1. INTRODUCTION

1.1 Background

Tea, *Camellia sinensis* is one of the most important and widely consumed beverages in the world. The fact behind the origin of popular wonder drink is steeped in legends but there are still considerable speculations about the place of its origin. It is generally believed that the people of China were the first to recognized tea as a beverage. Lu Yu, a renowned author , during the time of Tang Dynasty, published first tea classic named Ch'a ching , which is the first ever book written in tea, contains the details of cultivation and preparation of tea in China on 780(Hill, 1998). Also the legends had it that a Chinese emperor, Shen Nung accidentally discovered tea in 2737 B.C. when a leaf of tea dropped into his bowl containing hot water while he was in the garden near the tea plant. He sniffed the fragrant brew and tasted it and liked the taste and flavour of what he drank and from then onwards tea begins to occupy the place of right as a popular wonder drink in China (Jhowar, 2002).

For centuries, China remains the only superior tea leaves in the world. And the type of green, black, and oolong tea is made their first appearance of Ming Dynasty during 1368-1664, than Japan entered in scene in the 9^{th} century (Jhowar, 2002). In the early 8^{th} century green tea was transferred to Japan as for the medicinal purpose (Chu Juneja, 1997). The tea drinking habit generally spread along the trade route of Asia minor and was introduced to Europe by Dutch traders during 17^{th} century. In England, tea over took popularity during 18^{th} century and has been established "national drink" (Vernam and Sutherland). Britishers initiated commercial planting of

tea between 1818 and 1834 and this country is now world's largest producer of tea (Hill, 1998). Tea now grows at latitudes from 27 degree S (Argentina) to 43 degree N (Georgia. USSR) and from sea level up to an altitude of 2,500m. The soil on which the tea grows also varies widely. For example, alluvial in Assam and Malawi (India), podzols in USSR, volcanic ash in Japan, andosols in Indonesia, red yellow podzols in Taiwan, red soils in China, leterite in South India, Sri Lanka, East Africa, peaty in Cachar and sedimentary in Darjeeling (Banerjee, 1996).

Although, tea is a plant of widely adaptability of diseases caused by the attack of different types of pests and they specialized attacking different parts of plants such as leaves, stem, buds, and roots. Moreover, being planted as monoculture and perennial in habit, tea plant provides a stable microclimate for the existence of disease causing agents and pests. Varieties of tea pest inhabit the tea plants in different parts in different seasons with different damage pattern and intensity depending on climate, altitudes and cultural practices. Besides this, shed trees planted in tea garden also shelter number of pests. In the first ever comprehensive report on tea disease only about 12 fungal diseases were mentioned (Watt and Mann, 1903) and this rose to 17 in 1918. Today it is fairly known that about 385 species of pests occur on tea all over the world, of which just about half occur in North-East India (Banerjee, 1996). The causal factors of tea diseases prevailing in tea plants are below:

(i)Inanimate agents like fog, humidity, light, moisture, temperature etc.

(ii)Animate pathogens like bacteria, viruses, fungi, algae, nematodes

(iii)Arthropods like insects and mites.

Some of the common arthropods pests of tea are:

Mites, scale insects, thrips, caterpillars, grubs, aphids, beetles, termites, mealy bugs, tea mosquito bug, green leafhoppers, etc.

1.2 Background of Pesticides Use

Pesticides are unique toxic chemical substances which are potentially "biocides" and that are deliberately added to the environment to eliminate or suppress different types of pest in the agricultural field. Most of the pesticides released into the environment every year by human activity, persistent pesticides are among the most dangerous.

Pesticides have profoundly improved the human livelihood. Their dramatic effort in preventing crop loss and controlling vectors of diseases have led to their acceptance and expanded use throughout the world (Sharp, 2005). However, being toxic in nature, they are the agents of human diseases and environmental pollution. It has been observed that during cultivation of tea, many pests may attack it. Tea growers apply several agro-chemicals including pesticides. Pesticides do not differentiate between target and non target species and hence threatens the health and well beings of humans and wildlife's in every regions of the world (Wasseman and Wassemann, 1972).

These highly stable compounds can lasts for decades before breaking down. Their highly toxicity cause an array of adverse effects, notably death, diseases, and birth defects among human and animals. Specific effects can include cancer, allergies and hypersensitivity damage to the central and peripheral nervous system, reproductive disorders and disruption of the immune system (Strecct, 1981. Maroni, 1990). Being highly toxic, pesticides are essentially is subjected to safe and judicious use. In Nepal, due to injudicious and indiscriminate use of pesticides, many accidents have occurred in every parts of the country. Presence of pesticides in food, fruits, vegetables, and environment and even in the mother's milk is a matter of grave concern. They circulate globally and persistent pesticides released in one part of the world can be transmitted through a repeated process of evaporation and deposit through atmosphere to regions far away from the original source (Williams, 2000).

Use of pesticides in agriculture has created fourfold problem through tropic levels: health problems, environmental problems, yield loss due to non target pesticide application resulting in pesticide induced pests' resurgence and finally financial burden to the farmers (Ghimire N.P., 2007).

1.3 History of Pesticides Use in Nepal

Until the 1950s, the people of Nepal remain unaware of modern chemical pesticides and were dependent upon traditional organic techniques for killing pests. Chemical pesticides were first introduced to Nepal in 1952 when Paris Green, gamaxane, and nicotine sulphates were imported from USA for malaria control. DDT made its first impact in 1956. This was soon followed by a varieties of other organochlorines (in 1950s), organophosphates (in 1960s), Carbamates (in 1970s), and Synthetic pyrethroids (in 1980s) (Koirala P., 2008)

Use of pesticides in Nepal was introduced about 1952 and its' use has been increasing over the years. It has been estimated that the use of pesticides in the developing countries approximately doubled even ten years between 1945 and 1995. The establishment of Development of Agriculture, initiated the application of chemical pesticides for crop protection during the mid of the 1960s. Since then, the use of pesticides for plant protection has steadily increased. Increasing demands for chemical pesticides resulted in private dealerships selling and distributing pesticides throughout the country (Karlman, 1987).

In 1977, the Nepal Pesticides and Chemical Industries Pvt. Ltd. (NEPCIL) were established in Bahadurgunj to supply BHC dust, Malathion, Nepcil parathion among others locally. The Indian representative such as Crop Health Production Ltd., Excel Industries Ltd., Cyanamid India Ltd., and Bharat Pulverizing Mills Ltd. were the main suppliers of pesticides in Nepal. Organizations like the Cotton Development Board (CDB) and Nepal Malaria

Eradication Programs were also authorized to purchase pesticides from foreign distributors. Presently, Indian Pesticides Dealers cross the open border freely, selling pesticides in the Terai region and in major towns of Nepal (Palikhe, 2001).

There are around 50 common pesticides under 150 trade names available in the markets. Several available pesticides are possibly carcinogenic to humans. Benzene Hexachloride (BHC) dust is the most frequently sold chemical pesticide followed by parathion methyl, Zinc phosphide, Aluminum phosphide, Malathion, Dithane, and Phorate. Worldwide estimates suggest that there are about three million (1,000,000 intentional and 2,000,000 unintentional) acute pesticides poisonings and approximately 220,000 deaths each year. Most of the poisonings and 99% of deaths occur in the developing countries.

At present, large persistent chemical pesticides such as, Chlordane, DDT, dieldrin, aldrin, heptachlor, mirex, toxaphene, BHC, Lindane, Phosphamidon and Organo-mercury fungicides are banned in Nepal for agriculture and public health from 9th April, 2001. Prohibitions on the use of highly toxic pesticides in tea are quinalphos, ethion, monocrotophos, and phorate (Palikhe, 2005).

1.4 History of Tea Cultivation in Nepal

Nepal is an agricultural country. Hence, Nepalese economy is based on agriculture in the context of tea cultivation. In Nepal, tea cultivation was started in the year 1863 A.D. (1920 B.S.),the then ward officer chief Shri Gajaraj Singh Thapa initiated tea plantation in Ilam district, East zone of Nepal (NTCDB, 2002). Hence, Ilam tea estate is the oldest and historical tea estate of Nepal. After that tea plantation was started at Soktim in 1865. Both tea estates were nationalized after the time of Gajaraj Singh Thapa. Almost a century passed without addition of a single tea state. Then, in the year 2023B.S.(1967) Nepal Tea Development Corporation (NTDC)established, then in the year 2028 B.S (1972) Kanyam Tea State and similarly in the year 2029 B.S. (1973) Tokla and Baradashi Tea State as well as in 2035 B.S. (1979) Burne Tea State was established under NTDC (HOTPA, 2000). At present, tea cultivation has been extended besides Ilam to Jhapa, Panchthar, Dhankuta, Tehrathum and other district of Nepal as tea area (Tea and Coffee news, 2000). With this event, new horizons for tea development and extension were open in Nepal. In course of developing tea industry, various associations started coming up actively. After the privatization of NTDC, which was solely under His Majesty's Government prior to privatization, need for an autonomous body to regulate and promote the tea industry was felt and so the way for the establishment of Tea and Coffee Board was paved. Consequently, National Tea and Coffee Development Board (NTCDB) were established in 2023 B.S. (1967).

Tea plantation is an important source of income for the country and the status of Nepalese economy is almost similar to that of other cash crops like

sugarcane, ginger, cardamom, tobacco, oil seeds etc. Besides this, tea is also the favorite beverage of every Nepali individual. The Nepali tea is also exported to international market, thereby earning foreign currency. The value of tea in market is therefore relatively high but the production of it is limited. The low degree production may be attributed, in addition to other factors, to the loss caused by various pests, diseases and poor pest management practices.

1.5 Current Status of Tea in Nepal

The tea industries of Nepal comprises either of Government owned estates (public sector), private tea estates, small holders, marketers etc. The total area under tea plantation estimated in Nepal in 2006/07 has more than 16,420 hectares of land consisting of more than 85 tea estates and 38 tea processing factories with little more than 15.1 million kg of black tea and orthodox tea production (AEC/FNCCI, 2007). The production statistics shows that Ilam and Jhapa are the two major tea cultivation areas in Nepal. These two districts produce more than 95% of the total tea production of the country. In Ilam, the tea product is orthodox tea whereas Jhapa produce CTC tea. The orthodox tea is made from processing the leaves of hill grown tea and hence it is also known as hill tea. Nepalese orthodox tea is produce at an altitude of 3,000 ft. to 7,000 ft. They are famous for its aroma; slight fruity flavour and colour of extract which are mostly bought attributes by overseas consumers. The total land under orthodox tea production is around 6,949 hectares, which consists more than 35 tea estates, around 5,584 small farmers and 15 tea processing factories. The major orthodox tea production

districts are Ilam, Tehrathum, Dhankuta, Panchthar and it is expanding to other hilly districts also, particularly in Sindhupalchowk and Nuwakot.

Currently, Nepal is producing more than 1.66 million kg of orthodox tea of which, more than 90% is exported. It is reported that more than 2.5 million kg of CTC tea have been exported to India and Pakistan in 2004-05. The Nepalese orthodox tea is mostly exported to Germany, Japan and US. Apart from this, the tea industries also provide direct employment to about 29,993 peoples (NTCDB, 2002). Moreover, Government of Nepal has passed the National Tea Policy in 2000, which aims at:

a. Coverage of plantation area by 40,875 hectare within five years.

b. Production of 4,6,11,000 kg (46.11 million kg) tea in 10 years of plantation.

Therefore, it is necessary to impart proper knowledge about tea pests, diseases and their control measures to reach the set goal. Nepal orthodox tea has increasing demands in international markets but in current year's tea exported from Nepal has been reduced due to pesticide residues and other inorganic residue that comes from agricultural practices such as use of pesticides and chemical fertilizers.

1.6 Tea in Nepalese Economy

Tea is undoubtedly, the most important and widely consumed beverages in all over the world. In the Nepalese context, each and every individual starts their day with a cup of tea. It is not only a regular drink, traditional and habitual but besides all these it has a great medicinal value also. Nepal's specific geographic, agro-climatic and environmental friendly agriculture system has favored to capture international market. All together 7154 small farmers are engaged in tea cultivation. There is growing international and domestic markets of tea that is why the average growth rate of tea in the country is 17% per annum. Tea industry purchase green tea leaves as a raw materials from the tea growers and process it. The technology of cultivation of tea in the country is transferred from Darjeeling and Assam, India. Mostly tea technician working in this industry has been trained in India. Due to the suggestion of Indian technicians and pesticides dealers with open Indian boarder there is uncontrolled use of pesticides in tea during its cultivation.

Tea could be one of the valuable cash crops in Nepalese economy, on the export of Nepalese tea.. The international market for Nepalese CTC tea is limited to India and Pakistan only while the international demand to Nepalese orthodox tea has been expanded to Japan, Germany, U.S., and even to European nation due to its health benefits and good quality. On other hand continuous effort of private sector engaged to promote Nepalese tea in international market particularly Europe, Japan, and boosting up the cultivators and processor to acquire organic certification introduced tea policy in 2000 to encourage the tea industry in Nepal. But today Nepalese

tea encountered with the problem of pesticide residue time after time and several consignments have been also rejected by the importing countries.

The Plantation Area and Tea Estate Production that covering private sector and small Tea Holder's are shown in the table below;

Table 1: Plantation, and Production of Nepalese tea

B.S	A.D	Plantation (Hectares)	Production (Kilograms)
2051/52	1994/95	N/A	196403.00
2052/53	1995/96	N/A	2737329.00
2053/54	1996/97	3501.80	2905942.00
2054/55	1997/98	4515.00	3018571.00
2055/56	1998/99	10249.60	4492998.00
2056/57	1999/00	10249.60	5085237.00
2057/58	2000/01	11997.00	6638082.00
2058/59	2001/02	12346.00	7518575.00
2059/60	2002/03	12643.00	8198000.00
2060/61	2003/04	15012.00	11651204.00
2061/62	2004/05	15900.00	12606081.00
2062/63	2005/06	16000.00	13688237.00
2063/64	2006/07	16420.00	15167743.00
2064/65	2007/08	16594.00	16127490.00
2065/66	2008/09	16718.00	16208127.00

Source*: Statistical Information of Nepalese Agriculture, 2009*

1.7 Common Tea Pests and Diseases

Tea, as a monoculture and being perennial provides a stable microclimate and a good habitat and food supply for the existence of tea pests. Varieties of tea pests inhabit the tea plant in different parts in different seasons with different damage pattern and intensity, depending on climate, altitude and cultural practices. It has been estimated that about 150 insect pests and not less than 380 fungi attack the tea plant (Harler, 1966). The loss due to red spider mite, *Oligonychus coffeae* (Nietner) varies between 6% to 11% in Dooars, and 5% to 7% in Assam, India. A steady loss of 10% due to overall pest attack is a generally accepted figure though it could as high as 40% in devastating attacks by the defoliators (Banerjee, 1996). The tea leaves infested from pest and diseases deteriorate very rapidly after plucking. The result showed that different types of pesticides are used in tea cultivation to control the varieties of insects and pests.

1.8 Pest Control

The term “Pest control” can be defined as the application of technology, in the context of biological knowledge, to achieve a satisfactory reduction or maintenance of pest population below the damage threshold. It should be appreciated that the decisions whether or not to apply control measures are usually required before pest populations reach the damage threshold. The concept of pest management depends on the population dynamics of the pest and the level of the damage caused by them.

Pest control procedures may be categorized under different headings such as cultural, biological, chemical etc. However, there is now a strong tendency to use two or more approaches together in a system of integrated control and is called as “Integrated Pest Management” or IPM. Integrated Pest Management is therefore, can be defined as blending of two or more control measures in order to control pests below economic injury level.

1.9 Pest Management/ Use of Pesticides in Tea

As monoculture crop and being perennial, seasonal variability of pests in tea is maximum. So it provides stable microclimatic conditions for the existence of disease causing agents and pests. It also provides continuous supply of food and shelter for a large number of various kinds of insects, nematodes, and rodents. Therefore, it is essential to monitor the pests for scheduling effective control measures. Most of the tea pests are polyphagous and complete their life cycle in the tea fields. Therefore, use of chemical pesticides is dominant in the control of pests in tea though cultural practices are also followed. Moreover, spray techniques also varies with the individual pest.

In the context of Nepal, chemical pesticides are dominant in control measures. Due to open Indian border, most of the pesticides are brought from India. The use of organophosphate includes quinalphos, Malathion, monochrotophus, propanofus, acefate, dichlorovous, chloropyriphos were found in the tea field to control large varieties of pests like caterpillar (*Latoia spp., Andraca bipunctata, Gracilaria theivora*), Leaf roller (*Gracilaria theivora, Stringlina glaroela, Hamona coffearia*), Aphids

(*Toxoptera aurantii,* Jassids (*Empoasca flavescens*), Tea mosquito (*Heolipeltis theivora*) and other pests. Similarly, to control and prevent different types of mites' problem during tea cultivation acaricides such as dicofol, prapargite, sulphur and fenopthrin were used. Among these pesticides dichlorovous, monochrotophus, ethion, quinalphos and phorate are included in highly hazardous group (Ib) of pesticides by WHO (Palikhe, 2005).

Pest management in tea in Nepal is still in its infancy due to the lack of expert manpower, proper management, plantation procedure and supervision. The tea planters and the farmers lack the technical knowledge about the pesticides and their dose and use whatever is available and follow the instructions given by anybody. Biological control using predators and parasitoids and microbial control are still restricted in theory or in laboratory. It is appreciated that, however the use of botanicals is catching practices recently.

2. OBJECTIVES

This study aims to explore the arthropod pests infesting the tea plant and pesticides used and its handling practices in tea in two major tea producing districts; i.e., Jhapa and Ilam; which is being taken as a study sites. The study showed that contamination of pesticides in tea has a major unrecognized risk to public health. Pesticides residues thus occurred can have long term health implications. In Nepal, tea is one of the most potential exportable agri-products. This study highlights about the major tea insects pests and presents the existing practices of pesticides application in tea in Nepal. If need be, this study will try to look for suggesting and encouraging Integrated Pest Management practice, which may aid to control the pest populations below economic injury level and thereby, to some extent, check the loss of this valuable cash crop of the nation. At the same avoid the hazards of pesticides residue and adverse effects to any of the non-target species and the environment as a whole.

The specific objectives of the study are to:

- Assess the type of pest in tea in Jhapa and Ilam districts of Nepal.
- Assess the types of pesticides used in tea in Jhapa and Ilam districts of Nepal.
- Know peoples' behavior (knowledge and attitude) and practice on pesticides used.

3. LITERATURE REVIEW

A review of literature on various studies related to the present study was prior to the study till completion of this work. A brief account of the literature reviewed is presented in this chapter. This attempt has been made to achieve clarity in the discussion that follows.

3.1 Discovery of Tea and Its Dispersion

The origin of popular wonder drink was steeped in legends. It is believed that a Chinese emperor, Shen Nung discovered tea, *Camellia sinensis* in 2737 B.C. Apart from this, by the 17th century, tea begins to occupy right place among popular drinks in China (Jhowar, 2002). Lu. Yu, a renowned author in the time of Tang Dynasty, published first tea classic which contain the details of cultivation and preparation of tea in China in 780 (Hill, 1998). In the early 12th century, Buddhist monks brought tea from China to Japan but the commercial cultivation of tea is not started yet for that time in Japan (www.coffee-tea-etc.com). The tea drinking habit generally spread along the trade route of Asia minors and was introduced to Europe by Dutch traders during 17th century. In England, tea overtook popularity during 18th century and has been established “national drink” (Vernam and Sutherland). Britishers initiated commercial planting of tea between 1818 and 1834 and today this country has become world largest tea producers (Hill, 1998).

In India tea is believed to have known as early as 1824 A.D. The most authentic source of information on existence of tea came from Major Robert Bruce, who discovered tea in upper Assam. This discovery virtually laid the foundation of tea industry in India. Tea cultivation in Darjeeling started

around 1839. By 1856 major production centers began in Darjeeling and Cachar in the terai in 1862 and in Dooars in 1874. This was followed by rapid growth in South India. Tea from its center of prime distribution in South East Asia dispersed either naturally or by human agencies into other parts of the world (Banerjee, 1996).

Though tea was introduced in Russia as early as 1618 by a Chinese ambassador, regular trade did not develop until the end of the 17th century. In the early 20th century it flourished with the Trans-Siberian railway. In Europe tea was sold as a medicinal drink in the 1650s. After 1662, tea was served to guest, and then started as the fashion of a tea time in Britain. Tea was associated with the social functions and great ceremonies. In the 1980s a new trend developed where shops started selling varieties of fine teas. The media took hold of the event and tea once again came into fashion and has kept up the momentum (www.coffee-tea-etc.com).

Tea was introduced in Sri Lanka much earlier but it was not until the coffee blight in 1869, which totally ruined the coffee economy that people started planting tea. In a very short period of time tea production took over other cash crops. It has a perfect growing condition for fine teas with mountains as high as 6000 feet with ample rain and soil suited for tea. It is now the second largest exporters in the world next to India (www.coffee-tea-etc.com).

Tea in Nepal was introduced in the same decade as in that in Darjeeling Hills. Around 1920 B.S. (1863 A.D.), ward chief officer Shri Gajaraj Singh Thapa was responsible for tea plantation in Ilam tea state, East zone of Nepal (Ghimire, 1997). At present tea has been extended to other districts

where tea cultivation is made at commercial scale (NTCDB, 2002). Currently, in Nepal 134 tea estates and tea gardens were recorded and among them 89 were registered at NTCDB to the year 2006.

3.2 Tea Pests and Diseases

In the first comprehensive report on tea pests and diseases, only about 12 fungal diseases were mentioned by Watt and Mann in 1903 and this rose to 17 in 1918. Today, it is fairly known that about 385 species of pests occur in tea all over the world of which about half occur on North East India (Banerjee, 1996).

It has been estimated that 1034 species of arthropods and 82 species of nematodes are associated with tea plants. China, with the longest history of tea cultivation, has more than 430 species of insects and mites feeding on this crop. About 230 species of arthropods are known to attack in tea in India (Muraleedharan, 1993).

Banerjee and Das (1969) studied the effect of light on the oviposition rhythm of the red spider mite, *Oligonychus coffeae* (Nietner). Red spider mite is highly sensitive to changes in light intensity. Initiation of oviposition rhythm is triggered off by the change from light to darkness and vice versa, with the maximum oviposition at dawn and dusk when a rapid change in light intensity occurs.

The distribution of red spider mite is regulated by the light penetration within the tea canopy. The middle zone of bushes provides the optimum combination of temperature and light intensity for the highest concentration.

The growth and development cycle of the mite also change with cultivar characteristics, which includes morphological and biochemical attributes of Assam and China varieties of tea. The mite shows a marked preference for erect leaves of China varieties of tea (Banerjee, 1974).

In his book “Introduction to Agricultural Acarology” Banerjee, (1988) writes, the distribution and abundance of the tea mites are related to climatic factors like ambient temperature, rainfall, shade and cultural practices though it is not clear that which one is the most important. In fact, the relative contribution of each of these factors in regulating the mite population is not well understood. The population growth of mites synchronizes with the seasonal temperature but the statistical correlations are not always formally significant. Rainfall for example, is one of the most important climatic factors that control the mite population outbreak but since it only dislodges the pests physically from the upper surface of tea leaves, its effect is more of a mechanical nature. Moreover, the mites inhabiting the undersurfaces of the tea leaves are least affected.

Andrews, (1923), studied about the tea green fly (*Empoasca flavescence*). It is one of the major sap feeding pests of tea. Heavy infestation by these jassids leads to a condition called “rim- blight”, the affected leaf-margin turning brown. They leave no puncture marks on the leaves but the affected leaves become uneven and unusually curl downwards, shoot growth is prevented and the leaves become stunted, dry up and finally fall down. The seasonal cycle of these insects synchronizes well with flushing period of the bushes as a result; the insects cause a serious loss of crop by damaging the young pluckable shoots. Though adults and nymphs cause the damage, the

magnitude of the damage by the nymphs is particularly high. Pruned tea is prone to jassid attack particularly during drought. Damage during this period prevents shoot growth causing the leaves to remain stunted and eventually these leaves dries up and fall.

Dev (1964) did preliminary studies on the biology of Assam thrips, *Scirtothrips dorsalis* Hood. The population of *S. dorsalis* starts increasing from March and by August the population declines though it may persist in varying numbers on unpruned tea plants throughout the year. The life cycle is completed within 12 to 15 days depending on environmental conditions.

Aphids are of great economic importance since they suck up the plant sap, hamper plant growth as well as spread several viral plant diseases, thereby causing loss of output in agricultural, horticultural, floricultural, silvicultural and wild plants. Aphids are used to remain in colonies and are the most destructive to crop plants. They suck sap and secrete honeydew through anus which encouraged developing sooty mould, a fungus, which blocks the photosynthesis. They reproduced by parthenogenesis or by budding. Adult females are viviparous. Both nymphs and adults suck sap from the soft part of the plants mostly tender leaves and tender shoots. The feeding activities of the aphids produce pale colour in the area of the leaves which can turn into reddish colour. This discoloration is due to loss of Chlorophyll. The attack area increases and the leaves become or show blotchy patches. Some aphids are the vector of viral diseases of some plants (Tamrakar, *et. al*., 2000).

The main host of *Toxoptera aurantii* Boyr is citrus. Tea, coffee, cocoa are the alternative hosts. Adults are shiny black, winged or apterous measuring 1.2 to 1.8 mm. They have relatively short antennae. Only females are formed. They produce living young, which are dark brown in colour. At 25 degree Celsius, single generation completes in six days but above 30 degree Celsius, aphid population declines sharply (Hill, 1993).

T. aurantii is also reported to be a vector of Citrus Tristeza Virus (CTV). Tristeza virus is an aphid-borne clostero virus. This virus infect the tender citrus buds and therefore no foliage growth, hence no fruiting. Affected plants shows vein cleaning, stem pitting, cupping of new foliage, stunted growth and sometimes wilting symptoms are also recorded (Ghimire, 2000).

Tea mosquito bug, *Helopeltis theivora* Waterhouse is one of the important pests of tea. They are more active during morning and evening (Hill, 1993). These are also sap feeders. The adult bug is 7 to 10 mm. long with antennae nearly twice as long as the body. The antennae, head and wing are blackish. Most females have blood red body and like the nymphs the adults have a pin like projection on the thorax. The nymphs are slender, delicate and yellow with pale red markings. The full grown nymph has a body length of about 7mm, the antennae being much longer. There are five nymphal instars all except the 1st having pin like projection sticking up from the thorax. The nymphal period is about three weeks.

Sivapalan, *et. al*., (1975) while studying the integrated approach to tea pests in Sri Lanka wrote regarding termites. The precise reason for termite outbreak is not clearly understood. In some cases, mulching and use of

herbicides seems to have triggered the termite population but a causal relationship is difficult to establish. Some species show a marked colonel susceptibility and shade may also influence the termite activities.

Banerjee (1970) studied the aggregating behaviour of the caterpillars of the moth *Andraca bipunctata* Wlk. (Bombycidae: Lepidoptera). These caterpillars are found in close physical aggregations at day time, on leaf surfaces, but the aggregations break- up at night and they start feeding voraciously on the foliage. Hampson, 1976, reported that the habitat of *A. bipunctata*, a moth belonging to family Bombycidae is mainly in Sikkim and Assam.

Das and Ganguly (1961) studied the Coccoids on tea in North East India. Over 30 species of scale insects and mealy bugs (Coccoidae) infest tea plants in varying degrees; of them 12 are serious pests infesting stems and branches or leaves. The coccid and the scale infested branches and shoots become highly unproductive leading to serious leaf fall. If the attack prolongs, irregular swelling appears on the branches because of the callus growth inside. Prolonged attack also debilitates the bushes. As a result the branches die back and eventually the whole plant is killed. The long term effect of the damage could be devastating as a seriously infested plants fail to produce quality young shoots.

The shoot hole borer, *Xyloborus fornicatus* Eich, a major stem borer of tea plants and also others plants. A crop loss varying between 18% to 40% due to severe infestation is not uncommon. Most of the damage is caused by the female, which constructs galleries within the branches in which eggs are laid

by them. The larvae do not extend the galleries any further, but feed on the mycelia of the fungus (Ambrosia) growing on the walls of the gallery. The pupation also takes place inside the gallery. The newly emerged adult mate within the galleries. The female then emerges out through the exit hole made by them in the gallery so a new generations starts. They mostly attack on the fresh branch of the plant. The life cycle completes in an about 40 days (Joseph, 1975).

Rai, M. (2004) has worked on Pest of Tea and their Management Practices in Kanyam Tea Estate (KTE), Ilam District, Nepal for the investigation of the arthropods complex of Tea as well as their management practices followed by this firm. On her study, she found that about nine sps. of Arthropods pests in tea in KTE of them, *Scirtothrips* sp. (Thrips) and *Toxoptera aurantii* (Aphids) was considered as major Pests. It was also reported that tea plant suffered a lot (a loss of 14 mt. green leaves in a year 2002) from a disease called Blister blight caused by fungus *Exobasidium vexans*. The control measures taken in KTE against these pests were the traditional synthetic pesticides as well as some neem-based botanicals;

Similarly, Chettri S. (2010) has worked on Tea Pests of Temi Tea Estate, South Sikkim, India. On his work, he found a total of 205 specimens of arthropods pests damaging this crop. Among 205 specimens collected, 125 specimens were collected during autumn season and 80 specimens during monsoon season. Maximum sps. belongs from Aphididae, Formicidae and Thripidae family and minimum from Scarabaeidae and Chrysomelidae family. Hemiptera was found to be the most dominant order with the value of 0.2683 likewise Coleoptera was found to be recessive order with the value

of 0.0244. The species diversity was 1.662 with the evenness of 0.607 of autumn season and was 1.798 with the evenness of 0.968 for monsoon season, while the community dominance was 0.9121.

3.3 Pest Control/ Use of Pesticides

The seasonal appearance of pest during tea cultivation necessitates timely management of the crop through pesticides. The main reason for sub-optimal control of pest problem that pesticide application technology is not sufficiently developed to the target sites in the drift plant parts and within the canopy all resulting in the drift of spray droplets away from the tea (Banerjee, 1986)

Being highly toxic in nature, they do not differentiate between target and non-target species. The thick foliage of the unpruned tea often prevents spray droplets from penetrating deep into the canopy where pest are often located. The unpruned only about 30%of the spray droplets are able to penetrate the top 20% of the foliage with the balance getting drifted away.

Pesticides due to it’s highly toxicity adversely affect the balance between pest and their natural enemies like predators and parasitoids on many crops; including tea. An avoidance of pesticide during the main period of predator activity is desirable but in tea the periods of the activities of the major pests and their predators get synchronized at different density levels.

However, care should be taken not to overdose on pesticides because these can lead to a high residue level of toxic substances in the tea leaves in excess of the MRL set by the importing countries.

Pest that commonly attack tea crops include mites, thrips, jassids, tea mosquito bug, leaf eating beetles and defoliating caterpillars.

The control effect by mass-trapping technique on tea tussock moth, *Euproctis pseudoconspera* (Lepidoptera: Lymanteridae) was investigated by Wang *et. al*., (2006) with synthetic sex pheromone in South China. The optimal dosage of synthetic sex pheromone was 1.5mg/septum in a trap. Twenty-five traps per hector were used in two years, large scale mass trapping experiments and a total of 146,767 males were captured. In the pheromones treated field, mating rates were significantly reduced on 9 to 12 samples dates. Larva and egg densities were reduced by 27.87-50.85 and 38.89-51.11 percent respectively compared with the pheromone untreated field. The result of the experiment indicated that the mating disruption method with sex pheromone lure could all as an agents in controlling tea tussock moth.

Hen *et. al*., (2003) work on the behaviour and electrophysiological responses of the natural enemies to synomones from tea shoots and kairomones from tea aphids, *Toxoptera aurantii*. Olfactometer bioassays and electrophysiological studies showed that the aphid parasitoids, Aphidius sp., responded volatile from tea aphids, *Toxoptera aurantii*, to hexane or ether rinses off tea aphid cuticle, and so synomones released by aphid damaged tea shoots as well as to the tea shoot aphid complex. They found that the interaction between synomones from aphid damaged shoots and kairomones from tea aphid enhanced the responses to the plant host complex.

Similarly, several other investigations were also carried out for the control of tea pest. Sharma *et. al*., (2003) worked on the prospects in use of neem formulation and biocides in tea pest management in North-East India. From this investigation he found that neem formulations containing 0.03% and 1.5% azadirachtin showed percent reduction to the tune of 37.6-68.3%, 31.8-34.7% and 29.4% in red spider mites, thrips, and green fly respectively up to 4 weeks but 20.32-57.86% week. Their trails revealed that among sucking pest green fly was more sensible to neem formulations followed by red spider mites and thrips.

Tetradifon is the most effective pesticide to counter a potent pest- red spider mite (*Oligonychus coffeae).* For other mites dicofol and ethion are used. Endosulfan helps to tackle pest like thrips, aphids, tea mosquito bug and other sap feeders. Organophosphate, insecticides such as Quinalphos and Phosphamidon are also used to control sap feeders and leaf eaters. The conventional chlorinated hydrocarbons like endosulfan fails to control leaf eaters and defoliators, synthetic pyrethroids like deltamehrin are applied. On account of the complex pest situations in tea cultivation a total avoidance of pesticides does not appear feasible. It is in this context that MRL assumes importance (Tvedten, 2002).

Over the last 50 years, agriculture deeply changed with a massive utilization of pesticides to enhanced crop protection. For many reasons, the severity of pesticide hazards is much pronounced in third world countries (Maroni, 2006). In Nepal, about 319 types of pesticides (Insecticides-213, Fungicides-71, Herbicides-23, Rodenticides-8, Acaricides-2 and others-2) have been registered for used under Pesticides Act and Rules of Nepal. Several

available pesticides are possibly carcinogenic to humans. BHC (Benzene Hexachloride) dust is the most frequently sold chemical pesticide followed by Parathion methyl, Zinc phosphide, Aluminium phosphide, Malathion, Dithane and Phorate. Worldwide estimates suggest that there are about 3 million (1,000,000 intentional and 2,000,000 unintentional) acute pesticides poisionings and approximately 220,000 death each year (Koirala, P., 2008).

3.4 Pesticide Residue

Nepal has exported potential for agriculture and processed products in the international market. Nepal's specific geographic, agro-climatic environment friendly agriculture system, less use of fertilizer and pesticides are main reasons for the export possibilities. Nepalese tea due to its unique flavour, aroma, is popular in the domestic as well as in the international market. Therefore, there is a rise of export volume in the markets. But recent years, Nepalese agri-products have faced some problems in the export market due to the presence of pesticides and other chemicals (Koirala, P., 2008). The problem of pesticide residue on processed tea is receiving attention. The monitoring is strict for the tea which is exported. This problem has not been recognized in tea for local consumption. However, teas which contain more than tolerance limits of pesticides run the risk of being discarded or destroyed. The pesticides applied on tea are discarded and further, diluted by rain and dew, evaporation, photolysis through sunlight and biodegradation. Synthetic pyrethroids and also the organochlorines are lipophilic and they get bound to the cuticle. This is possibly why pesticides like dicofol are appearing in the exported tea. Considerable amount of pesticides on the leaves is lost during the process of

manufacture. The loss may be 30-60% (by evaporation on thermal decomposition) compounds with higher vapour pressure are likely to leave fewer residues than those with lower vapour pressure. Processed tea when infused with boiling water will extract smaller quantities of minimum residue leaves in tea in relation to standardized method of extraction in the liquor rather than on black/green tea as it is the liquor which is consumed (Agnihothrudu, 1993).

Sensitivity of pesticides to light is an important factor, which determines their residues on tea. One of the most commonly used pesticides is monochrotophos, listed by the World Health Organization as class Ib, highly hazardous. Monochrotophos, an organo phosphate used to kill insects and mites, is a nerve toxin that can cause weakness, blurred vision, profuse perspiration, confusion, vomiting and pain.

The pesticides on tea are generally applied after plucking. If the spray is done between plucking, the residue can be high. As spray is done after plucking the deposits are left on the matured tea leaves and on the shoots and leaves which are in different stages of growth. By the time of immature leaves attain the pluckable size the residue of the pesticides on them will be very low (Agnihothrudu, 1993)

In 1992-93, Germany refuse to import a shipment of Darjeeling tea contaminated with tetradifon, used against spider mite larva. A one kilogram sample from the shipment contained 240 micrograms of tetradifon. Twenty-four times above the maximum residue limit. As a result of continuous use

of pesticide, the plant resistance to pest and diseases has declined. At the same time, increased pesticide use has made pest immune to the chemical.

The presence of pesticide residues in food commodities has always a matter of serious concern. The level of pesticide residue in foodstuffs are generally legislated so as to minimize or unnecessary intake of pesticides (Zorka, 2009). The pesticide residues thus occurred can have long term health implications such as cancer, allergies hypersensitivity, damage of the central and peripheral nervous system, reproductive disorders, disruption of the immune system and even death (Strecct, 1981; Marooni, 1990). Thus the effective tea development policy along with scientific agriculture practice, efficient quality control mechanism and technology for cultivation, harvesting production, processing, storage and distribution is current need to strengthen Nepalese tea economy and consumers' safety.

4. METHODS AND MATERIALS

4.1 Methodology

The present work entitling “Study on Tea Pests and Pesticides Handling Practices in Tea in Jhapa and Ilam District of Nepal” was carried out on 24th Dec. 2009- 06thJan. 2010. This study was based on primary as well as secondary data.

4.2 Materials

The materials required for collecting the insect pest are insect collecting sweep net, insects collecting jars, Petri dish, vials. Forceps, camel hair brush, entomological pins, cardboard sheets, preservatives like 70% alcohol.

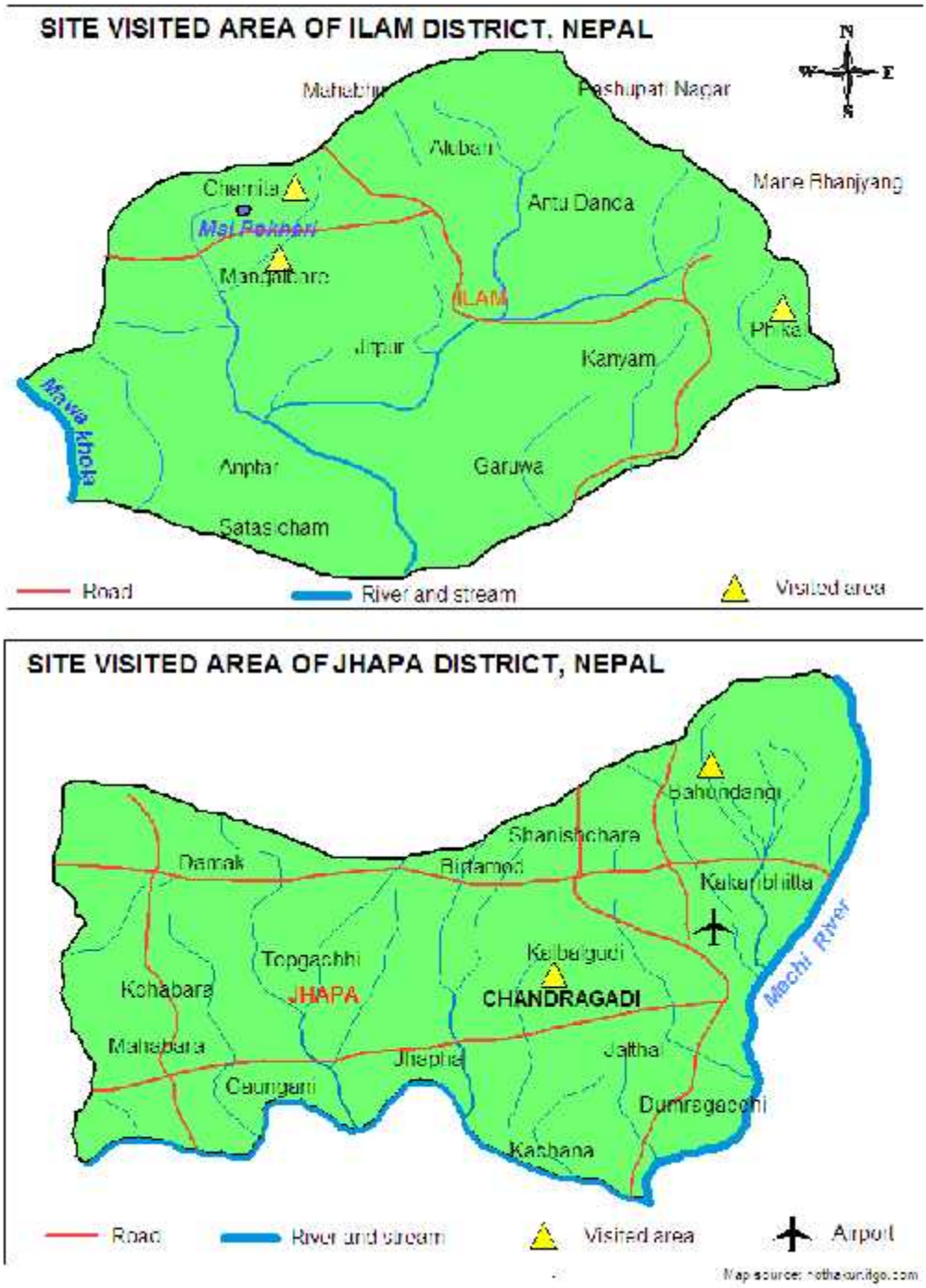
4.3 Study Area

For the study purpose two major tea producing districts representing two different agro-climatic zones, i.e., Jhapa and Ilam, which account more than 95% of total area production in the country, were selected. From each districts, three Greatest Village Development Committee/ Municipality and 4 wards from each VDC/Municipality were selected purposively based on the criteria of highest tea production. The farmers involved in the tea at large amount were selected for the study purpose and were interviewed by random questionnaire. One tea sample from each VDC/municipality (altogether six samples from six sampling units of two different districts) was collected for laboratory analysis. Information about tea samples are given in the table below:

Table 2: Sample collection details for pesticide residues

S. No.	Sample collection areas (Districts & VDCs)		Sample code	No. of Sample	Sample description
	Jhapa VDCs/Municipality	Ilam VDCs			
1.	Bhadrapur Municipality	-	J1	One	Handmade
2.	Bahundangi	-	J2	"	CTC
3.	Haldibari	-	J3	"	CTC
4.	-	Fikkal	IL1	"	Handmade
5.	-	Mangalbarey	IL2	"	Orthodox tea
6.	-	Jasbirey	IL3	"	Green tea
Total	2 VDCs and 1 Municipality	3 VDCs		6	

Fig 1: Map of Jhapa and Ilam Districts showing visited area.



4.4 Study Sites

Jhapa

Jhapa is the eastern most district of Nepal and lies in the fertile terai plains. It borders Ilam district in the North, Morang district in the west, the Indian state of Bihar in the south and east and the Indian state of West Bengal in the east. It is also the gateway to Darjeeling and Sikkim and the west of North-East India from Nepal. The word Jhapa means "Canopy" which suggests that the area was dense forest in the past. The district with Chandragadi as its headquarter, covers an area of 1,606 km square with an altitude having 64 m above from sea level and has a population (2001) of 688,109. It receives 250-300 cm of rainfall a year and mostly during the monsoon season in the summer. Jhapa has a good literacy rate of 66.93% which is highest in Nepal, after the capital city, Kathmandu. It is one of the major area for the productions of Tea & Rice.

Several large Tea Estates are also located in Jhapa, such as Giri Bandhu Tea Estates, Burne Tea State, Tokla Tea Estate, Sattigatta Tea Estate are the major ones. The district is divided into 49 VDCs and the major VDCs. The VDCs where the tea being cultivated are; Shantinagar, Anarmani, Mechi Nagar, Maheshpur, Haldibari, Bhadrapur, Damak, Bahundangi, Kechana, Kumarkhod, Gauriganj, Sanischare, Taghan dubha, Pathariya. Out of these VDCs, 3 VDCs were selected for the survey purpose and they are, Bahundangi VDC, Bhadrapur VDC and Haldibari VDC.

Ilam

It is situated in Mechi zone, which is a landlocked country of South-Asia and is situated at a distance of about 600 km from Kathmandu. Ilam stretches from terai belt to the upper hilly belt of this Himalayan nation. The name Ilam is derived from the Limbu language in which "I" means twisted & "lam" means road.

Ilam is today one of the most developed place in Nepal. The district covers an area of 1,703 km square with an altitude of 1600 m and the population of 282,806 (2001). Sex ratio (M/F) is 1/01, literacy rate (%) both sex 66.23, male 74.10 female 58.23. (District Demographic Profile of Nepal, 2002).

The main source of income of this district is tea, cardamom, potato, milk and ginger. Its Ilam Tea is very famous and is transported to many parts of Europe.

The major VDCs in Ilam where tea being cultivated are Kolbung, Kanyam, Fikkal, Ilam Municipality, Pasupati-Nagar, Sri-antu, Mai-Pokhari, Bajho, Sakhejung, Pyun, Nayabazar, Panchakanya, Phakphok, Amchok, Jeetpur, Sanrungba, Mangalbarey, Jasbirey.

From these VDCs, 3 VDCs were selected for the survey purpose, i.e., Mangalbarey VDC, Jasbirey VDC and Fikkal VDC.

4.5 Data Collection

For collecting data various sources and techniques were used to overview the relevant information. This study is based on primary as well as secondary data for the analysis.

4.6 Sources of Primary Data

The primary data have been collected by visiting the study site. Field visit was done during the dry season, i.e., Dec 2009-Jan 2010. The pests were collected from the tea garden by employing various collecting methods. The data were collected directly by observing the pests and their infestation in tea plants. The questionnaire survey was also done to know about the pests, their nature of damage, and awareness of people regarding pesticide hazards, its handling practices and major and minor pests.

4.7 Sources of Secondary Data

The secondary data has been collected from different sources like NTCDB, NTDC, other related institution, Tea Estate Office records, related publications, and websites, government and non-government organizations.

4.8 Field Visit

From each selected VDCs, 4 wards in which large numbers of teas are cultivated were selected. From each selected ward 2 household were visited and was interviewed with structural questionnaire with personal communications.

4.9 Questionnaire Survey

The local people who had grown teas in large amount as commercial farming was interviewed through random questionnaire survey method so as to gather information about the infestation caused by the pest and their control measures and peoples' awareness of hazards of chemicals and IPM practice. Total 8 growers from each VDC were interviewed. Interviewing with the farmers and also with some of the experienced people concerned with was quite enlightening and aided together information significantly.

4.10 Pest Collection

The best way to learn about insects is to collect them from the field of observation. For collecting the pest and studying their population density, six bushes were chosen from every corner of the respective garden. The specimens thus collected were preserved as wet collection in preservatives like 70% alcohol. The insects which were large enough to be seen by naked eyes were collected by hand picking method with the help of forceps and were put in bottles containing alcohol preservatives.

Specimen like aphids, which occurred in clusters was collected by using camel hair brush and was kept directly in small vials containing 70% alcohol. The smaller insects were also collected by placing the card board sheet covered with white paper below the tea bushes and then jerking the plant and finally fallen insects were picked up and put in vials. Sweeping net was also applied for collecting the flying insects pests like bug, grasshopper, crickets etc.

4.11 Identification

The collected specimens were identified at laboratory of Central Department of Zoology, Tribhuvan University. The identification was made by comparing with existing specimens and the photographs if the specimens at laboratory of Entomology Division and consulting insect taxonomic keys from the books (Borror and Delong, 5th Edition, Dennis S. Hill, Indian Reprint) and taxonomic expertise of entomology were also consulted.

5. RESULTS

For the study purpose, two major tea producing districts, i.e., Jhapa and Ilam were selected. The study was conducted during the dry season from 24th Dec 2009 - 06thJan 2010. Random questionnaire was also conducted so as to gather information about the infestation caused by the pest and its control measure through the farmers working in the tea field and also from the offices and administration associated with tea production.

During the cultivation of tea, varieties of insect pest may attack it. The common insect pests in tea were Thrips, Looper, White grubs, Tea mosquito bug, Flush worm, Red spider mite, Stem borer, Cut worm, Leaf roller, Bunch caterpillars, Aphids, Jassids and Red ant and narrow and broad weed leaves of different variety. Among them only Thrips and Aphids was considered as major pest while the remaining are considered as minor pest (Rai, M. 2004). But, during the field survey it has been observed that, Red Spider Mite are also considered as major pest in Jhapa district.

Table 3: Common tea Pest, its family, Time of occurrence in Tea in Jhapa and Ilam Districts of Nepal

Pest	Family	Site of Attack	Time of Occurrence	Site of Collection
Toxoptera aurantii (Boyr, 1856)	Aphididae	Buds, tender stem, young leaves	Jan/Apr	Jhapa and Ilam
Scirtothrips dorsalis (Hood, 1919)	Thripidae	Unopened or partly opened buds, young leaves	Jan/July	Ilam and Jhapa
Oligonychus coffeae (Nietner, 1861)	Tetranychidae	Upper surface of young foliage, leaves. Brownish discoloration	Whole year	Jhapa /Ilam
Helopeltis theivora (Waterhouse, 1886)	Miridae	Young leaves, buds tender stem	Feb-Nov	Jhapa/Ilam
Andraca bipunctata (Walker, 1865)	Bombycidae	Young leaf	Mar-Nov	Jhapa/Ilam
Biston suppressaria (Guenee, 1857)	Geometridae	Small holes on margin of young leaf	Feb-Mar/May/July/Oct	Jhapa/Ilam
Empoasca flavescene (Fabr)	Cicadellidae	(Rim blight) leaf curved inward, midrib and veins turned brownish	Feb-July	Jhapa

Gracilaria theivora (Walsingham, 1891)	Gracillaridae	Young leaves, Rolling and feeding	Apr/July	Jhapa
Melolontha melolontha (Linnaeus, 1758)	Scarabaeidae	Bark of Stem just below soil surface	May-September	Ilam
Exobasidium vexans (Masee, 1898)	Exobasidiaceae	Leaves infected	Apr-Nov	Ilam
Corticium theae (C. Bernard, 1908)	Corticiaceae	Upper leaf surface. Gradual deterioration in the health of bush	May-July, Mar/April	Jhapa
Acaphylla theae (Watt, 1903)	Eriophyidae	Upper surface of leaf. Pinkish discoloration on leaf and veins	Feb-Nov	Jhapa/Ilam

5.1 Characteristic features of Studied Pests

Toxoptera aurantii (Tea Aphid)

They are shiny black in colour. They may be apterous or winged. They were always found in clusters. The body length ranges from 1.2 to 1.8 mm in length. The anal segment has less number of filamentous structures than that of *Toxoptera citricidus*. The ptero-stigma sector of the forewings is distinctly dark to black in colour.

These black aphids were quite abundant on tea plants both in monsoon and dry season. They mostly cause the damage by sucking the plant sap and secret honey dew through the anus which attract sooty mould, fungus, to develop. As a result, photosynthesis is blocked due to which the growth is stunted and the plant becomes unproductive. There is no any particular control measure being practiced against the aphids but their populations can be controlled by spraying pesticides which are being applied against other pests like thrips, mites etc. In addition to this, a natural enemy like lady bird beetles plays the most significant role in controlling them.

***Scirtothrips* sp. (Thrips)**

Adults are yellowish-brown in colour. The body size measures 0.5 to 0.8 mm in length. Antenna 5 segmented with one segmented terminal style. Ovipositor well developed and curved downwards. Wings present, narrow and pointed apically.

They seem to be the major pest in most of the tea growing countries. They were the most abundant of the entire pest that cause the considerable damage in warm and humid weather. Their sizes are small and found in large numbers. The female lays eggs inside the leaf tissues by saw like ovipositor. The life cycle completes in 14-20 days. They mostly attack the young leaves and buds and produce lacerations, which appears as streak (stick like appearance). As a result, the leaf surface becomes curled, uneven and matty, i.e., the leaf looses shine.

***Oligonychus coffeae* (Red Spider Mite)**

They are oval in shape and red in colour. Adults have four pairs of legs while the nymphs have only three pairs of legs. Body size ranges from 0.3-0.5 mm in length. They are the largest mite pest of tea found on the upper surface of the mature leaves and can be seen easily with naked eyes. They make thin silky web on the tea plant. Females are bigger than the males. Eggs are reddish and apple shaped.

They are quite significant in unshadded areas in mature foliage especially in the dusty areas. The adults, nymphs and larvae actively feed on mature leaves causing reddish-brown spots at the point of sucking. These spots finally coalesce into a large single patches leading ultimately to leaf fall. Life cycle completes in 10-14 days.

***Andraca bipunctata* (Bunch Caterpillar)**

Body is cylindrical and hairy and is covered with spine like structure. Their size ranges from 1.8 to 2.3 cm in length. Presence of a pair of horn on the terminal somite. In addition to three thoracic pairs of legs, there are four pairs of prolegs and a pair of claspers at the hind end of the body.

They congregate on the branches in cluster at the day time. But at night time these aggregations break up and the larvae starts feeding on the foliage. Caterpillars are leaf eaters. They feed voraciously on the leaf surface, turning the bushes into skeleton. They were found only in the restricted places in the tea garden so they are not considered as a serious pest but if left neglected they do the considerable damage to the tea plant.

***Malolontha melolontha* (White Grub/ Cockchafer Grub)**

They are found in a few bushes of the newly planted tea. They occur in the root or the collar region of the young plants and eat away a ring bark in the collar region just below the soil surface. They do a negligible damage as their population was found to be occurring in few plants in the garden. Therefore, they can be considered as a minor pest. But if left neglected, they do the considerable damage as a result the plant may fail to survive. They may occur in May to September.

***Biston suppressaria* (Common Looper)**

The larva is dark green to black in colour measuring about 1-7 to 2 cm in length. They eat away the young and mature leaf. They are also considered as a minor pest.

***Empoasca flavescene* (Jassids)**

The green leafhoppers of tea are studied and described by Andrews (1923). Jassids, *Empoasca flavescens* Fabr. is a major sap feeding pest of tea and heavy infestation causes a condition known as rim blight. Though adults and nymphs cause the damage, but the magnitude of damage cause by nymphs is particularly high. They are found during both monsoon and dry season.

It has been observed that, among all prevailing pests in both Jhapa and Ilam districts, Thrips and Aphids are considered as major pest which cause a maximum crop loss as compared to other pest. But in Jhapa districts, Red

Spider mite was also considered as major pest because they are also a sap feeder and cause serious damage to crop.

Similarly, Bunch caterpillars are also one of the most important defoliating pests of tea. They cause a severe damage by feeding on young foliage leaf turning the bushes into skeleton within an hour. Devastating attack by the defoliators could result in the crop loss of 40% (Banerjee, 1996). Hence, they are not considered as serious pest in both districts but if they are neglected, they cause a serious damage.

It has been also found that beside arthropod pests, the crop loss is also due to several fungal diseases. Majority of the farmers in the Ilam districts commented that among all other fungal diseases, Blister blight, which is cause by a fungus called *Exobasidium vexans,* which cause the serious damage to the tea plant as Ilam lies at an attitude of 1600 m with an annual rainfall of 3250 mm. So, the temperature is usually low and the weather is misty and foggy most of the time as compared to Jhapa.

Table 4 : Control schedule practiced against tea pest in Jhapa and Ilam districts

Pest	Control Measures	
	Jhapa	**Ilam**
Toxoptera aurantii (Tea Aphids)	Spray of Organochlorines like Endosulfan (Thiodan) and other pyrethroids	Spray of Insecticides, Control by other natural enemies
Scirtothrips dorsalis (Thrips)	Spray of Endosulfan, Stop Farsa, Thimet	Spray of Endosulfan, some biopesticides like Tatamida, Josh etc
Oligonychus coffeae (Red Spider Mite)	Spray of Endosulfan, Cypermethrin	Spray of Monochrotophos, Neem based insecticides
Andraca bipunctata (Bunch Caterpillar)	Spray of Cypermethrin, Endosulfan, Omite	Hand picking method
Melolontha melolontha (Cockchafer grubs)	Spay of Endosulfan Decis, Stop	Mannual removal and taking mulch away from the collar region of the plant
Empoasca flavescene (Jassids)	Spray of Cypermethrin, Omite, Josh	Spray of Kelthane, Endosulfan, Omite
Biston suppressaria (Common Looper)	Spray of Thiodane Thimet, Gem, Farsa etc.	Spray of some Insecticide. Hand picking method also be done
Gracilaria theivora (Leaf roller)	Spray of Decis, Alpha Thiodane	Spray of Tatamida, Hand picking method
Exobasidium vexans (Blister Blight)	Spray of Tatamida, Blitox, Omite	Spray of biopesticides like Tatamida, Omite

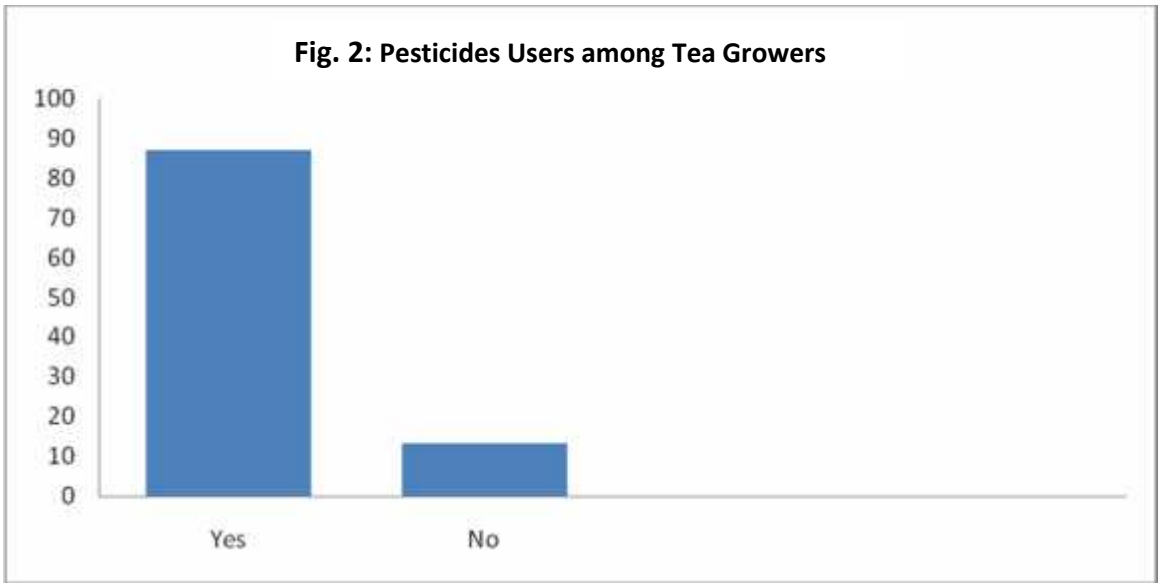
5.2 Pesticide Use

During the field survey, it has been found that about twenty one types of pesticides were used by the farmers in the tea field. The names of such pesticides are given in the table

Table 5 : Pesticide Applied in the Field During the Survey

S. No.	Pesticides	Chemical Type	Main Use	WHO class
1.	Decis	PY	I	II
2.	Alpha	PY	I	II
3.	Stop	PY	I	II
4.	Gem	PY	I	II
5.	Farsa	PY	I	II
6.	Thimet	OP	I	Ia
7.	Cypermethrin	OC	I	II
8.	Meothrin	PY	I	II
9.	Thiodan	OC	I	II
10.	Ekalux	OP	I	II
11.	Monosil	OP	I	1b
12.	Acephate	OP	I	III
13.	Glyphosate	H	H	NH
14.	2,4 D sodium salt	H	H	NH
15.	Tatamida	F	F	NH
16.	Josh	F	F	NH
17.	Blitox	F	F	NH
18.	Share	F	F	NH
19.	Omite	AC	AC	III
20.	Magister	AC	AC	II
21.	Kelthane	AC	AC	III

about 86.8% of Jhapa and Ilam district apply pesticide to their tea and about 13.2% do not use it.



The four tea growers out of five in Jhapa and Ilam were found using the pesticides that is hazardous to human health and environment to produce and preserve an abundance of high quality of teas.

5.3 Types of Pesticides Used

A registered pesticide has two names, i.e., common name and the trade name. The common name is given by international organizations or national traders whereas the trade name is the name given by the manufacturer. Both the names must appear on the label, but the trade (proprietary) name is usually more prominent.

Table 6: Common and Trade name of pesticides (applied in the field)

S. No.	Pesticide Group	Common Name	Trade Name
1.	Organochlorine	Endosulfan Dicofol	Thiodan Kelthane
2.	Organophosphate	Quinalphos Monochrotophos Acephate	Ekalux Monocil Starthene
3.	Pyrethroids	Phorate Deltamethrin Fenopropathrin Alphamethrin	Thimet Decis Meothrin Alpha, Stop, Gem, Farsa
4.	Fungicides	Copper Oxychloride Sulfur	Blitox Share
5.	Herbicides and acaricides	2,4 D sodium salt Glyphosate Dicofol Fenazaquin	2,4 D Round up Kelthane Magister
6.	Others	Imidachlorpid Propanofos Propargite	Tatamida, Josh Curacron Omite

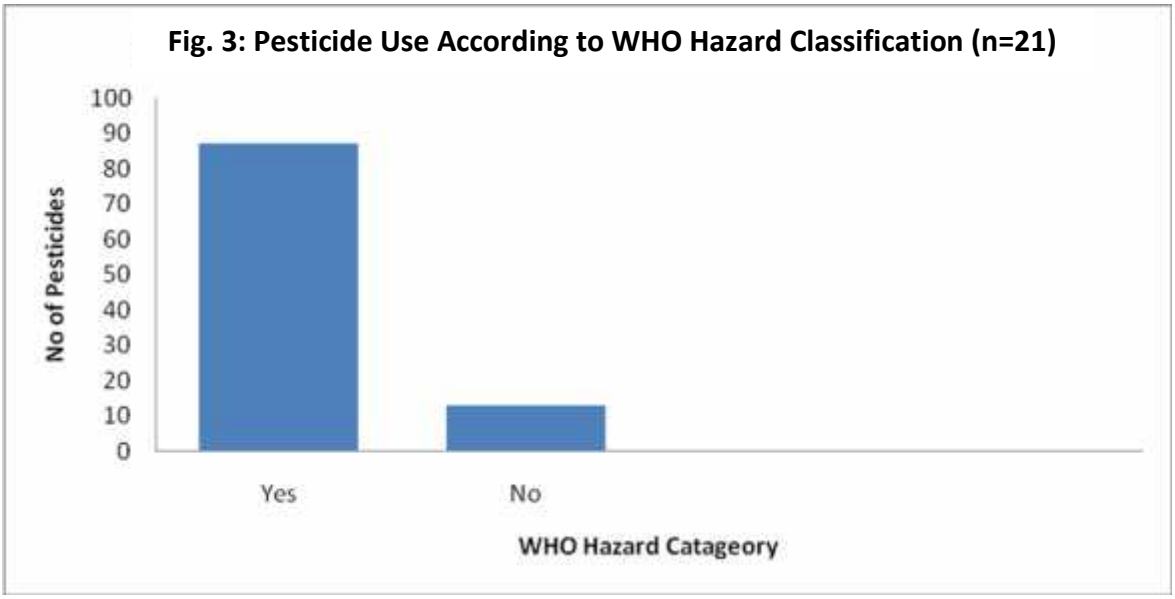
5.4 Types of Pesticides used according to hazard level of WHO

WHO has classified pesticides into the following categories as given in the table below.

Table 7: Hazard Classification of Pesticides.

S. No.	Hazard Level	Group	LD 50 mg/kg Body weight		Label Colour
			Solids	Liquids	
1.	Extremely Hazardous	Ia			
2.	Highly Hazardous	Ib	10 or less	40 or less	Red
3.	Moderately Hazardous	II	10-100	10-400	Blue
4.	Slightly Hazardous	III	100-1000	400-4000	Yellow
5.	Unlikely to present acute hazard in normal use	NH	Over 1000	Over 4000	Green

According to the above classification, it has been found that, the majority of pesticides being used in the field belongs to moderately hazardous; Class II.



5.5 Frequency of Pesticides Use

The frequency of pesticides use depends upon the infestation caused by the pest in the tea. The result showed that nearly half (40%) apply pesticides ten times or more in one crop cycle. This indicates that there is a high frequency of pesticides use in the tea that likely to increase toxic residue in the tea that pose higher risk to tea growers and consumers.

Table 8: Frequency of Pesticide Use

S. No.	Background variables	Jhapa		Ilam		Total	
		N	%	N	%	N	%
1.	Five or less times	6	25	-	-	6	25
2.	Five to ten times	8	33	-	-	8	33
3.	Ten times or more	10	40	-	-	10	40
4.	Total grower	24	100	-	100	24	100

5.6 Integrated Pest Management (IPM)

Integrated Pest Management means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations, keep pesticides use and other interventions to level that are economically justified and reduced or minimize the risk to human health and the environment. Integrated pest management can be applied to both agricultural and non-agricultural settings, such as home, garden and workplace. IPM strategy involves one or combinations of control techniques to optimize pest populations and keep use of pesticides and other interventions to level that reduce or minimize risks to human health and environment.

During the field survey it has been found that more than two out of three heard about IPM. But in practice, there was none of the farmers were adopting IPM in their field because of its high cost of labour as compared to pesticides application.

Fig. 4: Knowledge on IPM

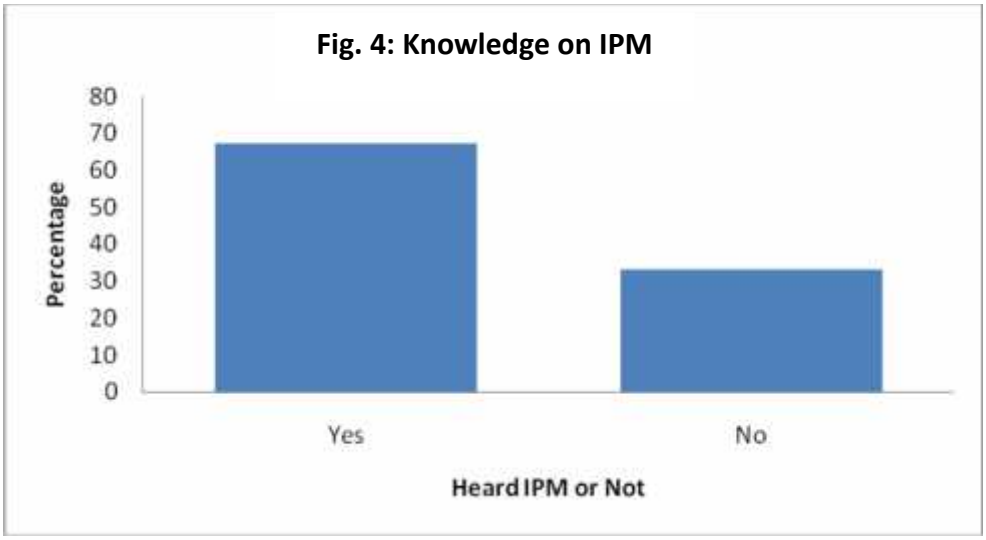


PLATE I

Figure 1 : Green Fly

Figure 2 : *Helopeltis theivora*

Figure 3 : Jassids

Figure 4 : Leaf Roller Caterpillar

Figure 5 : *Oligonychus coffeae* (Red Spider Mite)

Figure 6 : *Toxoptera aurantii* (Tea Aphids)

PLATE II

Figure 7 : *Corticium theae* (Black Rot)

Figure 8: *Exobasidium vexans* (Blister blight)

PLATE III

Figure 9: Types of Pesticides being applied during tea cultivation

6. DISCUSSION

The present study was conducted to assess the types of pests in tea and also to assess types of pesticides used and its handling practices among the users in tea in Jhapa and Ilam district of Nepal. From the study it has been observed that during the cultivation of tea, different types of pest belonging to different taxonomic groups affect the tea plant. The study showed that the common pests of tea are Aphids, Thrips, Red Spider Mite, Bunch Caterpillar Looper, Jassids, Mites and other fungal diseases. Among all prevailing pests in both Jhapa and Ilam districts, Thrips and Aphids are considered as major pest and cause a maximum crop loss.

Thrips (*Scirtothrips* sp.) was regarded as the major pest because they attack young leaves and buds and produce lacerations. As a result, the leaf surface is curled and become yellow along the leaf margin. They can cause a heavy loss and reduced the production and also the quality of the tea. During the field visit it has been known that the population of the thrips was found to be more in autumn than in the monsoon season because the humidity during the rainy season is very high (70-80 percent) which become unsuitable for their development.

Aphids (*Toxoptera aurantii*) were also considered as a major pest of tea. These black aphids were quite abundant on tea plants in both monsoon and dry season. They are found in clusters and are significantly injurious in some of the bushes. They suck the sap and secrete honey dew through anus which blocks the photosynthesis. As a result the infested leaves curl up and the growth becomes stunted. *Toxoptera aurantii*, was also reported to be the

vector of Citrus Triesteza Virus (CTV), which is an aphid borne clostero virus. This virus infect the tender citrus buds and therefore, the foliage fail to grow and hence no fruiting (Ghimire, 2000). Since, these aphids transmit disease causing virus in citrus. So it has also become possible that they may transmit disease in tea plant too.

Adult are shiny black in colour, winged or apterous. The ptero-stigma sector of the forewing is distinctly dark to black in colour. The main host of this black aphid is the citrus plants and tea, coffee and cocoa are the alternative host. Their population seems to be controlled by spraying pesticides and also employing some natural enemies like lady bird beetles, which plays a most significant role in their control. Larvae of Sirphid flies and Braconid parasites are also very effective natural enemies of aphid.

Mites have been considered as one of the notorious pest of tea plant worldwide. They also suck the sap and kill the vigour of the plant. Out of the 12 sps. recorded (Banerjee, 1988); Red spider mite, the scarlet mite, the pink mite and the purple mite are common in the North-East India.

The Red spider mite (*Oligonychus coffeae*) is the largest of all mites and can be easily seen with the naked eyes. They mainly occur in the upper surface of the leaves. The adults, nymphs and larvae feed actively on the mature leaves causing reddish brown spot at the point of sucking. As a result, these spots finally coalesce into a large single patch leading ultimately to leaf fall.
Similarly, Ants, termites, white grubs are considered as minor pests of tea plants. Grubs are found in the young plants. They eat away a ring of bark at the collar region just below the soil. There are no particular control measures

seen for the control of these pests, as their population was negligible but some of the respondent considered these grubs to be important pest as they tend to attack the young flourishing clones. So it is a wiser choice to prevent the damage rather than killing the pest; then staking of the mulch away from collar region is always helpful. Termites are seems to be active in cold weather. They may cause a negligible damage. Removal of the dead or damaged branches of tea and shed trees helps in discouraging the scavenging termites.

From the observation it was found that the environmental factors also play a major role in pest population. The increase on decrease of maximum and minimum temperature, humidity and precipitation also influenced the insects in tea plant. The increase of maximum temperature resulted in the increase of tea pest population; especially like Red spider mite, bunch caterpillar, thrips, aphids, tea mosquito bug etc. Similarly, it has been also observed that the populations of arthropod pests also decrease in tea plants with the fall of temperature. Beside all these, the tea plant also gets affected by several kinds of diseases. One of the most important diseases is Blister blight which is caused by fungus called *Exobasidium vexans*, and it is more prominent in Ilam than Jhapa because the temperature is usually low and the weather is misty and foggy most of the time in Ilam district.

The "age effect" also causes the pest infestation in tea plants to some extent. A comparison of the arthropod pest that inhabits tea in young and old habitat revealed that plants in older habitat harbored more species than in the younger plants (Banerjee, 1983). In large tea growing regions, the saturation

level in the number of species occurred during the period of 100-150 years (Agnihothrudu 1993).

The pesticides which have been applied to the tea plant during its cultivation also adversely affect the balance between pest and their natural enemies like predators and parasitoids. They also reduce the field population of natural enemies of the pests and the main reason for sub-optimal control of pests and recurrence of pest problems is that pesticide application technology is not sufficiently developed to hit the target site in different plants parts. The thick foliage of the unpruned tea often prevents spray droplets from penetrating deep in to the canopy where pests are often located (Banerjee, 1986).

Pesticide use and Health Hazards

Pesticides are those substances use to kill pests. Being highly toxic in nature they do not differentiate between target and non- target species and threaten health and well being of humans and wildlife in every region of the world (Wasseman and Wassemann, 1972). Pesticides can also affect local ecosystem by disrupting natural ecological balance. For example: by disseminating a certain species on which the survival of others depends. Pesticides can also affect predatory insects and other animals, resulting in initiating or increase of second pest infestations.

Unintentional exposure of the general public to pesticide can occur in various ways to various degrees. Contamination of food or drink with pesticides is an example of accidental poisoning. Living in a farm or in an

agricultural area where pesticides are frequently and heavily used confers a high risk of exposures.

In the surveyed areas, very few farmers (only 10%) were found suffered with pesticides hazards of which Eye/skin irritation and headache were the major symptoms associated with it. This may be due to the long term effect of pesticides.

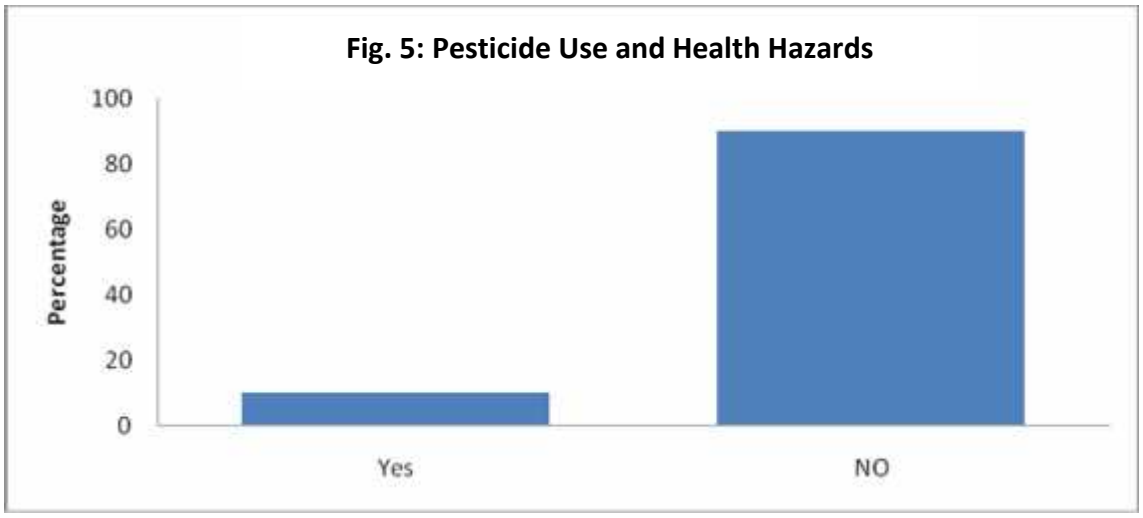


Fig. 5: Pesticide Use and Health Hazards

Use of Personal Protective Equipment (PPE)

Because of highly toxicity it is important to avoid absorption of pesticides through skin, lungs, eyes and mouth. Thus, the objective of personal protection is to keep the exposure of workers handling as low as possible. Personal protection benefits the person who uses it. The types of personal protective equipment used in the field of tea are mask, gloves, full length trouser/lunghi, full length shirt, shoes, hat or head cover etc. In the surveyed area, i.e., Jhapa and Ilam, only two-third of the farmers were using PPE. The others do not use it.

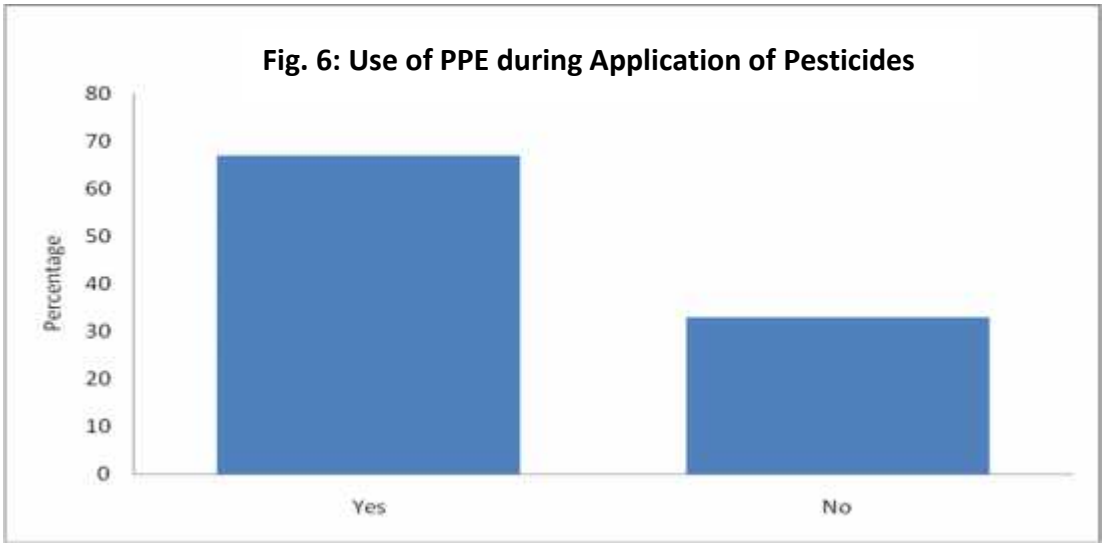


Fig. 6: Use of PPE during Application of Pesticides

7. CONCLUSION

The experimental results of the present investigation entitled "Study on Tea Pests and Pesticide Handling Practices in Tea in Jhapa and Ilam Districts of Nepal" was conducted at during 24thDec. 2009 - 06thJan. 2010.

From the study it has been concluded that different types of insect pests and diseases may attack tea plant during its cultivation. The common insect pests of tea are Thrips, Looper, White grubs, Tea mosquito bug, Red spider mite, Stem borer, Cut worm, Leaf roller, Bunch caterpillar, Aphids and Jassids. Among them only Thrips and Aphids was considered as major pest while the remaining as minor pest but in Jhapa district, Red Spider Mite was also considered as major pests. Beside arthropod pests, crop loss is also due to a fungal disease called Blister Blight, Black Rot, Brown Rot etc and among them only Blister Blight was considered as major tea disease which is caused by *Exobasidium vexans* in Ilam district.

The study also shows that the environmental factors also play a major role in visiting pattern of pest population. Similarly, the increase and decrease of maximum and minimum temperature also plays a significant role for the encouragement of pest population.

Moreover, the age effect also causes the pest infestation in tea bushes. For the control of pests, the natural enemies of the pest like ladybird beetle, Sirphid larva etc contributes to check the pest population below economic threshold level.

Nepal is predominantly an agricultural country with one-third of its gross domestic product originating in agriculture. Thus, for better production most of the farmers in the country are using chemical pesticides for the control of pest at low cost. At the same time increased use of pesticide has made pest immune to chemical.

Pesticides are the potential health hazards which have drawn attention to food quality control agencies, certification bodies, international community and trading partners. Due to the lack of regular monitoring of pesticides at the field level, the exports of tea are adversely affected in the recent years. Pesticides owing to their pest destroying properties are required in global food production but they remain inevitably present as residues in food from both vegetal and animal origin. Thus occurrence of pesticide residues in food is an immense anxiety of everyone. Therefore, pesticide use must be judicious and should be limited to a minimum because pesticides are toxic and can have serious negative effect on health and environment as well as agriculture ecosystem. Negative effect can occur throughout the life cycle of a pesticide i.e. from production, transport, storage and application to disposal. Because of these potential negative effects, pesticides should be used only as a last resort, as a part of an integrated pest management or integrated vector management programme.

8. RECOMMENDATIONS

The recommendation of the present study entitled "Study on Tea Pests and Pesticide Handling Practices in Tea in Jhapa and Ilam Districts of Nepal" is summarized as follows.

- From the observation it was found that the Aphids and Thrips are the major tea pests in both districts while Red Spider Mite is considered as major pests in Jhapa and rest are considered as minor pest. It has been recommended that proper monitoring of the pest for whole years and study of the seasonal variability and abundance is to be done in order to impart proper knowledge about the pest and their status and its control measures.
- Beside the use of pesticides it has been found that many pest populations were also reduce due to the presence of natural enemies such as ladybird beetles, Sirphid larva etc. So it is recommended to protect and encourage the natural enemy present in the tea field.
- Pest and disease vectors can be managed by various methods, the use of pesticides being only one. The control method chosen should be adapted to the local conditions and pesticides should be used only when absolutely necessary.
- Use of information from pesticides label and its dealer is most before applying it to the field. One should never use a pesticide from unlabelled container. A pesticide should not be poured into an unlabelled container unless it is to be diluted and used immediately.
- Use of Personal Protective Equipment (PPE) should be recommended during pesticides application in the field. Pesticides should be applied

only with good, well maintained equipment to reduce leaks and spillage.

- Training on Pesticide use and alternative techniques of pesticides such as integrated pest and vector management in agriculture pest control (cultural practices, including pruning, cultivation of resistance variety of tea plant, biological control agents, sanitation and creation of buffer zones are suggested.
- Human beings are most vulnerable to the health risk, because tea plant parts are directly consumed by the human. So, it is strongly recommended to use different bio-pesticides, plant based pesticides etc.