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National Academy of Agricultural Science (NAAS) Rating : 3. 03

Pesticide Usage and IPM in Vegetables Production in Western Uttar Pradesh: Environmental Impact Assessment

Siddayya[*] and Mahantesh[**]

ABSTRACT: *The present study intends to examine the economic and environmental issues of pesticide usage in vegetables in Western Uttar Pradesh. The specific objectives of the study were toassess the environmental risks associated with the pesticide use and farmer's willingness to pay for safer control measures. The assessing the environmental risks associated with pesticide use and farmers willingness to pay was analyzed using eco-rating formula and by using percentages and averages. High pesticide use was observed in Tomato and most of the pesticides belong to high and moderate risk chemicals.The IPM showed the potential of avoiding the pesticide risk hazards by 30 to 52 per cent in all the vegetables. Hence the result indicates that higher aggregate eco-ratings for each environment category on conventional farms as compared to IPM farms demonstrating higher environmental concerns. Farmers are willing to pay price premium up to 27 per cent for environmentally safer formulations of pesticides. This confirms that a market exists for safer or environment friendly pesticides in the study area. Increasing farmers' awareness of pesticide hazards, proper regulation of pesticides and promotion of bio-pesticides and IPM is essential for reducing adverse economic and environmental implications.*

Key words: *Environmental impact, IPM, Pesticide usage and Vegetables production.*

INTRODUCTION

India is one of the first countries to start large scale use of pesticides for control of insect pests of public health and agricultural importance from among the third world countries. Pesticides coupled with other modern inputs undoubtedly have enabled the country to achieve unparalleled increase in agricultural productivity over the last five decades and thus enabled to achieve food security. The pesticide consumption has not been uniform in the country, and it varies with the intensity of pests and diseases, cropping pattern and agro-ecological regions with good irrigational facilities and in areas where commercial crops are grown. Pesticide consumption is particularly high in regions with good irrigation facilities and also in those areas where commercial crops are grown. Evidences indicate that in India, pests cause crop loss of more than Rs. 6000 crores annually, of which 46 per cent is due to insects and diseases, 33 per cent is due to weeds, 10 per cent by birds and rodents and the remaining (11 per cent) is due to other factors (Rajendran, 2003).

As a consequence, the paradigm shift in the pest management policy in favour of IPM during the nineties has helped a lot in reducing pesticide consumption in the country. Integrated pest management (IPM), an alternative crop protection technology emphasizes the need for simpler and ecologically safer measures for pest control to reduce environmental pollution and other problems caused by excessive and indiscriminate use of the pesticides. The main components of IPM are pest surveillance, use of crop varieties resistant to pest, sound cultural practices, biological control and use of ecofriendly pesticides having less mammalian toxicity. However, chemical methods of plant protection have proven to be increasingly unsustainable and cost ineffective due to development of pest resistance, rising pesticide cost, pesticide induced outbreak of pest and negative effects of pesticide use on human health and environment. Visualizing the importance of various pesticide issues, the present study intends to examine the economic and environmental issues of pesticide usage in vegetables in Western Uttar Pradesh. The specific

* Associate Professor and Head, CWLR, NIRD&PR, Hyderabad-500 030, India.
** Deputy Commissioner, City Corporation, Davanagere-577 004, India.

objectives of the study were to assess the environmental risks associated with the pesticide use and farmer's willingness to pay for safer control measures. The assessing the environmental risks associated with pesticide use and farmers willingness to pay was analyzed using eco-rating formula and by using percentages and averages.

METHODOLOGY

Environmental Impact of Pesticide Use: The Concept and Model

Pesticide risk to the environment is often related to the amount of active ingredient applied or expenditure incurred on pesticides. Analysis of the environmental benefits of reduced pesticide use must examine the toxicity, mobility and persistence characteristics of the pesticides being used. When farmers reduced the total quantity of pesticidal active ingredient applied but simultaneously substitute highly toxic, mobile and persistent chemicals for relatively lower quantities, it is difficult to argue that environment has gained (Mullen, 1997). Most of the studies have focused on valuing the human health effects of pesticide (Rola and Pingali, 1993) and little attention has been given to other environmental categories. A few studies have suggested possible approaches for measuring the aggregate environmental costs of pesticides and benefits of IPM (Kovach *et al*., 1992, Mullen *et al.*1997, Cuyno *et al*., 2001). These studies considered the effects of pesticides on different components of environment namely surface water, ground water, aquatic organisms, birds, mammal, beneficial insects and humans (acute and chronic toxicity).

The present study identifies five environmental categories which include human health (acute and chronic effects) animals, birds, aquatic species, and beneficial insects. Active ingredient of each pesticide was assigned three levels of risk *i.e.* high, moderate and low for each of the five environmental categories. The Extension Toxicology Network (EXTOXNET), a collaborative education project of the environmental toxicology and pesticide education departments of several universities was the primary source used in developing the database. The IPM data regarding tomato and cabbage pertaining to the same region where the project was being carried out was utilized for this study. Both toxicity and exposure potential criteria were considered in arriving at the assigned risk for each pesticide used in vegetable production

Table 1
Pesticide Impact Scoring System

Environmental Categories	*Indicators*	*Score* *High Risk = 5*	*Moderate risk = 3*	*Low risk = 1*
Human Health				
1. Toxicity				
Acute toxicity	Pesticide Class (WHO Criteria)	la; lb	II	III
	Signal Word (EPA Criteria)	Danger/Poison	Warning	Caution
Chronic toxicity	Weight of Evidence of chronic effects	Conclusive Evidence	Porbable Evidence	Inconclusive Evidence
2. Exposure				
Leaching potential	Leaching potential score	High	Moderate	Low
Runoff potential	Soil half life	High	Moderate	Low
3. Food residues	Systemicity	–	Systemic, post-emergent	Non-systemic, Pre-Emergent
	Plant surface Residues half life	> 4 weeks	2-4 weeks	1-2 weeks
Aquatic Species				
1. Toxicity	95 hr LC 50 (fish) mg/L Fish/other aquatic Species Toxicity	< 1 ppm	1-10 ppm	> 10 ppm
2. Exposure	Runoff Potential Score	High	Moderate	Low
Beneficial Insects				
1. Toxicity	Insect Toxicity Ratings	Extreme/High	Moderate	Low
2. Exposure	Plant Surface	> 4 weeks	2-4 weeks	1-2 weeks
Residue Half life				
Mammalian Farm Animals	For animals and human beings, same level of risk has been assumed.			
Birds				
1. Toxicity	Birds Toxicity Ratings	High/Extreme	Moderate	Low
	8 days LC 50	1-100 ppm	100-1000 ppm	> 1000 ppm
2. Exposure	Plant Surface Half-life	> 4weeks	2-4 weeks	1-2 weeks

in the study area. A brief summary of these criteria was presented in Table 1. These criteria make use of the current state of knowledge with respect to data that indicate pesticide risk to individual environment category. However, in case of some of the pesticides, toxicity of pesticidal compounds to beneficial insects has not been formally assessed. However, in case of some of the pesticides, toxicity of pesticidal compounds has not been formally assessed or data gap exists. Hence, in such cases a low level of risk to any category was assigned to that pesticide.

After the data on individuals risk level associated with each environment category was collected, pesticides were grouped by classes (insecticide, fungicide and herbicide) and score assigned to each pesticide active ingredient were combined with usage data to arrive at an overall eco-rating for each pesticide. An overall eco-rating score was then calculated.

The formula for eco-rating can be expressed as

$$ES_{ij} = (IS) \times (AI_i) \times (Rate_i)$$

Where, ES_{ij} is the eco-rating score for active ingredient i and environmental category j, IS_j is the pesticide risk score for environmental category j, AIi, is the percent active ingredient in the formulation, and $Rate_i$, is the application rate per hectare of ith active ingredient.

Estimating Willingness to Pay for Environmentally Safer Pesticides

To examine the farmers' preference for use of safer pesticides, the values of Willingness to Pay (WTP) were obtained through contingent valuation (CV) method from field level data. The respondents were asked to provide WTP values for different formulations of their favorite pesticides. Five formulations were asked, one that avoiding risk to each of the five environmental categories. The farmers were asked to rank those five categories whose presence they would be willing to pay more. They were then asked how much if anything they were willing to pay per kg of active ingredient for their most preferred category and their least preferred category. The other categories were valued between the upper and lower bounds of these values. The respondents were given the chance of rearranging their ranks until they were completely satisfied that the rankings and WTP values were representative of their preferences.

RESULT AND DISCUSSION

Environmental issues of pesticide use in vegetable cultivation

The present study identifies five environmental categories which include human beings (acute and chronic effects), animals, birds, aquatic species and beneficial insects. Active ingredient of each pesticide was assigned three levels of risk, i.e. high, moderate and low for each of the five environmental categories. These risk levels were rated on a scale from one to five with one having a minimal impact on environment or low toxicity and five considered to be highly toxic or having a major negative effect on the environment. As mentioned earlier, the information regarding hazard rating as well as toxicity database for each pesticide was obtained from data bases such as EXTOXNET, CHEMNEWS, pesticide manual and previous studies. After the data on individuals risk level associated with each environmental category was collected, pesticides were grouped by classes (insecticides, fungicide and herbicide) and score assigned to each pesticide active ingredient were combined with usage data. Overall eco-rating score was then calculated separately for conventional and IPM categories of farmers. The difference between the two represents the amount of risk avoided due to adoption of IPM practices.

Environmental risk associated with pesticide use in vegetables

The environmental risk associated with pesticide use was arrived using eco-rating score for all the four vegetables namely potato, tomato, cabbage and brinjal. The result shows that higher aggregate eco-ratings for each environment category on conventional farms as compared to IPM farms demonstrating higher environmental concerns. In case of potato, the estimates presented in Table 2, shows that net reduction in eco-ratings was due to shift from conventional methods to

Table 2
Environmental Risk Associated with Pesticide Use in Potato under Farmers Practices and IPM

Category	*Types of pesticide*	*Eco-ratings*		*Aggregate % risk avoided to each environmental category*
		Conven-tional	*IPM*	
Human beings	Insecticides	91.39	82.48	35.22
	Fungicide	96.52	39.25	
Animals	Insecticides	91.39	82.48	35.22
	Fungicide	96.52	39.25	
Birds	Insecticide	68.90	66.28	39.20
	Fungicide	132.63	56.25	
Aquatic species	Insecticide	86.55	77.22	47.03
	Fungicide	217.32	83.75	
Beneficial insects	Insecticide	43.35	49.80	30.56
	Fungicide	60.40	22.25	

IPM. It was clearly evident that eco-ratings have reduced to 30 to 47 per cent as a result of adoption of IPM practices by IPM farmers in potato. The aggregate percentage risk avoided for human beings and animals was found to be 35 per cent, indicating risk due to pesticide use in conventional farming. In case of tomato, the aggregate percentage risk avoided was found to be highest for beneficial insects (52.51 per cent). This shows that, greater risk that can be avoided to beneficial insects due to adoption of IPM in tomato. This was followed by human beings and animals (47.45 per cent), birds (45.08 per cent) and aquatic species (42.78 per cent).

Table 3
Environmental Risk Associated with Pesticide Use in Tomato under Farmers Practices and IPM

Category	*Types of pesticide*	*Eco-ratings*		*Aggregate % risk avoided to each environmental category*
		Conven-tional	*IPM*	
Human beings	Insecticides	301.89	148.99	47.45
	Fungicide	67.14	44.93	
Animals	Insecticides	301.89	148.99	47.45
	Fungicide	67.14	44.99	
Birds	Insecticide	262.60	132.03	45.08
	Fungicide	91.64	62.53	
Aquatic species	Insecticide	224.38	116.03	42.78
	Fungicide	152.41	99.59	
Beneficial insects	Insecticide	215.96	95.49	52.51
	Fungicide	42.60	27.33	

Overall the estimates revealed that eco-ratings have declined to 42 to 52 per cent, as a result of adoption of IPM practices in tomato (Table 3).

Table 4
Environmental Risk Associated with Pesticide Use in Cabbage under Farmers Practices and IPM

Category	*Types of pesticide*	*Eco-ratings*		*Aggregate % risk avoided to each environmental category*
		Conven-tional	*IPM*	
Human beings	Insecticides	193.45	101.67	44.46
	Fungicide	70.52	44.93	
Animals	Insecticides	193.45	101.67	44.46
	Fungicide	70.52	44.93	
Birds	Insecticide	148.44	82.71	41.81
	Fungicide	101.16	62.53	
Aquatic species	Insecticide	171.41	97.13	38.85
	Fungicide	150.27	99.59	
Beneficial insects	Insecticide	135.05	78.59	39.45
	Fungicide	39.88	27.33	

Similarly, in case of cabbage, the aggregate percentage risk avoided due to adoption of IPM was found to be highest in case of human beings and animals (44.46 per cent). This indicates if farmers change from conventional methods of farming to improved IPM practice, there was a greater avoidance of pesticide use risk to human beings and animals (Table 4). This was followed by risk avoided on birds (41.81 per cent), beneficial insects (39.45 per cent) and aquatic species (38.85 per cent). Overall, the estimates in cabbage shows that, eco-ratings have reduced to 38 to 44 per cent (Table 4), as result of adoption of IPM.

In brinjal, it was found that, the aggregate percentage risk avoided was highest for beneficial insects (41.52 per cent) followed by human beings and animals (40 per cent), birds (39.22 per cent) and aquatic species (34.52 per cent). In total, brinjal showed that eco-ratings were reduced by 34 to 41 per cent as a

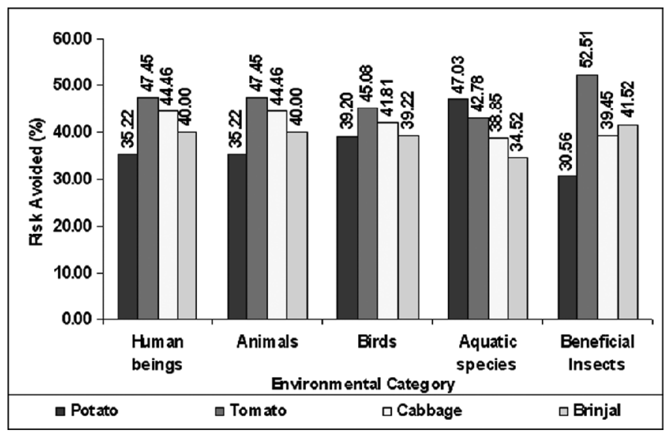

Figure 1: Estimated reduction in environmental risk from pesticide use due to IPM in Vegetables

Table 5
Environmental Risk Associated with Pesticide Use in Brinjal under Farmers Practices and IPM

Category	*Types of pesticide*	*Eco-ratings*		*Aggregate % risk avoided to each environmental category*
		Conven-tional	*IPM*	
Human beings	Insecticides	324.30	185.33	40.00
	Fungicide	67.63	49.81	
Animals	Insecticides	324.30	185.33	40.00
	Fungicide	67.63	49.81	
Birds	Insecticide	267.74	158.85	39.22
	Fungicide	101.48	71.03	
Aquatic species	Insecticide	250.93	145.85	34.52
	Fungicide	135.18	106.99	
Beneficial insects	Insecticide	213.77	116.17	41.52
	Fungicide	33.78	28.59	

result of adoption of IPM practices (Table 5). These reductions represented the per cent pesticide risks avoided due to reduced application as well as judicious selection of pesticides in vegetable cultivation. The above estimates were also presented in the form of diagram in Figure 1.

Farmers' Willingness to Pay for safer pesticides

The Contingent Valuation (CV) technique was employed for the estimation of farmers willingness to pay (WTP) for environmentally safer pesticides vegetable cultivation. Results showed that in case potato cultivation, 57.50 per cent of the sample farmers ranked first for the safer pesticides for human beings as most preferred category. Farmers were willing to pay 28.24 per cent price premium for those formulations that are certified to have no or least harmful effects on human health (Table 6).

Table 6
Rank and Willingness To Pay (WTP) for Risk Avoidance to each Environment Category

Category	*% of sample opting first choice*	*Average WTP (%)*	*Maximum WTP (%)*
Potato			
Human	57.50	18.34	28.24
Animals	4.50	16.45	24.04
Birds	0.00	2.30	10.64
Beneficial insects	38.00	14.74	26.99
Aquatic species	0.00	0.00	0.00
Tomato			
Human	36.00	21.73	39.58
Animals	6.00	17.12	26.32
Birds	0.00	10.00	12.00
Beneficial insects	58.00	22.30	34.34
Aquatic species	0.00	0.00	0.00
Cabbage			
Human	52.32	10.42	36.25
Animals	3.15	4.50	14.30
Birds	0.00	1.58	11.45
Beneficial insects	45.40	27.00	33.31
Aquatic species	0.00	0.00	0.00
Brinjal			
Human	42.50	21.73	42.34
Animals	6.50	17.12	25.31
Birds	0.00	8.72	18.30
Beneficial insects	51.50	22.30	43.86
Aquatic species	0.00	0.00	0.00

The average willingness to pay for those pesticides was estimated as 10 per cent over the present value. However, about 38 per cent respondents rated pesticide safer for beneficial insect as the most preferred one. For those characteristics, farmers were found to be ready to pay a maximum of 27 per cent higher prices (Table 6). Similarly, in case of tomato, about 58 per cent of sample farmers expressed their first choice towards safer pesticide formulations for beneficial insects. For that, farmers were ready to pay on an average around 34 per cent higher prices than what they are paying today (Table 6). Those who ranked human health as first category were found to be willing to pay a maximum of 39.58 per cent. In case of cabbage, more than 50 per cent of sample farmers ranked first the safer pesticides for human beings as the most preferred category. Upto 36 per cent price premium for safer formulations or least harmful effects on human health (Table 6). Those who ranked beneficial insects as first category were found to be willing to pay a maximum premium of 33 per cent.

The similar observations were also recorded in case of brinjal, where half of the farmers expressed their first choice towards safer pesticides formulations for beneficial insects (Table 6). For those farmers, who are willing to pay an average of 43 per cent higher prices than what they are actually paying. The sample farmers, who ranked human health as first category, were found to be willing to pay a maximum of 42 per cent. Aquatic species, animals and birds were the least preferred environment category with respect to willingness to pay was concerned in all the vegetable crops. These results confirm that a market exists for safer or environment friendly pesticides in the study area.

SUMMARY AND CONCLUSIONS

Pesticides coupled with other modern inputs undoubtedly have enabled the Indian farmers to achieve unparalleled increase in agricultural productivity over the last five decades and thus enables to achieve food security. In the present study, the environmental risk associated with pesticide use was arrived using eco-rating score for all the four vegetables namely potato, tomato, cabbage and brinjal. The result shows that higher aggregate eco-ratings for each environment category on conventional farms as compared to IPM farms demonstrating higher environmental concerns. It was clearly evident that eco-ratings have reduced to 30 to 47 per cent as a result of adoption of IPM practices by IPM farmers in potato. In tomato, the estimates revealed that eco-ratings have declined to 42 to 52 per cent, as a result of adoption of IPM practices. The estimates in cabbage show that, eco-ratings have reduced to 38 to 44 per cent, as result of adoption of IPM whereas in case of brinjal, the result showed that eco-ratings were reduced by 34 to 41 per cent as a result of adoption of IPM practices.

Farmers willingness to pay (WTP) for environmentally safer pesticides in vegetable cultivation showed that in case potato cultivation, 57.50 per cent of the sample farmers ranked first for the safer pesticides for human beings as most preferred category. Similarly, in case of tomato, about 58 per cent of sample farmers expressed their first choice towards safer pesticide formulations for beneficial insects. In case of cabbage, more than 50 per cent of sample farmers ranked first the safer pesticides for human beings as the most preferred category. The similar observations were also recorded in case of brinjal, where half of the farmers expressed their first choice towards safer pesticides formulations for beneficial insects. Aquatic species, animals and birds were the least preferred environment category with respect to willingness to pay is concerned in all the vegetable crops. These results confirm that a market exists for safer or environment friendly pesticides in the study area.

Policy implications

It was observed that farmers had limited knowledge of pest management as well as the consequences of pesticide use in vegetable cultivation. Increasing farmers' awareness of pesticide hazards to the environment should be included in the local extension activities. It was found that there was overuse of pesticides in some of the vegetables such as tomato. Hence better incentives interims of tax reduction or enhancing subsidy for prevention of excessive pesticide use and promotion of better formulations is required. Moreover, promotion of alternative pest management strategies such as use of bio-pesticides and Integrated Pest Management along with traditional knowledge is essential for reducing adverse effect on environment in the long run.

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