ISSN (Online): 2091-2609
DOI Prefix: 10.3126/ijasbt

International Journal of Applied Sciences and Biotechnology (IJASBT)

Case Study

Crop Protection Practices in Traditional Agriculture in mid-hills of Western Nepal: A Case of Palpa and Gulmi District

Pramod Gyawali[1], Saugat Khanal[2*], Jhalak Raj Joshi[2]

[1]College of Natural Resource Management, Agriculture and Forestry University, Tikapur, Kailali, Nepal
[2]Agriculture and Forestry University, Rampur, Chitwan, Nepal

Article Information

Received: 05 April 2021
Revised version received: 10 June 2021
Accepted: 14 June 2021
Published: 28 June 2021

Cite this article as:
P. Gyawali et al. (2021) Int. J. Appl. Sci. Biotechnol. Vol 9(2): 138-151. DOI: 10.3126/ijasbt.v9i2.36305

***Corresponding author**
Saugat Khanal,
Agriculture and Forestry University, Rampur, Chitwan, Nepal.
Email: ksaugat506@gmail.com

Peer reviewed under authority of IJASBT

Abstract

A field survey was conducted in two districts of western hills of Nepal during July-August, 2020 to study about the practices of traditional methods of horticultural crop disease management. A total of 125 farmers, 10 traders, 5 agro-vets, and 3 plant clinical doctors from four local bodies of two districts; Palpa and Gulmi, were selected for the interviews which employed a pretested questionnaire. Descriptive statistics were used to analyze the data. Almost half of the farmers interviewed (48%) were found to have an average level of knowledge regarding the application of indigenous methods. Mixture of kerosene and ash, mugwort solution, plant residues, bovine dung and urine, chilli powder, papaya leaves, onion mixed with garlic, etc. were popular as traditional techniques to effective control of disease and pest. Scaling technique used in this study showed the lack of indigenous information as the most serious constraint in adoption of traditional means, followed by lack of advertisement, poor social perception of farmers, and weak cooperation among social and agricultural scientists. The study recommended that documentation and scientific validation of indigenous means and support from government and extension agents are necessary to encourage farmers using traditional means. This study examines traditional diseases/pests control strategies implemented by the ancients and presently adopted in ongoing practices.

Keywords: Disease; horticulture; indigenous knowledge; Nepal; traditional methods

Introduction

Nepal is a developing country with an agricultural economy (Adhikari, 2015; Ghimire & GC, 2018), where farming has been the main economic job since antiquity, with two-third of the country's population engaged in agriculture (MoAD, 2015). The agriculture sector contributes to 28% of gross domestic product (GDP) in Nepal (Khanal, 2020). The peculiar agro-ecological zonings favored by diverse climate create a huge opportunity for producing various types of horticultural products (NHS, 2016). Globally, the predominant production of vegetables takes place in Asian countries, with Nepal being the sixth leading producer of fresh vegetables after China, India, Vietnam, Philippines, and Myanmar in 2016 (FAO, 2016). Vegetable production generates cash even from a small plot of farm in a short period and helps farmers to improve their livelihood (Gurung *et al*., 2016; Gurung *et al*., 2016). Owing to the high demand for vegetables, most farmers of the country are moving towards the commercial production of vegetables

(Bhatta and Doppler, 2010). Horticultural crops yield more compared with the cereal crops (Bhandari *et al*., 2015) as the tonnes of vegetable production usually surpasses the quantity of cereal production (Joosten *et al*., 2015).

Palpa and Gulmi districts have a great scope of fruit and vegetable farming due to the favorable environmental conditions and high domestic demand for food. In this regard, vegetable farming appears as one of the productive enterprises (Rai *et al*., 2019). The growing of fruits, vegetables, spices and flowers initiated from time immemorial through private sector in study areas (Thapa & Dhimal, 2017). With time, the vegetable farming has increasingly gained its importance in Nepal (Ghimire *et al*., 2018). Horticulture has contributed to higher agriculture growth rate (Acharya, 2019). According to the report of (MoAD, 2017), the area, production, and yield of major horticultural crops is in increasing trend. Vegetable farming has become a crucial sector of hilly agriculture (Bhatta and Doppler, 2010; De Zeeuw *et al*., 2011).

However, the most important curb in horticultural development is the severe outbreak of pests and diseases in different study areas specific to different crops. Tonnes of production go waste just due to the pest infestations every year. Several studies have found out the post-harvest losses of horticultural produces by 20-50% (Gautam & Bhattarai, 2012). Milbug, hairy caterpillar, lahi, stem cutting insects, snails and slugs and many other sap sucking insects have deteriorated the production of crops. All these pests and insects have a considerable role in yield declination. This has greatly impacted the production of the crop species. Mildew, blight disease, wilting of crops, mosaic diseases, spots appearance, rot diseases, scab in potato, etc. are the common diseases. The management is a must as agriculture ranging from subsistence farming to commercial-level plays an important role in bettering the sustenance of people (Veenhuizen & Danso, 2007). This review aims at targeting to assess the traditional means of pest infestation management so that the affected farmers can get the cheap method of solution for disease management through the locally available means.

Objectives of The Study

Keeping the production scenarios and pest infestation of horticultural crops in the study areas in focal point, this paper makes an attempt to assess the management techniques of the pests and diseases through locally available means. The general objective is to identify the traditional means of disease control in the study areas. However, the specific objectives include:

- To identify pests and diseases of various horticultural crops.
- To construe different methods of disease control with locally available means on traditional basis.
- To investigate the perception of farmers towards adoption of traditional means.
- To assess the major constraints in crop growth and provide relevant solutions for yield improvement.

Limitations of The Study

Research in use of indigenous technical knowledge (ITK) and traditional means of horticultural crop disease management is not a new approach and we recognize that there were a number of limitations to our study. We sought to cover the larger area and a greater number of respondents, but we acknowledge that we were not able to do so due to the global hit of COVID-19 pandemic. There were a number of practical difficulties we faced. The survey needed to be completed before expected date due to increased risk of corona virus infestation in Palpa and Gulmi districts.

Material And Methods

General Features of The Study Areas

Palpa and Gulmi district of western Nepal, part of province no. 5 of Federal Republic of Nepal was purposefully selected as identifiable number of commercial horticultural farmers cultivating vegetables, fruits, and flowers for last few years can be easily found in this region. Palpa, with latitude 27.86^0N and longitude 83.65^0E (Tageo, 2019) and Gulmi, with latitude 83.10^0N and longitude 83.33^0E, have a distinct agro-climatic diversity of the country (Fig. 1).

A total of four local bodies, two from Palpa; Tansen municipality and Nisdi rural municipality, and two from Gulmi; Ruru chhetra rural municipality and Chhatrakot rural municipality were taken into consideration. These areas have temperate climate and a wide diversity of flora and fauna. The climatic elements such as temperature, humidity, rainfall, and daylight conditions show a large spatial variation with place at short distance frequently which favors the successful horticultural production.

Data Collection and Sampling Techniques

The study was conducted during July-August 2020. The data was collected through both primary and secondary methods using different sources of techniques. For this study, field survey as well as review of literature was performed along with related expert consultation, pest management institutions, marketing experts, and experienced traders. Key Informant Survey (KIS), questionnaire survey, and Focus Group Discussion (FGD) were used as primary method to obtain the farming data. Similarly, municipalities, Ministry of Agriculture Development (MoAD) profile, agricultural reports, journal articles, Center Bureau of Statistics (CBS), Nepal Agriculture Research Council (NARC), etc. are the sources of secondary data. A total of 125 horticultural farmers, 10 traders (including local, district, wholesaler, and retailer level), 5 consumers, 5 agro-vets, and 5 doctors from plant clinics were selected randomly and interviewed using semi-structured questionnaire from the study areas. Likewise,

other actors like input suppliers, transporters, representatives from service providers like Pest control department of Agriculture, Plant quarantine centers, and NGOs and GOs were selected for expert consultation. Out of the respondents, 5 were mainly exporters and 3 from plant clinics are shown in Table 1.

Table 1: Major exporters and plant doctors in study areas

S. N	Exporters	Plant clinical doctors
1	Budhathoki agricultural farm	Srijan Wagle
2	Bhagwati nursing farm	Pabitra chhettri
3	Paicho pasal ltd. pvt.	Krishna pantha
4	Green angel botanical farm	
5	Srijana farm	

The interaction started with some of the major questions like.

- Are any crops damaged due to pests? If yes what is the extent and how you manage it?
- Are local available means or chemical pesticides used to control them?
- What is the trend of productions of different vegetables and fruits in your own field?
- Do you majorly export or import the horticultural goods?
- Have you ever heard about the traditional techniques to control pests with locally available means? If yes, how do you perceive it?
- How much knowledge do you have about the indigenous techniques to control diseases?
- Majorly, what is the purpose for your usage of traditional techniques?
- What factors do you perceive as major constraints in adoption of traditional means?
- What strategies do you think is a must to encourage the farmers use locally available materials for pest infestation management?

Data analysis

Data analysis was performed for evaluation of trend of production, and adoption of the traditional means of pest infestation management by using Microsoft Excel 2010. Scaling technique, with six-point scale (1, 2, 3, 4, 5, and 6) was used to assess significant differences. Farmers were asked to choose different categories; 1 for the least important constraints and 6 for the highly important. This category was scored and the sum of the score's measures farmer's perceptions towards certain constraints as shown in table 6. The index of importance was calculated through the following formula;

$$Iimp = \{(\sum Si*fi) /N\}/6$$

Where, Iimp = Index of importance

$\sum$ = summation

Si = Scale value

Fi = frequency of importance given by farmers

N = Total number of farmers

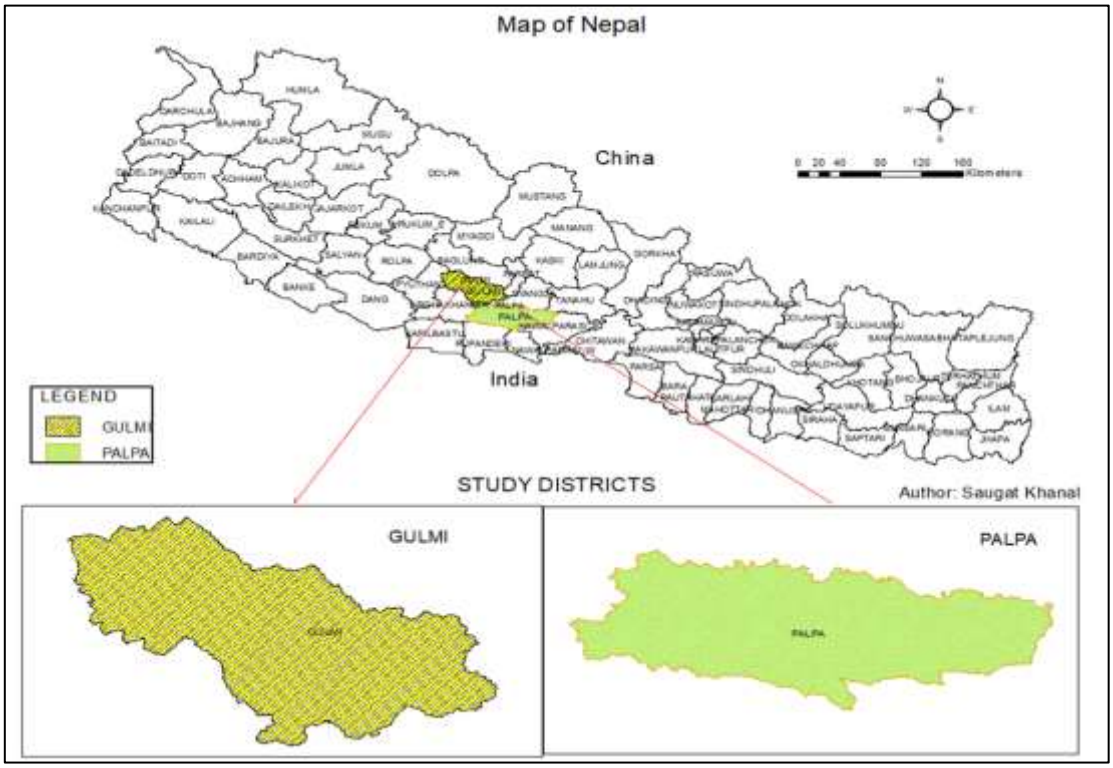

Fig. 1: Map of Nepal showing the study districts

Results and Discussions

Socio-Economic Characteristics of The Study Respondents

The majority (56%) of the respondents were male which indicates men's more involvement in horticultural crop production (Table 2). The society in the study areas, being nuclear (with mode of 4 members), was dominated by patriarchal family type, house ruled by the male group of population, and any decisions made depend on male. Most (76%) of the farmers interviewed had received at least some secondary education; thus, they were more educated and have more knowledge on farming practices. The average monthly income of farmers was $200-$250. The farmers from non-agricultural family background were very few (11%), while 89% belong from agricultural family background. Nearly two-thirds (66%) were exporters of their horticultural produce, and rest practiced just subsistence farming. More than half (58%) of the farmers had 6-10 years of farming experience. Less than three-fourths (72%) of the farmers produce vegetables as the major horticultural product, and rest (28%) were primarily fruit producers. Tomato and cauliflower among vegetable and lime and pineapple among fruit are the major horticultural produces. Large (93%) of respondents suffered from high risk of severe disease infestation. Aiming at reducing the pest risk, 76% of interviewed farmers adopts modern means majorly, particularly chemical pesticides which are environmentally toxic. They often use traditional means, but to very few extents.

Horticultural Production in The Study Areas

Nowadays, people prefer fresher, healthier and organic vegetables (CASA, 2020). To fulfill this demand, vegetable yield is also increasing. Yield increases attributed to the conducive environmental condition, timely availability of seed, good quality fertilizers, ecological management techniques, sustainable mechanization in crop cultivation along with area expansion (Pandey *et al*, 2017). Yet, several bottlenecks have impeded proper disease management practices. The yield could still be increased by adopting effective ways of disease control– through traditional and modern means in an integrated approach. Vegetables that majorly grown in Nepal are potatoes, tomatoes, cauliflower, brinjal, green leafy vegetables like mustard, spinach, radishes, squash, and various other seasonal local vegetables (Mero kalam, 2019). By cause of lack of fertile land in many areas of Palpa and Gulmi district, fresh vegetables are insufficient, so people tend to consume root vegetables and often dried and fermented vegetables (Fig. 2). Usually, green leafy vegetables like spinach, mustard greens, and capsicum are consumed daily in bulk wherever available. The produced vegetables are either consumed themselves or sold to the nearby/ distant market. The survey result clearly depicts the high yield of vegetables in the study areas and most of the vegetable growers claimed to be satisfied with their production. However, they stated quite difficulties in disease management, and failed on controlling diseases sometime make heavy yield losses.

Fruit production in western hills started since time immemorial. The availability of various indigenous, wild and cultivated species of fruits is the plausible support for this statement (Devkota, 2015). Furthermore, the intricate range of hills and ridges, infused by deep valleys are blessed with copious fruit resources (Kaini , 1994; (Kaini, 1999). Jackfruit, mandarin, lime, and guava are the most produced fruits in the study areas. Other fruits include sweet orange, pear, walnut, peach, kiwi, banana, litchi, etc. In both districts, nowadays, majority of the farmers seem to shift from agronomic farming to horticultural crops. In this regard, fruit production is gaining importance among the farmers of hills of western Nepal. Farmers are lagging behind in being commercial due to the paucity of effective research and experiments in fruit farming in hilly region; due to perishable nature of fruits. This study reveals the fact of utmost need to form appropriate strategies and commence fruit advancement programs in the potential areas of hills like Palpa and Gulmi districts (Fig. 3).

Table 2: Socio-economic characteristics of the study respondents

Variable code	Variable name and description	Mean	Mode category
GEN	Respondent gender (Male =1)	0.56	Male
AGE	Respondent age (25-35 =1)	0.63	24-28
HHS	Household size (4-7=1)	0.53	4
HHH	Household head (Male=1)	0.86	Male
EDU	Respondent educational level (Secondary=1)	0.76	Secondary education
INC	Respondent average income per month ($200-$250)	0.63	$210-$220
FBG	Family background (Agricultural=1)	0.89	Agricultural
FEN	Respondent years of Farming Experience (6-10 years =1)	0.58	6-10 years
EXP	Exporter of produce (export=1)	0.66	Inter-regional export
MFP	Main horticultural product (vegetables=1)	0.72	Tomato, Cauliflower, Lime, Pineapple
DIR	Farmers suffering from disease infestation risk (Risky=1)	0.93	Severe
PMT	Pest management techniques (modern pesticides=1)	0.76	Chemical pesticides

Source: (Survey, 2020)

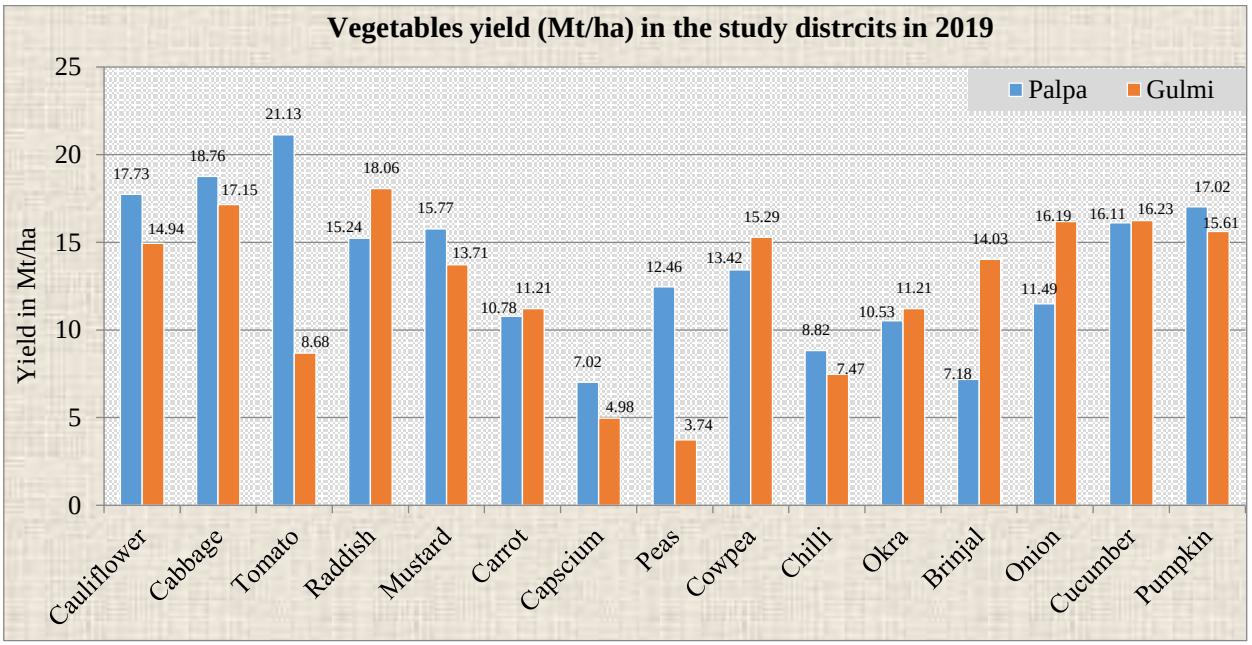

Fig. 2: Vegetables yield in Palpa and Gulmi: 2019 [Source: MoAD, 2020]

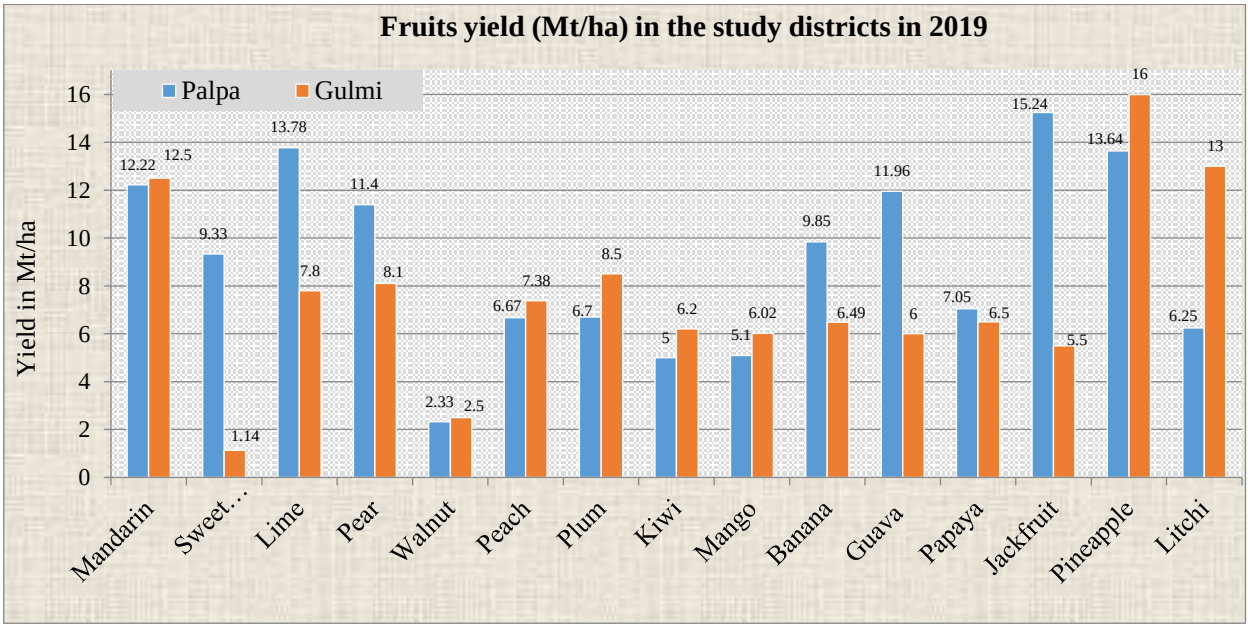

Fig. 3: Fruit yield in Palpa and Gulmi: 2019 (Source: MoAD, 2020)

Diseases of Vegetables in The Study Areas

Palpa district had more problem of vegetable diseases compared to Gulmi (Table 3). In tomato, late blight, viral diseases, whitefly, and bacterial wilt were more common disease in Palpa than in Gulmi. Damping-off disease of seedlings was more prevalent in tomato and crucifers. In Gulmi, downy mildew of cucurbits was more widespread. Viral disease in cabbage, cucumber, chilli, and okra were relatively more in the vegetable farm of Palpa. In contrast, viral disease in Brinjal and Tomato were common in Gulmi. Club root of cabbage and cauliflower, bacterial wilt of tomato, die-back of chilli, mosaic of cowpea, powdery mildew of cucurbits, and Cercospora leaf spot of okra were the major vegetable disease more common in the study areas. Brinjal mosaic was comparatively more noticed in Gulmi than in Palpa. Cabbage aphid seemed to be one of the most important pest diseases which caused heavy yield loss. Tomato leaf miner (insect disease) and tomato fruit worm (pest disease) had caused significant impact on the economical production of tomato. Occurrence of seed borne diseases such as Alternaria leaf spot in the commercial horticultural farm was due to inappropriate seed treatment

practice. Club root disease in the field occurred due to bulk of organic matter present in the farm (Shrestha, 2014), which is the source of pathogen survival (Singh, 1998).

Table 3: Vegetable diseases in study areas

	Diseases of vegetables in the study areas		
Vegetables	**Disease/Pest**	**Category**	**Scientific name**
Cauliflower and cabbage	Powdery mildew	Fungus	*Erysiphe cruciferarum*
	Club root	Fungus	*Plasmodiophora brassicae*
	Soft rot	Bacteria	*Erwinia caratovora*
	black rot	Bacteria	*Xanthomonas campestris*
	Downy mildew	Fungus	*Hyaloperonospora parasitica*
	Mosaic disease	Viral	*Mosaic virus*
	Cabbage aphid	Pests	*Brevicoryne brassicaea*
	Diamond Back Moth (DBM)	Insecta	*Plutella xylostella*
Tomato	Bacterial wilt of Tomato	bacteria	*Pseudomonas solanacearum*
	Late blight	Fungal	*Phytopthora infestans*
	Early blight	Fungal	*Alternaria solani*
	Tomato leaf miner	Insecta	*Tuta absoluta*
	Tomato fruit worm	Pest	*Heliothis asmigera*
	Whitefly	Pest	*Bemisia tabaci*
Chilli	Cercospora leaf spot	Fungal	*Cercospora capsici*
	Bacterial leaf spot	Bacterial	*Pseudomonas capsici*
	Leaf curl of chilli	Viral	*Begomovirus spp.*
	Mosaic disease	Viral	*Chilli mosaic virus*
	Die-back of chilli	Bacterial	*colletotrichum capsici*
Cowpea	Bacterial wilt of Cowpea	Bacterial	*Xanthomonas axonopodis pv phaseoli*
	Anthracnose of cowpea	Fungal	*Colletotrichum destructivum*
	Halo blight of cowpea	Bacterial	*Pseudomonas syringae pv. phaseolicola*
	Mosaic of cowpea	Viral	*Cowpea mosaic virus*
	Cowpea rust disease	Viral	*Uromyces phaseoli*
Cucurbits	Powdery mildew	Fungi	*Erysiphe/ Podosphaera spp.*
	Green stink bug	Insecta	*Chinavia halaris*
	Fruit fly	Insecta	*Bactrocera cucurbitae*
	Gummy stem blight of cucurbits	Fungal	*Phoma cucurbitacearum*
Okra	Jassids	Insecta	*Amrasca biguttula*
	Early blight of Okra	Fungal	*Alternaria solani*
	Cercospora leaf spot of Okra	Fungal	*Cercospora abelmoschi*
	Okra mosaic disease	Viral	*Okra yellow vein mosaic virus*
Brinjal	Phomopsis blight of Brinjal	Fungal	*Phomopsis vexans*
	Mosaic of Brinjal	Viral	*Tymovirus, Potyvirus*

Source: Field survey, 2020

Important fruits cultivated in the study areas include Citrus (Sweet orange, mandarin, lime), pineapple, guava, pear, papaya, banana, litchi, mango, etc. The Table 4 shows the major diseases of fruits produced in farmer's field of 4 local bodies of Palpa and Gulmi were citrus blast and citrus canker (Citrus), mealybug wilt and pink disease (Pineapple), guava wilt and weevil (Guava), fire blight and pear scab (Pear), internal yellowing and foot rot (Papaya), panama wilt and bunchy top (Banana). Other diseases reported during the surveyed period were citrus Tristeza disease, black citrus aphid, pineapple rot, guava leaf spot, pear decline, papaya ringspot, banana anthracnose, etc. Fungal diseases were found to be more infectious in the study areas.

Table 4: Fruits Diseases in the study areas

	Diseases of fruits in the study areas		
Fruits	**Disease/Pest**	**Category**	**Scientific name**
Citrus (Orange/ Mandarin/ Lime)	Black root rot	Fungal	*Thielaviopsis basicola*
	Citrus blast	Bacterial	*Pseudomonas syringae*
	Citrus canker	Bacterial	*Xanthomonas axonopodis*
	Tristeza disease	Viral	*Citrus Tristeza virus*
	Black citrus aphid	Insecta	*Toxoptera aurantii*
Pineapple	Heart rot disease	Fungal	*Phytopthora cinnamomi*
	Base (butt/black) rot	Fungal	*Ceratocystis paradoxa*
	Mealybug wilt	Viral	*Ampelovirus spp.*
	Pink disease	Bacterial	*Tatumella morbirosei*
Guava	Guava wilt	Fungal	*Fusarium oxysporum*
	Leaf spot	Algal	*Cephaleuros virescens*
	Fruit canker	Fungal	*Pestalotiopsis psidii*
	Guava weevil	Insecta	*Conotrachelus psidii*
Pear	Fire blight	Bacterial	*Erwinia amylovora*
	Pear scab	Fungal	*Venturia pyrina*
	Root-knot	Fungal	*Meloidogyne spp.*
	Pear decline	Phytoplasma	*Candidatus Phytoplasma pyri*
Papaya	Internal yellowing	Bacterial	*Enterobacter cloacae*
	Foot rot	Fungal	*Pythium aphanidermatum*
	Bumpy fruit	Disorder	*Boron deficiency*
	Papaya ringspot	Viral	*Papaya ringspot virus*
Banana	Panama wilt	Fungal	*Fusarium oxysporum*
	Anthracnose	Fungal	*Colletotrichum musae*
	Bunchy/curly top	Viral	*bunchy top virus*
	Infectious chlorosis	Viral	*Cucumber mosaic virus*

Source: Field survey, 2020

Extent of Disease Damage in The Study Areas

For many years, farming was a natural process that did not distress the farmland it was done on. Literally, farmers were competent to pass down their farm for several generations and it would still be fertile as before. Nevertheless, modern farming practices have brought agricultural pollution, leading to the degradation of the ecosystem and farm land. The imprudent application of chemicals in land has led to multitudinous effects, including increased residues on crops, pest-resistance, and soil degradation, water and air quality declination (Manchikant, 2019). Besides biotic causes for yield loss, lack of sufficient water in growth season, high temperatures, inappropriate irradiance, poor nutrient supply, etc. have the potential to increase the extent of damage to the crops substantially (Folnovic, 2018). The farmers are confronting significant crops yield decline on a global scale against pests and diseases at a time when they must enhance crop production to meet the burgeoning demand of growing population (Kan-Rice, 2019). Diseases are one of the primary causal factors to the yield loss (Raaijmakers *et al*., 2008).

This study assesses the overall extent of crop damage caused by biotic as well as abiotic agents in Palpa and Gulmi. The damage was observed in different parts of the crops and to different extents. Some crops were damaged severely, while some were not damaged at all. Majority (42%) of the farmers interviewed reported to have their crop damage upto 50% part of the plant and 30% to have their crop damage upto 25% part of the plant. 6% reported that their crop was disease free and 12% to have their plants in initial stage of disease development. A very few (2%) of farmers were heavily affected with total crop loss (100%). Most of the farmers pointed out injudicious use of modern chemical pesticides and fertilizers for the reason of severe disease damage to the crops. This is thus a high time to adopt efficacious and sustainable disease management strategies. Of several measures of disease management, bio-control by means of traditional use of locally available items has recently gained much interest in Palpa and Gulmi due to the constraints brought by the use of modern pesticides and healthy environmental concerns (Fig. 4). Also, giving healthiness and productiveness of soil a paramount importance, traditional means of disease management is a

need to today to favor the high crop yield and reduce the extent of disease damage.

Perception of Farmers to Traditional Means of Management

In general, majority of the farmers interviewed had positive perception towards traditional means of disease management. Most of the respondents had perceived traditional means as eco-friendly way of mitigating crop diseases risk. Approximately, one-fourths (26%) of the respondents from Palpa assumed traditional means as cost-effective and it was 21% from Gulmi (Fig. 5). The positive side which the farmers perceived includes healthiness of traditional means, non-toxical nature, and indigenous attributes. Among the surveyed group of population from Gulmi, most farmers adopt traditional ways of pest control due to its less environmental and human toxicity. Education and experience level play an important role in perception of human towards certain things. Most of the people in the surveyed areas are educated and had high level of farming experience, thus had positive perception towards adoption of local and indigenous techniques, along with traditional means of pest and disease infestation control. Intensive use of scarce natural resources, agro-chemicals, and machinery has jeopardized the ecological integrity of agro-ecosystems. This chaos had distinctly and closely been observed by the farmers of Palpa and Gulmi. Therefore, keeping this point in view, the farmers were shifting towards sustainable manner of farming, focusing on the use of traditional means that aimed to conserve the nature and increased yield as well.

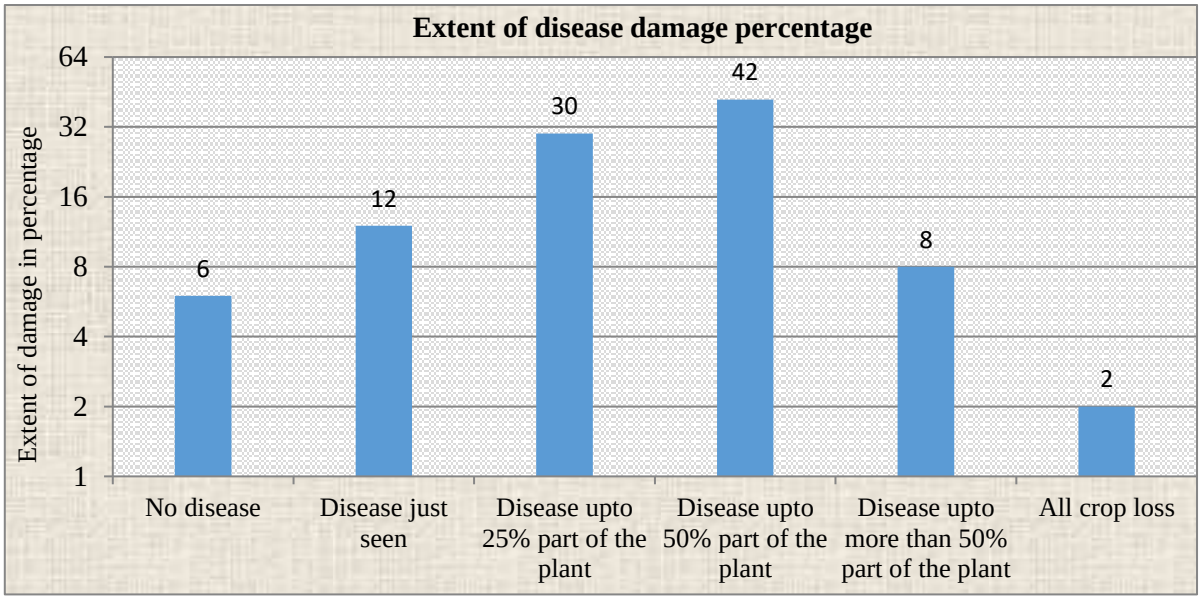

Fig. 4: Extent of damage in percentage (Source: Field survey, 2020)

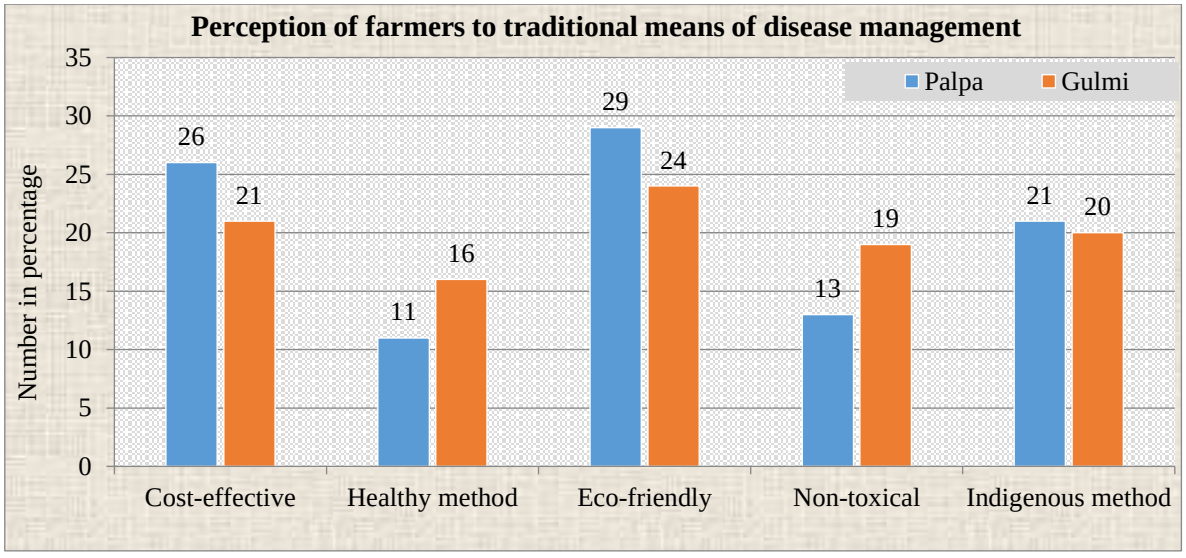

Fig. 5: Perception of farmers to traditional means of disease management

Knowledge on Use of Traditional Means

Efficient and sustainable crop protection is of determining economic and ecological significance for global food production. The unsafe and indiscriminate use of modern means in agriculture has been perilous to the environment and human health (Jallow, Awadh, Albaho, Devi & Thomas, 2017). And so forth, there is a need of knowledge build-up regarding the sustainable means which is alternative to modern means. A very few (9 farmers i.e., 12% of total) had very low level of knowledge. They were just aware about the existence of indigenous means but didn't know the way of its usage. It is because they were not interested in adopting traditional way of diseases control due to the influence of contemporary society and culture. Similarly, 26 interviewed farmers (20.08%) had low knowledge, which means they knew more about such means. However, there were unaware of how such means are more effective and sustainable for crop pest management. More than half (41.6%) of the farmers had average level of knowledge. Extension services and expert's visit to farm had increases the knowledge of many farmers in the study areas. Palpa and Gulmi have always been in the emphasized zone of agricultural production since many years. Thus, vegetables and fruits growers have trained themselves in better farming practices. Nowadays, understanding the possible negative impacts the modern pesticides could brought and increasing level of agro-knowledge, the producers in the study areas are gradually practicing old eco-friendly techniques of disease management. Fig. 6 shows that 21 consumers (16.8%) had high level of knowledge, and 11 consumers (8.8%) had very high level of knowledge. They were the one who also convinced other farmers to focus on traditional means of disease management instead of modern means. They are also well informed about such means. In overall, the farmers had average knowledge regarding the traditional usage of indigenous means for disease control.

Usage of Traditional Methods

The results showed that there is a growing interest to using traditional disease control methods in Palpa and Gulmi district (Fig.7). There are many indigenous pest control methods used to protect crops such as raw ash, bovine urine, decaying leaves, kerosene, etc. Figure 10 revealed that approximately half of the respondents used traditional means just to control the pests that have been proved to be infectious to the horticultural crops. The study divulged that Palpa and Gulmi are among the unique places for identifying the traditional farming methods. Farmers mainly cultivated vegetables for family consumption and also commercially aiming target groups to export. Less than one-thirds (i.e., 30% in Palpa and 29% in Gulmi) adopted traditional means to control diseases. Rest practiced modern ways. Similarly, 15% in Palpa and 23% in Gulmi practiced traditional ways to prevent from animal threat. Animal threats are usually prevented by making fencing around the field, hanging scarecrow in the middle of farm, making barriers and so on.

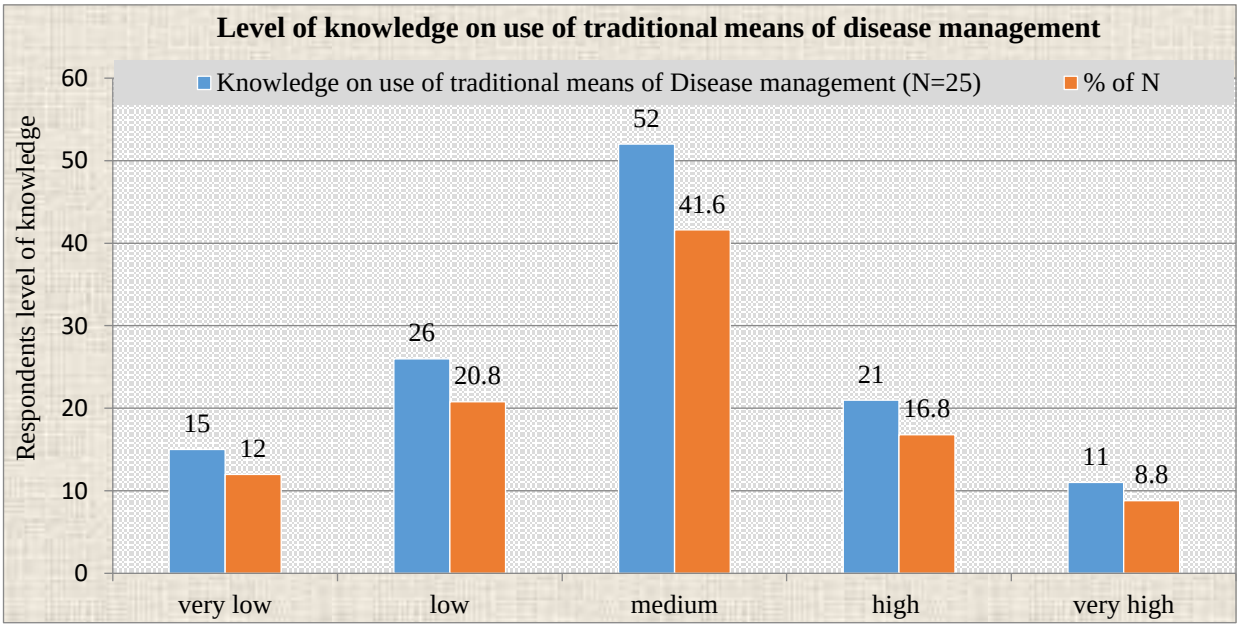

Fig. 6: Level of knowledge on use of traditional means of disease management

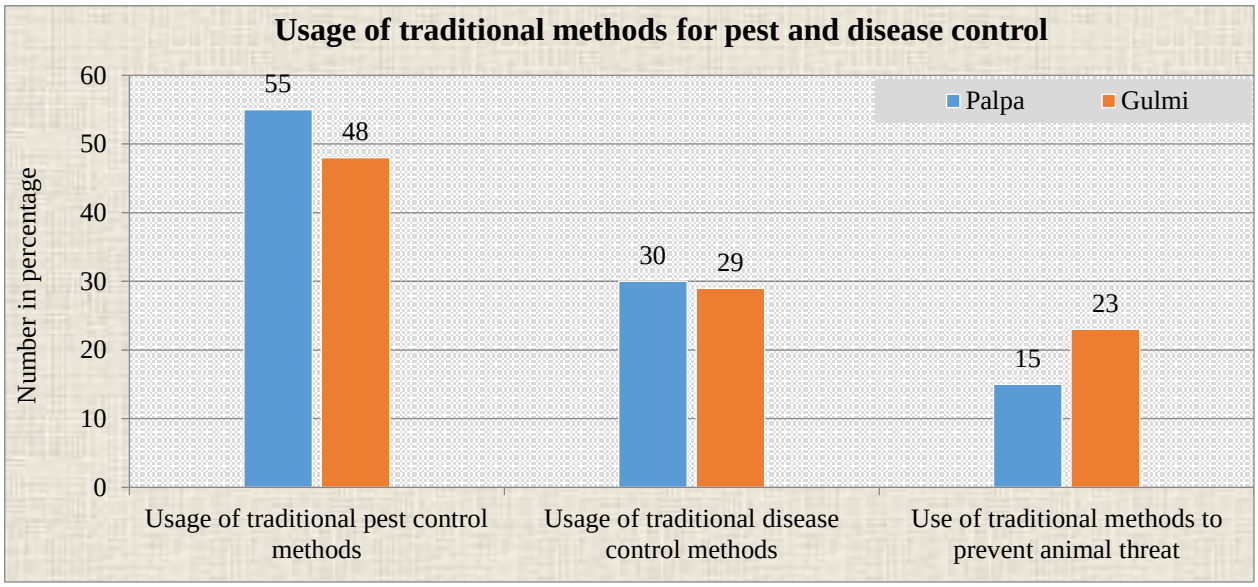

Fig. 7: Usage of traditional methods

Traditional Methods of Pest and Disease Control in Palpa and Gulmi

Contemporary farming systems during the last 5-6 decades have majorly followed 'substitution agriculture', in which weed, pest, and disease management is generally achieved through agrichemical usage that has led to severe ecological degradation, along with reductions in biodiversity (Fountain & Wratten, 2013). This type of farming practice is increasingly becoming unsustainable in Palpa and Gulmi as well. The organisms that we call pests and the creatures, that cause disease merely become 'pest and diseases' when their activities commence to damage crops and decline yields. Table 5 revealed that almost 15% of the interviewed farmers had followed crop rotation techniques to increase the soil fertility status which ultimately increases the disease resistance potentiality of the crops. Timely sowing of seeds in the field also controls disease and pest outbreaks in the farm. Traditional methods of biological control were popular in study areas. Other methods which are traditional were maintenance of healthy soil by keeping p^H normal, use of resistant plant varieties that can tolerate adverse environmental conditions, companion planting, growing trap plants to trap pests and insects, making barriers like fencing the field, hand picking of weeds, etc. Companion planting refers to growing specific plants to protect other plants from pests or diseases. This technique attracts the pests to the companion plant rather than the main crop. The results showed that the farmers in the study areas were highly conscious on disease management through eco-sustainable traditional and indigenous techniques as listed in Table 5. Thus, it resulted in synergistic impact on high yield and nature conservation. Farmers were aware of that their farming activities must not harm the nature's tranquility.

Table 5: Methods of Pest and Disease control in the study areas

Methods of Pest and Disease control in the study areas	(N=125)	% of N
Barriers	11	8.8
Light traps	9	7.2
Fly traps	10	8
Hand picking	6	4.8
Plants to attract predators and parasites	10	8
Timely sowing	14	11.2
Companion planting	11	8.8
Crop rotation	18	14.4
Use of resistant varieties	8	6.4
Biological control	14	11.2
Social prevention	6	4.8
Maintenance of healthy soil	8	6.4

From the survey, the above and following traditional practices of pest and disease management were identified in the study areas. The authors, from the study, were able to found out several remedies of pests and insects, which the indigenous people of surveyed areas had transmitted orally through many generations. Some of traditional pest and disease control ways are briefly described below:

Mixture of Kerosene and Ash

Predominantly in Palpa district, vegetables growers were found using right proportion of mixture of kerosene and ash to protect their plants from sap sucking insects. Generally, application of 2-3 spoonful of kerosene to around 1 kg of raw ash mixed thoroughly twice a week in morning or evening have resulted to be effective in disease control. This was found to be done in all development stages of every type of plants.

Solution Mixture of Fresh Cow Urine, Onion, Garlic, Mugwort, Chilli, Ageratina Adenophora, Adhatoda Vasica:

Some farmers from Gulmi district have reported using solution of fresh cow urine (4-5 liter) mixed with pest of onion (around 5-6), garlic (approximately 100 gram), mugwort, chilli, Ageratina adenophora, and Adhatoda vasica along with 4-5 liter of water and then filtered. Thus, produced extraction was then applied by foliar method. Farmers have claimed that this has helped them replicate many sap sucking insects and disease-causing pests from their farm.

Raw Ash

Farmers were found using raw ash to control pests like lahi, stem cutting insects, and chichle insect that decline the crop yield. They spray raw ash in powder form in plant affected with pests and insects. It is usually done in every 2-4 days. This technique can be done in every stage of plant but the care should be taken as ash is basic in nature and more application may make soil more alkaline. Fruits and vegetables diseases can be controlled through ash application in powder form.

Bovine Urine

Farmers from Palpa district were found having trouble with milbug. They have reported to control milbug by mixing water and urine in 2:1 ratio and spread by foliar method, which act as a good insect replicant. Sap sucking insects are also found to be protected from this method. Precautions should be taken while applying solution. Most importantly, low concentration should be applied in those plants which are at the edge of harvest because the crops may smell bad if applied prior to harvest.

Mugwort

Hairy caterpillars were found destroying field by damaging crops leaf. Farmers were found using mugwort to protect their plants from leaf eating hairy caterpillars. Generally, 2-3 liters of water mixed with half kilogram of mugwort is applied on farm by foliar method of application. This method was found to be done in every stage of developing plant.

Peppermint, Bari and Mugwort Solution

Hairy caterpillars were also found controlled by using solution of mixture of peppermint, babri, and mugwort solution. Additional of peppermint and Bari in mugwort has been found making the solution stronger as per the farmers which makes the solution more effective. Farmers were reported using solution by foliar method.

Chili Powder

Aphids had caused serious problems in the horticultural production in the study areas. Chilli powder can be used to control them. It is usually applied in powder form generally in sunny days when wind flow is stable.

Fresh Dung

Dung of animals was reported to work as a good replicant of pests and insects. Mixture of 1-2 kg of fresh dung and 4-5 liters of water is prepared and then filtered. Thus, obtained extracts was applied by foliar method. This technique can be applied in every stage of crop development.

Papaya Leaf

The surveyed group of farmers was found using papaya leaf pest to control fungal disease in crops. Application can be done by mixing papaya leaf pest mixed through with 1-2 liter of water and then filtered with clean cloth. The extract was than applied by foliar method of application.

Holy Basil

Besides having religious importance of basil, it was found to be beneficial for the control of leaf eating insects in citrus fruits. Leaves of holy basil are crushes and thoroughly mixed in 2-3 liter of water and applied by foliar method. Fruit's diseases are generally controlled through application of holy basil.

Constraints in Use of Traditional Means

Various constraints hold back the use of traditional means of disease management in horticulture in Palpa and Gulmi. The problems in adoption of indigenous means of disease control in the study areas were identified and ranked on the basis of seriousness of the problems (Table 6).

Table 6: Constraints in use of traditional means

Constraints	6	5	4	3	2	1	N	I_{imp}	Rank
Lack of indigenous information which could be used by farmers and by extension workers	44	28	20	14	12	7	125	0.74	I
Lack of advertisement and knowledge about the way of using such means	38	29	23	16	13	6	125	0.73	II
Sociological constraints (Social perception of farmers towards use of traditional means)	29	30	21	16	11	15	125	0.66	III
Lack of integration of ecological theory and crop disease management	9	26	31	27	19	13	125	0.59	IV
Lack of real efforts to work with farmers as support mechanisms that protect their knowledge.	27	20	16	18	21	23	125	0.59	V
Lack of cooperation among social and agricultural scientists	12	11	19	36	29	18	125	0.52	VI

Table 7: Strategies to promote use of traditional means

Strategies to promote use of traditional means of crop-disease control	6	5	4	3	2	1	N	I_{imp}	Rank
Documentation, scientific validation, and certification of native knowledge and practices	36	29	21	13	16	10	125	0.70	I
Support from government and extension agents to perform field demonstrations on its use	23	26	33	18	12	13	125	0.65	II
Encourage farmers to use their indigenous information to control crop disease in eco-friendly manner	25	28	20	23	14	15	125	0.64	III
Advertisements on the availability of traditional means	28	31	13	12	19	22	125	0.63	IV
Focus on future research related to the farmers traditional information in plant disease management	19	28	23	17	22	16	125	0.61	V
Changing poor social perception of farmers through media, conferences, and home-visit	18	17	26	22	28	12	125	0.57	VI

Major constraints to adoption of traditional means of disease management in horticultural crops in the study areas were lack of indigenous information, followed by improper advertisements and knowledge of such means, poor social perceptions of farmers towards use of local methods, lack of integration of ecological theory and crop disease management, less efforts of extension agents to work with farmers, and weak cooperation among social and agricultural scientists.

Likewise, besides adoption constraints, several other problems had hindered the horticultural development in surveyed areas. The producers had reported following problems during the interview:

a. Lack of pure and quality planting materials.
b. Farmer's ignorance about the healthiness of indigenous disease control methods.
c. Poor transportation services and difficult topography of high-hills.
d. Lack of adoption of appropriate technologies, which are sustainable and ecological.
e. Inappropriate storage and processing facilities.
f. Unorganized marketing channel and system.
g. Untimely and insufficient supply of inputs and credits to marginal farmers.
h. Weak extension services and failure to train the rural farmers.
i. Poor organization structures in research sectors regarding efficacy of disease control.
j. Weak coordination between research and development organizations.
k. Inadequacy in gender consideration in horticulture development.

Strategies To Promote the Traditional Ways of Disease Control in The Study Areas

Since the beginning of agriculture, generations of peasants have been evolving practices for encountering the various diseases suffered by crops (American Phytopathological Society, 2017). Building up effective strategies can enhance the use of sustainable and traditional means of plant disease control. Several strategies which need to be focused on were identified with the survey results. Table 7 illustrated the degree of importance of the strategies in the study areas (Table 7).

The results revealed that proper documentation, scientific validation, and certification of native knowledge and practices could promote the use of traditional means. Similarly, government and extension agents should support to perform field demonstrations on usage of such means so that farmers believe the effectiveness of traditional methods over conventional one. Media can help farmers encourage using their indigenous information. In a like manner, genuine research in plant disease management through traditional and modern means should be emphasized. Poor social perceptions of farmers to its use should be changed to make them adopt traditional means.

Conclusion

The descriptive results illustrated that most of the farmers in the surveyed areas were severely suffered from crop disease outbreaks and pest infestation risks. Modern method of using chemical pesticides to control disease was popular, which had caused negative impacts to the ecological sustainability, thus has raised the need to adopt traditional and indigenous techniques of disease management in the study areas. Vegetables and fruits were grown successfully in the western hills of Nepal due to environmental suitability. Most of the farmers had reported to have average damage to crops, while very few had total crop loss. The majority of the farmers perceived traditional means as eco-friendly, and some as cost-effective, indigenous method, non-toxical, and healthy approach. In general, farmers had medium level of knowledge on the use of such indigenous means, which had further increased their interest towards it. The study found out the usage of traditional means for different purposes; majorly for pest management, and few for preventing disease outbreaks, and very few to protect crops from animal threats. Several methods were in use such as kerosene mixture with ash, dung and urine of bovine, mugwort, chilli powder, holy basil, etc. Various constraints were reported to hold back the adoption of traditional means in study areas. The major constraints were lack of proper

use of indigenous information by farmers and extension workers, lack of advertisements of such methods, poor social perceptions of farmers to use of old techniques, lack of integration of ecological theory and crop disease management, and weak coordination among social and agricultural scientists.

Future Research Works

The authors recommend that future research endeavors should include indepth studies so that perceptions of farmers can be analyzed and more fully observed. The conducted research can be applied to improve horticultural sector through the use of traditional means for effective disease control using environmental-friendly technologies that sustain the natural system. Documentation, scientific validation, and certification of native knowledge are needed to enhance the use of traditional ecological way of controlling disease. Future research should be focused on changing the social perception of farmers and encourage them adopting own indigenous techniques. Training and extension programs in Nepal have been limited in scope. Initiatives such as extension services, seminars, and horticultural programs to make farmers educated on natural way of producing goods should be developed. These indigenous knowledge needs to be protected; it deserves to be documented for the purpose of well and healthy outcome. This will not just promote the production of healthy horticultural crops but also will safeguard our culture and practices. It is hoped that the findings of this study present clear insights into efforts that will encourage farmers to use their indigenous technical knowledge (ITK) and motivate them to adopt traditional means of disease management.

Authors' contribution

Saugat Khanal and Pramod Gyawali designed the research plan and prepared the manuscript; Pramod Gyawali collected the required data. Jhalak Raj Joshi critically revised the manuscript. Final form of manuscript was approved by all authors.

Conflict of Interest

The authors declare that there is no conflict of interest with present publication.

Acknowledgements

We want to acknowledge our parents whose guidance is always with us, our colleagues and the professors for helping us during manuscript preparation.

References

Acharya AK (2019) Horticultural Crop Species in Nepal: History, Investment, Achievement and Working Groups. Working Groups of Agricultural Plant Genetic Resources (APGRs) in Nepal, (pp. 227-236). Kathmandu, Nepal.

Adhikari S (2015) Contribution of agriculture sector to national economy in Nepal. *J Agric Environ* **16**: 180-187. DOI: 10.3126/aej.v16i0.19851

American Phytopathological Society (2017) Plant Disease Epidemiology: Temporal Aspects. Retrieved September 23, 2020, from Plant Disease Management Strategies: https://www.apsnet.org/edcenter/disimpactmngmnt/topc/EpidemiologyTemporal/Pages/ManagementStrategies.aspx

Bhandari N, Bhattarai D, and Aryal M (2015) Cost, Production and Price Spread of Cereal Crops in Nepal: A Time Series Analysis. Lalitpur, Nepal: Government of Nepal, Ministry of Agriculture Development, Department of Agriculture Harihar bhawan.

Bhatta G, and Doppler W (2010) Socio-economic and environmental aspects of farming practices in the peri-urban hinterlands of Nepal. *Journal of Agriculture and Environment* **11**: 26-39. DOI: 10.3126/aej.v11i0.3649

Bhattara DR (2018). Postharvest horticulture in Nepal. *Horticulture International Journal* **2**(6): 458-460. DOI: 10.15406/hij.2018.02.00096

CASA (2020) Commercial Agriculture for Smallholder and Agribusiness. Retrieved September 19, 2020, from Vegetable sector strategy-Nepal: https://www.casaprogramme.com/wp-content/uploads/CASA-Nepal-VegetablesSector-analysis-report.pdf

De Zeeuw H, Van Veenhuizen R, and Dubbeling M (2011) The role of urban agriculture in building resilient cities in developing countries. *The Journal of Agricultural Science* **149**(1): 153-163. DOI: 10.1017/S0021859610001279

Devkota S (2015) Status of fruit in Nepal. Retrieved September 21, 2020, from Government policies and periodic plan along with Statistical data and pocket area of different commercial fruits grown in Nepal: https://www.academia.edu/8977817/Status_of_fruit_in_Nepal

FAO (2016) FAO statistics. Rome, Italy: Food and Agriculture Organization of the United Nations.

Folnovic T (2018) Yield Losses Due to Pests. Retrieved from Agrivi: https://blog.agrivi.com/post/yield-losses-due-to-pests

Fountain E, and Wratten S (2013) Conservation Biological Control and Biopesticides in Agricultural. In: Encyclopedia of Ecology (Second Edition) (Vol. 1, pp. 377-381). Elsevier. DOI: 10.1016/B978-0-12-409548-9.00539-X

Gautam D, and Bhattarai (2012) Postharvest horticulture. Chabahil Kathmandu, Nepal: Bhawani Printers.

Ghimire D, Lamsal G, Paudel B, Khatri S, and Bhusal B (2018) Analysis of trend in area, production and yield of major vegetables of Nepal. *Trends in Horticulture* **1**(2): 1-11. DOI: 10.24294/th.v1i2.914

Ghimire K, and GC A (2018) A SWOT Analysis of Nepalese Agricultural Policy. *International Journal of Agriculture Environment and Food Sciences* **2**(4): 119-123. DOI: 10.31015/jaefs.18020

Gurung B, Regmi P, Thapa R, Gautam D, Gurung G, and Karki K (2016) Impact of PRISM Approach on Input Supply, Production and Produce Marketing of Commercial Vegetable Farming in Kaski and Kapilvastu District of Western Nepal. *Greener Journal of Agricultural Sciences* **6**(10): 320-325. DOI: 10.15580/GJAS.2016.10.110716200

Gurung B, Thapa R, Gautam D, Karki K, and Regmi P (2016) Commercial Vegetable Farming: An Approach for Poverty Reduction in Nepal. *Agronomy Journal of Nepal* **4**: 92-106. DOI: 10.3126/ajn.v4i0.15518

Huang SW (2018) Global Trade Patterns in Fruits and Vegetables. Retrieved September 6, 2020, from United States Department of Agriculture: https://eumed-agpol.iamm.fr/doc/global_trade_fruits_vegetables.pdf

Jallow MF, Awadh Dg, Albaho MS, Devi VY, and Thomas BM (2017) Pesticide Knowledge and Safety Practices among Farm Workers in Kuwait: Results of a Survey. *International Journal of Environmental Ressearch and Public Health* **14**(4): 340. DOI: 10.3390/ijerph14040340

Joosten F, Dijkxhoorn Y, Sertse Y, and Ruben R (2015) How Does the Fruit and Vegetable Sector Contribute to Food and Nutrition Security? The Hague, The Netherlands: LEI Wageningen UR.

Kaini B (1994) Status of fruit plant genetic resources in Nepal. In: Upadhya MP, Saiju HK, Baniya BK (eds) *Proceeding of the national*. Kathmandu, Nepal: Plant Genetic Resources, Nepalese Perspectives.

Kaini B (1999) The wild relatives of fruit crops in Nepal. National Conference on Wild Relatives of Cultivated. Kathmandu, Nepal: Green Energy Mission.

Kan-Rice P (2019). Pests and Diseases Cause Worldwide Damage to Crops. Retrieved September 21, 2020, from California Ag Today: https://californiaagtoday.com/pests-diseases-cause-worldwide-damage-crops/

Khanal S (2020). Consumers' willingness, behaviors, and attitudes to pay a price premium for local organic foods in Nepal. *International Journal of Environment, Agriculture and Biotechnology* **5**(3): 594-609. DOI: 10.22161/ijeab.53.11

Manchikant P (2019) Bioavailability and environmental safety of nano biopesticides. In: Nano-Biopesticides Today and Future Perspectives (pp. 207-222). Academic Press. DOI: 10.1016/B978-0-12-815829-6.00008-5

Mero kalam (2019) Names of Nepali Vegetables – English to Nepali. Retrieved September 20, 2020, from https://www.merokalam.com/nepali-vegetables-english-name/#:~:text=A%20typical%20Nepali%20diet%20consists,many%20other%20seasonal%20local%20vegetables

MoAD (2015) Statistical Information on Nepalese Agriculture, Time Series Information. Kathmandu, Nepal: Government of Nepal, Ministry of Agriculture Development.

MoAD (2017) Statistical information of Nepalese Agriculture, 2015/16. Signh Durbar, Kathmandu, Nepal: Kathmandu Ministry of Agricultural Development, Monitoring, Evaluation and Statistics Division Agri Statistics Section.

MoAD (2020) Statistical Information on Nepalese Agriculture 2075/76 (2018/19). Retrieved September 3, 2020, from Ministry of Agriculture and Livestock Development: https://s3-ap-southeast-1.amazonaws.com/prod-gov-agriculture/server-assets/publication-1595229368881-0dc12.pdf

NHS (2016) Six Decades of Horticulture Development in Nepal. Jubilee Special-International Horticulture Conference 2015 (pp. 186-209). Kathmandu, Nepal: Nepal Horticulture Society.

Pandey G, Basnet S, Pant B, Bhattarai K, Gyawali B, and Tiwari A (2017) An Analysis of Vegetables and Fruits Production Scenario in Nepal. *Asian Research Journal of Agriculture* **6**(3): 2456-561. DOI: 10.9734/ARJA/2017/36442

Raaijmakers J, Paulitz T, Steinberg C, Alabouvette C, and Moënne-Loccoz Y (2008) The rhizosphere: a playground and battlefield for soilborne pathogens and beneficial microorganisms. *Plant and Soil* **321**: 341-361. DOI: 10.1007/s11104-008-9568-6

Rai M, Paudel B, Zhang Y, Khanal N, Nepal P, and Koirala H (2019) Vegetable farming and farmers' livelihood: Insights from Kathmandu Valley, Nepal. *Sustainability* **11**(13): 889. DOI: 10.3390/su11030889

Shrestha G (2014) Soil properties and soil management practices in commercial organic and conventional vegetable farms in Kathmandu valley. *Nepal Journal of Science and Technology* **15**: 13-22. DOI: 10.3126/njst.v15i1.12005

Singh R (1998) Diseases caused by Plasmodiophoromycetes and Mastigomycotina. Seventh ed. New Delhi, India: Oxford and IBH. Plant Diseases.

Tageo (2019) Kingdom of Nepal. Retrieved September 6, 2020, from Tageo.com: http://www.tageo.com/index-e-np-v-00-d-m1507618.htm

Thapa MB, and Dhimal S (2017) Horticulture Development in Nepal: Prospects, Challenges and Strategies. *Universal Journal of Agricultural Research* **5**(3): 177-189. DOI: 10.13189/ujar.2017.050301

Veenhuizen V, and Danso G (2007) Profitability and Sustainability of Urban and Peri urban Agriculture. 19. Rome, Italy: Food and Agriculture Organization of the United Nations: https://ruaf.org/assets/2019/11/Profitability-and-Sustainability.pdf