Agricultural Economics Research Review
Vol. 18 July-December 2005 pp 209-221

Pesticide Use in Vegetable Crops: Frequency, Intensity and Determinant Factors

H. Jeyanthi[1] and S. Kombairaju[2]

Abstract

This paper has examined pest management practices in four important vegetable crops, viz. chillies, cauliflower, brinjal and bhendi using farm level cross-sectional data. Average pesticide usage has been estimated at 5.13, 2.77, 4.64 and 3.71 kg active ingredient per hectare on chillies, cauliflower, brinjal and bhendi crops, respectively. On an average, cauliflower and brinjal are each given 15 applications, chillies is given 13 and bhendi is given 12 applications. The study has suggested that for reducing pesticide-use, farmers need to be educated about different non-chemical control methods and should be encouraged to adopt integrated pest management (IPM) practices.

Introduction

Pesticides constitute the key control tactics for management of pests and diseases and the productivity of crops depends on their effective control. Together with high-yielding crop varieties and fertilizers, pesticides have helped the Indian farmers in achieving a substantial increase in agricultural productivity (Birthal *et al*., 2000). The area under plant protection has been continuously increasing in India. The average per hectare consumption of pesticides in Indian agriculture was only 1.2 gha^{-1} in 1953-54, it increased to 377 gha^{-1} in 1985-86 and further to 431 gha^{-1} in 1992-93. However, thereafter the fertilizer consumption has gradually declined to 288 gha^{-1} in 1999-2000 (Agnihotri, 2000). According to one estimate, every rupee invested in chemical pest control returns Rs 3 in crops saved (NCAER, 1967), while as per another estimate one rupee spent on chemical control of pests can fetch Rs

[1] SRF, Department of Agricultural Economics, [2] Dean, School of Post Graduate Studies, Tamil Nadu Agricultural University, Coimbatore.

7 to Rs 26 by managing huge losses on crops like cotton, paddy, sugarcane, sunflower, mustard, vegetables and groundnut (Bakhetia and Udean, 1998).

Excessive and indiscriminate use of pesticides not only increases the cost of production but also results in many human health problems and environmental pollution. According to WHO estimates, one million cases of pesticide poisoning occur every year and consequently there are 20,000 deaths globally (Nasir, 1999). The most damaging ecological disturbance of injudicious use of pesticides is the existence of high concentration of pesticide residues in food chain, including cereals, pulses, vegetables, fruits, milk and milk products (including mother's milk), fishes, poultry, meat products and water.

India is the second largest producer of vegetables in the world, next only to China with an estimated annual production of about 73 million tonnes from an area of about 4.5 million hectares at an average yield of 11.3 tonnes per hectare. India shares about 13 per cent of the world output of vegetables from about two per cent of the cropped area in the country. Fruits and vegetable crops receive considerably high quantity of pesticides, and with a cropped area of three per cent, they consume 13 per cent of the total pesticides in the country (Nigam and Murthy, 2000). The effect of chemical pesticide-use is more harmful in vegetables. These problems have necessitated the search for safer and effective methods of pest control, including behavioural (use of attractants, e.g. pheromone traps), biocontrol and botanical pesticides. Their use, however, has limitations and chemical control continuous to be the preferred strategy in practice. The aim of this paper was to understand farmers' pest management practices in four important vegetable crops, viz. chillies, cauliflower, brinjal and bhendi and to derive some implications for pest management in future.

Methodology

This paper is part of a larger study undertaken to evaluate the economic and environmental impact of pesticide-use in vegetable cultivation in the Oddanchatram block of Dindigul district of Tamil Nadu (Jeyanthi, 2002). Choice of this area was deliberate because the Dindigul district constituted approximately eight per cent of the total vegetable area in the state. Chillies, cauliflower, brinjal and bhendi were the four vegetables considered for the study. These four crops are frequently sprayed with pesticides due to higher pest incidence. A three-stage sampling procedure was followed to select the respondents. In the first stage, Oddanchatram block of the Dindigul district was purposively selected (Table 1). Thirty-nine villages in the block

Table 1. Area under selected vegetables in Tamil Nadu

Crop	Oddanchatram block (ha)	Dindigul district (ha)	Percentage share
Chillies	171	950	18.00
Cauliflower	139	541	25.69
Brinjal	148	218	67.89
Bhendi	673	2309	29.15

Table 2. Distribution of the sample farmers in Oddanchatram Block

Villages selected	Total no. of respondents	Number of respondents growing			
		Chillies	Cauliflower	Brinjal	Bhendi
Thasaripatti	23	15	21	3	3
Veeralapatti	15	11	1	11	6
Ambilikai	14	10	1	5	8
Arasappapillaipatti	12	12	3	-	-
Vadakadu	12	7	7	12	-
Kosavapatti	10	3	8	-	5
Krishnakavundanputhur	8	3	2	4	7
Virupachi	6	6	2	-	1
Total	100	67	45	35	30

were arranged in the descending order of their area under vegetables. In the second stage, the first eight villages having the largest vegetable area were selected as per the records of Assistant Directorate of Statistics, Dindigul district. In the third stage, farmers were selected randomly. The sample consisted of 100 vegetable growers from eight villages in proportion to the area under vegetables in each village. Among the 100 sample farmers, chillies, cauliflower, brinjal and bhendi were grown by 67, 45, 35 and 30 farmers, respectively (Table 2). Data on vegetable cultivation practices, plant protection techniques and other variables were collected for the agricultural year 2001-02.

Results and Discussion

Socio-economic and Cropping Characteristics

The average farm size of the sample farmers was 2.75 ha with garden lands constituting the major portion of total landholding (90.68%). Land was the major asset forming 90.79 per cent of the total value of farm assets. Wells were the only source of irrigation in the sample farms. The average

area commanded by a well was 1.42 ha. Fifty-three per cent of the farmers owned power sprayers and 15 per cent had both power and hand-operated sprayers.

Vegetables were the major crops grown in the sample farms, occupying 62.46 per cent of the gross cropped area. Sorghum and maize were the next most important crops. Groundnut, coconut and sugarcane were grown on a limited area. The cropping intensity was 119.48 per cent. The major crops considered for this study occupied 56.20 per cent of area under vegetables and 35.10 per cent of gross cropped area.

Pesticide Application

The sample farmers followed a number of pest control practices and used a variety of chemical pesticides to control pest infestation and minimize crop losses. It was observed that pesticides were applied without adequate understanding of pest ecology, economic injury level, types of pesticides to control specific insect pests, their quantities and methods of application, time lapse between last picking and spraying and precautionary measures. Some of these issues were studied and are discussed below.

Frequency of Pesticides Application

Farmers used pesticides frequently since pest infestation was relatively high in vegetable crops, particularly in chillies, cauliflower, brinjal and bhendi. Frequency of pesticides application by farmers is presented in Table 3.

Harvesting of the produce (picking) was done once in 15 days in chillies, once in five days in brinjal and on alternate days in bhendi and cauliflower. In the study area, it was a regular practice to spray pesticides immediately before or after the harvest. When the pesticide spray was done immediately before harvesting, the danger of pesticide residue on produce was more. With the help of bore-well irrigation, these farmers were cultivating the crops round the year, even during off-season and it resulted in heavy pest incidence. Even the minor pests became the major pests. Since pest-free produce fetched higher price in the market, frequency of pesticide spray was found more in the four crops studied.

For chillies, the number of spraying ranged from 11 to 17, with an average of 13. About 60 per cent of the farmers had an average of 13 or less sprayings, while the remaining gave 14-17 sprayings. For cauliflower, the number of spraying ranged from 11 to 22, with an average of 15. About 78 per cent of the farmers had on the average 15 or less sprayings, while the remaining applied 16 or more sprayings.

Table 3. Frequency of pesticide application on the selected vegetables

No. of applications	Chillies		Cauliflower		Brinjal		Bhendi	
	% of farmers	Cumulative %	% of farmers	Cumulative %	% of farmers	Cumulative %	% of farmers	Cumulative %
< 11	4.48	4.48	0.00	0.00	0.00	0.00	20.00	20.00
11	5.97	10.45	4.44	4.44	0.00	0.00	26.67	46.67
12	20.90	31.35	11.11	15.55	5.71	5.71	20.00	66.67
13	28.36	59.71	17.78	33.33	8.57	14.28	13.33	80.00
14	23.88	83.59	20.00	53.33	20.00	34.28	10.00	90.00
15	5.97	89.56	24.44	77.77	22.86	57.14	6.67	96.67
> 15	10.45	100.00	22.22	100.00	42.86	100.00	3.33	100.00
Average	13		15		15		12	
Range	4-17		11-22		12-19		9-16	

* Applications included both spraying and dusting

For brinjal, the number of spraying ranged from 12 to 19, with an average of 15. About 57 per cent of the farmers applied on the average 15 or less sprayings, while the remaining gave 16-19 sprayings. For bhendi, the number of spraying ranged from 9 to 16, with an average of 12. About 67 per cent of the farmers gave on the average 12 or less sprayings, while the remaining applied 13 or more sprayings.

Intensity of Pesticide Use

Frequency distribution of farms by pesticide-use intensity is presented in Table 4 for different vegetables.

Chillies

The study revealed that about 55 per cent the farmers applied 4 kg or less of technical grade pesticides per ha and the remaining 45 per cent used more than 4 kg of active ingredient (a.i)/ha. There was a substantial inter-farm variation in pesticide-use intensity, which ranged from 1.03 kg of a.i/ha to 6.69 kg of a.i/ha, with average of 5.13 kg of a.i/ha. Farms with pesticide-use intensity of 1-2 kg of a.i/ha formed only 5.97 per cent and of 6 kg of a.i/ha were 8.96 per cent. Farms with pesticide-use intensity of 3-4 kg of a.i/ha were maximum, 38.80 per cent.

Cauliflower

About 87 per cent of cauliflower growers applied pesticides amounting to 4 kg or less of a.i/ha and the remaining applied more than this quantity. The inter-farm variation in pesticide-use intensity ranged from 1.27 kg of a.i/ha to 6.43 kg of a.i/ha. Farms in the low range of pesticide-use intensity (1-2 kg of a.i/ha) formed 24.44 per cent, whereas with high range (more than 6 kg of a.i/ha) formed only 4.44 per cent. Highest number of farms (44.44 per cent) was observed in the pesticide-use intensity range of 2 to 3 kg of a.i/ha.

Brinjal

The pesticide application to this crop was more than the other three crops. The minimum range of pesticide-use intensity was 3-4 kg of a.i/ha and 31.43 per cent of the farms were within this range. The inter-farm variation in pesticide-use intensity ranged from 3.10 kg of a.i/ha to 8.65 kg of a.i/ha with average of 4.64 kg of a.i/ha. Same number of farmers were observed in all the pesticide-use intensity ranges, except in the case of more than 6 kg of a.i/ha, in which only 5.71 per cent farmers were observed.

Table 4. Frequency distribution of pesticide-use intensity in different vegetables

Pesticide-use intensity (kg a.i/ha)	Chillies		Cauliflower		Brinjal		Bhendi	
	% of farmers	Cumulative %	% of farmers	Cumulative %	% of farmers	Cumulative %	% of farmers	Cumulative %
< 2	5.97	5.97	24.44	24.44	-	-	3.33	3.33
2.0-3.00	10.45	16.42	44.44	68.88	-	-	36.66	39.99
3.0-4.0	38.80	55.22	17.78	86.66	31.43	31.43	23.33	63.32
4.0-5.0	23.88	79.10	8.89	95.55	31.43	62.86	20.00	83.32
5.0-6.0	11.94	91.04	-	95.55	31.43	94.29	10.00	93.32
> 6	8.96	100.00	4.44	100.00	5.71	100.00	6.67	100.00
Average	5.13		2.77		4.64		3.71	
Range	1.03 – 6.69		1.27 – 6.43		3.1 – 8.65		1.89-6.07	

Bhendi

About 63 per cent of the farmers used pesticides amounting to 4 kg or less of a.i/ha, while the remaining applied more than this quantity. The inter-farm variation in pesticide-use intensity ranged from 1.89 kg of a.i/ha to 6.07 kg of a.i/ha, with average of 3.71 kg of a.i/ha. Farms in the range of 1-2 kg of a.i/ha were 3.33 per cent, whereas with more than 6 kg of a.i/ha were 6.67 per cent. About 37 per cent of bhendi growers applied pesticides in the range of 2-3 kg of a.i/ha.

A comparison of pesticide-use intensity revealed highest use in chillies (5.13 kg of a.i/ha), followed by brinjal and bhendi with 4.64 and 3.71 kg of a.i/ha, respectively. In cauliflower, even though number of pesticide applications was more, pesticide-use intensity was low with 2.77 kg of a.i/ha. The percentages of farms applying pesticides in the range of 4 kg or less of a.i/ha were as follows: cauliflower, 87; bhendi, 63; chilli, 55; and brinjal, 31 per cent. About three per cent of bhendi, six per cent of chilli and 24 per cent of cauliflower growers were grouped in the pesticide-use intensity range of less than 2 kg of a.i/ha. More than 6 kg of a.i/ha of pesticide was used by 8.96, 4.44, 5.71 and 6.67 per cent of chilli, cauliflower, brinjal and bhendi growers, respectively.

Types of Pesticide Used

The sample farmers used different types of pesticides — insecticides, fungicides, bio- and botanical pesticides. None of the farmers applied any weedicide for vegetables. Insecticides were used by all the farmers since insect attack was severe than fungal attack in all the four crops in this region (Table 5). The application of fungicides on cauliflower was only 2.22 per cent since all the growers purchased seeds, which were already treated with fungicides.

The farmers also used a number of pesticides belonging to organochlorine, organophosphate and pyrithroid groups (Table 6). Most of the pesticides used on the sample farms belonged to the moderate risk (category II), followed by high risk (category I) and low risk (category III) groups as classified based on acute dermal LD_{50} for Rabbits/Rat. The application of

Table 5. Percentage of farmers using various types of plant protection chemicals

Pesticide class	Chillies	Cauliflower	Brinjal	Bhendi
Insecticides	100.00	100.00	100.00	100.00
Fungicides	28.36	2.22	8.57	10.00
Biopesticides	1.49	2.22	0.00	6.67
Botanical pesticides	1.49	2.22	0.00	3.33

Table 6. Types of pesticides used by vegetable growers

Pesticide	Category	Percentage of area applied				Price
		Chillies	Cauliflower	Brinjal	Bhendi	(Rs/ L or kg)
Organophosphates						
Profenofos 50% EC	II	67.46	62.22	26.72	28.13	450
Methyl Parathion 50%EC & 2% EC	I	28.06	32.00	33.62	-	370
Monocrotophos 36% SL	I	20.78	-	39.66	45.33	300
Quinalphos 25% EC	II	-	-	54.31	15.60	230
Acephate 75% SP	III	47.76	-	-	-	340 (500 g)
Carbamates						
Carbofuran 3%G	I	30.45	56.89	-	28.13	60
Indoxacarb14.5% SL	II	-	58.22	-	-	600 (200 mL)
Carbosulfan 25% EC	II	-	-	57.76	18.13	540
Pyrithroids						
Cypermethrin 25% EC & 10% EC	II	22.99	36.44	59.48	21.33	470,270
Fenvalerate 20% EC	II	-	-	53.45	22.67	240
Organochlorines						
Endosulfan 35% EC	II	-	-	56.90	24.93	230
Others						
Fipronil 5% SL	II	42.27	59.20	-	-	820
Imidacloprid 17.8% SL	II	22.69	34.67	-	-	340 (100 mL)
Spinosad 2.5% SL	III	-	44.09	-	-	300 (250 mL)

pesticides belonging to the low risk category (category III) was not found on brinjal and bhendi sample farms.

In brinjal, the application of high-risk pesticides, viz. Monocrotophos and Methyl Parathion was in about 40 and 34 per cent of area, respectively under the crop while in chillies, their usage was in about 21 and 28 per cent of area, respectively. In bhendi, high-risk pesticides, viz. Monocrotophos and Carbofuran were used in about 45 and 28 per cent of area, while in cauliflower, Carbofuran and Methyl Parathion were used respectively in about 57 and 32 per cent of its area.

Pyrithroids like Cypermethrin and Fenvalerate, and Organochlorine group of pesticides, Endosulfan, were the most frequently used pesticides in brinjal and bhendi. Organophosphate pesticide, Profenofos, was the most frequently used pesticide in chillies and cauliflower with about 67 and 62 per cent of areas, respectively. Even though the prices of new group of chemicals like Fipronil, Imidacloprid and Spinosad were high, they were also most frequently used in cauliflower due to their high pest-control efficiency.

Impact of Pesticides on Human Health and Environment

The intensive use of pesticides had significantly increased productivity of the vegetables. However, the on-farm benefits of pesticides were offset to some degree by the off- farm costs imposed by them on the environment. Environmental contamination from pesticides ranges from the disruption of natural water, air and soil functions, to the alteration of the eco-system, resulting in detrimental effects on nutrient cycles or the toxicity of non-target organisms. According to Knight and Norton (1989), pesticide-use could result in water pollution and food contamination, endangering human health and non-target species. Bindra and Kalra (1971) had estimated insecticidal residues in vegetables of different markets of Delhi, Hyderabad and Punjab. Their analysis indicated that 75 per cent of the samples were contaminated and 50 per cent contained residues higher than the tolerance limits. Among the thirty okra samples, three samples, one in each with Fenvalerate, Endosulfan and Cypermethrin exceeded the MRL and four out of ten cauliflower samples exceeded the MRL with Cypermethrin, Fenvalerate and Monocrotophos.

Kumar and Yadav (1998) have found that spraying the cauliflower crop blindly throughout the growing period on calendar-based interval would be wasting of the pesticides and would unnecessarily increase the cost of production, contaminate the human diet and environment. Ali (2001) has cautioned that the spraying of pesticides in the fields was particularly dangerous for the women because it was not only affecting their health but

also jeopardizing the health of the future generation. Reproductive performance of the males exposed to pesticides also got reduced.

In a joint statement, the UN, FAO and the WHO (2001) had warned that around 30 per cent of pesticides marketed in developing countries with an estimated market value of US $ 900 million annually did not meet internationally accepted quality standards and they were posing a serious threat to human health and the environment.

Reasons for Pesticide Use — Farmers' Perception

Farmers were asked about their perception on the quantity of pesticide being used by them as to its adequacy, under-use or over -use and the reasons for the same (Table 7).

'Quantity currently used is enough to control pests' was the main reason as per the perception of adequate use of pesticides with 56.41 per cent farmers. About 34.62 per cent responses reasoned the use of this quantity of pesticides for getting higher returns, while 8.97 per cent applied it on the recommendations of pesticide dealers.

Those farmers who reported over-use of pesticides reasoned out that higher pest incidence (41.32 per cent), followed by ineffectiveness of pesticides (19.83 per cent) as the major reasons for their over-use. Some farmers (19.01) felt the necessity of over dose because of 'over-use of pesticides by their neighbours. About 12.40 per cent responses were in favour of higher returns from the over-use. Pest resistance (7.44 per cent) also made the farmers to use over doses to control pests.

The major reasons stated by the farmers for less use of pesticides were lack of funds (38.46%), low pest incidence (38.46%), and lack of knowledge about prophylactic dose (23.08%).

Conclusions and Implications

Vegetables like chillies, cauliflower, brinjal and bhendi are infested with a number of insect pests and if left uncontrolled may cause heavy damage. The study has revealed that chemical control is the principal pest control method followed by the farmers in the study area. Biopesticides and botanical pesticides are applied by a limited number of growers, while application of weedicide has been observed absent. On an average, cauliflower and brinjal crops are each given 15 sprayings, chilli is given 13 and bhendi is given 12 applications of pesticides.

Table 7. Opinion of sample farmers on pesticide use

Reasons	Adequate-useresponses		Over-use responses		Less-use responses	
	No.	%	No.	%	No.	%
Quantity currently used is enough to control pests	44	56.41				
Getting higher returns from this quantity	27	34.62	15	12.40		
Recommended by the pesticide seller	7	8.97				
Higher pest incidence			50	41.32		
Pesticides are not effective			24	19.83		
Neighbouring farmers apply, so it is necessary for me to use			23	19.01		
Pest resistance			9	7.44		
Lack of funds					5	38.46
Lack of knowledge on prophylactic dose					3	23.08
Low pest incidence					5	38.46
Total	78	100.00	121	100.00	13	100.00

The average pesticide-use intensity has been found high in chillies (5.13 kg of a.i/ha), followed by brinjal (4.64 kg of a.i/ha), bhendi (3.71 kg of a.i/ha) and cauliflower (2.77 kg of a.i/ha). Pesticide-use has been observed indiscriminate because of farmers' risk aversion and lack of awareness about economic threshhold levels of pest control.

The study has revealed that for reducing pesticide-use, farmers need to be educated about different non-chemical control methods and encouraged to adopt Integrated Pest Management (IPM) practices. Also, there is need of in-depth research on non-chemical management of pests in vegetables wherein pest infestation is relatively high.

References

Agnihotri, N.P., (2000) Pesticides consumption in agriculture in India – An update, *Pesticides Research Journal*, **12** (1): 150-155.

Ali, Farad, (2001) Pesticides — It is safety above all, *Agricultural Today*, **IV** (8): 60.

Bakhetia, R.C. and A.S. Udean, (1998) Safe and judicious use of pesticides, *Pesticides World*, **3**(1): 19-27.

Bindra, O.S and R.L. Kalra, (1971) A review of work done in India on pesticide residues, *Presented at Symposium on Progress and Problems in Pesticide Residue Analysis*, Punjab Agricultural University, Ludhiana.

Birthal, P.S, O.P. Sharma, Sant Kumar and A. Dhandapani, (2000) Pesticide use in rainfed cotton: frequency, intensity and determinants, *Agricultural Economic Research Review*, **13(**2): 107-122.

Jeyanthi, H., (2002) *A Study on Economic and Environmental Impact of Pesticide Use in Vegetable Cultivation*, Unpublished M.Sc. (Agri) dissertation submitted to Tamil Nadu Agricultural University, Coimbatore.

Knight, Alan L. and George W. Norton, (1989) Economics of agricultural pesticides resistance in arthropods, *Annual Review of Entomology*, **34**: 293-313.

Kumar, Surender and P.R. Yadav, (1998) Insect pest population fluctuation on early season cauliflower crop under Haryana agro-climatic conditions, *Indian Journal of Plant Protection*, **26**(2): 145-148.

Nasir, Shazla, (1999) Biology vs chemistry, *Pesticides World*, **4**(6): 16-20.

Nigam, G.L and K.S. Murthy, (2000) An optimum use of pesticides in integrated pest management technology, *Pesticides Information*, **25**(1): 6-9.