

**DISSIPATION DYNAMICS OF
CERTAIN INSECTICIDES IN POLY
HOUSE AND OPEN FIELD
SITUATIONS IN TOMATO
(*Lycopersicon esculentum* Mill.)**

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B.Sc. (Ag.)

**MASTER OF SCIENCE IN AGRICULTURE
(ENTOMOLOGY)**



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FIELD SITUATIONS IN TOMATO
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BY

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B.Sc. (Ag.)

**THIS THESIS SUBMITTED TO THE
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CHAIRPERSON: Dr. CHERUKURI SREENIVASA RAO



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CERTIFICATE

Mr. SUDHAKAR. S. KELAGERI has satisfactorily prosecuted the course of research and that thesis entitled “DISSIPATION DYNAMICS OF CERTAIN INSECTICIDES IN POLY HOUSE AND OPEN FIELD SITUATIONS IN TOMATO (*Lycopersicon esculentum* Mill.)” submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any university.

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This is to certify that the thesis entitled “DISSIPATION DYNAMICS OF CERTAIN INSECTICIDES IN POLY HOUSE AND OPEN FIELD SITUATIONS IN TOMATO (*Lycopersicon esculentum* Mill.)” submitted in partial fulfilment of the requirements for the degree of ‘Master of Science in Agriculture’ of the Acharya N.G. Ranga Agricultural University, Hyderabad, is a record of the bonafide research work carried out by Mr. SUDHAKAR. S. KELAGERI under our guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigation have been duly acknowledged by the author of the thesis.

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DECLARATION

I, **SUDHAKAR. S. KELAGERI**, hereby declare that the thesis entitled **“DISSIPATION DYNAMICS OF CERTAIN INSECTICIDES IN POLY HOUSE AND OPEN FIELD SITUATIONS IN TOMATO (*Lycopersicon esculentum* Mill.)”** submitted to the **Acharya N. G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that any material contained in the thesis has not been published earlier in any manner.

Place: Hyderabad

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ABSTRACT

The survey on pesticide use pattern was carried out interviewing farmers growing tomato in open fields and poly houses based on the questionnaire prepared to assess their knowledge and practices on crop cultivation, general awareness on pesticide recommendations and use. Studies were undertaken to establish dissipation dynamics of commonly used insecticides at recommended dose both in open field and poly house situations to assess the differences in rate of dissipation, and also to recommend Pre-Harvest Intervals based on MRLs established by CAC and FSSAI. Insecticides *viz.*, dimethoate 30% EC @ 300 g a.i ha⁻¹, λ-cyhalothrin 5% EC @ 15 g a.i ha⁻¹, phosalone 35% EC @ 450 g a.i ha⁻¹, flubendiamide 20% WG, profenophos 50%EC @ 500 g a.i ha⁻¹ were sprayed and tomato samples collected at regular intervals analyzed for residues. Various decontamination methods were evaluated to assess the efficiency of method for removal of pesticide residues from tomato for food safety.

Education levels of poly house farmers are high compared to open field farmers, where 28.57% poly house farmers are college educated, while 33.33% open field farmers are illiterates. All farmers use nursery of 25 days and grow in <0.5 acre poly house in *summer* and *rabi*, and <1 acre open field during *khariif*. Awareness on pesticide related issues is varying among poly house and open field farmers with some commonality, where 35.71% poly house farmers know about recommended pesticides while only 16.67% open field farmers aware on this issue. However, in general, all farmers contact pesticide dealer for recommendations and some farmers prefer to contact scientists (38-43%). Most farmers are unaware about pesticide classification and toxicity symbols on packing. Farmers are aware about endosulfan ban, but only 28.57%

poly house and 13.33% open field farmers know about ban of monocrotopos on vegetables. Very few farmers know about pesticide residues and related issues, but know washing helps to reduce contamination.

The dissipation pattern of insecticides varies in poly houses and open fields, where initial deposits are comparatively higher and dissipates slow in poly houses, however, all pesticides dissipates BDL in a week time except in case of profenofos. Dimethoate initial deposits (1.76 mg kg^{-1}) are less than FSSAI MRL of 2 mg kg^{-1} , hence a PHI of 1 day can be recommended. As no MRLs are available for lambda-cyhalothrin, PHI of 5 days to be recommended as residues dissipates BDL, though the initial residues are 0.18 mg kg^{-1} and 0.13 mg kg^{-1} in poly house and open fields, respectively, due to very less field dose. In case of phosalone, initial deposits of 4.55 mg kg^{-1} recorded in poly house and hence a safe waiting period of 5 days should be recommended since FSSAI MRL is 1 mg kg^{-1} . Spray of flubendiamide at recommended dose results in 1.23 mg kg^{-1} deposits which dissipated to BDL by 10th day in poly house. However, as the Codex MRL is 2 mg kg^{-1} , a PHI of 1 day is ideal for food safety. As per the Insecticide Act, 1969, profenofos is not recommended for use, but when sprayed at farmer's dose on tomato, 3.25 mg kg^{-1} and 1.51 mg kg^{-1} initial deposits recorded in poly house and open field, respectively. Codex suggests MRL as 10 mg kg^{-1} , hence it can be concluded that profenofos application does not leave residues above MRL. Out of five insecticides tested in poly house, profenofos residues are found in tomatoes up to 15 days, while dimethoate and flubendiamide are detected up to 7 days, and lambda-cyhalothrin and phosalone dissipates faster and reach BDL by 7th day.

Among various decontamination methods tested, veggy wash found to be very effective in removing pesticide residues to an extent of 55-77% varying with type of pesticides, and common method i.e. 2% salt solution wash is also effective method for removing residues in the range of 40-59%.

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LIST OF ABBREVIATIONS

%	:	Per cent
±	:	Plus or minus
µg g ⁻¹	:	Microgram per gram
µl	:	Microlitre
a.i.	:	Active ingredient
AINP	:	All India Network Project
BDL	:	Below Determination Level
CD (P = 0.05%)	:	Critical Difference at 5 per cent level
cm	:	Centimeter
DAS	:	Days After Spraying
EC	:	Emulsifiable Concentrate
<i>et al.</i>	:	and others
FYM	:	Farm Yard Manure
g a.i. ha ⁻¹	:	Gram active ingredient per hectare
g	:	Gram
ha	:	Hectare
GC	:	Gas Chromatography
hrs	:	Hours
<i>i.e.</i>	:	that is
kg ha ⁻¹	:	Kilogram per hectare
kg	:	Kilogram
km hr ⁻¹	:	Kilometre per hour
l	:	Litre
m	:	Metre
m ²	:	Metre square
mg kg ⁻¹	:	Milligram per kilogram
mg	:	Milligram
min	:	Minute
ml ha ⁻¹	:	Millilitre per hectare
ml l ⁻¹	:	Millilitre per litre
ml	:	Millilitre

mm	:	Millimetre
mm/day	:	Millimetre per day
MRL	:	Maximum Residue Limit
ng	:	nano gram
nm	:	nanometre
No.	:	Number
°C	:	Degree Celsius
ppb	:	Parts per billion
ppm	:	Parts per million
q ha ⁻¹	:	Quintals per hectare
RBD	:	Randomized Block Design
RL ₅₀	:	Half life
SC	:	Soluble Concentrate
SEm	:	Standard Error of mean
t	:	Tonne
t ha ⁻¹	:	Tonnes per hectare
T _{tol}	:	waiting or safe period
viz.,	:	namely
WG	:	Wettable Granules

INTRODUCTION

Chapter I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crop of tropical and subtropical regions of the world. It is consumed in raw form as salad, home-cooked, or processed as juice, paste, or sauce (Singh and Dikshit, 2007). The popularity of tomato and its products continue to rise as it contains significant amounts vitamin A and C and it is the richest source of carotene, lycopene one of the powerful natural antioxidants. During 2012-13 in India, tomato was cultivated in an area of 879.6 thousand ha with an average annual production of 18226.6 thousand t and productivity of 20.7 t ha⁻¹, which contributed about 9.6% of total vegetable area and 11.2% of total vegetable production. The major producing states were Andhra Pradesh, Karnataka, Madhya Pradesh, Odisha and Gujarat. Andhra Pradesh ranked first in area (260.91 Thousand ha) and production (5218.10 Thousand t), while Karnataka ranked first in productivity with 33.2 t ha⁻¹ (NHB 2014).

Tomato, like other vegetables, is more prone to insect pests and diseases mainly due to the tenderness and softness as compared to other crops. The tomato yield in India is considerably lower because of several factors of which the damage caused by insect pests is most important. The tomato crop is frequently infested by jassids, aphids, tobacco caterpillar, flea beetles, leaf miner, spider mites, and fruit borer (Singh *et al.*, 1989).

As per insecticides Act of 1968 (www.cibrc.nic.in), 28 insecticide formulations are registered and recommended for use on tomato targeting various pests (Table 1.1). However the pesticide use at farm level by growers varies based on pest status, local recommendations, and in most cases at higher dosage without following the pre harvest intervals (PHI) and also use of non recommended pesticides which is a common phenomenon at farmers level.

The synthetic pesticides are the important tool in integrated pest management, but their indiscriminate use causes severe ecological consequences like destruction of natural enemy fauna, effect on non-target organisms, secondary pest outbreaks. Besides, unguided use of pesticides leads to pesticide residues in food and also contaminates the environment which may lead to deleterious impacts not only on human health but also on other biota (Sreelatha and Diwakar, 1997). Studies from Anupgarh, Rajasthan, where

intensive agriculture was taken up and farmers used high amounts of pesticides to boost crop productivity, exposure of humans to these hazardous chemicals directly in the fields and indirectly through contaminated diet resulted in the occurrence of organochlorine residues in blood (3.3-6.3 mg l⁻¹) and milk (3.2-4.6 mg l⁻¹) samples of lactating women (Kumar *et al.*, 2005).

According to Pesticide Action Network Asia Pacific, 1999 about 51% of the food material is contaminated with residues in the developing world compared to 21% worldwide, of which 20% were above maximum residue limit (MRL) prescribed by Food and Agricultural Organization (FAO) standards (Anonymous, 1999). The World Health Organization and United Nations Environmental Program (UNEP) estimated that each year 3 million farm workers in the developing world experienced severe pesticide poisoning in which about 18000 were fatal (Miller, 2004). Approximately 2.5 million t of pesticides are consumed annually throughout the world. The UNEP estimated that accidental pesticide poisoning causes 20,000 deaths and 1 million cases of illness per year worldwide (Meena *et al.*, 2008).

Insecticide poisoning in agricultural workers is more pronounced as the safety precautions in handling and spraying remain grossly inadequate (Anonymous, 1999). Study conducted in Hoogly district of West Bengal revealed that main problems faced by the vegetable growers during application of pesticides were bad dour, breathing problem, weakness, vomiting, and headache and after application of pesticides farmers faced problems like burning of skin, drowsiness, headache and vomiting (Jana *et al.*, 2012 b).

In India, about 13-14% of the total pesticides used in agriculture are used for fruits and vegetables covering only 3% of the cropped area (Arora and Singh, 2004). Repeated application of pesticides on vegetables often results in the buildup of their residues (Handa, 1992). Surveys carried out in the country indicated that 50-70% of vegetables are contaminated with insecticide residues (Karanth, 2000).

Studies on farm gate monitoring of vegetables carried out in different parts of India (Madan *et al.*, 1996; Chahal *et al.*, 1997; Parihar *et al.*, 1997; Gupta *et al.*, 1998; Singh *et al.*, 1999) revealed contamination mostly with organophosphorous and synthetic pyrethroids insecticides, indicating clearly the changes in the usage pattern from organochlorine to other groups of pesticides.

Maximum Residue Limits (MRLs) are set by Codex Alimentarius Commission (CAC) at international level and by Food Safety and Standards Authority of India (FSSAI) of Ministry of Health and Family Welfare, Government of India, as per Food Safety and Standards Act, 2006 (Food Safety and Standards Regulation, 2011) at national level based on the Good Agricultural Practices. The data presented in table 1.2 indicates that CAC fixed MRLs for most of the pesticides on tomato, while Food Safety and Standards Authority of India set MRLs for only few (Table 1.3) and out of 28 insecticides recommended for use (Table 1.1), MRLs are set for 9 pesticides only (Table 1.3). In this context, food trade is affected due to unavailability of MRLs for commonly used pesticides and also recommended pesticides as per the insecticides Act of 1968.

With changing food habits tomato being consumed as salad hence food safety issues are gaining importance. Further, with the intensive use of pesticides in poly house crops, residues may be accumulated at levels higher than those permitted by the EU or international maximum residue levels. International buyers are more quality conscious and are reluctant to buy produce with quality constraints. The major hurdles in Asian exports are aflatoxin and pesticide residues. The risk of pesticide residues in foods need to be addressed as per FSSAI (Food Safety and Standards Authority of India) and hence for the protection of consumer health and interests, household risk mitigation methods for removal of pesticide residues in tomato are to be recommended based on the scientific evaluation, as the food habits are changing enormously.

As per Central Insecticides Board and Registration Committee (CIBRC), dimethoate, lambda cyhalothrin, phosalone and flubendiamide are recommended for use on tomato but no MRLs are set, and from survey data it is evident that profenophos is most commonly used pesticide on tomato, therefore these five pesticides were selected for conducting experiment.

Keeping all these most important issues of concern, the present study is planned with the following objectives.

OBJECTIVES

- 1) Survey on pesticide usage on Tomato grown in poly house and open fields.
- 2) Dissipation dynamics of certain pesticides on Tomato grown in poly house and open field situations.
- 3) Evaluation of decontamination methods for removal of pesticide residues.

Table 1.1. Insecticides Recommended for use on Tomato as per Insecticide Act, 1968 (www.cibrc.nic.in)

S,No	Insecticide	Target pest	Dosage (g a.i. ha ⁻¹)	Formulation (gm/ml)	Dilution in Water (Litre)	Waiting Period (days)
1.	Azadirachtin 5%	Aphids, Whitefly, Fruit borer	-	200	400	5
2.	Bacillus Thuringiensis var. Galleriae	<i>Helicoverpa armigera</i>	-	1-1.5	500	-
3.	Carbofuron 3% CG	Whitefly	1200	40000	-	-
4.	Chlorantraniliprole 18.5% SC	Fruit borer	30	150	500	3
5.	Dazomet Technical (Tomato nursery)	Root knot nematode	30-40	30-40	-	-
6.	Dimethoate 30% EC	Whitefly	300	990	500-1000	-
7.	Fenazaquin 10% EC	Two spotted spider mite	125	1250	500	7
8.	Flubendiamide 20% WG	Fruit borer	48	100	375-500	5
9.	Flubendiamide 39.35% SC	Fruit borer	48	100	375-500	5
10.	Imidacloprid 17.8% SL	Whitefly	30-35	150-175	500	3
11.	Indoxacarb 14.5% SC	Fruit borer	60-75	400-500	300-600	5
12.	Lambda cyhalothrin 4.9% CS	Fruit borer	15	300	500	5
13.	Lambda cyhalothrin 5% EC	Fruit borer	15	300	400-600	4
14.	Malathion 50% EC	Whitefly	750	1500	500-100	-

15.	Methomyl 40% SP	Pod borers	300-450	750-1125	500-1000	5/6
16.	Novaluron 10% EC	Fruit borer	75	750	500-1000	1-3
17.	Ha NPV 0.43% AS	<i>Helicoverpa armigera</i>	-	1500	400-600	-
18.	NPV (Ha) 2% AS	Fruit borer	-	250-500	500	-
19.	Biotech International AS STRAIN NO. BIL/HV-9	<i>Helicoverpa armigera</i>	-	250-500	500	-
20.	Oxydemeton methyl 25% EC	Whitefly	250	100	500-1000	-
21.	Phorate 10% CG	Whitefly	1500	15000	-	-
22.	Phosalone 35% EC	Fruit borer	450	1285	500-1000	-
23.	Quinalphos 20% AF	Fruit borer	250	1000	500-1000	-
24.	Spiromesifen 22.9% SC	Whiteflies & mites	150	625	500	3
25.	Thiomethoxam 25% WG	Whiteflies	50	200	500	5
26.	Trichlorofon 5% Dust	Tobacco caterpillar	750	-	-	-
27.	Trichlorofon 50% EC	Tobacco caterpillar	750	-	-	-
28.	Novaluron 5.25% + Indaxacarb 4.5% SC	Fruit borer, Tobacco caterpillar	43.31+37.13-45.94+39.38	825-875	500	5

Table 1.2. Maximum Residue Limits (MRLs) for Pesticides on Tomato as per Codex Alimentarius Commission (CAC)

(www.codexalimentarius.org)

Pesticide	Mg kg⁻¹	Pesticide	Mg kg⁻¹
Ethoprophos	0.01	Pyrimethanil	0.7
Quintozene	0.02	Trifloxystrobin	0.7
Abamectin	0.02	Azinphos-Methyl	1.0
Pyrethrins	0.05	Tebufenozide.	1.0
Spinetoram	0.06	Buprofezin	1.0
Methidathian	0.1	Methomyl	1.0
Hexythiazox	0.1	Permethrin	1.0
Penconazole	0.2	Fenpropathrin	1.0
Tebuconazole	0.2	Chlorpyrifos-Methyl	1.0
Triadimefon	0.2	Clethodim	1.0
Cyfluthrin/beta cyfluthrin	0.2	Acephate	1.0
Cypermethrins (Including alpha- and zeta-cypermethrin)	0.2	Fenbutatin Oxide	1.0
Benalaxyl	0.2	Fenvalerate	2.0
Spinosad	0.3	Zoxamide	2.0
Dinocap	0.3	Propamocarb	2.0
Bifenthrin	0.3	Propergite	2.0
Myclobutanil	0.3	Dichlofluanide	2.0
Mandipropamide	0.3	Methoxyfenozide	2.0
Deltamethrin	0.3	Fenhexamide	2.0
Pyraclostrobin	0.3	Oxamyl	2.0
Cyprodinil	0.5	Flubendiamide	2.0
Amitraz	0.5	Famoxadone	2.0
Metalaxyl	0.5	Piperonyl Butoxide	2.0
Malathion	0.5	Ethephon	2.0
Difenoconazole	0.5	Dithiocarbamates	2.0
Carbendizim	0.5	Folpet	3.0
Fludioxonil	0.5	Bitertanol	3.0
Spirodiclofen	0.5	Tolyfluanide	3.0
Diazinon	0.5	Carbaryl	5.0
Clofentezine	0.5	Iprodione	5.0
Endosulfan	0.5	Captan	5.0
Thiacloprid	0.5	Chlorothalonil	5.0
Bifenazate	0.5	Profenofos	10.0
Imidacloprid	0.5	Bromide Ion	75.0
Indaxacarb	0.5	Triforine	0.5
Metaflumizone	0.6		

Table 1.3. Maximum Residue Limits (MRLs) for Pesticides on Tomato as per FSSAI (www.fssai.gov.in)

Pesticide	Mg kg ⁻¹	Pesticide	Mg kg ⁻¹
Formothion	1.00	Ethephon	2.00
Fenthion	0.50	Iprodione	5.00
Ferbam / Ziram	3.00	Metiram	5.00
Phorate	0.10	Novaluron	0.01
Captafol	5.00		

Table 1.4. Recommended Doses as per Insecticide Act, 1968 and Maximum Residue Limits (MRLs) for Pesticides on Tomato as per FSSAI and CAC of Test Insecticides under study.

Pesticide	Recommended dose as per insecticide act, 1968 (g a.i. ha ⁻¹)	Target Pest	MRLs (mg kg ⁻¹)		PHI (Days)
			CAC	FSSAI	
Dimethoate 30% EC	300	Thrips	-	2.0*	-
λ- cyhalothrin 5% EC	15	Fruit borer	-	-	4
Phosalone	450	Fruit borer	-	1.0**	-
Flubendiamide 20% WG	48	Fruit borer	2.0	-	5
Profenophos 50% EC	-	-	10.0	-	-

* MRLs for fruits and vegetables

** MRLs for vegetables

**REVIEW
OF
LITERATURE**

Chapter II

REVIEW OF LITERATURE

2.1 Survey on pesticide usage on Tomato grown in poly house and open fields.

2.1.1 Pesticide use pattern

In developed countries like USA, Europe, Japan etc., pesticide use is 20 times more than in India. Per hectare consumption of pesticide in India is 381 g a.i. ha⁻¹ which is lower than the world average of 500 g a.i ha⁻¹. Lower consumption of pesticides in India can be attributed to the fragmented land holdings, dependence on monsoons, inadequate awareness among farmers and low investment capabilities of small and marginal farmers. Only 25-30 % of the total cultivated area in the country is under pesticide cover (IVRI, 2013). Pesticide consumption in India during 2012-13 was 45386 MT and Uttar Pradesh (9035 MT), Andhra Pradesh (6500MT), Maharashtra (6617 MT), Punjab (5725 MT) were the major consumers of pesticides (Ministry of statistics and programme implementation, Govt. of India, 2013). Karnataka, Andhra Pradesh, Maharashtra and Punjab account for 38.14 % of the total amount of pesticides used in the country (Agnihotri, 2000).

Among different classes of pesticides used in India, the share of insecticides (60%) is high followed by fungicides (19%), herbicides (16%), biopesticides (3%) and others (3%). It is estimated that around 13-14 % of total pesticides used in the country are applied on vegetables of which insecticides account for two-thirds of total pesticides used in vegetables. Among different vegetable crops, the maximum pesticide usage is in chilli (5.13 kg a.i ha⁻¹) followed by brinjal (4.60 kg a.i ha⁻¹), cole crops (3.73 kg a.i ha⁻¹) and okra (2-3 kg a.i ha⁻¹). The global agro-chemical consumption on the other hand, is dominated by fruits and vegetables, which account for 25% of the total market (IVRI, 2013).

Fumigants are classified under the deadly poisonous and it acts as a carcinogen and found in use especially in the green house agricultural commodities (Takagi, *et al.*, 1997). The main use of pesticides in India is for cotton crops (45%), followed by paddy and wheat. Pesticide use is high in regions with good irrigation facilities and in areas where commercial crops are grown (Shetty, 2004).

Food and Agriculture Organization recommends that WHO Ia (extremely hazardous) and Ib (Highly hazardous) pesticides should not be used in developing countries. It also suggests that class II (Moderately hazardous) pesticides be avoided. But the practice of spraying these “powerful” pesticides continues. Large chemical industries reinforce the myth by adopting aggressive marketing strategies that more potent pesticides are necessary to prevent crop loss. This scenario has been reported from other countries also (Grace *et al.*, 2007).

Nagendra (2009) revealed that among the various pesticides used by the cabbage growers of Belgaum district of Karnataka, organophosphates, pyrethroids, organochlorines and fungicides were the major groups. Among the organophosphates, monocrotophos was major insecticide used by the farmers. Pyrethroids and organochlorines were also major groups of pesticides used by the farmers.

The study conducted by Jeyanthi and Kombairajum (2005) examined pest management practices in four important vegetable crops, *viz.* chillies, cauliflower, brinjal and bhendi reported that on an average cauliflower and brinjal received 15 applications while chillies and bhendi were given 13 and 12 applications, respectively.

2.1.2 Health hazards of pesticide exposure

Majority of Indian population is engaged in agriculture and are therefore, exposed to the pesticides used in agriculture. Chemical pesticide use is associated with risk and health hazards if not handled properly. Improper handling and unsafe spraying of the agrochemicals cause high risk of health hazards reported in the past studies (Bag, 2000, Gupta, 2004). Organophosphate pesticides are highly toxic to human and livestock compared to other groups of insecticides (Langhm and Edward, 1969). Organochlorines were less toxic in nature but highly persistent in the environment and the effect of these insecticides were observed to be manifested in the long run, through storage in human\animal bodies as bioconcentrations (Arun Kumar, 1995).

Pesticides cause 14 % of all known occupational injuries in agriculture and 10 % of all fatal injuries (Patil *et al.*, 2012).

Work carried out by different researchers regarding health hazards of pesticide exposure based on survey has been presented in Table 2.1.

Table 2.1. Health hazards of pesticide exposure

% of respondents				
Sl.No		Nagendra, 2009	Jana <i>et al.</i> , 2012 b	Patil <i>et al.</i> , 2012
1	Skin irritation	51.67	16.00	97.43
2	Eye irritation	44.17	-	82.05
3	Dizziness	40.83	23.00	52.56
4	Head ache	35.83	22.00	-
5	Breathing problems	31.67	60.00	70.51
6	Sweating and salivation	23.33	-	-
7	Vomiting sensation	13.33	22.00	39.74
8	Blurred vision	11.67	-	-
9	Diarrhea	8.33	-	12.82
10	Heart palpitation	5.00	-	-
11	Bad odour	-	70.00	-
12	Pain in body	-	17.00	-
13	Weakness	-	35.00	-

2.1.3 General awareness of farmers in using pesticides

Considerable numbers of farmers do not follow the specified precautions properly, hence general awareness of farmers towards pesticide usage plays an important role in reducing perceived health hazards of pesticide exposure and extension agencies must carry out more awareness programmes on it (Jana *et al.* 2012 a).

Howitt and Moore (1975) in their study reported that 20% of farm workers could not understand pesticides warning labels.

Arun Kumar (1995) reported that 8% of farmers did not follow the wind direction and 12% of them applied chemicals across the wind direction thus, increasing the risk of inhaling hazardous chemical particles. Only 7.5% of farmers under take chewing tobacco and 3.3% smoking activity while pesticide application.

Work carried out by different researchers regarding general awareness of farmers in using pesticides has been presented in Table 2.2.

Table 2.2. General awareness of farmers in using pesticides

Per cent of respondents							
Sl.No		Nagenthirarajah, 2008	Hosamani, 2009	Nagendra, 2009	Indira Devi, 2010	Jana <i>et al.</i> , 2012 a	Patil and Katti, 2012
1	Contact with agricultural staffs for suggestions of pest control	-	-	5.80	-	0	-
2	Use of pesticides as per the recommendations	-	8.33	11.67	-	25.00	-
3	Application of pesticides after careful reading of label	-	45.00	40.00	33.00	97.00	-
4	Opening pesticide bottles by using knife not with mouth	-	-	-	-	98.00	-
5	Application of pesticides with protective clothing		93.33	23.33		93.00	30.00
6	No taking of food or smoking during application of pesticides	100.00	-	91.00	20.00	100.00	40.00
7	No use empty bottles of pesticides for other purpose	-		85.00	-	53.00	-
8	Taking bath after spray	60.00	98.33	23.30	93.00	-	-
9	Washing of hands with soap after spray	-	93.33	100.00	-		-
10	No application of pesticides against the direction of wind blowing	48.00	95.00	90.83	-	30.00	-
11	No application of pesticides during middle period of the day when very hot and bright sunlight prevailed	-	-	76.67	-	100.00	-
12	Awareness of harmful effects of pesticide residues	-	-	53.33	-	-	-
13	Awareness of labels and colour symbols on PPC containers	-	14.17	27.50	0.5	-	-
14	Mixing of pesticides with wooden stick not with bare hands	-	64.17	40.83	-	-	57.00
15	Following of pre harvest interval for harvesting of fruits/vegetables	-	-	-	-	15.00	-

2.2 Dissipation dynamics of certain pesticides on Tomato grown in green house / poly house and open field situations.

Tomato crop is often sprayed with chemical pesticides like quinalphos, phosalone, fenvalerate, cypermethrin, deltamethrin etc. to offer protection from severe damage caused by the insect pests (Awasthi 1986 and Singh *et al.*, 1980), and assessment of dissipation rate of a pesticide after application is a key process for determining the residual behavior of pesticides in agricultural crops. Brouwer *et al.* (1997) and McCrady and Maggard (1993) observed that dissipation of pesticide deposit was a complex process depending on various environmental factors like temperature, relative humidity and UV irradiation, metabolism and translocation (pesticide penetration and plant growth), application technique and pesticide formulation. Additionally, residue dissipation curves can be used to estimate the time required for decreasing the residues below MRLs (Ambrus and Lantos, 2002; Castillo-Sanchez *et al.*, 2000 and Fenoll *et al.*, 2009).

2.2.1 Dissipation pattern of Dimethoate

Dimethoate is an organophosphorus insecticide with excellent systemic, contact and acaricidal action. It is highly effective against wide range of sucking pests, chewing insects and mites in most of the crops. In tomato dimethoate is used to manage sucking pests like thrips, whiteflies, leafhoppers etc. Dimethoate is an effective insecticide in controlling thrips in vegetable crops like tomato, chilli, watermelon (Patel *et al.*, 2009). Indian MRL values of Dimethoate for fruits and vegetables are 2 ppm and there are no MRLs for tomato as per CAC. So therefore there is a need to study dissipation pattern of Dimethoate on tomato in order to suggest safe waiting periods based on scientific investigation.

An effort is made to present the review of literature pertaining to dissipation pattern of dimethoate in tomato, wherever the literature is inadequate regarding dissipation pattern in tomato, literature pertaining to dissipation of dimethoate on related crops is collected and presented in Table 2.3.

Table 2.3. Dissipation pattern of dimethoate on various crops

Crop	Pesticide / Formulation	Concentration	Deposits (ppm)	BDL (Days)	Safe waiting period (Days)	Half-life values (Days)	Reference
Rice	Dimethoate	0.05%	29.50	-	-	7.16	Rajukkannu <i>et al.</i> , 1983
Pigeon pea	Dimethoate	0.03%	4.33	15	4	1.70	Mishra <i>et al.</i> , 1985
Round guards	Dimethoate	262 g a.i. ha ⁻¹	9.05	10	4.20	1.93	Pareek <i>et al.</i> , 1990
Bottle gourd	Dimethoate 30 EC	360 g a.i. ha ⁻¹	1.20	7	3	-	Gajbhiye <i>et al.</i> , 1994
Ridge gourd	Dimethoate 30 EC	360 g a.i. ha ⁻¹	2.15	7	3	-	
Bitter gourd	Dimethoate 30 EC	360 g a.i. ha ⁻¹	1.15	7	3	-	
Musk melon	Dimethoate 30 EC	360 g a.i. ha ⁻¹	1.10	7	3	-	
Water melon	Dimethoate 30 EC	360 g a.i. ha ⁻¹	0.80	7	3	-	
Okra	Dimethoate 30 EC	0.06%	2.93	-	2.19	3.17	Khan, 1997
Acid lime	Dimethoate 30 EC	0.05%	2.10	60	1.00	5.5	Mohapatra <i>et al.</i> , 2004
		0.10%	3.50	60	3.65	5.5	
Cabbage	Dimethoate 35 EC	1.5 ml.L ⁻¹	2.46	45	-	4.59	Pandey <i>et al.</i> , 2004
		2.5 ml.L ⁻¹	4.89	45	-	4.50	
Chilli	Dimethoate	300 g a.i. ha ⁻¹	0.33	15	1	4.70	Reddy <i>et al.</i> , 2007
Guava	Dimethoate	120 g a.i. ha ⁻¹	2.06	-	3	3.30	Khan <i>et al.</i> , 2009
Tea Leaf	Dimethoate	200 g a.i. ha ⁻¹	9.07	10	-	-	Jaggi <i>et al.</i> , 2011
		400 g a.i. ha ⁻¹	18.31	10	-	-	

2.2.2 Dissipation pattern of Lambda-Cyhalothrin

Lambda-Cyhalothrin is pyrethroid insecticide and has very high activity against a wide range of chewing and sucking insect insect pests, particularly Lepidoptera, coleopteran and mites in fruits, vegetables, cereals, maize, cotton, wheat, pulses, oilseeds and in public health as a vector control agent (Davey *et al.*, 1992; Roberts *et al.*, 1993; Dikshit *et al.*, 2000; Mathirajan *et al.*, 2000).

In India lambda cyhalothrine is registered for use in plant protection practices but public health considerations have to be taken into account for the residue levels not higher than the maximum permissible intake in order to ensure safety. From the environmental and food safety view point, the persistence of lambda cyhalothrin in animals, soil, water and plants has been studied (Hill and Inaba, 1991; Dikshit *et al.*.,2000; 2001).

Since it is used at various stages from flowering to fruiting stages for the control of insect pests, the chemical may reside and remain in the edible parts till maturity and ripening stages of tomato (Jayakrishnan *et al.*, 2005).

There are no CAC or Indian MRL values available for lambda-cyhalothrin on tomato or on vegetables.

An effort is made to present the review of literature pertaining to dissipation pattern of lambda cyhalothrin in tomato, wherever the literature is inadequate regarding dissipation pattern in tomato, literature pertaining to dissipation of lambda cyhalothrin on related crops is collected and presented in Table 2.4.

Table 2.4. Dissipation pattern of lambda cyhalothrin on various crops

Crop	Pesticide/Formulation	Concentration	Deposits (ppm)	BDL (Days)	Safe waiting period (Days)	Half-life values (Days)	Reference
Brinjal	Lambda-cyhalothrin	0.005%	0.130	8	1	-	Natekar <i>et al.</i> , 1988
Okra	Lambda-cyhalothrin 5 EC	20 ppm	2.032	6.80	3.10	0.71	Pawar <i>et al.</i> , 1993
	Lambda-cyhalothrin 5 EC	30 ppm	2.621	6.82	3.04	0.73	
	Lambda-cyhalothrin 5 EC	40 ppm	3.562	6.90	3.20	0.82	
	Lambda-cyhalothrin 5 EC	50 ppm	4.730	6.91	3.40	0.83	
	Lambda-cyhalothrin 5 EC	60 ppm	5.129	6.97	3.30	0.90	
Cauliflower	Lambda –cyhalothrin	15 g a.i. ha ⁻¹	0.81	10	5.0	2.2	Sharma and Awasthi, 2002
		30 g a.i. ha ⁻¹	1.59	15	5.2	2.4	
Chickpea	Lambda-cyhalothrin	25 g a.i. ha ⁻¹	0.33	-	-	4.9	Singh and Singh, 2003
		50 g a.i. ha ⁻¹	0.46	-	-	5.0	
Tomato	Lambda cyhalothrin (karate)	15 g a.i. ha ⁻¹	0.38	7	3	3.6	Jayakrishnan <i>et al.</i> , 2005
		30 g a.i. ha ⁻¹	0.52	10	3	3.7	
Brinjal	Lambda-cyhalothrin 2.5 EC	15 g a.i. ha ⁻¹	0.75	10	3.8	2.02	Ahuja <i>et al.</i> , 2006
	Lambda-cyhalothrin 2.5 EC	30 g a.i. ha ⁻¹	1.27	10	3.9	1.35	
	Lambda-cyhalothrin 5 EC	15 g a.i. ha ⁻¹	0.81	10	4.1	2.07	
	Lambda-cyhalothrin 5 EC	30 g a.i. ha ⁻¹	1.31	10	4.0	1.43	
Chilli	Lambda cyhalothrine	50 g a.i. ha ⁻¹	0.62	15	4.2	6.4	Reddy <i>et al.</i> , 2007
Tomato	Lambda cyhalothrine	30 g a.i. ha ⁻¹	3.04	-	18	-	Elbashir <i>et al.</i> , 2013

2.2.3 Dissipation pattern of Phosalone

Phosalone is an organophosphorus insecticide used in tomato to manage pests namely fruit borer, aphids, mites and thrips. Phosalone @ 0.04% was effective to control fruit borer (*Helicoverpa armigera* Hubner) and *Spodoptera litura* Fab in chilli (Kumar *et al.* 2010).

Phosalone 24%+Cypermethrin 5% (Sherlone) @ 435 and 510 g a.i.ha⁻¹ were found effective in managing fruit borer and leafhoppers in okra (Panda *et al.* 2002).

Indian MRL values of phosalone for vegetables are 1 ppm and there are no MRLs for tomato as per CAC.

An effort is made to present the review of literature pertaining to dissipation pattern of Phosalone in tomato, wherever the literature is inadequate regarding dissipation pattern in tomato, literature pertaining to dissipation of Phosalone on related crops is collected and presented in Table 2.5.

Table 2.5. Dissipation pattern of phosalone on various crops

Crop	Pesticide/Formulation	Concentration	Deposits (ppm)	BDL (Days)	Safe waiting period (Days)	Half-life values(days)	Reference
Tomato	Phosalone	700 g a.i. ha ⁻¹	7.80	7	2.01	1.02	Rajukannu <i>et al.</i> , 1979
Okra	Phosalone 35 EC	0.05%	10.08	15	4.01	1.20	Pokharkar and Dethe, 1980
		0.10%	17.18	15	5.74	1.34	
Brinjal	Phosalone	700 g a.i. ha ⁻¹	4.00	5	1.55	1.56	Rajukannu <i>et al.</i> , 1980
Blackgram	Phosalone (Irrigated)	0.05%	11.84	-	10.96	3.07	Anand and Murthy, 1982
	Phosalone (un irrigated)	0.05%	10.39	-	11.12	3.29	
	Phosalone (Irrigated)	0.10%	20.34	-	15.03	3.44	
	Phosalone (unirrigated)	0.10%	19.79	-	16.34	3.79	
Cauliflower	Phosalone	0.05%	9.85	15	5.91	3.15	Murthy <i>et al.</i> , 1982
		0.10%	17.90	20	8.95	2.83	
Blackgram	Phosalone	1000 g a.i. ha ⁻¹	28.15	22	-	1.80	Rajukkannu <i>et al.</i> , 1982
Rice	Phosalone	0.05%	15.30	-	-	9.75	Rajukannu <i>et al.</i> , 1983
Green gram	Phosalone 35 EC	250 g a.i. ha ⁻¹	12.60	30	25	8.70	Dikshit <i>et al.</i> , 1986
Tomato	Phosalone	0.05%	7.40	10	2.74	1.45	Narasimha rao <i>et al.</i> , 1986
		0.075%	8.44	10	3.30	1.69	
		0.10%	10.62	10	4.35	1.90	
Round gourd	Phosalone	310 g a.i. ha ⁻¹	4.74	7	6.64	2.96	Pareek <i>et al.</i> , 1990

2.2.4 Dissipation pattern of Flubendiamide

Flubendiamide belongs to a new chemical class, the phthalic acid diamides and is widely used against lepidopteran pests on a variety of annual and perennial crops. It provides superior plant protection against a broad range of economically important lepidopterous pests including *Helicoverpa* spp. *Heliothis* spp. *Spodoptera* spp. *Plutella* spp. *Trichoplusia* spp. and *Hyrotis* spp. (Kooner *et al.*, 2010).

Flubendiamide has a favourable ecological, ecotoxicological and environmental profile with low mammalian toxicity and no genotoxic, mutagenic or oncogenic properties (Shane, 2006).

CAC MRLs of flubendiamide for tomato is 2 PPM and in India there are no specified MRLs of flubendiamide for tomato.

An effort is made to present the review of literature pertaining to dissipation pattern of flubendiamide in tomato, wherever the literature is inadequate regarding dissipation pattern in tomato, literature pertaining to dissipation of flubendiamide on related crops is collected and presented in Table 2.6.

Table 2.6. Dissipation pattern of flubendiamide on vegetables

Crop	Pesticide/Formulation	Concentration applied	Deposits (ppm)	BDL (Days)	Safe waiting period (Days)	Half-life values (Days)	Reference
Chilli	Flubendiamide 480 SC	60 g a.i. ha ⁻¹	1.06	7	-	0.96	Sahoo <i>et al.</i> , 2009
		120 g a.i. ha ⁻¹	2.00	10	-	0.91	
Tomato	(Flubendiamide 24%Thiacloprid 24%) 480 SC	48 g a.i. ha ⁻¹	0.08	3	-	0.33	Kooner <i>et al.</i> , 2010
		96 g a.i. ha ⁻¹	0.16	5	-	1.00	
Cabbage	Flubendiamide 480 SC	24 g a.i. ha ⁻¹	0.33	15	10	3.90	Mohapatra <i>et al.</i> , 2010
		48 g a.i. ha ⁻¹	0.49	15	10	4.45	
Brinjal	Flubendiamide 480 SC	90 g a.i. ha ⁻¹	0.17	5	2	2.68	Chawla <i>et al.</i> , 2011
		180 g a.i. ha ⁻¹	0.42	10	2	2.55	
Okra	Flubendiamide 39.35% SC	24 g a.i. ha ⁻¹	0.28	7	5	4.80	Das <i>et al.</i> , 2012
		48 g a.i. ha ⁻¹	0.53	10	5	5.10	
Tomato	Flubendiamide 20 WG	50 g a.i. ha ⁻¹	0.27	7	3.62	1.64	Paramasivam <i>et al.</i> , 2011
		100 g a.i. ha ⁻¹	0.46	7	3.62	1.98	
Brinjal	Flubendiamide 480 SC	90 g a.i. ha ⁻¹	0.33	5	0	0.96	Takkur <i>et al.</i> , 2011
		180 g a.i. ha ⁻¹	0.61	5	0	0.65	
Gherkin	Flubendiamide 480 SC	60 g a.i. ha ⁻¹	1.35	10	5.13	1.65	Jyothsna <i>et al.</i> , 2012
	Flubendiamide 480 SC + Thiacloprid 240 SC	48 + 48 g a.i. ha ⁻¹	0.92 & 0.81	7 & 7	4.13 & 1.15	1.78 & 1.96	
Chilli	Flubendiamide+thiacloprid 480 SC						Parmar <i>et al.</i> , 2012
	Flubendiamide	60 g a.i. ha ⁻¹	0.24	3	-	1.12	
	Flubendiamide	120 g a.i. ha ⁻¹	0.39	5	-	1.76	
	Thiacloprid	60 g a.i. ha ⁻¹	0.15	5	-	2.17	
Cabbage	Flubendiamide 20 WG	12.5 g a.i. ha ⁻¹	0.16	10	1.63	3.6	Paramasivam <i>et al.</i> , 2013
		25 g a.i. ha ⁻¹	0.31	15	1.63	3.4	
Tomato	Flubendiamide 24 %Thiacloprid 24 % (480 SC)	48 g a.i. ha ⁻¹	0.29	5	1	0.72	Sharma <i>et al.</i> , 2013
		96 g a.i. ha ⁻¹	0.64	7	1	1.32	
Gherkin	Flubendiamide 480 SC	60 g a.i. ha ⁻¹	0.79	10	4.86	1.87	Paramasivam <i>et al.</i> , 2014
		120 g a.i. ha ⁻¹	1.52	15	7.51	2.16	

2.2.5 Dissipation pattern of Profenophos

Profenophos is an organophosphorus insecticide, used in tomato crop basically to control fruit borer (*Helicoverpa armigera*). Profenophos @ 1000 g a.i. ha⁻¹ recorded the highest population reduction of tomato fruit borer and was superior to all other treatments (Katroju *et al.*, 2014).

In India Profenophos is also available in combination with synthetic pyrethroid cypermethrin, in a ready pre-mix formulation in 44EC (profenophos 40% +cypermethrin 4%). These insecticides, separately or in combination, have been found effective in controlling insect pests of vegetables (Tripathi *et al.*, 2003; Mishra 2002; Rai and Satpathy 1999).

Good agricultural practices (GAP) demand the use of insecticides keeping in view the safe waiting periods. Studies on dissipation of insecticides are crucial under different agro climatic conditions and for each crop before making recommendations on safe waiting period for specific insecticides and crops as the weather conditions and host plant play an important role in the dissipation of insecticide residues.

CAC MRLs of profenophos for tomato is 10 ppm and there are no specified MRLs are available in India for tomato or vegetables.

An effort is made to present the review of literature pertaining to dissipation pattern of profenophos in tomato, wherever the literature is inadequate regarding dissipation pattern in tomato, literature pertaining to dissipation of profenophos on related crops is collected and presented in Table 2.7.

Table 2.7. Dissipation pattern of Profenophos on various crops

Crop	Pesticide/Formulation	Concentration applied	Deposits (ppm)	BDL (Days)	Safe waiting period (Days)	Half-life values(Days)	Reference
Green pepper	Profenophos	1280 g a.i. ha ⁻¹	10.67	14	10	1.74	Radwan <i>et al.</i> , 2004 a
Hot pepper	Profenophos	1280 g a.i. ha ⁻¹	11.62	-	14	1.84	
Brinjal	Profenophos	1280 g a.i. ha ⁻¹	4.50	14	14	1.96	
Tomato	Profenophos	500 g a.i. ha ⁻¹	1.37	15	3	-	Sahoo <i>et al.</i> , 2004
Tomato	Profenophos	500 g a.i. ha ⁻¹	2.58	-	1	1.026	Ahmed <i>et al.</i> , 2009
Green cardamom	Profenophos 50 EC	0.05%.	2.76	-	11.1	4.0	Renuka <i>et al.</i> , 2006
Cured cardamom	Profenophos 50 EC	0.05%.	2.00	30	7.8	3.7	
Chilli	Profenophos	0.1%	0.36	30	-	41	Reddy <i>et al.</i> , 2007
Tomato fruits	Profenophos 72 EC	540 g a.i. ha ⁻¹	11.55	-	7	2.25	Romeh <i>et al.</i> , (2009)
Tomato leaves	Profenophos 72 EC	540 g a.i. ha ⁻¹	33.95	14	-	1	
Tomato	Roket (Profenophos 40%+Cypermethrin4%)	440 g a.i. ha ⁻¹	2.14-2.24	11	2.75	2.70	Sarangdevot <i>et al.</i> , 2010
		660 g a.i. ha ⁻¹	2.69-2.83	13	2.36	2.16	
Tomato	Rocket 44 EC (profenophos 40% + cypermethrin 5%)						
	Profenophos	400 g a.i. ha ⁻¹	0.33	15	1	2.2	Gupta <i>et al.</i> , 2011
	Profenophos	800 g a.i. ha ⁻¹	0.41	-	1	5.4	
	Cypermethrin	40 g a.i. ha ⁻¹	0.08	10	1	2.0	
	Cypermethrin	80 g a.i. ha ⁻¹	0.09	-	1	3.6	
Pigeonpea pods	Profenophos	1000 g a.i. ha ⁻¹	3.28	11	6.30	2.32	Jain and Gupta, 2012 a
Pigeonpea pods	Profenophos	2000 g a.i. ha ⁻¹	5.01	13	8.48	2.55	
Pigeonpea pods	Roket 44 EC	1500 g a.i. ha ⁻¹	4.83	13	8.67	2.68	
Pigeonpea pods	Roket 44 EC	3000 g a.i. ha ⁻¹	6.64	15	10.01	2.68	
Soyabean pods	Profenophos	1000 g a.i. ha ⁻¹	3.14	11	6.27	2.36	Jain and Gupta, 2012 b
Soyabean pods	Profenophos	2000 g a.i. ha ⁻¹	4.92	13	7.73	2.34	
Tomato	Profenophos	1000 g a.i. ha ⁻¹	1.16	7	1	4.81	Katroju <i>et al.</i> , 2014

2.3 Evaluation of decontamination methods for removal of pesticide residues.

Vegetables constitute an important component of a balanced diet. Being a rich source of vitamins and minerals, they protect us from micronutrient deficiencies and gastrointestinal disturbances. However, along with life-saving nutrients, they have turned into a major source of life-taking poisonous substances called pesticides and their residues into the human body. Indiscriminate use of pesticides particularly at fruiting stage and non adoption of safe waiting period leads to accumulation of pesticide residues in consumable vegetables.

Presence of these persistent chemicals as residue elicits multiple health complexities ranging from mild allergies to deadly diseases. To minimize dietary exposure to pesticides, it is pertinent to explore strategies that effectively help in reducing the residue content at individual level.

Several simple, labor-less and cost effective unit operations like washing with tap water, washing with acidic and alkaline solutions, peeling and cooking singly or in combination can prove an effective means in reducing dietary consumption of pesticide residues even in poor populace. Washing is the most common form of processing which is a preliminary step in both household and commercial preparation. Loosely held residues of several pesticides are removed with reasonable efficiency by varied types of washing processes (Street, 1969).

Removal of pesticides is related to the physiochemical properties of pesticides. In a developing country like India, dissipation techniques at household level can serve as an effective tool in reducing risk related to dietary exposure to residues and henceforth controlling pesticide related adversities. Several studies have examined the effects of washing solutions on removing pesticide residues from various food commodities and an effort is made to present such studies in Table 2.8.

Table 2.8. Per cent removal of pesticides by various decontamination methods.

SI. No	Commodity	Type of treatment	Pesticide	Removal (%)	Reference
1	Orange	Washing with tap water for 2 min	Carbaryl 0.05%	78.91	Sachan <i>et al.</i> , 1982
		Washing with water by rubbing with hands for 1.5 min		78.22	
		Washing with tap water for 2 min	Carbaryl 0.1%	79.83	
		Washing with water by rubbing with hands 1.5 min		73.72	
		Washing with tap water 2 min	Carbaryl 0.2%	83.29	
		Washing with water by rubbing with hands 1.5 min		80.51	
2	Green beans	Washing in cold water for two min	Ethylene thiourea	45.00	Marshall., 1982
3	Cowpea	Washing with water	Metasystox	84.30	Dikshit <i>et al.</i> , 1984
		Washing with 5% NaCl solution		86.40	
		Washing with 1% Acetic acid solution		85.70	
		Washing with water	Carbaryl	87.50	
		Washing with 5% NaCl solution		88.70	
		Washing with 1% Acetic acid solution		88.60	
4	Bitter gourd	Washing with water for 30 s	Endosulphan	59.05	Nath and Agnihothri, 1984
5	Egg plant	Washing in water	Dithen M 45	47.50	Kumar and Agarwal, 1991
6	Rice grains	Washing with water	Chlorpyriphos	60.00	Lee <i>et al.</i> , 1991
7	Rice grains	Washing with water	Permethrin	100.00	Fukuhara <i>et al.</i> , 1994
8	Soya bean	Two aqueous washing	Dichlorovos	80-90	Miyahara and Saito, 1994
			Malathion		
			Chlorpyrophos		
			Captan		
9	Peaches	Washing in water	Iprodione	50.40	Lentza-Rizos, 1995
10	Apple	Washing in water	Phosalone	30-50	Mergnat <i>et al.</i> , 1995

11	Okra	Tap water wash and steam cooking	Monocrotophos	13.57	Srinivas <i>et al.</i> , 1996
		2% salt solution dip, tap water wash and steam cooking		40.71	
		2% tamarind solution dip, tap water wash and steam cooking		41.85	
		Tap water wash and steam cooking	Fenvalerate	80.00	
		2% salt solution dip, tap water wash and steam cooking		80.00	
		2% tamarind solution dip, tap water wash and steam cooking		100.00	
		Tap water wash and steam cooking	Carbaryl	25.00	
		2% salt solution dip, tap water wash and steam cooking		100.00	
2% tamarind solution dip, tap water wash and steam cooking	100.00				
12	Apple	Washing in water	Azinphos-methyl	53.00	Ong <i>et al.</i> , 1996
13	Tomato	Washing in water	HCH	9.62	Abou-Arab, 1999
			Lindane	15.30	
			<i>p,p</i> DDT	9.17	
			Dimethoate	18.80	
			Profenophos	22.17	
			Pirimiphos methyl	16.20	
		Washing with acetic acid solution	HCH	51.30	
			Lindane	47.00	
			<i>p,p</i> DDT	33.70	
			Dimethoate	91.50	
			Profenophos	86.00	
			Pirimiphos methyl	93.70	
		Washing with 10% NaCl solution	HCH	42.90	
			Lindane	46.10	
			<i>p,p</i> DDT	27.20	
			Dimethoate	90.80	
			Profenophos	82.40	
			Pirimiphos methyl	91.40	
14	Cardamom	Washing in water	Mancozeb	62.00	Mathew <i>et al.</i> , 1999

15	Tomato	Washing in water	Ethylene thiourea	70.00	Knio <i>et al.</i> , 2000
16	Tomato	Washing in water	Capatn	60-80	Krol <i>et al.</i> , 2000
17	Chick pea	Washing in water	Deltamethrin	15.69	Lal and Dikshit., 2001
18	Potato	Washing in water	Chlorpropham	33-47	Lentza-Rizos and Balokas, 2001
19	Potato	Washing in tap water	Lindane	12.00	Zohair, 2001
			Aldrin	10.00	
			Heptachlor epoxide	9.80	
			<i>o,p</i> -DDE	2.00	
			<i>p,p</i> -DDE	3.50	
			<i>o,p</i> -DDD	3.90	
			Pirimphos-methyl	12.90	
			Malathion	11.6	
		Profenophos	13.5		
		Acetic acid solution (10%)	Lindane	78.30	
			Aldrin	84.00	
			Heptachlor epoxide	96.60	
			<i>o,p</i> -DDE	86.70	
			<i>p,p</i> -DDE	97.40	
			<i>o,p</i> -DDD	97.40	
			Pirimphos-methyl	100.00	
Malathion	100.00				
Profenophos	100.00				
NaCl solution (10%)	Lindane	42.00			
	Aldrin	76.00			
	Heptachlor epoxide	85.60			
	Pirimphos-methyl	100.00			
20	Okra	Washing in water	Beta cyfluthrin	42.20-35.70	Dikshit <i>et al.</i> , 2002

21	Hot pepper	Tap water wash	Pirimophos-methyl	52.82	Radwan <i>et al.</i> , 2004 b
		Washing with 2% Acetic acid solution		76.61	
		Washing with 1% NaCl solution		37.10	
22	Sweet pepper	Tap water wash		52.63	
		Washing with 2% Acetic acid solution		95.74	
		Washing with 1% NaCl solution		85.64	
23	Eggplant	Tap water wash		58.82	
		Washing with 2% Acetic acid solution		94.58	
		Washing with 1% NaCl solution		92.00	
24	Grape	Dipping in 5% tamarind solution for 10 min, followed by water wash	Acephate	47.60	Reddy and Rao, 2004
		Dipping in 2% salt solution for 10 min, followed by water wash		72.80	
		Dipping in 1% acetic acid solution for 10 min, followed by water wash		68.60	
		Dipping in 5% tamarind solution for 10 min, followed by water wash	Chlorpyriphos	57.90	
		Dipping in 2% salt solution for 10 min, followed by water wash		67.50	
		Dipping in 1% acetic acid solution for 10 min, followed by water wash		51.80	
		Dipping in 5% tamarind solution for 10 min, followed by water wash	Monocrotophos	87.30	
		Dipping in 2% salt solution for 10 min, followed by water wash		89.30	
		Dipping in 1% acetic acid solution for 10 min, followed by water wash		79.80	

Grape	Dipping in 5% tamarind solution for 10 min, followed by water wash	Quinalphos	44.20	Reddy and Rao, 2004
	Dipping in 2% salt solution for 10 min, followed by water wash		51.80	
	Dipping in 1% acetic acid solution for 10 min, followed by water wash		46.60	
	Dipping in 5% tamarind solution for 10 min, followed by water wash	Dichlorovos	93.90	
	Dipping in 2% salt solution for 10 min, followed by water wash		95.60	
	Dipping in 1% acetic acid solution for 10 min, followed by water wash		95.60	
	Dipping in 5% tamarind solution for 10 min, followed by water wash	Carbaryl	100.00	
	Dipping in 2% salt solution for 10 min, followed by water wash		100.00	
	Dipping in 1% acetic acid solution for 10 min, followed by water wash		100.00	
	Dipping in 5% tamarind solution for 10 min, followed by water wash	Isoprocab	73.10	
	Dipping in 2% salt solution for 10 min, followed by water wash		100.00	
	Dipping in 1% acetic acid solution for 10 min, followed by water wash		79.80	
	Dipping in 5% tamarind solution for 10 min, followed by water wash	Bifenthrin	60.00	
	Dipping in 2% salt solution for 10 min, followed by water wash		58.20	
	Dipping in 1% acetic acid solution for 10 min, followed by water wash		70.00	

25	Asparagus	Washing in water	Chlorpyriphos	24.00	Chavari <i>et al.</i> , 2005
			Cypermethrine	32.00	
			Ethylene bisdithiocarbamate	52.00	
26	Tomato	Washing in water	Chlorpyriphos	38.00	
			Ethylene bisdithiocarbamate	43.00	
27	Tomato	Washing in water	Lamda cyhalothrin	29-30	
28	Cucumber	Washing in water for 15 s	Diazinon	22.30	Cengiz <i>et al.</i> , 2006
29	Cabbage	10% NaCl solution for 20 min	Chlorpyrifos	67.20	Zhang <i>et al.</i> , 2006
		10% acetic acid solution for 20 min		79.80	
		Tap water wash 20 min		17.60	
		10% NaCl solution for 20 min	<i>p,p</i> -DDT	65.00	
		10% acetic acid solution for 20 min		65.80	
		Tap water wash 20 min		17.10	
		10% NaCl solution for 20 min	Cypermethrin	73.30	
		10% acetic acid solution for 20 min		74.00	
		Tap water wash 20 min		19.10	
		10% NaCl solution for 20 min	Chlorothalonil	74.10	
		10% acetic acid solution for 20 min		75.00	
		Tap water wash 20 min		15.20	
30	Tomato	Washing in water for 15 s and rubbing under running water	Procymidone	68.00	Cengiz <i>et al.</i> , 2007

31	Chinese kale	Washing in water	Methomyl	37.90	Klinhom, 2008
		0.9% NaCl solution		39.33	
		0.1% NaHCO ₃ solution		43.19	
		0.001% KMnO ₄ solution		47.57	
		0.1% Acetic acid solution		43.40	
		Washing in water	Carbaryl	88.77	
		0.9% NaCl solution		91.18	
		0.1% NaHCO ₃ solution		91.24	
		0.001% KMnO ₄ solution		93.50	
		0.1% Acetic acid solution		90.46	
32	Brinjal	Washing in water for 15 s	OP Compounds	77.00	Kumari, 2008
33	Cauliflower	Washing in water for 15 s		74.00	
34	Okra	Washing in water for 15 s		50.00	
35	Apple	Washing in water for 10- 15 s with hand rubbing	Captan	50.00	Rawn <i>et al.</i> , 2008
36	Tomato	Washing in water for one min	Endosulfan	67.93	Kapoor, 2010
			Carbaryl	65.10	
37	Tomato	Washing with tap water	Chlorpyrifos	46.60	Ling <i>et al.</i> , 2011
38	Cherry tomato	Tap water wash	Myclobutanil	30.04	Sherif <i>et al.</i> , 2010
			Fenhexamid	49.99	
			Boscalid	41.25	
		Acetic acid	Myclobutanil	28.07	
			Fenhexamid	53.44	
			Boscalid	48.93	
39	Pepper	Tap water wash	Myclobutanil	35.75	
			Fenhexamid	53.76	
			Boscalid	65.47	
		Acetic acid	Myclobutanil	29.74	
			Fenhexamid	29.42	
			Boscalid	53.06	

40	Brinjal	Washing in water	Cypermethrin	25.47	Walia <i>et al.</i> , 2010
41	Carrot	Washing in water for 5 min	Boscalid	78.00	Bonnechere <i>et al.</i> , 2012
			Difenconazole	89.00	
			Tebuconazole	68.00	
			Chlorpyrifos	60.00	
			Dimethoate	33.00	
42	Rice grains	Three aqueous washing in 30 min	Acephate	35.30	Kong <i>et al.</i> , 2012
			Methamidophos	45.20	
43	Cucumber	Tap water wash for 10 min	Trichlorfon	36.60	Liang <i>et al.</i> , 2012
			Dimethoate	21.70	
			Dichlorovos	22.60	
			Fenitrothian	22.20	
			Chlorpyrifos	59.20	
		Washing with 2% NaCl solution for 10 min	Trichlorfon	46.30	
			Dimethoate	47.80	
			Dichlorovos	70.20	
			Fenitrothian	28.90	
			Chlorpyrifos	60.50	
		Washing with 2% NaHCO ₃	Trichlorfon	73.20	
			Dimethoate	58.70	
			Dichlorovos	96.40	
			Fenitrothian	51.10	
			Chlorpyrifos	77.80	
44	Rice grains	Washing four times for five min	Malathion	95.00	Nair <i>et al.</i> , 2012
			Methyl parathion		
			Chlorpyrifos		
			Quinalphos		
			Fenvalerate		
			Cypermethrine		

45	Tomato	Tap water wash	Bifenthrin	17-19	Chauhan <i>et al.</i> 2012
46	Tomato	Washing with 0.001% KMnO ₄	Parathion	86.50	Satpathy, 2012
		Washing with 0.1% Acetic acid		88.10	
		Washing with 0.1% NaHCO ₃		73.10	
		Washing with 0.9% NaCl		78.70	
		Washing with water		37.00	
		Washing with 0.001% KMnO ₄	Methyl Parathion	92.60	
		Washing with 0.1% Acetic acid		91.00	
		Washing with 0.1% NaHCO ₃		77.40	
		Washing with 0.9% NaCl		83.80	
		Washing with water		32.00	
		Washing with 0.001% KMnO ₄	Malathion	88.90	
		Washing with 0.1% Acetic acid		79.20	
		Washing with 0.1% NaHCO ₃		86.80	
		Washing with 0.9% NaCl		95.30	
		Washing with water		41.00	
		Washing with 0.001% KMnO ₄	Fenitrothion	81.00	
		Washing with 0.1% Acetic acid		74.00	
		Washing with 0.1% NaHCO ₃		57.00	
		Washing with 0.9% NaCl		55.00	
		Washing with water		34.00	
Washing with 0.001% KMnO ₄	Formothion	90.70			
Washing with 0.1% Acetic acid		89.60			
Washing with 0.1% NaHCO ₃		86.40			
Washing with 0.9% NaCl		90.30			
Washing with water		27.00			
Washing with 0.001% KMnO ₄	Chlorpyriphos	87.60			
Washing with 0.1% Acetic acid		87.70			
Washing with 0.1% NaHCO ₃		87.20			

		Washing with 0.9% NaCl		50.30	
		Washing with water		39.00	
47	Grape Berries	Washing under tap water for 10 minutes	Monocrotophos	23.81	Shashi Bhushan <i>et al.</i> , 2012
		Soaking and washing with water for 10 minutes		25.93	
		Washing with 2% salt water for 10 minutes		30.80	
		Soaking and washing with 10% butter milk		5.50	
		Juice extraction for canning		29.06	
		Washing under tap water for 10 minutes	Phoslone	43.33	
		Soaking and washing with water for 10 minutes		49.75	
		Washing with 2% salt water for 10 minutes		73.33	
		Soaking and washing with 10% butter milk		63.33	
		Juice extraction for canning		16.60	
48	Creeping Beans	Washing with tap water	Monocrotophos	36.61	
		Washing with 10% buttermilk for 10 minutes		36.95	
		Washing and Steam cooking for 10 minutes		46.48	
		Washing with 2% salt water and cooking 15 minutes		47.90	
		Washing with tap water	Malathion	56.63	
		Washing with 10% buttermilk for 10 minutes		68.06	
		Washing and Steam cooking for 10 minutes		79.52	
		Washing with 2% salt water and cooking 15 minutes		68.07	
		Washing with tap water	Dimethoate	14.20	
		Washing with 10% buttermilk for 10 minutes		15.97	
		Washing and Steam cooking for 10 minutes		30.69	
		Washing with 2% salt water and cooking 15 minutes		36.50	
49	Rice	Ordinary cooking	HCH	25.26	
		Washing and hand scrubbing with tap water		6.92	
		Steam cooking in pressure cooker		33.54	
		Washing with 2 % salt soln. and steam cooking		16.03	
		Washing with 2 % salt soln. and ordinary cooking		23.66	

		Ordinary cooking		26.79	Shashi Bhushan <i>et al.</i> , 2012
		Washing and hand scrubbing with tap water		6.84	
		Steam cooking in pressure cooker		16.31	
		Washing with 2 % salt and steam cooking		18.03	
		Washing with 2 % salt soln. and ordinary cooking		22.53	
50	Tomato	Washing with 2% tamarind	Monocrotophos	32.06	
		Washing with 2% salt soln.		22.58	
		Washing with tap water		16.13	
		Washing with 2% tamarind	Carbaryl	37.95	
		Washing with 2% salt soln.		27.39	
		Washing with 2% tamarind soln. for 5 min.	Fenvalerate	46.77	
		Washing with 2% salt soln.		26.63	
		Washing with tap water		23.22	
51	Chilli	Washing with 2 % salt soln.	Acephate	78.95	
		Water dipping		77.36	
		Washing with 2 % salt soln.	Triazophos	32.56	
		Water dipping		16.28	
		Washing with 2 % salt soln.	Cypermethrin	90.56	
		Water dipping		28.37	
52	Okra	Running water	α - HCH	36.00	
		Cooking in open vessel		54.00	
		Running water	α - Endosulfan	57.00	
		Cooking in open vessel		100.00	
		Running water	Chlorpyrifos	60.00	
		Cooking in open vessel		100.00	
		Running water	λ - Cyhalothrin	74.00	
		Cooking in open vessel		100.00	
53	Brinjal	Running water	α - HCH	73.00	
		Cooking in open vessel		100.00	

		Running water	α - Endosulfan	19.00	
		Cooking in open vessel		100	
		Running water	Chlorpyriphos	62.00	
		Cooking in open vessel		100	
		Running water	λ - Cyhalothrin	48.00	
		Cooking in open vessel		100	
54	Tomato	Running water	α - HCH	78.00	
		Cooking in open vessel		96.00	
		Running water	α - Endosulfan	29.00	
		Cooking in open vessel		90.00	
		Running water	Chlorpyriphos	43.00	
		Cooking in open vessel		81.00	
		Running water	λ - Cyhalothrin	31.5	
		Cooking in open vessel		100	
55	Okra	Washing with tap water	Triazophos	39.57	
		Steam cooking		55.31	
		Washing with tap water	Lindane	50.99	
		Steam cooking		49.23	
56	Brinjal	Washing with tap water	Triazophos	64.00	Shashi Bhushan <i>et al.</i> , 2012
		Steam cooking		68.00	
		Washing with tap water	Lindane	41.00	
		Steam cooking		56.00	
		Washing with tap water	Dimethoate	13.00	
		Washing with 2% salt solution		12.00	
		Cooking in pressure cooker		74.00	
		Washing with tap water	Chlorpyriphos	16.00	
		Washing with 2% salt solution		30.00	
		Cooking in pressure cooker		75.00	
		Washing with tap water	Quinalphos	4.00	

		Washing with 2% salt solution		14.00	
		Cooking in pressure cooker		35.00	
		Washing with tap water	Profenophos	18.00	
		Washing with 2% salt solution		32.00	
		Cooking in pressure cooker		39.00	
		Washing with tap water	Endosulfan	14.00	
		Washing with 2% salt solution		29.00	
		Cooking in pressure cooker		38.00	
57	Tomato	Washing with tap water	Dimethoate	17.00	Shashi Bhushan <i>et al.</i> , 2012
		Washing with 2% salt solution		11.00	
		Cooking in pressure cooker		93.00	
		Washing with tap water	Chlorpyriphos	22.00	
		Washing with 2% salt solution		54.00	
		Cooking in pressure cooker		75.00	
		Washing with tap water	Quinalphos	8.00	Shashi Bhushan <i>et al.</i> , 2012
		Washing with 2% salt solution		34.00	
		Cooking in pressure cooker		71.00	
		Washing with tap water	Profenophos	53.00	
		Washing with 2% salt solution		59.00	
		Cooking in pressure cooker		87.00	
58	Okra	Washing with tap water	Endosulfan	9.00	Sheikh <i>et al.</i> , 2012
		Washing with 2% salt solution		29.00	
		Cooking in pressure cooker		31.00	
		Washing in water	Imidacloprid	27.69	
59	Wheat	Washing four times for five min	E. benzoate	24.00	Nair <i>et al.</i> , 2013
			Malathion	95.00	
60	Chinese cabbage	Soda-salt solution	Methyl parathion		Zang <i>et al.</i> , 2013
			Dimethoate	32.50	
			Dicofol	26.90	

61	Brinjal	Washing with 2% salt solution for 10 min	Dimethoate	45.30	Cherukuri <i>et al.</i> , 2014
			Chlorpyrifos	43.00	
			Quinalphos	52.10	
			Profenophos	50.00	
			Phosalone	54.00	
			λ -cyhalothrin	48.00	
			Malathion	76.50	
		Tap water wash for 10 min	Dimethoate	30.70	Cherukuri <i>et al.</i> , 2014
			Chlorpyrifos	35.30	
			Quinalphos	45.60	
			Profenophos	42.00	
			Phosalone	44.10	
			λ -cyhalothrin	40.90	
			Malathion	70.30	
		Washing with lemon water wash for 10 min	Dimethoate	39.00	
			Chlorpyrifos	41.50	
			Quinalphos	49.50	
			Profenophos	47.10	
			Phosalone	49.90	
			λ -cyhalothrin	45.70	
			Malathion	69.90	
		Washing with 2% tamarind solution for 10 min	Dimethoate	26.80	
			Chlorpyrifos	24.10	
			Quinalphos	34.40	
			Profenophos	30.50	
			Phosalone	29.50	
			λ -cyhalothrin	26.30	
			Malathion	65.30	
Washing with 0.1% sodium bi carbonate for 10 min	Dimethoate	25.40			

			Chlorpyriphos	21.50	
			Quinalphos	34.00	
			Profenophos	29.80	
			Phosalone	33.60	
			λ-cyhalothrin	30.40	
			Malathion	61.30	
		Washing with 4% acetic acid solution	Dimethoate	24.40	Cherukuri <i>et al.</i> , 2014
			Chlorpyriphos	14.80	
			Quinalphos	28.10	
			Profenophos	23.10	
			Phosalone	23.40	
			λ-cyhalothrin	12.70	
			Malathion	54.20	
		Bio wash	Dimethoate	36.50	
			Chlorpyriphos	42.70	
			Quinalphos	48.80	
			Profenophos	47.90	
			Phosalone	51.30	
			λ-cyhalothrin	52.50	
			Malathion	72.50	
		Cooking	Dimethoate	64.00	
			Chlorpyriphos	45.90	
			Quinalphos	39.40	
			Profenophos	52.90	
			Phosalone	42.00	
			λ-cyhalothrin	48.70	
			Malathion	81.40	

**MATERIAL
AND
METHODS**

Chapter III

MATERIAL AND METHODS

Open field experiment was conducted with selected insecticides for dissipation and decontamination studies during *kharif* 2013 at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad and Polyhouse experiment was conducted for dissipation studies at farmers field in Huggelli village, Mandal: Zaheerabad, District: Medak. The residue analysis for dissipation and decontamination studies was carried out at All India Network Project on Pesticide Residues, Rajendranagar. The different materials used in conducting the experiment and the various methods employed during the course of investigation are given in detail here under.

3.1 Survey on pesticide usage on Tomato grown in poly house and open fields

Survey on pesticide use pattern was conducted at farmer's fields of 6 villages of Ranga Reddy district for open field survey and 14 villages of 5 districts of Andhra Pradesh for poly house survey. 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. Model questionnaire is presented in Appendix-A.

3.1.1 Selection of villages

Based on considerable area under tomato cultivation, six villages of three mandals of Ranga Reddy districts namely Moinabad, Chevella and Ibrahimpatnam were selected for open field survey. For polyhouse survey, availability of polyhouses and cultivation of tomato under polyhouse played important role in selecting villages, and based on criteria, 14 villages of five districts were selected. Details of locations for open field study is presented in Table 3.1 and for polyhouse study is presented in Table 3.2.

Table 3.1. Details of locations for open field survey conducted in Ranga Reddy district

Sl.No	Mandal	Village	Sample farmers
1	Moinabad	Peddamangalaram	10
		Sriramnagar	10
2	Chevella	Chanvally	10
		Bastepur	10
3	Ibrahimpattanam	Mangalpally	10
		Kongara kalan	10
Total			60

Table 3.2. Details of locations for polyhouse survey

Sl.No	District	Mandal	Village	Sample farmers
1	Ranga Reddy	Ibrahimpattanam	Kongara kalan	1
		Saror nagar	Jalpally	1
2	Medak	Zaheerabad	Huggelli	1
		Zaheerabad	Ranjole	1
3	Warangal	Bhupalpalli	Gorlaveetu	1
		Kompalli	Ghanapur	1
4	Guntur	Nandendla	Nandendla	1
			Narasarao peta	1
			Pamidimara	1
			Thubadu	1
5	Karimnagar	Karimnagar	Thimmapur	2
		Husnabad	Mirjapur	2
Total				14

3.1.2 Nature and source of data

To evaluate the objective of the study, the farmers were interviewed personally using a questionnaire and the information pertaining to type of pesticides used at different crop growth stages, dose of pesticides, target pests and commonly occurring pests, waiting period followed for harvesting after application of pesticides, and other socio economic aspects etc. were elicited.

3.1.3 Analytical Tools and Techniques employed

Simple statistical tools like frequency and percentage are used to analyse the data.

3.2 Dissipation dynamics of selected pesticides on Tomato under two different situations (poly house and open field)

3.2.1 Layout of the open field experiment

The field was ploughed thrice thoroughly with a tractor drawn cultivator and evenly leveled after removing all the stubbles and weeds. Furrows of 20 cm deep, 15 cm broad were formed at a spacing of 1.0 m. Across the furrows, irrigation water drains were formed at a spacing of 3-4 meters and connected with main water channels. The experiment was laid out in a Randomized Block Design (RBD) with six treatments including untreated control replicated four times as depicted in Figure 3.1. with individual plot size of 20 m (5m X 4 m) with bunds all round and irrigation channels in between the replications. After this, the furrows were irrigated, so as to make the field ready for transplanting. A popular tomato hybrid Nirupama (TO-1988) was chosen for the study (Plate 1).

3.2.2 Raising of crop

3.2.2.1 Variety and nursery raising

Tomato seeds were sown on 12th August 2013 in the well prepared raised nursery bed. The nursery bed was regularly irrigated till the time of transplanting .

3.2.2.2 Transplanting and spacing

One month old seedlings were transplanted in the main field after providing good irrigation. An inter row spacing of 60 cm and intra row spacing of 45 cm was adopted, so as to maintain optimum plant population in the field.

3.2.2.3 Fertilization

Recommended fertilizer doses of Nitrogen @ 100 kg ha⁻¹, Phosphorous @ 60 kg ha⁻¹ and Potassium @ 160 kg ha⁻¹ was applied in the form of Urea, Di Ammonium Phosphate (DAP) and Muriate of Potash (MOP), respectively. Nitrogen was given in the form of Urea as basal and pocket application in three equal splits at different growth stages of crop, while Phosphorous and Potash were applied at the time of transplanting as per the Good Agricultural Practices of ANGRAU.

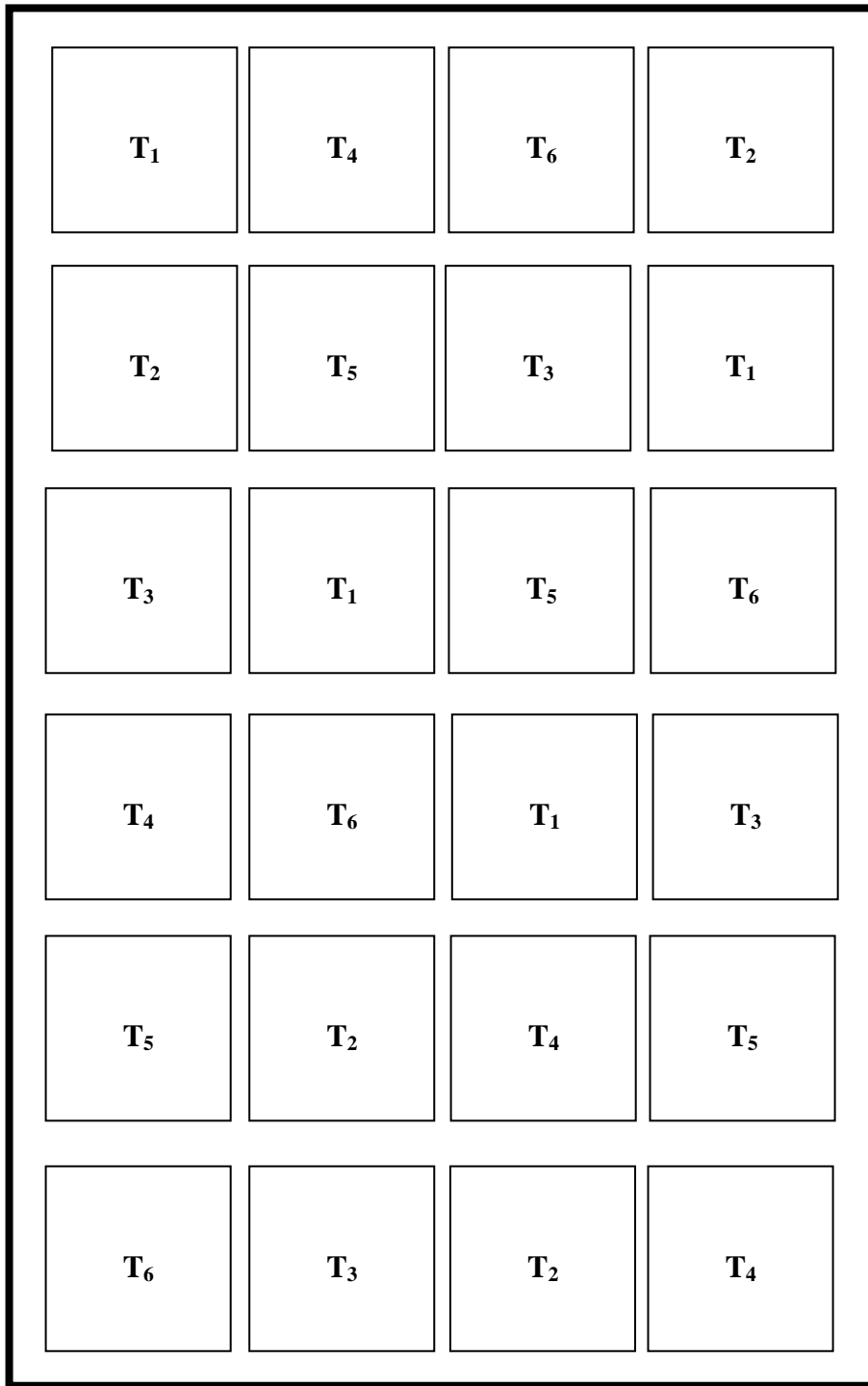


Fig. 3.1. Field Layout of Experiment in Randomised Block Design

Design : RBD
 Field Size : 5 x 4 cm
 Replications : 4
 T₁ : Dimethoate 30% EC @300 g a.i. ha⁻¹
 T₂ : λ-cyhalothrin 5 % EC @15 g a.i. ha⁻¹
 T₃ : Phosalone 35% EC @ 450 g a.i. ha⁻¹
 T₄ : Flubendiamide 20% WG @ 48 g a.i. ha⁻¹
 T₅ : Profenophos 50% EC @500 g a.i. ha⁻¹
 T₆ : Control

3.2.2.4 Irrigation

The experimental plots were adequately irrigated at the time of transplanting followed by irrigation whenever required throughout the crop period.

3.2.2.5 Intercultivation

The crop was kept free from weeds by hand weeding whenever needed and was kept well managed throughout the period of experiment by adopting the recommended package of practices of ANGRAU.

3.2.2.6 Polyhouse experiments

Poly house experiment was conducted at farmers field by utilizing the treatments presented in Table 3.3 and Good Agricultural Practices of ANGRAU were followed in order to ensure the proper crop growth (Plate 2).

3.3 Application of insecticidal treatments

All the selected insecticide treatments and dosages applied as foliar sprays are presented in Table 3.3. The first spray was given after fruit initiation and second spray was given at 10 days after first spray. A total of two sprays were given during the experiment.

3.3.1 Preparation of spray fluid

The measured quantities of test insecticides were mixed with small quantity of water and remaining quantity of water added to it subsequently to make up the spray volume required for the plot. The spray fluid was evenly mixed with a stick before spraying.

3.3.2 Insecticidal application

Test insecticides were applied using a high volume knapsack compression sprayer. Sprayings were undertaken during morning hours and necessary care was taken to prevent the drift of spray fluid reaching the adjacent plots. The sprayer and the container used for preparing spray fluid were thoroughly cleaned with water before changing the insecticide and rinsed with the fluid to be applied next. A total of two sprays were given at 10 days interval during the course of study.

Table 3.3. Details of Insecticides treatments

Treatment	Common Name of Insecticide	Dosage (g a.i ha⁻¹)	Trade Name & Formulation
T ₁	Dimethoate	300	Rogor 30% EC
T ₂	λ-cyhalothrin	15	Karate 5 % EC
T ₃	Phosalone	450	Zolone 35% EC
T ₄	Flubendiamide	48	Takumi 20% WG
T ₅	Profenophos	500	Curacron 50% EC
T ₆	Control		



Plate 1. Open field trial view



Plate 2. Poly house trial view

3.4 Pesticide Residue Analysis Method Validation

3.4.1 Preparation of working standards

Certified Reference Materials (CRMs) of Dimethoate, λ -cyhalothrin, Phosalone, Flubendiamide and Profenophos were purchased from Dr. Erhenstorfer, Germany during 2013. Primary standards, intermediary and working standards were prepared from the CRMs using acetone and hexane as solvents.

Working standards of all the pesticides were prepared in the range of 0.01 ppm to 0.5 ppm in 10 ml calibrated graduated volumetric flask using distilled n-hexane as solvent. All the standards were stored in deep freezer maintained at -20°C (Plate 3).

3.4.2 Limit of Detection and Linearity of dimethoate, λ -cyhalothrin, phosalone and profenophos

The working standards of dimethoate, λ -cyhalothrin, phosalone and profenophos were injected in Gas Chromatograph with Electron Capture Detector (ECD) and Thermionic Specific Detector (TSD) for estimating the lowest quantity of these pesticides which can be detected with injector split ratio of 1:10 under standard operating parameters as given below in Table 3.4.

Standard Chromatograms of each pesticide at different concentration are presented in Appendix-B.

For confirmatory analysis dimethoate, λ -cyhalothrin, phosalone and profenophos were analysed on both ECD and TSD as these pesticides can be detected on both detectors simultaneously using “Universal Y splitter” at the detector end and samples on GC-MS/MS. One micro litre of each working standard was injected for the study. The GC operating parameters for above mentioned pesticides detection and estimation are presented in Table 3.4. and the GC used for the study is shown in Fig 3.2.

Under the GC operational parameters given in Table 3.4. the retention times of dimethoate, λ -cyhalothrin, phosalone and profenophos were 9.95, 11.87, 6.99 and 5.27 min respectively. Each working standards of above mentioned pesticides

(0.01 ppm, 0.025 ppm, 0.05 ppm, 0.075 ppm, 0.10 ppm, 0.25 ppm and 0.50 ppm) were injected 6 times and the linearity lines were drawn.

The laboratory general view and instrumentation is presented in Plate 4.



Plate 3. Certified Reference Materials in Deep Freezer

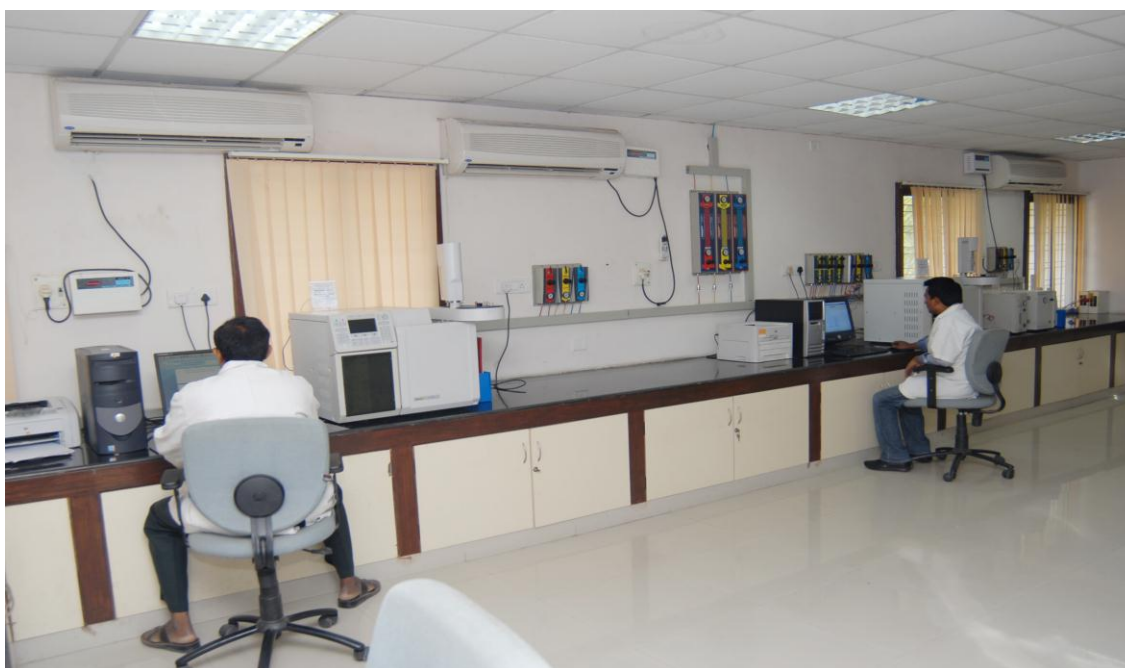


Plate 4. Laboratory view

Table 3.4. Details of GC parameters

Gas Chromatograph	Gas Chromatography- AGILENT- 7890B
Column	VF-5ms Capillary Column 30 m length, 0.25 mm Internal Diameter, 0.25 µm film thickness; 1% methyl siloxane
Column Oven (0C)	Initial 50 ⁰ C for 1 min - increase @ 20 ⁰ C/min upto 325 ⁰ C – hold for 14 min
Detectors	Electron Capture Detector (ECD) Thermionic Specific Detector (TSD)
Detector Temperature (0C)	300
Injector Temperature (0C)	280
Injector Status	Split Ratio: 1:10
Carrier Gas	Nitrogen, Iolar II, Purity 99.999%
Carrier Gas Flow (ml min ⁻¹)	1 ml min ⁻¹
Make-up Flow (ml min ⁻¹)	35 ml min ⁻¹
Retention time (min)	Dimethoate 9.95 min λ-cyhalothrin 11.87 min Phosalone 6.99 min Profenophos 5.27 min
Total run time (min)	28.75 min

3.4.2.1 Dimethoate

Based on the response of the detector (ECD) to different quantities (ng) of CRM standards injected, it was found that the LOD (limit of detection) for dimethoate is 0.01 ng, and the linearity is in the range of 0.01 ng to 0.10 ng as given in Fig 3.3.

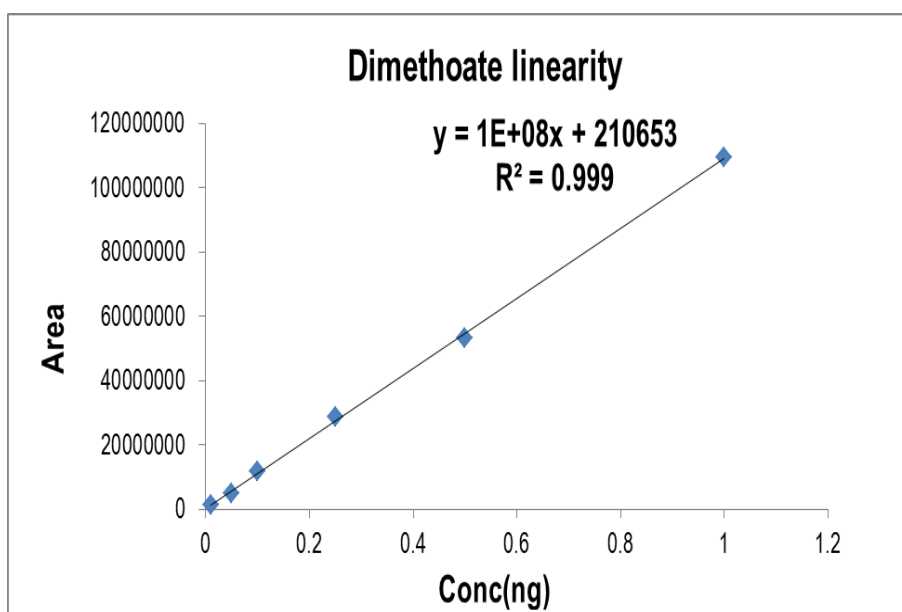


Fig. 3.3. Calibration curve for dimethoate (Concentration Vs Area)

3.4.2.2 Lambda cyhalothrin

Based on the response of the detector (ECD) to different quantities (ng) of CRM standards injected, it was found that the LOD (limit of detection) for lamda cyhalothrin is 0.01 ng, and the linearity is in the range of 0.01 ng to 0.10 ng , as given in Fig 3.4.

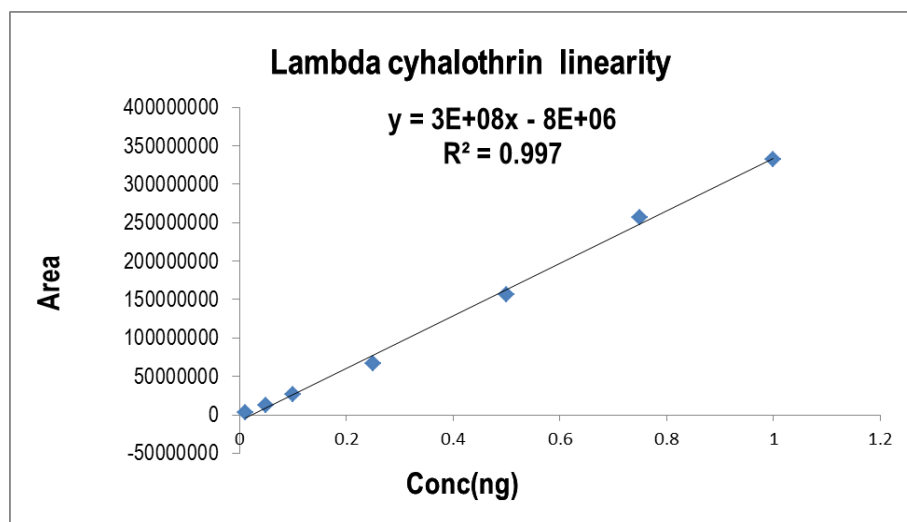


Fig. 3.4. Calibration curve for lambda cyhalothrin (Concentration Vs Area)

3.4.2.3 Phosalone

Based on the response of the detector (ECD) to different quantities (ng) of CRM standards injected, it was found that the LOD (limit of detection) for phosalone is 0.01 ng, and the linearity is in the range of 0.01 ng to 0.10 ng , as given in Fig 3.5.

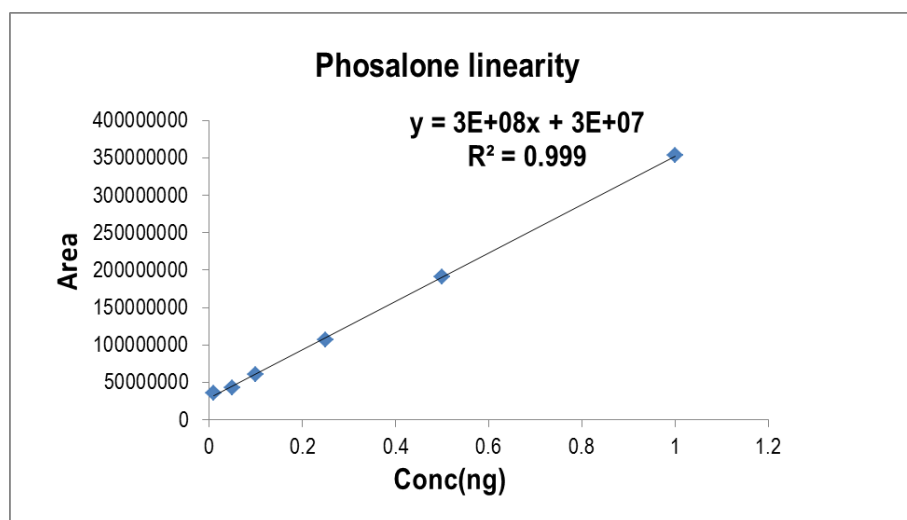


Fig. 3.5. Calibration curve for phosalone (Concentration Vs Area)

3.4.2.4 Profenophos

Based on the response of the detector (ECD) to different quantities (ng) of CRM standards injected, it was found that the LOD (limit of detection) for profenophos is 0.01 ng, and the linearity is in the range of 0.01 ng to 0.10 ng, as given in Fig 3.6.

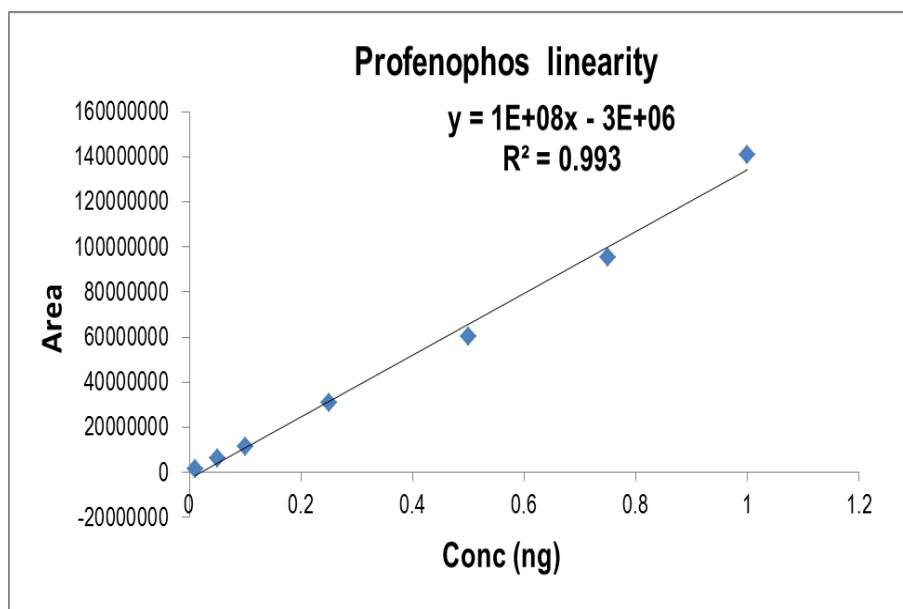


Fig. 3.6. Calibration curve for profenophos (Concentration vs Area)

3.4.3 Limit of Detection and Linearity of Flubendiamide

The working standards of flubendiamide were injected in Liquid Chromatograph with Photo Diode Array (PDA) Detector for estimating the lowest quantity of flubendiamide which can be detected under standard operating parameters as given below in Table 3.5.

For confirmatory analysis samples are also injected in LC-MS/MS. The LC operating parameters for flubendiamide detection and estimation are presented in Table 3.5. and the LC used for the study is shown in Fig 3.7.

Under LC operational parameters given in Table 3.5, the retention time of flubendiamide is 4.12 min. Working standards of flubendiamide (0.05 ppm, 0.075 ppm, 0.10 ppm, 0.25 ppm and 0.50 ppm) were injected 6 times and the linearity lines were drawn.

Table 3.5. Details of HPLC operating parameters

HPLC	SHIMADZU LC-20		
Detector	HPLC Photo Diode Array Detector (PDA)		
Column	HPLC Column Kinetex 5U –C18 column, 100 X 4.6 mm ID		
Wave Length	254 nm		
Solvents in Pump A	Water		
Solvents in Pump B	Acetonitrile		
Solvents Gradient Program	Water: Acetonitrile (40:60) mixture run for 10 min		
Solvents Gradient rate	0.8 ml min ⁻¹		
Quantity of sample injected	20 µl		
Run time	10 min		
Retention time	Flubendiamide – 4.12 min		
LC Program	Time	Acetonitrile	Water
	0.00	60	40
	10.0	80	20

3.4.3.1 Flubendiamide

Based on the response of the detector (PDA) to different quantities (ng) of CRM standards injected under the HPLC operational parameters given in Table 3.5, it was found that the LOD (limit of detection) for flubendiamide is 0.05 ng, and the linearity is in the range of 0.05 ng to 0.10 ng , as given in Fig 3.8.

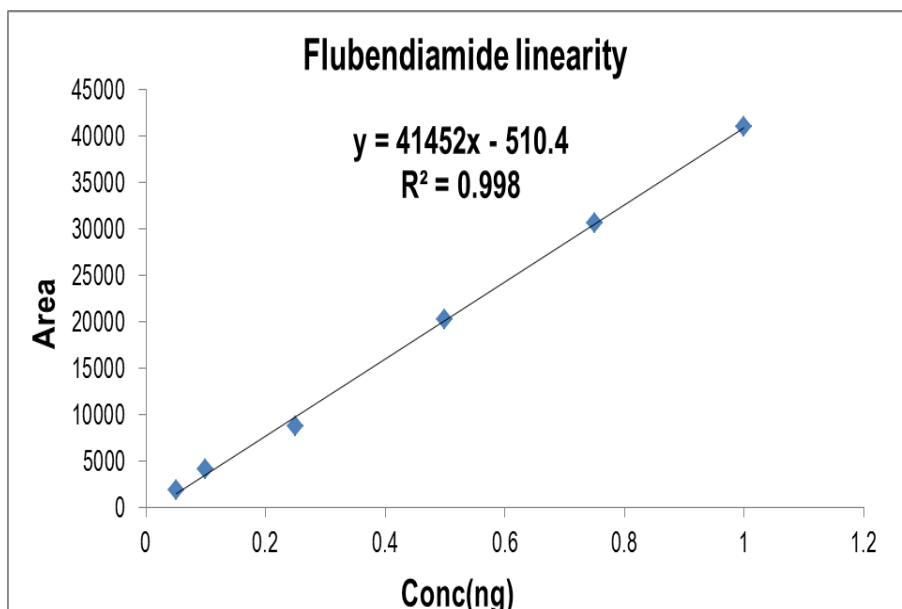


Fig. 3.8. Calibration curve for flubendiamide (Concentration Vs Area)



Fig. 3.2. Gas Chromatograph

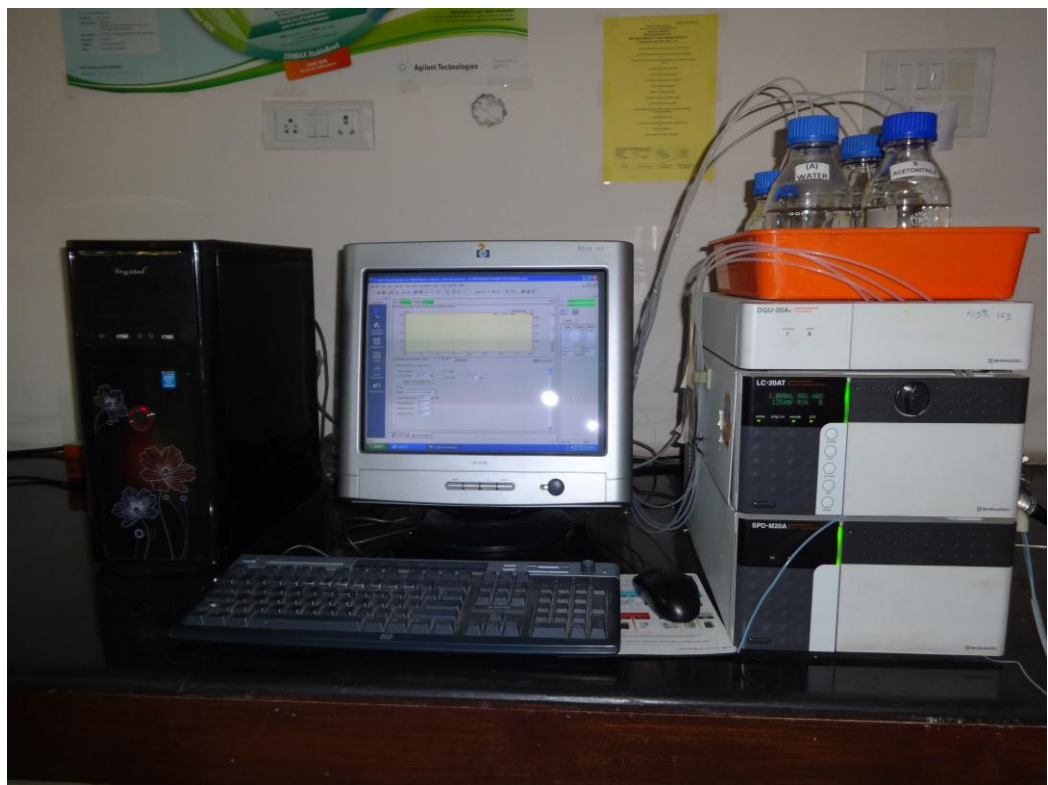


Fig. 3.7. Liquid Chromatograph

3.4.4 Method validation

Prior to pesticide application and field sample analysis, the residue analysis method was validated following the SANCO document (12495/2011). The tomato fruits (5 kg) collected from untreated control plots were brought to the laboratory and the stalks were removed prior to samples preparation. The sample was homogenized using Robot Coupe Blixer (High volume homogenizer) and homogenized sample of each 15 g was taken in to 50 ml centrifuge tubes. The required quantity of Dimethoate, λ -cyhalothrin, Phosalone, Flubendiamide and Profenophos intermediary standard prepared from CRM is added to each 15 g sample to get fortification levels of 0.05 ppm, 0.25 ppm and 0.5 ppm in three replications each. These fortification levels are selected to know the suitability of the method to detect and quantify pesticides in tomato below Maximum Residue Limits (MRLs) of Codex Alimentarius Commission (CAC).

The AOAC official method 2007.01 (Pesticide Residues of Foods by Acetonitrile Extraction and Partitioning with Magnesium Sulfate) was slightly modified to suit to the facilities available at the laboratory and the same was validated for estimation of LOQ (Limit of Quantitation) of above mentioned pesticides in Tomato matrix. The method followed is presented in the flow chart given below (Fig 3.9) and Plate 5.

The final extract of the sample i.e. 2 ml is equal to 1 g of the sample as given in Fig 3.10, is evaporated using turbovap and made up to 1 ml (equal to 1 g sample) using suitable solvent for analysis on GC, while for LC analysis, filtered 1 ml final extract (equal to 0.5 g sample) is directly injected in LC and the residues of pesticides recovered from fortified samples were calculated using the following formula.

$$\text{Residues (mg kg}^{-1}\text{)} = \frac{\text{Sample peak area X conc of std (ppm) X } \mu\text{l std. injected X}}{\text{Final volume of the sample}} \\ \frac{\text{Standard Peak area X weight of sample analysed X}}{\mu\text{l of sample injected}}$$

$$\text{Wt of the Sample analysed} = \frac{\text{Sample weight (15 g) X aliquot taken}}{\text{Volume of acetonitrile (30 ml)}}$$

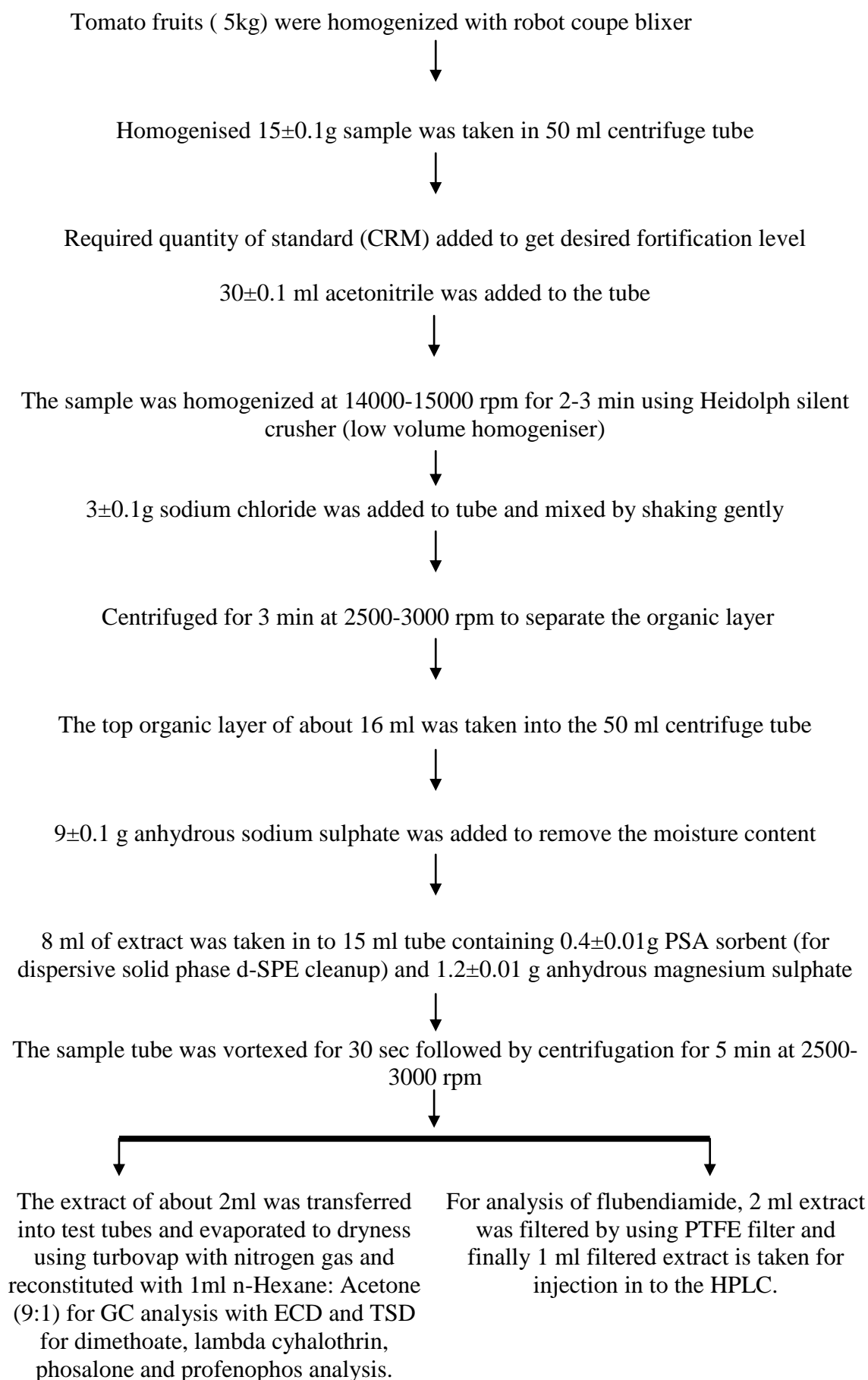


Fig. 3.9. Flow chart of QuEChERS method



Sample collection



High Volume Homogenization



Weigh 15 g homogenized sample in 50 ml centrifuge tube



Add 30 ml of acetonitrile



Plate 5. Flow chart of QuEChERS method (1/3)



Homogenization at 14000 rpm for 2-3min with silent crusher (low volume Homogenizer)



Add 3 g NaCl and mix thoroughly



Centrifuge for 3 min at 2500-300 rpm to separate organic layer



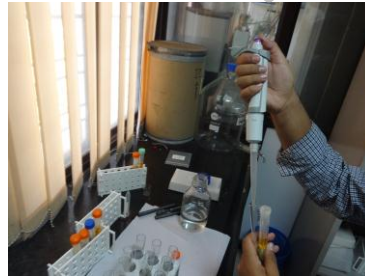
Take 16 ml top organic layer in to 50 ml centrifuge tube



Plate 5. Flow chart of QuEChERS method (2/3)



Add 9 g anhydrous sodium sulphate to remove moisture and mix with vortex



Take 8 ml extract into 15 ml tube with 0.4 g PSA and 1.2 g anhydrous $MgSO_4$



Mix contents with vortex, then Centrifuge for 5 min at 2500-3000 rpm



Pipette 2ml in glass tube and evaporate to dryness with turbovap, make up to 1 ml and analyse on GC

Take 2ml and filter
Analyze samples on HPLC

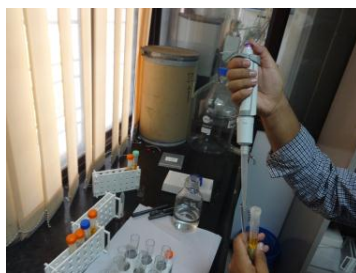


Plate 5. Flow chart of QuEChERS method (3/3)

The recovery per centage and recovery factors was calculated using the following formula.

$$\text{Per cent Recovery} = \frac{\text{Residue quantified in fortified sample}}{\text{Fortified level}} \times 100$$

$$\text{Recovery factor} = \frac{100}{\text{Per cent recovery}}$$

3.4.4 Limit of Quantification (LOQ) / Limit of Determination

The fortified samples (0.05, 0.25 and 0.5 mg kg⁻¹) were analysed as per the method given in 3.4.2 , 3.4.3 and the recovery factors were calculated. Tomato samples fortified with dimethoate at 0.05 mg kg⁻¹, 0.25 mg kg⁻¹ and 0.5 mg kg⁻¹ were analysed and the mean recovery of the residues using the method was 99.23%, 94.68% and 88.27% respectively. The results showed that the method is suitable for the analysis of dimethoate residues up to 0.05 mg kg⁻¹, and the limit of quantitation (LOQ) is 0.05 mg kg⁻¹.

Table 3.6. Recovery of dimethoate residues in tomato

Details	Recoveries of dimethoate from fortified tomato samples					
	Fortified level (mg kg ⁻¹)					
	0.05 mg kg ⁻¹		0.25 mg kg ⁻¹		0.50 mg kg ⁻¹	
	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %
R1	0.050	100.80	0.244	97.71	0.446	89.15
R2	0.053	105.20	0.232	92.78	0.433	86.68
R3	0.046	91.70	0.234	93.55	0.445	89.00
Mean		99.23		94.68		88.27
SD		6.907		2.652		1.379
RSD		6.961		2.801		1.563

Tomato samples fortified with lamda cyhalothrin at 0.05 mg kg⁻¹, 0.25 mg kg⁻¹ and 0.5 mg kg⁻¹ were analysed and the mean recovery of the residues using the method was 91.44%, 105.08% and 113.46% respectively and the results show

that the method is suitable for the analysis of lambda cyhalothrin residues up to 0.05 mg kg⁻¹, and the limit of quantitation (LOQ) is 0.05 mg kg⁻¹.

Table 3.7. Recovery of lambda-cyhalothrin residues in tomato

Details	Recoveries of lambda-cyhalothrin from fortified tomato samples					
	Fortified level (mg kg ⁻¹)					
	0.05 mg kg ⁻¹		0.25 mg kg ⁻¹		0.50 mg kg ⁻¹	
	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %
R1	0.047	94.66	0.267	106.74	0.549	109.87
R2	0.046	91.57	0.256	102.47	0.594	118.71
R3	0.044	88.10	0.265	106.03	0.559	111.79
Mean		91.44		105.08		113.46
SD		3.284		2.291		4.648
RSD		3.592		2.181		4.096

Tomato samples fortified with phosalone 0.25 mg kg⁻¹ and 0.5 mg kg⁻¹ were analysed and the mean recovery of the residues using the method was 95.16% and 97.43% respectively and the results show that the method is suitable for the analysis of lambda cyhalothrin residues up to 0.25 mg kg⁻¹, and the limit of quantitation (LOQ) is 0.25 mg kg⁻¹.

Table 3.8. Recovery of Phosalone residues in tomato

Details	Recoveries of Phosalone from fortified tomato samples					
	Fortified level (mg kg ⁻¹)					
	0.05 mg kg ⁻¹		0.25 mg kg ⁻¹		0.50 mg kg ⁻¹	
	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %
R1	-	-	0.224	89.67	0.499	99.73
R2	-	-	0.242	96.94	0.498	99.50
R3	-	-	0.247	98.87	0.465	93.07
Mean	-	-		95.16		97.43
SD				4.851		3.781
RSD				5.097		3.881

Tomato samples fortified with profenophos at 0.05 mg kg⁻¹, 0.25 mg kg⁻¹ and 0.5 mg kg⁻¹ were analysed and the mean recovery of the residues using the method was 95.85%, 95.16% and 95.27% respectively and the results show that

the method is suitable for the analysis of profenophos residues up to 0.05 mg kg⁻¹ and the limit of quantitation (LOQ) is 0.05 mg kg.

Table 3.9. Recovery of Profenophos residues in tomato

Details	Recoveries of Profenophos from fortified tomato samples					
	Fortified level (mg kg ⁻¹)					
	0.05 mg kg ⁻¹		0.25 mg kg ⁻¹		0.05 mg kg ⁻¹	
	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %
R1	0.049	98.59	0.238	95.14	0.480	95.95
R2	0.047	94.49	0.236	94.21	0.479	95.77
R3	0.047	94.49	0.240	96.13	0.470	94.07
Mean		95.85		95.16		95.27
SD		2.367		0.960		1.025
RSD		2.469		1.008		1.076

Tomato samples fortified with flubendiamide at 0.05 mg kg⁻¹, 0.25 mg kg⁻¹ and 0.5 mg kg⁻¹ were analysed and the mean recovery of the residues using the method was 117.79%, 104.00% and 97.93% respectively and the results show that the method is suitable for the analysis of flubendiamide residues up to 0.05 mg kg⁻¹, and the limit of quantitation (LOQ) is 0.05 mg kg⁻¹.

Table 3.10. Recovery of Flubendiamide residues in tomato

Details	Recoveries of Flubendiamide from fortified tomato samples					
	Fortified level (mg kg ⁻¹)					
	0.05 mg kg ⁻¹		0.25 mg kg ⁻¹		0.50 mg kg ⁻¹	
	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %	Residues recovered (mg kg ⁻¹)	Recovery %
R1	0.059	118.34	0.302	120.97	0.470	94.06
R2	0.056	111.22	0.262	104.99	0.521	104.27
R3	0.062	123.81	0.215	86.05	0.477	95.47
Mean		117.79		104.00		97.93
SD		6.314		17.479		5.533
RSD		5.360		16.806		5.650

Hence, the method described and followed in 3.4.3 is suitable for the analysis of samples collected from the field sprayed with dimethoate, lambda cyhalothrin, phosalone, flubendiamide and profenophos to study the residue

dynamics / dissipation pattern. The data on fortification and recovery results were presented in Table 3.6, 3.7, 3.8, 3.9 and 3.10.

3.5 Dissipation pattern of insecticides on tomato

3.5.1 Sample collection

Samples of tomato were collected in both poly house and open field from individual treatments in all replications after two sprays, in labeled polybags. Care is taken to wear hand gloves to avoid contamination. Pest damage free and crack free tomato fruits were collected in saperate polythene bags and brought to labarotary. Samples were collected at regular intervals i.e. 0, 1, 3, 5, 7, 10, 15, 20 days after last spray.

3.5.2 Sample analysis

Collected samples were analysed for residues following the validated methods. Residues (mg kg^{-1}) were calculated using the formula given below.

$$\text{Residues}(\text{mg kg}^{-1}) = \frac{\text{Sample peak area X conc of std (ppm) X } \mu\text{l std. injected X Final volume of the sample}}{\text{Standard Peak area X weight of sample analysed X } \mu\text{l of sample injected}} \times \text{recovery factor}$$

The following parameters were calculated to know the dissipation pattern of the insecticides on tomato.

Dissipation per centage:

$$\text{Per cent dissipation} = \frac{\text{Initial deposit - Residues at given time}}{\text{Initial deposit}} \times 100$$

Waiting period: Waiting period (T_{tol}) is defined as the minimum number of days to lapse before the insecticide reaches the tolerance limit.

The waiting periods were calculated wherever MRLs are available as per CAC/FSSAI, by the following formula.

$$T_{tol} = \frac{[a - \text{Log tol}]}{b}$$

Where

T_{tol} = Minimum time (in days) required for the pesticide residue to reach below the tolerance limit.

a = Log of apparent initial deposits obtained in the regression equation

$$(Y = a+bX)$$

tol = Tolerance limit of the insecticide (MRL)

b = Slope of the regression line

Half-life (RL₅₀): The time in days required to reduce the pesticide residues to half of its initial deposits. Mathematically, it is

$$RL_{50} \text{ (or) } t_{1/2} = \frac{\text{Ln}(2)}{b} = \frac{0.693147}{b}$$

where

b = Slope of regression line (Hoskins, 1961)

3.6 Evaluation of decontamination methods for removal of pesticide residues.

The zero day samples which are free from pests and cracks from various treatments were collected separately in large quantities and made into 6 sets, each in 4 replications. One set of sample from each treatment (in 4 replications) is analyzed for deposits of the pesticide. The remaining sets of samples of zero day from each treatment samples were subjected to various decontamination methods separately and the residues were calculated to know the efficiency of the various decontamination methods in removal of pesticide residues from the tomato samples. The following decontamination / risk mitigation methods selected for evaluation of efficiency in removal of pesticide residues from tomato (Plate 6).

3.6.1 T₁ (Tap water wash):

Four lit of tap water was taken into the plastic tub of 7 lit capacity and 2 Kg of tomato fruits were dipped in the tub for 10 min, followed by the tap water wash for 30 sec, further the fruits were kept for air drying on tissue paper for 5 min.

3.6.2 T₂ (Soaking in 2% salt solution for 10 min followed by tap water wash):

Four lit of 2 % salt solution was prepared by mixing 80 g of table salt in 4 lit of water in plastic tub of 7 lit capacity and 2 Kg tomato fruits were dipped in the tub for 10 min, followed by the tap water wash for 30 sec, further the fruits were kept for air drying on tissue paper for 5 min, followed by analysis.

3.6.3 T₃ (Dipping in 0.1% baking soda) (NaHCO₃) :

Four lit of 0.1% baking soda solution was prepared by mixing 4 g of baking soda in 4 lit of water in plastic tub of 7 lit capacity and 2 Kg tomato fruits were dipped in the tub for 10 min, followed by the tap water wash for 30 sec, further the fruits were kept for air drying on tissue paper for 5 min, followed by analysis.

3.6.4 T₄ (Soaking in 4% acetic acid solution for 10 min followed by tap water wash):

Four lit of 4% acetic acid solution was prepared by mixing 160 ml of acetic acid glacial 100% in 4 lit of water in plastic tub of 7 lit capacity, mixture was kept for 1 min and 2 Kg of tomato fruits were dipped in the tub for 10 min, followed by the tap water wash for 30 sec, further the fruits were kept for air drying on tissue paper for 5 min, followed by analysis.

3.6.5 T₅ (Veggy wash):

Four lit of veggy wash was prepared by mixing 160 ml of acetic acid glacial 100%, 4 g of baking soda and lemon juice of 4 lemons in 4 lit of water in plastic tub of 7 lit capacity, mixture was kept for 1 min and 2 Kg tomato fruits were dipped in the tub for 10 min, followed by the tap water wash for 30 sec, further the fruits were kept for air drying on tissue paper for 5 min, followed by analysis.

Per cent removal of pesticide:

$$\text{Per cent removal} = \frac{\text{Initial deposit} - \text{Residues after treatment}}{\text{Initial deposit}} \times 100$$



T₁- Tap water wash
Dipping in tap water for 10 min followed by tap water wash for 30 sec



T₂- 2% salt solution
Dipping in 2% salt solution for 10 min followed by tap water wash for 30 sec



T₃- 0.1% baking soda
Dipping in 0.1% baking soda solution for 10 min followed by tap water wash for 30 sec



T₄-4% acetic acid solution
Dipping in 4% acetic acid solution for 10 min followed by tap water wash for 30 sec



T₅- veggy wash
Dipping in veggy wash for 10 min followed by tap water wash for 30 sec



Prior to analysis, fruits were allowed to air dry on tissue papers.

Plate 6. Decontamination methods

3.7 Meteorological data

Data on maximum and minimum temperature, relative humidity, rainfall and sunshine hours were recorded at meteorological Centre of Agricultural Research Institute, Acharya N.G. Ranga Agricultural University, Rajendranagar and compiled in Table 3.11.

Table 3.11. Meteorological data during the crop period

Standard Met week	Date & month	Temperature (°c)		R.H. (%)		Rainfal (mm)	Sunshine (hrs.)
		Max	Min	I	II		
26	25-01 July	32.1	24.5	79.1	57.6	33.5	1.5
27	02-08	34.3	23.7	84.1	57.4	63.0	6.5
28	09-15	30.9	23.0	85.3	63.7	23.8	2.6
29	16-22	33.5	24.2	78.6	46.0	23.4	5.0
30	23-29	30.9	25.0	81.4	60.6	24.0	3.9
31	30-05 Aug	27.8	21.6	86.1	77.9	28.5	3.5
32	06-12	29.0	22.2	89.0	66.1	54.4	5.7
33	13-19	28.1	22.1	89.7	77.6	72.8	2.2
34	20-26	29.2	22.0	91.7	77.3	1.4	3.4
35	27-02 Sept	30.2	21.4	90.6	80.4	9.0	3.6
36	03-09	31.5	21.2	87.6	61.0	8.6	4.8
37	10-16	31.4	20.7	87	62	45.5	6.0
38	17-23	29.9	20.5	90	70	56.5	2.9
39	24-30	31.5	19.9	84	60	0.0	9.0
40	01-07 Oct	30.5	22.0	84	63	2.0	4.8
41	08-14	31.1	20.8	87	62	18.0	6.4
42	15-21	31.8	17.7	87	53	11.2	8.1
43	22-28	26.3	19.4	96	81	222.0	1.4
44	29-04 Nov	30.1	17.5	87	56	0.0	7.4
45	05-11	28.5	14.3	84	49	0.0	7.2
46	12-18	27.8	11.4	84	37	0.0	8.1
47	19-25	28.4	15.1	89	58	28.8	5.8
48	26-02 Dec	28.4	14.8	90	51	2.2	6.3
49	03-09	27.6	11.2	77	37	0.0	8.5
50	10-16	29.1	7.5	86	27	0.0	9.6
51	17-23	28.1	8.8	81	35	0.0	9.3
52	24-31	27.1	11.0	87	40	0.0	8.5

RESULTS AND DISCUSSION

Chapter IV

RESULTS AND DISCUSSION

The survey on pesticide use pattern was conducted in tomato crop both in polyhouse and open field situations, dissipation pattern of selected insecticide was studied in tomato grown in poly house and open field situation to study the variations in dissipation pattern, and selected decontamination methods were evaluated for removal pesticide residues from tomato. The results of these studies are presented in this chapter.

4.1 Survey on pesticide usage on tomato grown in poly house and open fields

Survey on pesticide use pattern was conducted at farmer's fields of six villages of Ranga Reddy district for open field survey and 14 villages of five districts of Andhra Pradesh for poly house survey. The results of survey on pesticide usage on tomato in poly house and open fields are presented here under.

For poly house survey, necessary data was collected from the sample farmers spread over Ranga Reddy, Medak, Warangal, Guntur and Karimnagar districts of Andhra Pradesh and for open field survey, data was collected from the sample farmers spread over Moinabad, Chevella and Ibrahimpatnam mandals of Ranga Reddy district. The data was subjected to various statistical tools and techniques to draw meaningful conclusions. The major findings of the study are presented here under.

4.1.1. General characteristics of farmers

4.1.1.1 Age of the farmers

About 42.86% of the poly house farmers were in the age group of >50 years followed by 40-50 years (35.75%) and 20-30 years (21.43%), whereas in case of open field farmers, about 43.33% of the farmers were in the age group of 40-50 years followed by 30-40 years (30%), 20-30 years (16.67%) and >50 years (10%).

4.1.1.2 Education level of farmers

The analysis of education level of poly house respondents showed that 42.86% of respondents studied high school education; 28.57% farmers with college education; 21.43% farmers with secondary education; 7.14% farmers with primary school education, where as in case of open field farmers, 33.33% of respondents were illiterates, followed by high school, primary school, college and secondary school education with 31.67%, 13.33%, 13.33% and 8.33%, respectively.

4.1.1.3 Type of family

More than 70% of the poly house farmers belonged to nuclear family (71.42%) and 28.57% of farmers belonged to joint family. Similarly, more than 75% of the open field farmers belonged to nuclear family (78.33%) and 21.67% of sample farmers belonged to joint family.

Data pertaining to general characteristics of sample farmers is presented in Table 4.1.1.

4.1.2 General information on tomato cultivation

4.1.2.1 Age of the nursery

More than 85% of poly house farmers preferred to use nursery of 25 days old (85.71%), 7.14% farmers use 20 days and 30 days old nursery. Similarly, more than 75% of open field farmers used nursery of 25 days old (78.33%), 13.33% farmers used 30 days old nursery, while only 8.33% farmers used 20 days nursery. Farmers were usually had good awareness regarding age of the nursery to be used both in poly house and open fields, variations might be due to non availability of nursery at the time of planting, improper planning while sowing nursery, etc.

4.1.2.2 Crop area

Most of the poly house farmers (92.86 %) cultivated tomato in less than 0.5 acre and 7.14% farmers cultivate in more than 0.5 acre. In case of open field farmers, about 40% of respondents were cultivated tomato in crop area of 1 acre, followed by 36.67%, 13.33% and 10% in 2 acre, 3 acre and more than 3 acre, respectively. It is expected that poly house growers will have less cropped area because the size of poly house is directly proportional to cropped area.

4.1.2.3 Season of cultivation

About 92.86% of poly house farmers cultivated tomato in poly houses in *summer* season, and 64.29% poly house farmers grow tomato in *rabi* season. Farmers did not prefer to cultivate tomato in poly houses during *kharif* season. In case of open fields, 100% of sample farmers cultivated tomato in open fields during *kharif* season, 28% farmers in *rabi* and 19% farmers cultivate tomato during *summer* season. Poly house farmers preferred to cultivate tomato in *summer* and *rabi* season due to good market prices in these seasons. Most of the open field farmers preferred to cultivate tomato in *kharif* season basically due to the availability of water.

4.1.2.4 Crop duration

More than 60% of poly house farmers were growing crop more than five months (64.29%); 28.57% for five months and 7.14% poly house famers grow tomato up to four months. Whereas in case of open fields, no farmers were growing crop more than five months, and majority of (66.67%) of farmers growing crop up to five months, while 18.33% and 15% farmers grow tomato for 4 and 5 months, respectively. Most of the poly house farmers preferred to grow tomato more than five months basically to harvest more amounts of fruits from established crop, which is supported by long duration hybrids/varieties. Whereas in open field's farmers were more concerned about water for their crop and also to protect crop from adverse climatic conditions, therefore they preferred to grow crop up to five months.

Data pertaining to general information regarding tomato cultivation is presented in Table 4.1.2.

4.1.3 General awareness of farmers in using pesticides

4.1.3.1 Awareness of pesticide recommendations and classifications

About 35.71% of poly house and 16.67% of open field respondents were aware of recommended pesticides against different pests, and about 14.29% of poly house and 6.67% of open field respondents were aware of pesticide classification based on toxicity. It is expected that due to good literacy level in poly house farmers, they were keener about knowing pesticide recommendations, still large per cent of poly house farmers using pesticides without knowing recommendations. Where as in open fields majority of farmers were illiterates and literate's negligence led to application of pesticide without proper recommendation. Most of the poly house and open field farmers were unaware of pesticide classification based on toxicity. Both these issues might be attributed to literacy level, insufficient extension activities, and also negligence of farmers.

4.1.3.2 Following safe methods while storing / mixing / spraying pesticides

About 7.14% of poly house and 3.33% of open field farmers followed safe methods while storing or mixing or spraying pesticides.

About 92.85% of poly house and 45% open field farmers measured chemical by bottle cap and 7.14% of poly house and 55% of open field farmers measured approximately. About 100% of poly house and 95% of open field farmers mixed chemical by using stick, not with bare hands.

Both in poly houses and open fields, majority of the farmers did not followed safe methods while storing or mixing or spraying pesticides, and it might be attributed to non availability of protective coverings and unawareness of pesticide effect on health. Majority of poly house farmers measured chemical by bottle cap as most of them know recommendations. Where as in open fields, more than half of the respondents measured chemical approximately as most of them were unaware of recommendations. Both in poly house and open fields most of the farmers mixed chemical with stick not with hand because they were concerned about pesticide ingestion along with the food they eat.

4.1.3.3 Pesticide effect on health of spray men and first aid followed

Among the respondents, about 85.71% of poly house and 95% of open field respondents observed pesticide effect on health of spray men during spray. Most common health problems observed during spray in poly houses includes bad odour (71.43%), cough (57.14%), skin irritation (43.86%) and head ache (42.86%). In case of open fields, most common health problems observed during spray includes bad odour (88.33%), skin irritation (48.33%), cough (38.33%), head ache (21.67%) and breathlessness (10%).

To combat with these effects, majority of poly house farmers used first aid methods like Induced vomiting if pesticide is swallowed (78.57%), washing the affected area with water (78.57%), washing the affected area with soap water (85.71%). First aid followed by open field farmers includes washing the affected area with water (90%), induced vomiting if pesticide is swallowed (88.33%), washing the affected area with soap water (76.67%).

Both in poly house and open fields 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 help full to victim until he was taken to hospital.

4.1.3.4 Awareness on banned insecticides

Both poly house and open field famers had good awareness of ban of endosulfan in agriculture (92.86 and 93.33% respectively), in contrast only 28.57% of poly house and 13.33% of open field famers were aware that monocrotophos is banned for use on vegetables. Majority of the farmers both in poly house and open fields were aware about endosulfan ban in agriculture, this might be due to kasargod incident which became global news. Most of the farmers were unaware of ban of monocrotophos in vegetables; this might be due to insufficient extension activities.

4.1.3.5 Contact person for pesticide recommendations

Both poly house and open field farmers preferred to contact pesticide dealers (100%), followed by scientists (42.86% and 38.33% in poly house and open fields respectively) and agricultural officers (0% and 15% in poly house and open fields respectively) for pesticide recommendations.

Majority of both poly house and open field farmers contacted pesticide dealers, because farmers think that dealers are having more experience in recommending pesticides and also most often they will neglect 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.

4.1.3.6 Pesticide mixtures and frequency of pesticide application

Majority of both poly house (78.57%) and open field (67.67%) respondents used pesticide mixtures rather than applying single pesticide at a time, this is basically to save time, labour, money and to combat two or more pests with single spray. About 78.57% of poly house farmers applied pesticides at weekly interval followed by 4 days (21.43%), whereas in open fields, farmers preferred to go for 4 days interval (60%) followed by weekly interval (33.33%) and 2 days interval (6.66%).

Most of the poly house farmers applied pesticides at weekly interval this shows that farmer is giving some time to pesticide to act upon pests and also he is not spraying until again pest population builds up. In contrast most of the open field farmers preferred to spray pesticides at 4 days interval, most often it may lead pesticide resistance.

4.1.3.7 Awareness on pesticide residues

Only 14.29% of poly house and 11.67% of open field farmers were aware that pesticide residues are found in vegetables and only 7.14% of poly house and 8.33% of open field farmers knew that pesticide residues in food enter into body and accumulate. About 7.14% of poly house and 1.67% of open field farmers were aware that for each pesticide, pre-harvest interval is recommended.

Common waiting period of one week (78.57%) was followed by most poly house farmers (78.57%) and 21.43% follows by 4 days PHI. Whereas in case of open fields, most farmers (93.33%) follow 2 days PHI, and very few farmers harvest crop with 7 days PHI.

About 71.43% of poly house and 68.33% of open field farmers respond that they did not heard any kind of bad effects due to pesticide residues.

Majority of poly and open field farmers were unaware of pesticides residues, their bad effects, pre harvest intervals this might be attributed to literacy level of the farmers and insufficient extension activities.

4.1.3.8 Awareness of decontamination methods

About 92.86 % of poly house and 81.67 % of open field respondents were aware about decontamination methods. About 85.71% of poly house and 80% of open field farmers say that they wash vegetables, and also responded that 21.43% of poly house and 16.67% of open field farmers think that salt water washing helps to remove pesticide residues.

Majority of both poly house and open field farmers were unaware of various decontamination methodologies, but as a regular kitchen practice they wash vegetables with tap water.

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

Among the sample farmers, 28.57% of poly house and 35% of open field farmers thought that the quantity of pesticides used at their farm is adequate, and about 64.29 % of poly house and 81.67% of open field farmers had perception that pesticides are helpful in getting good returns.

Among the sample farmers 35.71% of poly house and 25% of open field farmers know that integrated pest management practices are alternative to pesticides and only 21.43% of poly house and 13.33% of open field farmers feels that natural control as an alternative to pesticides.

About 35.71% of poly house and 65% of open field farmers had perception that high pesticide dose will give higher yields.

Majority of the farmers thought that pesticides are helpful in getting good returns and very few feel 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 case of natural control.

4.1.3.9 Use of empty pesticide bottles and their disposal

About 28.57% of poly house and 28.33% of open field farmers use empty pesticide bottles for house or farm purposes. Majority of the farmers both in poly houses (92.86%) and open fields (91.67%) simply throw empty bottles in trash and few farmers also say that they sell empty bottles.

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 unaware of bad effects of pesticides. Disposal of these empty pesticides bottles was not carried out in a satisfactory way, as majority of the farmers simply throw bottles in trash.

Data pertaining to general awareness of farmers in using pesticides is presented in Table 4.1.3 a. and 4.1.3 b.

4.1.4 Information on occurrence of insect pests

Poly house farmers feels that the major pest is serpentine leaf miner (*Liriomyza trifolii*) followed by fruit borer (*Helicoverpa armigera*), thrips, leaf eating caterpillar (*Spodoptera litura*) and leaf hopper. While the open field farmers say that fruit borer (*Helicoverpa armigera*) is the major pest followed by serpentine leaf miner (*Liriomyza trifolii*), leaf eating caterpillar (*Spodoptera litura*), thrips and leaf hopper.

Data pertaining to Information on occurrence of insect pests is presented in Table 4.1.4.

4.1.5 Types of pesticides used by tomato growers

Major pesticides used by the ploy house farmers were Fiponil 5%SC, Chlorantraniliprole 18.5% SC, Thiomethoxam 25% WG, Imidacloprid 17.8% SL, Spionsad 48% SC, Emamectin benzoate 5 % SG and Chlorfenapyr 10% SC, where 92.86%, 85.71%, 78.57%, 71.43%, 71.43%, 64.29% and 64.29% farmers uses above pesticides, respectively. In case of farmers growing tomato in open fields, major pesticides used were Chlorantraniliprole 18.5%SC, Imidacloprid 17.8%SL, Fipronil 5%SC, Chlorpyrifos 2% EC, Novaluron 5.2% + Indaxacarb 4.5 % SC, Spionsad 48% SC and Flubendiamide 48%SC, where 81.67%, 81.67%, 80.00%, 73.33%, 73.33%, 71.64% and 68.33% respectively.

Data pertaining to types of pesticides used by tomato growers is presented in table 4.1.5.

4.1.6 Abridged information on various parameters studied with discussion

Nagendra (2002) reported that only 5.8% of respondents contacted agricultural officers for suggestions on pest control, and in present study also only 15% of respondents contacted agricultural officers for suggestions in open field survey where as in poly house farmer never contacted agricultural officers for suggestions which is in line with the work done by the Jana *et al.* (2012).

The poly house farmers are highly educated compared to open field farmers, and are also progressive in their crop management and hence it is expected that poly house farmers usually contact specialist instead of local Agricultural Officer for suggestions. In present study 35.71% of poly house growers and 16.67% of open field growers had awareness of pesticide recommendations which are in conformity with the findings of Hosamani (2009), Nagendra (2002) and Jana *et al.* (2012) who reported 8.33%, 11.67% and 25% of respondents aware of pesticide recommendations, respectively.

Usually, very few farmers will have knowledge on pesticide recommendations as per Act and GAPs of ICAR and SAUs, and are fully depend on neighbour farmer, local dealer or press / media reports, and in most cases pesticide dealer, except in case of progressive farmers and also vegetable growers for export purposes, who follow GAPs to avoid the pesticide residues.

The present study revealed that 6.67% of open field and 14.29% poly house growers had awareness of pesticide classification based on toxicity, which indicates that very few farmers look at the colour code triangle on the pesticide bottle, and similar results were reported by Hosamani (2009) and Nagendra (2002) who reported 14.17% and 27.50% of respondents had awareness of pesticide classification based on toxicity respectively. Such reports depends on place, crop, purpose of product, use of the product, size of the pack etc. and it gives 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 present study 95% of open field and 100% of poly house growers mixed pesticide with wooden stick not with bare hands, these results are in agreement with the findings Hosamani (2009) and Patil *et al.* (2012) who reported 64.17% and 57% of respondents mixed pesticide with wooden stick not with bare hands. This study gives very happy information that farmers are taking care to avoid the pesticide contamination to their body parts.

Present investigation revealed 71.67% and 71.43% of poly house growers not used empty pesticide bottles for house/farm purpose, which is in line with the findings of Nagendra (2002) and Jana *et al.* (2012) who reported 85% and 53% of respondents not used empty pesticide bottles for house/farm purpose respectively. This information is an important piece of information that most farmers are aware that empty pesticide bottles are not good use at both farm / house level, and further it was noticed that very few farmers try to sell the empty bottles to rag buyers, but no farmer aware about the scientific disposal procedures for used packs / bottles.

In present study, 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, head ache, breathlessness in the spray men during and after spray operations at farm level. Similar observations also noticed by farmers growing tomato in open fields, and few feels that head ache also observed in some people. These findings are in agreement with the findings of Patil *et al.* (2012) and Nagendra (2002) who reported 97.43% and 51.67 % of skin irritation, respectively and reports of Nagendra (2002) where 44.17% respondents reported eye irritation, 35.83 and 22.00% head ache, among the farmers who were engaged in spraying of pesticides by Nagendra (2002) and Jana *et al.* (2012) respectively. Jana *et al.* (2012) reported 70% of the respondents experienced bad odour which is in line with the findings of present investigation.

Table 4.1.1. General characteristics of the farmers growing tomato

Note: Figures in percentage are with respect to their respective frequency

Particulars		Poly house (n=14)		Open field (n=60)	
Sl.No	Particulars	Frequency	Percentage	Frequency	Percentage
1	Age				
	20-30	0	0.00	10	16.67
	30-40	3	21.43	18	30.00
	40-50	5	35.75	26	43.33
	>50	6	42.86	6	10.00
2	Educational status				
	Illiterate	0	0	20	33.33
	Primary school	1	7.14	8	13.33
	Secondary school	3	21.43	5	8.33
	High school	6	42.86	19	31.67
	College	4	28.57	8	13.33
3	Type of family				
	Nuclear	10	71.42	47	78.33
	Joint	4	28.57	13	21.67

Table 4.1.2. General information regarding tomato cultivation

Particulars		Poly house (n=14)		Open field (n=60)	
Sl.No	Particulars	Frequency	Percentage	Frequency	Percentage
1	Age of nursery used				
	20 days	1	7.14	5	8.33
	25 days	12	85.71	47	78.33
	30 days	1	7.14	8	13.33
2	Crop area				
	0.5< acre	13	92.86	-	-
	>0.5 acre	1	7.14	-	-
	1 acre	-	-	24	40.00
	2 acre	-	-	22	36.67
	3 acre	-	-	8	13.33
	>3 acre	-	-	6	10.00
3	Season				
	Kharif	0	0	60	100.00
	Rabi	9	64.29	28	28.00
	Summer	13	92.86	19	19.00
4	Crop duration				
	4 months	1	7.14	11	18.33
	5 montns	4	28.57	40	66.67
	>5 months	9	64.29	9	15.00

Note: Figures in percentage are with respect to their respective frequency

Table 4.1.3 a. General awareness of farmers on pesticides and their use

Particulars		Poly house (n=14)				Open field (n=60)			
Sl.No	Particulars/comments	Frequency		Percentage		Frequency		Percentage	
		Yes	No	Yes	No	Yes	No	Yes	No
1	Are you aware about recommended pesticides against different pests	5	9	35.71	64.29	10	50	16.67	83.33
2	Are you aware about the pesticide classification based on toxicity	2	12	14.29	85.71	4	56	6.67	93.33
3	Do you follow safe methods while storing / mixing / spraying pesticides	1	13	7.14	92.86	2	58	3.33	96.67
4	Do you observe pesticide effect on health of spray men during spray	12	2	85.71	14.29	57	3	95.00	5.00
5	Are you aware that endosulfan is banned for use	13	1	92.86	7.14	56	4	93.33	6.67
6	Are you aware that Monocrotophos is banned for use on vegetables	4	10	28.57	71.43	8	52	13.33	86.67
7	Do you use pesticide mixtures	11	3	78.57	21.43	40	20	67.67	33.33
8	Are you aware that for each pesticide, pre-harvest interval is recommended	1	13	7.14	92.86	1	59	1.67	98.33
9	Are you aware that pesticide residues are found in vegetables	2	12	14.29	85.71	7	53	11.67	88.33
10	Do you know that pesticide residues in food enter into body and accumulate	1	13	7.14	92.86	5	55	8.33	91.67
11	Are you aware about pesticide decontamination method	13	1	92.86	7.14	49	11	81.67	18.33
12	Are you aware that food exports are rejected due to pesticide residues	2	12	14.29	85.71	5	55	8.33	91.67
13	Do you think the quantity of pesticides used as adequate	4	10	28.57	71.43	21	39	35.00	65.00
14	Do you think that pesticides are helpful in getting good returns	9	5	64.29	35.71	49	11	81.67	18.33
15	Do you think high pesticide dose gives higher yields	5	9	35.71	64.29	39	21	65.00	35.00
16	Use of empty bottles for house / farm purpose	4	10	28.57	71.43	17	43	28.33	71.67

Table 4.1.3 b. General awareness of farmers on pesticides and their use

Particulars		Poly house		Open field	
SI.No	Particulars/comments	Frequency	Percentage	Frequency	Percentage
17	Since how long you are growing tomato crop				
	< 3 years	4	28.57	4	6.67
	>3years	10	71.43	56	93.33
18	How do you measure the chemical				
	Bottle cap	13	92.85	27	45.00
	Approximately	1	7.14	33	55.00
19	How do you mix the chemical				
	Bare hands	0	0.00	3	5.00
	Stick	14	100.00	57	95.00
20	Most common health problem observed during spray				
	Skin irritation	6	42.86	29	48.33
	Cough	8	57.14	23	38.33
	Breathlessness	0	0.00	6	10.00
	Eye irritation	0	0.00	14	23.33
	Bad odour	10	71.43	53	88.33
	Head ache	6	42.86	13	21.67
21	Best first aid you follow				
	Induce vomiting if swallowed	11	78.57	53	88.33
	Washing the affected area with water	11	78.57	56	90.00
	Washing the affected area with soap water	12	85.71	43	76.67
22	Whom you contact, for pesticide recommendations				
	Agricultural officer	0	0.00	9	15.00
	Dealer	14	100.00	60	100.00
	Scientist	6	42.86	23	38.33

Particulars		Poly house		Open field	
SI.No	Particulars/comments	Frequency	Percentage	Frequency	Percentage
23	How frequently you apply the pesticides				
	2 Days	0	0.00	4	6.66
	4 days	3	21.43	36	60.00
	Week	11	78.57	20	33.33
24	Common waiting period you follow after pesticide spray				
	1 Day	3	21.43	2	3.33
	2 Day	11	78.57	56	93.33
	4 Day	0	0.00	4	6.67
	Week	0	0.00	0	0.00
25	What type of bad effects you heard due to pesticide residues in food				
	Cancer	1	7.14	5	8.33
	Physical impairments	4	28.57	14	23.33
	Not heard any bad effects	10	71.43	41	68.33
26	Common method of decontamination followed				
	Salt water wash	3	21.43	10	16.67
	Water wash	12	85.71	48	80.00
27	Best alternative for pesticide use				
	Crop change	0	0.00	0	0.00
	Natural control	3	21.43	8	13.33
	Integrated pest management	5	35.71	15	25
28	What is the disposal method you follow for empty pesticide bottles				
	Bury in soil	0	0.00	0	0.00
	Sell	1	7.14	5	8.33
	Throw in to trash	13	92.86	55	91.67

Note: Figures in percentage are with respect to their respective frequency

Table 4.1.4. Information on occurrence of insect pests

Particulars		Poly house (n=14)		Open field (n=60)	
SI. No	Insect pest	Frequency	Percentage	Frequency	Percentage
1	Fruit borer (<i>Helicoverpa armigera</i>)	11	78.57	57	95.00
2	Leaf eating caterpillar (<i>Spodoptera litura</i>)	8	57.14	42	70.00
3	Serpentine leaf miner (<i>Liriomyza trifolii</i>)	12	85.71	53	88.33
4	Thrips	10	71.43	41	68.33
5	Leaf hopper	7	50.00	29	48.33

Table 4.1.5. Types of pesticides used by tomato growers

Particulars				Poly house (n=14)		Open field (n=60)	
Sl.NO	Chemical name	Trade name	Price (Rs per lit / kg)	Frequency	Percentage	Frequency	Percentage
1	Imidacloprid 17.8% SL	Confidor	2400	10	71.43	49	81.67
2	λ -Cyhalothrin 5% EC	Karate	712	8	57.14	32	53.33
3	Monocrotophos 36% SL	Monophos	466	4	28.57	7	11.67
4	Thiomethoxam 25% WG	Actara	4040	11	78.57	30	50.00
5	Chlorantraniliprole 18.5% SC	Coragen	15000	12	85.71	49	81.67
6	Emamectin benzoate 5 % SG	Proclaim	8900	9	64.29	19	31.67
7	Novaluron 5.2 % + Indaxacarb 4.5% SC	Plethora	2600	8	57.14	44	73.33
8	Chlorfenapyr 10% SC	Interprid	2500	9	64.29	13	21.67
9	Spionsad 48 % SC	Tracer	13500	10	71.43	43	71.67
10	Acetamaprid 20% SP	Pride	1600	7	50.00	16	26.67
11	Fipronil 5 SC	Regent	1200	13	92.86	48	80.00
12	Flubendiamide 48% SC	Fame	15000	7	50.00	41	68.33
13	Lufenuron 5.4% EC	Cigna	2776	6	42.86	36	60.00
14	Chlorpyrifos 2% EC	Chlorocil	370	7	50.00	44	73.33
15	Deltamethrin 1% + Triazophos 35%	Sarpunch	640	3	21.43	25	41.67

Note: Figures in percentage are with respect to their respective frequency

4.2 Dissipation dynamics of selected insecticides on Tomato under two different situations (poly house and open field).

Dissipation pattern of most commonly used insecticides *viz.*, dimethoate, lambda-cyhalothrin, phosalone, flubendiamide and profenophos was studied in two situations (farmers field and poly house) spraying @ 300 g a.i. ha⁻¹, 15 g a.i. ha⁻¹, 450 g a.i. ha⁻¹, 48 g a.i. ha⁻¹ and 500 g a.i. ha⁻¹, respectively twice; first spray at fruit formation stage and second spray after 10 days.

The fruit samples were collected at regular intervals after second spray and analysed for initial deposits and residues following the validated QuEChERS method. The results on dissipation pattern of above mentioned pesticide in tomato fruits were presented here under.

4.2.1 Dissipation of Dimethoate

The dissipation dynamics of dimethoate from the studies conducted in open field and poly house situation was studied by collecting samples at 0, 1, 3, 5, 7, 10, 15 and 20 days after second spray and results are presented in Tables 4.2.1a and 4.2.1b and depicted in Figures 4.2.1a and 4.2.1b.

In open field situation, initial deposits of 1.31 mg kg⁻¹ dimethoate were detected at 2 hours after last spray, which dissipated to 0.62, 0.47 and 0.12 mg kg⁻¹ and Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 1, 3, 5 and 7 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 5th day and residues were dissipated by 52.67, 64.12 and 90.83 % at 1, 3, and 5 days, respectively. The regression equation was $Y = 1.035 + (-0.165) X$ with R² of 0.843.

There are no maximum residue limit (MRL) for dimethoate on tomato as per Codex Alimentarius Commission (CAC), while Food Safety and Standards Authority of India (FSSAI) suggests 2 mg kg⁻¹ for fruits and vegetables, and hence safe waiting period of 1 day can be suggested, as the initial deposits are less than the MRL. The half life of dimethoate on tomato was 4.20 days in open field situation.

In poly house, initial deposits of 1.76 mg kg⁻¹ dimethoate detected at 2 hours after last spray, dissipated to 1.14, 0.55, 0.20, 0.09 mg kg⁻¹ and BDL by 1, 3, 5, 7 and 10 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 10th day and the residues dissipated by 35.22, 68.75, 88.63 and 94.88% at 1, 3, 5 and 7 days, respectively. The regression equation was $Y = 1.338 + (-0.165) X$ with R² of 0.805.

There are no maximum residue limit for dimethoate in tomato are suggested by Codex Alimentarius Commission (CAC) and Food Safety and Standards Authority of India (FSSAI) suggests 2 mg kg^{-1} for fruits and vegetables, and the suggested safe waiting period of 1 day can be recommended based on the recommended dose of dimethoate spray, as the initial deposits are less than the MRL. The half life of dimethoate on tomato was 4.20 days in poly house.

From Tables 4.2.1a and 4.2.1b, it is evident that there is clear difference in dissipation pattern of dimethoate in poly house and open fields. Initial deposit of 1.76 mg kg^{-1} was recorded in poly house, where as in open fields it was 1.31 mg kg^{-1} . Dimethoate reached Below Determination Level (BDL) of 0.05 mg kg^{-1} by 10th day in poly house where as in open field trial by 7th day.

The above findings are in agreement with findings of Gajbhiye *et al.* (1994) who reported dimethoate @ $360 \text{ g a.i. ha}^{-1}$ sprayed on bottle guard, bitter gourd and musk melon recorded initial deposit of 1.20, 1.15 and 1.10 mg kg^{-1} respectively and which dissipated to Below Determination Level (BDL) by 7th day in all three crops, safe waiting period of 3 days was suggested in all three crops. The trials conducted on okra spraying dimethoate @ 0.06% recorded initial deposit of 2.93 mg kg^{-1} and the PHI (Pre-Harvest Interval) of 2 days is suggested by Khan, 1997.

Since sufficient literature is not available on the dissipation pattern dimethoate in tomato or on related crops in poly houses, discussion part for poly house data is not done. However, it can be attributed that the dissipation is slow in poly houses compared to open fields due to very common factors such as cool climatic conditions and less sun light penetration in poly house.

The studies are very helpful for the fixation of MRLs and recommendation of MRLs based on the dose recommendations of dimethoate in poly houses / controlled environmental conditions, and based on the present scientific studies 1 day PHI can be recommended taking in to consideration of initial deposits and dissipation dynamics of dimethoate in both open field and poly house.

Table 4.2.1 a. Dissipation of dimethoate in tomato in open fields

Days after last spray	Residues of dimethoate (mg kg ⁻¹)					Dissipation (%)
	R1	R2	R3	R4	Average	
0	1.31	1.33	1.31	1.31	1.31	0
1	0.62	0.62	0.63	0.61	0.62	52.67
3	0.46	0.48	0.46	0.48	0.47	64.12
5	0.14	0.14	0.11	0.11	0.12	90.83
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 1.035 + (-0.165) X					
R ²	0.843					
Half-life	4.20 days					
Safe waiting period	: 1 day					
Codex MRL	: NA					
FSSAI MRL	: 2 mg kg ⁻¹ for Fruits and Vegetables					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

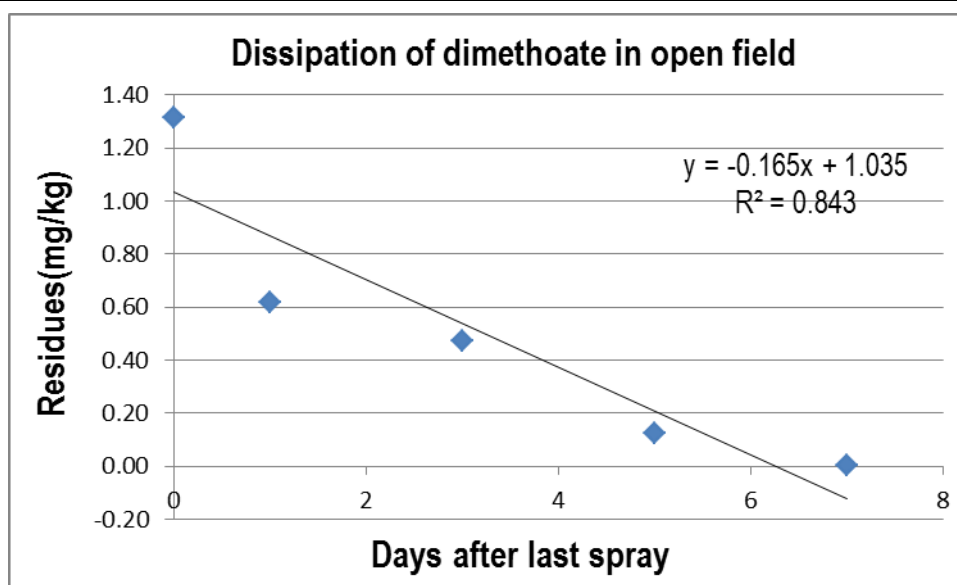


Fig. 4.2.1 a. Dissipation of dimethoate in tomato in open fields

Table 4.2.1 b. Dissipation of dimethoate in tomato in poly house

Days after last spray	Residues of dimethoate (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	1.81	1.77	1.65	1.80	1.76	0
1	1.16	1.14	1.14	1.12	1.14	35.22
3	0.56	0.54	0.56	0.56	0.55	68.75
5	0.20	0.19	0.20	0.20	0.20	88.63
7	0.08	0.09	0.09	0.09	0.09	94.88
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 1.338 + (-0.165) X					
R ²	0.805					
Half-life	4.20 days					
Safe waiting period	: 1 day					
Codex MRL	: NA					
FSSAI MRL	: 2 mg kg ⁻¹ for Fruits and Vegetables					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

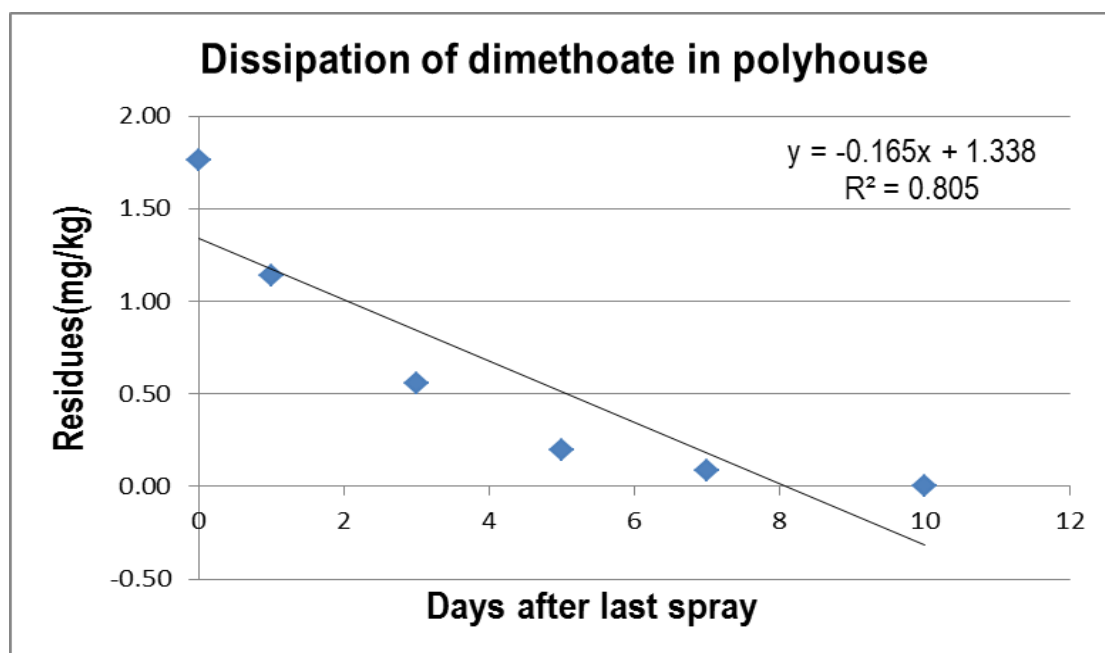


Fig. 4.2.1 b. Dissipation of dimethoate in tomato in poly house

4.2.2 Dissipation of Lambda cyhalothrin

The dissipation kinetics of lambda cyhalothrin on tomato in open field and poly house situation studied collecting fruit samples at 0, 1, 3, 5, 7, 10, 15 and 20 days after second spray of lambda cyhalothrin @ 15 g ai ha⁻¹ are presented in Tables 4.2.2a and 4.2.2b and depicted in Figures 4.2.2a and 4.2.2b.

Initial deposits of 0.13 mg kg⁻¹ lambda cyhalothrin were detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 5th day after last spraying on tomato in open field trials. The initial deposits were dissipated to 0.08 and 0.06 mg kg⁻¹ by 1, and 3 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 3rd day and residues dissipated by 38.46 and 53.84% at 1 and 3 days, respectively. The regression equation was $Y = 0.121 + (-0.024) X$ with R² of 0.957.

There are no MRLs suggested for lambda cyhalothrin in tomato by either Codex Alimentarius Commission (CAC) or by Food Safety and Standards Authority of India (FSSAI), but as per Insecticide Act, 1968, while recommending lambda cyhalothrin @ 15 g ai ha⁻¹ for fruit borer management, PHI of 3 days was recommended. Since no MRLs are available, PHI of 3 days can be recommend as the residues dissipated to 0.06 mg kg⁻¹.

In poly house, an initial deposit of 0.18 mg kg⁻¹ lambda cyhalothrin was detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 7th day after last spraying on tomato. The initial deposits were dissipated to 0.10, 0.07 and 0.06 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 5th day. The residues dissipated by 44.44, 61.11 and 66.66% at 1, 3 and 5 days, respectively. The regression equation was $Y = 0.148 + (-0.021) X$ with R² of 0.867.

There are no MRLs suggested for lambda cyhalothrin in tomato by either Codex Alimentarius Commission (CAC) or by Food Safety and Standards Authority of India (FSSAI), but as per Insecticide Act, 1968, while recommending lambda cyhalothrin @ 15 g ai ha⁻¹ for fruit borer management, PHI of 5 days was recommended for poly house sprays. Since no MRLs are available, PHI of 5 days can be recommend as the residues dissipated to 0.06 mg kg⁻¹.

Table 4.2.2 a. Dissipation of lambda cyhalothrin in tomato in open fields

Days after last spray	Residues of lambda cyhalothrin (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	0.13	0.13	0.13	0.13	0.13	0
1	0.09	0.09	0.08	0.08	0.08	38.46
3	0.06	0.05	0.05	0.06	0.06	53.84
5	BDL	BDL	BDL	BDL	BDL	100.00
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 0.121 + (-0.024) X					
R ²	0.957					
Half-life	28.87 days					
Safe waiting period	: 3 days					
Codex MRL	: NA					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

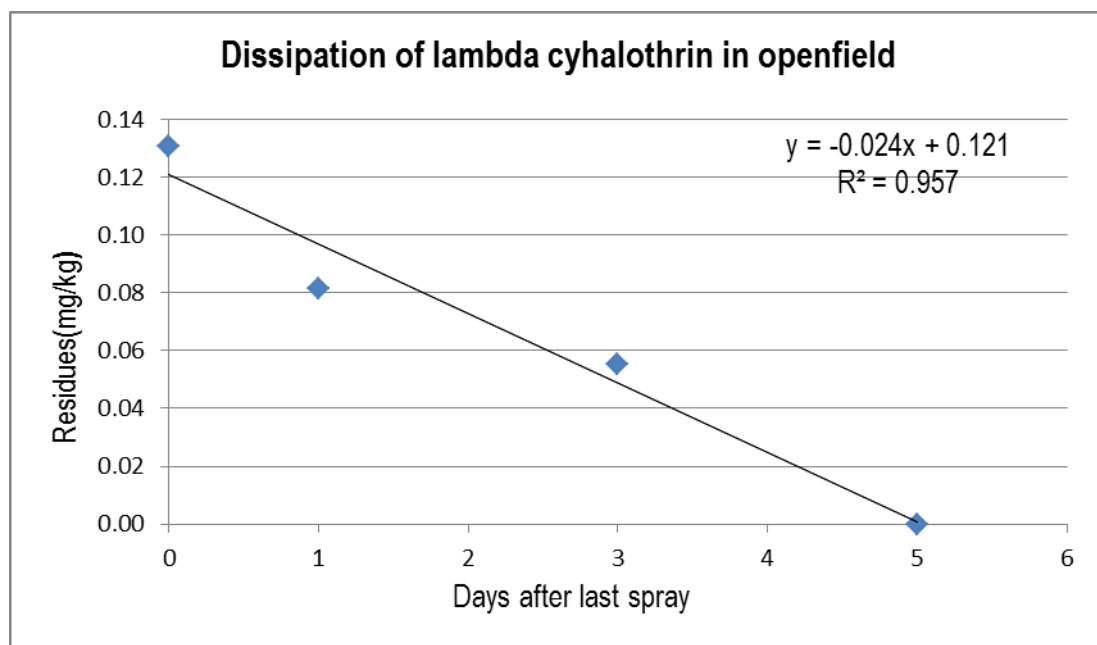


Fig. 4.2.2 a. Dissipation of lambda cyhalothrin in tomato in open fields

Table 4.2.2 b. Dissipation of lambda cyhalothrin in tomato in poly house

Days after last spray	Residues of lambda cyhalothrin (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	0.18	0.18	0.18	0.17	0.18	0
1	0.11	0.10	0.10	0.10	0.10	44.44
3	0.07	0.07	0.07	0.07	0.07	61.11
5	0.05	0.06	0.06	0.05	0.06	66.66
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 0.148 + (-0.021) X					
R ²	0.867					
Half-life	33 days					
Safe waiting period	: 5 days					
Codex MRL	: NA					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

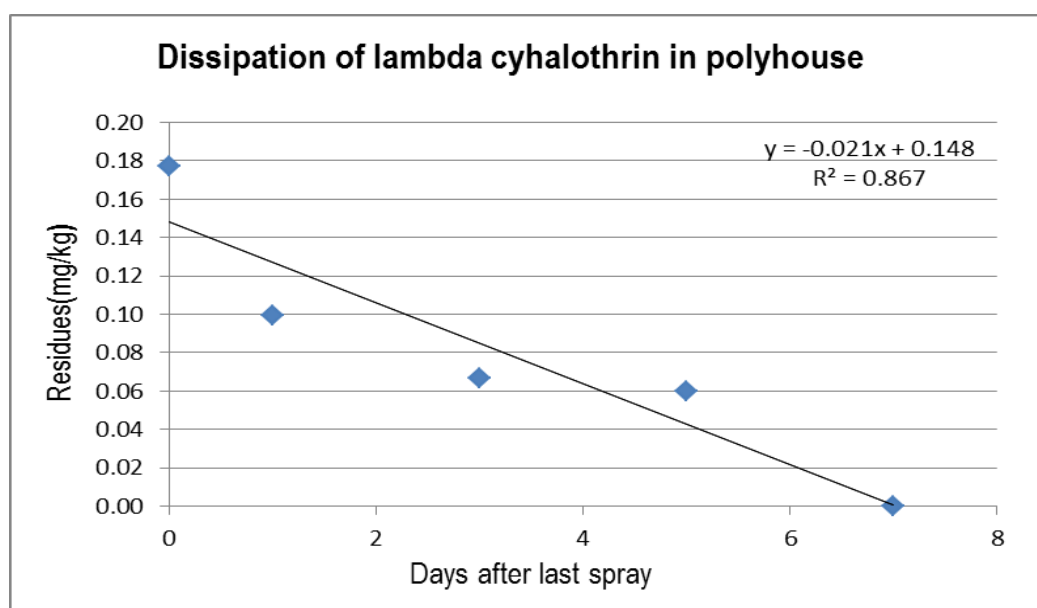


Fig. 4.2.2 b. Dissipation of lambda cyhalothrin in tomato in poly house

From Tables 4.2.2a and 4.2.2b, it is evident that there is no much difference in dissipation pattern of lambda cyhalothrin in poly house and open fields. Initial deposit of 0.18 mg kg⁻¹ was recorded in poly house, where as in open fields it was 0.13 mg kg⁻¹. Half life value of 33 days was recorded in poly house and 28.87 days in open field trial, R² value of 0.867 was recorded in poly house and 0.957 in open field.

Dimethoate reached Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 7th day in poly house where as in open field trial by 5th day.

Since sufficient literature is not available on the dissipation pattern lambda cyhalothrin in tomato or on related crops in poly houses, discussion part for poly house data is not done. The information available on related crops is also taken into account for discussion of open field data.

The above findings are in agreement with results of Jayakrishna *et al.* (2005) who reported that lambda cyhalothrin sprayed @ 15 g a.i. ha⁻¹ on tomato fruits recorded initial deposit of 0.38 mg kg⁻¹ and residues reached Below Determination Level (BDL) by 7th day, they suggested waiting period of 3 days. At double the recommended dose i.e. @ 30 g a.i. ha⁻¹, initial deposit of 0.52 mg kg⁻¹ dissipated to BDL by 10th day, with half-life of 3.7 days. The findings of present investigations are also in line with results of Natekar *et al.* (1988) who reported that lambda cyhalothrin sprayed @ 0.005% on brinjal reported initial deposit of 0.13 mg kg⁻¹ and residues reached Below Determination Level (BDL) by 8th day and suggested waiting period was 1 day.

The dissipation dynamics of lambda cyhalothrin on tomato in both open field and poly house are in first order kinetics, and are in agreement with the results reported by Ahuja *et al* (2006) on brinjal at both recommended (@ 15 g a.i. ha⁻¹) and double dosage (@ 30 g a.i. ha⁻¹) where the initial deposits of 0.75 mg kg⁻¹ dissipated to BDL in 10 days, and 1.27 mg kg⁻¹ dissipated to BDL in 10 days, respectively. Further, it was also reported that the initial deposits may vary with formulation for the same dosage.

The initial deposits and dissipation vary from crop to crop depending up on the crop canopy, season, age of the crop, sample matrix, surface area of sample etc., and the same can be witnessed based on the test reports published by Pawar *et al* (1993), Sharma and Awasthi (2002), Singh and Singh (2003) and Ahuja *et al* (2006) on various crops at different doses.

4.2.3 Dissipation of Phosalone

The residue data of phosalone from the studies conducted in open field and poly house situations through analysis of tomato fruit samples collected at 0, 1, 3, 5, 7, 10, 15 and 20 days after second spray are presented in Tables 4.2.3a and 4.2.3b and depicted in Figures 4.2.3a and 4.2.3b.

The tomato fruit samples collected from phosalone sprayed @ 450 g ai ha⁻¹ plots in open fields recorded an initial deposit of 2.52 mg kg⁻¹ at 2 hours after last spray, dissipated to 1.55 and 0.60 mg kg⁻¹ by 1 and 3 days, respectively, and BDL of 0.25 mg kg⁻¹ by 5th day. The dissipation pattern showed fast decrease / dissipation of residues from first day to 3rd day where the residues dissipated by 38.49% and 76.19% at 1 and 3 days, respectively. The regression equation was $Y = 2.259 + (-0.485) X$ with R² of 0.949.

Phosalone is recommended for use on tomato against fruit borer as per Insecticide Act, 1968 @ 450 g a.i. ha⁻¹ and Food Safety and Standards Authority of India (FSSAI) fixed MRL as 1 mg kg⁻¹ for vegetables. As per the Act, PHIs are not recommended. As Codex, MRLs are not fixed for phosalone on tomato. Based on the present studies, it was found that the half life of phosalone on tomato was 0.82 days in open field, and hence a safe waiting period (PHI) of 3 days can be recommended as the residues dissipated to LOQ of 0.05 mg kg⁻¹ by 3rd day.

In poly house studies, initial deposits of 4.55 mg kg⁻¹ phosalone were detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.25 mg kg⁻¹ by 7th day after last spraying on tomato. The initial deposits were dissipated to 3.62, 2.09 and 0.86 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 5th day. The residues dissipated by 20.43, 54.06, 81.09% at 1, 3 and 5 days, respectively. The regression equation was $Y = Y = 4.313 + (-0.652) X$ with R² of 0.949. The half life of phosalone on tomato was 1.06 days.

There are no maximum residue limit for phosalone in tomato as per Codex Alimentarius Commission (CAC) while Food Safety and Standards Authority of India (FSSAI) suggests 1 mg kg⁻¹ for vegetables, and hence based on the present study, PHI of 5 days can be recommended as the residues degraded to BDL by 7th day.

Table 4.2.3 a. Dissipation of phosalone in tomato in open fields

Days after last spray	Residues of phosalone (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	2.34	2.58	2.72	2.44	2.52	0
1	1.68	1.50	1.49	1.53	1.55	38.49
3	0.63	0.70	0.55	0.54	0.60	76.19
5	BDL	BDL	BDL	BDL	BDL	100.00
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	$Y = 2.259 + (-0.485) X$					
R ²	0.949					
Half-life	1.42 days					
Safe waiting period	: 3 days					
Codex MRL	: NA					
FSSAI MRL	: 1 mg kg ⁻¹					
BDL	: Below Determination Level (< 0.25 mg kg ⁻¹)					
NA	: Not available					

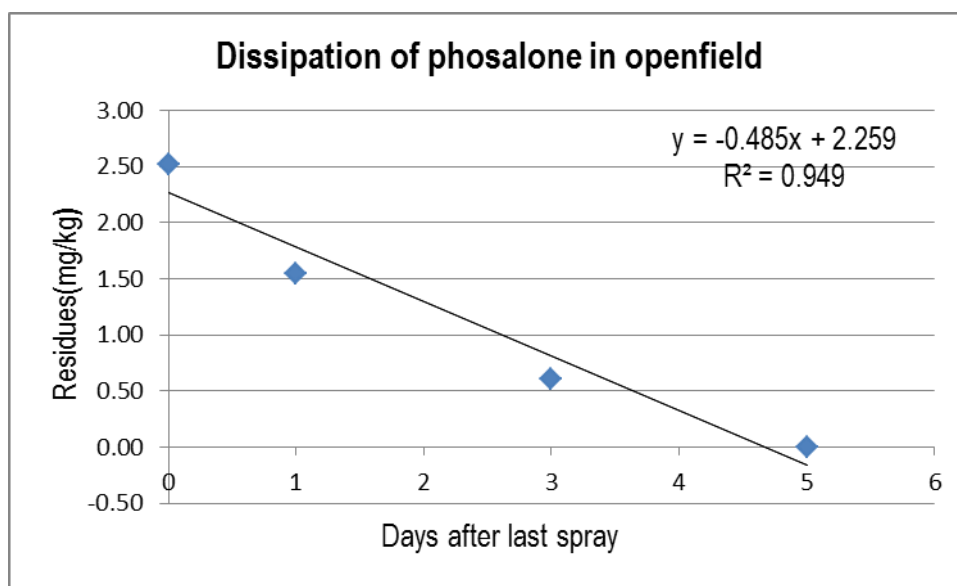


Fig. 4.2.3 a. Dissipation of phosalone in tomato in open fields

Table 4.2.3 b. Dissipation of phosalone in tomato in poly house

Days after last spray	Residues of phosalone (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	4.51	4.73	4.72	4.24	4.55	0
1	3.65	3.59	3.63	3.62	3.62	20.43
3	2.00	2.00	2.16	2.19	2.09	54.06
5	0.95	0.78	0.77	0.94	0.86	81.09
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 4.313 + (-0.652) X					
R ²	0.983					
Half-life	1.06 days					
Safe waiting period	: 5 days					
Codex MRL	: NA					
FSSAI MRL	: 1 mg kg ⁻¹					
BDL	: Below Determination Level (< 0.25 mg kg ⁻¹)					
NA	: Not available					

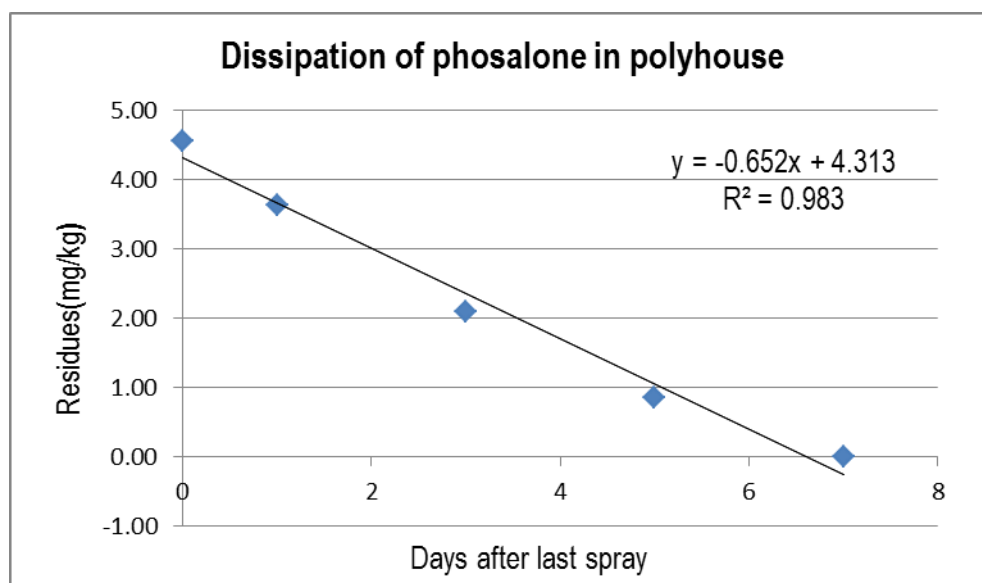


Fig. 4.2.3 b. Dissipation of phosalone in tomato in poly house

From Tables 4.2.3a and 4.2.3b, it is evident that there is a clear difference in dissipation pattern of phosalone in poly house and open fields. Initial deposit of 4.55 mg kg⁻¹ was recorded in poly house, where as in open fields it was 2.52 mg kg⁻¹ which dissipated to BDL of 0.25 mg kg⁻¹ by 7th day and 5th day, respectively. Half life value of 1.06 days was recorded in poly house and 1.42 days in open field trial.

In general, the studies conducted by various groups of scientists (Rajukannu *et al*, 1979 and Narasimha Rao *et al* 1986) on dissipation of phosalone on tomato, suggests that an initial deposit of 7.40-7.80 mg kg⁻¹ were recorded, which dissipated to BDL by 7-10 days depending up on the stage of application at a dose of 700 g ai ha⁻¹, and in the present study, an initial deposit of 2.52 mg kg⁻¹ in open field, and 4.55 mg kg⁻¹ in poly house from 450 g ai ha⁻¹ applied plots suggests that the results are in full agreement with the general trend. Further, based on the reports published by Pokharkar and Dethe, 1980; Anand and Murthy, 1982 suggests that when applied at 0.05% level on okra and black gram, respectively, initial deposits of phosalone around 10-11 mg kg⁻¹ was recorded.

The findings of present investigation are in agreement with results of Pareek *et al*. (1990) who reported that initial deposits of 4.74 mg kg⁻¹ phosalone dissipated and persisted up to 7th day with half life values of 2.96 days when applied @ 310 g a.i. ha⁻¹ on round gourd. Rajukannu *et al*. (1980) reported that phosalone when applied @ 700 g a.i. ha⁻¹ on brinjal reached Below Determination Level (BDL) by 5th day with half life value of 1.56 and suggested waiting period was 1.55 days. Based on the available literature on dissipation of phosalone on various vegetable crops, it is clear that in most cases, the initial deposits are in the range of 7 to 10 mg kg⁻¹ at recommended doses which dissipated to BDL in 7-15 days, depending up on the season and crop. In the present study on tomato, phosalone dissipation pattern is in agreement with all available literature clearly indicating that phosalone dissipates to BDL in 5-7 days depending up on the crop management practices. In the existing circumstances where no MRLs are available, PHI of 5 days can be safety suggested for food safety.

4.2.4 Dissipation of Flubendiamide

The residue data of flubendiamide from the studies conducted in open field and poly house situation are presented in Tables 4.2.4a and 4.2.4b and depicted in Figures 4.2.4a and 4.2.4b.

Initial deposits of 0.90 mg kg^{-1} flubendiamide were detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.05 mg kg^{-1} by 7th day in open field conditions. The initial deposits were dissipated to 0.49, 0.29 and 0.93 mg kg^{-1} in 1, 3 and 5 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 5th day. The residues dissipated by 45.55, 67.77 and 85.55% at 1, 3 and 5 days, respectively. The regression equation was $0.727 + (-0.114) X$ with R^2 of 0.876.

Maximum Residue Limits (MRLs) are not fixed for flubendiamide on tomato as per FSSAI, while Codex Alimentarius Commission (CAC) set as 2 mg kg^{-1} . Based on the present study, safe waiting period of 1 day can be suggested as the initial deposits are less than the MRL. The half life of flubendiamide on tomato was 6.07 days.

In poly house studies, initial deposits of 1.23 mg kg^{-1} flubendiamide were detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.05 mg kg^{-1} by 10th day after last spraying on tomato. The initial deposits were dissipated to 0.76, 0.34, 0.15 and 0.08 mg kg^{-1} by 1, 3, 5 and 7 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 7th day. The residues dissipated by 38.21, 72.35, 87.80 and 93.49% at 1, 3, 5 and 7 days, respectively. The regression equation was $Y = 0.912 + (-0.112) X$ with R^2 of 0.782.

Maximum Residue Limits (MRLs) are not fixed for flubendiamide on tomato as per FSSAI, while Codex Alimentarius Commission (CAC) set as 2 mg kg^{-1} . Based on the present study, safe waiting period of 1 day can be suggested as the initial deposits are less than the MRL. The half life of flubendiamide on tomato was 6.18 days.

From tables 4.2.4a and 4.2.4b, it is evident that there is a clear difference in dissipation pattern of flubendiamide in poly house and open fields. Initial deposit of 1.23 mg kg^{-1} was recorded in poly house, where as in open fields it was 0.90 mg kg^{-1} , reaching Below Determination Level (BDL) of 0.05 mg kg^{-1} by 10th day and 7th day, respectively.

Table 4.2.4 a. Dissipation of flubendiamide in tomato in open field

Days after last spray	Residues of flubendiamide (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	0.93	0.87	0.92	0.87	0.90	0
1	0.47	0.48	0.50	0.49	0.49	45.55
3	0.28	0.28	0.30	0.29	0.29	67.77
5	0.14	0.13	0.12	0.14	0.13	85.55
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	$Y = 0.727 + (-0.114) X$					
R ²	0.876					
Half-life	6.07 days					
Safe waiting period	: 1 day					
Codex MRL	: 2 mg kg ⁻¹					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

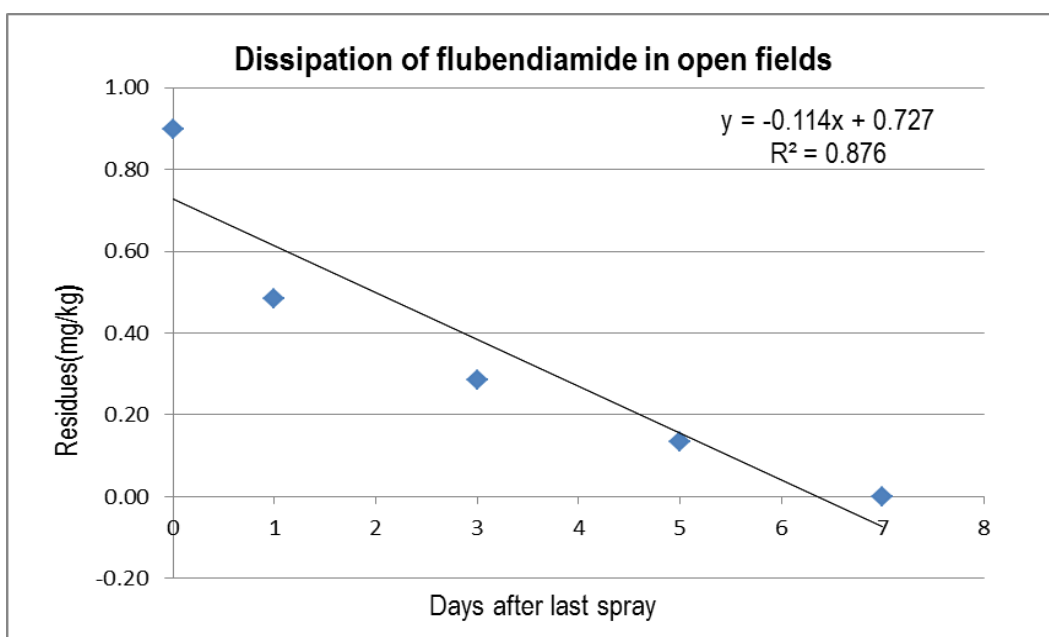


Fig. 4.2.4 a. Dissipation of flubendiamide in tomato in open field

Table 4.2.4 b. Dissipation of flubendiamide in tomato in poly house

Days after last spray	Residues of flubendiamide (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	1.23	1.23	1.23	1.23	1.23	0
1	0.77	0.74	0.76	0.77	0.76	38.21
3	0.35	0.30	0.34	0.35	0.34	72.35
5	0.15	0.14	0.14	0.15	0.15	87.80
7	0.08	0.09	0.07	0.08	0.08	93.49
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 0.912 + (-0.112) X					
R ²	0.782					
Half-life	6.18 days					
Safe waiting period	: 1 day					
Codex MRL	: 2 mg kg ⁻¹					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

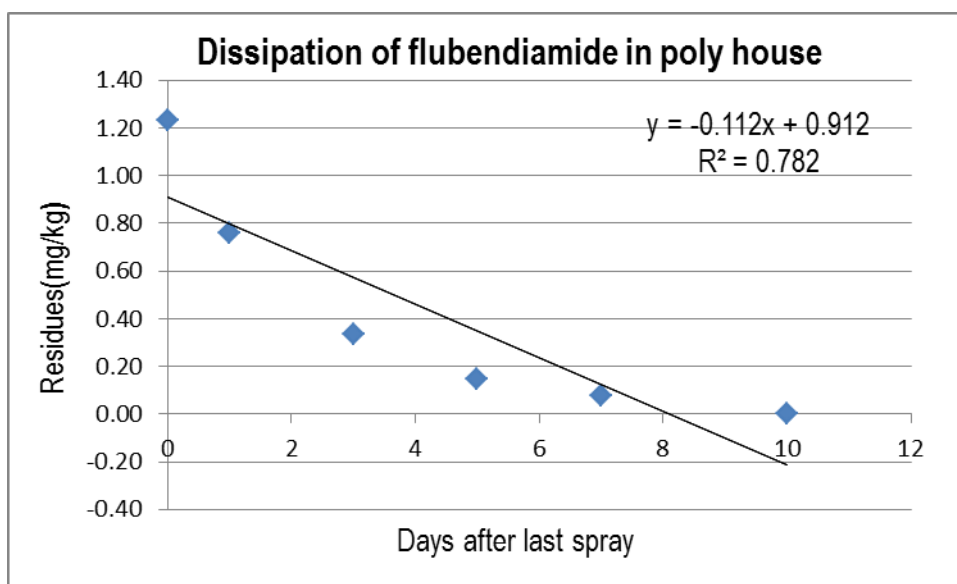


Fig. 4.2.4 b. Dissipation of flubendiamide in tomato in poly house

As per CIBRC and Insecticide Act, 1968, flubendiamide is recommended for use on tomato @ 48 g a.i. ha⁻¹ for controlling fruit borer. The same dosage was used in the present study to know the dissipation dynamics in tow situations and it is evident that 0.90 mg kg⁻¹ initial deposits dissipated to BDL level by 7th day in open field situation, and the findings of present investigation are in agreement with the results of Sharma *et al.* (2013) who reported that flubendiamide persisted up to 5 days after application on tomato @ 48 g a.i. ha⁻¹. Similar results were reported by Kooner *et al.* (2010) who reported that flubendiamide persisted up to 5 days after application on tomato @ 48 g a.i. ha⁻¹.

The dissipation of flubendiamide is very slow in case of flubendiamide compared to other pesticides tested in the study in both poly house and open field situations. The flubendiamide in poly house (controlled environment) dissipated at very slow rate and it is degraded to BDL by 10th day. Similar trends are also reported by many workers studied on other vegetables as well. Sahoo *et al.* (2009) reported that flubendiamide sprayed on chilli @ 60 g a.i. ha⁻¹ resulted initial deposit of 1.06 mg kg⁻¹ dissipated to BDL in 7 days and at higher dose, it took 10 days. Jyothsna *et al.* (2012) reported that flubendiamide sprayed on gherkin @ 48 g a.i. ha⁻¹ reported initial deposit of 0.92 mg kg⁻¹ and residues reached Below Determination Level (BDL) by 7th day.

The research findings of various workers such as Paramasivam (2013), shows that flubendiamide spray on cabbage @ 25 g a.i. ha⁻¹ resulted in 0.31 mg kg⁻¹ deposits but persisted up to 15 days to reach BDL, indicating very slow dissipation rates on cabbage. Similar results were reported by Mohapatra *et al.* (2010) where flubendiamide spray on cabbage @ 48 g a.i. ha⁻¹ resulting 0.49 mg kg⁻¹ deposits took 15 days for dissipation to BDL.

Based on the literature it is very clear that flubendiamide dissipates at very slow rate, but however, as the Codex MRL is 2 mg kg⁻¹ on tomato, it can be safely recommended for use with 1 day PHI as initial deposits are below MRL in both cases. Since the Indian government recommends flubendiamide on tomato, MRL of 2 mg kg⁻¹ can also be taken as provisional MRL as per FSSAI, since the initial deposits are very low due to low dose recommendations.

4.2.5 Dissipation of Profenophos

The residue data on profenophos from the studies conducted in open field and poly house situations is presented in Tables 4.2.5a and 4.2.5b with graphical representations in Figures 4.2.5a and 4.2.5 b.

Profenophos is not registered for use on tomato as per Insecticide Act, 1968, but based on the survey reports, it is very much evident that profenophos is most popular and commonly used pesticide and hence field trial was conducted based on the farmer's practice dose @ 500 g ai ha⁻¹ to study the dissipation pattern. The study reveals that, the dose results in initial deposits of 1.51 mg kg⁻¹ profenophos (at 2 hours after last spray) which dissipated to Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 7th day after last spraying on tomato. The initial deposits were dissipated to 0.83, 0.43 and 0.24 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 5th day. The residues dissipated by 45.03, 71.52 and 84.10% at 1, 3 and 5 days, respectively. The regression equation was $Y = 1.219 + (-0.192) X$ with R² of 0.868.

As the Indian Government does not recommend profenophos on tomato, MRLs are also not set. However, maximum residue limit for profenophos in tomato are set by Codex Alimentarius Commission (CAC) and European Union (EU) as 10 mg kg⁻¹. Based on the present investigation, it can concluded and recommended that a PHI of 1 day is good for food safety when applied profenophos.

In poly house experiment, initial deposits of 3.25 mg kg⁻¹ profenophos were detected at 2 hours after last spray, which dissipated to Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 15th day after last spraying on tomato, indicates that profenophos dissipation is slow in poly house compared to open fields. The initial deposits were dissipated to 2.67, 1.66, 0.70, 0.41 and 0.18 mg kg⁻¹ by 1, 3, 5, 7 and 10 days after last spray, respectively. The dissipation pattern showed decrease of residues from first day to 10th day. The residues dissipated by 17.84, 48.92, 78.46, 87.38 and 94.46% at 1, 3, 5, 7 and 10 days, respectively. The regression equation was $Y = 2.520 + (-0.214) X$ with R² of 0.781.

Table 4.2.5 a. Dissipation of profenophos in tomato in open field

Days after last spray	Residues of profenophos (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	1.51	1.57	1.46	1.50	1.51	0
1	0.86	0.82	0.83	0.82	0.83	45.03
3	0.45	0.44	0.46	0.37	0.43	71.52
5	0.25	0.19	0.27	0.26	0.24	84.10
7	BDL	BDL	BDL	BDL	BDL	100.00
10	BDL	BDL	BDL	BDL	BDL	100.00
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	Y = 1.219 + (-0.192) X					
R ²	0.868					
Half-life	3.60 days					
Safe waiting period	: 1 day					
Codex MRL	: 10 mg kg ⁻¹					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

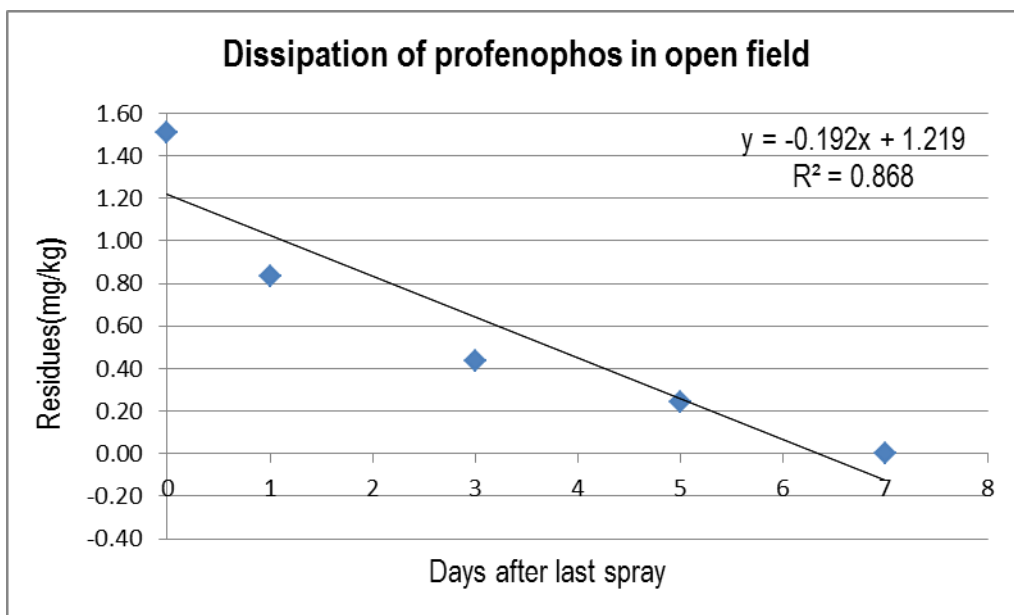


Fig. 4.2.5 a. Dissipation of profenophos in tomato in open field

Table 4.2.5 b. Dissipation of profenophos in tomato in poly house

Days after last spray	Residues of profenophos (mg kg ⁻¹)					Dissipation %
	R1	R2	R3	R4	Average	
0	3.26	3.33	3.22	3.18	3.25	0
1	2.77	2.62	2.65	2.64	2.67	17.84
3	1.70	1.76	1.62	1.58	1.66	48.92
5	0.71	0.71	0.70	0.70	0.70	78.46
7	0.41	0.43	0.37	0.41	0.41	87.38
10	0.18	0.20	0.19	0.15	0.18	94.46
15	BDL	BDL	BDL	BDL	BDL	100.00
20	BDL	BDL	BDL	BDL	BDL	100.00
Regression equation	$Y = 2.520 + (-0.214) X$					
R ²	0.781					
Half-life	3.23 days					
Safe waiting period	: 1 day					
Codex MRL	: 10 mg kg ⁻¹					
FSSAI MRL	: NA					
BDL	: Below Determination Level (< 0.05 mg kg ⁻¹)					
NA	: Not available					

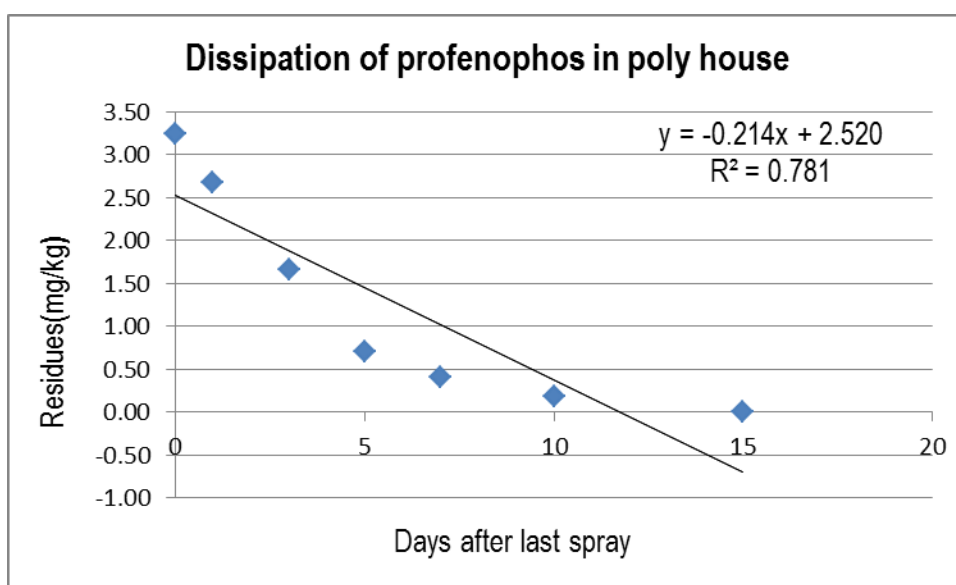


Fig. 4.2.5 b. Dissipation of profenophos in tomato in poly house

As the Indian Government does not recommend profenophos on tomato, MRLs are also not set. However, maximum residue limit for profenophos in tomato are set by Codex Alimentarius Commission (CAC) and European Union (EU) as 10 mg kg⁻¹. Based on the present investigation, it can conclude and recommended that a PHI of 1 day is good for food safety when applied profenophos on tomato cultivated in poly house.

From tables 4.2.5a and 4.2.5b, it is evident that there is a clear difference in dissipation pattern of profenophos in poly house and open fields. Initial deposit of 3.25 mg kg⁻¹ was recoded in poly house, where as in open fields it was 1.51 mg kg⁻¹. Profenophos reached Below Determination Level (BDL) of 0.05 mg kg⁻¹ by 15th day in poly house where as in open field trial by 7th day.

The results are in full agreement with the findings of Sahoo *et al.* (2004) who reported that profenophos spray on tomato @ 500 g a.i. ha⁻¹ first at 50% flowering stage and subsequently at 15 days intervals, resulted in to initial deposit of 1.37 mg kg⁻¹ dissipating to BDL in 15 days, and similar results also reported by Ahmad *et al* 2009 on tomato. Various workers suggested safe waiting periods varying from 1 to 14 days, but as per CCPR guidelines based on CAC MRLs (10 mg kg⁻¹) it is not necessary to recommend waiting periods till the residues reach BDL, and taking into consideration of MRLs set by CAC and results on dissipation dynamics on tomato in present study, it can be scientifically concluded and recommended that PHI of 1 day is exceedingly well as the initial deposits as well below 10 mg kg⁻¹.

Experimental results of Radwan *et al.* (2004a) shows that at application of very high dose @ 1280 g a.i. ha⁻¹ on three crops *viz.*, green pepper, hot pepper and brinjal results in very high initial deposit of 10-11 mg kg⁻¹ on pepper, and 4.50 mg kg⁻¹ on brinjal, which dissipated to BDL in 2 weeks. However, the studies conducted by various workers (Gupta *et al* 2011, Renuka *et al* 2006, Katroju *et al* 2014) on dissipation on profenophos on different crops clearly indicate that when applied at recommended dose, the initial deposits are less than 3 mg kg⁻¹ and dissipates to BDL in 7-10 days depending on the crop, except on cardamom.

4.3 Evaluation of decontamination methods for removal of pesticide residues from tomato

The tomato samples were collected from various plots treated with recommended doses of dimethoate, lambda-cyhalothrin, phosalone, flubendiamide and profenophos to estimate the initial deposits, and efficiency of different test decontamination methods was evaluated through quantification of their residues after subjecting to risk mitigation methods, and the results were presented in Table 4.3.

4.3.1 Dimethoate

Dimethoate is an organophosphorus insecticide with excellent systemic, contact and acaricidal action. Dipping in veggy wash solution for 10 min followed by tap water wash for 30 sec was found to be most effective (76.77% removed) than other treatments. The percentage removal of dimethoate residues due to various decontamination treatments in descending order are tap water wash for 30 sec were veggy wash (76.77 %) > 4% Acetic acid solution (65.49 %) > 2% salt solution (58.69 %) > 0.1% Baking soda solution (52.30 %) > Tap water (23.29 %).

Based on the percentage removal of residues, it was statistically proved that there is significant difference in the efficiency of decontaminating solutions in removing dimethoate residues.

Percentage removal of dimethoate residues from various decontamination methods is depicted in Fig. 4.3.1.

4.3.2 Lambda cyhalothrin

Various decontamination methods were evaluated in order to know their efficiency in removing lambda cyhalothrin residues from tomato fruits. Results revealed that all the treatment solutions significantly differed among each other in their efficiency in removing lambda cyhalothrin residues. Dipping in veggy wash solution for 10 min followed by tap water wash for 30 sec was found to be most effective (68.87%) than other treatments. Next promising treatment was dipping in 4% acetic acid solution for 10 min followed by tap water wash for 30 sec (59.31 %). Other treatments like 2% salt solution (48.02 %), 0.1% baking soda solution (39.59 %) and tap water wash (29.43 %) were also found to remove significant amount of residues from tomato fruits.

Percentage removal of lambda cyhalothrin residues from various decontamination methods is depicted in Fig. 4.3.2.

4.3.3 Phosalone

Tomato fruits sprayed with recommended dose of phosalone were collected 2 hours after spraying and subjected to various decontamination methods. Among the different treatments employed, dipping fruits in veggy wash solution for 10 min followed by tap water wash for 30 sec were found to be more effective (55.13%) than other treatments. Acetic acid solution of 4% (52.34 %) was found to be next promising treatment, followed by 2% salt solution (47.60 %), 0.1% baking soda solution (44.40 %) and tap water wash (39.06 %).

Percentage removal of phosalone residues from various decontamination methods is depicted in Fig. 4.3.3.

4.3.4 Flubendiamide

Flubendiamide residues in tomato were removed significantly when subjected to different decontamination solutions at 2 hours after spraying. Results revealed that dipping in veggy wash solution for 10 min followed by tap water wash for 30 sec was found to be most effective than other treatments. In this treatment residues were reduced up to 65.39 %. Next promising treatment was 4% acetic acid solution (61.63 %) followed by baking soda solution (45.30 %), 2% salt solution (39.75 %) and tap water wash (17.71 %).

Percentage removal of flubendiamide residues from various decontamination methods is depicted in Fig. 4.3.4.

4.3.5 Profenophos

The percentage removal of profenophos residues in tomato when subjected to different decontamination solutions at 2 hours after spraying showed that dipping in veggy wash solution for 10 min followed by tap water wash for 30 sec was found to be most effective removing 75.84% residues, than other treatments. The next promising treatment was 4% Acetic acid solution (71.22 %), followed by 2% salt solution (55.31 %), 0.1% Baking soda solution (47.60 %) and tap water (37.60 %).

Based on the percentage removal of residues, it was statistically proved that there is significant difference in the efficiency of decontaminating solutions in removing residues of above mentioned pesticides.

Percentage removal of profenophos residues from various decontamination methods is depicted in Fig. 4.3.5.

In the present study, veggy wash, a formulation prepared by AINP on Pesticide Residues proved to be the most efficient in removing various pesticides. The next promising treatment was dipping in 4% acetic acid solution for 10 min followed by tap water wash for 30 sec, these findings are in agreement with the results of Dikshit *et al.* (1984) who reported that washing of cowpea with 1% acetic acid solution was capable of removing 85.70 and 88.60 % of metasystox and carbaryl residues. Similar results were reported by Radwan *et al.* (2004b) who reported that washing of hot pepper, sweet pepper and brinjal with 2% acetic acid removed pirimophos-methyl residues by 76.61, 95.74 and 94.58 %.

Reddy and Rao (2004) found that dipping of grapes in 1% acetic acid solution for 10 min, followed by water wash removed 51.80, 46.60, and 70.00% of chlorpyrifos, quinalphos and bifenthrin residues, respectively. Similarly, Zhang *et al.* (2006) found that 79.8, 65.8, 74.0 and 75.0% residues of chlorpyrifos, *p,p*-DDT, cypermethrin and chlorothalonil were removed by washing cabbage with 10% acetic acid solution for 20 min, respectively.

2% salt solution was found to be third best treatment except in case of profenophos where 0.1% baking soda solution was found as third best treatment. The results are in agreement with the findings of Reddy and Rao (2004) who reported 72.80, 67.50, 51.80 and 58.20% removal of acephate, chlorpyrifos, quinalphos and bifenthrin residues from grapes by dipping them in 2% salt solution for 10 min, followed by water wash.

Washing of tomato fruits with 10% salt solution removed 90.80 and 82.40% of dimethoate and profenophos residues (Abou-Arab, 1999), the residues of metasystox and carbaryl were removed up to 86.4% and 88.7% from cowpea by washing with 5% salt solution respectively (Dikshit *et al.*, 1984). Washing of cucumbers in 2% salt solution for 10 min removed residues of trichlorfon, dimethoate, dichlorovos, fenitrothian and chlorpyrifos residues by 46.30, 47.80, 70.20, 28.90 and 60.50 % respectively.

Dipping in 0.1% baking soda (NaHCO_3) solution for 10 min followed by tap water wash was the 4th best treatment in removing residues from tomatoes. The results are in line with the findings of Liang *et al.* (2012) who reported that washing of cucumber with 2% NaHCO_3 was efficient enough to remove the trichlorfon, dimethoate, dichlorovos, fenitrothian and chlorpyrifos residues by 73.20, 58.70, 96.40, 51.10 and 77.80%. Similarly the results are in agreement with Satpathy (2012) who found that tomato fruits washed with 0.1% NaHCO_3 solution removed residues of

parathion, methyl parathion, malathion, fenitrothion, formothion and chlorpyrifos by 73.10, 77.40, 86.80, 57.00, 86.40 and 87.20% respectively. Washing of chinese kale with 0.1% NaHCO₃ solution removed methomyl and carbaryl residues by 43.19 and 91.24 % respectively (Klinhom, 2008).

Tap water wash was the least effective treatment and the findings of present investigations are in agreement with the findings of Abou-Arab (1999) who reported that washing of tomato fruits with water removed dimethoate and profenophos residues up to 18.80 and 22.17 % respectively. Jayakrishnan *et al.* (2005) reported that washing of tomato fruits with water removed lambda cyhalothrin residues by 29-30%. Similar results were obtained by Mergnat *et al.* (1995) who reported that washing of apples with water removed 30-50 % of phosalone residues. 13.5% of profenophos residues were removed from potato tubers when washed with tap water (Zohair, 2001). Similarly tap water wash for 10 min removed trichlorfon, dimethoate, dichlorovos, fenitrothian and chlorpyrifos residues by 36.60, 21.70, 22.60, 22.20 and 59.20 % in cucumber respectively (Liang *et al.*, 2012).

Based on the test reports, it can be concluded that pesticides such as dimethoate, lambda-cyhalothrin, phosalone, flubendiamide and profenophos can be removed from tomato for food safety with simple house processing methods, and out of all methods, washing with AINP formulation i.e. veggy wash proved to be the best, and also economical. So, this result can be propagated and popularized among home makers for removal of pesticides from tomato when used as fresh vegetable salad, and also create confidence that they eat safe food without pesticide residues.

Table 4.3. Effectiveness of various decontamination methods

Figures in the parenthesis are concentration of insecticide residues mg kg⁻¹

Insecticides	Mean per cent removal of insecticides (%) ± SD					
	Decontamination methods					CD (5%)
	Tap water	2% salt solution	0.1% Baking soda solution	4% Acetic acid solution	Veggy wash	
Dimethoate	23.29 ± 1.44 (1.01)	58.69 ± 0.46 (0.54)	52.30 ± 0.68 (0.63)	65.49 ± 0.36 (0.45)	76.77 ± 0.04 (0.31)	1.55
Lambda cyhalothrin	29.43 ± 2.81 (0.09)	48.02 ± 2.14 (0.07)	39.59 ± 2.50 (0.08)	59.31 ± 0.05 (0.05)	68.87 ± 2.19 (0.04)	3.89
Phosalone	39.06 ± 0.72 (1.54)	47.60 ± 1.57 (1.32)	44.40 ± 0.72 (1.40)	52.34 ± 1.04 (1.20)	55.13 ± 0.74 (1.13)	2.10
Flubendiamide	17.71 ± 1.85 (0.74)	39.75 ± 0.95 (0.54)	45.30 ± 0.81 (0.49)	61.63 ± 0.55 (0.34)	65.39 ± 1.15 (0.31)	1.55
Profenophos	37.60 ± 0.95 (0.94)	55.31 ± 0.23 (0.68)	47.60 ± 0.75 (0.79)	71.22 ± 0.42 (0.43)	75.84 ± 1.37 (0.37)	1.57

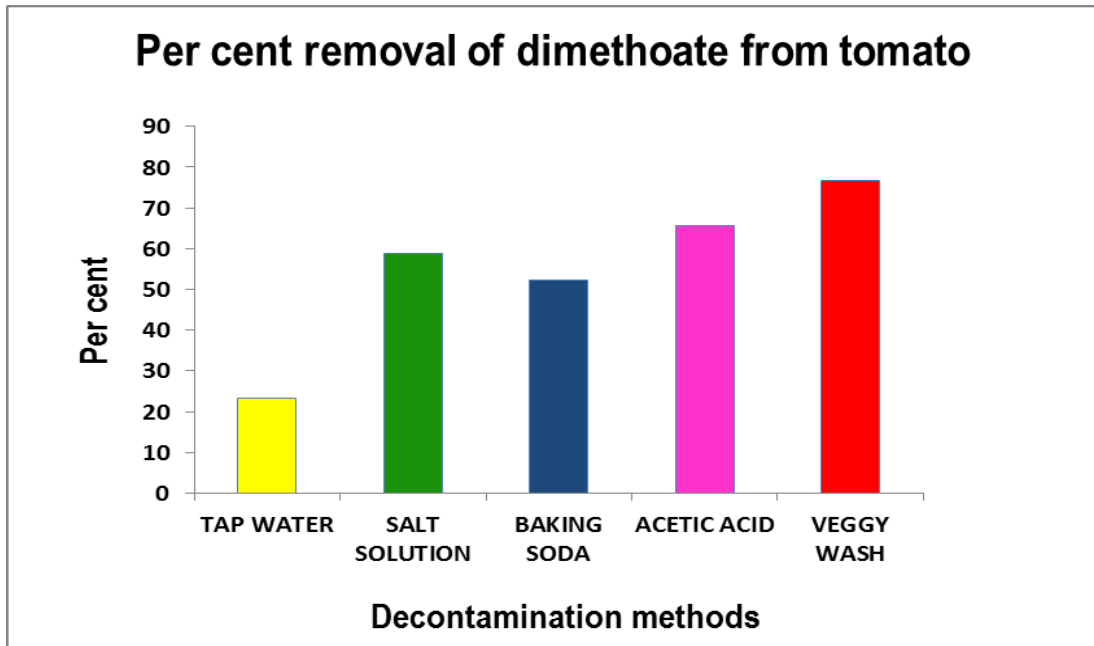


Fig. 4.3.1. Per cent removal of dimethoate residues from tomato by various decontamination methods

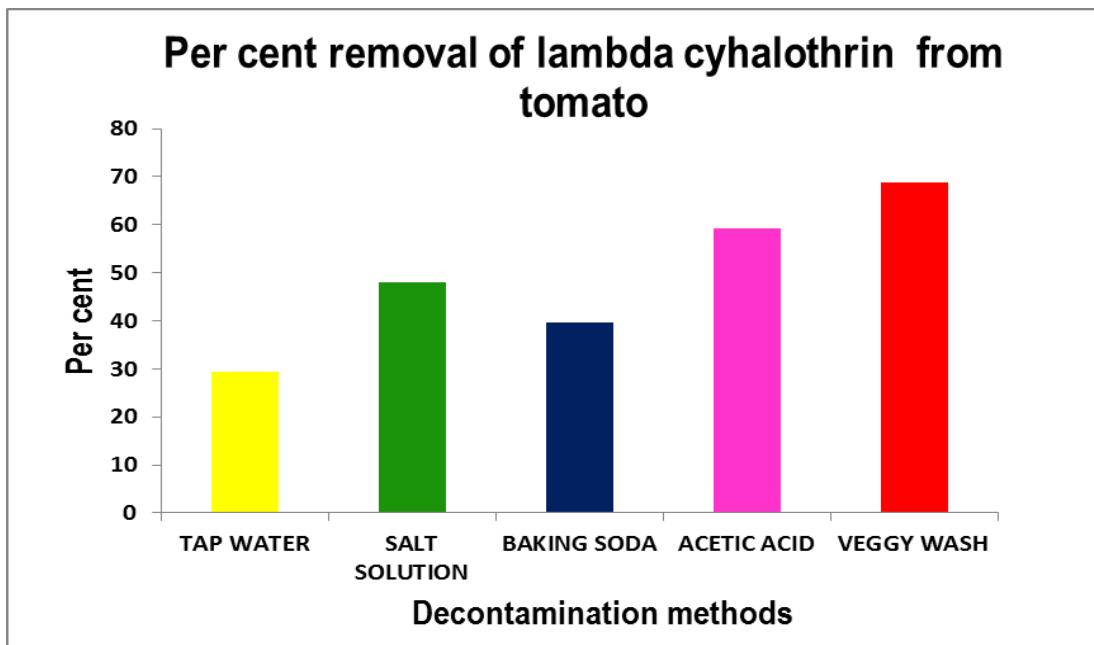


Fig. 4.3.2. Per cent removal of lambda cyhalothrin residues from tomato by various decontamination methods

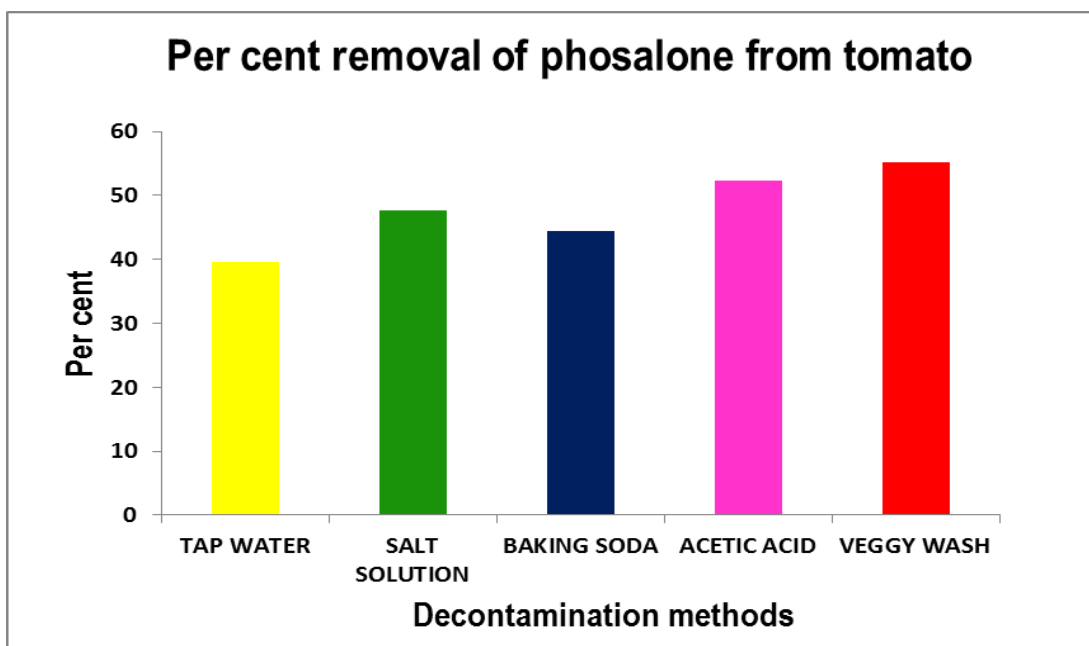


Fig. 4.3.3. Per cent removal of phosalone residues from tomato by various decontamination methods

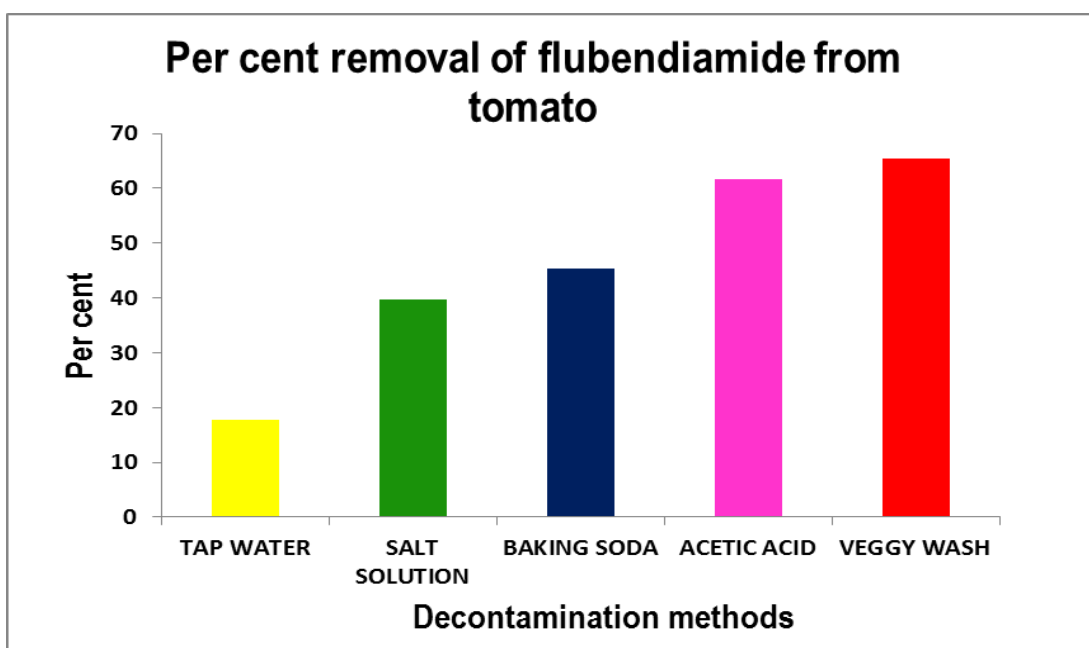


Fig. 4.3.4. Per cent removal of flubendiamide residues from tomato by various decontamination methods

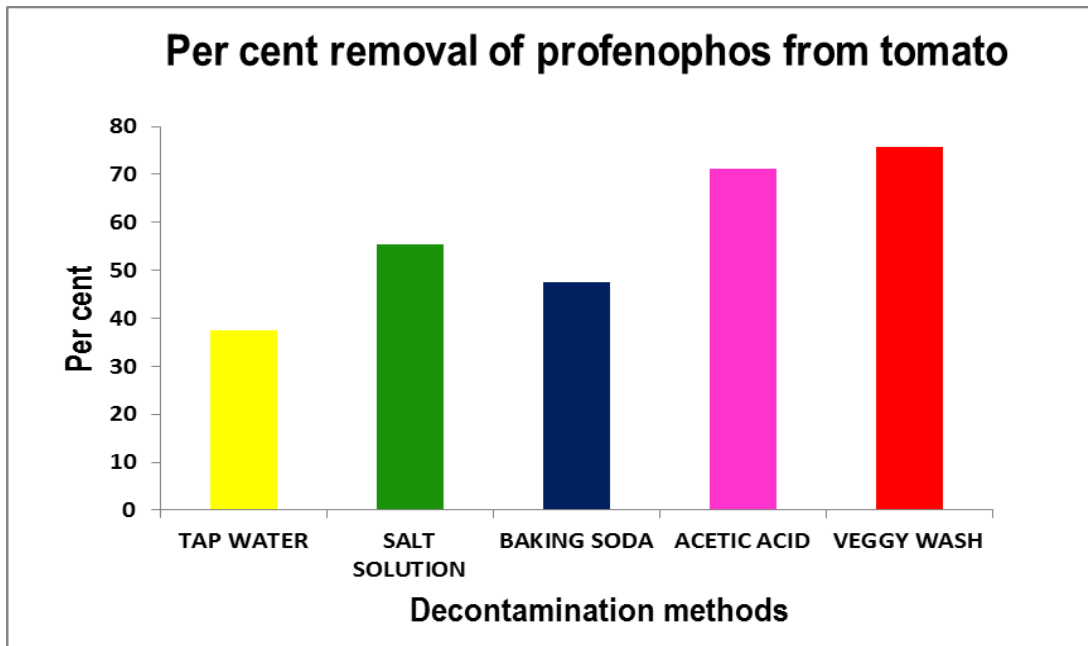


Fig. 4.3.5. Per cent removal of profenophos residues from tomato by various decontamination methods

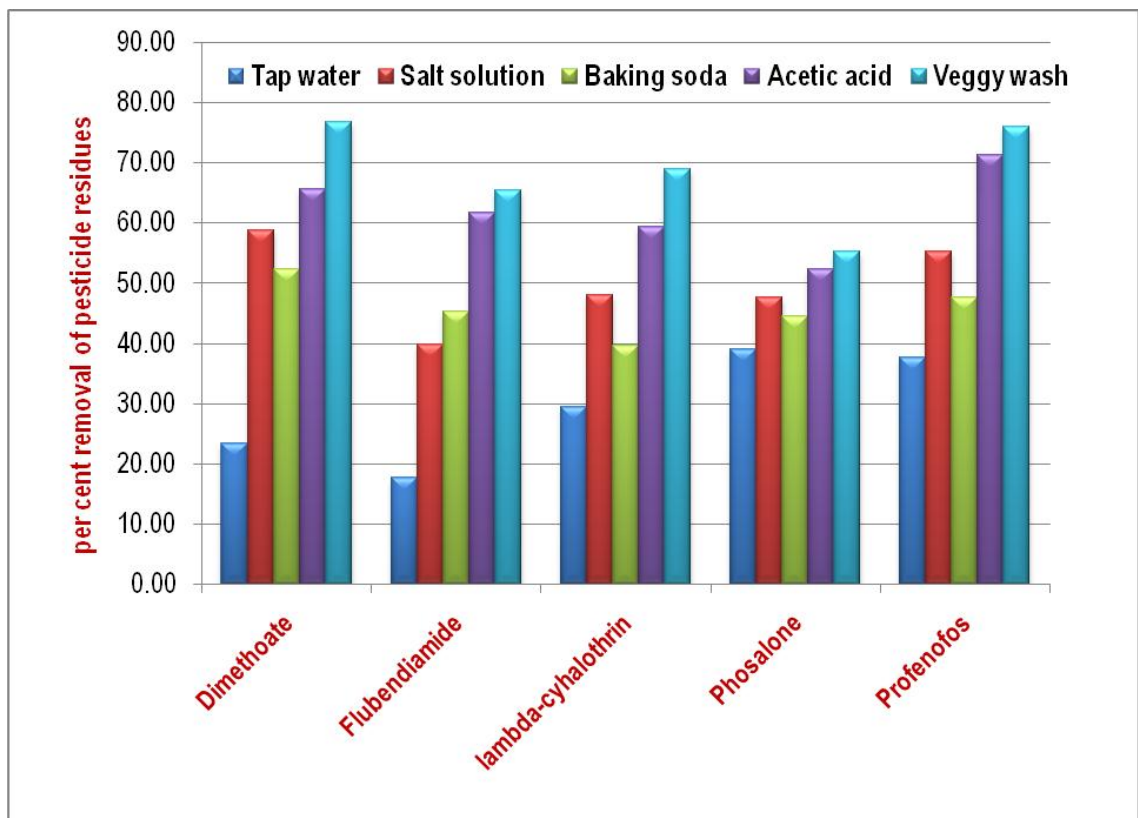


Fig. 4.3.6. Per cent removal of pesticide residues from tomato by various decontamination methods

**SUMMARY
AND
CONCLUSIONS**

Chapter V

SUMMARY AND CONCLUSIONS

To meet the objectives of the study, farmers growing tomato in open fields and in poly houses (controlled environment) were interviewed based on the questionnaire prepared to assess their knowledge and practices on crop cultivation, general awareness on pesticide recommendations and use, pesticide classifications, toxicity, pesticide residues and disposal mechanisms. Based on the survey data on insecticides and most commonly used in their farms, studies on dissipation pattern / dynamics of selected insecticide was studied in tomato grown in poly house and open field situation to establish the variations in dissipation pattern. Further, selected decontamination methods were evaluated for removal pesticide residues from tomato to recommend the best house hold practice for food safety.

Based on the survey, results of the study can be summarized as majority of the farmers growing tomato in poly house survey were in the age >50 years (42.86%), while 43.33 % of farmers growing tomato in open fields were in between 40-50 years. Majority of poly house tomato growers (42.86 %) studied high school, while open field tomato farmers are illiterates (33.33%). More than 70% of sample farmers belonged to nuclear family.

In both poly houses (85.71 %) and open fields (78.33%) farmers, preferred seedlings of 25 days old for planting purpose. Most of the poly house growers cultivating tomato in area of < 0.5 acre (92.86 %) and incase of open fields, most of them cultivated in 1 acre area (40.00 %). Most of the poly house famers preferred to cultivate tomato in *summer* (92.86 %) and *rabi* (64.29 %) seasons, whereas open field growers preferred to cultivate crop in *kharif* (100%). More than 65% of farmers in open fields preferred to grow crop up to 5 months and more than 60% poly house farmers preferred to grow crop > 5 months. Based on the survey, it is clear that most of the famers are regular tomato growers, growing tomato since more than 3 years both in poly house and open fields.

Majority of the farmers both in poly houses (83.33%) and open fields (64.29 %) were not aware about recommended pesticides against different pests, similarly 93.33% of open field and 85.71% of poly house farmers were not aware about the pesticide classification based on toxicity. Majority of poly house farmers measure required chemical quantity using bottle cap (92.85 %) and in open fields most of the farmers preferred to measure chemical approximately (55%). Both in poly houses and open

fields (more than 95%) farmers preferred to mix chemical by using stick rather than using bare hands. When interviewed, 96.67% of open field and 92.86% of poly house farmers disclosed that they do not follow safe methods while storing / mixing / spraying pesticides. Majority of the respondents both in poly house (85.71%) and open field (95%) observed pesticide effect on health of spray men during spray and most commonly observed health effects includes skin irritation, cough, and head ache and major first aid techniques followed were inducing of vomiting if swallowed, washing affected area with water and soap water in case of skin irritation. All farmers say that bad odor of the chemical is the criteria for selection of pesticide for spray in tomato, and responds that odorless chemical is highly preferred.

Farmers are aware on ban of endosulfan in agriculture (93.33% of open field and 92.86% of poly house farmers), while most of the farmers (71.43% in poly house and 86.67% in open field) are not aware about ban of monocrotophos use on vegetables. Majority of poly house (78.57%) and open field (67.67%) famers use pesticide mixtures rather than spray of single chemical to save the money. Most of the farmers had poor awareness regarding pesticide residues in vegetables and pre harvest intervals. As a regular practice, majority of the farmers follow decontamination of vegetables with tap water and very less number of farmers aware about salt water wash.

Majority of farmers (91.67 % in open fields and 85.71 % in poly houses) are not aware about food exports rejections due to pesticide residues in international trade. Majority of famers think pesticides are helpful in getting good returns, and 65% of open field farmers believe that the dose recommended is not sufficient for pest control and hence apply high pesticide dose for higher yields, but in contrast only 35.71% poly house farmers agree to open field farmers view, and majority of poly house farmers apply recommended dose.

Most of respondents think that integrated pest management practices are the alternative to pesticides. While survey, it is clear that majority of farmers (more than 70%) do not use empty bottles for house / farm purpose and most common method of disposal of these empty bottles was throwing in to trash.

During the survey it is very clear that farmers prefer to contact pesticide dealers (100%) for recommendations, followed by scientists (>35%) and very less number of respondents contact agriculture officer (<20%). Most of the poly house farmers (78.57%) said that they apply pesticides at weekly interval, whereas most of open field

farmers (60%) applied pesticides at 4 days interval, and majority of both poly house (78.57%) and open field (93.33%) farmers follows waiting period of 2 days after pesticide spray. Further, it was expressed by majority of poly house (71.43%) and open field (68.33%) farmers that they are not aware about bad effects due to pesticide residues in food.

Based on the survey and interaction with farmers to know about the pest occurrence and intensity, poly house farmers feels that the major pest is serpentine leaf miner (*Liriomyza trifolii*) followed by fruit borer (*Helicoverpa armigera*), thrips, leaf eating caterpillar (*Spodoptera litura*) and leaf hopper against which pesticides are sprayed, while the open field farmers say that fruit borer (*Helicoverpa armigera*) is the major pest followed by serpentine leaf miner (*Liriomyza trifolii*), leaf eating caterpillar (*Spodoptera litura*), thrips and leaf hopper.

Major pesticides used by the ploy house farmers were Fiponil 5%SC, Chlorantraniliprole 18.5%SC, Thiomethoxam 25%WG, Imidacloprid 17.8%SL, Spionsad 48%SC, Emamectin benzoate 5%SG and Chlorfenapyr 10%SC, whereas open field farmers use pesticides like Chlorantraniliprole 18.5%SC, Imidacloprid 17.8%SL, Fipronil 5%SC, Chlorpyrifos 2% EC, Novaluron 5.2%+Indaxacarb 4.5% SC, Spionsad 48%SC and Flubendiamide 48%SC.

Study on dissipation dynamics of certain insecticides was carried out both in open field and poly house situations to assess the differences rate of dissipation. open field study revealed that initial deposits of 1.31 mg kg⁻¹ dimethoate dissipated to 0.62, 0.47 and 0.12 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively, and below detectable level by 7th day. Whereas in poly house, initial deposit of 1.76 mg kg⁻¹ dimethoate dissipated to 1.14, 0.55, 0.20 and 0.09 mg kg⁻¹ by 1, 3, 5 and 7 days after last spray, respectively, and below detectable level by 10th day. Safe waiting period of 1 day can be suggested both in open fields and poly houses as the initial deposits are less than the MRL suggested by FSSAI (2 mg kg⁻¹).

Similarly, spray of lambda cyhalothrin in open field resulted in initial deposits of 0.13 mg kg⁻¹ which dissipated to 0.08 and 0.06 mg kg⁻¹ by 1 and 3 days after last spray, respectively, and below detectable level by 5th day. Whereas in case of poly house, initial deposit of 0.18 mg kg⁻¹ lambda cyhalothrin dissipated to 0.10, 0.07, and 0.06 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively, and below detectable level by 7th day. Safe waiting period of 3 days and 5 days can be suggested in open fields and poly

houses respectively, as there are no MRLs suggested for lambda cyhalothrin in tomato by either Codex Alimentarius Commission (CAC) or by Food Safety and Standards Authority of India (FSSAI). Since no MRLs are available, these safe waiting periods can be recommended as the residues dissipated below detectable level.

Phosalone sprayed at recommended doses resulted in initial deposits of 2.52 mg kg⁻¹ phosalone at 2 hours after last spray dissipated to 1.55 and 0.60 mg kg⁻¹ by 1 and 3 days after last spray, respectively, and below detectable level by 5th day in open field study, while in case of poly house, initial deposit of 4.55 mg kg⁻¹ phosalone dissipated to 3.62, 2.09, and 0.86 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively, and below detectable level by 7th day. Safe waiting period of 3 days and 5 days can be suggested in open fields and poly houses respectively, as there are no MRLs suggested for phosalone in tomato by either Codex Alimentarius Commission (CAC) or by Food Safety and Standards Authority of India (FSSAI). Since no MRLs are available, these safe waiting periods can be recommended as the residues dissipated below detectable level.

Open field study, initial deposits of 0.90 mg kg⁻¹ flubendiamide dissipated to 0.49, 0.29, and 0.13 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively, and below detectable level by 7th day. Whereas in case of poly house initial deposit of 1.23 mg kg⁻¹ flubendiamide at 2 hours after last spray dissipated to 0.76, 0.34, 0.15 and 0.08 mg kg⁻¹ by 1, 3, 5 and 7 days after last spray, respectively, and below detectable level by 10th day. Maximum Residue Limits (MRLs) are not fixed for flubendiamide on tomato as per FSSAI, while Codex Alimentarius Commission (CAC) set as 2 mg kg⁻¹. Based on the present study, safe waiting period of 1 day can be suggested as the initial deposits are less than the MRL.

Dissipation pattern of profenophos in open fields revealed that initial deposits of 1.51 mg kg⁻¹ profenophos at 2 hours after last spray dissipated to 0.83, 0.43, and 0.24 mg kg⁻¹ by 1, 3 and 5 days after last spray, respectively, and below detectable level by 7th day, while in poly house studies, initial deposit of 3.25 mg kg⁻¹ profenophos dissipated to 2.67, 1.66, 0.70, 0.41 and 0.18 mg kg⁻¹ by 1, 3, 5, 7 and 10 days after last spray, respectively, and below detectable level by 15th day. A safe waiting period of 1 day is recommended in both poly house and open field based on the MRL of 10 mg kg⁻¹ given by Codex Alimentarius Commission, as the initial deposits are less than the MRL.

Evaluation of various decontamination methods was carried out, and out of all simple household methods tested, veggy wash, a formulation prepared by AINP on

Pesticide Residues, treatment was found most effective in removing dimethoate, lambda cyhalothrin, phosalone, flubendiamide and profenophos residues from tomato fruits. The efficacy of various decontamination methods in removing residues of all test insecticides in descending order were veggy wash > 4% Acetic acid solution > 2% salt solution > 0.1% Baking soda solution > Tap water, except in case of flubendiamide where 0.1% Baking soda solution found more effective than 2% salt solution.

The essence of whole experiment is concluded as here under:

- Most of the farmers had very less knowledge on pesticide recommendations as per Insecticide Act, toxicity classification, and majority of open field famers contact pesticide dealer for recommendations, compared to poly house farmers.
- Poly house farmers are better educated compared to open field farmers, and hence it is clear that poly house farmers are usually spraying pesticides at lees frequency compared to open field farmers.
- Majority of the farmers were not aware of pesticide residues and their consequences in food stuffs, and were also not aware of various decontamination methods, but as a regular practice they follow washing of vegetables with water.
- Majority of farmers noticed common health problems like skin irritation, head ache, cough, etc. during spray, and prefer to buy pesticide without bad odour.
- Most of the farmers had good awareness about ban of endosulfan in agriculture, but very few knew about ban of monocrotophos in vegetables.
- Disposal of empty pesticides bottles was not carried out in a satisfactory way, as majority of the farmers simply throw bottles in trash, but >70% farmers do not use the empty bottles for house hold or farm purposes.
- In all cases, initial deposits are high in poly house compared to open field situations, and it is very clear that the dissipation rate is slow in poly house.
- Based on dissipation studies on dimethoate in both open field and poly house, it is concluded that residues dissipated to BDL in 7 and 10 days, respectively and taking into consideration of initial deposits and MRLs suggested by FSSAI, one day PHI can be recommended.
- Lambda cyhalothrin applied @ 15 g ai ha⁻¹ recorded initial deposits of 0.18 mg kg⁻¹ which dissipated to BDL in 7 days in poly house, while in open field trial, residues dissipated to BDL in 5 days. MRLs are fixed for the pesticide as per CAC and

FSSAI, but for recommended for use against fruit borer with PHI of 4 days. However, based on the present study, PHI of 3 day and 5 day were recommended in open field and poly house respectively.

- Phosalone applied in both open field and poly house, dissipates at faster rate taking into consideration of high initial deposits, but taking into consideration MRL as FSSAI i.e 1 mg kg^{-1} , PHI of 3 day and 5 day were recommended in open field and poly house, respectively.
- Based on dissipation studies on flubendiamide in both open field and poly house, it is concluded that residues of dissipated to BDL in 7 and 10 days, respectively. Taking BDL into consideration PHI of 3 day and 5 day were recommended in open field and poly house respectively.
- Keeping tomatoes in Veggy wash for 10 min followed by washing under tap water gave very efficient removal results compared to other methods, besides good old practice of 2% salt solution can also removes residues of dimethoate, phosalone, lambda-cyhalothrin, flubendiamide and profenophos to an extent of 40-59% depending on the type of pesticide.

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The pattern of 'Literature cited' presented above is in accordance with the 'Guidelines' for thesis presentation for Acharya N.G. Ranga Agricultural University, Hyderabad.

APPENDICES

APPENDIX-A

Survey on pesticide use pattern in tomato (Open fields / poly houses)

General information

- Date of survey :
- 1) Name of the farmer :
 - 2) Age :
 - 3) Education :
i. Illiterate ii. Primary iii. Secondary iv. High school v. college
 - 4) Village :
 - 5) Taluk : District:
 - 6) Family particulars : Nuclear family / Joint family
 - 7) Crop area (Tomato) : _____ acres
 - 8) Season : Kharif / Rabi / Summer
 - 9) Age of the nursery :
 - 10) Crop duration :

Information on plant protection chemicals:

Stage of the crop	Name of the pest	Pesticide applied	Trade name	Dose	Cost

- 1) Information on application of bio-pesticides, if any :
- 2) Information on light traps / pheromone traps, if any :
- 3) List of predominant pests :

Questionnaire on general awareness:

- 1) Since how long you are growing tomato crop : 1 yr/2yr/3 yr
- 2) Are you aware about recommended pesticides against different pests : yes / no
- 3) Are you aware about the pesticide classification based on toxicity : yes / no
- 4) If Yes, what is the color code for extremely toxic pesticide :
Red/Yellow /Blue/Green
- 5) Do you follow safe methods while storing / mixing / spraying pesticides : yes / no
- 6) How do you measure the chemical :
bottle cap / approx
- 7) How do you mix the chemical :
bare hands / stick / others
- 8) Do you observe pesticide effect on health of spray men during spray : Yes / No
- 9) If Yes, what is most common problem observed :
Irritation / cough / breathlessness / any other
- 10) What is the best first aid you follow :
- 11) Are you aware that endosulfan is banned for use : yes/ no
- 12) Are you aware that Monocrotophos is banned for use on Vegetables : yes / no

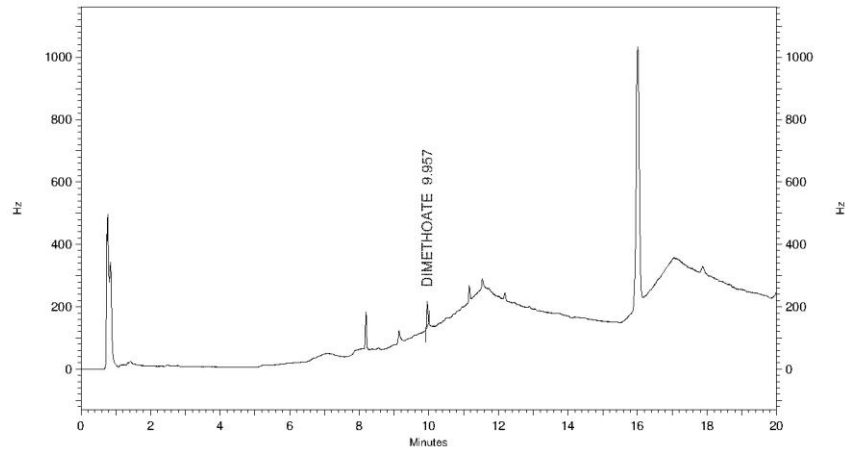
- 13) Whom you contact, for pesticide recommendations :
AO / Dealer / Scientist
- 14) Do you contact Agril Officer for suggestions : Yes / No
- 15) Do you use pesticide mixtures : Yes / No
- 16) If Yes, what are the common pesticides you mix :
- 17) How frequently you apply the pesticides :
2 days / 4 days / week /
- 18) Are you aware that for each pesticide, pre-harvest interval is recommended :
Yes / No
- 19) If yes, what is the common waiting period you follow after pesticide spray :
1 day / 2 days / week
- 20) Are you aware that pesticide residues are found in vegetables :
Yes / No
- 21) Do you know that pesticide residues in food enter into body and accumulate :
Yes / No
- 22) What type of bad effects you heard due to pesticide residues in food :
cancer / others
- 23) Are you aware about pesticide decontamination method :
Yes / No
- 24) If Yes, what is the common method :
- 25) Are you aware that food exports are rejected due to pesticide residues :
Yes / No
- 26) Do you think the quantity of pesticides used as adequate? :
Yes / No
- 27) Do you think that pesticides are helpful in getting good returns :
Yes / No
- 28) If No, what is your best alternative :
crop change / Natural methods / IPM / others
- 29) Do you think high pesticide dose gives higher yields :
Yes / No
- 30) If Yes, what is the recommended dose for profenophos in tomato :
- 31) List out most common used pesticides on tomato :

Name of the pesticide	Formulation & Trade Name	Target Pest	Dose	Waiting period

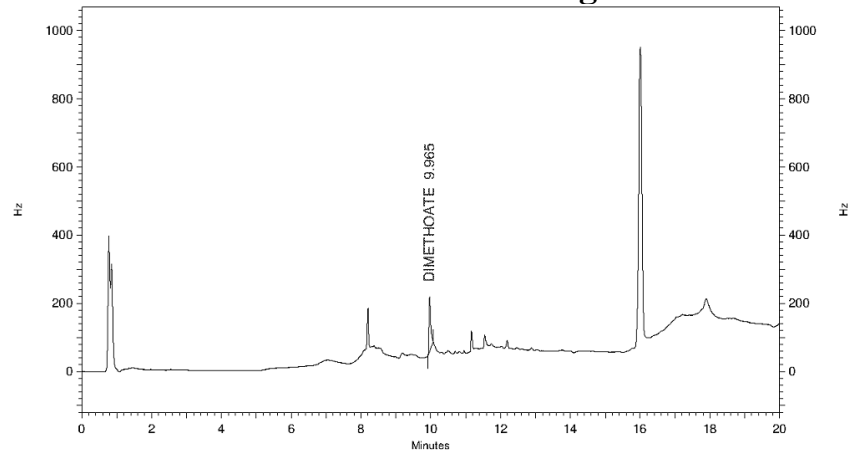
- 32) Do you use the empty bottles for house / farm purpose :
Yes / No
- 33) If no, what is the disposal method you follow :
Burry in soil / sell /

APPENDIX-B

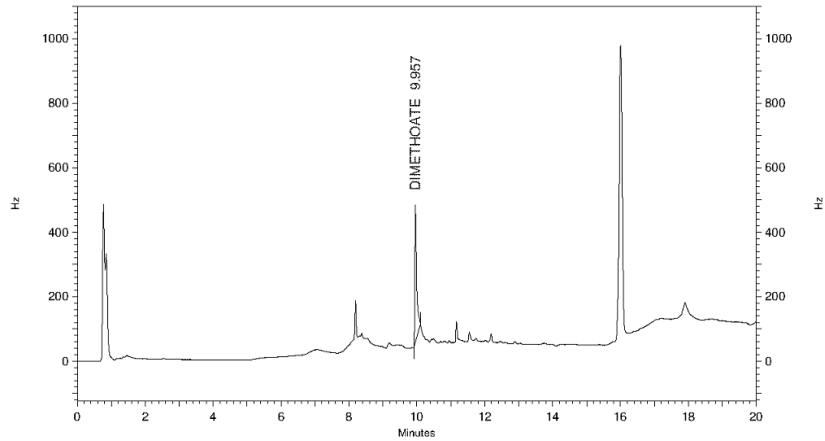
Standard chromatograms of each pesticide at different concentration



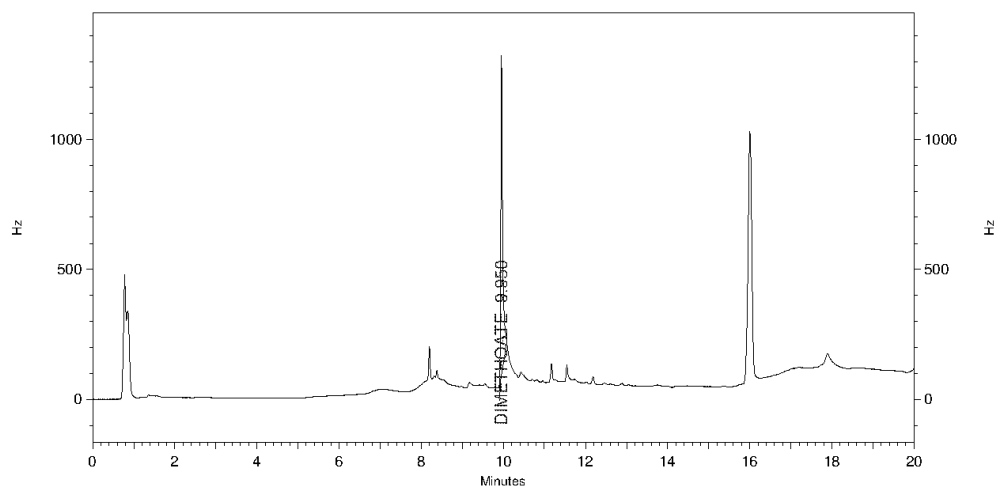
Dimethoate – 0.01 ng



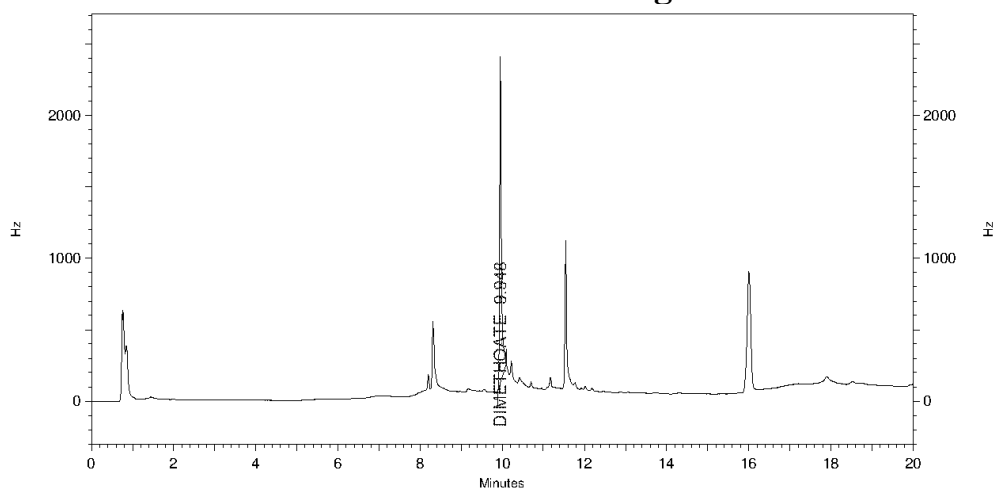
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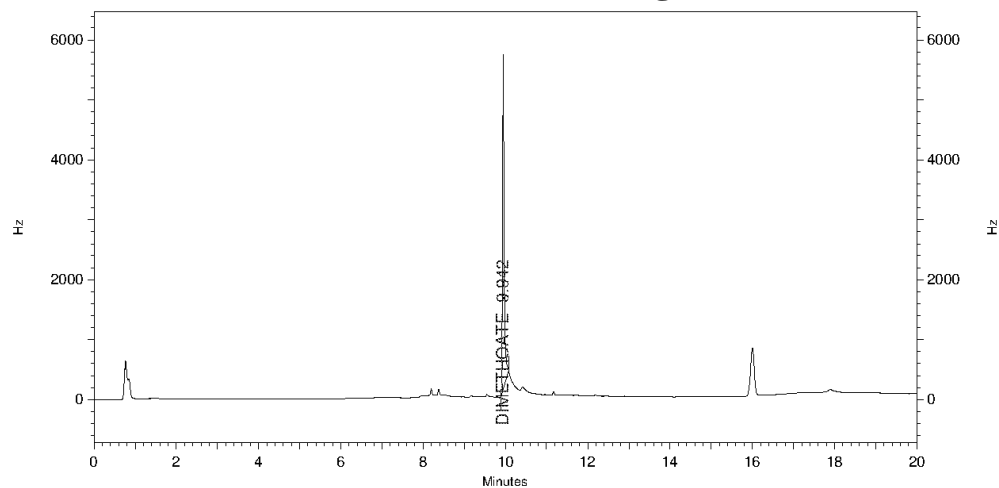
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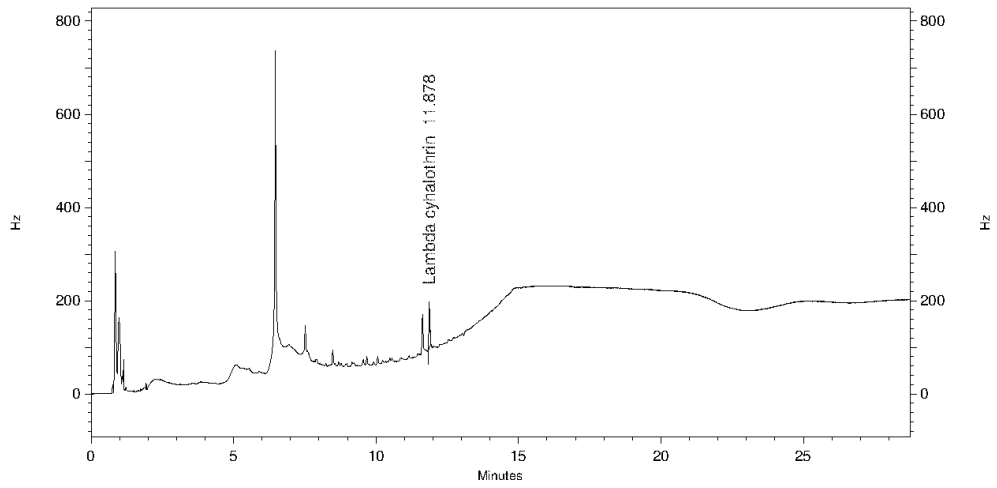
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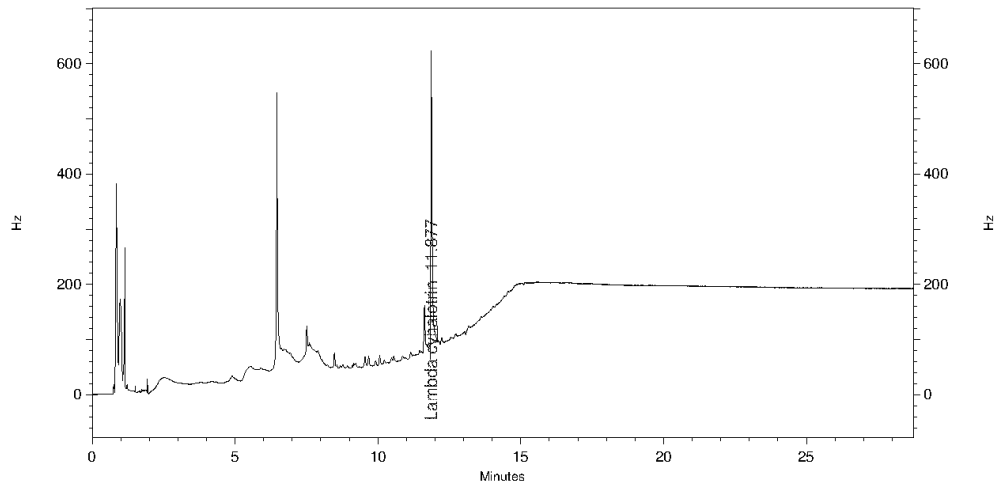
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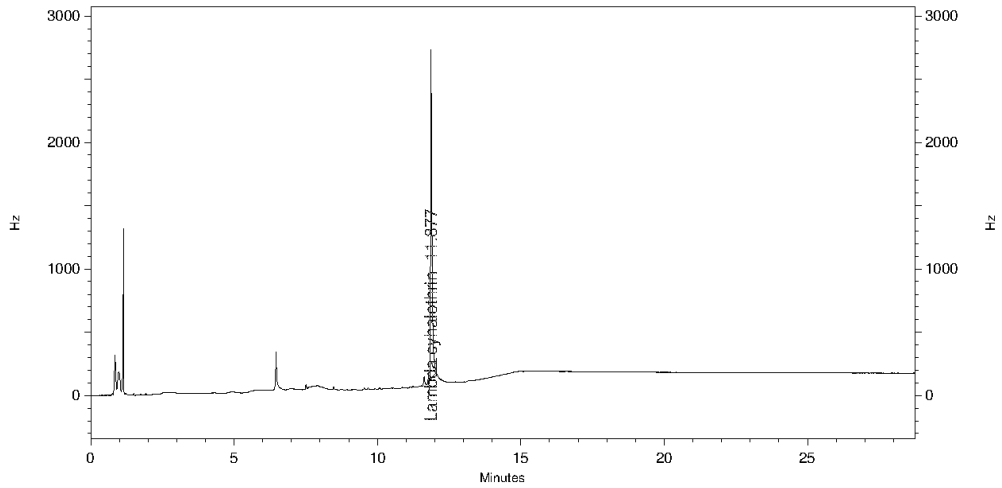
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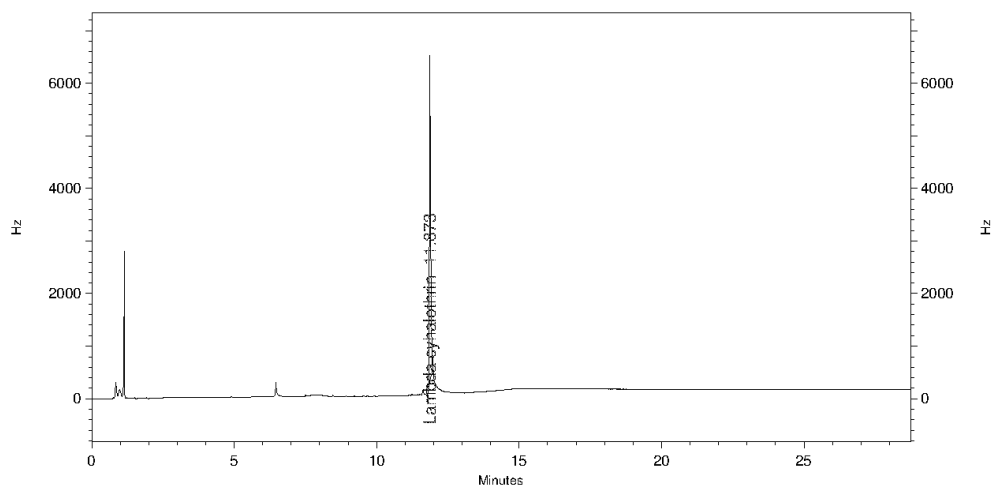
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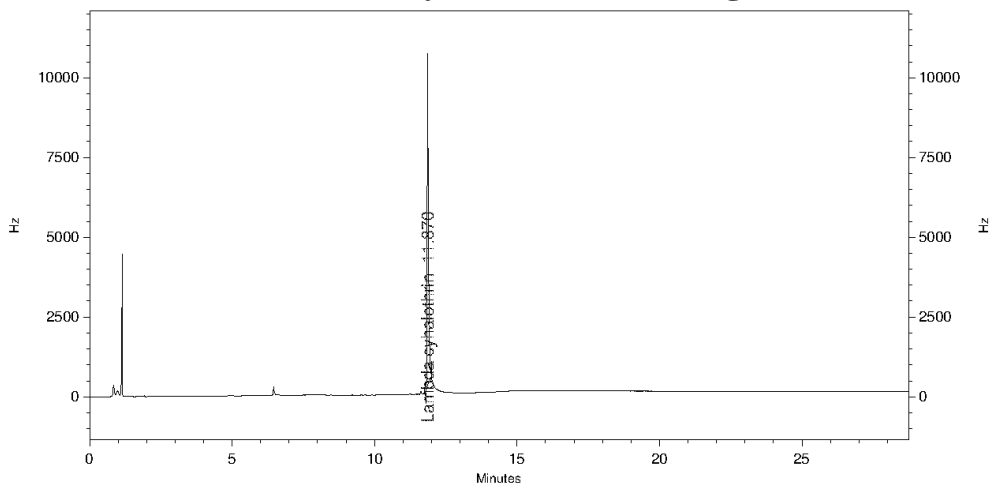
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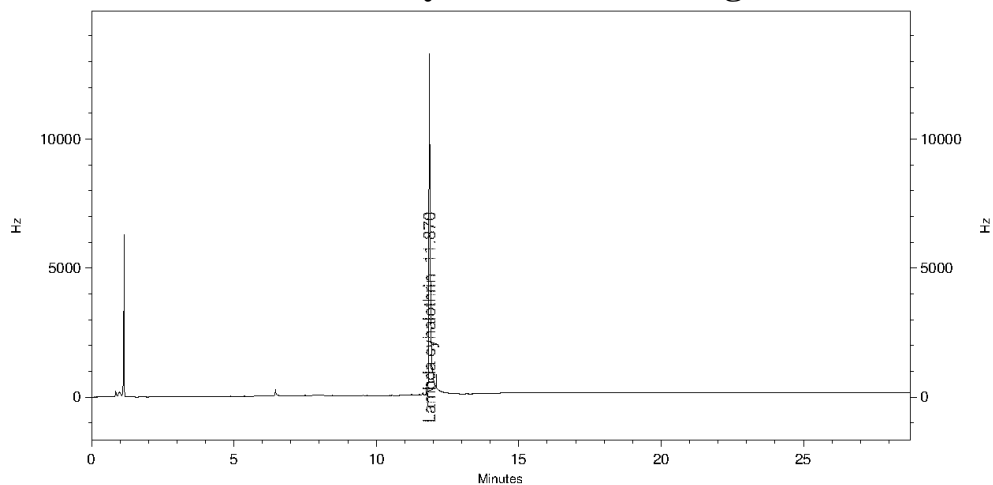
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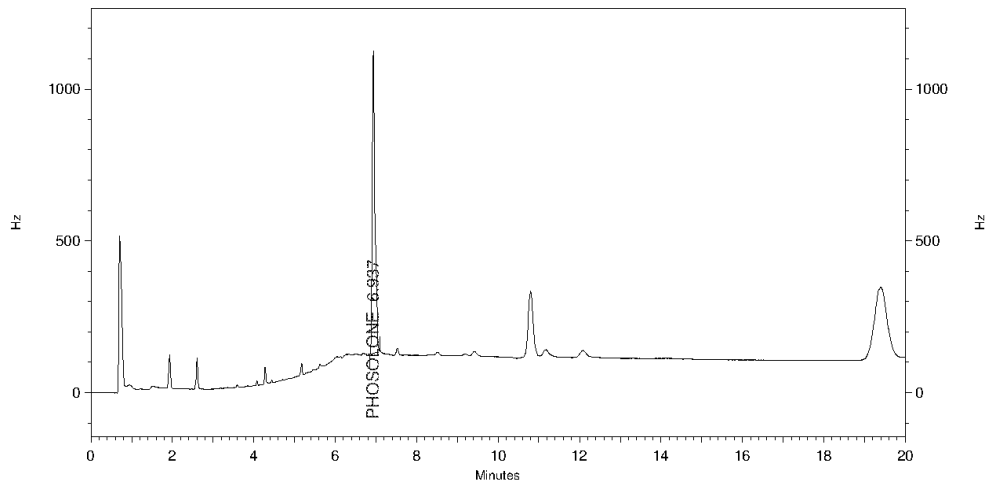
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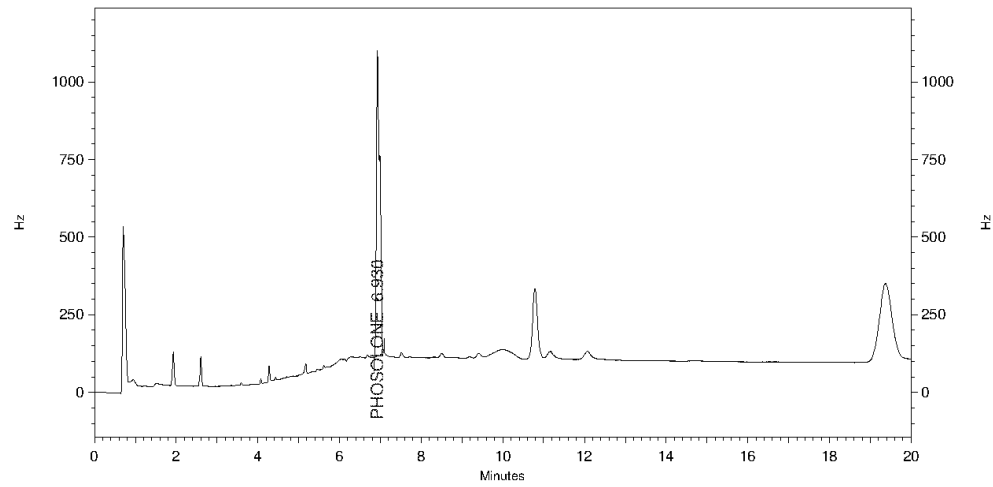
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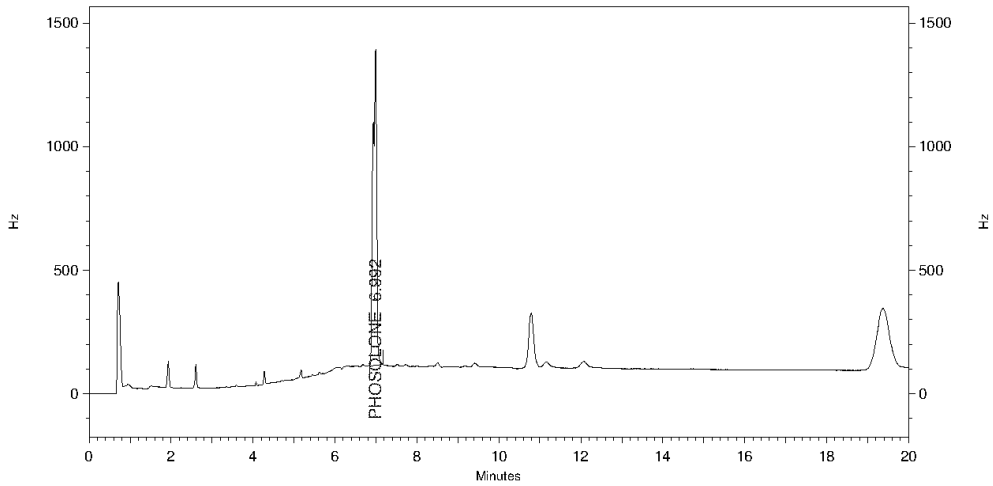
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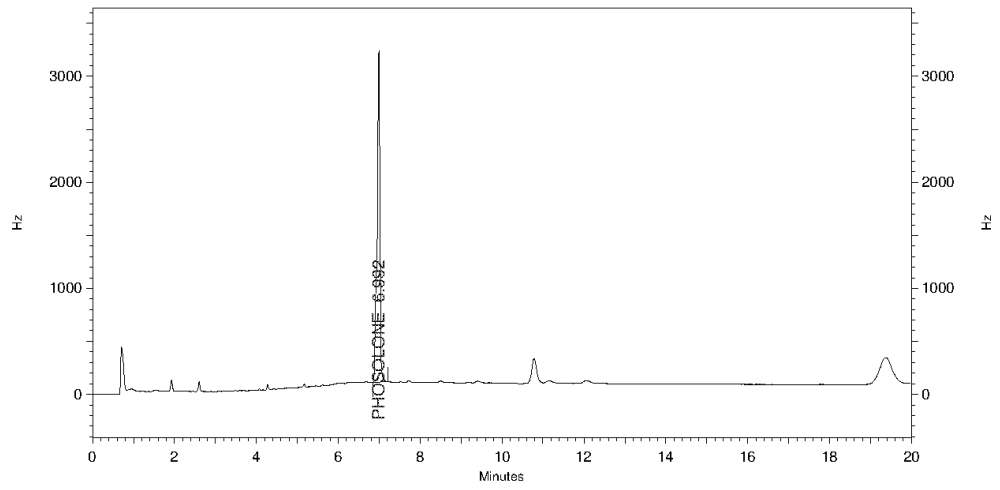
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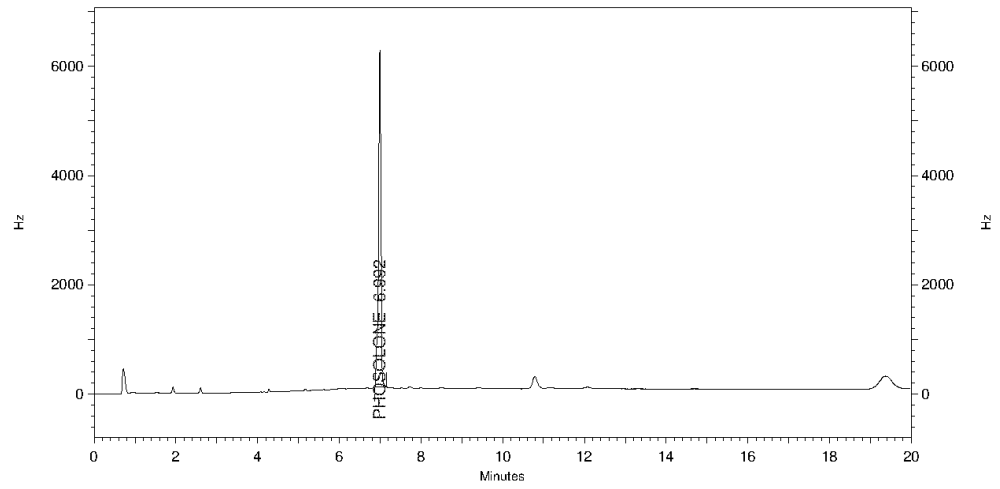
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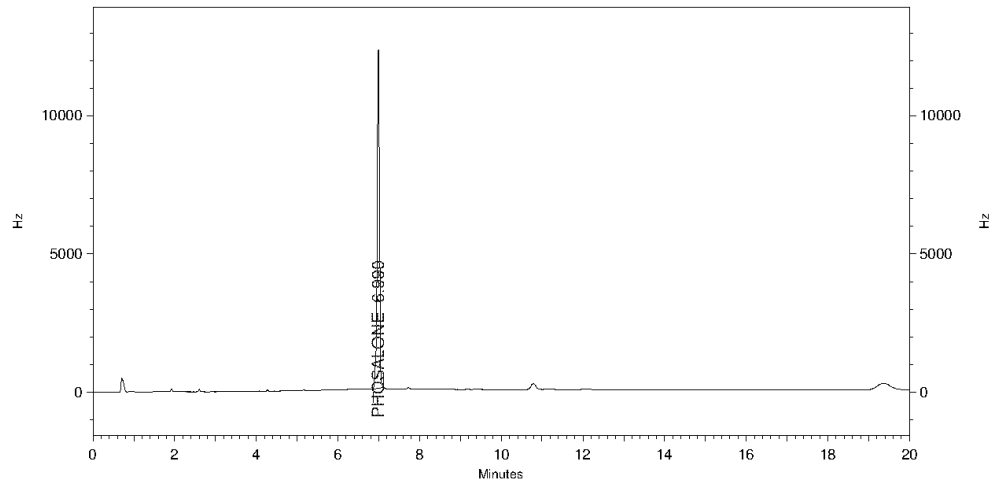
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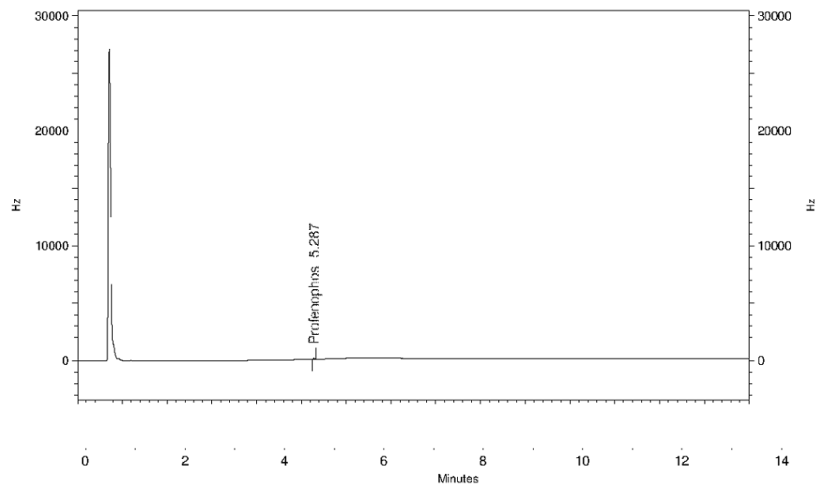
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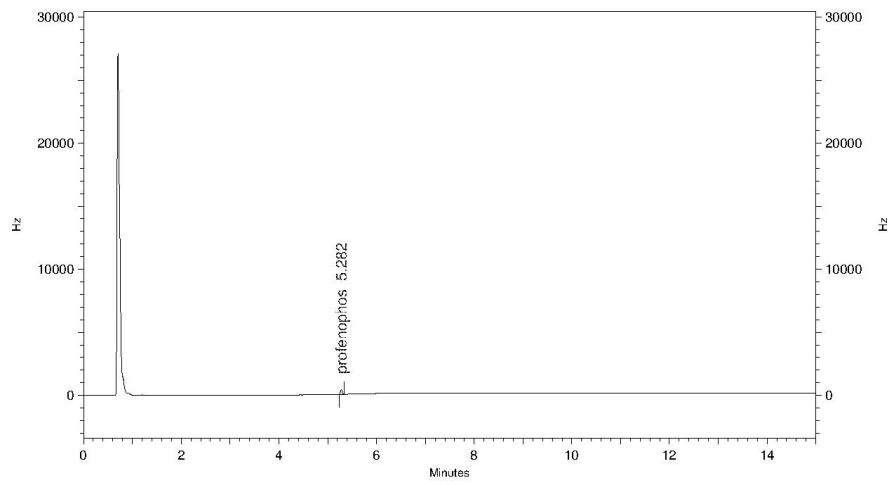
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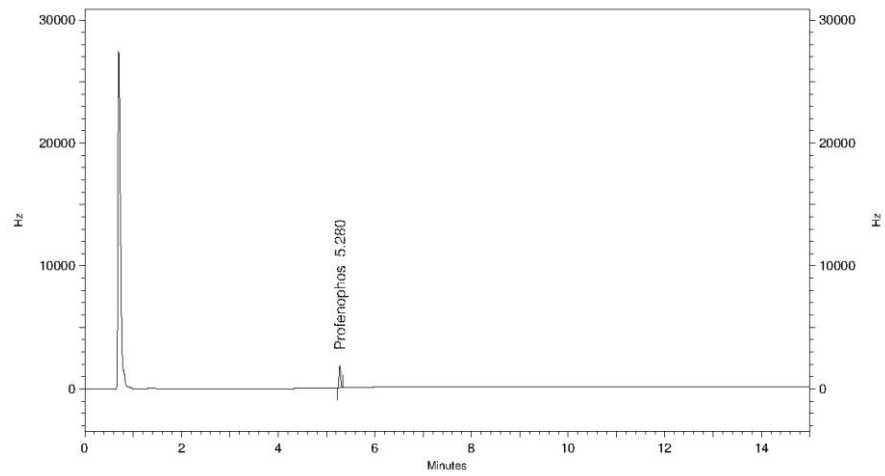
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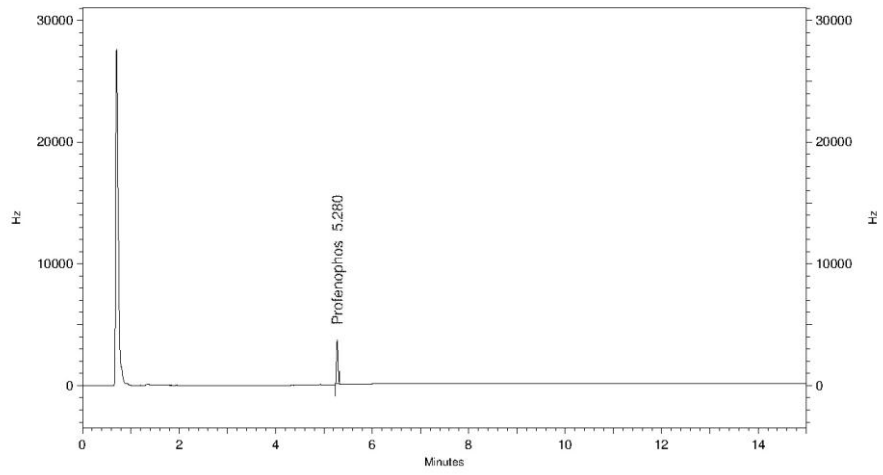
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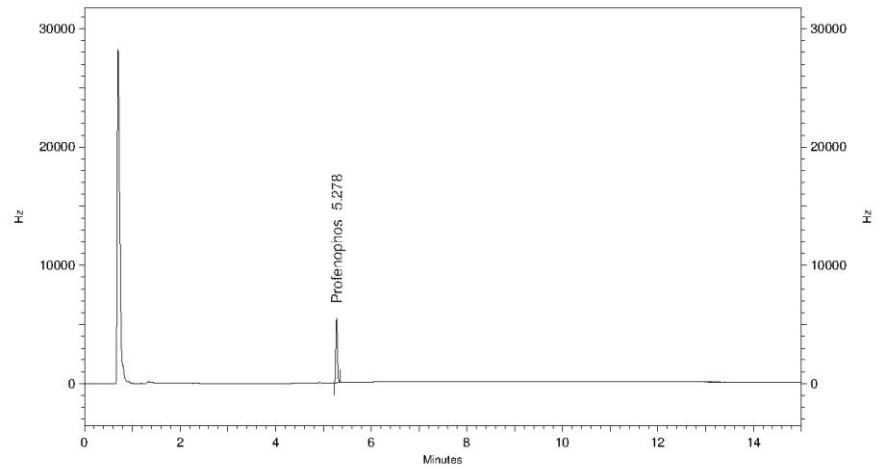
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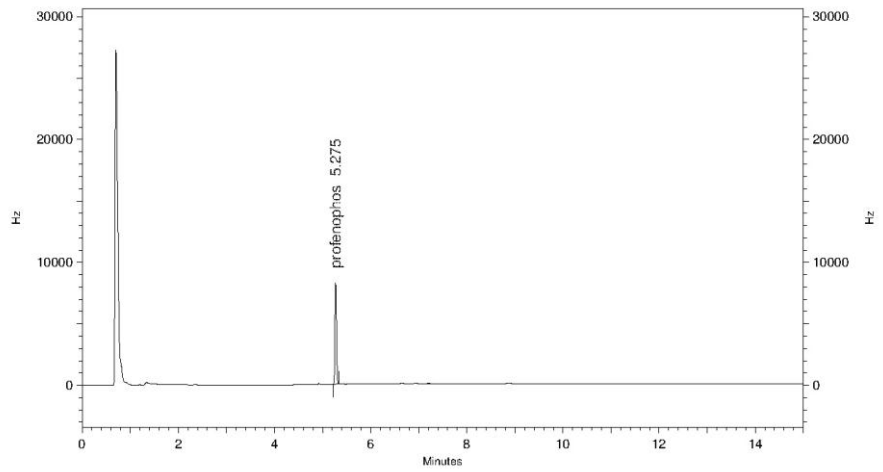
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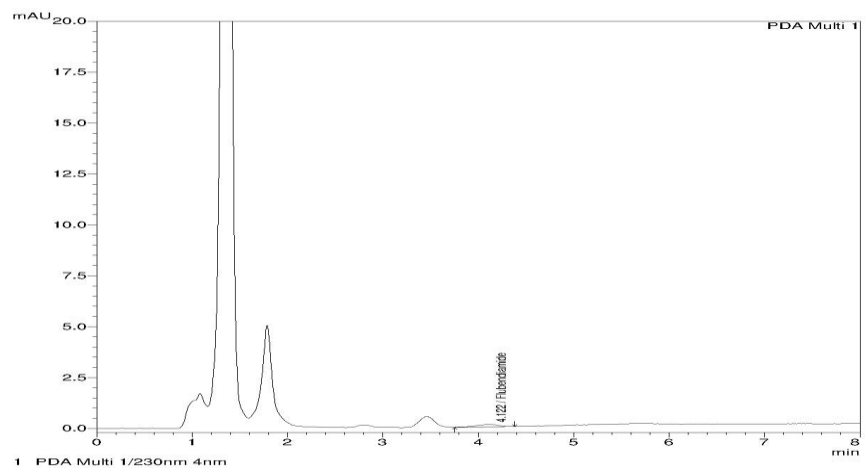
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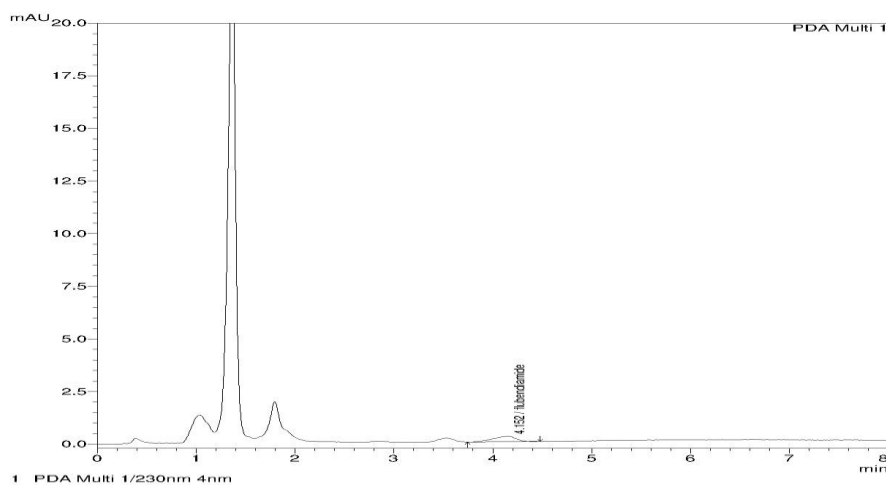
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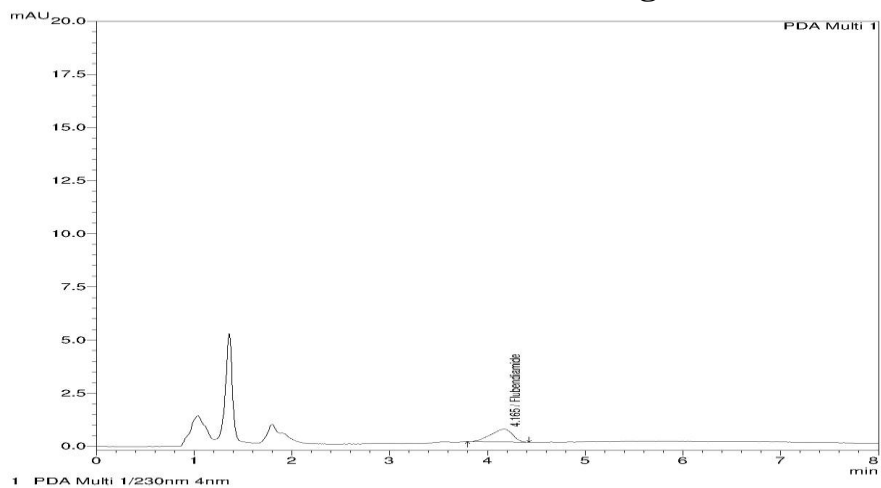
Profenofos – 1.00 ng



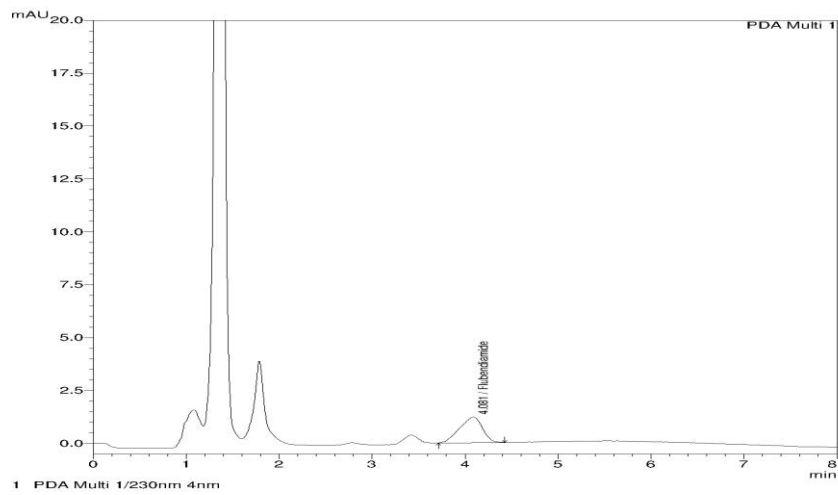
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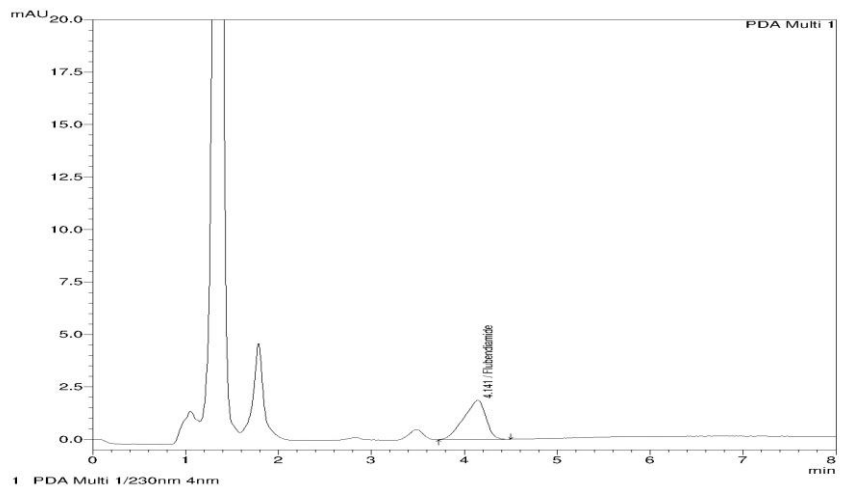
Flubendiamide – 0.10 ng



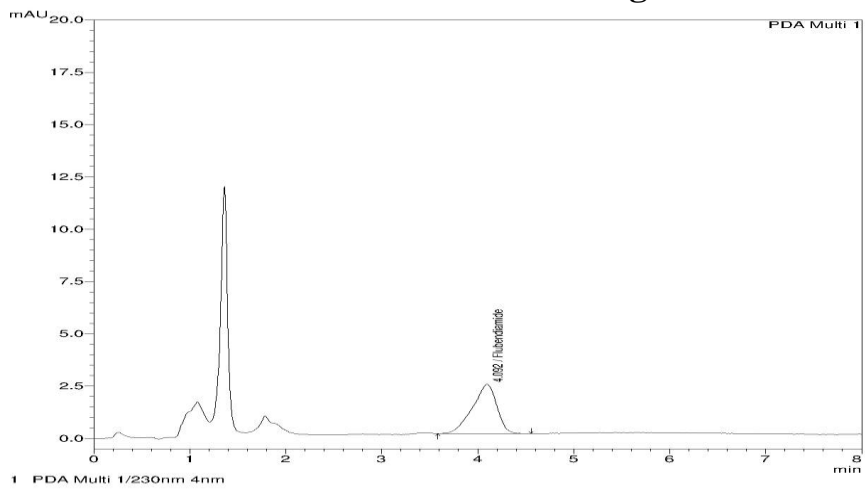
Flubendiamide – 0.25 ng



Flubendiamide – 0.50 ng



Flubendiamide – 0.75 ng



Flubendiamide – 1.00 ng