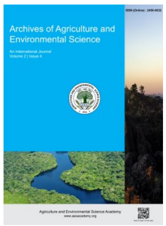
Archives of Agriculture and Environmental Science 9(2): 359-366 (2024)
https://doi.org/10.26832/24566632.2024.0902022

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes



ORIGINAL RESEARCH ARTICLE

CrossMark

Impact of IPM training on pest management practices in major vegetables in Palpa, Nepal

Mamata Adhikari[1], Sapana Acharya[1*] and Pankaj Raj Dhital[2]

[1]Agriculture and Forestry University, Faculty of Agriculture, Rampur, Chitwan, NEPAL
[2]Agriculture and Forestry University, Faculty of Agriculture, Department of Agricultural Extension and Rural Sociology, Rampur, Chitwan, NEPAL
[*]Corresponding author's E-mail: sapanaacharya59@gmail.com

ARTICLE HISTORY

Received: 06 April 2024
Revised received: 09 June 2024
Accepted: 17 June 2024

Keywords

Bio-pesticides
Botanicals
Pesticides
Soil
Waiting period

ABSTRACT

A study assessed the impact of Integrated Pest Management (IPM) training on pest management practices in major vegetable crops in Palpa district. A total of 138 respondents were selected through purposive random sampling from Tansen municipality and the rural municipalities of Bagnaskali and Ribdikot. Data was collected via semi-structured interviews on prevailing IPM practices, pesticide handling, and challenges in IPM adoption. The analysis, employing descriptive and inferential statistics including chi-square tests, revealed that most trained respondents were from Tansen municipality, with more females than males receiving training. Although respondents preferred botanical methods, they predominantly used chemical pesticides due to availability, lack of biopesticides, high costs of IPM, social constraints, and the absence of block farming. Agro-vet stores were the main information source on pesticides. The level of pest control influenced chemical pesticide purchases, with low awareness of pest resistance. Both trained and non-trained respondents sprayed pesticides during pest outbreaks, with few reporting symptoms from exposure. Trained respondents exhibited greater awareness of the impacts of chemical pesticides on beneficial insects and soil health, the importance of waiting periods, safe pesticide disposal, and safety precautions. Significant associations were found between IPM training and chemical pesticide use, awareness of their impacts on beneficial insects, pesticide disposal methods, waiting periods, safety precautions, and perceptions of soil impact. The study highlighted the critical role of training in enhancing pest management practices and awareness of the adverse effects of chemical pesticides, underscoring the need for increased availability of biopesticides and support for IPM adoption.

Citation of this article: Adhikari, M., Acharya, S., & Dhital, P. R. (2024). Impact of IPM training on pest management practices in major vegetables in Palpa, Nepal. *Archives of Agriculture and Environmental Science*, *9*(2), 359-366, https://dx.doi.org/10.26832/24566632.2024.0902022

INTRODUCTION

Globally, vegetable production has grown intensively between 2000 and 2018. In 2018, the world produced 1,089 million tons of vegetables, with international trade of fresh fruit and vegetables representing only around 7-8% of total global production (FAOSTAT). Despite this, fruits and vegetables rank among the most valuable crop and livestock commodity groups. Recognizing their importance, the UN declared 2021 as "The International Year of Fruits and Vegetables" (FAO, 2020). Most vegetable production occurs in Asian countries, with Nepal being the sixth leading producer of fresh vegetables (FAO, 2016). Vegetable farming in Nepal is increasing and contributes significantly to the total horticultural GDP (USAID Nepal, 2011). Over 200 vegetable species are grown in different climatic zones of Nepal, with 50 species cultivated commercially (Shrestha *et al.*, 2004). In the fiscal year 2075/76, vegetable production was 4,271,270 metric tons on a total area of

297,195 hectares (MoALD, 2020). Vegetable production greatly influences farm economy and diet enrichment. Perfect potatoes, beautiful tomatoes, and choicest cabbage must be appealing to buyers, but pests and diseases can reduce them from Grade A to being dumped. Above 30% of crop losses have been reported without crop protection measures (Damalas, 2016). Global potential loss due to pests varies from 50 to 80% among crops (Oerke, 2006). Such losses threaten food security and lead to excessive chemical pesticide use. Pesticides, classified by target organisms and chemical class, pose health, environmental, and residue problems. Healthier production is essential. Integrated Pest Management (IPM) is a solution, reducing reliance on toxic chemical pesticides. Initiated in Nepal in 1997 with FAO support, IPM is now practiced in various crops, including vegetables. The UN's FAO (2020) describes IPM as the integration of pest control techniques that emphasize healthy crop growth with minimal agro-ecosystem disruption and encourage natural pest control mechanisms (IDE Nepal, 2013). IPM-trained farmers in Nepal have increased rice yields by about 15-25% and reduced pesticide use by about 40% (Upadhyaya, 2002).

Palpa is a major vegetable-producing district in Nepal's mid-hill region, with increasing production due to climatic suitability and market access. Major vegetables include cauliflower, tomato, cucumber, cabbage, cowpea, and asparagus. As vegetable farming interest grows, so does pesticide use. Globally, pesticide use is higher among vegetable growers, though it is lowest in Nepal (142g a.i./ha) compared to other Asia-Pacific countries (Sharma, 2015). However, increased agrochemical uses leads to environmental and health degradation, threatening long-term farming sustainability (Atreya, 2008). The adverse environmental effects of unsafe pesticide use and farmers' lack of awareness of health consequences necessitate IPM training. Vegetable farming in Palpa, conducted on commercial and semi-commercial scales, increasingly relies on pesticides to boost production, protect crops, and prevent post-harvest losses. Irrational pesticide uses causes health issues, environmental damage, and soil degradation. Problems include pesticide resistance, resurgence, non-target organism deaths, herbicide drift injuries, water contamination, and bioaccumulation. IPM addresses these issues, but adoption among vegetable farmers remains low. Constraints include the easy availability of chemical pesticides, higher costs of IPM products, lack of technical knowledge, and insufficient government policies (Paudel *et al*., 2020).

This study aimed to assess the impact of IPM training on pest management in vegetable cultivation in Palpa. Data shows pesticide use among vegetable growers increased from 7.1% in 1991/92 to 16.1% in 2001/2002 (Ghimire *et al*., 2018). Misuse of chemical pesticides demands more thorough study, better education, and improved grassroots control measures. Limited research exists on IPM in Nepal. This study identifies major issues in IPM adoption and the proportion of farmers using IPM methods. It evaluates physical, biological, chemical, and cultural practices in pest management, highlighting the importance of soil testing, field scouting, pest management decisions, resistant varieties, beneficial insects, safety precautions, and the hazards of chemical pesticides.

MATERIALS AND METHODS

About the study area

Palpa, a district in Lumbini Province, extends form 27° 34' N to 27° 57' N latitude and 83° 15' E to 84° 22' E longitude is one of the seventy-seven districts of Nepal. The temperature ranges from 2 to 32 ˚C with annual average rainfall of 1903 mm. Vegetables are cultivated in the total area of 2090 ha with the production of 33622.0 MT/ha (AKC Palpa, 2020). The study was conducted in one municipality and two rural municipalities namely Tansen municipality and Bagnaskali and Ribdikot rural municipalities. The reason behind the selection of these areas for this study include is that they are famous and important for production of vegetables in commercial scales and most of the farmers had access to IPM training and sites were easily accessible too.

Method of data collection

A total of 138 households were selected based on purposive random sampling. The farmers were divided into two categories purposively on the basis of their involvement in any forms of IPM related training. The two categories of farmers were:1) who have taken IPM training 2) who haven't been involved in any forms of such training sessions. Research instruments like household survey of total 138 respondents, focus group discussion, key informant interview, field observation, secondary information collection from various sources, etc. were used to collect and triangulate the reliable data. To check the validity and reliability of Interview schedule, questionnaire was pretested by interviewing 14 vegetable growers outside the study area before conducting household survey.

Data and data types

The collected data was of two types i.e., primary and secondary data. Primary type of data was collected from a previously constructed questionnaire targeted to the respondents. Both subjective and objectives types of questionnaires were prepared for primary data collection. This type of data was collected by direct interviews with farmers through questionnaires, FGD, Telephone survey, and KII. Secondary data was collected by reviewing relevant literature on the subject matter including AKC profiles, bulletin, newsletters, annual reports, different journals, Nepal Agricultural Research Council, Agricultural Diary 2077, Central Bureau of Statistics, data from various NGOs and INGOs etc. Internet browsing was done for additional information.

Data analysis and interpretation

Both qualitative and quantitative data obtained were analyzed by STATA and Microsoft excel. Various statistical tools, diagrams, charts and graphs were used to analyze the result obtained.

General descriptive method

The collected data were edited and the local units of measurements were standardized into the scientific one. All the important primary data that were collected from households were entered in MS-Excel and STATA for further analysis. Collected data were analyzed using the descriptive method by using frequencies and percentages.

Chi-square test

Chi square test was used to assess the level of association of different variables with the use of IPM technologies learned in training.

$$\sum \frac{(O_{ij}-E_{ij})^2}{E_{ij}}$$

χ^2 = Where χ^2=Chi-square

O_{ij} = observed frequency of each ijth term

E_{ij} = indicates expected frequency of ijth term

i= 1, 2, 3……….r

j= 1, 2, 3………..k

Indexing

Problems faced by respondents on adoption of IPM techniques were ranked with the use of index. The formula given below was used to find the index.

$I_{prob} = \Sigma S_i F_i / N$

Where,

I_{prob} = Index value for intensity

Σ = Summation

S_i = Scale value of i^{th} intensity

F_i = Frequency of i^{th} response

N = Total number of respondents

RESULTS AND DISSUSSION

Socio-demographic status of farmers

Out of 138 respondents, 41.30% were from Tansen Municipality, 29.71% from Bagnaskali, and 28.98% from Ribdikot Rural Municipality. The respondents comprised 50.72% males and 49.27% females, with more females (40) than males (29) having received IPM training. Conversely, 41 males and 28 females had not received any IPM training. The majority ethnic group was Brahmin (50.72%), followed by Aadibasi/Janajati (23.91%), Dalit (7.24%), and Muslim (2.17%). Most trained respondents were Brahmins, followed by Chhetris, Aadibasi/Janajati, and Dalits, with the least from the Muslim community. Agriculture was the primary occupation for 85.50% of households, followed by government jobs (5.07%), business (3.62%), private jobs (2.89%), and foreign employment (2.89%). Among trained farmers, 84.05% were engaged in agriculture, followed by government jobs (7.24%), private jobs (4.34%), foreign employment (2.89%), and business (1.44%). For non-trained farmers, 86.95% were in agriculture, followed by business (5.79%), government jobs (2.89%), foreign employment (2.89%), and private jobs (1.44%). The average age of respondents was 46.06 years, with trained farmers averaging 44.26 years and non-trained farmers 47.86 years. The average family size was 4.78, identical for both trained and non-trained farmers. The average education level was 7.64 years, with trained farmers averaging 9.59 years and non-trained farmers 8.36 years. Among the respondents, 22 were illiterate, with 8 illiterate farmers having received IPM training and 14 not trained. The average total cultivated land in the study area was found to be 10.98 ropani and average area under vegetable cultivation was found to be 4.47 ropani. This indicates that farmer of study area grows different type of crops along with vegetable crops simultaneously (Table 1).

Table 1. Sociodemographic characteristics of respondent.

Characteristics	Trained	Non-trained	Overall
Gender			
Male	29 (42.02)	41 (59.42)	70 (50.72)
Female	40 (57.97)	28 (40.57)	68 (49.27)
Ethnicity			
Brahmin	44 (63.76)	26 (37.68)	70 (50.72)
Chhetri	6 (8.69)	16 (23.18)	22 (15.94)
Aadibasi/Janajati	13 (18.84)	20 (28.98)	33 (23.91)
Dalit	5 (7.24)	5 (7.24)	10 (7.24)
Other (Muslim	1 (1.44)	2 (2.89)	3 (2.17)
Occupation			
Agriculture	58 (84.05)	60 (86.95)	118 (85.50)
Private Jobs	3 (4.34)	1 (1.44)	4 (2.89)
Government Jobs	5 (7.24)	2 (2.89)	7 (5.07)
Foreign Employment	2 (2.89)	2 (2.89)	4 (2.89)
Business	1 (1.44)	4 (5.79)	5 (3.62)
Variables			
Age of Respondents	46.06 (9.21)	44.26 (8.81)	47.86 (9.32)
Family Size	4.78 (1.67)	4.78 (1.21)	4.79 (2.04)
Education in Years	7.64 (4.16)	9.59 (2.74)	8.36 (2.79)
No. of illiterate respondents	22	8	14

Source: (Fieldwork, 2021) Figures in parentheses indicate percentage.

Integrated pest management approach

Major pests of vegetables crops

Diseases and pest cause severe pre- and post-harvest losses in vegetables. Mealybug, hairy caterpillar, aphid, stem cutting insects, snails and slugs and many other sap sucking insects have deteriorated the production of crops whereas Mildew, blight disease, wilting of crops, mosaic diseases, spots appearance, rot diseases, scab in potato, etc. are the common diseases (Gyawali *et al*., 2021). This has highly affected the production of the crop species. Hence their safe management is a must for sustainable agriculture production.

IPM training

Out of 138 respondents, half of the respondents (69) had taken the IPM training. Out of 69 respondents, majority (74%) of them had taken the training in less than 2 years whereas 13% had taken the training 6 years ago, 9% had taken it 4 to 6 years ago and only 4% of them had taken it 2 to 4 years ago. This data shows that number of farmers taking the IPM training has increased in past 2 years.

Source of IPM training

Among 69 respondents, a great deal of respondents (68.57%) had taken the training from NGOs/INGOs in collaboration with governmental organization followed by Governmental only (23.19) and Cooperatives (7.25). Also, some of the farmers had taken the training more than once. The number of farmers who had taken the training from both Government only and NGOs/INGOs in collaboration with Government was 12 whereas only 3 farmers had taken the training from both NGOs/INGOs and Cooperatives. Likewise, only one farmer had taken the training from both Governmental and Cooperatives (Table 2).

Pest management techniques

Figure 1 shows that 73.91% of trained farmers used both IPM and chemical pesticides for pest management and 100% of non-trained farmers used both. But 26.09 % of trained farmers used only IPM techniques with strict prohibition of chemical pesticides for pest management. Bee keeping was the major reason behind not using chemical pesticides. Misuse and overuse of pesticides, easy availability of chemical pesticides, higher cost in using IPM products, lack of technical knowledge, and lack of government policies are the major constraints for the adoption of alternative way of pest management like IPM (Poudel *et al*., 2020).

Preference of vegetable growers over different IPM practices

Various IPM methods were identified at the farm level through focused group discussion and were ranked based on farmers' preference towards those methods. Index value was obtained and ranking was done based on higher index value. Botanical, Chemical, Physical and Cultural methods were ranked 1st, 2nd, 3rd, 4th important IPM methods adopted by farmers in vegetable cultivation respectively as shown in table 3.

Adoption of different IPM Practices

From the study, it was evident that, a large mass of respondents used chemical pesticides more than any other IPM techniques despite their higher preference over botanical method. However, majority of trained respondents adopted botanical method (89.86%). After IPM training major changes were observed in the use of improved seeds, use of mixture of organic and inorganic fertilizers, reduction in use of chemical pesticides, applying right pesticides at right time, applying right seed rate, crop rotation, proper irrigation and fertilizer application (Bhandari, 2012). Botanical method was followed by chemical (78.26), hand picking (72.46%), sanitation (71.01%), trap/lure (71.01%), crop rotation (59.42%), adjusted planting (36.23%), trap crop (27.54%) and resistant varieties (21.74%). But higher percentage of non-trained respondents used chemical pesticides (95.65%) followed by botanical (71.01%), trap/lure (46.38%), sanitation (42.03%), hand picking (40.58%), crop rotation (31.88%), trap crop (14.49%), adjusted planting (11.59%) and resistant varieties (11.59%). Resistant varieties were least used by both the categories of farmers, mainly due to lack of knowledge and access to resistant varieties (Figure 2).

Table 2. Source of IPM training of farmers in Palpa, 2021.

Source of Training	Frequency
Government only (1)	16 (23.19)
NGOs/INGOs in collaboration with Government (2)	48 (69.57)
Cooperatives (3)	5 (7.25)
Both 1 and 2	12 (17.39)
Both 2 and 3	3 (4.34)
Both 1 and 3	1 (1.44)

Source: (Fieldwork, 2021) Figures in parentheses indicate percentage.

Table 3. Ranking of IPM methods on vegetable cultivation adopted by farmers in Palpa, 2021.

IPM Techniques	Index	Rank
Botanical	0.72	I
Chemical	0.62	II
Physical	0.54	III
Cultural	0.49	IV

Source: (Fieldwork, 2021)

Table 4. Distribution of respondents based on factors affecting use of IPM techniques in Palpa, 2021

Factors	No. of Farmers
Easy availability of chemical pesticides	47 (34.05)
Lack of bio pesticides	31 (22.46)
High cost	26 (18.84)
Social constraints	20 (14.49)
No block farming	14 (10.14)
Total	138 (100.00)

Source: (Fieldwork, 2021) Figures in parentheses indicate percentage.

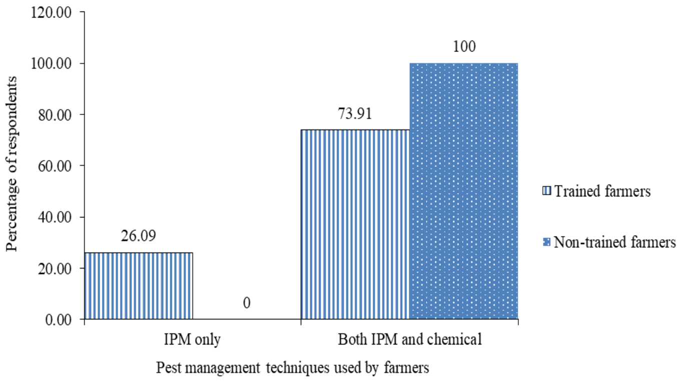


Figure 1. *Distribution of respondents based on Pest Management techniques in Palpa, 2021.*

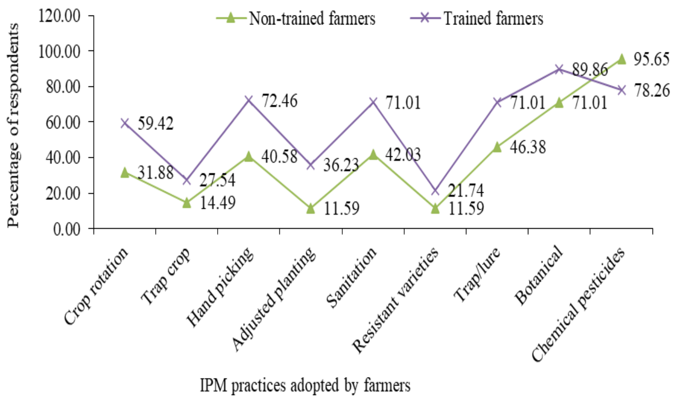


Figure 2. *Distribution of respondents based on adoption of different IPM practices in Palpa, 2021.*

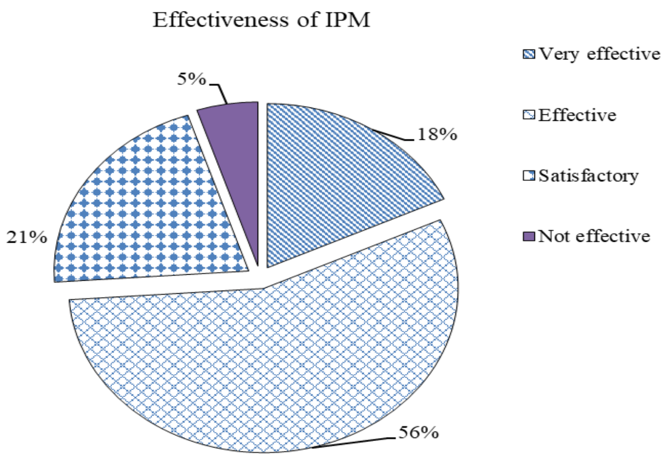


Figure 3. *Distribution of respondents based on effectiveness of IPM in Palpa, 2021.*

Factors affecting use of IPM techniques by the vegetable growers

In spite of higher preference to botanical methods, majority of the farmers used chemical pesticides without proper monitoring and deviating from the principles of IPM. Several factors could be the reason behind lower adoption of IPM such as easy availability of pesticides (34.05%), lack of bio pesticides (22.46%), high cost in implementation of IPM (18.84%), social constraints (14.49%) and no block farming (10.14%) (Table 4). This suggests a communication gap among government extension organizations, related agencies and farmers as well as the gap between IPM concepts and practices in the field. It clearly depicts a need of proper extension training, workshops for increasing farmers' knowledge in adopting Integrated Pest Management practices, adequate government pesticide regulation enforcement, increasing availability of insect control and monitoring options and so on. It clearly depicts a communication gap among government extension organizations, related agencies, and farmer as well as a need for education and training programs for farmers and government employees through community or other forms of IPM programs (Rijal *et al.*, 2018).

Effectiveness of IPM

Majority of the respondents (56%) from the study area found IPM effective whereas 18% found it very effective. Similarly, 21% found it satisfactory. And only 5% of the respondents did not find IPM effective (Figure 3). Despite many constraints in IPM adoption, large number of respondents found it effective due to environmentally friendly and ecologically sound techniques that combat pests without the use of unnecessary chemical pesticides.

Recommendations of IPM techniques

Among trained respondents, 84.06% recommended IPM techniques to others whereas 8.70% of them did not recommend it. And 7.25% of them recommended it based on crop type. Similarly, 56.52% of non-trained farmers recommended IPM whereas 24.64% of them did not recommend and 18.84% recommended it according to the crop type (Figure 4) Higher respondents with IPM training tended to recommend IPM to others due to their experiences where real field problems were observed, recorded and analyzed from planting to harvest of the crop with participatory discussions, group decisions and agro-ecosystem analysis (AESA). In addition to that, appropriate measures that discourage the pests were selected, applied in a manner that minimized risks to environmental, human health, beneficial and non-target organisms which was better than a reactive spray-based approach to pest control.

General practices and awareness about the use of chemical pesticides

Types of pesticides: Various types of pesticides were used by farmers of Palpa which included insecticides, fungicides and herbicides. Further, different classes of chemicals were used mostly from Organophosphate to Carbamate, Pyrethroid ranging from highly to slightly hazardous or non-hazardous. The major insecticides were Chloropyriphos+ Cypermethrin, Emamectin Benzoate, Chlorotrapronile, Flubendamide, Imidacloprid, Dichlorvos and fungicides were Mancozeb, Mancozeb+ Cymoxanil, Mancozeb+ Metalyxyn, Dimethomorphs and herbicides Glyphosate and Paraquat.

Source of information about chemical pesticides: About 80% of farmers were dependent on Agro-vet for the information about chemicals, technical help for overall pest and disease management. 12.5 % of farmers depended on cooperatives and only 7.5% of farmers depended on extension officers for the information regarding chemical pesticides. Despite having agricultural extension system at district and local levels, agro-vets were the major sources of information regarding chemical pesticides. Since, agro-vets are private for- profit companies, the information received from them could be misleading in many instances (Rijal *et al*., 2018).

Factors considered while buying chemical pesticides: Pesticide label reading and following instructions, environment safety, expiry date etc. while buying pesticides are important for safe handling. The majority of farmers (71.67%) considered level of control buying chemical pesticides. It was found that while 61.67% checked the hazard levels on chemical pesticides but the results found by Rijal *et al.* (2018) was quite lower (34%) in terms of reading hazard level. Similarly, 46.67% observed expiry date, 35% went for environment safety, and 32.50% noticed risk to applicators whereas only 10% thought about pest resistance while buying pesticides (Table 5). Very few farmers were aware about pest resistance which had resulted in use of same pesticide repeatedly.

Time of pest management decision: Farmers in the study area did not appear to make spray decisions based on economic threshold values. The majority of the non-trained farmers (68.12%) and trained farmers (57.97%) sprayed pesticides during the outbreak of insect pests, while 24.64% trained farmers and 27.54% non-trained farmers used pesticide before pest appearance (Figure 5). Applications of pesticide even before the appearance of pests in the field ultimately lead to unnecessary expenses (Atreya, 2007). 17.39% of trained farmers and 4.35% of non-trained farmers responded that they sprayed pesticides after the pest arrival based on the nature of the pest. Higher numbers of trained farmers used chemical pesticides as a last option for pest management after major damage.

Table 5. Relationship between variables and training of respondents.

Variables	Overall (n=138)	Trained (n=69)	Non-trained (n=69)	Chi-square value
Chemical pesticide use				
Yes	120 (86.96)	54 (45.00)	66 (55.00)	9.2000
No	18 (13.04)	15 (83.33)	3 (16.67)	
Awareness about beneficial insects				
Yes	42 (35.00)	29 (69.05)	13 (30.95)	
No	52 (43.33)	10 (19.23)	42 (80.77)	25.4575
Little	26 (21.67)	15 (57.69)	11 (42.31)	
Way of disposal				
Safe	34 (28.33)	28 (82.35)	6 (17.65)	31.8888
Burn	74 (61.67)	22 (29.73)	52 (70.27)	
Throw in water bodies	12 (10.00)	4 (33.33)	8 (66.87)	
Waiting period				
Less than 4 days	61 (50.83)	11 (18.03)	50 (81.97)	
5-8 days	52 (43.33)	37 (71.15)	15 (28.85)	26.7988
9-13 days	7 (5.83)	6 (85.71)	1 (14.29)	
Safety precaution				
No precaution	37 (30.83)	8 (21.62)	29 (78.38)	
Complete	10 (8.33)	8 (80.00)	2 (20.00)	14.5881
Masks only	73 (60.83)	38 (52.05)	35 (47.96)	
Soil impact				
Neutral	70 (58.33)	13 (18.57)	57 (81.43)	
Moderately affected	41 (34.17)	33 (80.49)	8 (19.51)	47.6217
Severely affected	9 (7.50)	8 (88.89)	1 (11.11)	

Source: (Fieldwork, 2021) Significant at 1% level of significance; Figures in parentheses represents percentage.

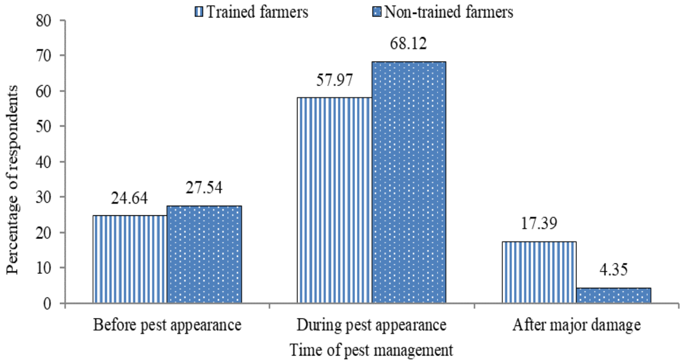


Figure 5. *Distribution of respondents based on the time of pest management decision in Palpa, 2021.*

Symptoms due to pesticide exposure

Many health issues were observed by the respondents due to continuous exposure to chemical pesticides depending on method of exposure like allergy, mild headache, nausea, and eye problems like itching and redness. 40.91% of non-trained respondents observed such symptoms whereas only 24.07% of trained respondents observed the symptoms. It is evident that majority (75.93%) of trained respondents and 59.09 % of non-trained respondents didn't observe any symptoms due to exposure to chemical pesticides. The reason behind higher number of respondents for not reporting any symptoms might be due to the use of safety precautions or not being able to distinguish that their health-related issues were either due to pesticide use or any other factor/cause.

Relationship between variables and training of respondents

Chemical pesticide use: Among the respondents that used chemical pesticides, 45% were trained farmers and 55% were non-trained. Similarly, among the respondents that did not use chemical pesticides, majority (83.33%) were trained farmers and only 16.67% were non-trained. Chi square test was performed and it was found that IPM training was significantly associated with chemical pesticide use at 1% level of significance with chi square value 9.20. This was in line with the report (GC, 2011) which stated reduced pesticide application in FFS implemented areas as compared with non-FFS areas.

Awareness about effects of chemicals on beneficial insects

Among respondents who were aware about the effects of chemical pesticides on beneficial insects 69.05% were trained farmers and 30.95% of them were non-trained. Similarly, among the respondents who were unaware about the effects, 80.77% were non-trained farmers and only 19.23% were trained. 57.69% of trained farmers and 42.31% of non-trained farmers belonged to those who had little knowledge about the effects of chemicals on beneficial insects. This finding conflicts with the findings of (Jha, 2008) where only 47 % of non-participants were unaware the negative effects of pesticides on beneficial organisms of agro-ecosystem.

Way of disposal

Among the safe disposers, majority (82.35%) of the respondents was trained and 17.65% were non-trained. Similarly, 29.73% of trained respondents and 70.27% of non-trained burnt the remaining pesticides. 33.33% of trained farmers and 66.87% of non-trained farmers belonged to those who disposed remaining pesticides by throwing them in water bodies.

Waiting period followed by farmers

Out of respondents who followed less than 4 days as waiting period for chemical pesticides, 18.03% were trained farmers and 81.97% were non-trained. Similarly, among those who followed 5-8 days as waiting period, 71.15% were trained and 28.85% were non-trained. Likewise, respondents following 9-13 days as waiting period included 85.71% trained farmers and 14.29% non-trained.

Safety precautions adopted by farmers

It was found that 21.62% of trained farmers and 78.38% of non-trained farmers did not adopt any kind of safety precautions. Similarly, among the respondents who used masks only, 80% were trained farmers and 20% were non-trained. Out of respondents using complete precaution, 52.05% were trained and 47.96% were non-trained.

Farmers' perception on soil impact due to chemical pesticides

About 18.57% of respondents who were unaware or did not feel the effect of chemical pesticides on soil health were trained farmers and 81.43%% of them were non-trained. Similarly, among the respondents who felt moderate effects of chemical on soil health 80.49% were trained farmers and only 19.51% were non-trained. 88.89% of trained farmers and 11.11% of non -trained farmers belonged to those who felt severe effects of chemicals on soil health. Due to IPM training, most of the farmers felt the moderate and severe impacts of chemical pesticides on soil health. In a survey conducted on Boro rice farmers regarding pesticide use and explore the farmers who participated on the IPM training also used fewer numbers of spray and granular application than that of untrained farmers (Mohammad, 2013) due to awareness about several effects on chemical pesticides on soil.

Conclusion

The survey concluded that most trained farmers used both IPM and chemical pesticides for pest management, while 100% of non-trained farmers relied on both. Notably, 26.09% of trained farmers exclusively used IPM techniques, avoiding chemical pesticides due to beekeeping concerns. Despite the botanical method being ranked highest among IPM techniques, many respondents still favored chemical pesticides, although trained respondents predominantly adopted the botanical method. The lower adoption of IPM practices in Palpa was attributed to the easy availability of pesticides, lack of biopesticides, high implementation costs, social constraints, and the absence of block farming. Agro vets were the primary source of information on chemical pesticides. Most farmers prioritized the level of control when purchasing pesticides, with few considering pest resistance. Both trained and non-trained farmers typically sprayed pesticides during pest outbreaks. Trained respondents generally disposed of leftover pesticides safely, while non-trained respondents were more likely to burn them. A significant information gap left many non-trained farmers unaware of the waiting period concept, unlike their trained counterparts. Additionally, a higher percentage of trained respondents used complete safety precautions compared to non -trained farmers.

DECLARATIONS

Authors contribution

Conceptualization: M.A. , Methodology: M.A. and P.R.D., Data collection: M.A. and S.A. ,Formal analysis : M.A., Software and validation: M.A. and P.R.D., Resources: M.A., Data curation: M.A., writing -original draft preparation: M.A, writing- review and editing: M.A., P.R.D. and S.A., Article preparation, review and editing: S.A., Supervision: P.R.D. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest: The authors declare no conflict of interest.

Ethics approval: This study did not involve any animal or human participant and thus ethical approval was not applicable.

Consent for publication: All co-authors gave their consent to publish.

Data availability: The data that support the findings of this study are available on request from the corresponding author.

ACKNOWLEDGEMENTS

We extend our sincere gratitude to our parents, whose unwavering guidance has been a constant source of inspiration. We are also grateful to AFU and PMAMP for incorporating Learning for Entrepreneurial Experience (LEE) in the Undergraduate curriculum, providing us with valuable opportunities to engage in research. Additionally, our appreciation goes to Agriculture Knowledge Centre (AKC), Palpa for the guidance and support.

REFERENCES

AKC Palpa. (2020). Annual Progress Report Book. Agriculture Knowledge Center, Palpa.

Atreya, K. (2007). Pesticide use knowledge and practices: A gender differences in Nepal. *Environmental Research*, *104*(2),305 311. https://doi.org/10.1016/J.ENVRES.2007.01.001

Atreya, K. (2008). Health costs from short-term exposure to pesticides in Nepal. *Social Science and Medicine*, 67(4), 511–519. https://doi.org/10.1016/j.socscimed.2008.04.005

Damalas, C. A. (2016). Safe food production with minimum and judicious use of pesticides. In S. Torok & J. J. Tóth (Eds.), Food Safety: Basic Concepts, Recent Issues, and Future Challenges (pp. 43–55). Springer International Publishing. https://doi.org/10.1007/978-3-319-39253-0_3

Bhandari, P. (2012). Farmers Perception about gains from Integrated Pest Management Farmer Field School. *International Journal of Agricultural Science*, 2 (3). https://www.researchgate.net/publication/349670370

Food and Agriculture Organization. (2016). FAO Statistics. Rome, Italy.

Food and Agriculture Organization. (2020a). Fruit and vegetables – your dietary essentials. The International Year of Fruits and Vegetables, 2021, background paper. https://doi.org/10.4060/cb2395en

Food and Agriculture Organization. (2020b). NSP-Integrated Pest Management, FAO definition. Retrieved from http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/

GC, Y. D. (2011). Status of plant protection activities in Nepal. In Conference on Capacity building in use of the International Phytosanitary Portal and APPPC website for information exchange, 4-9 July 2011, Kuala Lumpur, Malaysia.

Ghimire, K., & Gc, A. (2018). Trend of Pesticide Use in Nepal. Plant Protection Society, Nepal.

Gyawali, P., Khanal, S., & Joshi, J. R. (2021). Crop Protection Practices in Traditional Agriculture in mid-hills of Western Nepal: A Case of Palpa and Gulmi District. *International Journal of Applied Sciences and Biotechnology*, 9(2), 138-151. https://doi.org/10.3126/ijasbt.v9i2.36305

Jha, R. K. 2008. An assessment of farm-level use of bio-pesticides in Nepal: A case study based on IPM Farmers' Field Schools of Bhaktapur District. Paper presented in 3rd annual meeting of Plant Protection Society of Nepal, Kathmandu, Nepal.

Ministry of Agriculture and Livestock Development. (2020). Statistical Information on Nepalese Agriculture 2018/19. Retrieved November 2021, from https://www.moald.gov.np/publication/Agriculture%20Statistics

Oerke, E. (2006). Crop losses to pests. *The Journal of Agricultural Science*, *144*(1), 31-43. https://doi.org/10.1017/S0021859605005708

Paudel, M., Parajuli, K., & Regmi, R. (2020). Assessment on Pesticides Use and adoption of Integrated Pest Management Practices Among Commercial Vegetable Growers in Dang and Palpa Districts. *Food & Agribusiness Management*, *1*(2), 54–58. https://doi.org/10.26480/fabm.02.2020.30.34

Rijal, J. P., Regmi, R., Ghimire, R., Puri, K. D., Gyawaly, S., & Poudel, S. (2018). Farmers' knowledge on pesticide safety and pest management practices: A case study of vegetable growers in Chitwan, Nepal. *Agriculture*, 8(1). https://doi.org/10.3390/agriculture8010016

Sharma, D. R. (2015). Use of pesticides and its residue on vegetable crops in Nepal. *Journal of Agriculture and Environment*, *16*, 33–42. https://doi.org/10.3126/aej.v16i0.19838

Shrestha, H. K., Ghimire, S. B., Gurung, C. B., & Lal, K. K. (2004). Vegetable seed production, supply and quality control situation in Nepal. In Proceeding of the fourth national workshop in horticulture. Nepal Agricultural Research Council, Khumaltar, Lalitpur, Nepal.

Upadhyaya, N. S. (2002). Experience of community IPM in Nepal. Country Report, Landschaftsökologie und Umweltforschung, 256-264, Braunschweig, Germany.

USAID. (2011). Value chain/market-analysis of the off-season vegetable sub-sector in Nepal. Nepal Economic Agriculture, and Trade Activity, USAID, Kathmandu.