thiomethoxam 25WG, Flubendiamide 39.35SC) followed by Organophosphorous insecticides (Dimethoate 30EC) majorly under highly toxic category for different insect pest management. Lack of awareness on pesticide residues, safe waiting period, safety measures, label claim was observed. However, a positive sign was none of the respondents were using bare hands for mixing of spray fluid. The farmers are to be educated in terms of safety of insecticide usage and their recommendations. This study provided insecticide usage profile of different districts and also extensive insecticide usage areas, from where, insecticide tolerant strains of entomophages may be explored and developed for ecofriendly insect pest management.

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