INSECT PESTS OF TOMATO (*Lycopersicon esculentum* Mill.) AND THEIR MANAGEMENT IN KAVRE DISTRICT, NEPAL

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DECLARATION

I hereby declare that the work presented in this thesis has been done by myself and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

Date: June, 2014 …………………………

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RECOMMENDATION

This is to recommend that the thesis entitled "**INSECT PESTS OF TOMATO** (*Lycopersicon esculentum* Mill.) **AND THEIR MANAGEMENT IN KAVRE DISTRICT, NEPAL"** has been carried out by Mrs. Aruna Thapa for the partial fulfillment of Master's Degree of Science in Zoology with special paper Entomology. This is her original work and has been carried out under my supervision. It is her original work and to the best of my knowledge, this work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Aruna Thapa entitled "**INSECT PESTS OF TOMATO** (*Lycopersicon esculentum* Mill.) **AND THEIR MANAGEMENT IN KAVRE DISTRICT, NEPAL**" has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Entomology.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
°F/ °C	Degree Fahrenheit/ Degree Centrigrade
a.i.	Active ingredient
AD/BS	After Death/ Bikram Shambat
DOA	Department of Agriculture
CBS	Central Bureau of Statistics
CDZ	Central Department of Zoology
cm/mm	Centimeter/Millimeter
DADO	District Agriculture Development Office
DFTQC	Department of Food Technology and Quality Control
FAO	Food and Agricultural Organization
GIS	Geographic Information Survey
Gm/Kg	Gram/Kilogram
Mt. /Ha	Metric Ton/ Hector
INGOs	International Non-governmental Organizations
IPM	Integrated Pest Management
MoAC	Ministry of Agriculture and Cooperatives
MoAD	Ministry of Agriculture Development
Msl	Mean sea level
NARC	National Agriculture Research Council
NAST	National Academy of Science and Technology
NEPCIL	Nepal Pesticide and Chemical Industries Pvt. Ltd.
NGOs	Non-governmental Organizations
PPE	Personal Protective Equipment
PMRD	Pesticide Management and Registration Division

POPs	Persistent Organic Pollutants
PPD	Plant Protection Division
Sq. Km. / Sq. ft.	Square Kilometer/ Square Feet
UNICEF	United Nations International Children's Emergency Fund
VDC	Village Development Committee
VDD	Vegetable Development Directorate
W H O	World Health Organization
WTO	World Trade Organization

ABSTRACT

Insect pests of tomato and their management practices were explored in three VDCs (Panchkhal, Nala and Mahadevsthan) of Kavre District from January to April 2011. The data were collected by direct observation and also by using semi-structured questionnaires. Altogether 48 tomato farms were observed during the study that included 16 farms in each VDC. The study revealed White fly (*Bemisia tabaci*), Aphid (*Aphis gossypii*), Tomato fruit worm (*Helicoverpa armigera*) and White grub as the insect pests of tomato. Aphid (*Aphis gossypii*) and Tomato fruit worm (*Helicoverpa armigera*) were recorded as the most problematic insects during winter and summer respectively. Farmers were found to be relied on pesticides from bedding of plant till harvesting to control pests. Commonly used pesticides include Endosulfan, Dimethoate, Cypermethrin, Chloropyrifos, Methyl parathion, Methomyl and Thiametoxan. Farmers had positive thoughts towards the pesticide use despite their familiarity on ill-effects of pesticides. Personal safety measures during application of pesticides have not been followed. Scanty knowledge, labor intensiveness and lack of coordination between the farmers were the major factors which prevented the adoption of eco-friendly alternative pest management methods.

1. INTRODUCTION

1.1 Background

Nepal is situated along the southern slopes of the Himalayas and covers 147,181 sq. km. area. Nepal is the home place of natural beauty with traces of artifacts. Agriculture is the source of livelihood for the majority of people. About 80% population is engaged in agriculture. The agricultural sector contributes about 40% of national gross domestic product (Palikhe 2002a). In Nepal different types of vegetation are grown by farmers as cash crops but some are of high value. Diverse climatic condition favors the cultivation of different kinds of fruits and vegetables in Nepal. Among various crop-cultivations, tomato cultivation is one of the important income-generating activities for small and large farmers of the hills and terai (Budhathoki et al. 2004).

The tomato (*Lycopersicon esculentum* Mill.) is a herbaceous fruiting plant which is originated in Latin America and has become one of the most widely grown vegetables with ability to survive in diverse environmental conditions (Rice et al. 1987). It is the word "tomato" may refer typically red fruit that it bears to the plant (*Solanum lycopersicum*) or the edible, particularly rich in pigments and secondary metabolites like lycopene (red pigment in tomato fruit) - a strong anti-carcinogen, and Vitamin (Sams et al. 2011). Tomato fruit is considered to be fairly high in vitamins, of high cash value and with potential for value-added processing. Tomato was regarded as a top priority vegetable by the Technical Advisory Committee of the Consultative Group on International Agricultural Research-CGIAR (FAO 2002). Recently, there has been more emphasis on tomato production not only as source of vitamins, but also as a source of income and food security. Tomato grows best in fertile, well-drained soils, with pH 6 and ambient temperatures of about 25^0C (Villareal 1979, Rice et al. 1987).

It is widely grown vegetables in the world remaining second in importance to potato in many countries, although consumption and preparation methods differ in various countries. Much of the tomato is produced for the fresh market and consumed as a component of relishes and is an important vegetable grown by both commercial and small scale farmers in open fields.

The physical and chemical characteristics of the soil or artificial media, the greenhouse internal environment and the nature of the plant determine the most critical productivity parameters for plant growth (Johnson 1991).

1.2 Tomato cultivation and production in Nepal

Nepal has a marvelous opportunity for producing vegetables as diverse agro-eco-zone favors both season and off-season varieties. Due to this advantage farmers are encouraged to produce vegetables (Budathoki 2006). Thus production and productivity of vegetables has been increasing significantly for the last decade. Nepal has potential for fresh vegetables in the international market as well (Koirala and Tamarkar 2008).

Tomato is commercial vegetable crops in Nepal and has constant demand throughout year (Ghimire et al. 2001). It is grown all over country and is used in a variety of ways. Cultivation of this crop is getting popular day by day for quick and high income generation. It is reported that income of Rs.65,000 to Rs.100000 per ropani of plastic house is obtained by farmers at Kathmandu, Pokhara, Lamjung, Lalitpur, Bhaktapur, Palpa, Parbat, etc. (Budhathoki et al. 2004). In Nepal, tomatoes of different varieties are grown like Srijana, Roma, Manorekas, NBL-1, Pusa Ruby. These types can be grown in high hills, mid hills and in terai regions (NARC 2010).

Though tomato is best suited to the terai, in low and mid hills, it is becoming increasingly attractive for cash generation in the high hills also (Pandey and Chaudhary 2004). Since, tomato supply from Terai is constrained by high temperature, low fruit set, low flowering, bacterial wilt, etc (Pandey et al. 2006). Tomato produced from mid June to November in the hills (400-1800 m) fetches higher market price ranging from Rs.20 to Rs.35/kg in domestic and external markets (Budhathoki et al. 2004). Tomato varieties are very sensitive to micro-climatic condition. Due to this reason, those varieties performing better in western region may not be suitable for eastern region. Maximum day and minimum night temperature above 32^0C and 21^0C respectively are known to limit fruit set due to an impaired physiological process in flower and fruit setting (Bhattarai and Subedi 1996).

In 2009/10, total area and production of this crop in Nepal was estimated Rs.15,609/ha and 242,018 mt. respectively with an average productivity of 15.5 mt/ha (VDD 2010). According to statistical agricultural data of 2011/2012, in Kavre district 2520 ha area were used for tomato production with 40320 mt and yield were 16 mt/ha (Atreya 2007).

1.3 Tomato pests

Tomatoes are subject to attack by a large number of insect pests from the time plants first emerge in the seed bed until harvest. Common tomato pests are stinkbug, cutworm, tomato horn worm and tobacco hornworm, whitefly, aphid, Cabbage lopper, tomato fruit worm, red spider mite, flea beetle, slug and Colorado potato beetle (Sharma 1996). However, severe damages may result either from their feeding on the fruit or by spreading certain diseases (Hahn 2009).

Farmers are using different types of pesticides as control measures to damage such pests so as to increase crop yield. They are using pesticides to decrease or destroy their enemy pests. Pesticides in the form of organic or inorganic types are used either to destroy whole or partial life cycle of insects. Pesticides have contributed increase in crop yield in quantity and varieties. Pesticides are toxic in nature and do not differentiate between targeted and non targeted species hence should essentially be subject to safe and judicious use (Koirala and Tamrakar 2008).

1.4 Development and Uses of Pesticides

The international code of conduct on the distribution and use of pesticides defines pesticides as “any substance or mixture of substances intended for preventing, destroying or controlling any pests including vector of humans or animals causing harm during or otherwise interfering with, the production, processing, storage, transport or marketing of foods, agricultural commodities, wood and wood products or animal feed stuffs or which may be administered to animal for the control of insects, arachnids or pests in or on their bodies” (FAO 1994).

Synthetic chemical pesticides like Organochlorine, Organophosphate, Carbamates and Synthetic pyrethroids were invented after DDT and used from 1950 to 1970 A.D. (MoAD 2011a). NEPCIL was the first pesticide production factory established in 1977 at Bahadurganj, Kapilbastu to produce some major pesticides gammaxene, methyl parathion and zinc phosphide. Presently, Indian Pesticide dealers cross the open border freely, selling pesticides in the Terai region and in major towns of Nepal (Palikhe 2001).

There are around 71 common pesticides under 306 trade names in which 210 insecticides, 64 fungicides, 18 herbicides, 9 rodenticides, 1 miticide and 4 others are available in the market while several available pesticides are possibly carcinogenic to humans (MoAC 2005).

1.5 Statement of the Problems

The use of pesticides in the tomato plant is to control pest attacks. The pests cause wide spread destruction in tomato cultivation. Once identified, the pests can be controlled by biological or physical methods. The present study was carried out in the pocket areas of Kavre district such as Panchkhal, Nala and Mahadevsthan VDCs to identify the major pest problems and pesticides used in the tomato field. Nepal has enough export potential for agriculture and processed products in the international market. As Nepal has already become a member of WTO, this opportunity can be best utilized.

Pesticide use or disuse in the production and distribution of products has become an important public policy issue. Although, average consumption of pesticides in Nepal is far lower than many other developed countries, the problems of pesticide remain very high in Nepal. Pesticide surveillance report revealed that the presence of pesticides in different vegetables commodities is high in the country.

1.6 Objectives of the study

The main objectives of this study are to find out the insect pest infesting the tomato plant and the control measures being followed against the pests in tomato plants.

- To report insect pests of tomato.
- To study chemicals used in control of tomato pests.
- To explore knowledge, attitudes and practices regarding use of pesticides.
- To know the awareness level related to pesticide use.

1.7 Rationale of the study

This study will report pest and its problems in tomato cultivated areas of Kavre district. This vegetable is most vulnerable to pests and number of pesticides used is also high. This district has high production rate of tomato. Identification of various pests and use of different types of pesticides for pest control will be helpful for farm authorities in implementing desired control measures. The survey will also be helpful to planners, policy makers, farmers, governmental and non- governmental organizations.

1.8 Limitation of the study

The study covers a limited physical area within Kavre district, even though it contains number of VDCs. Time factor, budget, difficulties to accessibility, one man research work and small study area were the major constraints of the study.

2. LITERATURE REVIEW

2.1 Tomato

Tomato is classified as order Solanales with Solanaceae (nightshade) family, and genus as *Solanum* and species as *Lycopersicon esculentum,* which is a key food and cash crop for many low income farmers in the tropics (Prior et. al. 1994). Tomato is a fresh vegetable with increasing popularity and the global production of tomato is 80 million tons (INTA 2002).

Tomato is herbaceous annual plant with a creeping stem covered with hairs. The plants are characterized either as indeterminate or determinate types based on plant habit and vigor (Papadopoulos 1991). The plants typically grow to 1–3 meters (3–10 ft) in height and have a weak stem that often sprawl over the ground and vines over other plants. It is perennial in its native habitat, although often grown outdoors in temperate climates as an annual. The determinate types eventually form a flower cluster at the terminal growing point, causing the plant to stop growing in height (Papadopoulos 1991). Determinate tomatoes are bushy and usually stop growing at about 1.5 m. The leaves are compound and alternate. The flowers are borne in inflorescences of 4–6 yellow flowers. The fruits are in a variety of shapes; round, elongated, cylindrical and oval or pear shaped and in varying sizes (UNICEF 2006).

2.2 Origin and dispersion of tomato

The tomato is native to South America. Genetic evidence shows the progenitors of tomatoes were herbaceous green plants with small green fruit and a center of diversity in the highlands of Peru. One species, *Solanum lycopersicum*, was transported to Mexico, where it was grown and consumed by Mesoamerican civilization. The large, lumpy tomato, a mutation from a smoother, smaller fruit, originated in Mesoamerica, and may be the direct ancestor of some modern cultivated tomatoes (Smith 1994).

The tomato is native to South America. The poor taste and lack of sugar in modern garden and commercial tomato varieties resulted from breeding of tomatoes which ripen uniformly red. This change occurred after discovery of a variety in the mid 20th century which ripened uniformly which was then widely cross-bred to produce attractive red fruit without the typical green ring surrounding the stem on uncross-bred varieties. Prior to general introduction of this trait tomatoes were able to produce more sugar during the process of ripening and were sweeter and more flavorful (Gina 2012).

2.3 Ecological requirements

Tomatoes should be planted in well prepared, fertile soil, mulched and properly watered to promote vigorous growth. Tomatoes grow best when the daytime temperature is between 65°F and 85°F. They stop growing above 95°F. If nighttime temperatures are above 85°F, the fruit will not turn red. Tomatoes need full sun and warm, well-drained soil. Tomato plants need night temperature above 32°F and daytime temperatures above 60°F. They are readily killed by a light frost. A week of cool daytime temperatures (below 55°F) will stunt plants, reducing yields. The time from planting to harvest is 50 to 180 days from transplants, depending on the variety. The color when ripe depends on the variety. Ripe tomatoes should feel firm, neither squashy nor too hard. Tomatoes have a low nitrogen requirement. Under high nitrogen conditions, vines grow excessively large at the expense of fruit production (Rice et al. 1987).

The tomato is grown around the world, both outdoors and under glasses for fresh market consumption and for processing. Stressed plants tend to attract more insect pests than healthy plants and healthy plants are better able to tolerate insect damage (Villareal 1979). It requires protection from a variety of pests, including pathogens, weeds, nematodes, and insects and other arthropods. A review of arthropods in tomato pests complex is timely new programs for management of tomato pests are emerging. Tomatoes wherever grown are hosts for many kinds of insects all parts of the plant offer food, shelter and reproduction sites for insects. Insects can cause unthrifty growth or death of tomato plant and damage to fruit in the form of scarring, tissue destruction, and aberrations in shape or color. Fruit can become contaminated by whole insects; insects’ excreta and insects’ parts that cause growth disorders or death of plant (Lange and Lorin 1981).

2.4 Tomato cultivation in the World

According to FAO (2003) reports, tomato is now the most important vegetable in the tropics. It is annually planted on almost 4 million ha worldwide. The tomato is now grown worldwide for its edible fruits, with thousands of cultivars having been selected with varying fruit types, and for optimum growth in different growing conditions. Tomato is one of the important and popular vegetable and plays an important role in balanced nutrition. Tomato crop not only provides maximum output but also give more income per unit area of land to the farmers (Gandhi et al. 2008).

2.5 Factors Limiting Tomato Yield

Low tomato yields are due to a number of factors. These include (1) lack of improved well-performing varieties, (2) poor fruit setting due to heavy rains and excessively high temperatures, which limit pollination, more specifically fecundation plus pollen viability, and (3) pests and diseases (Villareal 1979, Lyons and Howard 1985, Ladipo 1988). In eastern and southern Africa, arthropods, and fungal as well as bacterial diseases are considered to be the major constraints to tomato production. Viral diseases have been ranked as the third most important constraint among tomato diseases, basically because of absence of enough information on them (Varela 1995).

2.6 Pests of tomato and their impacts on their production

Insect pests can damage tomato throughout the growing season, but severity varies with location and time of year. While many insects that feed on tomato are only occasional pests, a few species are common pests and occur every season. The severity of damage to tomato by insect pests is largely due to abundance of the pests, which is related to environmental conditions (Sharma 1996). According to Neupane (2000), the pests of tomatoes which are mostly found in Nepal are (A) Leaf and stem eating insect a) Tobacco caterpillar (*Spodoptera litura*), b) Potato tubermoth *(Phthorimaea operculella*), c) Spotted beetles *(Epilachna vigitioctopunctata, Epilachna pusillanima).* (B) Leaf and stem sap-sucking insects a) Aphid (*Aphis gossypii, Myzus persicae*), b) Cotton jassid (*Amrasca biguttula biguttula*), c) White tailed Mealy bug (*Ferrisia virgata*) and d) White fly (*Bemiia tabaci*). (C) Leaf miner -Leaf digging fly (*Phytomyzea horticola* Gourear) (D) Fruit infect insect-fruit borer a) Chickpea Pod Borer (*Helicoverpa armigera*) b) Fruit fly (*Bactrocera dorsalis*).

a) **Chickpea pod borer** (*Helicoverpa armigera*, Hubner)

It is one among major biotic constraints in chickpea under farmer's field and is the key pest that causes economic losses throughout the Indo-Gangetic Plain (IGP) (Pande et al. 2000). Besides, it has been identified as most important biotic constraint in tomato production (Pandey et al. 1996) and causes more than 80 percent fruit damage (Atwal and Dhaliwal 2002). It is cosmopolitan, polyphagous pest (Mehto et al. 1985) attacking more than 200 plant species (Pawar, C.S. 1998). It is one of the most notorious pests and regarded number one among the 10 worst pests all over the world (Manjunath 1997). Regarding pest problem in Nepal, *H. armigera* is widespread across the country and considered as the national priority entomological research problems (Manandhar 1997). In addition, this pest is increasingly becoming a severe threat of winter season tomato for the last few years in Nepal (G.C. et al. 1997). The caterpillars are voracious feeders of developing fruit and single larva can completely destroy a lot before it reaches to the maturity (Atwal and Dhaliwal 1997). It feeds on fruit and contaminating it with excrement and decay causing organisms. They usually bore deeply into the fruit, feeding with the entire body inside. Fruits become unmarketable due to disfigured surface and rotting through secondary infection (Tiwari and Rao 1987). The life cycle of *H. armigers* passes through egg, larva, pupa and adult stages within 28-30 days and adults are nocturnal.

b) Whitefly (*Bemisia tabaci*)

Its main hosts are cotton, tobacco and some winter vegetables; including tomato, the infestation on these crops is sporadically severe and found in most of the countries in tropics and subtropics. It is white, tiny, scale-like insects may be seen darting about near the plants or crowding in between the veins on ventral surface of leaves, sucking the sap from the infested parts. As a result of their feeding the affected parts become yellowish, the leaves wrinkle and curl downwards and are ultimately shed. Besides the feeding damage, the severe infestation that this black coating is so heavy that it interferes with the photosynthetic activity of the plant resulting in stunted growth. This whitefly also acts as a vector, transmitting the leaf curl virus. Adults are minute insects, about one mm long, covered completely with a white waxy bloom (Paul and Navarajan 2007).

c) Aphids (*Aphis gossypii*)

It is soft-bodied, pear-shaped insects which feed in colonies, cause discoloration or mottling of the foliage; excrete honeydew on which sooty mold grows. The damage reduces fruit set and if severe enough can kill the plant. In addition as a byproduct of feeding, aphids excrete honeydew, which acts as a growth medium for sooty mold. The black-colored mold, on the foliage, reduces the light available for photosynthesis and on the fruit, causes discoloration and acts as a solar heat sink, increasing the severity of fruit sunburn (Farrar et al. 1986). High levels of aphids cause significant fruit quality and yield losses. Fruit quality loss also results from sunscald because of plant defoliation resulting from aphid feeding (Hummel 2004).

d) Colorado Potato Beetle (*White grub*)

The Colorado potato beetle is one of the more serious pests of tomatoes because it can completely defoliate tomato plants resulting in substantial yield reduction. Overwintering adult beetles begin emerging from the soil in mid May when tomatoes are transplanted or when seedlings break ground in direct-seeded fields. Eggs are deposited on tomato leaves. Upon hatching, the larvae feed on the foliage for two to three weeks. Following 5-10 days pupation period in the soil, the adults return to feed on plants. Research has shown that untreated tomato plants incurred 85% defoliation from beetles (Ghidiu and Linduska 1989). Tomato yield in the untreated plots averaged about two tons per hectare while the treated plots yielded 20 tons per hectare (Linduska 1978).

2.7 Management of pests and pesticides use

Vegetables are part of a healthy diet but can be source of poisonous toxic substance-pesticides (Knezevic and Serdar 2008). Over 1000 compounds may be applied to agricultural crops in order to control objectionable moulds, insects and weeds (Otelli et al. 2006). Pesticides' striking effort in preventing, crop loss and controlling pests and vectors of diseases have led to their acceptance and expanded use throughout the world (Sharpdan and Peter 2005).

In most of the cases, pests are also controlled by using pesticides. Pesticide is one of the input factors used to increase agricultural productivity by protecting plants and crops from pests and diseases. The use of pesticides varies with the types of land and crops, access to market and socio-economic condition of the people. Modern chemical pesticides were used in this area in late 1950s for the eradication of malaria by the government. But the use of pesticides for the protection of plants and crops by local farmers in the area started since 1983/84. The use of pesticides has been increasing with the increase in area under cash crops. Local people perceive that more input of pesticides gives more output of crops without paying adequate attention on the negative impact on environment and health (Pujara et al. 2002).

2.7.1 Pesticides consumption in the world

Asia dominates the global market for agrochemicals accounting for 43.1% of global agrochemical revenue in 2008 (Agronews 2009). China is the world's biggest user, producer and exporter of pesticides (Yang 2007) and India is the Second largest pesticide producer in Asia and ranks in the 12th position globally (WHO 2009) with a value of US $ 0.6 billion, which is 1.6% of the global market. Also, India is the second largest user of pesticides after China in Asia (Shetty et al. 2010), where consumption of pesticides is 0.381 kg a.i./ha which is more than double as compared to Nepal (142 gm a.i./ha) but low as compared to the world average. Pesticides classified as being extremely or highly hazardous by FAO and WHO. According to WHO, developing countries use about twenty-five percent of the pesticides in the world and the use is in increasing trend. This intrinsically dangerous technology is being promoted in a setting without technical and human resources to control it properly.

2.7.2 History of pesticides use in Nepal

Nepal has immense diversity in agro-climate and crop production allowed by spatial variation, but pests are the major constraint in agriculture production system. Studies indicated that about 35-40% pre- and post harvest losses are caused by pests (PPD and FAO 2004). And several types of chemicals are used to control pests of the major crops in Nepal (Thapa 1999). Chemical pesticides are useful in reducing pest population and incidence; however, there exists a problem of environmental pollution, possibility of development of resistance, degradation of soil fertility and destruction of natural enemies. Due to misuse and over use of pesticides, many harmful effects have been observed on human beings and the environment (Thapa 2003). The sequential order of different groups of pesticides introduced in Nepal is: 1950s–organochlorines; 1960s–organophosphates; 1970s–carbamates; 1980s–synthetic pyrethroids (Manandhar 2007). Now, Nepal import pesticides from six different countries-India, China, Malaysia, Singapore, Italy and Japan (PRMD 2009). Local manufacture is in small quantities. At present, there are four industries that have been registered to manufacture and formulate pesticides. Pesticide Registration and Management Division (PRMD) under the Ministry of Agriculture and Cooperatives is responsible for registration of pesticides as well as providing license for import and distribution of pesticides to retailers and wholesalers according to Pesticide Act 1991.

Majority of registered pesticides are insecticides (36/76) followed by fungicides (18/76) (Koirala et al. 2009). There is possibility of an open border trading of commonly used pesticides and some of the banned pesticides such as DDT and BHC. It is somewhat difficult to document the amount of illegal trading and thus the size of such trading has not been reflected in the public data so far. Even pesticides banned by the government like chlordane, DDT, dieldrin, aldrin, endrin, heptachlor, toxaphene, mirex, lindane, BHC, lindane, phosphamidon, organ mercury fungicide, methyl parathion, monocrotophos, endosulfan and others are being used illegally (Acharya 2013).

Though pesticides are used to prevent crops from pests and birds, many farmers use these harmful chemicals to earn a huge profit in a short time. Over 3 million people across the world are affected by pesticides out of which 220,000 die, according to the World Health

Organization (WHO 2003). Endosulfan is used in ponds, streams and rivers for killing fishes. This has created potential danger for extinct of the most commonly and in large quantities available native species of fishes. Similarly, endosulfan is also used to attain polished appearance in vegetables such as tomato, brinjal, mustard leaves. Use of date expired pesticides and throwing pesticide containers at public places is a wide-ranging practice (Manandhar 2007). In Nepal, the number of farmers using chemical pesticides has been increasing. The proportion of vegetable growers using pesticides increased from 7.1% in 1991/92 to 16.1%in 2001/2002 (CBS 2006). Among the development regions the use of chemical pesticides was higher (31.9% of the total use) in the Central Development Region and the lowest (6.4%) in the Far Western Development Region in 2001/02. Studies have shown that more than 90% of the total pesticides are used in vegetable farming (Atreya and Sitaula 2010).

The trend of pesticide use is increasing in Nepal by about 10-20% per year and expenses on pesticide in market oriented vegetables and fruit production has been a major cost factor. A study showed that chemical pesticides are used by 25% of Terai households, 9% of mid hill households and 7% of mountain households (CBS 2003).

2.7.3 Effects of pesticides in environment and human health

Human health depends on the environmental conditions people live in. Occupational health, which is well researched in developed countries, remains neglected in developing countries (Nuwayhid 2004) including Nepal (Poudel et al. 2005).

Pesticides belong to chlorinated hydrocarbons, organophosphates, carbamates, synthetic pyrethroids and zinc compounds are used widely, which have carcinogenic effects on human health (Vainio 1999). In the areas of semi-commercialized agriculture, farmers are injudiciously using various pesticides for an increased productivity and risk mitigation in crop production (Adhikari 2002). According to Palikhe (2006), more than 60% of the applied pesticide remains in the soil materials polluting soil environment as a risk to terrestrial as well as aquatic biosphere. The residual effects of some of the chlorinated hydrocarbons like Chlordane, BHC, DDT and aldrin remain in soil for a period of more than nine years (DOA

2001). Imprudent disposal of obsolete pesticides is also of serious concern as a considerable quantity of persistent organic pollutants (POPs) stored indifferent warehouses would be detrimental to the prevailing ecosystem in the locality. The potent chemicals for killing pests have elevated anxiety that they are agents of human diseases and environmental pollution. Pesticide residues in food are global problems (Abinash and Singh 2009).

Excessive use and inappropriate handling of pesticides cause damages of environmental resources and different health related problems. Nepal has been experiencing various environmental and health hazards due to misuse of pesticides (Klarman 1987, Baker and Gyawali 1994 and Dahal 1995).

Agriculture work is one of the most prevalent types of employment in the world. Nearly 50 percent of the world labor is employed in agriculture and they carry significant risk for development of pesticide risk (Das et al. 2001). Global warming will create a promising threat in pesticide safety in foods and human health (Koirala et al. 2009). The potential impact of climate change on pesticide safety is a widely debated and investigated issue (Bailey 2008). Most of the farmers are not aware of the chemical hazards, lack knowledge to the right use of pesticides and do not have adequate knowledge of safety measures. In the Nepalese context, pesticides are not only hazardous but also highly persistent in nature (Neupane 2000). They leave long term effects, such as effect in soil, environment, human health, ground water contamination, pesticide resistance, pest resurgence and other ecological effects but these effects are being neglected by the farmers (Thapa and G.C. 2000). So at least application of pesticides only on identified problems on right time can reduce quantity and hazard to non-targeted organisms.

One issue of particular importance is the use of pesticides on farms, which has a significant negative impact on farmers' health (Rola and Pingali 1993, Ajayi 2000). Pesticide pollution not only affects human health, but also affects other environmental factors, such as soil, surface and ground water, crop productivity, micro and macro flora and fauna, etc. (Pimental 2005). Despite such environmental and health effects, farm workers continue to use pesticides in ever increasing quantities (Wilson and Tisdell 2001). Pesticide exposure can have chronic and acute impacts on human health. Long-term, low-dose exposure to pesticides is increasingly linked to human health effects such as immune-suppression, hormone disruption, diminished intelligence, reproductive abnormalities, and cancer (Gupta 2004). Farm workers also experience day-to-day acute effects of pesticide poisoning, including symptoms such as headache, dizziness, muscular twitching, skin irritation, respiratory discomfort, etc (Antle and Pingali 1994, Yassin , Abu Mourad and Safi 2002, Maumbe and Swinton 2003).

Majority of the farmers are unaware of pesticide types, level of poisoning, safety precautions and potential hazards on health and environment (Yassin et al. 2002). The resultant effects on human health include cancer, birth defects, reproductive problems, tumors, and damage of liver, kidney and neural organs. In any developing countries like Nepal, most pesticides are associated with adverse effects on human health and environment due to inappropriate use and handling of pesticides by inadequately trained farm workers (Naidoo et al. 2010).

Farmers use pesticides indiscriminately at higher dosages as per their access and perceived knowledge. In some pocket areas of Nepal, they spray chemical pesticides frequently without considering the economic threshold of the pests and at higher dosages than it is required (Maharjan et al. 2004). There has been growing concern all over the world about the adverse effects of pesticides in agriculture, human health and the environment including soil health and water pollution (Manandhar 2004).

2.7.4 Misuse of pesticides

Misuse of pesticides, especially the broad spectrum ones in Nepal has caused pests to adapt and become resistant to the pesticides (Yadav and Lian 2009). Most pesticides are then required at higher doses to achieve the same level of control. Farmers generally do not follow the pre-harvest waiting period. They apply pesticides near harvesting time, and some farmers even dip vegetables in pesticides before selling (Dahal 1995). Misuse of pesticides has been reported from farmers, distributors and importers who do not realize the extent to which pesticides are poisonous and hazardous to human beings and environment. For instance, endosulphan is a broad spectrum insecticide and has been restricted in many countries as it is highly toxic to fish, but Nepalese farmers place pesticides into rivers and streams in order to catch fish (Sharma 2011). Unregistered and illegal products, open air sales, sales of banned products, cases of decanting and reweighing, fake pest control products using counterfeit labels, sales of expired products with modified expiry dates are among the misuse cases that have been reported in Nepal (Sharma 2011).

2.7.5 Alternative methods of pest management

Market-oriented production and agricultural intensification are leading farm workers to increase pesticide use at a rapid rate. There is also inappropriate and excessive use of chemical pesticides in some highly commercialized agriculture sectors. In response, Nepal's National Agricultural Perspective Plan has emphasized integrated pest management (IPM) to reduce pesticide use (Atreya 2005).

Integrated Pest Management (IPM) is a philosophy and approach of reducing the status of pest, however, it has been lately realized in Nepal. The indiscriminate use of pesticides and their negative consequences had necessitated its urgency (Thapa 1991, Thapa et al. 1995, Thapa 2003) and it was emphasized since 10th five-year plan as a best pest management alternative (Neupane 2003). IPM seeks to integrate all possible actions available to the farmer, such as selection of resistant crop varieties, correct planting time, optimal growing conditions, manual pest control, use of repellents and pheromones, use of biopesticides, careful and correct use of synthetic pesticides, etc. to reduce pest damage to a minimum. IPM programmed combine knowledge from plant physiology, plant nutrition, applied entomology, plant pathology, weeds science and nematology (Palikhe et al. 2003). Underpinning the work of each of these functional disciplines, however, are the more fundamental scientific principles of ecology, population genetics, socio-economics, and crop production (IPM 1978). Realizing its relevance and potential, the Nepal government has given priority to train farmers in IPM methodologies through IPM farmer field schools. The field schools are both a technical and a social process that relies on well-functioning institutions and must be implemented through an ecological and farmer-driven program (MoAD 2011b).

3. MATERIALS AND METHODS

3.1 Study area

The study areas are Panchkhal, Mahadevsthan and Nala VDCs of Kavre district which fall under central development region of Nepal and a part of Bagmati Zone. The district, with Dhulikhel as its district headquarters, covers an area of 1,396 km^2. The three VDCs of district were taken purposively based on the criteria of highest production statics. Panchkhal, Mahadevsthan and Nala VDCs of Kavre district were selected as the study sites, are on the way of Araniko highway through Banepa municipality and Dulikhel municipality. In each VDC 16 farmers and all together forty eight farmers with their field were visited. The farmers involved in the production of the high value food production have been selected for the purpose. Then enlisting all the commercial farmers in the selected VDCs was done and at least 10% of the sample population was taken for the study purpose and questionnaire survey.

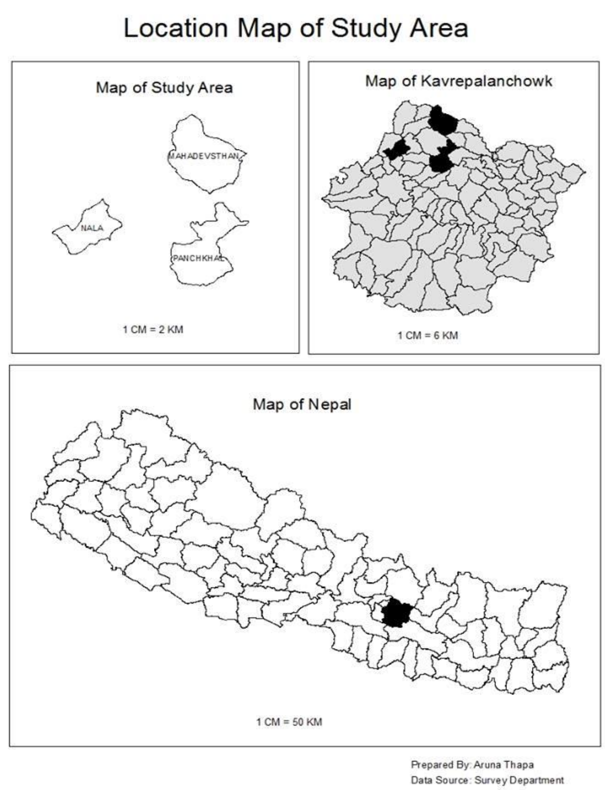

Figure 1: Location map of study area

3.2 Climate

As the climate data of Panchkhal, Nala and Mahadevsthan VDCs was not available so the climatic record of the nearest metrological station, Dulikhel (elevation 1552) was used. The climate of these three VDCs is sub-tropical type.

According to the meteorological data 2011 (Appendix 1: Source: Department of Hydrology and Metrology, 2011) the mean of monthly maximum temperature ranged from 15.5ºC during December and 27.9 ºC during May and minimum temperature ranged from 2.2ºC during January and 18.8ºC during July (figure 2).

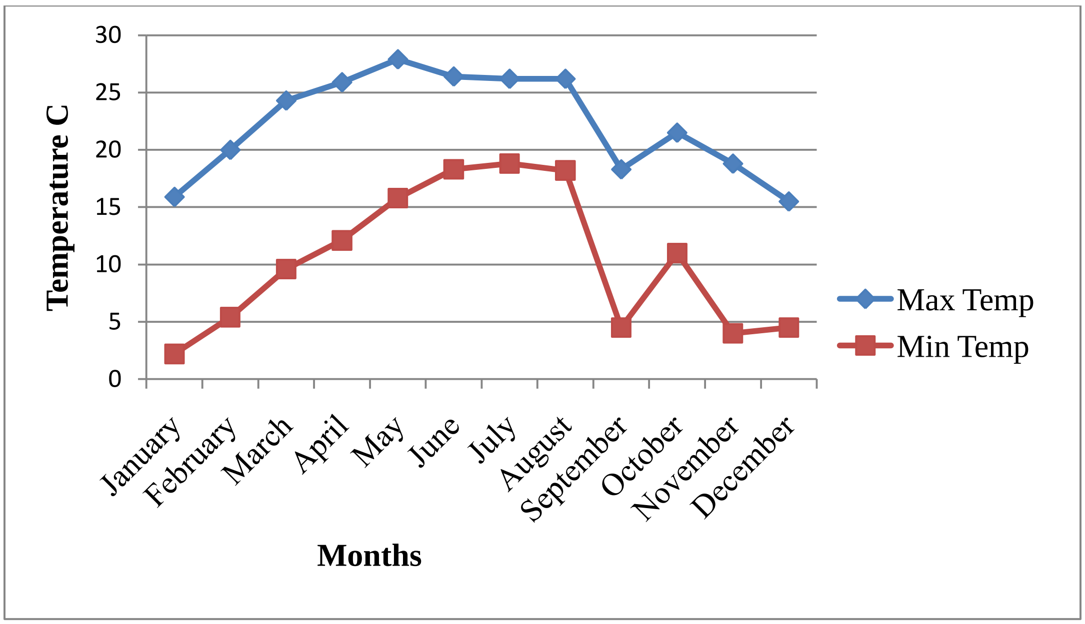

Figure 2: Monthly Maximum and Minimum Temperature (ºC) of Kavre district.

The average monthly relative humidity in morning ranged from 96.1% during August and 64.9% during April and average monthly relative humidity during evening ranged from 89.1% during July and 63% during March. The most humid month was June, July, August, September and October (figure 3).

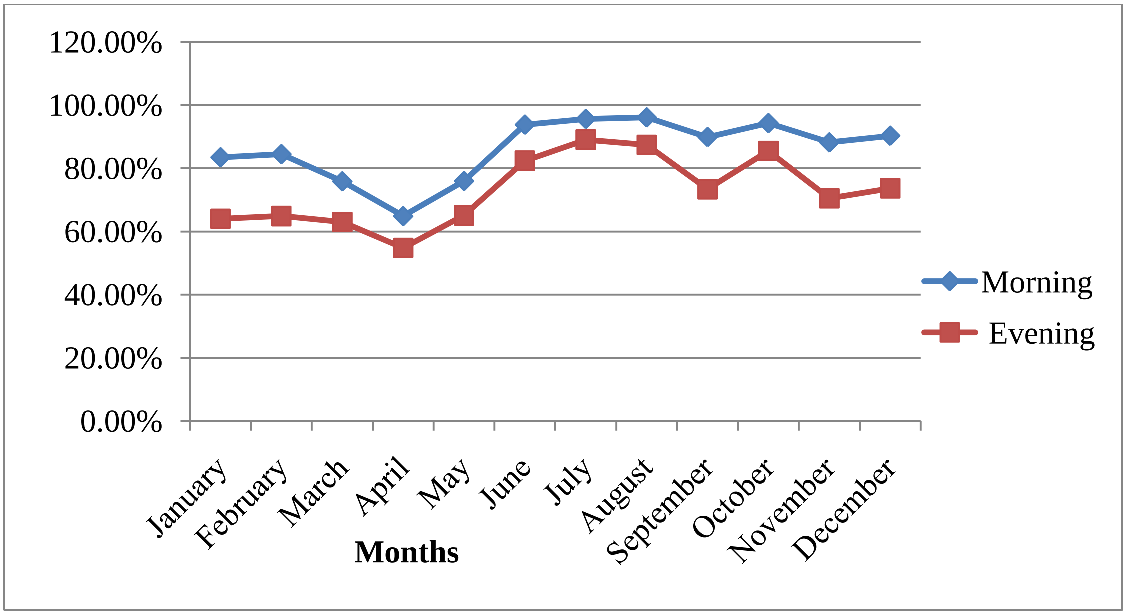

Figure 3: Monthly Relative Humidity of Morning and Evening (%) of Kavre district.

The average annual rainfall ranged from 1.2 mm during March and 423.2 mm during July. The mean annual precipitation recorded in this station was highest during July and lowest during August, October, November and December (figure 4).

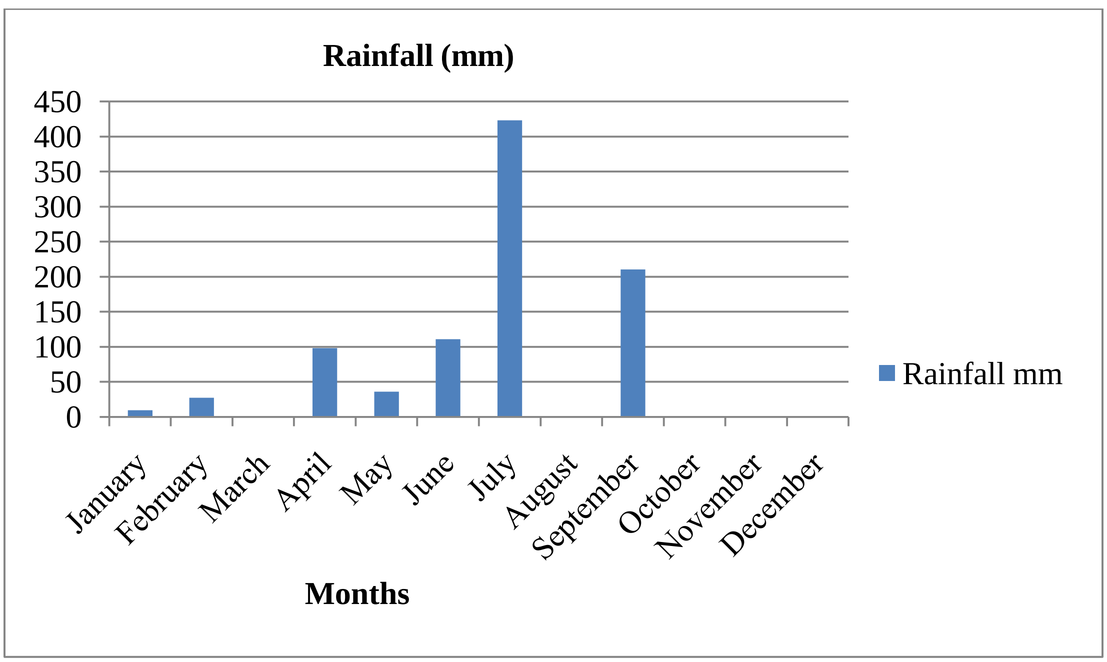

Figure 4: Monthly Average Rainfall (mm) of Kavre district.

3.3 Data collection

The study was based on primary as well as secondary data. The secondary data have been collected from both published and unpublished literature from different sources like related publication, journals, scientific papers, websites, government and non-government institutions.

The primary data have been collected by visiting the study sites. Interview with structured questionnaires and field observations are the two major tools for data collection. The data was collected on January, February and March in 2011 A.D.

In addition, tomato field has also been visited for direct observation of the plants and insect pest collection, the information on pesticide used was also taken from farmers, agro-vet dealers, government agencies and related associations through a structured questionnaire (Appendix 4).

3.4 Pest collection and Preservation

For collecting the pest and studying their incidence level a random sampling method was applied which covered 10-15% of the total tomato plants of their respective field. Pests which are large enough to be seen readily with naked eyes were collected by hand picking method with the help of forceps and were put in bottle containing 70% alcohol. Each specimen was then labeled including date of collection, condition of host plant and location.

3.5 Specimen deposition

The collected specimens were deposited in Central Department of Zoology.

3.6 Data analysis

Species diversity includes both species richness and evenness. It was calculated by following the index methods of Shannon-Weiner (1948) for measuring species diversity of communities.

$\overline{H} = -\Sigma pi \ln pi$ Where,

$\overline{H}$ = Shannon diversity index.

pi = the proportion of individuals of species i = ni/N

ln = loge = Natural logarithms(base e)

3.7 Photography

The specimen photographs were then taken by Nikon 8.0 digital camera. The photography of nursery plants and infestations of pest in natural state were captured. The photographs of pesticides container and pesticides appliances were also taken for further study.

4. RESULTS

4.1 Land holding of the respondent farmers in tomato cultivation

Mean land holding size under tomato cultivation of total 48 respondent farmers of the study area were different in different VDCs. It was the highest (40.6%) in Nala and lowest (21.4%) in Mahadevsthan and 38% in Panchkhal of the respondent farmers are commercial growers of the study area. Few of them have as low as 7 Ropanis land and some of them have as low as 1 Ropani land under tomato cultivation. The data show that more land has been used for tomato cultivation in Nala VDCs than Panchkhal and Mahadevsthan VDCs, where as in Mahadevsthan VDCs lesser land has been used for tomato cultivation than Nala and Panchkhal VDCs (Table 1).

Table 1: Land used for tomato cultivation by the respondent farmers in the study area

VDCs	Land used (Ropani)
Panchkhal	28.5 Ropani
Nala	30.5 Ropani
Mahadevsthan	16 Ropani

4.2 Arthropod pests infesting tomato plant in three different sites

Different arthropod pests were found in tomato field during field visit. Altogether 4 species of insect pests were recorded from tomato field in the study area. The arthropod pest species belonging to 4 orders i.e. Hemiptera, Homoptera, Lepidoptera and Coleoptera. Their families are Aphididae, Aleyrodidae, Noctuidae and Scarabeidae of arthropod pests (Appendix 2).

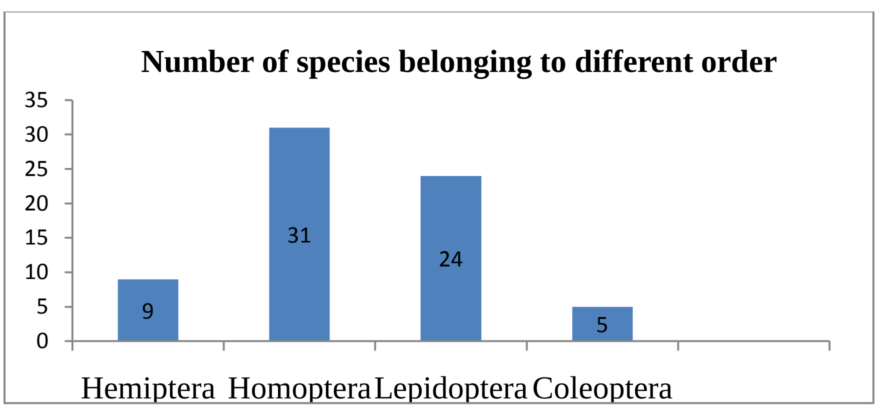

Figure 5: Number of species belonging to different orders

In site A, White fly (*Bemisia tabaci*), Aphid (*Aphis gossypii*) and Tomato fruitworm (*Helicoverpa armigera*) were found. Among these three species Aphid (*Aphis gossypii*) was found more in number where as White fly (*Bemisia tabaci*) was less in number. (Appendix 2).

In site B, Aphid (*Aphis gossypii*), Tomato fruitworm (*Helicoverpa armigera*) and White grub were found. Among these five species, Aphid (*Aphis gpssypii*) was found more in number and White Grub was found less in number. (Appendix 2).

In site C, White fly (*Bemisia tabaci*), Aphid (*Aphis gpssypii*), Tomato fruitworm (*Helicoverpa armigera)* and White grub were found, Among these four species, Aphid *(Aphis gossypii*), was found more in number and White Grub was found less in number. (Appendix 2).

4.2.1 Number of insect species found in different sites

The species number found in three different sites were variable. The data shows that site C (Mahadevsthan) constituted the highest number of species with a total of 4 species whereas site A (Panchkhal) and site B (Nala) constituted the lowest number of species with a total of 3 species.

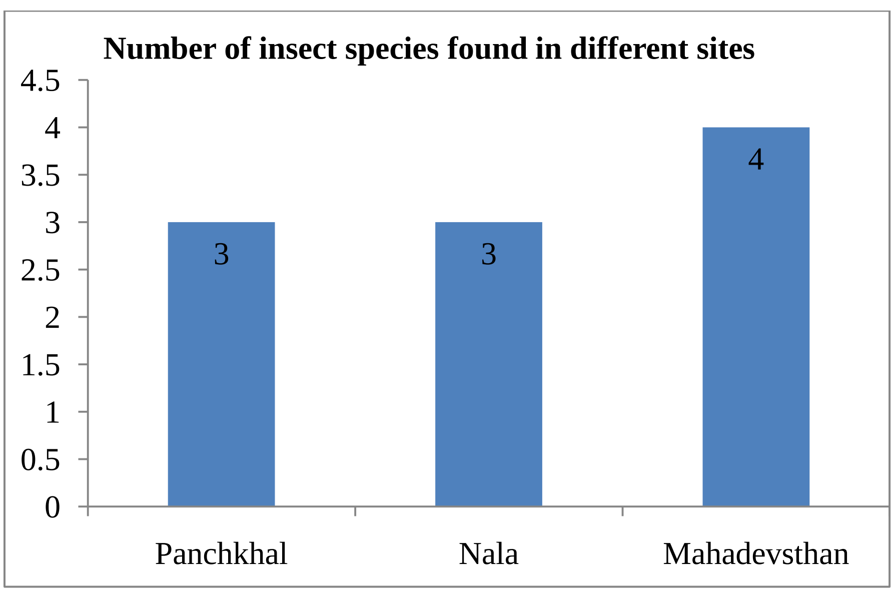

Figure 6: Number of insect species found in different sites.

4.2.2 Distribution of total number of specimens in different sites.

The distribution of total number of specimens were the highest in site B (Nala) with a total number 27 whereas the lowest in site A (Panckhal) with the total number 18. The number of species found in site C (Mahadevsthan) were 24 (Appendix 2). The distribution of total number of specimens are shown in the following figure.

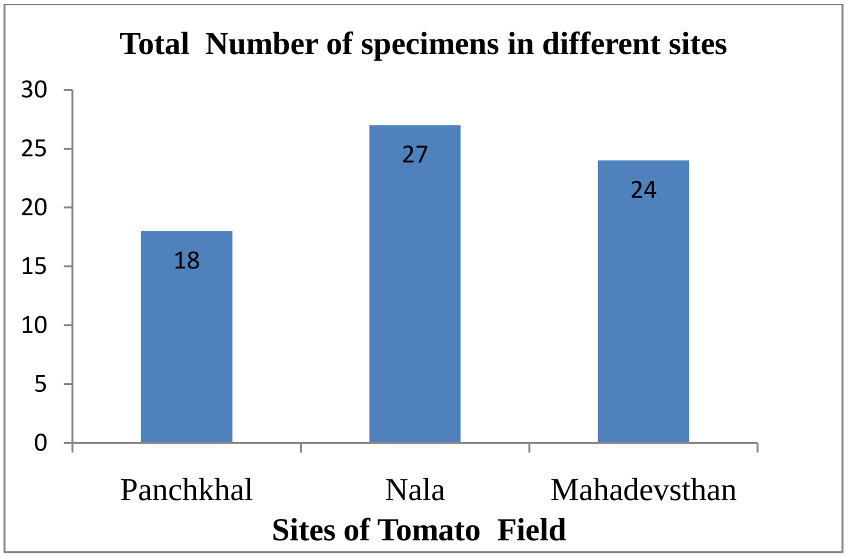

Figure 7: Distribution of total number of specimens in different sites.

4.2.3 Species Diversity

The species recorded during the present study area were White fly (*Bemisia tabaci*), Aphid (*Aphis gossypii*) and Tomato fruitworm (*Helicoverpa armigera*) and White grub. The species diversity index of pests was $\overline{H}$ (A)=1.05, $\overline{H}$ (B)=1.11 and $\overline{H}$ (C)=1.23 in Kavre districts (Appendix:3).

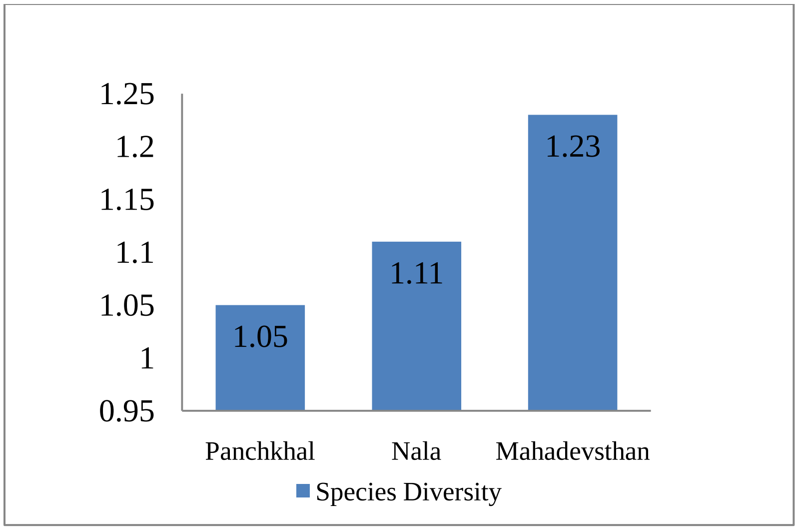

Figure 8: Species Diversity index of pests.

4.3 Pest management practices followed by the farmers

During the study we found that almost tomato growers in different sites were using pesticides for control of pest or for high yield. More than half of them had heard about the IPM practice but they do not practice IPM in their field.

4.3.1 Opinion of farmers on application of pesticide in the field

The opinions of farmer towards the use of pesticide were not found similar. 79.2% out of 48 farmers of the study area had positive opinion towards the use of pesticides. The reasons behind the increase of use of pesticides in the field i) properly and safely use for health and environment, ii) should increase for more crop production and reduce loss due to pest damage and iii) knowledge, awareness and training about pesticides are required. 20.8% farmers had negative opinion about pesticides used. They told that use of pesticides must be decreased in the field i) to prevent health and environment hazard, ii) huge application must be minimized and iii) other alternatives method must be know.

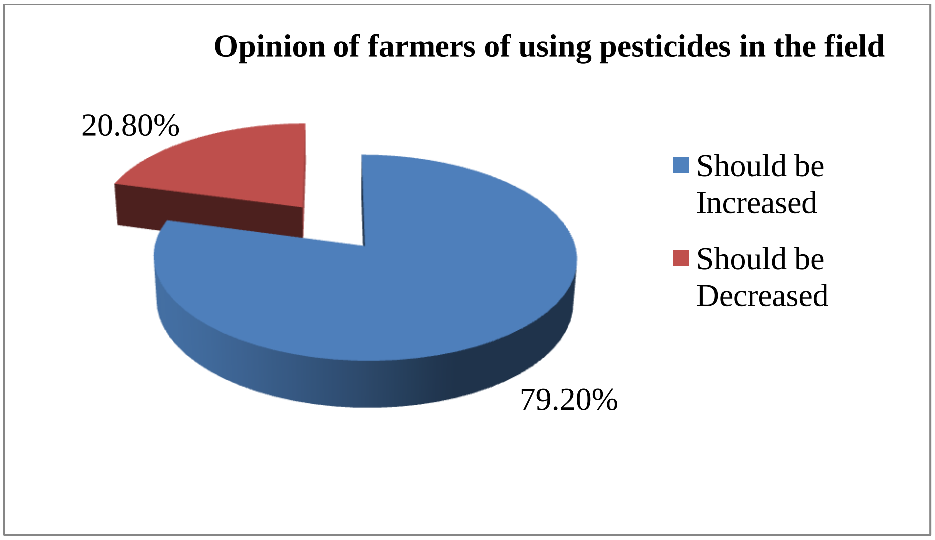

Figure 9: Opinion of farmers of using pesticides in the field

4.3.2 Pesticides used for pest control

A total of 48 farmers and their field were surveyed during the study. Half (50%) of the tomato growers were literate and majority of them (70%) had only primary education. Forty percent work daily about 5-9 hours in the vegetable field. All of them100% applied pesticides in tomatoes in their field as pest control measure. It indicates that there is a high frequency of pesticides use in the vegetable that are possibly to increase toxic residue in the vegetable that might pose higher risk to vegetable growers and consumers. Almost the pesticides posses hazard to human health and environment. Thus, the tomato grown in the study area was found using pesticide hence the tomato cultivation is found totally non-organic which can be hazardous to grower, consumer, human health and environment.

Table 2: Percentage of Pesticides User and Non User in Tomato field

Pesticides user among tomato grower	**Percentage**
Yes- use pesticides	100%
No- do not use pesticides	0%

4.3.3 Application of pesticides to control different pest species

In the study area, pests were controlled by using pesticides in their field. Pesticides were abundantly used and almost all farmers practice the use of pesticides in their field. Different types of pesticides were used which are even hazardous to our health and environment. Most of the pesticides used in the field were poisonous and of danger group, whereas different classes of pesticides with their residue in pest and crop production were found used abundantly. Pesticides like Renova, Rogar, Dusban and Endosulfan were found used high and pesticides like Dunet, Super-D and Dhanuka were found used low.

Table 3: Pesticides used to control pest in study area

Trade name	Common name	Pesticides Group	WHO Class	Physical state
Rogar	Dimethoate	Organophosphates	II	Solid
Super-D,	Cypermethrin	Synthetic Pyrethroids	II	Liquid
Dusban, Spin, Classic, Dhanvan	Chloropyrifos	Organophosphates	II	Solid
Endocel	Endosulfan	Organochlorines	II	Solid
Dhanuka	Methyl parathion	Organophosphates	Ia	-
Dunet	Methomyl	Carbamates	Ib	-
Renova	Thiametoxan	-	-	-

(-) Not known

4.3.4 Tools used for application of pesticide

The pesticide users use different kinds of appliances for using pesticides in the field. Some of them are sprayers, dusters, hand compression, knapsack sprayer, bucket, hand sprayer, broom and brushes.

4.3.5 Knowledge and practice regarding use of pesticides

During study, 80% farmers use pesticides to increase productivity, 18% uses to kill pest, 2% use to improve color. About 25% determine amount of pesticides to be used according to the information given in the label, 60% determine through retailer where they purchase the pesticide and 15% determine with their local agriculture expert. About 95.8% farmers buy pesticides from authorized shop or retailers where as 4.2% from any shop.

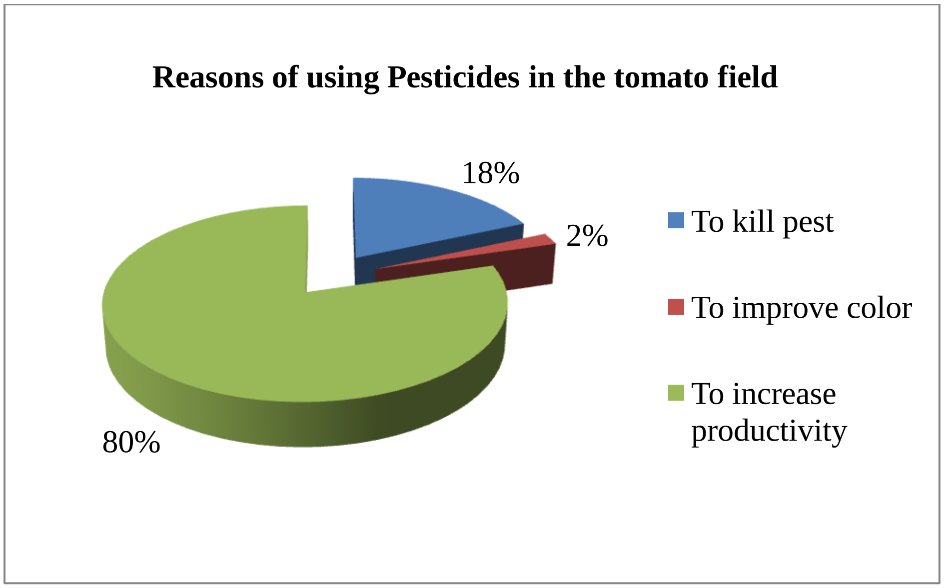

Figure 10: Reasons of using pesticides in the tomato field.

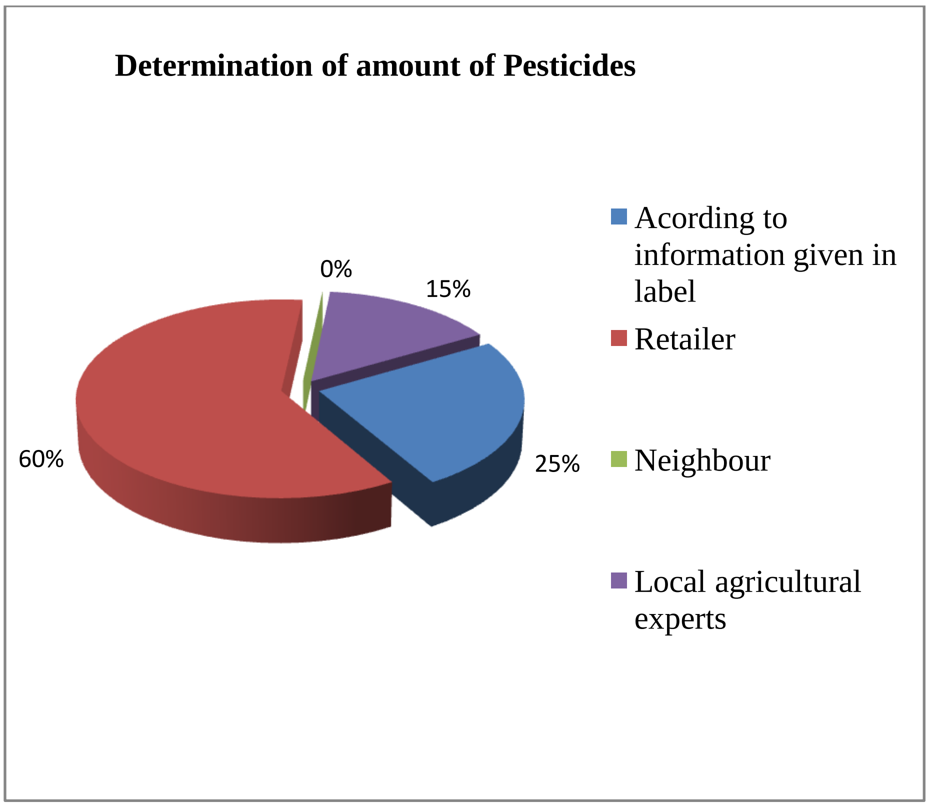

Figure 11: Determination of amount of pesticides in the field

4.3.6 Safety precautions during application of pesticides

Farmers (91.6%) read the label in the bottle or package where as 8.3% didn't read the label. About 70.8% mixed the pesticides with hands and wearing hand gloves , 4.2% mixed with bare hands and 25% mixed with stick and wearing hand gloves. None of them use eye shield or glasses while mixing the pesticides. 58.4% clean spray nozzle with water or hand or other processes and 41.6% clean by using thin wire. During study, we found that none of them eat, drink or smoke while spraying pesticides in the field. Most of them, 50% wash the pesticide bottle or pesticide sprayer in the river, pond or well, whereas 45.8% wash in a distance place far from pond, river or well and 4.2% wash in tap at home. None of them display a signboard or red flag or empty bottles in the sprayed area after an application in order to inform others and also none of them keep the pesticides in the same place where they used to keep their food.

Table 4: Safety handling of the pesticides

Read label	**Mix Pesticides**	**Clean sprayer**	**Wash Pesticides bottle/sprayer**	**Display signal**	**Keep the pesticides**
Yes - 91.6%	With bare hands - 4.2%	With mouth - 0%	In rivers/ pond/well - 50%	Yes - 0%	In the same place where keep food - 0%
No - 8.3%	With stick and wearing hand gloves – 25%	By thin wire - 41.6%	In Tap at home – 4.2%	No - 100%	Different from place where food are kept – 100%
	With hands and wearing gloves - 70.8%	Water or hand or stick - 58.4%	In a distant place far from river-pond-well – 45.8%		

4.3.7 Personal protective equipment and personal hygiene

Those who sprayed pesticide in the field were found 100% wearing shoes, 66.6% they did not use hat or head cover while only 33.4% they use, 95.8% they didn't wear glasses and

4.2% only used, all of them found to be wearing full sleeves shirt and full length trousers, 95.8% they did not use gloves and 4.2% used it, none of them used mask during application of pesticides. During study, 100% change the clothes right after the application of pesticides and also keep the personal hygiene right after the application of pesticides. Out of them, 25% take a bath and 75% just clean hands and foots after application of pesticides.

Table 5: Use of Personal Protective Equipments (Total no. of Respondents-48)

Items	Yes (%)	No (%)
Shoes	100%	-
Hat/Head cover	33.4%	66.6%
Glass	4.2%	95.8%
Full sleeves shirt/trouser	100%	-
Gloves	4.2%	95.8%
Mask	-	100%
Change the clothes	100%	-
Take a bath	25%	75%
Clean hands and foots	75%	25%

4.3.8 Disposal techniques

About 58.3% of the farmers dispose the pesticides bottles or packets by throwing in the field 29.2% buried in the field and 12.5% dispose by other ways like burning or used for household purpose after washing or throw in dumping sites. If pesticide is spilled in some places all of them clean the places with water only but they do not use any cleaning agent. During the application of pesticides, 87.5% had experience of pesticide spoil in their body part and 12.5% had not of such.

4.3.9 Health problem due to use of pesticides

In the study area, all of the interviewed farmers (48- farmers=100%) knew about the adverse effects of pesticides to human health. Out of them 75% knew that pesticide use can cause short term health effect and only 25% knew that pesticides can also cause long term health effects. The different types of health hazards experienced by the farmers due to the use of pesticides were eye irritation, vomiting, skin irritation dizziness, headache, diarrhea and shortness to breathe. The symptoms of health effects they suffered due to the use or exposure of pesticides were determined by the doctor 0%, health worker 37.5%, self by the farmers 50% and neighbor 12.5%.

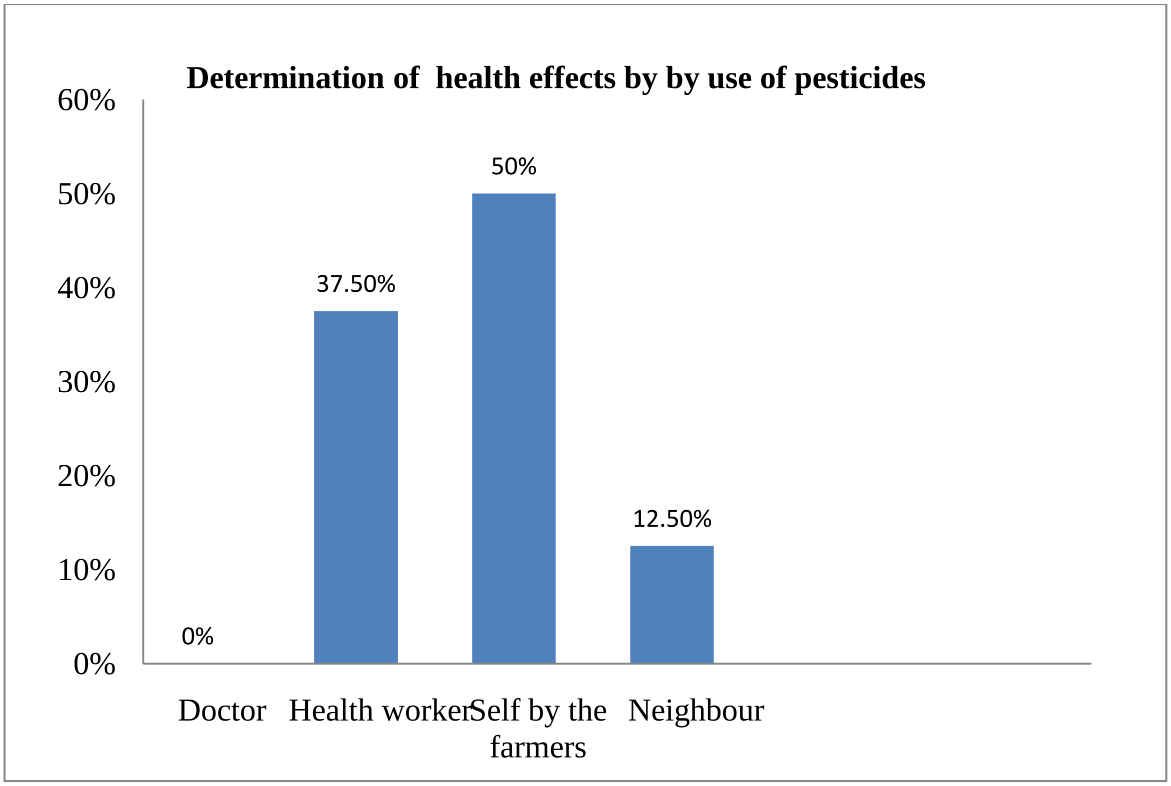

Figure 12: Determination of Health effects by use of Pesticides

4.4 Knowledge about integrated pest management (IPM)

During the study, 96% farmers had heard about IPM where as 4% didn't know about it. 91.5% had not practice IPM where as only 8.5% had only practice. Those who had practice IPM use method like organic production, biological control, smoke and rotation of crops. We had found that farmer did not practices IPM because 62.5% told that pesticides are cheaper, 8.4% told that IPM requires lot of labor, 12.5% told neighbor didn't practice and about 16.6 % told that there was lack of IPM training. Government should promote IPM program for healthier agriculture practices because there is lack of awareness, knowledge and training using IPM technique.

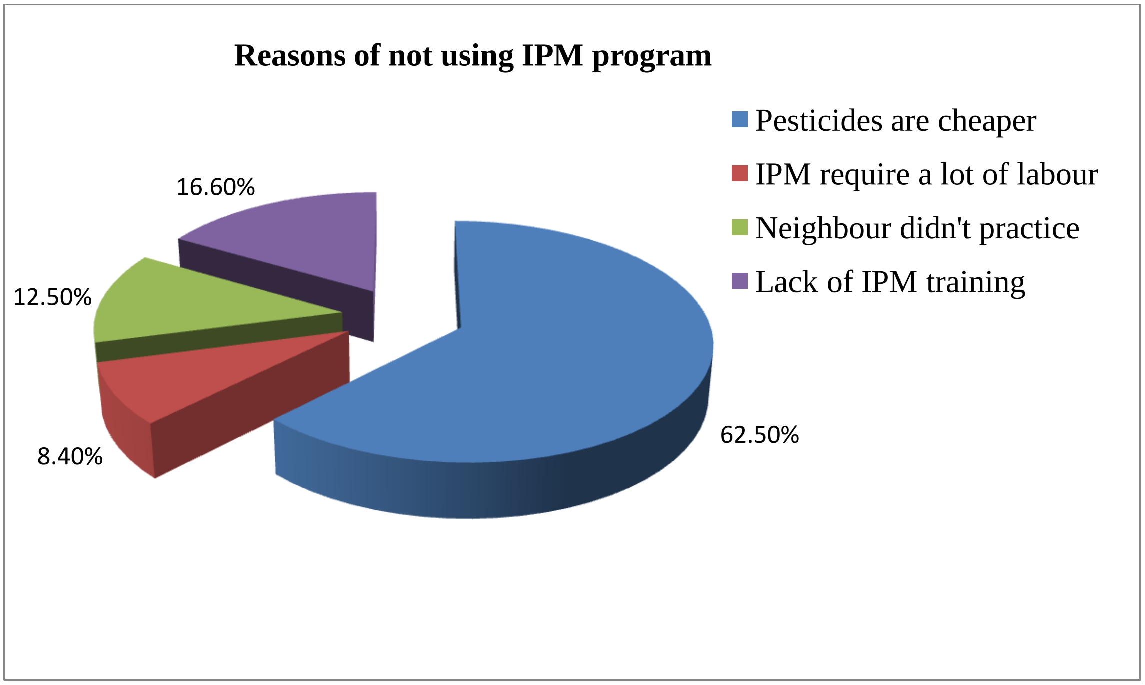

Figure 13: Reasons of not using IPM Program

5. DISCUSSION

From the study it was observed that different pests belonging to different taxonomic groups were found in tomato plant, a total of 4 arthropod pests were recorded belong to four orders. The orders identified were Hemiptera, Homoptera, Lepidoptera and Coleoptera. Their families are Aphididae, Aleyrodidae, Noctuidae and Scarabeidae of arthropod pest. Among the recorded arthropod pest, the pest collected and identified were White fly *(Bemisia tabaci*), Aphid (*Aphis gossypii*) and Tomato fruit worm (*Helicoverpa armigera*).

The species diversity index of pests found in tomato plant in the study area were found 1.05, 1.11 and 1.23 respectively in Panchkhal, Nala and Mahadevsthsan VDCs. Among the species collected order Homoptera-Aphid (*Aphis gossypii*) has high in number where as Lepidoptera-Tomato fruitworm (*Helicoverpa armigera*) was in second in number and other as less in number. Aphid mostly infected the plant during winter season which cause high loss of plant growth and vector of different types of diseases (Neupane 2000).

As the farming of tomato were done totally by the use of chemical pesticides. Farmers use pesticides for control of pests as well as for eradication of pests. They used pesticides in their field for increased productivity so the loss due to pest infestation can be decreased. Karmacharya (2012) has also similar result in his study. This study result supported the Deshar (2013) research work the use of pesticides and chemical fertilizer in the crops has increased the crop production. They complain that without the use of the pesticides, the crops in this area cannot be grown well. All of them said that along with increase in the crop production, the amount of pesticides and investment on pesticides has also increased. They have positive opinion towards the use of pesticides in the field because they do not want economic loss even though, they know about the ill effects and hazards caused by pesticides.

Different types of pesticides used in the study area were Dimethoate, Cypermethrin, Endosulfan, Methyl parathion, Methomyl and Thiametoxan. Endosulfan is highly toxic pesticides which are highly hazardous to health and environment (Koirala et al.2009).

Even though they bought the pesticides directly from shop or agro-vet dealer and used that according to the label in containers or according to shopkeeper. They used pesticides for increased productivity and to kill the pests so that more profit and high yield can be achieved. Lack of knowledge about pesticides, its composition and its formulation made more misuse of pesticides. They used pesticides in the field may not be targeted to the specific pests. Studies documented by Palikhe (2002b) showed that misuse and overuse, particularly among commercial farmers, pose a health risk to the public and have numerous cases caused serious poisoning. The illegitimate use is due to unawareness of toxicity, availability of toxic pesticides, aggressive marketing by dealers and profit interests. Many farmers did not understand the instructions written on the pesticide labels. The harmful effects of pesticides have been experienced by farmers and their families. There is a higher risk of presence of pesticides residue in vegetables which poses higher health risk to vegetable growers as well as consumers.

The adoption of safety measures during and after pesticide application is very important factor for preventing against harmful impacts of pesticide. The adoption of safety measures during and after pesticide application is very important factor for preventing against harmful impacts of pesticide. The various safety options could be use of gloves, masks, long sleeved cloth, glass, long boots etc. Pesticide users were using less method of safety precaution during use of pesticides. They did not like to use safety measure as they thought that they disturb their work and uncomfortable to work in the field. For example, they thought that wearing a mask makes breathing difficult and they don't have habit of wearing (Palikhe 2002b). This may put them in the risk of pesticides that health of these people is not secure of the disease caused by the inhalation, ingestion and absorption via skin (Karmacharya 2012). One of the main reasons for not using any safety measure is the lack of awareness of the acute and chronic affects that pesticides are known to have on human health.

Personal protective devices were also found used less because of lack of awareness, not available easily and feeling discomfort by using them. The reason for not using personal protective equipments (PPE) was lack of knowledge. From the field study, as expressed by farmers themselves, it was difficult for them to change their behavior in which they were adopted. This was the reason that they were careless regarding the adoption of safety measures during and after pesticide application. Due to unsafe practices, vegetable growers are more vulnerable to expose with toxic pesticides and are in higher health risks as there has been too much use of pesticides with too little or no protection. This result is also supported by Shrestha (2010).

Farmers know about health effects and they suffered by different kind of symptoms. Most of the farmers knew about short term effects of pesticides where as only some know about long term effects of pesticides (Shrestha 2010). The different health problems they suffered were eye irritation, skin irritation, dizziness, shortness to breathe, vomiting, headache and diarrhea. They even diagnosed their health effects direct by themselves or by their neighbor and very few by health workers. They rarely consult health personnel and take treatment in health centers, and they used their home treatment by themselves which was comparable with the research work carried out by Koirala et al. (2009). Farmers treat acute symptoms with local cures such as salt-water gargle, oil massage, turmeric (*Curcuma longa*) water, papaya (*Carica papaya*) and tomato, eating mint (*Mentha spp.*) and basil (*Ocimum sanctum*) plant; they seek medical attention only when suddenly exposed to pesticides (Atreya 2005). The pesticides can also have severe effect after some years of continuous and unproductive application (Karmacharya 2012).

Pesticides application in the field is not only the solution of pests control and high yield of crops besides these famers need awareness programs, training and proper guidance for application of pesticides. Shrestha (2001), reported that overuse of synthetic pesticides has also resulted in pest resistance to pesticides, resurgence of pests, elimination of natural enemies and disruption of ecosystems. Although the agricultural policies during the last few decades promoting higher input of chemicals have resulted in higher yields and more food, they have also resulted in poisoning, health related poverty and environmental degradation. There is, therefore, a need for alternative pest control measures for both commercial farmers currently overusing pesticides and food insecure subsistence farmers living at the mercy of pests. A healthy, effective and lasting mechanism for plant protection is required for food security, food safety, poverty reduction and rural development (Shrestha 2001).

According to Palikhe (2002b), many farmers/workers are unaware of some of the properties of pesticides, in what conditions they present danger and how to protect one from poisoning. The general belief seems to be that if one does not die immediately then pesticides present no harm. There is widespread ignorance of the existence of chronic pesticide poisoning. Concept of pesticide resistance/resurgence is not understood by farmers. Importers/Resellers/Farmer refers to pesticides as medicines rather than poisons.

Farmers used pesticides in pest management and they had little or no knowledge on alternative pest management and IPM. Majority of the respondents had not taken any training regarding the pesticide handling and modern agriculture (Karmacharya 2012). IPM were not found practiced in the study area as majority of the farmers did not know about IPM and very few of them know about such practices. During the study, we did not found any one using IPM method for pest control. There were not any kind of program related about IPM either by government or NGOs and INGOs. There is need of IPM practice knowledge and training. This study also suggests that the government should promote IPM program for healthier agriculture practices because there was lack of awareness, knowledge and training of IPM technique. It states that IPM should be the guiding principle for pest control and that it is the best method for the future as it guarantees yield, reduces costs, is environmental friendly and contributes to the sustainability of agriculture which coincides very much with Palikhe (2002b).

Atreya (2010), reported that farmers need to know what is the information printed on a pesticide label. Instructions written on the label or an accompanying leaflet need to be followed to obtain the recommended dosage. Farmers need to be reminded that pesticides are not the only control measures for pest problems. Because of the serious and adverse effects of pesticides, various efforts have to be made to develop alternative approach aiming at eliminating or reducing their use or dependence.

In this context, there is urgent need of the awareness among the farmers and the community regarding the pesticides issues and their alternative methods and IPM practice.

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

A total of four arthropod pests were recorded from the collected specimens during the study period which belongs to five orders Hemiptera, Homoptera, Lepidoptera and Coleoptera and their families are Aphididae, Aleyrodidae, Noctuidae and Scarabeidae of arthropod pest.

On the basis of the investigation it can be concluded that, major problem of tomato cultivation of the study area were increasing infestation of Aphid during winter seasons and tomato fruit worm during summer or throughout the year. Other insects pests are White fly and White Grub and their losses are less negligible as compared to Aphid and tomato fruit worm. Aphid is also found as vector of different kind of diseases. The species diversity of pests in the study area is recorded as 1.23 as highest in Mahadevsthan VDCs and 1.05 and 1.11 respectively in Panchkhal and Nala VDCs.

Farmers in the research site are growing high value crop tomato and other crop in place of traditionally grown cereals. They do not like to take any kind of risk such as pest damage in their crops. Hence they have started using pesticides lavishly. Farmers use pesticide for control of pests and to increase productivity so that they do not have to face economic loss and have profit. The other reasons for high use of pesticides are their cheapness and very low share in the total cost of production of the crops. The farmers have lack of knowledge on effects of pesticides and the pesticide regulations have not been enforced properly.

During study, it was found that tomato cultivation was done by using pesticides. All farmers in their field use pesticides. Farmers have positive opinion about use of pesticides and they told that its use should be increased properly and safely for health and environment, to increase crop production, to reduce loss due to pest damage and also suggested that knowledge, awareness and training of safe use of pesticides are required.

Uses of pesticides from tomato planting to till harvesting are found very high. Different types of pesticides used in the tomato field were Dimethoate, Cypermethrin, Endosulfan, Methyl parathion, Methomyl and Thiametoxan. The present study shows extremely hazardous pesticides are being used in field which are banned for normal agriculture use by Government of Nepal. Majority growers did not receive any training on pesticides and its handling.

Determination of amount of pesticides during application was found mostly determined by the retailer and according to the information given in label and very few take agricultural experts advice. Safety precaution during handling of pesticides and personal protective equipments were found used less due to various reasons like lack of awareness, easily not available, hinder the work, uneasy, not affordable and uncomfortable.

The awareness level of interviewed farmers regarding pesticide use and health safety was very less. From the field study, as expressed by farmers themselves, it was difficult for them to change their behavior in which they were adopted. This was the reason that they were careless regarding the adoption of safety measure during and after pesticide application. Most of the growers were not using PPE during pesticide application in field. Even they know about the ill effects of pesticides and different health hazards and environment degradation caused by it.

Farmers have experience symptoms associated with pesticides hazards. The different health problem they suffered was eye irritation, skin irritation, dizziness, shortness to breathe, vomiting, headache and diarrhea. The health effects on them were found mostly determined by themselves or neighbor and only few of their problems were determined by health workers. There is lack of council and treatments of such problem by health personnel.

There was no practice of IPM method and most of the farmers they did not know about it also. They did not use IPM because they told that pesticides are cheaper and IPM requires lot of labor. Some even told that neighbor didn’t practice and some told that there was lack of knowledge and training.

6.2 Recommendations

On the basis of this study following points are recommended.

- Farmers must be trained about different types of pests and diseases which attack their crops, their biology and their infestation parts and season. So that farmers themselves identify the pests and diseases and take precaution, which help to lessen the pests' problem in the field and their yield.
- Farmers should also be well informed that using pesticide in recommended amount does not result with harmful impacts. It brings hazard when farmers don't follow the recommendation and use it haphazardly. The need for awareness, education and training on the uses of pesticides to the farmers and effective monitoring program for pesticide residues. In this context, there is urgent need of the awareness among the farmers and the community regarding the pesticides issues.
- Selection of appropriate pesticides and their handling and use as per the label are the most important steps for safe use of chemical pesticides. For this, the government need to develop mechanism for enforcing the regulation for the overall management and use of pesticides, adopting FAO guidelines with adequate educational and training interventions.
- Farmers needed training on alternative pest management and IPM to reduce reliance on pesticides, reduce costs of pest management and to ensure correct choice and use of fertilizers and pesticides.
- Research and development on the use of bio pesticides and eco-friendly measures are highly recommended to minimize the use of hazardous pesticides. For this, research laboratories must be strengthened in terms of both human resources and physical infrastructure.
- The study recommend an increased emphasis on seeking alternative ways of controlling pests, such as the use of IPM program for healthier agriculture practices along with further education, training and awareness for farmers.
- Use of banned pesticides and highly hazardous pesticides should be completely restricted. And if have to use, use only least hazardous to health and environment.

Government regulatory agencies, development organizations, consumers associations should work successfully together work out the problems.

- Long-term implications of pesticide use on human health and environment need to be studied for sustainable agriculture, safety to human health and the environment as a whole. A central authority for chemical safety needs to be formed to work on chemical safety and risk management for coping with pesticide problems.

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PHOTOGRAPHS

Plate 1: Tomato Field

Plate 2: A Healthy Tomatoes

Plate 3: *Helicoverpa armigera* larva damaging tomato fruit

Plate 4: Tomato Fruit worm Damage

Plate 5: Cluster of Aphid in tomato leaf

Plate 6: Pesticide Sprayer

Plate 7: Pesticides Container (A)

Plate 8: Pesticides Container (B)

Plate 9: Pesticides Container (C)

Plate 10: Pesticides Container (D)

Plate 11: Author with farmer in the tomato field

Plate 12: Author with Agro-vet Dealer

Appendix 1

Maximum And minimum temperature, maximum and minimum rainfall and relative humidity record at meteorological station of Dulikhel in Kavre Districts during study period in 2011.

Months	Max. temp.	Min. temp.	Annual Rainfall	Relative Humidity% (Morning)	Relative Humidity% (Evening)
January	15.9°C	2.2°C	9.2mm	83.5%	64.0%
February	20.0°C	5.4C	27.2mm	84.5%	64.9%
March	24.3°C	9.6°C	1.2mm	75.9%	63.0%
April	25.9°C	12.1°C	98.0mm	64.9%	54.8%
May	27.9°C	15.8°C	36.1mm	76.0%	65.1%
June	26.4°C	18.3°C	110.9mm	93.8%	82.4%
July	26.2°C	18.8°C	423.2mm	95.6%	89.1%
August	26.2°C	18.2°C	0.0mm	96.1%	87.4%
September	18.3°C	4.5°C	210.1 mm	89.9%	73.4%
October	21.5°C	11.0°C	0.0mm	94.3%	85.5%
November	18.8°C	4.0°C	0.0mm	88.2%	70.5%
December	15.5°C	4.5°C	0.0mm	90.3%	73.7%

(Source: Department of Hydrology and Metrology, 2011).

Appendix 2

List if insects infesting tomato fruit and its plants in three different sites.

Orders	Scientific name	Common Name	Nature of Damage	Season of damage	Site A Panchkhal	Site B Nala	Site C Mahadevsthan	Total species
Hemiptera	*Bemisia tabaci*	White fly	Suck the sap of the leaf	summer	4	-	5	9
Homoptera	*Aphis gossypii*	Aphid	suck the sap of the leaf	winter	8	13	10	31
Lepidoptera	*Helicoverpa armigera*	Tomato fruitworm	Feed on fruit	summer	6	11	7	24
Coleoptera	-	White grub	Defoliate tomato plants	summer	-	3	2	5
Total					18	27	24	

Appendix 3

Distribution of tomato pests in study sites of Kavre districts in 2011.

Species Diversity [$\bar{H}$ = -Σpi ln pi]

Site A: Panchkhal

Order	Scientific Name	Common Name	No. of ind. Sps. (site A)	Pi	In Pi	Pi In Pi
Hemiptera	*Bemisia tabaci*	White fly	4	0.22	-1.51	-0.33
Homoptera	*Aphis gossypii*	Aphid	6	0.33	-1.10	-0.36
Lepidoptera	*Helicoverpa armigera*	Tomato fruit worm	8	0.44	-0.82	-0.36
Coleoptera	-	White grub	-	-	-	-
		Total(N)	18			$\bar{H}$ (A) = -Σpi ln pi=1.05

Site B: Nala

Order	Scientific Name	Common Name	No. of ind. Sps.	Pi	In Pi	Pi In Pi
Hemiptera	*Bemisia tabaci*	White fly	-	-	-	-
Homoptera	*Aphis gossypii*	Aphid	13	0.44	-0.82	-0.36
Lepidoptera	*Helicoverpa armigera*	Tomato fruitworm	11	0.37	-0.99	-0.36
Coleoptera	-	White grub	3	0.10	-2.30	-0.23
			Total(N)= 27			$\bar{H}$ (B) = -Σpi ln pi=1.11

Site C: Mahadevsthan

Order	Scientific Name	Common Name	No. of ind. Sps.	Pi	In Pi	Pi In Pi
Hemiptera	*Bemisia tabaci*	White fly	5	0.2	-1.60	-0.32
Homoptera	*Aphis gossypii*	Aphid	7	0.29	-1.23	-0.35
Lepidoptera	*Helicoverpa armigera*	Tomato fruitworm	10	0.4	-0.91	-0.36
Coleoptera	-	White grub	2	0.4	-2.52	-0.20
			Total(N)= 24			$\bar{H}$ (C) = -Σpi ln pi=1.23

Appendix 4

List of Questions

Survey questionnaire

Central Department Of Zoology, Tribhuvan University, Kathmandu

Survey ID number:……………….

Date of interview:…………………..

Do you agree to participate in the survey 1Yes 2 No

District:……………….

Village:……………..

Ward No:…………

Name of respondent:……………….

1. How much area of cultivated land do you have?

2. In how much area do you cultivate tomato?

3. Pest related informations:

   3.1. Do you have pest problem in your field?

   3.2. What type of problem you are facing by pests in the field?

S. No.	Pest	Type of pest problems	Parts of plant	Time

   3.3. What are the major insects that are harmful to tomato plant?

4. Knowledge and practice of pesticide.

   4.1. Do you use pesticides in your field?

   4.2. If yes, why do you use it?

a. To kill pest b. To improve color c. To increase productivity

4.3. What do you think about the use of pesticides?

a. Should be increase c. Use in the same trend

b. Should be decreased d. Should not use at any level

4.4. What are different types of pesticides use in your tomato field?

Serial No.	Pest	Pesticides Used

4.5. How do you determine amount of pesticides to be used?

a. According to the information given in the label b. Retailer

c. Neighbor d. Local agricultural expert

4.6. From where do you pesticides?

a. Shop b. Authorized shop/retailers c. Other places

4.7. Do you read the label in the bottle/package? a. Yes b. No

4.8. Do you follow instruction in the label? a. Yes b. No

4.9. How do you mix the pesticides?

a. With bare hand b. With a stick, but bare hands

c. With hands and wearing gloves d. With stick and wearing hand gloves

4.10. Do you wear glasses/eye shield while mixing the pesticides?

4.11. With what do you clean the sprayers nozzle?

a. By blowing air through it with your mouth

b. By using thin wire c. Others (water / hand /stick)

4.12. Do you display a signboard or red flag or empty bottles in the sprayed area after an application in order to inform other?

4.13. Do you keep the pesticides in the same place where you keep the food?

5. Personal protective equipment

5.1. What do you typically wear during the application of pesticides?

Items	Yes	No
a. Shoes		
b. Hat/Head cover		
c. Glasses		
d. Full sleeves shirt/Trouser		
e. Gloves		
f. Mask		

5.2. Do you keep the personal hygiene right after the application of pesticides?

a. Yes b. No

5.3. Do you change the clothes right after the application of pesticides?

a. Yes b. No

5.4. If yes, what do you do?

a. Take a bath b. Clean hands and foots only

6. Disposal Technique

6.1. How do you dispose the pesticides usually?

a. Spraying in the field b. Burial in the field

c. Burn d. Thrown in dumping sites

e. Used in household purpose after washing

6.2. What do you do if pesticides are spilled in some place?

a. Clean the place with soap b. Clean the place with water only

c. Leave as it is d. Dispose it in the safe place with soil

6.3. During the application of the pesticides, do you have the experience of pesticides spoil in your body part?

6.4. Do you have opinion about for the safe management and use of pesticides?

7. Integrated Pest Management (IPM)

7.1. Do you heard about integrated pest management? i) Yes ii) No

7.2. If yes, do you currently practice any IPM management? i) Yes ii) No

7.3. If yes, which method do you use?

a. Organic production   b. Biological control   c. Smoke

d. Rotation of crops   e. Smoke   f. Manual clearing

g. Light Trap   h. Enemy Plant   i. Pheromone Trap

7.4. If not, why don't you practice IPM?

a. Pesticides are cheaper   b. IPM requires lot of labor

c. Neighbor farmer do not practice   d. Lack of training of IPM

Appendix 5

List of banned pesticides in Nepal (POPs and non-POPs pesticides covered).

S.N.	**Name of pesticide**	**Remarks**
1.	Chlordane	Persistent Organic Pollutant
2.	DDT	Persistent Organic Pollutant
3.	Dieldrin	Persistent Organic Pollutant
4.	Endrin	Persistent Organic Pollutant
5.	Aldrin	Persistent Organic Pollutant
6.	Heptachlor	Persistent Organic Pollutant
7.	Toxafen	Persistent Organic Pollutant
8.	Mirex	Persistent Organic Pollutant
9.	Lindane	Persistent Organic Pollutant
10.	BHC	
11.	Phosphamidon	
12.	Organo-mercury fungicides	
13.	Methyl parathion	
14.	Monocrotophos	

(Source:-Statistical pesticide book 2068 B.S. PRMD)