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Pesticides usage pattern of okra, *Abelmoschus esculentus* (L) Moench in Tamil Nadu

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Abstract
An extensive survey on pesticide usage pattern was conducted using well structured questionnaire format among 120 farmers in six major okra growing districts of Tamil Nadu *viz.*, Vellore, Salem, Dharmapuri, Dindigul, Coimbatore and Trichy during 2016. Among the list of 24 pesticides identified belonging to slightly to highly hazardous toxicity class, the widely used pesticides by farmers were imidacloprid (36.67%), acephate (33.33%), exodus (15.00%), flubendiamide (14.17%) and dimethoate (14.17%). Major source of information on pesticide was pesticide dealers (75.83%). A very paltry percentage of respondents sprayed based on the recommended dose (20.83%) and gave attention towards pesticide label (5.83%). Majority of the farmers followed the common waiting period of 1 day after spraying (65.00%) and spraying interval of 10-14 days (52.33%). The farmer's knowledge was lagging on the recommended pesticide, dosage, safe harvest interval, label claim and personnel protection during spray operation but their knowledge was fair enough on disposal of pesticide containers, mixing and measurement of pesticides.

Keywords: Farmers, Okra, Pesticide use pattern, Tamil Nadu

1. Introduction
Okra *Abelmoschus esculentus* (L) Moench is an economically important vegetable crop grown in tropical and sub-tropical parts of the world. In Tamil Nadu, okra occupies an area of 8,000 ha, with an annual production and productivity of 56.67 thousand metric tones and 7.10 metric tones ha^{-1}, respectively [1]. Among various biotic and abiotic stresses, the damage caused by insect pests is of considerable importance. The pest complex of okra varies from region to region and the number of recorded species ranges from 13 to 72 depending on the agro-climatic conditions [2, 3]. The recorded yield losses caused by sucking pests were 32.06 to 56.0 per cent by leafhopper *Amrasca biguttula biguttula* (Ishida) [4], 94.0 per cent by whitefly *Bemisia tabaci* (Gennadius) [5], 54.04 per cent by aphids *Aphis gossypii* (Glover) [6] and 17.46 to 48 per cent by two spotted spider mite *Tetranychus urticae* (Koch) [7]. The estimated avoidable yield loss caused by *Earias* spp. due to fruit damage was 36 to 90 per cent [8]. In order to combat the above losses, farmers resort to haphazard use of pesticides on vegetable crops. In addition to high-yielding crop varieties and fertilizers, pesticides helped the Indian farmers in achieving a substantial increase in agricultural productivity [9]. About 3 per cent cropped area of fruits and vegetable crop receives 13 per cent of the total pesticides in the country [10]. The abusive use of broad spectrum chemicals against insect pests is fraught with tribulations of resistance, resurgence, secondary pest out breaks, phyto-toxicity, toxicity to beneficial organisms, intoxication of farm personnel and environmental pollution [11, 12]. In vegetable crops like okra, there is always little time lag between pesticide application and harvest. Thus, the use of pesticides at fruiting stage and non adoption of safe waiting period, leads to possible accumulation of pesticide residues. As per the report of Monitoring of Pesticide Residues at National Level (MPRNL), the residues of non-approved pesticides were detected in 1180 vegetable sample. Okra was found to have higher level of pesticide residue above Maximum Residual Limit (MRL) [13] among those vegetables. During recent years, the problem of pesticide residues in harvested produce of okra is assuming importance, not only elicit multiple health complexities but also act as a major bottleneck in international trade. European Union (EU) rejected three okra consignments from India, due to presence of pesticide residues exceeding their Maximum Residual Limit (MRL) *viz.*, monocrotophos, triazophos and acephate [14]. Thus, watch kept on pesticide usage patterns against crop pests became obligatory not only to safeguard human and environmental health by ensuring food

safety, but also to prevent resistance development in insect at the earliest possible. In the light of the above facts, the present study was undertaken to understand the status of farmer's management practices against pest and to explore their knowledge on pesticide usage in okra agro-ecosystem of Tamil Nadu.

2. Materials and methods

2.1 Details of study location

During September 2016 to November 2016, an extensive survey was conducted to understand the pesticide usage pattern of okra ecosystem, Tamil Nadu. Major okra growing districts *viz.*, Vellore, Salem, Dharmapuri, Dindigul, Coimbatore and Trichy were selected based on the extent of okra cultivation of about 1835, 1073, 501, 403, 273 and 67 ha, respectively [15]. Further, blocks and villages were selected for the study as per the personal communication obtained from Assistant Director of Horticulture office located in each district (Table 1).

2.2 Nature of data

The information on pesticide usage pattern was collected from 20 selected progressive farmers per district and thus, a total of 120 farmers formed the sample of this study. The objectives and scope of the study were explained to farmers for their fair cooperation. Based on the objectives of the present study, a questionnaire format consisting of following three sections was prepared and data was collected by interviewing the farmers individually using it.

Section 1: General information about farmer (farmer name, address, age, education, family particulars).

Section 2: Major pesticides used (chemical name, trade name, dose, manufactured company).

Section 3: Pesticide usage pattern (source of information on recommended pesticides, attention towards labels, measurement and mixing of pesticide, safety methods followed, dosage of insecticides, type of sprayer used, time of spraying, number of spray, waiting period followed, spray intervals, handling and disposal of pesticide containers).

Table 1: Details of location of okra growing fields surveyed in Tamil Nadu.

Sl. No.	District	Block	Village	Number of respondants per village	Total number of respondants per district
1.	Coimbatore (CBE)	Thondamuthur	Thennamanallur	2	20
			Thondamuthur	5	
			Narasipuram	3	
		Annur	Kattampatti	3	
			Pattakaranpudur	4	
			Pachapalayam	3	
2.	Dharmapuri (DPJ)	Pennagaram	Alamarathupatti	4	20
			Pauparapatty	2	
			Pallipatty	2	
		Palakkode	Mungapatti	7	
			Erranahalli	5	
3.	Vellore (VLR)	Tirupattur	Kakkangarai	4	20
			Kannalapatti	6	
			Natrampalli	6	
			Kunichi	4	
4.	Salem (SA)	Konganapuram	Kachipalli	5	20
			Ettikuttamedu	7	
			Edaiyapatti	3	
		Thalaivasal	Nagakurichi	5	
5.	Dindigul (DG)	Reddiarchatram	Mangarai	4	20
			Ponnimanthurai	4	
			Kottarapatti	2	
			Thamarikulam	10	
6.	Trichy (TPJ)	Vayyampatti	Nadupatti	10	20
			Periyapodhu	10	

3. Results and discussion

3.1. Status of pesticides used in okra ecosystem

Overall pesticide usage profile in okra growing districts of Tamil Nadu depicts (Table 2) that the use of imidacloprid was maximum (36.67%) followed by acephate (33.33%), exodus (15%); flubendiamide and dimethoate (14.17%). Other pesticides like chlorpyriphos + cypermethrin (10.83%); propargite (10.00%); acetamiprid and chlorantraniliprole (9.1%); triazophos + deltamethrin (8.33%); fenazaquin (7.50%); flonicamid (6.67%); profenophos + cypermethrin (5.00%); thiamethoxam, encounter (5.00%); monocrotophos, profenophos and quinolphos (4.17%); triazophos (3.33%); emamectin benzoate, mite care and acephate + imidacloprid (2.50%); spiromesifen and azadirachtin (1.6%) for management of sucking pests and borer complex. The use of maximum number of pesticides in okra was observed due to regular pest occurrence throughout the year and to combat the economic loss caused by fruit borers. Except Coimbatore district, the usage of insecticide mixtures *viz.*, profenophos 40 + cypermethrin 4 EC (5.00%), chlorpyriphos 50 + cypermethrin 5 EC (10.83%), triazophos 35 + deltamethrin 1 EC (8.33%) and acephate 50 + imidacloprid 1.8 SP (2.50%) were observed in all other districts. This result was in agreement with earlier study conducted at Karimnagar district, that majority of the okra farmers (73.33%) were using pesticide mixtures [16].

Table 2: List of pesticides used in okra ecosystem in different parts of Tamil Nadu.

Sl. No.	Pesticides used	% Respondants						
		CBE	DMR	VLR	SA	DN	TPJ	Mean percentage*
1	Acetamiprid 20% SP	0	25	20	10	15	5	9.17
2	Azdirachtin 0.03% W/W	10	0	0	0	0	15	1.67
3	Flonicamid 50 % WG	0	20	20	0	0	0	6.67
4	Imidacloprid 17.8% SL	80	35	40	65	50	70	36.67
5	Thiamethoxam 25% WG	10	15	5	0	0	0	5.00
6	Dimethoate 30% EC	55	20	0	10	10	0	14.17
7	Acephate 75% SP	45	55	65	35	60	20	33.33
8	Monocrotophos 36% SL	10	0	5	10	5	0	4.17
9	Profenophos 50% EC	10	5	0	10	5	20	4.17
10	Triazophos 40 % EC	0	5	15	0	0	0	3.33
11	Quinolphos 25% EC	0	15	5	5	0	0	4.17
12	Flubendiamide 39.35% SC	10	30	20	25	30	10	14.17
13	Chlorantraniliprole 18.5% SC	30	0	0	25	10	10	9.17
14	Emamectin benzoate 5% SG	0	0	5	10	0	0	2.50
15	Fenazaqin 10% EC	10	15	15	5	0	10	7.50
16	Propargite 57% EC	20	10	20	10	15	0	10.00
17	Spiromesifen 22.9% SC	0	10	0	0	0	0	1.67
18	Profenophos 40% + Cypermethrin 4% EC	0	5	0	0	0	25	5.00
19	Chlorpyriphos 50% + Cypermethrin 5% EC	0	15	15	0	20	15	10.83
20	Triazophos 35% + Deltamethrin 1% EC	0	15	20	15	0	0	8.33
21	Acephate 50% + Imidacloprid 1.8% SP	0	10	5	0	0	0	2.50
22	Encounter	10	0	0	0	0	10	5.0
23	Exodus	0	20	20	5	25	0	15.0
24	Mite care	15	0	0	0	0	0	2.5

*Multiple answers possible

The farmers under study used pesticides with label claim recommended by Central Insecticide Board and Registration Committee (CIB & RC) viz., acetamiprid 20 SP, imidacloprid 17.8 SL, thiamethoxam 25 WG and dimethoate 30 EC for the management of sucking insect pests; chlorantraniliprole 18.5 SC and emamectin benzoate 5 SG for the management of borer complex; fenazaquin 10 EC and spiromesifen 22.9 SC for the management of red spider mite. Other pesticides not registered for its use in okra but found to be used by the farmers were flonicamid 50 WG and acephate 75 SP against sucking pests; profenophos, monocrotophos, triazophos and flubendiamide for management of borer complex; propargite against red spider mite. In a survey undertaken in Coimbatore district, recorded the similar list of pesticides used by okra farmer [17]. The non recommended pesticides used by okra farmers were registered for.

Table 3: Information on pesticides used in okra ecosystem.

Sl. No	Name of pesticides	Chemical group	Toxicity* class	Product status	CIB & RC recommendation
1	Acetamiprid 20% SP	Neonicotinoid	-	Registered	Okra
2	Flonicamid 50 % WG	Neonicotinoid	-	Registered	Cotton, Rice
3	Imidacloprid 17.8% SL	Neonicotinoid	II	Registered	Okra
4	Thiamethoxam 25% WG	Neonicotinoid	-	Registered	Okra
5	Dimethoate 30% EC	Organophosphate	II	Registered	Okra
6	Acephate 75% SP	Organophosphate	II	Registered	Cotton, Rice, Safflower
7	Monocrotophos 36% SL	Organophosphate	Ib		Banned
8	Profenophos 50% EC	Organophosphate	O	Registered	Cotton, Soyabean
9	Triazophos 40 % EC	Organophosphate	Ib	Registered	Cotton, Rice, Soyabean
10	Quinolphos 25% EC	Organophosphate	II	Registered	Okra
11	Flubendiamide 39.35% SC	Diamide	-	Registered	Cotton, Rice, Chill, Cabbage, Tomato, Grams
12	Chlorantraniliprole 18.5% SC	Diamide	U	Registered	Okra
13	Emamectin benzoate 5% SG	Avermectin	-	Registered	Okra
14	Fenazaqin 10% EC		II	Registered	Okra
15	Propargite 57% EC	Organophosphate	III	Registered	Tea, Chilly, Apple, Brinjal
16	Spiromesifen 22.9% SC	Ketoenol		Registered	Okra
17	Profenophos 40% + Cypermethrin 4% EC	-	Unknown	Registered	Cotton
18	Chlorpyriphos 50% + Cypermethrin 5% EC	-	Unknown	Registered	Cotton, Rice
19	Triazophos 35% + Deltamethrin 1% EC	-	Unknown	Registered	Cotton, Brinjal
20	Acephate 50% + Imidacloprid 1.8% SP	-	Unknown	Registered	Cotton
21	Encounter	Unknown	Unknown	Unknown	-
22	Exodus	Unknown	Unknown	Unknown	-
23	Mite care	Unknown	Unknown	Unknown	-
24	Orion	Unknown	Unknown	Unknown	-

*Toxicity class as classified by the WHO (2005) where Ia - Extremely hazardous; Ib -Highly hazardous; II - Moderately hazardous; III - Slightly hazardous; U -Unlikely to present acute hazard in normal use.

Its use on other crops like cotton, rice, brinjal, chilli, cabbage and tomato [18]. Most of the hazardous synthetic insecticides recommended for cotton was used on okra, since both the crops belongs to malvaceae family and harbors similar insect and mite pests. A survey conducted in vegetable and cotton growing areas of the Greater Accra and Upper East Regions of Ghana revealed similar results [19].

The major group of pesticides used in okra ecosystem (Table 3) belongs to slightly hazardous group (class III) like propargite; moderately hazardous (class II) group like dimethoate, profenophos, acephate and imidacloprid; highly hazardous (class Ib) toxicity chemical classes like monocrotophos and triazophos [20]. This result goes in parallel with the report that the vegetable farmers of Dindugal district used of high (class III), moderate (class II) and low risk (class I) toxicity class pesticides [21]. The use of monocrotophos (4.17%) by okra farmers was recorded, although its use was banned on vegetable in India from 5th October, 2005. The present study showed a clear trend in the declined use of synthetic pyrethroids and the greater use of newer molecules followed by organo phosphates. In order to give synergistic effect along with organo phosphate compounds, sythetic prethroid compounds were used only as a component of insecticide mixture. But, the increased use of synthetic pyrethroids in okra ecosystem was recorded, according to a survey conducted in major vegetable growing tracts of Tamil Nadu during the year 2000 [22].

3.2. Pesticide usage pattern

The knowledge level of okra growing farmers on pesticide usage pattern (Table 4) revealed that in order to get information on pesticide recommendation 75.83 per cent of okra farmers approached pesticide retail shops. This result was in accordance with the previous findings that the major source of information on pesticide recommendation was pesticide dealers [23, 24, 25, 26, 27]. In the present study, 92.50 per cent of farmers did not pay attention towards label information given in pesticide containers and they used bottle caps containing measurement mark provided along with pesticide package for measuring pesticide. Farmers could not understand the toxicity level after reading the colour code given in the pesticide bottle [28]. Only around 20.83 per cent of farmers sprayed pesticides at recommended dose and remaining followed approximate doses. Though most of the farmers (93.33%) did not follow any safety measures while undertaking spraying operation, all the farmers (100.0%) have used stick for mixing of pesticides. These results are in agreement with the finding that only very few vegetable and fruit growers used protective clothing during spraying [29]. None of the farmers have used empty pesticide containers for house/farm purpose. Throwing the empty pesticide containers in neglected areas (86.67%) was the commonly adopted disposal method and none of them buried the pesticide containers in soil. But, this result is in disagreement with earlier work that around 50 per cent of empty pesticide containers were buried in the field itself [30]. Nearly 96.96 per cent of farmers carried out spraying operation in morning hours by using power sprayer (99.17%) and no one preferred afternoon time. The spraying interval of 7 to 10 days (53.33%) between two spraying and the pre harvest interval of 1 day (65.0%) was mostly followed by farmers. Around 35.0 per cent of the farmers did not follow any waiting period and harvested fruits on the same day after pesticide application. This might be one of the reasons for increased detection of pesticide residue in okra farm gate sample at national level.

Table 4: Knowledge level of okra growing farmers on pesticide usage pattern.

Sl. No	Pesticide usage pattern	% Respondants						
		CBE	DMR	VLR	SA	DN	TPJ	Mean percentage*
Source of information on pesticide recommendation								
1	Pesticide retail shop	60	75	70	95	85	70	75.83
2	Fellow farmers	20	15	20	5	15	10	14.17
3	Government agricultural personnel	20	10	10	0	0	20	10.00
4	Reading label before use	20	5	0	0	0	10	5.83
5	No attention towards labels	80	90	100	100	100	85	92.5
Measurement of pesticide								
6	Bottle cap	100	100	80	90	85	100	92.5
7	Approximately	0	0	20	10	15	0	7.50
Dose								
8	Recommended dose	35	15	20	25	15	15	20.83
9	Approximate dose	70	85	80	75	85	85	80.00
Mixing of pesticide								
10	Stick	100	100	100	100	100	100	100
11	Hand	0	0	0	0	0	0	0
Safety methods followed while spaying								
12	No safety method	80	95	95	100	100	90	93.33
13	Mouth and nose cover	15	5	0	0	0	10	5.00
14	Gloves	5	0	5	0	0	0	1.66
Disposal of pesticide container								
15	Buried in soil	0	0	0	0	0	0	0
16	Thrown in neglected area	95	90	95	80	75	85	86.67
17	Leaving them randomly by the field	5	10	5	20	25	15	13.33
Type of sprayer used								
18	Hand sprayer	0	5	0	0	0	10	2.50
19	Power sprayer	100	95	100	100	100	100	99.17
Time of application of pesticides								
20	Morning	90	100	95	100	100	95	96.67
21	Afternoon	0	0	0	0	0	0	0

22	Evening	10	0	5	0	0	5	3.33
Temporal frequency of pesticides application in okra leaf								
23	Weekly interval (7 days)	10	30	45	55	40	25	34.17
24	Fortnight intervel (10-14 days)	65	50	40	45	60	60	53.33
25	Related to pest infestation	25	20	15	0	0	15	12.50
Common waiting period followed								
26	No waiting period	20	30	30	45	60	25	35.00
27	1 day	80	70	70	55	40	75	65.00
28	2 days	0	0	0	0	0	0	0

*Multiple answers possible

4. Conclusion

The study has revealed that both recommended and non recommended pesticides belonging to slightly to highly hazardous toxicity class were used in okra agro-ecosystem. A clear trend in greater use of newer molecules followed by organo phosphorous group of insecticides for management of pests was noted. A sign of changing trend in awareness among farmers like use of stick for mixing, use of measuring cups and not reusing the pesticide containers for household purpose was observed. However, farmer's knowledge on recommended pesticide, dosage, safe harvest interval, label claim and personnel protection during spray operation were lagging. In order to produce pesticide residue free okra fruit, it becomes imperative to educate the farmers about the significance of following of proper pre harvest interval, color code given in pesticide containers, eco-friendly pest management and health hazardous caused by misuse of pesticides.

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