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RESEARCH ARTICLE

ASSESSMENT ON PESTICIDES USE AND ADOPTION OF INTEGRATED PEST MANAGEMENT PRACTICES AMONG COMMERCIAL VEGETABLE GROWERS IN DANG AND PALPA DISTRICTS, NEPAL

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ABSTRACT

With the introduction of hybrid and modern cultivars of crops and intensification in agriculture system, the use of pesticides in recent years have increased at an alarming rate. Switching of cropping systems from cereal crops to vegetable crops, offseason and year round production of vegetable crops has increased pesticide use in vegetables in comparison to cereal crops. Hence, a study was conducted among commercial vegetable growers of Dang and Palpa districts to knowt the knowledge of farmers regarding pesticide use and rate of adoption of Integrated Pest Management (IPM) practices. Pesticide use was found more at Dang, a Terai district in comparison to Palpa, a hill district. Porous border in Terai areas and easy availability of pesticides are the main reasons. Descriptive statistics, chi-square test, logit model and index score ranking method were used for the data analysis. Active ingredient of pesticide use per hectare in Dang was found to be 4.788 kg a.i.ha^{-1} which was higher than that of Palpa district with 663.08 gm a.i.ha^{-1}. Rate of adoption of IPM was lower in both Dang and Palpa. There was significant relationship between technical training obtained and adoption of IPM, χ^2 (1, N=90) 16.982, $p < 0.05$. Farmers who obtained technical trainings were 15.267 more likely to adopt IPM technology in comparison to those with no technical trainings. Easy availability of chemical pesticides and lack of bio pesticides were the major constraints for the adoption of IPM.

KEYWORDS

Active-ingredient, Commercial, Intensification, Pesticide, Pollution.

1. INTRODUCTION

Pesticides are chemical substances for killing, repelling or reducing insects, weeds, rodents, fungi or other organisms that can cause damage to crops and reduce their yields. Chemical pesticides for the first time were introduced in Nepal in 1952 when DDT was used for malaria control program (Atreya, 2008). Pesticide use is more in vegetable crops in comparison to cereal crops and its misuse is more common in commercial vegetable pocket areas. In the year 2014, fresh vegetable production was 34, 21,035 Mt. tons from the area of 2, 54,932 ha in Nepal (MOAD, 2013/14). Developing countries have been using many older, non-patented, more toxic, environmentally persistent and inexpensive chemicals intensively (Rijal et al., 2018).The annual import of pesticides in Nepal is about 211t a.i. with 29.19% insecticides, 61.38% fungicides, 7.43% herbicides and 2% others (Sharma et al., 2012). The trend of pesticide use is increasing in Nepal by about 10-20% per year (Diwakar et.al., 2008). A recent study shows that the average pesticide used in Nepal is about 396 gm a.i.ha^{-1} which is very low in comparison to other countries like 500gmha^{-1} in India, 6.6 kgha^{-1} in Korea and 12 kgha^{-1} in Japan (PPD, Annual Report, 2014; Gupta, 2004). However concentration of pesticides being used in vegetable crops alone is very high. In the case of cereal crop growers the rate of increase is small. Studies have shown that more than 90% of the total pesticides are used in vegetable farming (Atreya and Sitaula, 2011) .

For the better management of pesticides, Nepal has prepared the Pesticide Act, 1991 and Pesticide Regulation, 1993 and enforced them from July 16, 1994.21 pesticides have been banned in Nepal till date (MOAD, 2019). Due to poor regulation and monitoring even banned pesticides have been used by the farmers. According to WHO estimates, one million cases of pesticide poisoning occur every year and consequently there are 20,000 deaths globally. There are strong correlations among persistent chemical use, environmental degradation and human health effects in countries adopting widespread commercial agriculture (Wilson, 2010). High concentration of pesticide residues are present in food chain including cereals, vegetables, pulses, fruits, milk and milk products including mothers' milk (Jeyanthi and Kombairaju, 2005). In addition pesticide overuse has resulted in pesticide resistance and resurgence. Misuse of pesticides has caused pests to become more resistant to pesticides thereby leading to the use of higher dose of pesticide for same level of control. The losses in crops due to insects and mites is more in post- green revolution era than pre- green revolution era in spite of the widespread use of pesticides (Dhaliwal et al., 2010).

IPM denotes the ecological approach for management of pests in a way that economic damage is avoided and adverse effects are minimized

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(Kalsariya and Nidhi, 2017). Pesticides not only kill the harmful insects but also kill the natural enemies and predators of harmful insects which results in increased number of harmful pests. The best alternative for reducing the use of pesticides is adoption of Integrated Pest Management (IPM) technology by the farmers which focuses on biological control of pesticides. IPM was first time introduced by Government of Nepal in 1996 to solve farming problem however IPM-FFS approach as an extension program was adopted in May 1997 in early rice after the outbreak of Brown Plant Hopper (BPH) of rice in Chitwan district (Tiwari et al., 2015). Strong science-based and research-supported intensive IPM program is required for increasing the rate of IPM adoption (Sharma et al., 2012).

Along with the increase in vegetable production, use of pesticides has also been significantly increasing these years. Use of similar pesticides repeatedly, overuse and misuse of pesticides, lack of technical knowledge on pesticide handling are the major issues related to pesticides (Bhandari, 2014). The main objective of the study is to find out the types and active ingredient of pesticides being used in the commercial vegetable areas and to know the integrated pest management practices being adopted. This study also focuses on assessing the determining factors and constraints for the adoption of Integrated Pest Management Practices which will be helpful for creating awareness among farmers and pesticide sellers about the safe handling of pesticides and will also help the stake holders take effective actions for addressing the problem.

2. METHODOLOGY

2.1 Study area and Survey Design

The study was done in one hill district Palpa and the other Terai district Dang to know about the knowledge level of commercial farmers about the use of pesticides and adoption of IPM Technology. Figure 1 shows the study area. Dang lies on latitude of 28.0^0 N and longitude of 82.15^0 E. Rampur is the pocket area of Ghorahi Sub-Metropolitan City for vegetables. Palpa lies on latitude of 27.86^0 N and longitude of 83.54^0 E. Madanpokhara of Tansen Municipality is the pocket area for different vegetables like Tomato, Cauliflower, Cabbage, Brinjal, Beans etc.

Figure 1: Location of the study area

A total of 90 commercial vegetable growers, 45 from Dang and 45 from Palpa were surveyed and the sample was selected on the basis of purposive random sampling. For the study, the semi-structured questionnaires were used to obtain the primary information from commercial vegetable growers which included both open ended and closed ended questions. Closed ended questions had multiple choices and allowed the respondents to select a single option whereas open ended questions allowed the participants to respond openly without any options. Amount and frequency of pesticides used were recorded to find out the active ingredients of pesticide being used. Information was also obtained through Focused Group Discussion (FGD), Key Informant Interview with five farmers from each municipality based on their experience and willingness of sharing knowledge. Key Informants were identified through local level governments, Local NGOs who possessed sufficient local agriculture knowledge. Secondary Information were collected from various sources like journals, research articles, Government Reports, Nepal Agriculture Research Council, and Central Bureau of Statistics.

2.2 Statistical Analysis

Data were entered into Statistical Package for Social Sciences (SPSS Version-25.0) and Microsoft Excel 2013 for analysis. A descriptive statistics and frequency distribution analysis were conducted among all parameters obtained. Binary Logit Regression model was used to identify the determinants of IPM technology. In this model, dependent variable was the adoption of IPM technology whereas the explanatory variables used were the gender of household head, education level of household head, trainings obtained or not, total land area possessed and the frequency of agriculture technical support obtained.

Constraints of adoption of IPM were identified through FGDs and were ranked by using the **index score** method by using the formula,

$$I=\frac{\sum Sf}{N}$$

Where, I= Index score (0<I<1)
S= Score obtained by an individual
F= frequency
N= Total number of respondents

3. RESULTS AND DISCUSSIONS

3.1 Socio-demographic characteristics and land holdings

Age, ethnicity, gender, education and occupation of the respondents were measured, categorized and presented in Table 1. 86.7% male and 13.3% female in Dang and 33.3% male and 66.7% female in Palpa were interviewed for the study. People of age group 41- 60 were found active in agriculture because most of the youths of age group 21-40 were abroad for work force. 46.7 % were Brahmin followed by indigenous group of people, Chaudhary community comprising 43.3 % in Dang district. 23.3% were illiterate in Dang and 10% in Palpa. 83.3 % people had agriculture as their main occupation while 10 % had foreign employment as main occupation in Dang. In case of Palpa, 77.3 % had agriculture as their main occupation and 9.7% involved in agriculture and other business. Agriculture contributes 20% to 60 % share of household income even for those with other occupations.

Table 1: Socio-demographic status of surveyed vegetable growers

	Category	Frequency (%)	
		Dang	Palpa
Household Head			
	Male	86.7	33.3
	Female	13.3	66.7
Education Level			
	Illiterate	23.3	10
	Just Literate(Primary Level)	46.7	50
	Secondary Level	24.7	23.3
	Higher Secondary Level	3.3	13.3
	University degree	2	3.3
Income Source			
	Agriculture	83.3	77.3
	Private Job	3.3	10
	Foreign Employment	10	3
	Agriculture and Other	3.3	9.7
Land Holding			
	Less than 0.5 Bigha	46.7	51.3
	0.5 to 1 Bigha	26.7	40
	1 to 2 Bigha	16.7	6.7
	Greater than 2 Bigha	10	2
Agriculture Purpose			
	Household Consumption	6.7	3.3
	Sale	93.3	96.7

3.2 Active ingredients of pesticide being used in crops

Active ingredients are the chemicals that make a part of a whole product which kills, controls or repels pests. Active ingredient of pesticide use in Dang district for vegetables was found to be very high that is 4.788kg a.i. ha^{-1} which is much higher than national average i.e. about 396 gm a.i. ha^{-1}. However, it was comparatively lower in Palpa district. Active ingredient of pesticide used per hectare was found to be 663.08 gm a.i. ha^{-1} which is very low in comparison to developed countries like 6.6 kg ha^{-1} in Korea and 12 kg ha^{-1} in Japan (Gupta, 2004). The pesticide use is more in Terai district due to comparatively more infestation of pests and diseases in Terai district. Also due to porous and open borders and easy availability of pesticides, its use was found more in Terai area. More doses of pesticides need to be used at present than in past to kill the same level of insect due to pesticide resistance (Yadav and Lian, 2009).

93.3 % people cultivated for sale in Dang while 96.7% cultivated for sale in Palpa. Most of the pesticides belonged to Organophosphorus (Methyl

Parathion, Monocrotrophos, Acephate) and Pyrethroids (Cypermethrin, Fenvelerate) group . A group researchers noted that the highest level of residues were found in root vegetables (11.9%) followed by leaf vegetables (10.9%) (Sharma et al., 2012). In case of Dang, 96.7% pesticide is applied in vegetable crops while only 3.3 % pesticide is applied in cereals. In case of Palpa 90% pesticide is applied in vegetables while only 10% pesticide is applied in cereals. Pesticides used for different vegetable crops are shown in Table (2) .Increased use of pesticide is due to higher pest incidence, ineffectiveness of pesticides, heavy use by the neighbors and hope for higher returns (Jeyanthi and Kombairaju, 2005). Majority of commercial farmers in Dang district used Yellow label pesticide (80%) followed by Green (13.3%) and Red (6.7%). In case of Palpa, majority of farmers used Yellow label pesticide (43.3%) followed by Green (26.7%) and Blue (20%).

Table 2: Pesticides used for different vegetable crops

Crops	Pesticides
Tomato	Chloropyrifos, Imidachloropid, Mancozeb, Dichlorovus
Cabbage/ Cauliflower	Imidachloropid, Triazophos, Deltamethrin, Mancozeb
Cucurbits	Emamectin Benzoate, Cypermethrin, Mancozeb, Dimethoate

3.3 Pest Management Practices and pesticide use patterns in Dang and Palpa districts

Pest Management Practices and Pesticide use patterns are shown in Table (3) .The average frequency of pesticide application ranged from 8 times to 50 times a year. Nepal (2010), also revealed that the farmers spray pesticides from 15 to 35 times for one crop cycle. 26.7 % spray if major damage is experienced. In case of Palpa, frequency of pesticide application was comparatively lower.

Table 3: Pest Management Practices and Pesticide use patterns

	Category	Frequency (%)	
		Dang	Palpa
Control Methods			
	Biological Method	2.7	6.7
	Cultural Method	3.3	6.7
	Chemical Method	67.3	20
	Combination of chemical and others	26.7	66.7
Application of pesticides			
	Before appearance of insects/ pests/ diseases	76.7	56.7
	After appearance of insects/ pests/ diseases	23.3	43.3
Cropwise pesticide use			
	Cereals	3.3	10
	Vegetables	96.7	90
Pesticides Storage			
	Farm House	66.7	90
	Inside home	33.3	10
Precautions followed while spraying			
	Spraying after 4pm	3.3	50
	Spraying safe pesticides	26.7	3.3
	Do not consider	60	36.7
	Spraying before flowering	10	10

Majority people, 67.3 % used chemical method of pest control in Dang and about 27% farmer used both chemical and other methods of pest management, while for Palpa, majority of people 66.7 % adopted combination of chemical with other biological methods and one fifth of farmers are using chemical for management of insect pest. Farmers adopting biological and mechanical method of controlling pests were found considerably smaller.

Knowledge level of farmers was very poor regarding use of pesticides. Table (4) shows knowledge and practices of farmers about pesticide use. About 23% farmers in Dang and one fifth farmers in Palpa didn't use any Personal Protective Equipment while spraying pesticides which may be very hazardous for human health. About 13% farmers in Dang and 7% in Palpa didn't know about the waiting period of pesticides. Vegetables and crops consumed immediately after spraying pesticides without following waiting period have pesticide residues in them which may cause several short term and long term effects on human health.

In case of Dang district, 76.7% use Personal Protective Equipment while spraying pesticides whereas in Palpa the figure is up to 80%. In Dang, 66.7% stored pesticides in farm house. In Palpa 90% farmer stored chemical pesticides in farm houses while 10% stored inside the home. Keeping pesticides inside home is very risky. Children can reach the pesticides easily which may result in serious accidents. Involvement of male members in spraying of pesticide was significantly higher in comparison to female. The results were in consistent with other studies done in developing countries (Gupta, 2004; Atreya, 2007). Though farmers were aware about the negative impacts of unsafe use of pesticides, there is no significant positive correlation between awareness and use of protective measures (Atreya, 2007). Farmers feel uneasy to spray pesticides using Personal Protective Equipment and also they report such instruments are costly.

Table 4: Awareness and practices of pesticide use by districts

	Dang	Palpa	χ^2	p-value
Practice separate organic plot				
Yes	10	20	1.684	0.641
No	90	80		
Read pesticide label before using				
Yes	23.3	62.1	10.235**	0.001
No	76.7	37.9		
Know meaning of different colors in pesticide				
Yes	23.3	56.7	8.718*	0.013
No	76.7	43.3		
Know mode of action of pesticide				
Yes	6.7	23.3	2.32	0.313
No	93.3	76.7		
Aware of adverse effects of pesticide				
Yes	93.3	83.3	4.59*	0.032
No	6.7	16.6		
Know banned pesticides				
Yes	30	30	0.083	0.959
No	70	70		
Use same type of pesticide throughout crop growing season				
Yes	50	43.3	3.012	0.222
No	50	56.7		
Idea about waiting period				
Yes	86.7	93.3	0.744	0.689
No	13.3	6.7		
Use of Personal Protective Equipment				
Yes	76.7	80	3.422	0.181
No	23.3	20		
Obtained technical training on IPM				
Yes	40	56.7	8.385*	0.015
No	60	43.3		

Note: * and ** indicate significance at probability levels of 0.05 and 0.01 respectively

Comparative study was done in Dang and Palpa districts to know the awareness level and practices of pesticide use and Chi-square test was done to find out the significant differences. In some cases farmers of Palpa districts were found to have comparatively more knowledge regarding safe handling of pesticides. Significant difference was noticed in the number of people reading pesticide label in Dang and Palpa districts with higher number in Palpa. Significantly more farmers in Palpa district knew the meaning of pesticide label. Though farmers in Dang district were aware about the adverse effects of pesticides, but they were not practicing safe use of pesticides. Significantly higher number of farmers had received technical training on IPM in Palpa districts and positive correlation was found between technical training obtained and adoption of IPM technology. Significant relationship was found between technical training obtained and adoption of IPM, χ^2 (1, N=90) 16.982, $p < 0.05$.

In order to determine the factors affecting the adoption of IPM technology, a binary logistic regression was performed. The frequency of IPM based trainings obtained and the education level of household head were found to significantly determine the adoption of IPM technology. Farmers receiving the regular IPM based technology were 15.267 times more likely to adopt the IPM technology as compared to those who receive the technician support rarely or never. Similarly, literate household head or household head with minimum up to primary level of education were 5.686 more inclined to adoption of IPM technology than the household with no education level.

Table 5: Binary logistic regression of factors affecting the adoption of IPM Technology

Variables	Coefficient	Significance level	Exp(B)
Technical trainir obtained	2.656*	0.019	15.267
Gender of household head	0.000	0.331	1.00
Land area	0.43	0.784	1.469
Education level of housel	1.657*	0.014	5.686
Frequency of agric technical support	0.019	0.678	0.224
Constant	-2.172	0.084	0.131

3.4 Constraints of adoption of IPM Technology

Index score method was used to rank the constraints on adoption of IPM technology by the commercial vegetable growers. Though many farmers were aware about the negative effects of chemical pesticides, however there were some hindrances in adoption of IPM.

Table 6: Constraints of adoption of IPM Technology

S.N.	Constraints of adoption of IPM Technology	Index Score	Rank
1	Easy availability of chemical pesticides	0.886	I
2	Lack of bio pesticides	0.686	II
3	Lack of technical trainings	0.702	III
4	No separate price for organic vegetables	0.352	IV
5	No block farming	0.338	V

Easy availability of chemical pesticides was ranked the major constraint with an index score of 0.886 which was followed by lack of bio pesticides with index score of 0.686. Lack of technical trainings, no separate price for organic vegetables and no block farming were ranked by the respondents as third, fourth and fifth major constraints in adoption of IPM technology with index score of 0.702, 0.352 and 0.338 respectively. A group researchers also reported the lack of technical trainings and easy availability of chemical pesticides to be the hindrance for adoption of IPM technology (Rijal et al., 2018).

3.5 Human Health and Environmental Effects of Pesticides

Irrational use of pesticides causes several impacts upon human health and environment. The problems of toxicity occur when proper procedures are not followed (Dey, 2010). Residue problems are seen when growers apply the wrong pesticide or apply too much of it too soon before harvest. Excessive and indiscriminate use of pesticides not only increases cost of production but also causes several short term health problems like headache, skin and eye irritation, dizziness, vomiting etc. and long term health problems like cancer, birth defects, reproductive problems, tumors, damage of liver, kidney and neural organs etc. (Sharma et al., 2012). Effects of pesticide seen on health of farmers in Dang and Palpa districts are shown in Figure 2 and 3 respectively. In Dang, 40% farmers reported skin and eye irritation. In case of Palpa, 46.7% reported headache, 6.7% reported skin and eye irritation when pesticides were used unsafely. Similar results were found (Atreya, 2008).

More than 98% of sprayed insecticides and 95% of herbicides reach a destination other than their target, including non-target species, air, water, bottom, sediments and food. In Dang, only 26.7 % people were aware about the beneficial insects, pests in surrounding. In Palpa 53.3 % knew about the effect of pesticides on pollinator and natural enemies. Serious effect is seen upon the environment due to random spraying of pesticides. Bees which are chief pollinators of different species of crop plants have been severely affected by the pesticides.

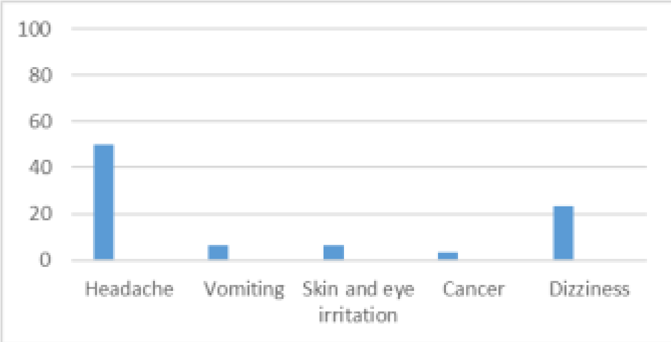

Figure 2: Effects of pesticides seen at Dang

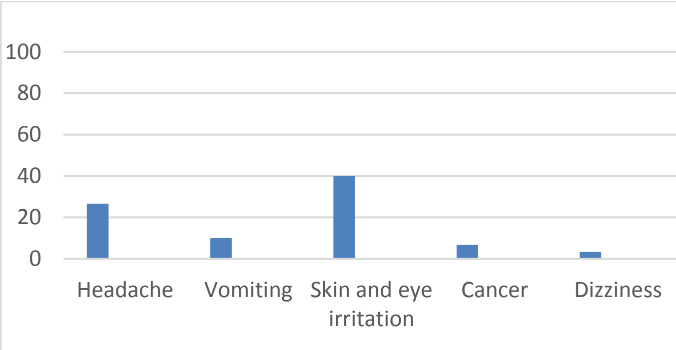

Figure 3: Effects of pesticides seen at Palpa

3.6 Role of Agrovets and IPM Adoption

Agrovets played a significant role in providing agricultural inputs like seeds, pesticides etc. to the farmers. There was more influence of agrovets among farmers than government bodies. A researcher also reported more dependence of farmers upon agrochemical dealers for suggestions (Dey, 2010). In Dang, 66.7 % farmers took technical advice from agrovet before spraying pesticides. Only 20% obtained technical advices from DADO (District Agriculture Development Office) / Service Centre. In case of Palpa, 76.7 % farmers were dependent upon agrovets for technical advices and other agricultural inputs while only 6.7 % farmers were associated with DADO for technical advices. This data depicts very poor presence of government authorities among farmers. There is high chance of pesticide misuse and overuse if pesticide resellers do not have technical knowledge about the safe use of pesticide.

IPM not only minimizes pesticide use but also generates high yields and high net returns and reduces health, environmental and social costs of pesticide pollution. Rate of adoption of IPM was found low in both districts. Use of IPM materials like Pheromone trap, Sticky traps were found lower. Most of the people hadn't heard about IPM. Even those who had taken trainings on IPM weren't practicing it. Most farmers found IPM methods to be costly. Crops raised through IPM practices have comparatively shorter post-harvest life in relation to those of pesticides sprayed. Adoption of IPM practice in a small area by a single farmer was found ineffective as such areas were easily influenced by the neighboring farms using pesticides. Hence IPM need to be practiced in a large block of land for its effectiveness. 40 % farmers in Dang and 56.7% in Palpa had obtained technical trainings on IPM through different organization like

LiBird, DADO etc. (Table 4), however, rate of adoption was low. Only 13.3% farmers were found to adopt IPM in Dang district and 66.7 % in Palpa, also reported only 20% IPM trained individuals in the research. Only 10% farmers had separate organic plot for home consumption in Dang whereas in Palpa 20% farmers had separate organic plot (Atreya, 2005). There was growing interest of people in practicing IPM. High willingness for IPM program indicates that farmers are aware of negative effects of pesticides on human health and ecology. Hence focusing on IPM based technical trainings helps in IPM adoption among farmers. IPM uses locally available resources which are effective and cheaper. Increased adoption of IPM will help reduce pesticide use without adverse consequence on agriculture (Dey, 2010).

4. CONCLUSION

The knowledge level of farmers regarding safe use and handling of pesticides was found to be very poor. Main reason behind this is the lack of education and sufficient technical trainings about the safe use of pesticides. Unsafe handling of pesticides resulted in several health hazards of the farmers and the consumers. Pesticides use was found much greater in Dang district, a Terai district in comparison to Palpa, Hill district. Main reason behind this is the easy availability of pesticides in Terai region due to open border with India. Pesticides enter Nepal easily without any legal procedures. Porous border, easy availability of pesticides, sales of banned pesticides, lack of strict regulation and monitoring system, poor technical knowledge of agrovet runners, less priority programs to IPM are the other reasons for overuse of pesticides. Pests attack is also found more severe in Terai region. IPM based technical trainings need to be run from the government levels and other organizations to aware farmers about the importance of organic farming. Easy availability of chemical pesticides, lack of government policies in favor of farmers such as subsidies in case of crop failure, labelling system and market price for IPM products, strict regulation of the pesticide industry are the major hindrances in adoption of IPM. IPM practiced by single farmer in small area is found ineffective due to effect of neighboring farms using chemical pesticides. Hence IPM needs to be practiced in the entire block of the community. Long-term implications of pesticide use on human health and environment need to be studied for sustainable agriculture, safety to human health and the environment as a whole.

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