The Pharma Innovation Journal 2023; SP-12(7): 2675-2680

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(7): 2675-2680
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www.thepharmajournal.com
Received: 02-04-2023
Accepted: 09-06-2023

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Pesticide usage patterns and farmer awareness among Solanaceae crop farmers in Tiruchirappalli

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Abstract
The cultivation of Solanaceae crops, including Brinjal, green chillies, and tomatoes, is prevalent in India. However, the excessive use of pesticides and the lack of farmer awareness about their risks pose significant concerns. This study aimed to investigate pesticide usage patterns, farmer knowledge, and the main insect pests affecting these crops in the Tiruchirappalli district of Tamil Nadu, India. A survey was conducted among 30 farmers, focusing on socio-economic factors, pest incidence, pesticide usage, and awareness. The findings revealed that farmers predominantly relied on synthetic chemical pesticides, with diamide insecticides being the most frequently used. However, farmers demonstrated limited knowledge about recommended pesticides, pesticide toxicity classification, safe handling practices, and the presence of pesticide residues in vegetables. Pest-wise, brinjal was primarily attacked by shoot and fruit borers, brown leaf hoppers, and hadda beetles, while green chillies faced challenges from chilli thrips and mites. Fruit borers, serpentine leaf miners, and striped mealybugs were prominent pests affecting tomato crops. The study emphasizes the need for awareness campaigns and training programs on integrated pest management to reduce pesticide usage and promote safer vegetable production practices. Future research should focus on field trials with less persistent pesticides and closely monitor their effectiveness. By addressing pesticide misuse and increasing farmer knowledge, sustainable and eco-friendly farming practices can be achieved, ensuring the well-being of both the environment and human health.

Keywords: Brinjal, tomato, green chillies, pest pesticides

Introduction
Vegetables belonging to nightshades (Solanaceae) family are widely used by humans as ornamental plants, drugs and mainly for food, highlighting potato, tomato, eggplant, bell pepper, peppers and physalis, among others (Pozzatti *et al*., 2017) [14]. Eggplant (*Solanum melongena* L.) is thought to have originated in tropical India. It is a staple vegetable in many tropical countries (Lawande & Chavan 1998) [10]. In the fiscal year 2021-22, Tamil Nadu, ranking 8th among Indian states, contributed 2.76% to the overall Brinjal production in India, with an annual output of 352,970 tonnes (APEDA). Green chillies (*Capsicum annuum*)are believed to have originated in Central and South America, overall production in India in 2021 to 22 is 1,874.01tonnes (APEDA).The tomato (*Solanum lycopersicum*) initially originated in Peru in South America, and in the span of 2021 to 22 there was a total of 20,300.19 tonnes produced worldwide **(**APEDA).But crop production is controlled by different biotic and abiotic factors; Among them, insects play an important role in reducing crop yields and attack crops all the way from nurseries to harvest (Regupathy *et al*., 1997) [16]. In order to control insect pests, farmers typically rely on synthetic chemical pesticides, which cause target insects to become resistant and has a detrimental effect on natural foes. Due to excess use of pesticide cause Contamination of vegetables with pesticide (Madan *et al*. (1996) [11] and Kumari *et al*. (2003) [11]. The World Health Organisation claims that 20% of the world's pesticides are used in poor nations, endangering both human health and the environment. With this context in the mind, a survey was conducted to ascertain pesticide usage patterns, assess farmers' understanding of pesticide use and its negative impacts, and observe the main insect pests that attack these crops.

Materials and Methods

A. Electing of study area

Thuraiyur, Manachanallur, Marungapuri, Uppiliapuram were the four major vegetable area of Tiruchirappalli Districts based on the report of Department of Horticultural and Plantation crops (Figure 1). In addition, Brinjal, Green chillies and tomato growing villages have been selected as production areas and Table 1 shows the eggplant, pepper and tomato growing regions in Tiruchirappalli, Tamil Nadu, India.

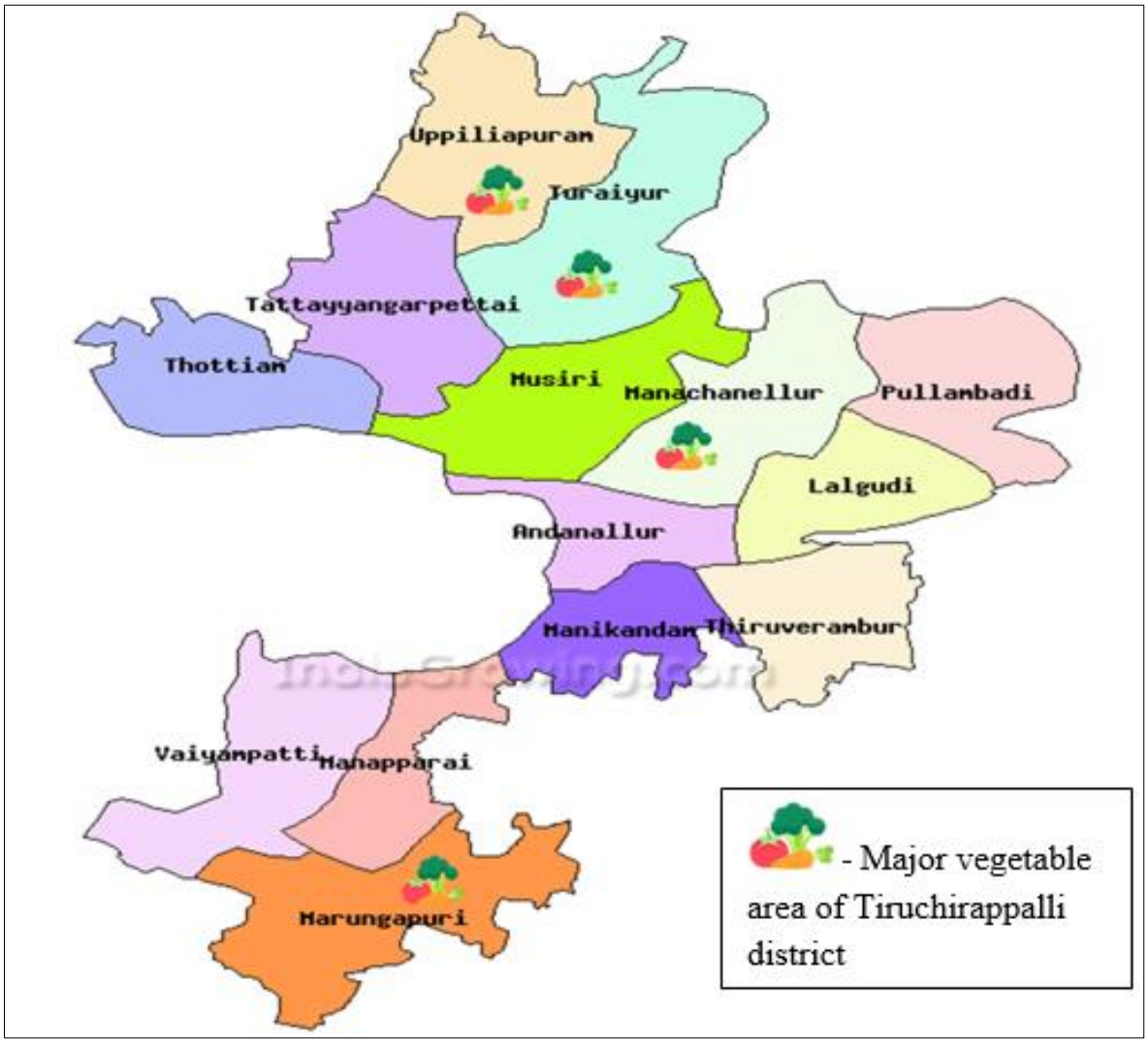

Fig 1: Major vegetable growing area of Tiruchirappalli District

Table 1: Details of Major Vegetables field in Tiruchirappalli

S. No.	Block	Village	No of Farmers
1.	Thuraiyur	Thuraiyur	6Nos
2.	Manachanallur	Ayyampalayam	6 Nos
3.	Manikandam	Navalur kuttapattu	6 Nos
4.	Marungapuri	Yagapuram	6 Nos
5.	Uppliyapuram	Venkatachalapuram	6 Nos
Total			30 Nos

B. Nature and Source of Data

Information on pest status, pesticide use patterns and pesticide use were obtained from six farmers in their villages. A total of 30 farmers who grow Brinjal (12 farmers), Green chillies (10 farmers) and Tomatoes (8 farmers) were surveyed. Due to the nature of my research, a useful questionnaire was prepared and data was collected by interviewing a farmer. The survey consists of three parts.

Section 1: Socio-Economic Status of the farmers i.e.: Farmers name, age, address, educational qualification, and cropping area.

Section 2: Pesticide usage pattern i.e.: About recommended pesticides against different pests, the pesticide classification based on toxicity, contact agriculture officer for suggestions, measurement and mixing of pesticide, type of sprayer used, time of spraying, number of sprays, pre-harvest interval is recommended and high pesticide dose gives higher yields.

Section 3: Awareness about pesticide usage i.e.: safe methods while storing/ mixing/ spraying pesticides, Use the empty bottles for house farm, mix the chemical with bare hand / stick, the common waiting period you follow after pesticide spray and disposal method you follow.

During the study, the farmers were interviewed. Select interested farmers and ask questions, they are given enough time as some farmers are illiterate/less educated.

C. Data analysis

To achieve useful results, research articles are classified according to the information and analysis necessary to examine the factors impacting pesticide use and patterns of use and awareness of pesticide usage.

Result and Discussion

A. Socio economic factors of the farmers

Socio economic status of Brinjal, Green chillies and Tomato farmers, with an emphasis on age, educational status, crop area and other socioeconomic aspects are given in Table 2.

Table 2: Socio economic factor of Brinjal, Green chillies and Tomato farmers

Particulars		Field (n=30)	
Sl. No	**Particulars**	**Frequency**	**Percentage**
1.	**Age(years)**		
	Upto 25 years	3	10.00
	25 to 35	7	23.33
	35 to 45	9	30.00
	Greater than 45 years	11	36.66
2.	**Educational status**		
	Illiterate	3	10.00
	Primary school	10	33.33
	Secondary school(upto 10th)	8	26.66
	Higher Secondary school	5	16.66
	Graduate	4	13.33
3.	**Crop area(acre)**		
	Less than 1 acre	22	73.33
	1 to 2	8	26.66
	More than 2 acres	0	0

From the survey finding, 88 percent of the Brinjal, Green chillies and tomatoes farmers were men, while 12 percent were women. This outcome was consistent with (Berni *et al*., 2021) [3] findings that 90.3% of the 402 farmers polled were men and 9.7% were women. It shows that more of men were interested and practiced in pest management, farming and management than women.

There are four groups of farmers according to their age. The majority of farmers are 36.66 percent are beneath the age of 45. This was followed by those who are 35 to 45, who made up about 30% of the total, those who are 25 to 35, who made up about 23.33 percent, and those who are under 25 years old, who made up about 10%. This research demonstrates that younger age groups are less interested in farming than older generations. Farmers who are primarily engaged in agriculture compelled their kids to pursue other careers.

Education is crucial, because it broadens farmers' horizons and introduces them to a variety of agriculture-related topics and opportunities and new technologies related to agricultural fields. In this present investigation farmers are divided into five categories on the basis of their education status. Out of 30 Farmers, 10 percent of farmers had no education, 33.33 percent of farmers had primary level education, 26.66 percent of farmers had secondary education, 16.66 percent of farmers had higher secondary education and 13.33 percent of farmers had graduation. These findings are consistent with (Nyakundi *et al*., 2012) [13], which found that among 100 farmers, 50% had completed secondary school, fifteen percent had completed college, but 8% had not completed any formal education. Although most of the farmers participating in the study were educated, it was observed that their knowledge about pest control was low. In contrast, the average Indonesian farmer (91.1%) appears to use pesticides partially without compromising their crops, according to the National Integrated Pest Management (IPM) program (Indraningsih *et al*., 2005) [7].

Based on the amount of land that can be used for growing respective vegetables, farmers are divided into three categories. According to the research, approximately 73.33 percent of farmer cultivable land is less than one acre, and approximately 26.66 percent of farmer cultivable land is between one and two acres.

B. Status of Pests

Table 3: Pest incidence in Brinjal in surveyed area as per farmer's perception

Particulars			Field(n=12)	
Sl. No	**Insect pest**	**Scientific name**	**Frequency**	**Percentage**
1.	Brinjal shoot and fruit borer	*Leucinodes orbonalis*	12	100.00
2.	Brinjal stem borer	*Euzophera perticella*	3	25.00
3.	Aphids	*Aphis gossypii*	5	41.66
4.	Brown leaf hopper	*Cestius phycitis*	9	75.00
5.	Ash weevils	*Myllocerus subfasciatus*	4	33.33
6.	Hadda beetle	*Henosepilachna vigintioctopunctata*	7	58.33

Table 4: Pest incidence in Green chillies in surveyed area as per farmer's perception

Particulars			Field(n=10)	
Sl. No	**Insect pest**	**Scientific name**	**Frequency**	**Percentage**
1.	Chilli thrips	*Scirtothrips dorsalis*	8	80.00
2.	Muranai mite	*Polyphagotarsonemus latus*	5	50.00
3.	Tobacco cutworm	*Spodoptera litura*	2	20.00
4.	Green peach aphid	*Myzus persicae*	4	40.00

Table 5: Pest incidence in Tomato in surveyed area as per farmer's perception

Particulars			Field(n=8)	
Sl. No	**Insect pest**	**Scientific name**	**Frequency**	**Percentage**
1.	Fruit Borer	*Helicoverpa armigera*	6	75.00
2.	Serpentine leaf miner	*Liriomyza trifolii*	4	50.00
3.	Striped mealybug	*Ferrisia virgata*	6	75.00
4.	Leaf eating caterpillar	*Spodoptera litura*	3	37.50
5.	Whitefly	*Bemisia tabaci*	2	25.00
6.	Pinworm	*Tuta absoluta*	5	62.50

All of the aforementioned vegetables were subjected to thorough surveys in the corresponding tiruchirappalli blocks. Among these, Brinjal shoot and fruit borer (*Leucinodes orbonalis*), Brown leaf hopper (*Cestius phycitis*), and Hadda beetle (*Henosepilachna vigintioctopunctata*) had 50% of occurrences in brinjal fields (Table 3) and Chilli thrips (*Scirtothrips dorsalis*), Muranai mite (*Polyphagotarsonemus latus*) had 50% of occurrences in Green chillies (Table 4) and Fruit Borer (*Helicoverpa armigera*), Serpentine leaf miner (*Liriomyza trifolii*), Striped mealybug (*Ferrisia virgata*) and Pinworm (*Tuta absoluta*) had 50% of occurrences in Tomato. Differences in pest incidence across the region may be due to varieties and hybrids, planting date, crop stage, geographic location of the study area, and climate change, particularly changes in pest-related temperature and rain (Meenambigai *et al*. 2017) [12]. This is consistent with the reports of Borkakati *et al*. (2019) [4] that a total of six insect species under three order and six families *viz*., aphid, *Aphis gossypii* (Glover); leafhopper, *Amrasca biguttula biguttula* (Ishida); Brinjal Shoot and Fruit Borer (BSFB), *Leucinodes orbonalis*

(Guenee); Epilachna beetle, *Henosepilachna vigintiopunctata* (F.); leaf roller, *Antoba (Eublema) olivaceae* (Walker) and flea beetle, *Monolepta signata* (Olive) were recorded. Most crop losses took place during the reproductive stage (fruiting) of the crop.

B. Status of Pesticides

Table 6: Pesticide usage in Brinjal in surveyed area as per farmer's perception

Particulars				Field(n=12)	
Sl. No	**Insecticide name**	**Trade name**	**Chemical group**	**Frequency**	**Percentage**
1.	Chlorantraniliprole 18.5% SC	Coragen	Diamide	11	91.66
2.	Profenophos 50% EC	Profex	Organophosphate	8	66.66
3.	Lambda cyhalothrin 4.9% CS	Don	Synthetic pyrethroid	8	66.66
4.	Flubendiamide 39.35% SC	Fame, Ju-Fluben	Diamide	9	75.00
5.	Dimethoate 30% EC	Rogor	Organophosphate	7	58.33
6.	Imidacloprid 17.8% SL	Confidor	Neonicotinoid	4	33.33
7.	Emamectin benzoate 5% SG	Proclaim, Amnon	Avermectin	3	25.00
8.	Chlorpyriphos 50% + Cypermethrin 5%	Anaconda	Organophosphate + Synthetic pyrethroid	7	58.33
9.	Indoxacarb 14.5% + Acetamiprid 7.7% SC	Kite	Oxadiazine + Neonicotinoid	3	25.00

Table 7: Pesticide usage in Green chillies in surveyed area as per farmer's perception

Particulars				Field(n=10)	
Sl. No.	**Pesticide name**	**Trade name**	**Chemical group**	**Frequency**	**Percentage**
1.	Imidacloprid 17.8% SL	Confidor, Imidastar	Neonicotinoid	8	80.00
2.	Dimethoate 30% EC	Rogor	Organophosphate	6	60.00
3.	Proporgite 57% EC	Omite	Sulfite ester	4	40.00
4.	Hexythiazox 5.45% EC	Exmite	Not known	7	70.00
5.	Imidacloprid 6% + Lambda cyhalothrin 4% SL	Judo-karate	Neonicotinoid + Synthetic pyrethroid	5	50.00
6.	Fipronil 40% + Imidacloprid 40% WG	Police	Phenylpyrazole + Neonicotinoid	4	40.00

Table 8: Pesticide usage in Tomato in surveyed area as per farmer's perception

Particulars				Field(n=8)	
Sl. No	**Insecticide name**	**Trade name**	**Chemical group**	**Frequency**	**Percentage**
1.	Profenophos 50% EC	Profex	Organophosphate	4	50.00
2.	Flubendiamide 39.35% SC	Fame, Ju-Fluben	Diamide	6	75.00
3.	Emamectin benzoate 5% SG	Proclaim, Amnon	Avermectin	3	37.50
4.	Chlorantraniliprole 18.5% SC	Coragen	Diamide	5	62.50
5.	Cyantraniliprole 10.20% w/w	Benevia	Diamide	4	50.00
6.	Thiamethoxam 25% WG	Actara	Neonicotinoid	6	75.00
7.	Imidacloprid 17.8% SL	Confidor, Imidastar	Neonicotinoid	4	50.00
8.	Profenofos 40% + Cypermethrin 4% EC	Polytrin	Organophosphate + Synthetic pyrethroid	3	37.50

The studies were based on the pesticide use mentioned above in Tiruchirappalli blocks. The total use of insecticides in Brinjal crops is diamide insecticides was chlorantraniliprole 18.5% SC and Flubendiamide 39.35% SC, followed by organ phosphorus insecticides that are profenphos with 50% EC. This was followed by synthetic pyrethroids it was Lambda cyhalothrin 4.9% CS, followed by the Neonicotinoid insecticide where imidacloprid is 17.8% stop loss. The greenhouse plant contains high levels of acephate and residues of its metabolite methamidophos (Sharma *et al.* (2012) [19] (Table 6).

The total use of pesticide in Green chillies is neonicotinoid group of insecticide is Imidacloprid 17.8% SL, followed by Hexythiazox 5.45% EC and it is followed by organophosphate is Dimethoate 30% EC. This was followed by combination of insecticide i.e., Imidacloprid 6% + Lambda cyhalothrin 4% SL and Fipronil 40% + Imidacloprid 40% WG (Table 7). This is consistent with the reports of Sangle *et al.* (2017) [18] that imidacloprid 17.8 SL @ 0.005% (5.12 thrips/3 leaves and 0.96 whiteflies/leaf), acetamiprid 20 SP 0.004% (0.58 whiteflies/leaf) and triazophos 40 EC @ 0.04% (1.09 whiteflies/leaf) found most effective.

The total use of insecticide in Tomato is diamide and nionicotinoid group of insecticide is Flubendiamide 39.35% SC and Thiamethoxam 25% WG respectively, and it was followed by organophosphate is Profenophos 50% EC. Some of the other diamide and nionicotinoid group of insecticide were Chlorantraniliprole 18.5% SC, Cyantraniliprole 10.20% w/w and Imidacloprid 17.8% SL respectively and combined insecticide was Profenofos 40% + Cypermethrin 4% EC(Total 8). This is consistent with the reports of Ghosh *et al.* (2010) that Spinosad was effective against *H. armigera* on tomato at 73 to 84 gm a.i./ha than Quinalphos, Lambda cyhalothrin and Cypermethrin were recorded.

D. Pesticide usage pattern

Table 9: Farmers know about the pesticide use in Tiruchirappalli district of respective blocks

Particulars		Field (n=30)			
Sl.No	Particulars/comments	Frequency		Percentage	
		Yes	No	Yes	No
1.	Are you aware about recommended pesticides against different pests?	18	12	60.00	40.00
2.	Are you aware about the pesticide classification based on toxicity?	9	21	30.00	70.00
3.	Do you follow safe methods while storing/ mixing/ spraying pesticides	14	16	46.66	53.33
4.	Do you observe pesticide effect on health of spray men during spray	5	25	16.66	83.33
5.	Do you contact agriculture officer for suggestions	4	26	13.33	86.66
6.	Do you use pesticide mixtures	11	19	36.66	63.33
7.	Are you aware that for each pesticide, pre-harvest interval is recommended	4	26	13.33	86.66
8.	Are you aware that pesticide residues are found in vegetables	17	13	56.66	43.33
9.	Are you aware about pesticide decontamination method	12	18	40.00	60.00
10.	Do you think high pesticide dose gives higher yields	19	21	63.33	70.00
11.	Do you use the empty bottles for house farm	2	28	6.66	93.33

In the current study, 60 percentages of farmers know the best pesticides to use for various pests, 30 percentages know how to classify pesticides as toxic Similar results were found in Chetna *et al*. (2012) [5] Reported Gender Differences in Literacy and Understanding of Pesticides, Labels, and Shields Chapter Text Letter apparently differs in location, crop, consumption, consumption, package size, etc. it depends., 46.66 percentages take safety precautions when storing pesticides,this is consistent with report of Khan *et al*. (2006) [9] showed that 16% of vegetable and fruit growers wore protective clothing when using pesticides and Rashid *et al*. (2008) [15] reported that 29% of growers covered their face and body during spraying, 17% covered their body and 17% covered their face and 16.66 percentages evaluate pesticide health. 13.33 percentages of farmers call AO for advice on using pesticides, and 36.66 percentage use pesticide mixture. 13.33 percentages of the farmers know the pre-harvest time, 56.66 percentages know the pesticide residue, 40 percentages know the pesticide decontamination methods, 63.33 percentages think there is too much pesticide and the yield is high, and 6.66 percentages of farmers using pesticide bottles on family farm. According to Jana *et al*. (2012) [8], participants did not use pesticide containers for home use (85%) or agricultural use (53%) (Table 9).

Table 10: Pesticide Usage and Practices among vegetable Growers in Tiruchirappalli district of respective blocks

Particulars		Field (n=30)	
Sl. No.	Particulars/comments	Frequency	Percentage
1.	Since how long you are growing crop		
	Less than three years	7	23.33
	More than three years	23	76.66
2.	How do you measure the chemical		
	Bottle cap	11	36.66
	approximately	19	63.33
3.	How do you mix the chemical		
	Bare hands	4	13.33
	stick	26	86.66
	others	0	0
4.	Most common health problem observed during spray		
	Skin Irritation	19	63.33
	Cough	8	26.66
	Breathlessness	1	3.33
	Any other	2	6.66
5.	Whom do you contact for pesticide recommendation		
	AO	4	13.33
	Dealer	23	76.66
	Scientist	3	10.00
6.	How frequently you apply the pesticides		
	2 days	0	0
	4 days	0	0
	week	3	10.00
	10 to 15 days	27	90.00
7.	The common waiting period you follow after pesticide spray		
	2 days	2	6.66
	4 days	12	40.00
	week	16	53.33
8.	what is the disposal method you follow		
	Bury in soil	2	6.66
	Sell	6	20.00
	Throw into trash	22	73.33

In this study, 76.66% of farmers have cultivated for more than three years, 23.33% of farmers have cultivated for less than three years, 63.33% of farmers' fields use bottle cap to measure chemicals and 30% of farmers measure chemicals using the approximately. 13.33% of the farmers mixed the pesticide with their hands and 86.66% with sticks. The most common health problems among farmers are skin irritation (63.33%), cough (26.66%), difficulty in breathing (3.33%) and other causes (6.66%). Anjali Singh and Mandeep Inder Kaur (2012) [1] reported that most of the nebulizers experienced vomiting symptoms such as nausea, eye irritation, painful urination, nail discoloration, nail loss, finger swelling, insomnia, headache, excessive sweating. 13.33% of farmers contact Agricultural Offices for pesticide advice, 76.66% of farmers spray pesticides based on recommendations from dealers, and 3% of farmers contact scientists. 10% of farmers apply pesticides once a week, 90% of farmers apply pesticides every 10 to 15 days, most farmers follow for about a week for waiting period (53.33%), followed by 4 days (40%) and 2 days (6.66%) This is consistent with the findings of Saini *et al*. (2008) reported that participants had little knowledge of "wait time" and participants had little understanding., the majority of farmers (73.33%) throw away pesticides, 20% sell bottles and 6.66% bury them in the ground (Table 10).

Conclusion

Solanaceae crop were most common and frequently used vegetables in India. So we must take concerned about the pesticide use and its residues. Because they are ignorant of the risks pesticides represent to the environment and human health, farmers improperly use pesticides. Therefore, awareness campaigns are necessary to alter farmers' mindsets. Additionally, farmers should receive training on integrated crop and pest management techniques to minimise the use of pesticides and produce vegetables in a safer manner.

Future scope

Considering the significance of pests in Brinjal, Green chillies and Tomatos appropriate, broad-spectrum, and less persistent pesticides should be used in conjunction with closely monitored field trials.

Acknowledgement

I would like to express my gratitude to my chairperson and the members of my advisory committee for providing me with excellent guidance throughout my studies and I would like thank to my seniors and friends for their support.

Conflict of interest

The authors declare that they have no conflict of interest.

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