



Pattern of Pesticide Usage in Curry Leaf and Farmers Views

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Authors' contributions

This work was carried out in collaboration between all authors. Author GP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SV and CNR managed the analyses of the study. Author SS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Curry leaf [*Murraya koenigii* (L.) Sprengel] exported from India had insecticide residues above maximum residue limits, which are hazardous to consumer health and caused rejection of the commodity at point of entry in Europe and middle east resulting in a check on export of curry leaf. Hence to study current pesticide usage patterns in major curry leaf growing areas, a survey on pesticide use pattern was carried out in curry leaf growing areas in Medak district of Telangana; Anantapur and Guntur districts of Andhra Pradesh during 2014-15, interviewing farmers growing curry leaf utilizing the questionnaire to assess their knowledge and practices on crop cultivation, general awareness on pesticide recommendations and use and to ensure minimal pesticide residue levels in consumer food. Education levels of farmers are less (68.00 per cent were high school educated. 43.29 per cent of farmers had curry leaf area below five acres, while 3.00 per cent of farmers had above thirty acres. Awareness on pesticide related issues was varying among farmers with some commonality, where 35.71 per cent farmers knew about recommended pesticides while

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only 24.29 per cent of farmers were aware of pesticide classification based on toxicity. However, in general, most of the farmers (70 per cent) contacted pesticide dealer for recommendations, where as 30 per cent per cent of the farmers preferred to contact scientists and agricultural officers. Farmers were aware of endosulfan ban (93.86 per cent), but only 38.57 per cent of farmers knew about the ban of monocrotophos on vegetables. Very few farmers knew about pesticide residues and decontamination by washing. Extension educational interventions are necessary to produce fresh curry leaf free from pesticide residues.

Keywords: *Murraya koeinigii*; leaf roller; curry leaf; pests; pesticide; decontamination.

1. INTRODUCTION

Curry leaf [*Murraya koeinigii* (L.) Sprengel] belonging to family Rutaceae, is a native of Sri Lanka. It is also seen in Burma, Huawei, South China and Indo-China and widely distributed in dry regions. In India, it is widely used in Kerala and cultivated in southern states viz. Tamil Nadu, Kerala and Andhra Pradesh. It is a major ingredient in Indian cuisine, due to its aroma which is due to presence of volatile oils. Due to high demand in Ayurveda medicinal use and culinary purpose, the commercial cultivation of curry leaf was started in some parts of south states in India. Exports of curry leaf from India contained insecticide residues above maximum residue limits, hazardous to consumer health and caused rejection of the commodity at point of entry. It is important to study current insecticide usage patterns in major curry leaf growing areas. Farmers feel it necessary to use larger quantities of insecticides causing greater than legal levels of residues on the products [1].

In Andhra Pradesh and Telangana curry leaf cultivation as a commercial crop is mostly confined to areas in Guntur, Krishna, Nellore, Medak and Nizamabad districts. Since it was hitherto grown in back yards, near the farm houses and cattle sheds and also due to the fact that not much damage is caused by pests and diseases the usage of pesticides was almost negligible. However, due to the increased crop area and changing scenario of weather, many pests and diseases are noticed, infesting the crop significantly in both qualitative & quantitative measures. The major insect pests noticed in this crop are citrus butter fly, psyllid scales, mealy bugs and the fungal leaf spots leading to crop losses both in terms of quality and quantity in curry leaf [2,3]. This has resulted in farmers taking up pesticide sprays spoiling the quality of the leaves. With an intention to obtain remunerative price and increased yield, farmers are resorting to excessive use of pesticides in

order to control sucking pests and leaf spot diseases effectively, leading to the Pesticide residue on foliage which is an important export commodity from India, is rich in vitamin A and calcium [4]. The plant has been identified as one of five vegetables with export potential. Fresh leaves are mainly exported to Persian Gulf and European nations. However, exported products can be contaminated with high residual concentrations of the insecticides resulting in rejection of the commodity [5]. Currently there are no insecticide recommendations nor threshold levels for curry leaf. Producers use pesticides that are designed to control the insect even if there are no recommendations for the crop. Pesticides are applied irrespective of the presence of the pest. To promote appropriate use of insecticides, it is critical to understand their current use in major curry leaf growing areas. There have been no published reports regarding insecticide use patterns in curry leaf. Hence survey was done to explore insecticide use patterns among curry leaf farmers [1].

2. MATERIALS AND METHODS

Survey on pesticide usage on Curry leaf pesticide use pattern was carried out in curry leaf growing areas in Medak district of Telangana; Anantapur and Guntur districts of Andhra Pradesh during 2014-15, interviewing curry leaf farmers with the help of a questionnaire to assess their knowledge and practices on crop cultivation, general awareness on pesticide recommendations and use. To ensure minimal pesticide residue levels in consumer food, based on the considerable area under curry leaf cultivation. A Questionnaire was prepared to collect the data scientifically for statistical analysis on various parameters such as type of pesticides used at different crop growth stages, target pests and commonly occurring pests, waiting period followed for harvesting after application of pesticides and other socio economic aspects. Details of locations for field study are presented in Table 1.

Table 1. Details of locations surveyed for curry leaf growing fields in Telangana and Andhra Pradesh

State	District	Mandal	Village	Number of sample farmers
Telangana	Medak	Zaheerabad	Thummukunta	5
		Kohir	Chinthalghat	5
Andhra Pradesh	Guntur	Mangalagiri	Padavatlapi	5
			Nutakki	5
			Revendrapadu	5
			Ippatam	5
			Venigandla	5
	Ananthapur	Bukkaraya Samudram	Bhadrampally	5
			Bukkaraya Samudram	5
			Korrapadu	5
			Pothuraj kaluva	5
		Singanamala	Peravally	5
			Nayanapally	5
			Muchukota	5
			Yerraguntapally	5
		Narpala		
		Peddapappuru		
		Tadipatri		

3. RESULTS AND DISCUSSION

Age and education level of the farmers: About 49.33 per cent of the farmers were in the age group of >50 years followed by 40-50 years (40.00 per cent) and 30-40 years (10.67 per cent). The analysis of education level of respondents showed that 68.00 per cent of respondents had high school education; 20.00 per cent farmers with college education; 10.67 per cent farmers with upper primary education and 1.33 per cent farmers had primary school education.

Type of family: About 69.33 per cent of the farmers belonged to nuclear family and 30.67 per cent of farmers belonged to joint family. Data pertaining to general characteristics of sample farmers is presented in Table 2.

Curry leaf crop area (in acres): Most of the curry leaf farmers (43.29 per cent) cultivated curry leaf in less than five acres and 35.71 per cent farmers cultivated in between five to ten acres. About 15.75 per cent of respondents cultivated curry leaf in crop area of 10 to 20 acres, followed by 2.25 per cent and 3.00 per cent in 20 to 30 acres and more than 30 acres, respectively (Table 3). Maximum acreages under curry leaf cultivation was found in Tadipatri area of Anantapur districts followed by Pedavatlapi area of Guntur district. Very less crop area under curry leaf cultivation was found in Medak district.

Pests observed in curry leaf by farmers were citrus psylla (*Diaphorina citri*), two spotted mites (*Tetranychus spp.*), citrus butterfly (*Papilio*

polytes), mealy bug (*Planococcus citri*), Aphids (*Toxoptera aurantii*), leaf miner and white fly (*Aleurodiscus dispersus*). White fly infestation was the common problem and it had developed resistance to all pesticides, hence farmers were shifting from curry leaf to other crops. Data pertaining to information on occurrence of pests is presented in Table 4. Major insecticides used by the curry leaf farmers were organophosphates (OP), synthetic pyrethroids (SP), organochlorines (OC), neonicotinoids, carbamates and avermectins. The analysis of farm gate samples has revealed contamination mostly with organophosphates and synthetic pyrethroids, which denotes a clear change in the usage pattern from organochlorines to other groups. Among fungicides, carbendazim, chlorothalonil, hexaconazole, tebuconazole, metalaxyl and trifloxystrobin were commonly used by the farmers. In addition to these, herbicides like pendimethalin, alachlor and butachlor were found in farm gate samples.

About 35.71 per cent of respondents were aware of recommended pesticides against different pests, and about 24.29 per cent of respondents were aware of pesticide classification based on toxicity (label colour). It is observed that farmers were not keen about knowing pesticide recommendations and still large per cent of farmers used pesticides without knowing the recommendations. Most of the farmers were unaware of pesticide classification based on toxicity. Both these issues might be attributed to insufficient extension activities and also negligence of farmers (Table 5).

Table 2. General information about the farmer growing curry leaf

Particulars	Frequency	Percentage
Age		
20-30	0	0.00
30-40	08	10.67
40-50	30	40.00
>50	37	49.33
Educational status		
Illiterate	0	0.00
Primary school	01	1.33
Upper primary school	08	10.67
High school	51	68.00
College	15	20.00
Type of family		
Nuclear	52	69.33
Joint	23	30.67

Table 3. General information on curry leaf cultivation

Particulars	Percentage
Crop area (acres)	
< 5	43.29
5-10	35.71
11-20	15.75
21-30	2.25
>30	3.00
Planting	
Seed	90.00
Cuttings	10.00
Variety	
Desi	70.00
Suwasini	15.00
Senkampu	10.00
Bhuvaneshwar	5.00

Note: Figures in percentage are with respect to their respective frequency; (n=75)

Safe methods while storing / mixing / spraying pesticides: About 10.14 per cent of farmers followed safe methods while storing or mixing or spraying pesticides. About 37.15 per cent of farmers measured chemical by bottle cap and 62.85 per cent of farmers measured approximately. About 95 per cent of farmers mixed chemical by using stick and not with bare hands because they were concerned about pesticide ingestion along with the food they eat. Majority of the farmers did not follow safe

methods while storing or mixing or spraying pesticides which might be attributed to non availability of protective coverings and unawareness of pesticide effect on health. Majority of respondents measured chemical approximately as most of them were unaware of recommendations.

Pesticide effect on health of spray men:

Among the respondents, about 85.71 per cent of respondents observed pesticide effect on health of spray men during spray. Most common health problems observed during spray included bad odour (80.33 per cent), skin irritation (40.33 per cent), cough (38.33 per cent), head ache (21.67 per cent), burning sensation (16.00 per cent) and breathlessness (10 per cent). To combat these effects, majority of the farmers used first aid methods like washing the affected area with water (90 per cent), induced vomiting if pesticide is swallowed (88.33 per cent), washing the affected area with soap water (76.67 per cent) and about 10.00 per cent of respondents wore helmet while spraying pesticides to reduce burning sensation on face.

Majority of the farmers experienced bad effects due to pesticide exposure due to improper protective coverings, eating or smoking during pesticide application and not having proper bath after pesticide application. Farmers usually followed simple first aid practices which were helpful to victim until he was taken to hospital.

Awareness on banned insecticides: Farmers had good awareness on the ban of endosulfan in agriculture (93.86 per cent), in contrast, only 38.57 per cent of farmers were aware that monocrotophos is banned for use on vegetables. Majority of the farmers were aware of the ban of endosulfan in agriculture, which might be due to the Kasargod incident which became global.

Contact person for pesticide recommendations:

Farmers preferred to contact pesticide dealers (70 per cent) and fellow farmers (30 per cent) for pesticide recommendations. Majority of the farmers contacted pesticide dealers, as they felt that dealers are having more experience in recommending pesticides and also other farmers of nearby fields. Most often they neglected to contact agricultural officers or scientists because they need to travel some distance to contact them and due to less rapport with these officials when compared to pesticide dealers.

Table 4. Information on occurrence of pests in curry leaf

Common name	Scientific name	Frequency	Percentage
Citrus butterfly	<i>Papilio polytes</i>	31	41.33
Citrus psylla	<i>Diaphorina citri</i>	12	16.00
Mealy bug	<i>Planococcus citri</i>	35	46.67
Aphids	<i>Toxoptera aurantii</i>	40	53.33
Two spotted mites	<i>Tetranychus spp.</i>	42	56.00
Leaf miner	-	25	33.33
White fly	<i>Aleurodiscus dispersus</i>	60	80.00

Note: Figures in percentage are with respect to their respective frequency; (n=75)

Table 5. General awareness of farmers on pesticides and their use

Particulars/ Comments	Frequency		Percentage	
	Yes	No	Yes	No
Are you aware about recommended pesticides against different pests in other crops	27	48	35.71	64.29
Are you aware about the pesticide classification based on toxicity	18	57	24.29	75.71
Do you follow safe methods while storing / mixing / spraying pesticides	08	67	10.14	89.86
Do you observe pesticide effect on health of spray men during spray	64	11	85.71	14.29
Are you aware that endosulfan is banned for use	70	05	93.86	6.14
Are you aware that Monocrotophos is banned for use on vegetables	29	46	38.57	61.43
Do you use pesticide mixtures	51	24	67.67	32.33
Are you aware that for each pesticide, pre-harvest interval is recommended	03	72	4.14	95.86
Are you aware that pesticide residues are found in vegetables	14	61	18.92	81.08
Do you know that pesticide residues in food enter into body and accumulate	07	68	9.33	90.67
Are you aware about pesticide decontamination method	55	20	72.67	27.33
Are you aware that food exports are rejected due to pesticide residues	12	63	15.41	84.59
Do you think the quantity of pesticides used as adequate	19	56	25.37	74.63
Do you think that pesticides are helpful in getting good returns	61	14	81.67	18.33
Do you think high pesticide dose gives higher yields	49	26	65.00	35.00
Do you use empty bottles for house / farm purpose	21	54	28.57	71.43

Note: Figures in percentage are with respect to their respective frequency; n = 75

Table 5 continued....

Particulars / Comments	Frequency	Percentage
Since how long you are growing curry leaf crop		
< 5 years	17	23.33
> 5 years	58	76.67
How do you measure the chemical		
Bottle cap	28	37.15
Approximately	47	62.85
How do you mix the chemical		
Bare hands	04	5.00
Stick	71	95.00
Most common health problem observed during spray		
Skin irritation	30	40.33
Cough	29	38.33
Breathlessness	08	10.00

Particulars / Comments	Frequency	Percentage
Bad odour	60	80.33
Head ache	16	21.67
Burning sensation on body	12	16.00
Best first aid you follow		
Induce vomiting if swallowed	66	88.33
Washing the affected area with water	68	90.00
Washing the affected area with soap water	58	76.67
Whom you contact, for pesticide recommendations		
Agricultural officer	11	15.00
Dealer	53	70.00
Scientist	29	38.33
Fellow farmers	23	30.00

Note: Figures in percentage are with respect to their respective frequency; n = 75

Table 5 continued....

Particulars / Comments	Frequency	Percentage
How frequently you apply the pesticides		
3-4 days	70	94.00
Weekly once	05	6.00
Common waiting period you follow after pesticide spray		
No waiting period (Guntur and Medak districts)	70	93.00
7-10 day (Ananthapur district)	49	66.00
What type of bad effects you heard due to pesticide residues in food		
Cancer	06	7.00
Physical impairments	16	21.00
Not heard any bad effects	53	71.00
Common method of decontamination followed		
Salt water wash	00	0.00
Water wash	19	26.00
Best alternative for pesticide use		
Crop change	00	0.00
Natural control	16	21.00
Integrated pest management	27	36.00
What is the disposal method you follow for empty pesticide bottles		
Bury in soil	00	0.00
Sell	69	92.00
Throw in to trash	06	8.00

Note: Figures in percentage are with respect to their respective frequency; n = 75

Pesticide mixtures and frequency of pesticide application: Majority of respondents (67.67 per cent) used pesticide mixtures rather than applying single pesticide at a time, which was basically to save time, labour, money and to combat two or more pests with a single spray. About 93.77 per cent of farmers applied pesticides at 3-4 days interval during winter season as there is more pest infestation in curry leaf, followed by weekly interval in rainy season. During summer season there was no need of pesticide spray as there was no pest incidence. Need based sprayings were done once in a month during summer season. Most of farmers applied pesticides frequently during winter and rainy seasons, hence often it led to pesticide

resistance as there was no gap to develop the susceptible population of the pest.

Awareness on pesticide residues: Only 18.92 per cent of farmers were aware that pesticide residues are found in curry leaf and only 9.33 per cent knew that pesticide residues in food enter into body and accumulate. About 4.14 per cent of farmers were aware that for each pesticide, pre-harvest interval is recommended. Common waiting period of one week to ten days was followed by most of the farmers (65.89 per cent) in Anantapur district, whereas in case of Guntur and Medak, most farmers (93.33 per cent) send curry leaf to the market immediately after spraying without any waiting period. About 71.33

per cent of farmers responded that they have not heard of any kind of bad effects due to pesticide residues. About 84.59 per cent of farmers were not aware that food exports are rejected due to pesticide residues. The majority of farmers were unaware of pesticides residues, their bad effects, pre harvest intervals and this might be attributed to literacy level of the farmers and insufficient extension activities [1].

Awareness of decontamination methods:

About 72.67 per cent of respondents were aware of decontamination methods. About 25.71 per cent quoted that they washed curry leaf by applying sprinkler irrigation before cutting. Most of the middle men who transported curry leaf from field to market washed curry leaf bundles in trucks with water 3-4 times per day, so that leaf remained fresh without drying. In this process of washing, indirectly surface residues would be reduced to some extent. Majority of farmers were not aware of various decontamination methods, but as a regular kitchen practice, they wash curry leaf with tap water.

Perception of farmers about pesticides and alternative methods of pest control:

Among the sample farmers, 25.37 per cent thought that the quantity of pesticides used at their farm was adequate and about 81.67 per cent of farmers had the perception that pesticides are helpful in getting good returns. Among the sample farmers 35.71 per cent of farmers knew about integrated pest management practices as the alternative to pesticides alone and only 21.43 per cent of farmers felt that natural control was an alternative to pesticides. About 65 per cent of farmers had perception that high pesticide dose would give higher yields. Majority of the farmers thought that pesticides are helpful in getting good returns and very few felt that integrated pest management practices and natural control measures are alternative to pesticides. This might be due to unavailability of natural pest control / management components, slow knock down of pests when compared to chemical pesticides and lower yields in initial years in the case of natural control.

Use of empty pesticide bottles and their disposal:

About 28.57 per cent of farmers used empty pesticide bottles made up of aluminium for house or farm purposes. The majority of the farmers (91.67 per cent) collect empty bottles made up of plastic and when considerable quantity gathered they simply sold them to the plastic buyers. Proper disposal of empty pesticide bottles without using them for house or

farm purpose is essential in order to avoid health hazards due to pesticides.

Very few farmers were using pesticide bottles for house or farm purposes as they were aware of bad effects of pesticides. However, disposal of these empty pesticide bottles was not carried out in a satisfactory way, as the majority of the farmers simply threw bottles in the trash.

Marketing of curry leaf: All the respondents were selling fresh curry leaf to the market, but not dried powder. 97.33 per cent of the farmers sold curry leaf on their farm itself to the middle men, who further transported the curry leaf in trucks (approximately 4 tons per truck) to different cities like Hyderabad, Bombay, Chennai, Bangalore, Cochin, Coimbatore etc., Later some quantity was sent to local vegetable markets and the remaining produce was converted to curry powder and oil for export to other countries like Italy, Qatar, Oman, Bahrain, Lebanon, Norway etc. Only 2.67 per cent of farmers in Medak district sold fresh leaf directly to supermarkets in small packets of 50 g each. About 23.56 per cent of farmers in Guntur district sold curry leaf which was of lower quality in field itself at comparatively low price to the people who prepare curry leaf powder. Fresh leaf was dried in air driers to make powder out of it. But the colour of leaf changes due to drier temperature compared to normal sun drying. Around 2.67 per cent of farmers sold curry leaf to the people who prepare oil from it by steam distillation process. This oil was used in cooking and also has many health benefits.

Types of pesticides used by curry leaf growers:

Major pesticides used by the curry leaf farmers are Imidacloprid 17.8 per cent SL, Bifenthrin 10 per cent EC, Profenophos 72 per cent EC, Acephate 75 per cent WP, Imidacloprid 70 per cent WG, Profenophos 40 per cent EC, Chlorpyrifos 20 per cent, Triazophos 40 per cent, Chlorantraniliprole, Acetamiprid 20 per cent SP, Thiomethaxim 25 per cent WG, Diafenthiuron 50 per cent SC, Carbendazim 50 per cent WP, Monocrotophos 36 per cent SL, Bifenthrin 250 per cent EC, Carbosulfan 25 per cent SD and Spiromesifen 22.9 per cent SC, where 100.00 per cent, 97.67 per cent, 97.67 per cent, 95.34 per cent, 95.34 per cent, 93.02 per cent, 90.69 per cent, 81.39 per cent, 81.39 per cent, 69.76 per cent, 53.48 per cent, 51.16 per cent, 41.18 per cent, 39.53 per cent, 30.23 per cent, 27.90 per cent, and 13.95 per cent farmers used above pesticides, respectively. Nagendra [6] reported that only 5.8 per cent of respondents contacted

agricultural officers for suggestions on pest control, and in present study also only 15 per cent of respondents contacted agricultural officers for suggestions which is in line with the work done by [7]. The highly educated and also progressive farmers in their crop management usually contact specialist instead of local Agricultural Officer for suggestions. In present study growers had awareness of pesticide recommendations which are in conformity with the findings of [6] and [8] who reported 11.67 per cent and 25 per cent of respondents were aware of pesticide recommendations, respectively. In the present study 15 per cent and 38.33 per cent of respondents contacted agricultural officers and scientists for suggestions, respectively while 70 per cent contacted pesticide dealers which are in line with work done of [9] who reported that about 84 per cent of farmers got plant protection advice from pesticide dealers. In the present study 35.71 per cent of growers had awareness of pesticide recommendations which are in conformity with the findings of [6,7,10] who reported that 11.6, 25 and 28.57 per cent of respondents were aware of pesticide recommendations, respectively. Usually, very few farmers had knowledge on pesticide recommendations as per Act and GAPs (Good Agricultural practices) of ICAR and SAUs and are fully dependent on neighboring farmer, local dealer, press or media reports and in most cases pesticide dealers except in case of progressive farmers and also vegetable growers for export purposes, who follow GAPs (Good Agricultural practices) suggested by the Universities to avoid the pesticide residues. The present study revealed that 24.29 per cent growers had awareness of pesticide classification based on toxicity, which indicated that very few farmers look at the label colour on the pesticide bottle. Similar results were reported by [6,10] who reported 27.50 and 14.29 per cent of respondents, respectively had awareness of pesticide classification based on toxicity. Such reports depend on place, crop, purpose of product, use of the product, the size of the pack etc. and it gives a clear message to all those concerned to educate the farmers about the toxicity codes of pesticides and care to be taken while using the same at both farm and home level. In the present study, 95 per cent of farmers mixed pesticide with wooden stick and not with bare hands and these results are in agreement with the findings of [11,10] who reported that 57 and 96.66 per cent of respondents mixed pesticide with wooden stick and not with bare hands. This study gives very pleasing information

that farmers are taking care to avoid the pesticide contamination on to their body parts. It is observed that 91.67 per cent of growers have not used empty pesticide bottles for house/farm purpose, which is in line with the findings of [6,10] reporting 85 per cent, 92.86 per cent and 71.67 per cent of respondents have not used empty pesticide bottles for house or farm purpose, respectively. This is an important piece of information as it indicates that most farmers are aware that empty pesticide bottles are not good for use at both farm or house level, and further it was noticed that very few farmers try to sell the empty bottles to rag buyers, but no farmer was aware of the scientific disposal procedures for used packs or bottles. In these investigations, most farmers reported that they feel that bad odour of pesticides is harming people and noticed common health problems like skin irritation, cough, eye irritation, burning sensation, head ache and breathlessness in the spray men during and after spray operations at farm level and these findings are in agreement with those of [11] who reported 97.43 per cent skin irritation. [6] reported 51.67 per cent of skin irritation followed by eye irritation and head ache at 44.17 and 35.83 per cent, respectively. [8] reported that 70.00 per cent of the respondents experienced bad odour followed by head ache (22.00 per cent) among the farmers who were engaged in spraying of pesticide. [12] reported that 70 per cent of farmers spray pesticides without protection, 68 per cent spill pesticides on their body, hence head ache (43 per cent), watering of eyes (26 per cent) and blurred vision (18 per cent) are the most common poisoning symptoms by the respondents. In these studies, it was observed that about 93.77 per cent of farmers applied pesticides at 3-4 days interval during the winter season as there is more pest infestation in curry leaf, followed by weekly interval in the rainy season.

4. CONCLUSION

From these studies it can be concluded that majority of the farmers applied pesticides at 3-4 days interval irrespective of the pests and were lacking the knowledge on toxicity, formulations and mode of action of pesticides, pesticide residues, alternative methods like IPM, environmental protection and insect resistance etc. There is a need to educate the farmers on various aspects of pest control, safety measures quality aspects and to reduce the pesticide usage for better market. Hence, farmers and pesticide dealers should be educated on risks

and the safe use of pesticides to protect their health and enhance their livelihoods.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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