

Research Article

## Diversity and occurrence of major diseases of vegetables and fruits during spring season at Aanbukhairesni rural municipality of Tanahun, Nepal

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### ABSTRACT

A survey has been conducted to assess the diversity and occurrence of major vegetables and fruits cultivated in Aanbukhairesni rural municipality of Tanahun district, Nepal during spring season of 2019. The surveyed areas were Satrasayaphant, Baradiphant and Dumridanda of ward no (WN) 1, Yeklephant, Markichowk and Pateni of (WN 2), Gaadapani of (WN 3), Saakhar of (WN 4) and Ghummaune of (WN 5). The surveyed area consists of upper tropical and sub tropical climate. The total no of farmers field selected were 34, 32, 24, 17 and 21 from ward no 1,2,3,4 and 5 respectively. The major vegetables cultivated were tomato, cucurbits, bean, brinjal, chilli, cowpea and okra while banana, papaya, mango, litchi, peach, guava, lemon and mandarin orange were the major fruits in the surveyed area. The major diseases of vegetables noticed were early and late blight, cercospora leaf spot, powdery mildew, downey mildew, fruit rot, bacterial wilt, bacterial spot, leaf curl and mosaic whereas sigatoka leaf spot, panama wilt, algal leaf spot, canker, root rot, sooty mold, red rust, anthracnose, rust, mosaic, and leaf curl were the major fruit diseases. The higher disease incidence (70%) and severity (48%) in vegetables were recorded in ward no 2 where as the lower incidence (45.2%) and severity (37.71%) were found in ward no 4. Similarly, the higher fruit disease incidence (70.24%) and severity (51.27%) in ward no 1 followed by ward no 2 with disease incidence and severity of 66.79% and 45.14% respectively. The reasons for those results are low educational level, lack of best bet technology, no proper irrigation and fertilizer, unavailability of pesticides for controlling the diseases. This study will be useful to identify the major diseases of vegetables and fruits of terai and inner terai region of Nepal and applying control measure, looking for the best possible solutions.

**Keywords:** Disease Incidence, Disease Severity, diversity, fruits, vegetables

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## INTRODUCTION

Farmers in Nepal are known to grow a great richness of vegetable and fruit crops even at the household level, which is often attributed to different micro-environments of their fragmented land parcels, cultural importance and the social prestige too. Vegetables and fruits both are the cheapest and richest sources of calories, natural vitamins, minerals, dietary fiber and are therefore, named as "protected foods" which are essential to tackle the problems of malnutrition and improve quality of life (Choudhary *et al.*, 2009). In Nepal, the total area under fruit production was 162660 ha with the productive area of 130449 ha and production 1058519 mt and productivity 8.12 mt/ha (MOALD, 2018). Vegetables are grown in 286864 ha with the production of 3958230 mt and productivity of 13.79 t/ha in Nepal (MOALD, 2018). Pests and disease are destroying about one fifth of all crop production around the world and at least 10% of the global food production is lost through plant disease alone (FAO, 2000) mainly in West Africa and South Asia (Dhami *et al.*, 2015). Diseases and pests are the major factors contributing to crop loss which hinders the income of rural families and global food security worldwide (Cerda, 2017). The resulting losses are, to a significant extent, the consequences of crops grown in monocultures and continuing evolution of new races of pests and pathogens that are able to overcome resistance genes introduced by modern breeding (Manandhar *et al.*, 2016). Local crop genetic diversity, and the associated indigenous knowledge is a tool for small-scale farmers in developing countries to meet their livelihood needs. The key factor to prevent the losses in the crop yield and quantity of agricultural products, proper identification and diagnosis of plant disease is utmost (Kumar & Kaur, 2015). The use of a diversity of traditional crop varieties continues to be part of disease management strategy in genetically diverse systems for such farmers (Jarvis *et al.*, 2011). Loss of local crops, which reduces the varietal choice, also reduces the farmers' capacity to cope with changes in pest and disease infestations, and leads to yield instability. Vegetables and fruit cultivation are one of the major economically important tool to contribute the livelihood of most of the farmers of Aanbukhaireni rural municipality of Tanahun district, Nepal. Diseases are the major limiting factors for the higher production of those commodities in this particular area which resulted great economic loss to the farmers. However, the potential disease pests of vegetables and fruit crops attacked their diversity and even occurrence and damage has not been systematically studied yet. The plant protection part has remained largely neglected from the research perspectives in Nepal. Farmers and researchers often do not report disease incidence or damage on fruit and vegetable crops in most part of the Nepal. Hence it is important to identify the major diseases of vegetables and fruits and applying control measure, looking for the best possible solutions. The main objective of this study is to survey of various diseases, their diversity, occurrence and intensity on vegetables and fruits cultivated in the farmersfields of Aanbukhaireni rural municipality of Tanahun district, Nepal.

## MATERIALS AND METHODS

### Survey site

Aanbukhaireni rural municipality is located at 12 km north west from Mugling town on the Prithivi highway road on the bank of the Marshyangdi river and covers an area of 67.3 km<sup>2</sup> with 6 wards. It is the part of Tanahun district in Gandaki province in middlemost of country where Chitwan and Gorkha district lies in the east, Bandipur municipality and Devghat rural

municipality lies in the west, Bandipur municipality and Gorkha district in the north and Devghat rural municipality and Chitwan district in the south. The geographical location of the survey site is 27°89' N latitude and 84°51' E longitude at an altitude of 760 meters above sea level. Most of the surveyed areas are dominated by mid hills and plain. The climate is warm and temperate and fluctuating in the whole year in Aanbukhaireni. When compared with winter, the summers have much more rainfall. The total annual average rainfall is about 2379 mm and the major amount of rainfall occurs between June and August. The average annual temperature varies from 6.5° to 30.5°C. The soil of the Aanbukhaireni is predominantly sandy loam followed by clay loam. The pH values for these soils are in the range of 5.5 up to 7.5, suitable for vegetable and tropical fruit cultivation.

### Survey procedures and observations recording

The survey has been conducted in spring season (March-May) of 2019 on vegetables and fruits crops grown in Aanbukhaireni rural municipality of Tanahun district, Nepal. The survey has been executed in farmers field of five wards i.e. Satrasayaphant, Baradiphant and Dumridanda villages of ward no 1, Yeklephant, Markichowk and Pateni villages of ward no 2, Gaadapani village of ward no 3, Saakhar village of ward no 4 and Ghummaune village of ward no. 5. The surveyed area consists of upper tropical and sub tropical climate. The total no of farmers field selected for the survey was 34, 32, 24, 17 and 21 from ward no 1,2,3,4 and 5 respectively. The selected sites were approximately equal distance from each other along the sampling pathway. The major vegetables cultivated during survey period in the surveyed area were bean, bitter-gourd, brinjal, chilli, cowpea, cucumber, okra, pumpkin, sponge-gourd, tomato, snake-gourd and bottle-gourd. Similarly, the fruits found in the region were banana, papaya, grapes, mango, litchi, peach, guava, lemon, mandarin orange etc. For the surveillance, farmers, representatives from cooperatives, agricultural officers and technicians from line agencies and scientists from NARC Research stations were concerned. The disease data were recorded from 5 randomly tagged plants or branch/1 m<sup>2</sup> plot on the basis of 1-5 scoring scale (Manandharet al., 2016).

- 1- No disease
- 2- Disease start or seen
- 3- Disease up to 25% part of the plant
- 4- Disease up to 50% part of the plant
- 5- Disease more than 50% part of the plant

Based on the counts, disease incidence and index (severity) were recorded and suspected diseased specimens were collected for isolation and identification of pathogens under laboratory condition. Disease incidence was calculated based on the following formula.

$$\text{Disease incidence (\%)} = \frac{\text{No. of infected plants}}{\text{Total no of plant assessed}} \times 100$$

Percent Disease Index (PDI) was computed on the basis of recorded data according to the formula (Wheeler, 1969; Shrestha et al., 2019).

$$\text{PDI (\%)} = \frac{\text{Sum of all numerical values}}{\text{No of plants observed}} \times \frac{100}{\text{Maximum diseases rating}}$$

A disease monitoring form was developed to record the surveyor name, location detail, date of the survey, latitude, longitude and elevation of the survey site, crop growth stage, soil type, soil texture, soil color, crop history, field area size, if disease sample collected (sample ID number) and finally any comments or observations like sex, age, occupation, education etc to understand the socio economic impact of the disease.

The data on meteorological factors, such as atmospheric temperature (maximum and minimum), relative humidity and rainfall during crop and survey period were recorded from the nearby meteorological stations installed at Bandipur and Damauli area.

### **Isolation, identification and confirmation of the pathogen**

Infected plant samples of leaves, fruits and twigs have been collected in paper packets and brought to laboratory of National Maize Research Program (NMRP), Rampur, Chitwan for identification of pathogens. All materials which are used in this experiment were sterilized using ethyl alcohol except the samples. The diseased parts were cut into small pieces of 1-2 cm with some healthy part. The small pieces were washed with tap water and surface sterilized with 10 % NaOCl for 30 to 60 sec, again rinsed with sterile water and blotted to dry on clean tissue paper. After drying, three pieces were aseptically placed into Petri dishes containing Potato Dextrose Agar (PDA) medium. Then, the inoculated Petri dishes have been marked with name of the sample and date of inoculation and incubated at a temperature of 25°C for 5 days, until pathogen proliferation on medium surface. Fungal identifications were carried out on the basis of characterization of colonies and have also been examined under a compound microscope with 40X magnification (Aneja, 2004).

### **Data analysis**

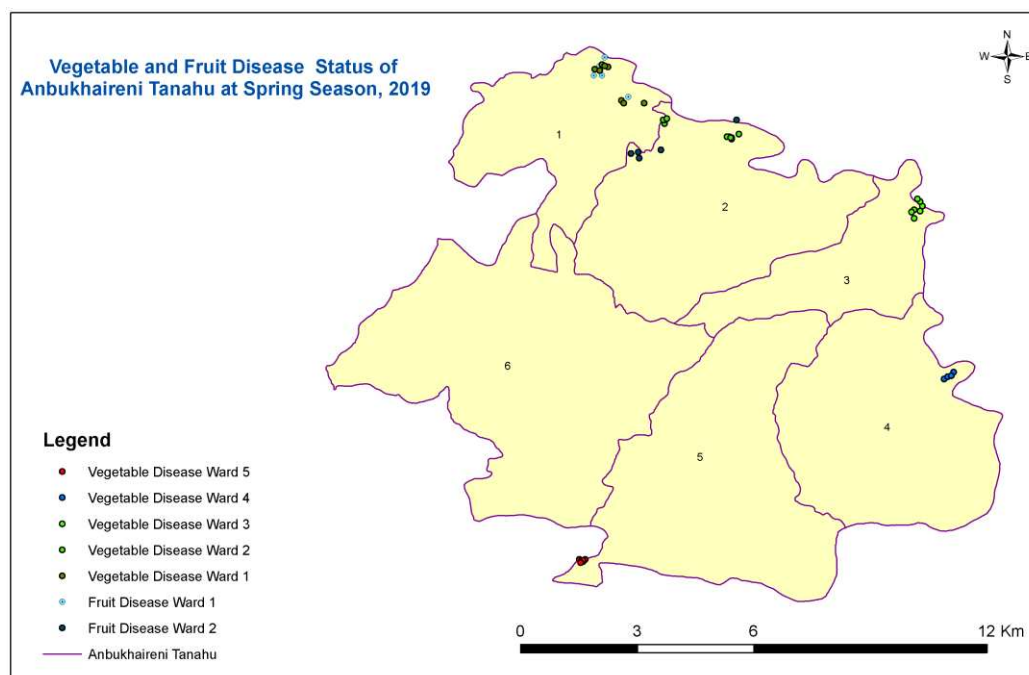
All data were analyzed statistically using Microsoft Excel (2007) computer package program. The average mean, standard deviation and standard error was calculated. Disease maps were developed by using ArcGIS 10.3 software.

## **RESULTS AND DISCUSSION**

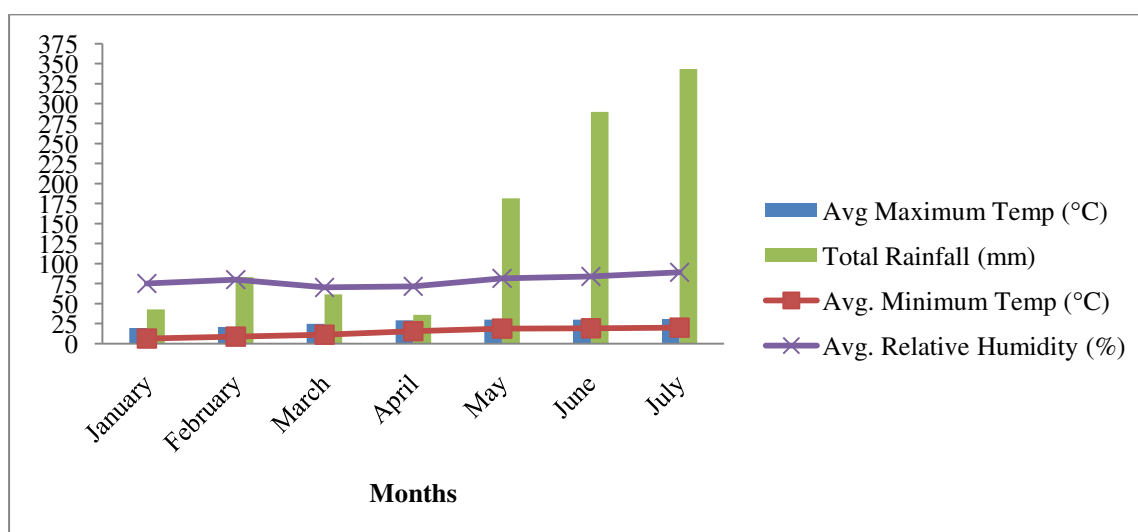
### **Surveyed map and meteorological observations**

The vegetable and fruit disease status of surveyed areas is shown in the map (Figure 1). The weather data related to crop and survey period is shown in the figure 2. The average maximum temperature ranges from 19.3 to 30.44°C, average minimum temperature ranges from 6.16 to 19.75°C. The total annual rainfall during crop period was 1037.2 mm and average relative humidity ranges from 78.69% (Figure 2).

Climatic factors play major role for the production of most of the vegetables and fruits worldwide. Moreover, increasing temperatures, reduced irrigation-water availability, flooding, and salinity will be the major limiting factors in sustaining and increasing vegetable and fruit productivity (Abewoy, 2018).



**Figure 1:** A map showing vegetable and fruit disease status of Aanbukhaireni, Tanahun of Nepal during spring season 2019



**Figure 2:**The data on meteorological factors, as atmospheric temperature (maximum and minimum), relative humidity and rainfall of Aanbukhaireni, Tanahun of Nepal during crop and survey period 2019.

Climate change influence the pest and disease occurrences, host-pathogen interactions, distribution and ecology of pests, time of appearance, migration to new places and their overwintering capacity, there by becoming major setback to vegetable and fruit cultivation. Excessive soil moisture due to heavy rain becomes major problem that can be overcome by growing crops on raised beds. Development of genotypes tolerant to high temperature, moisture stress, salinity and climate proofing through conventional, non-conventional, breeding techniques, genomics and biotechnology etc. are essentially required to meet these

challenges (Abewoy, 2018). The changing patterns of climatic parameters like rise in atmospheric temperature, changes in precipitation patterns, excess UV radiation and higher incidence of extreme weather events like droughts and floods are emerging major threats for vegetable and fruit production in the tropical zone (Tirado *et al.*, 2010). Vegetable and fruit crops are very sensitive to climatic vagaries and sudden rise in temperature as well as irregular precipitation at any phase of crop growth can affect the normal growth, flowering, pollination, fruit development and subsequently decrease the crop yield (Afroza *et al.*, 2010).

### Diseases of vegetables

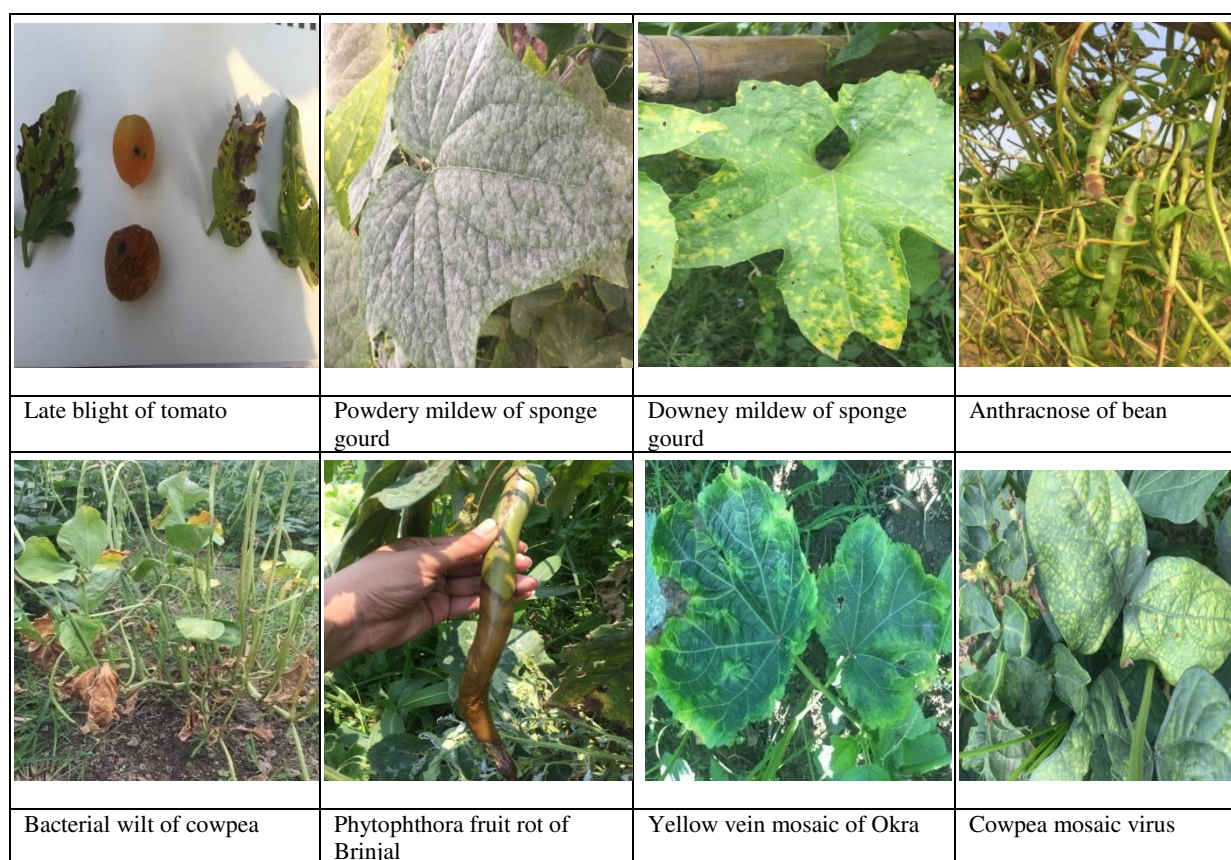
The major vegetables cultivated during survey period in the surveyed area were bean, bitter-gourd, brinjal, chilli, cowpea, cucumber, okra, pumpkin, sponge-gourd, tomato, snake-gourd and bottle-gourd. The major diseases of vegetables cultivated in farmer's field of 5 wards of Aanbukhaireni rural municipality were early blight, late blight, cercospora leaf spot, powdery mildew, downey mildew, fruit rot, bacterial wilt, bacterial spot, leaf curl and mosaic (Table 1, Plate 1).

**Table 1:** Major diseases on vegetables cultivated in farmers field of 5 wards of Aanbukhaireni rural municipality of Tanahun district, Nepal during spring season of 2019

Ward no 1 (n=15)	Ward no 2 (n=18)	Ward no 3 (n=21)	Ward no 4 (n=14)	Ward no 5 (n=19)
Bacterial brown spot of Bean <sup>B</sup>	Bacterial brown spot of Bean <sup>B</sup>	Mosaic of Brinjal <sup>V</sup>	Cercospora leaf spot of Chili <sup>F</sup>	Cercospora leaf spot and Phomopsis blight of Brinjal <sup>F</sup>
Anthraco-nose of Bean <sup>F</sup>	Leaf curl of Bean <sup>V</sup>	Bacterial leaf spot of Chili <sup>B</sup>	Leaf curl and Mosaic of Chili <sup>V</sup>	Mosaic of Brinjal <sup>V</sup>
Phomopsis blight of Brinjal <sup>F</sup>	Cercospora leaf spot of Chili <sup>F</sup>	Cercospora leaf spot of Chili <sup>F</sup>	Taro leaf blight of Colocasia leaf <sup>B</sup>	Cercospora leaf spot of Chili <sup>F</sup>
Cercospora leaf spot and Fruit rot of Chilli <sup>F</sup>	Bacterial wilt of Cowpea <sup>B</sup>	Mosaic of Chili <sup>V</sup>	Bacterial leaf blight of Cowpea <sup>B</sup>	Leaf curl and Mosaic of Chili <sup>V</sup>
Mosaic of Chili <sup>V</sup>	Anthraco-nose of Cowpea <sup>F</sup>	Taro leaf blight of Colocasia leaf <sup>B</sup>	Mosaic of Cowpea <sup>V</sup>	Bacterial blight and Bacterial wilt of Cowpea <sup>B</sup>
Bacterial wilt of Cowpea <sup>B</sup>	Late blight of Tomato <sup>F</sup>	Halo blight of Cowpea <sup>B</sup>	Anthraco-nose of Okra <sup>F</sup>	Rust of Cowpea <sup>F</sup>
Anthraco-nose of Cowpea <sup>F</sup>	Bacterial wilt of Cucurbits <sup>B</sup>	Anthraco-nose of Cowpea <sup>F</sup>	Bacterial wilt of Cucurbits <sup>B</sup>	Early blight of Okra <sup>F</sup>
Mosaic of Cowpea <sup>V</sup>	Alternaria leaf spot, Downy mildew and Gummy stem blight of Cucurbits <sup>F</sup>	Mosaic of Cowpea <sup>V</sup>	Gummy stem blight of Cucurbits <sup>F</sup>	Mosaic of Okra <sup>V</sup>
Choanephora fruit rot and Early blight of Okra <sup>F</sup>	Mosaic of Cucurbits <sup>V</sup>	Cercospora leaf spot of Okra <sup>F</sup>	Mosaic of Cucurbits <sup>V</sup>	Early blight of Tomato <sup>F</sup>
Bacterial spot of Tomato <sup>B</sup>		Mosaic of Okra <sup>V</sup>		Bacterial wilt of Cucurbits <sup>B</sup>
Late blight of Tomato <sup>F</sup>		Bacterial wilt of Cucurbits <sup>B</sup>		Downy mildew and Gummy stem

Powdery mildew, Downy mildew and Gummy stem blight of Cucurbits <sup>F</sup>	Alternaria leaf spot, Gummy stem blight and Downy mildew of Cucurbits <sup>F</sup>	blight of Cucurbits <sup>F</sup>  Mosaic of Cucurbits <sup>V</sup>
Mosaic of Cucurbits <sup>V</sup>	Mosaic of Cucurbits <sup>V</sup>	

Note: <sup>B</sup> - Bacterial disease, <sup>F</sup> - Fungal disease, <sup>V</sup> - Viral disease, n-sample size, ward no1: Satrasayaphant, Baradiphant and Dumridanda, ward no2: Yeklephant, Markichowk and Pateni, Ward no3: Gaadapani, Ward no 4: Saakhar Ward no 5: Ghummaune



**Plate 1:** Photographs illustrated symptoms of major diseases on vegetables noticed in farmers field of 5 wards of Aanbukhaireni rural municipality of Tanahu district, Nepal during spring season of 2019.

**Table 2:** Disease incidence and severity of vegetable diseases in farmers field of 5 wards of Aanbukhaireni rural municipality of Tanahu district, Nepal during spring season of 2019

Surveyed ward	Disease incidence (DI%)			Percent Disease Index (PDI%)		
	Mean	SD	SE±	Mean	SD	SE±
Ward no 1 (n=15)	51.23	13.57	3.50	40.00	6.41	1.66
Ward no 2 (n=18)	70.00	25.13	5.92	48.00	12.04	2.84
Ward no 3 (n=21)	52.82	16.47	3.59	42.48	7.85	1.71
Ward no 4 (n=14)	45.20	17.09	4.57	37.71	6.60	1.44
Ward no 5 (n=19)	49.55	15.22	3.49	38.32	6.84	1.57

Note: SD- Standard deviation, SE± - Standard error, n-sample size, ward no1: Satrasayaphant, Baradiphant and Dumridanda, ward no2: Yeklephant, Markichowk and Pateni, Ward no3: Gaadapani, Ward no 4: Saakhar Ward no 5: Ghummaune

The higher disease incidence (70%) and severity (48%) in vegetables were recorded in ward no 2 followed by ward no 3 with incidence of 53% and severity 42.48%. The lower incidence (45.2%) and severity (37.71%) were found in ward no 4 (Table 2).

The findings regarding to the vegetable diseases of this survey are in line with many earlier research reports. Bose and Som (1986) reported that early blight of tomato caused by *Alternaria solani* was first recorded in 1882 in New Jersey, USA. Bacterial spot of tomato and pepper plants caused by *Xanthomonas axonopodis* pv. *vesicatoria* has been observed causing significant losses, estimated of about 10–20% per year and is observed in the area where *Capsicum annuum* and *Solanum lycopersicum* L. are cultivated. The pathogen causing bacterial spot have been a subject to many studies and reclassifications since the last 20 years (Stoyanova *et al.*, 2014). Powdery mildew caused by *Erysiphe cichoracearum* is the world's most frequently encountered plant pathogenic fungi, infecting leaves, stems, flowers and fruits of nearly 10,000 species of angiosperms (Glawe, 2008) including many vegetable crops (Dixon, 1978). Downy mildew, caused by *Pseudoperonospora cubensis* in cucurbits was first recorded from Cuba in 1868 (Berkeley & Curtis, 1868). It was then reported from Japan after 20 years (Kurosawa, 1927). It has since spread to almost all countries in which cucurbits are grown commercially. Numerous soil-borne fungi belonging to *Pythium* and *Phytophthora*, and some seed-borne fungi, have been reported to cause damping-off on a large number of crops. These pathogens can be spread via non-anthropogenic and anthropogenic activities, including water run-off through irrigation or rain (Zappia *et al.*, 2014), soil contamination by improperly sanitized tools, introduction of infected plants, improperly sanitized greenhouse, and the use of contaminated irrigation water (Papavizas & Davey, 1961; Duniway, 1983; Schmitthenner & Canaday, 1983; Huang & Kuhlman 1990; Starkey & Enebak 2012). The symptoms of cowpea aphid borne mosaic polyvirus (CABMV) was recorded during 1989–1990 at Rampur which was transmitted by both aphids and sap inoculations (Dahal & Albrechtsen, 1996). Cucumber mosaic virus (CMV), Chili vein mottle polyvirus (CVMV) and Tomato yellow leaf curl gemini virus (TYLCV) were the most common viruses in chili identified in Nepal (Joshi & Shrestha, 2001).

### Diseases of fruits

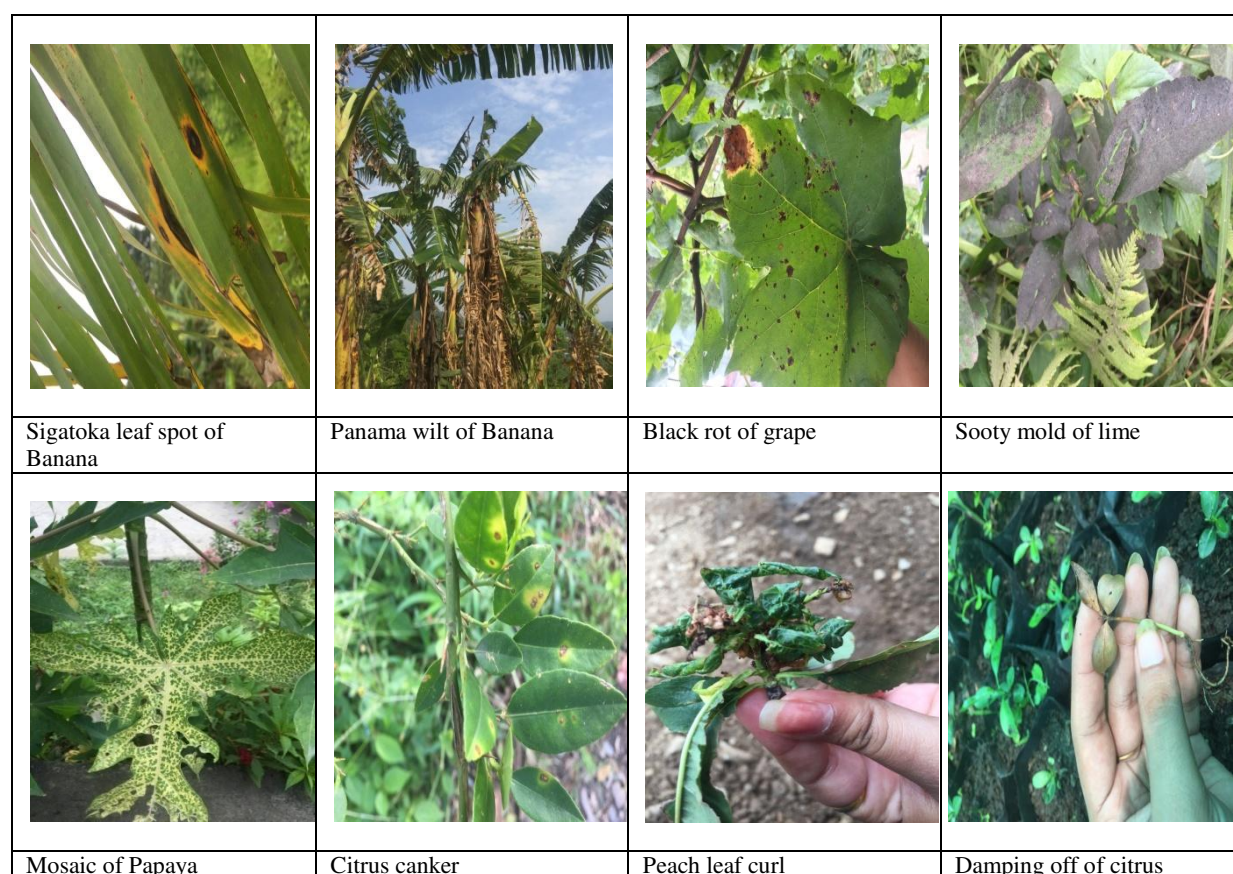
The major fruits found in the surveyed area were banana, papaya, grapes, mango, litchi, peach, guava, lemon, mandarin orange etc.

**Table 3:** Major fruit diseases of 2 wards of Aanbukhaireni rural municipality of Tanahu district, Nepal during spring season of 2019

Ward no 1 (n=7)	Ward no 2 (n=11)
Sigatoka of Banana <sup>F</sup>	Sigatoka and Panama wilt of Banana <sup>F</sup>
Black rot of Grapes <sup>F</sup>	Black rot of Grapes <sup>F</sup>
Algal leaf spot of Guava <sup>A</sup>	Bacterial canker, Citrus canker and Foot rot of Citrus <sup>B</sup>
Citrus canker of Citrus <sup>B</sup>	Root rot and Sooty mold of Citrus <sup>F</sup>
Sooty mold of Citrus <sup>F</sup>	Red rust and Algal leaf spot of Litchi <sup>A</sup>
Twig blight of Litchi <sup>B</sup>	Sooty mold of Litchi <sup>F</sup>
Rust of Mango <sup>A</sup>	Leaf curl of Peach <sup>F</sup>
Mosaic of Papaya <sup>V</sup>	Anthraco nose of Mango <sup>F</sup>
Alternaria leaf spot and Downy mildew of Watermelon <sup>F</sup>	

Note: <sup>A</sup> - Algal disease <sup>B</sup> - Bacterial disease, <sup>F</sup> - Fungal disease, <sup>V</sup> - Viral disease, n-sample size, ward no1: Satrasayaphant, Baradiphant and Dumridanda, ward no 2: Yeklephant, Markichowk and Pateni





**Plate 2:** Photographs illustrated symptoms of major fruit disease noticed in farmers field of 2 wards of Aanbukhareni rural municipality of Tanahu district, Nepal during spring season of 2019.

**Table 4:** Disease incidence and severity of fruit diseases in farmers field of 2 wards of Aanbukhareni rural municipality of Tanahu district, Nepal during spring season of 2019

Surveyed ward	Disease incidence (DI%)			Percent Disease Index (PDI%)		
	Mean	SD	SE±	Mean	SD	SE±
Ward no 1 (n=7)	70.24	17.25	6.52	51.27	7.90	2.99
Ward no 2 (n=11)	66.79	27.99	8.44	45.14	21.60	6.51

Note: SD- Standard deviation, SE± - Standard error, n-sample size, ward no1: Satrasayaphant, Baradiphant and Dumridanda, ward no2: Yeklephant, Markichowk and Pateni,




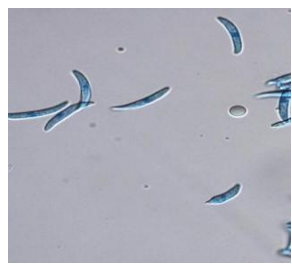


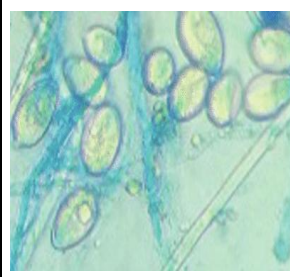
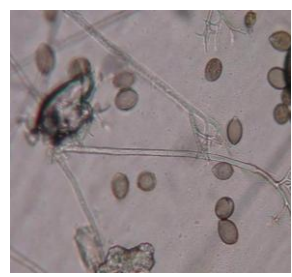
Diseases like sigatoka leaf spot, panama wilt, black rot, algal leaf spot, canker, root rot, foot rot, sooty mold, red rust, anthracnose, rust, mosaic, alternaria leaf spot, downey mildew and leaf curl were the major diseases noticed during survey period (Table 3, Plate 2).

The higher fruit disease incidence (70.24%) and severity (51.27%) in ward no 1 followed by ward no 2 with disease incidence and severity of 66.79% and 45.14% respectively were recorded (Table 4). The finding of the survey is well supported by Coates & Johnson (1997) who reported that the quality and quantity of the fruits produced is mainly affected by the many diseases. It becomes noticeable during pre- harvest stage and if no any precautions are taken during the picking, storing, packaging and transporting processes, the situation

becomes much worst. According to the infection started, they are named as 'quiescent' or 'latent' infections, where the pathogen infects the host commonly at pre-harvest. During ripening process, intense physiological changes of the fruit may activate the quiescent infections (Coates & Johnson, 1997). Most of the fungi causing fruit diseases belong to the phylum Ascomycota in which the asexual stage of fungus (anamorph) is commonly found to be the causal agent of fruit rot. A number of diseases such as brown rot in citrus caused by *Phytophthora citrophthora* and *P. parasitica* are due to the main fruit rot pathogens in Oomycota of genera *Phytophthora*. *Rhizopus* and *Mucor* in Zygomycota are the important genera of fruit rot pathogens and the common pathogen that caused wound in wide range of fruit and vegetables was found to be *Rhizopus stolonifer* (Snowden, 1990; Coates *et al.*, 1995; Johnson & Coates, 2009). The production of banana is the important earning source for most exporting countries including China, Philippines, Brazil, Ecuador, Indonesia, Costa Rica, Mexico, Thailand, Colombia (Nath *et al.*, 2015), Sri Lanka (Anthony *et al.*, 2004; Indrakeerthi & Adikaram, 2011), Windward Islands, Eastern Caribbean (Krauss & Johanson, 2000), Egypt (Abd- Alla *et al.*, 2014), Australia (Nelson, 2008), Africa and Latin America (Lassoiset *et al.*, 2010). Fungal species isolated from finger rot disease of banana are *Lasiodiplodia theobromae*, *Musicillium theobromae*, *Alternaria triticina*, *Cladosporium oxysporum*, *Acremoniums spp.*, *Culvularia sp.*, *Bipolaris sp.* and *Eupenicillium sp.* mostly affect the fingers of banana fruits due to the their first infection on the crown part of banana fruit, *Aspergillus sp.* and *Penicillium sp.* may cause secondary infection to the banana fruits (Sepiah *et al.*, 1990; Anthony *et al.*, 2004; Faber *et al.*, 2007; Nelson, 2008; Ewane *et al.*, 2012; Abd- Alla *et al.*, 2014; Twumasiet *et al.*, 2014). The research report is also in line with the many earlier research findings of fruit diseases. Powdery mildew of mango caused by *Oidium mangiferae* Barthet is reported in the countries like Burma, Bangladesh, Nepal, Pakistan, Sri Lanka, Israel, Lebanon (Asia); New South Wales, Queensland and New Calodonia (Australia); Congo, Egypt, Ethiopia, Kenya, Malawi, Mozambique, Mauritius, Reunion, Tanzania, Zambia, Zimbabwe, Zaire, South Africa, (Africa); California, Florida (USA); Mexico, Jamaica, Costa Rica, Guatemala (Central America): Brazil, Venezuela, Colombia, Peru (SoUUI America) (Prakash, 1988). Anthracnose caused by *Colletotrichum gloeosporioides* is reported from India, USA, Cuba, Philippines, British Guiana, Dominican Republic, Mauritius, Fiji, Sierra Leone, Brazil, Columbia, Guatemala, Mozambique, Dutch East Indies, Portugal, Pakistan, Trinidad, Peru, French Guiana, Taiwan, Uganda, Jamaica, Sri Lanka, Congo, Morocco, South Africa (Prakash & Srivastava, 1987). Mango malformation was first introduced by Maries from Darbhanga, Bihar in 1891. The disease is mainly restricted to northern India, where over 50% of the trees are affected. Other countries like Egypt, South Africa, Israel, Central America, Mexico, Florida (U.S.A.), Sudan, Cuba, Brazil, Australia, Bangladesh, Pakistan and United Arab Emirates has also been infected by mango malformation (Kumar & Beniwal, 1992; Kumaret *et al.*, 1993). Die back of mango is caused by *Botryodiplodia theobromae* Pat. (Prakash & Raof, 1989; Rathet *et al.*, 1978). Twig blight of mango was found associated with *Botryosphaeria ribis* in U.S.A. (California) (Prakash & Eckert, 1992). Sooty mould in mango is caused by several fungi such as *Meliola mangiferae* Earle, *Capnodium mangiferae* and, *Capnodium ramosum* (Ke.) and *Tripospermum acerinum* (Syd.) Speg. (Das & Mohanty, 1972). Authors found that the disease is also caused by *Microxyphium columnatum*, *Leptoxyphium fumago* and *Tripospermum myrti* (Prakash, 1988).

### Fungal pathogens isolated from the disease sample

The microscopic images of the fungal pathogens isolated from the diseased samples collected from different wards of the surveyed areas were shown in the plate3.

			
<i>Alternaria alternata</i>	<i>Alternaria solani</i>	<i>Cercospora capsici</i>	<i>Colletotrichum capsici</i>
			
<i>Colletotrichum lindemuthianum</i>	<i>Erysiphe cichoracearum</i>	<i>Phytophthora infestans</i>	<i>Pseudoperenospora cubensis</i>

**Plate 3:** Photographs illustrated microscopic images of the fungal pathogens isolated from the diseased samples collected from different wards of the surveyed areas during spring season of 2019.

### Socioeconomic factors

**Education:** The education level of the farmers from surveyed area was mostly basic and secondary level only. Among the farmers were surveyed, some of them follow informal education and also significant number of farmers were illiterate. The farmers' educational level has a major affect in improving their total production and per capita income, by having majority control over diseases and insect pests.

**Occupation:** Agriculture is the main occupation in the surveyed wards. However, because of the migration of youth peoples towards abroad and gulf countries for job and other purposes, only elder peoples, women and children were found in the villages and involved in the farming. Among others, one of the reasons behind the rural migration is the distraction of youths from agriculture as the image of the farmer is less than attractive.

**Age:** Data showed that the average age of farmers in surveyed area already exceeds 50 and there is an exodus of rural youths to the cities, creating a shortage of manpower to even carry the sick to hospital or dead bodies to the ghats. There are only women, children and elderly people in many villages whereas the youth are either in the towns or in foreign countries in

search of employment and opportunities for study. Among others, one of the reasons behind the rural exodus is the distraction of youths from agriculture as the image of the farmer is less than attractive.

**Land holding:** Most of the farmers have small land holdings (5-10 ropani) in the surveyed area. Large proportion of farm households occupy small proportion of total farm land, small proportion of farms occupies a large proportion of land. Low productivity is also the reason for poverty. Rapid agricultural growth is essential for rapid reduction in incidence of poverty.

**Agricultural inputs:** The use of agricultural inputs like fertilizers and chemicals play an important role to maximize the yield of crops as well as the attraction of farmers towards farming. Most of the farmers interviewed described that fertilizers and chemicals are not easily available in the market and if available, they are very expensive that cannot be afforded by them. Increasing investment in the small farmer for integrated rural development, orientation, training and education for the youth in agriculture, ensuring access and control of the youth on land, market, credit, seeds, pesticides, fertilizers and other resources are necessary to change the image of farming from one that is dirty and difficult to one that is decent and highly income-generating. Furthermore, professionalism, mechanization and commercialization of production can change the image of farming. Subsidies, insurance, grants and creation of a conducive environment are equally important to attract the new and young generation to this important sector.

## CONCLUSION

During the survey, among all the diseases occurred on vegetables and fruits, some were due to fungal, some were caused by bacteria and viral infections and a few were affected by physiological disorders and algal infections too. These diseases were identified based on their symptoms occurred throughout the plant and the pathogen identifications were carried out in the Pathology laboratory of National Maize Research Program, Rampur, Chitwan. The major diseases of vegetables noticed were early blight, late blight, cercospora leaf spot, powdery mildew, downey mildew, fruit rot, bacterial wilt, bacterial spot, leaf curl and mosaic. In case of fruits, sigatoka leaf spot, panama wilt, black rot, algal leaf spot, canker, root rot, foot rot, sooty mold, red rust, anthracnose, rust, mosaic, alternaria leaf spot, downey mildew and leaf curl were the major diseases. This study explored the major diseases of vegetables and fruits of terai and inner terai region of Nepal and applying control measure, looking for the best possible solutions.

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### Author Contributions

S.S. designed the survey, analysed data and wrote the paper; S.K. helped during conducting the survey and recording observations. S.N. helped during manuscript preparation.

### Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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