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Research Article

Status of Pesticide Use in Vegetables in Kaski, Nepal

Sudikshya Baral R.[1]*, Kiran Gyawali[1]

[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal

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***Corresponding author**
Sudikshya Baral R.,
Agriculture and Forestry University, Rampur, Chitwan, Nepal
Email: baralsudi@gmail.com

Abstract

This study was conducted in Kaski district among 100 commercial vegetable farmers using a pretested interview schedule to access the pesticides used, respondent's knowledge, health hazards experienced and safety measures on use of pesticides. MS Excel and SPSS were used to analyze the data. Insecticides, fungicides and neem-based herbal pesticides were majorly used in vegetables while agro-vets were the major source of information to the farmers. Majority of the farmers were aware about the trade names, color label, banned pesticides, waiting period and effect of misuse of pesticides while only a minority of them were aware about the working mode of action of pesticides. About 40% farmers reported health issues on use of pesticides; major symptoms experienced were dizziness and skin irritation. Majority of farmers only used mask and gloves during application of pesticides. It was found that a majority 52% farmers were categorically spending less on pesticides while pesticide use was found to be a determining factor of income in vegetable farms.

Keywords: Expenditure; Fungicides; Insecticides; Knowledge; Pests; Safety.

Introduction

Nepal is an agricultural country and its economy is predominantly agriculture based. Agriculture sector provides employment to around 65% of the total population and contributes about 23.95% to national GDP (MoALD, 2021). Vegetables in Nepal are considered very important crops, both for food security and as source of income for smallholder producers. Vegetable production / Olericulture account for 16.67 % of national GDP and 5.99 % share of agriculture GDP (MOALD, 2021). Vegetable farming is appealing because it ensures cash revenue within a short period of time, even from small area of cultivation. Vegetable crops are an integral part of farming system in Nepal and the sector has been growing rapidly in recent years. In fiscal year 2020/21, the production of vegetables is estimated to have increased by 5.9% to 4.196 million metric tons compared to that of fiscal year 2019/20 (MoF, 2021).

Pesticide refers to any substance utilized to eliminate, repel, or manage specific types of plant or animal life considered as pests (NIEHS, 2019). Pesticide classifies into various chemical compounds such as insecticides, fungicides, herbicides, nematicides, molluscicides, rodenticides acaricides, bactericides, bio-pesticides and herbal pesticides. The use of pesticides in Nepal began in the early 1950s, particularly with the application of DDT for malaria control (Manandhar, 2005). In 1955, chemical pesticides were first introduced in Nepal with the purpose of malaria control in public health sector, when Paris green, Gamaxone, and Nicotine sulphates were imported from United States of America (Dahal, 1995). Later in early 1960s, chemical pesticides were introduced in agriculture sector and during mid-sixties, when green revolution started in India, traditional farmers were taught to use agrochemicals specially fertilizers, insecticides and fungicides (Kansakara, 2001). On the present context, total of 165 pesticides (56 insecticides, 42 fungicides, 30 herbicides, 5 acaricides, 2 rodenticides, 14 bio-pesticides, 13 herbal pesticides, 1 bactericide, 1 molluscicide and 1 nematicide) have been registered in Nepal (PQPMC, 2021). While 24 pesticides have been banned in Nepal so far (PQPMC, 2021). Total of 6,81,506.71 a.i.(kg) pesticides have been imported in Nepal in fiscal year 2019/20 (PQPMC, 2021). On an average, 1605 gm/ha pesticide is consumed annually in Nepal for vegetable production (PQPMC, 2021).

On one hand, the growing population has led to a higher demand for agricultural products, while on the other, losses caused by pest infestations pose a significant threat to food security. One of the major constraints reported in vegetable production is infestation of pests. On a global scale, potential loss due to pests ranges from 50% to 80%, depending on the crop type (Oerke, 2006). With the ever-increasing demand of food and rising pest population, pesticide use has become a necessity in modern agriculture. Chemical pesticides are extensively used in commercial vegetable farming in Nepal (Rijal *et al*., 2006). More than 90% of imported pesticides in the country are utilized in vegetable cultivation (Ghimire & Arun, 2018). While pesticides are convenient to use and deliver immediate results (Aktar *et al*., 2009), their improper use can lead to significant challenges for agricultural sustainability (Enserink *et al*., 2013).

Kaski with its mild agro-climatic conditions all year round (annual av. temperature of 25-35℃& annual av. rainfall> 2500 mm) is a hub of wide range of vegetables. Kaski district has 5344 ha area occupied for vegetable production, 75,276 mt. vegetable production and productivity of 14.09 mt./ha (MoALD, 2021). As per PPL (2021), Kaski district reported the use of 2696 liter. and 8775 kg. liquid and powder insecticides in the year fiscal year 2019/20. Similarly, 130 liters. liquid fungicides, 4587 kg. powder fungicides, 580 liters. liquid herbicides, 200 kg. granular herbicides, 2100 liter. and 30 kg. of liquid & powder herbal & bio-pesticides were reported in the same year (PPL, 2021). Furthermore, 3610 kg. of powder/cake rodenticides and 20 kg. of bactericides were reported (PPL, 2021).

Materials and Methods

This study was carried out in Kaski district, which is located at the hilly region of Nepal in Gandaki province. It is located in between 28°04′39″ to 28°36'48" N latitudes and 83°42'11" to 84°16'53" E longitudes. Its altitude ranges from the lowlands of the Terai (450 m) to the mountainous region of the Annapurna range (8091 m). The district covers a total area of 2,017 km^2. Pokhara Metropolitan was selected purposively as the study area because of its inclusion under the PMAMP Vegetable Super zone. Commercial vegetable farmers within the study site form the sampling frame of the research. Simple random sampling method was used to select 100 commercial vegetable farmers as the sample, as it tends to make selection more unbiased and provides equal chance of selection for each element of the sampling frame (Scheaffer *et al*., 1987).

Research instruments include Preliminary field visit, Pre-testing of interview questionnaire, Household interview / Field survey, Key informant interview (KII) and Focus group discussion (FGD). Primary data of farmers was collected through semi-structured interview schedules through face-to-face interview, FGD and KII. Some of the pesticide retailers in the study site were also included under KII. Secondary data was gathered by reviewing pertinent literature on the subject matter, including the profiles and annual reports of PMAMP PIU Kaski Vegetable Super zone, AKC Kaski and ALDS Pokhara Metropolitan, journal articles and publications, publications of MoALD, Nepal Agricultural Research Council & Central Bureau of Statistics, and proceedings from various NGOs and INGOs.

The data were coded, tabulated and analyzed using SPSS and Microsoft Excel. Descriptive statistical tools such as mean, standard deviation, percentage and frequency were used to analyze socio-economic and demographic characters of the respondents and status of use of pesticides. Correlation analysis was done to analyze the relationship between the variables. Graphical representations like bar diagrams and pie charts were used to present the collected data.

Results and Discussions

Household and Farm Characteristics

A high majority of respondent farmers were female (71%) while 29% were male. The age of the respondents was categorized into three groups by using mean and standard deviation. Majority of the respondents (68%) were between the age group 35-59 years followed by below 35 years (23%) and above 59 years (9%). Education level was categorized into six groups. It was found that the highest number of farmers (27%) had below SEE level education followed by SEE (25%), intermediate (22%) and graduate level (16%). Illiterate (those with no formal schooling) were 10% while there were no any post-graduates among the farmers. Furthermore, respondents reported to have an average of seven years of experience in commercial vegetable farming. More than half of the sampled respondents i.e. 60% had agriculture as their only income source while the remaining 40% were also involved in other occupations apart from agriculture. About 4/5th of commercial vegetable farms (83%) were on rented land and only a small minority (17%) were cultivating vegetables in their own land. The average area under vegetable cultivation was found to be 5.7 ropani. Similarly, average annual income from vegetable sale was found to be NRs. 8,35,875. Also, majority of the farmers (68 %) had received training on vegetable farming.

Pest Occurrence in Vegetables

Amongst all crops, vegetables are more prone to insect pests and diseases and loss is estimated well above than overall crops (Bhusal *et al*., 2017). Tomato leaf miner, Aphids, Thrips, Mealy bugs, Stem and fruit borers, Cutworm, White grub, Diamond Back Moth (DBM), Loopers and Semi loopers, etc. were the major pests observed in the region. Similarly, diseases like blights, mildews, anthracnose, wilts, viral diseases like mosaic and die-off, club roots, damping off and rusts were majorly reported by vegetable farmers. Eighteen percent of the farms were found to be severely infested with diseases & pests while remaining were moderately infested.

Pesticide Uses in Vegetables

All of the respondents (100%) were found to be using chemical pesticides while 68% reported to be using both chemical and biological (bio) pesticides for disease and pest management. Respondents i.e. the commercial vegetable farmers showed greater affinity for chemical pesticides over bio-pesticides (Table 1).

Table 1: Reasons for the preference of chemical pesticide over bio-pesticide

Reasons for preference of chemical pesticide	Frequency
Comparatively inexpensive	25 (25)
Easy availability	7 (7)
Immediate response	68 (68)
Total	100 (100)

*Figures in parentheses indicate percentage

It was found that early immediate response was a major cause for farmers to choose chemical pesticide over biological alternatives for 68 percent of respondents. Similarly, 25 percent respondents preferred chemical pesticide for its comparative cheaper price than biological alternatives and only 7 percent preferred chemical pesticide because of its easier availability.

Insecticides and fungicides were the major two group of pesticides widely used in vegetables along with neem-based herbal pesticides which is similar to the findings of Sharma *et al*. (2021). All the respondents (100%) were found to be using insecticides and fungicides in vegetable cultivation (Table 2 & 3).

Dichlorovos (WHO Class: Ib) has been banned in Nepal since 2018. However, its use was still common among vegetable growers in Kaski under different altered trade names Nuvan and Novan. Similarly, Aluminium Phosphide 56% TAB-3gm has been banned in Nepal since 2019, hence its powder formulation Aluminium Phosphide 56% P was used in vegetables under trade name Celphos.

Table 2: Major insecticides used in commercial vegetable farming in Kaski

S.N.	Chemical name	Trade names	Chemical group	WHO Class	Color label
1	Chloropyrifos 50% + Cypermethrin 5% EC	G- Attack, Kisan 505, LARA-909, Hitlor 505, G-Sunami, Bullet 505, Tiger, Royal	Synthetic Pyrethroid + Organophosphate	II	Yellow
2	Emamectin benzoate 5% SG	Ema Star, Ki-Star, King Star	Avermectin	II	Blue
3	Imidacloprid 70% WG	Imida, Looper, Midas Powder	Neonicotiniod	II	Yellow
4	Dimethoate 30% EC	Rogor Plus, Tara 909, Rogor	Organophosphate	II	Yellow
5	Chlorantraniliprole 18.5% SC	Allcora	Organophosphate	U	Green
6	Malathion 50% EC	Malathion 50	Organophosphate	III	Blue
7	Chloropyrifos 20% EC	Trishul 20 EC, Action-500, Commando	Organophosphate	II	Yellow
8	Nitenpyram 10% SL	King Guard	Neonicotiniod	III	Yellow
9	Cypermethrin 25% EC	Missile	Synthetic Pyrethroid	II	Yellow
10	Cartap Hydrochloride 4%G	Bullet, Current	Nereistoxin analogue	II	Yellow

Table 3: Major fungicides used in commercial vegetable farming in Kaski

S.N.	Chemical name	Trade names	Chemical group	WHO Class	Color label
1	Mancozeb 75% WP	Mancozeb, Dithane M-45, Adchem M-45, Mancozab, Stargem-45, Dythine M-45	Carbamate	U	Green
2	Carbendazim 50% WP	Bavistin, Carbendazim, Bawestin, Sristone-50	Benzimidazole	U	Green
3	Carbendazium 12% + Mancozeb 63% WP	SAAF, All Clear	Carbamate + Benzimidazole	U	Green
4	Mancozeb 64%+ Metalaxyl 8% WP	Krilaxyl	Benzimidazole + Phenylamide	U	Blue
5	Mancozeb 64% + Cymoxanil 8% WP	Real-Mil, King-Mil	Carbamate + Cyanoacetamide	II	Blue
6	Copper Oxychloride 50% WP	Allcop, Curex, Blitox	Inorganic compound	III	Blue
7	Dimethomorph 50% WP	G-Tuphan	Morpholine	U	Blue
8	Thiophanate – Methyl 70% WP	Control	Benzimidazole	U	Green
9	Metalaxyl 7.5% + Mancozeb 52.5% + Dimethomorph 11.5% WP	Trishakti	Phenylamide + Carbamate + Morpholine	II	Blue
10	Tebuconazole 50% + Trifloxystrobin 25%WG	Nativo	Triazole + Strobilurin	II	Blue

Similarly, 8% were found to be using herbicides, amongst which all of them reported to have used them exclusively only during the land preparation phase. Glyphosate 41% SL and Preetilachlor 50% EC were used. Majority of the pesticides reported to be used in the region are broad-spectrum in coverage, i.e. they kill a wide range of pests, including natural enemies. In case of herbal pesticides, Neem (Azadirachtin) based oil and cake was found to be used by 65% of respondents. Rodenticide Bromadiolone 0.005% was used by 22% respondents. Molluscicide Metaldehyde 5% GR was used by 13% respondents. Bactericide with chemical composition Streptomycin sulphate 9% w/w + Tetracycline hydrochloride 1% w/w was used by the majority (74%). Within bio-pesticides, *Trichoderma pseudomonas* was used by 15%, *Pseudomonas fluorescens* by 12% and *Verticillium lecani* by 2% of respondents. No use of nematicides and acaricides was reported among the respondent farmers. Similarly, all of the respondents (100%) responded that the required dose and frequency of pesticide to be applied in the field to control the same pest or disease had been increasing over the years.

Source Of Information on Pesticide Use

Farmers relied on varied sources in order to identify different pesticides required in their field. Most farmers (41%) used suggestions from agro-vet owners, 34% identified required pesticides based on their own knowledge & experience, 23% farmers used suggestions from technical assistance (extension workers) and trainings while a minority 2% depended on other neighbouring local farmers for suggestions.

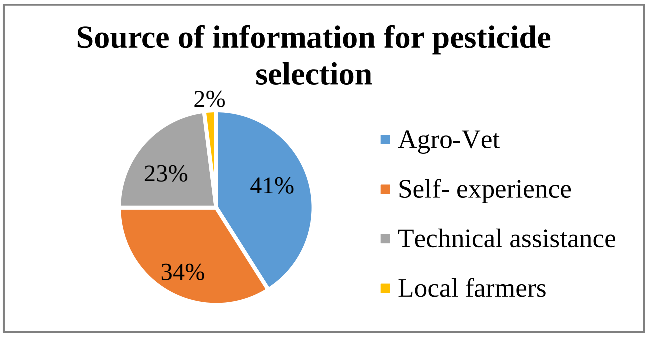

Fig. 1: Information source to identify and select required pesticide.

Dose and frequency of application of pesticide was another important area where source of information was important for farmers. It was found that agro-vet owners from whom they bought pesticides were the major source of information for a large majority (96%) of farmers. Agro-vet owners suggested the farmers and recommended the dose and frequency by labeling them in the bottle and packets. Remaining 4% farmers took assistance from technical extension workers and other local farmers for dose and frequency recommendations.

Respondent's Knowledge on Pesticides

i. Varied trade names of same chemical compositions:
A majority (83%) respondent farmers were found to be aware about the fact that varied trade names of same chemical composition of pesticides exist in the market. And majority of them reported to know this via. agro-vet owners. While the remaining 17% had reported cases of confusion while buying similar chemicals with different trade names in the market.

ii. Type of pesticides (on the basis of mode of action):
Pesticides can be classified on varied basis, but classification on the basis of working mode is quite important whose knowledge can be beneficial to the farmers for selection of appropriate pesticides as per need. It was found that only 15% of farmers were aware about the systemic and contact mode of action of different pesticides while remaining 85% had no clue.

iii. Color label of pesticides:
It was found that 87% of farmers were aware about the color label present in different pesticides i.e, its indication of toxicity level but remaining 13% were quite unaware and were incapable to separate most toxic and safe pesticides during handling and storage.

iv. Banned pesticides:
24 pesticides have been banned so far (PQPMC, 2021) and use, marketing and distribution of these pesticides are punishable. It was found that 76% of respondents were aware about the banned pesticides. They had heard about few pesticides being banned from the government but not all of them were able to say the names of banned pesticides. Out of 76% aware respondents, only 43% were able to tell few names of banned pesticides and the most common banned pesticides known to farmers was dichlorovos.

v. Waiting period:
It was found that all of the respondents (100%) were aware about waiting period of pesticides.

Table 4: Waiting period practiced by commercial vegetable farmers in Kaski

Color label	Average waiting period (days)
Green	2
Blue	3
Yellow	4
Red	7

However, the average waiting periods reported by the respondent farmers was found to be extremely alarming since the recommended waiting periods are much higher. Major reasons behind this as reported by farmers were the short shelf life of ripe vegetables, inadequacy of crop insurance provision to cover crop loss risk and the unavailability of a fixed regulated market.

vi. Effect of misuse of pesticides:
It was seen that all of the respondents were conscious about health-related problems that may be caused by misuse of pesticide, 83% respondents were aware about environmental effects of pesticide, 38% were aware about the effect of pesticide on standing crop while only 29% were aware about the effect of pesticide on natural enemies.

vii. Integrated Pest Management (IPM):
It was found that 56% respondents had heard about IPM but a higher majority of 80% were following IPM practices in their field.

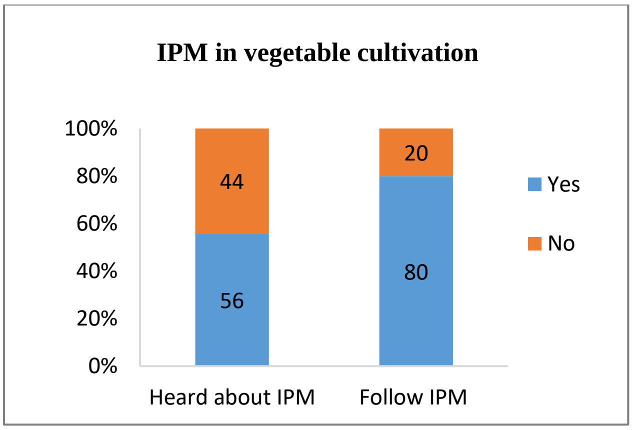

Fig. 2: Integrated Pest Management (IPM) in vegetable cultivation in Kaski.

Time Of Pesticide Application
Pesticide application is a sensible process. It requires good knowledge on pesticide, spraying instrument used and other factor including time and direction of wind. Fig. 3 shows different proportion of farmers who used different time for spraying pesticide.

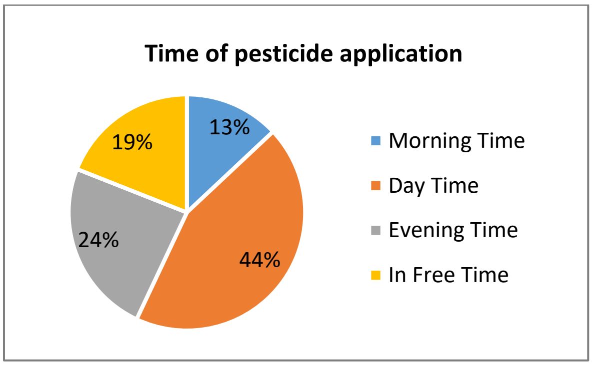

Fig. 3: Different time period preferred by farmer to spray pesticide in vegetables.

Health Hazards Associated with Pesticide Use

Although no any long-term major health hazard was reported among the respondent farmers, 40% reported cases of minor health issues, out of which major symptoms as experienced were dizziness and skin irritation.

Table 5: Health issues associated with pesticide use in commercial vegetable growers in Kaski

Health issues	**Overall (n=100) Respondents in percentage**
Dizziness	19
Skin irritation	17
Uneasiness	14
Insomnia	10
Eye irritation	8
Nausea	7

Safety Measures

i. Safety during pesticide application:

One of the most important precautions to be followed by farmers during pesticide application is the use of protective uniforms. These typically include protective mask, gloves, body coverall, goggles, head cover and boots.

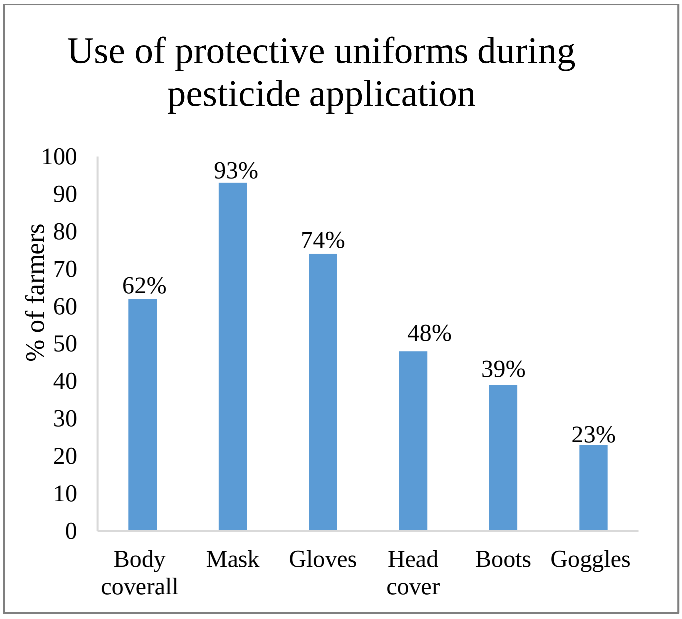

Fig. 4: Use of protective uniforms during pesticide application by vegetable farmers in Kaski

ii. Pesticide storage and waste disposal

Pesticides are available in bottles and plastic packets. Remaining of pesticide after application were stored by farmers for further use. Fig. 4 represents different storage location of pesticides.

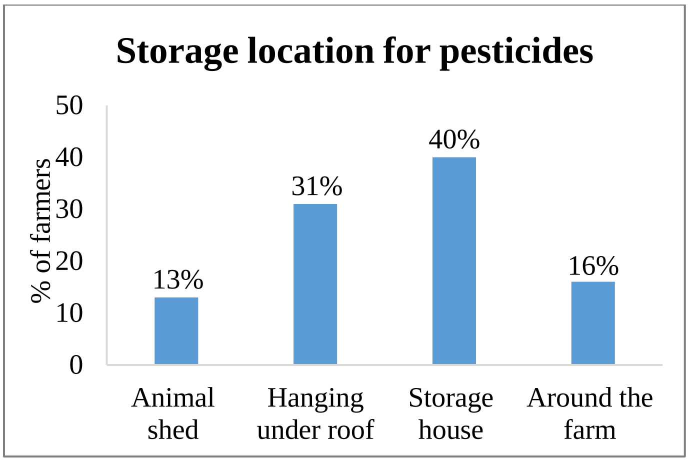

Fig. 5: Storage location of pesticides among commercial vegetable farms in Kaski

Pesticide waste disposal is one of the major factors inducing pesticide poisoning, residue, contamination and bio-magnification. Proportion of farmers using different locations to dispose of their pesticide bottles and packets is shown in Fig. 6.

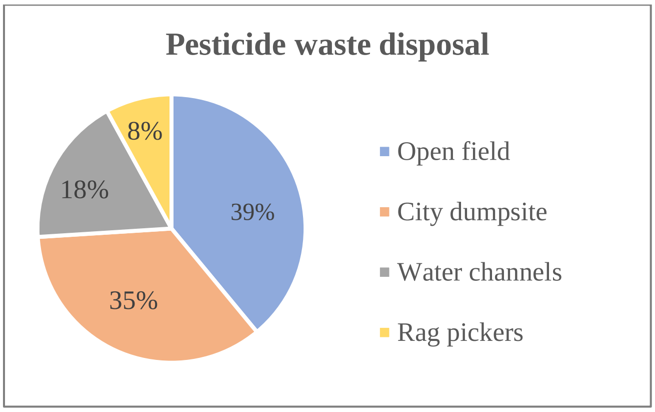

Fig. 6: Major pesticide waste disposal locations for vegetable farmers in Kaski.

Training on Use of Pesticides

About 60% farmers had participated in trainings on pests and pesticides, use and safety measures conducted by different public and private entities. Proportion of trainings conducted by different institutions is shown in Figure 7.

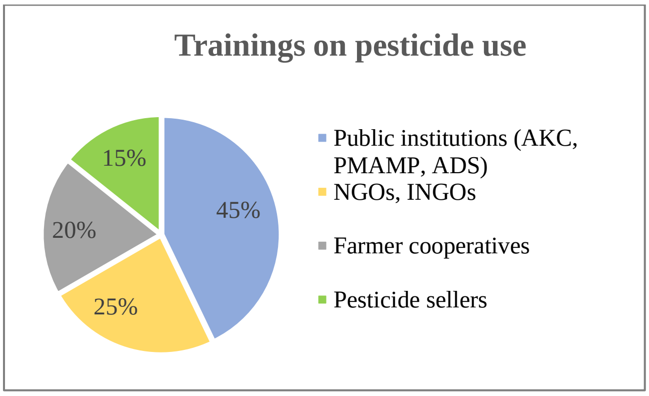

Fig. 7: Training on pesticide use amongst vegetable farmers in Kaski.

Table 6: Annual farm income and annual expenditure on pesticide per hectare

Particulars	Maximum (Rs)	Minimum (Rs)	Average (Rs)	Std Deviation
Annual Farm Income per hectare	11234274	327653.6	3296387	1860589
Annual Expenditure on Pesticide per hectare	158263	1867.7	58150.94	40214.46

r^2 value = 0.516 (** Correlation is significant at the 0.01 level.)

Annual Farm Income and Expenditure on Pesticides

Both the annual vegetable farm revenue and the pesticide cost per hectare exhibit substantial variation in the data, with large differences between the minimum and maximum values (Table 6). The average cost of pesticides was found to be Rs. 58,150.94, whereas the average vegetable farm income was reported to Rs. 32,96,387. High standard deviations show that different farms have different farming methods and conditions. Correlation coefficient ($r^2 = 0.516$) between annual vegetable farm income and annual expenditure on pesticides per hectare revealed a significant positive relationship between them at p= 0.01.

The variance (r^2) value obtained was 0.516 which showed that change in annual farm income per hectare brought 51.6 percent change in annual expenditure on pesticide per hectare and vice versa. Hence farm income and expenditure on pesticide were strongly related characteristics of vegetable farms of Kaski. It also showed that pesticide was one of the important inputs of vegetable farms of Kaski and a determining factor of farm income. Increase in expenditure on pesticide significantly increased farm income.

On the basis of expenditure per year on pesticide, farmers were categorized into two groups as less expending (those falling below mean) and more expending (those falling above mean).

Table 7: Categorization of farmers on the basis of annual expenditure on pesticide

Category		Percentage
Less Expending	≤ mean	52
More Expending	> mean	48

Conclusion

Commercial vegetable farming is a major economic activity in Kaski owing to the favorable climate for production and growing access to markets. This study was conducted to access the status of pesticide use among such commercial vegetable farms. Insecticides, fungicides and neem- based herbal pesticides were found to be the major forms of pesticides used in vegetables. Commercial vegetable growers tend to prefer chemical pesticides majorly because of their immediate response to pest control. Findings indicate the need to increase farmer's knowledge on the working mode of action of pesticides and conduct more training programs on use and safety of pesticides. Pesticide was found to be an important input of vegetable farms and a determining factor of farm income in Kaski with a slight majority of 52% commercial farmers categorized as less expending on pesticides. Hence, findings suggest that pesticides couldn't be avoided completely in farms but the current need is the careful and responsible application of pesticides to achieve sustainable agriculture with the least deleterious effect on human health, non-target species and environment.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding publication of this paper.

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