PEST STATUS OF MAIZE *Zea mays* (Linnaeus, 1753) IN SIPADOL VILLAGE OF BHAKTAPUR DISTRICT, NEPAL

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DECLARATION

I hereby declare that the work presented in this thesis entitled **"PEST STATUS OF MAIZE** *Zea mays* **(Linnaeus, 1753) IN SIPADOL VILLAGE OF BHAKTAPUR DISTRICT, NEPAL"** 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).

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RECOMMENDATION

This is to recommend that the thesis entitled **"PEST STATUS OF MAIZE** *Zea mays* **(Linnaeus, 1753) IN SIPADOL VILLAGE OF BHAKTAPUR DISTRICT, NEPAL"** has been carried out by **Ms. Binita Shrestha** 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. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

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This thesis work submitted by **Ms. Binita Shrestha** entitled **"PEST STATUS OF MAIZE** *Zea mays* **(Linnaeus,1753) IN SIPADOL VILLAGE OF BHAKTAPUR 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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ABBREVIATION

ADB -	Asian Development Bank
a.i. -	Active Ingredient
CDZ -	Central Department of Zoology
DADO -	District Agriculture Development Office
DHM -	Department of Hydrology and Metrology
EC -	Emulsifiable Concentrate
FAO -	Food and Agriculture Organization
FFS -	Farmers Field School
Gr -	Granule
HMGN -	His Majesty's Government of Nepal
ICIPE -	International Centre of Insect Physiology and Ecology
IPM -	Integrated Pest Management
JTA -	Junior Technical Assistant
MOAD -	Ministry of Agricultural Development
NARC -	Nepal Agricultural Research Council
NHM -	Natural History Museum
PRMS -	Pesticides Registration and Management Section
qt -	quintal
SAARC -	South Asian Association for Regional Cooperation
SL -	Soluble liquid
VDC -	Village Development Committee
WHO -	World Health Organization
masl -	meter above sea level
WTO -	World Trade Organization

ABSTRACT

Insect pest cause serious threats to Maize farms, resulting heavy reduction in their yield. The present study focused on the insect pest of Maize (*Zea mays*) in the Sipadol VDC of Bhaktapur District. It was carried out in four months May, June, July and August 2016. The pests were collected through different methods such as hand picking, beating process, sweeping etc depending on size of pests. Two- way analysis of Variance (ANOVA) was used to test the significance difference in number of pest observed in different sites. Multilevel pattern analysis was performed under R 3.3.2 platform by using multipatt package to see whether there is species associated with particular month. Management practices data were collected by direct observation and also by using semi-structured questionnaires was carried out ten from each plot altogether 40 farmers from surrounding of each plot were sampled. Altogether, 16 species of pests belonging to five orders and 12 families were found. However population density of pest was higher in June. Maize stem borer (*Chillo partellus*) was most common and dominant species occurring almost in all months. The overall diversity index of Maize pests was 2.593 and evenness 0.935. The use of synthetic chemical pesticides is commonly used pest management practice in this area. Commonly used pesticides include Chloropyriphos 50% EC + Cypermethrin 5% EC, Furadon 3 Gr, Confidor 200 SR and Chloropyriphos 20% EC. Because of lack knowledge of biological control and others increasing trend of chemical pesticide used day by day in study area of Sipadol.

1. INTRODUCTION

1.1. Background

Maize (*Zea mays* L.) originated from Central America and has now become the highest production cereal grown worldwide. In the world, maize is cultivated over an area of about 120 million hectares with a production of about 394 million tons of grains (Singh, 1983). Its area, production and productivity in Nepal is 928761 ha, 2283222 mt and 2458 mt/ha, where mid hill, terai and high hill occupies 72.85, 17.36 and 9.79% respectively (MoAD, 2014). It is the second most important staple food crop after rice and a major food crop in the hills grown mainly during the summer season of Nepal (Upadhyay *et al.,* 2007). It has a very high yield potential than any other cereals and thus is popularly known as the 'queen of cereals' (Singh, 2002). Maize is a traditional crop grown for food, feed and fodder and its demand has been constantly growing by about 5% annually in the last decades (Sapkota and Pokhrel, 2010).

The maize growing environments of Nepal is very diverse and varied along north to south parts of the country. It is the only crop which is adaptive to across different agro-ecological zones because of its great diversity (Ferdu *et al.,* 2002). Maize is produced in three distinct agro-climatic zones within Nepal, the terai and inner terai (below 900m), mid-hills (900-1800) and the high-hills (above 1800m). The productivity level is higher in the terai region than in the hills and mountains (Adhikari, 2001). The productivity of the cereal grains including maize is basis for food security as well as the means of earning surplus income and better livelihood of the farm families (HMGN/ADB, 1995). Maize contributes to food security in the hills while in the accessible areas it is gradually becoming a commercial commodity due to increasing demand of nutrients in poultry and animal feed (Pathik, 2002). Annually 86,166 mt maize worth of Rs.1,200 million is imported in Nepal from India and it accounts for 40-45% of Nepal's demand. The rest of the demand is fulfilled by its own production. As the rate of increase of consumption of livestock products like meat, milk, and egg is 3.5% per annum, the number of feed industries are being increased as a result of which maize, soybean like raw materials demand is inevitably increased (DADO, 2065/66).

Like other crops, maize is also not safe from attack of insects. Maize suffers from the attack of insect pests from seedling to maturity. Number of insect pests attacking maize is high. Lepidopterous pests (which include cutworms, armyworms, earworms, borers, and grain moths) are the most damaging to maize worldwide, followed by the Coleoptera (root worms, grubs, grain borers). Similarly, insects that serve as carriers (vectors) for disease agents or pathogens, among which the sap-sucking bugs (leaf hoppers and aphids) are the greatest problems (Alejandro, 1987). More than 40 species of insects have been recorded on maize in the field (Abraham *et al.,* 1993). Out of these pests, the maize stalk borer (*Busseola fusca*), spotted stalk borer (*Chilo partellus*), and various termite species (*Macrotermes* sp. and *Microtermes* sp.) are recognized to be the key pests. Insects such as the armyworm, cutworms, chafer grubs, grasshoppers, leafhoppers, pink stalk borer and maize aphid are sporadically important (Abraham *et al*., 1993).

1.2 Status of insect pest

Insects are undoubtedly the most adaptable form of life as their total numbers far exceed that of any other animal category. The majority of insects are directly important to humans and the environment. For example, several insect species are predators or parasitoids on other harmful pests; others are pollinators, decomposers of organic matter or producers of valuable products such as honey or silk. Some can be used to produce pharmacologically active compounds such as venoms or antibodies. Less than 0.5 percentage of the total number of the known insect species are considered pests, and only a few of these can be a serious menace to people. Insect pests inflict damage to humans, farm animals and crops. Insect pests have been defined by Williams (1947) as any insect in the wrong place. Depending on the structure of the ecosystem in a given area and man's view point, a certain insect might or might not be considered a pest. Some insects can constitute a major threat to entire countries or a group of nations (ICIPE, 1997).

1.3 Maize Pests

Maize (*Zea mays* L.) crop suffers from various biotic and abiotic constraints resulting in considerable yield loss (Tehon and Daniels, 1925). However, both biotic and abiotic factors have played a decisive role for grain production. Of the biotic constraints, stem borer complex: maize stem borer (*Chilo partellus*), pink stem borer (*Sesamia inferens*), and the stripped stem borer (*Chilo suppersalis*) are frequently noticeable species (Jyoti and Shivakoti, 1992). Among them, *C. partellus (*Swinhoe, 1885) is most destructive pest in Nepal (Neupane *et al*., 1984). Newly hatched larvae of stem borer migrate to whorl and feed on leaf as a result of damaged leaf appears pin holes and window panes. Subsequently the second generation larvae emigrate inside the collar region of the plant and start making tunnel into stalk. The larvae that feed into stalk may pupate inside the stem or exit out from stem by making a hole, which is called exit hole. In this way, roughly, up to five generations of *C. partellus* recorded in the Chitwan valley of Nepal (Neupane *et al*., 1984). Regarding the destructiveness of maize stem borer in maize can be expressed in terms of leaf feeding, whorl and stalk infestation, tunnel length measurement per plant, and exit holes on stalk in which various studies found 20% to 80% of damage level (Thakur *et al*., 2013).

White grubs (*Phyllophaga* sp. and *Cyclocephala* sp.), stem borers (*Chilo partellus*), and termites (*Microtermes* sp. and *Macrotermes* sp.) are major maize field insects in all agro-ecologies (Sherpa *et al*., 1997). Army worms (*Spodoptera* sp., *Mythimna* sp.) and cutworms (*Agrotis* sp. and other species) are also major problems in all agro ecologies except the eastern mid hills (Paudyal *et al*., 2001). Blister beetle is a major problem in the central/western and mid-western/ far-western mid hills and the terai, and field cricket, a serious pest in the eastern and mid-western/far western mid-hills and high hills. Aphid (*Rhopilosiphum* sp.), locust, red ant, and tassel beetle are also reported by farmers. Among insect pests, Weevils (*Sitophilus* sp.) and Angoumois grain moth (*Sitotroga cerealella*) are major problems in stored grain (Paudyal *et al*., 2001) throughout the country.

Maize is attacked by a wide range of insect pests both in the field and in the storage condition (Neaupane *et al*., 1991). Nearly a dozen of insect pests are reported to be economically important in Nepal causing a greater loss of yield. They destroy the grains and contaminate the rest with undesirable odors and flavors. In general the loss (pre and post-harvest) of grains due to insect pests has been estimated to be 15-20% (Neupane, 1997). KC (1992) mentioned that grain storage losses in Nepal ranges from 15-30% annually. The damage due to insect pest complex depends upon their population trends in the field which, in turn, rely upon their dynamically of the physical factors of their immediate environment (Isard, 2004).

Among the insects, stem borer was major threat of maize in the field condition. Insect pests and diseases have been playing a significant role in reducing production and productivity of maize (Shivakoti and Manandhar, 2000). They also reported that these organisms are responsible for decline in quantity, quality and germination potential of maize seeds in storage. Stem borer only causes 27-85% damage (Dhaliwal and Arora, 2001) of the 130 insect-pests that affect maize crop, stem borers, shoofly, armyworm, jassids, thrips, white ants, pyrilla, grasshoppers, grey weevil, hairy caterpillars, root worms, earworms and leaf miner are more serious, though the spectrum varies in different agro-ecological regions.

1.4 Pest Management

Crop pest management has great importance in crop cultivation to ensure quality and quantity production. Crops are part of a healthy diet but can be sources 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). 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 without paying adequate attention on the negative impact on environment and health (Pujara et al., 2002).

The use of chemical pesticides is considered to be useful in reducing pest population and incidence; however, there exists a problem of environmental pollution, possibility of development resistance, degradation of soil fertility and destruction of natural enemies. Due to misuse and over use of pesticides, not the economic condition of the farmer is scaling up but many harmful effects on human beings and the environment is being scaled up (Thapa, 2003). Thus, pest management was defined as a broad ecological pest control approach aiming at best mix of all known pest control measures to keep the pest population below economic threshold. It is the best combination of cultural, biological, behavioral and chemical measures, which yields the most cost-effective environmentally friendly and socially acceptable insect, disease and weed management in given situation. (Umarani, 1999).

Modern pest management makes us of the "ecosystem approach" taking into account the life-cycle and ecology of pests and their natural enemies, and pest-host interactions. It then uses this knowledge to minimize pest damage to the crop through agronomic interventions or other non-chemical techniques that suppress the development of the pest or disease. Pesticides are only used in those cases where there are no effective or economically viable alternatives, It is recognized that overuse and other inappropriate use of pesticides can actually exacerbate the pest problem (e.g. destruction of natural enemies of pests, development of pesticide resistance, etc.) and trigger further unnecessary use of pesticides (FAO, 2010).

1.5 Statement of the Problems

Maize (*Zea mays* L.) is one of the most important staple food crop globally and Nationally too. Kathmandu is one of the best agricultural sectors of Nepal. The Maize plants are threatened by many insects but there is no detail study of the insect pest from the proposed study area. Nevertheless, only some studies concerning pest of Maize were done but research concentrating only on Maize pest was less observed. The opinion of people about the pest management practices is need to be evaluated. So, this study highly signifies for the documentation of insect pest from Maize farm and the pest management status from the study area.

1.6 Objectives of the study

1.6.1 General objective

To study the Insect Pests of Maize (*Zea mays* L.) and their Management practices in Sipadol VDC of Bhaktapur.

1.6.2 Specific objectives

- To explore the diversity and dominance of insect pest species of maize.
- To assess the Monthly variations of insect pest species present in maize.
- To document the management practices carried by farmer to control pest.

1.7 Limitation of the study

- The study was conducted in a short period of time so couldn't cover much sample sites.
- The study covers a limited physical area within Bhaktapur 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.
- Taxonomic problem for identifying some of the samples upto species level.

2. LITERATURE REVIEW

2.1 In global context

Maize is the main staple food in sub-Saharan Africa. An area of 20.7 million hectares is planted to maize in the whole of the African continent, with an average annual production of 29 million tons (Christopher et al., 1996). In sub-Saharan Africa, three quarters of the total production of maize is consumed as human food, which is also the case with other cereals such as sorghum and millet.

Almost 80 percentage of food crops are produced by small scale farmers and stored on the farm (Wongo, 1996). Due to poor storage structures and conditions, severe losses in quality and quantity of stored food are inflicted annually. In Kenya, the National Food Policy Document reported up to 30 percentage destruction of harvested maize due to pests during storage and handling (Wongo, 1996).

Ebregt et al. (2004) observed the Millipede damage in germinating maize seeds in the first and second rainy seasons amounted to 34% and 29%, respectively. The species *O. sudanica, Spirostreptus ibanda* and *Tibiomus* sp. were found in the vicinity of the maize seeds but were only found feeding on them during the second rainy season.

One of the major causes of low productivity is the damage done at various stages of the crop by variety of insect pests. The insect pest complex changes in time and space. The insect pests have increased due to the large scale cultivation of maize as sole crop and widespread use of pesticides for pest control (Mathur, 1983).

Different researcher recorded 160 insects and mite species which attack maize crop (Fletcher, 1914, 1917; Ayyar, 1963; Bhutani, 1961; Pant and Kalode, 1964) but afterward Mathur (1983) observed over 250 species of pests associated with maize in field and storage conditions. Dick and Guthrie (1988) identified 87 species that directly or indirectly exert severe stress on corn culture in tropical and temperate regions throughout the world. Excluding stored grain insects. Luckman (1978) lists 34 pests or pest groups for which chemical controls are recommended on corn in the United States.

More than 130 insect pests have been reported to cause damage to maize in India but only about a dozen cause economic losses (Sarup *et al*., 1987). The pyralid; *Chilo partellus,* the noctuid; *Sesamia inferens* and muscids; *Atherigona soccata* and *A. naqvi* are of major importance.

Population dynamic of *Chilo partellus* and its natural enemies in maize was studied at Krishi Vigyan Kendra, S.D. Agricultural University, Khedbrahma during 2007 and 2008 (Patel *et al.*, 2016) where parasitoid, *Cotesia flavipes* showed significant positive correlation with larval population and significantly negative association with *C. partellus* and damage was significantly negatively correlated with minimum temperature (2008), and significantly positively correlated with maximum temperature (2007).

Sekhon and Kanta 1997; Pingali 2001; Dhaliwal and Arora 2001 reported among the serious pests, Maize stem borer (*Chilo partellus*) (Lepidoptera: Pyralidae) is one of the major biotic constraints in successful maize production throughout the country and abroad.

Dhaliwal *et al*., 2007 reported that in world, food plant are damaged by more than 10,000 species of insects and the yield loss by insects reaches as high as 60-70% from which the pest becomes major concern for the farmers across the world.

Dhaliwal *et al*. (2010) again reported that the Indian agriculture is currently suffering an annual loss of about Rs. 863,884 million due to insect pests.

In the Kenyan highlands, total losses due to pests in maize were estimated to 57 %, with insect pests being more important than diseases (Grisley, 1997).

In Zimbabwe, grain damage of 92 % in stored maize was reported due to insect pests. Where treatment with malathion reduced the damage by only 10 % (Mutiro *et al*., 1992).

In Brazil, Santos *et al*. (1990) showed that the presence of *Sitophilus zeamais* and *Sitotroga cerealella* in maize grains led to a reduction in germination with increasing developmental stage of the insects, from 13 percentage at the egg stage for *Sitophilus zeamais* and 10.9 percentage for *Sitotroga cerealella*, to 93 percentage and 85 percentage at the adult stage for *S. zeamais* and *S. cerealella* respectively.

According to Bess and Haramoto (1959),Nukamura *et al*.(1964), Howse and Diamond (1965), Redfern (1968) galls are easily counted, but many harbour a variable number of insects and it is usually impossible to determine externally whether these have been parasitized or not.

According to Jepson and South wood (1958) and Gomez and Bemardo (1974), some stem borer cause the growing shoot to die; when multiple invasion is sufficiently rare to be over loaded, estimates of these dead hearts, may be taken as equivalent to the total number of larvae invading and the same approach can be applied to insects in grains and seeds.

Maize stem borer (MSB), *Busseola fusca* ; spotted stem borer (SSB), *Chilo partellus* and pink stem borer (PSB), *Sesamia calamistis* have been recorded attacking maize and sorghum in Ethiopia (Assefa, 1981, 1985; Melaku and Gashawbeza, 1993; Abraham *et al*., 1998). The maize stem borer and spotted stalk borer are the major stem borer species in Ethiopia (Crow *et al*., 1977; Assefa and Tessema, 1982; Adhanom and Abraham, 1985; Assefa, 1985; Abraham, 1987; Abraham *et al*., 1993).

Maize yields have been on the decline as indicated by yield gap between experimental research station plot and average yields that farmers typically realize on their farms (De Groote , 2002). Decline in maize production is attributed to biotic and abiotic stresses. The biotic constraints include insect pests, diseases and weeds while the abiotic constraints include lack of farm inputs such as certified seeds, fertilizers, chemicals, high prices of farm inputs and high cost and unavailability of farm labour (Pingali, 2001). However, drought and declining soil fertility are frequently cited as the most limiting factors to maize production and productivity in the semi-arid tropics (Diallo *et al*., 2004).

Attack by insect pests especially the stem borers is consistently cited as a major constraint to maize production everywhere in Kenya (De Groote, 2002). Stem borers including *Chilo partellus, C. orichalcociliellus, Busseola fusca, Eldana saccharina* and *Sesamia calamistis*, are estimated by Kenyan farmers to cause losses of around 15% and in some areas are recognized as the most severe pest problem facing maize production (De Groote, 2002) by contributing up to 80% grain yield losses (Kfir *et al*., 2002). Other maize insect pests include field pests such as African armyworm, African bollworm, maize aphids, cutworms, leafhopper, chafer grub, termites and storage insect pests which include maize weevil, larger grain borer, anguomois grain moth and red flour beetles. Diseases of economic importance include grey leaf spot, head and ear smut, northern leaf com blight, maize streak vims and ear rots. Weeds of high economic importance include purple witch weed (*Striga* sp.), couch grass (*Cynodon dactylon* and *Cyperus rotundas*).

Although there are over 90 insect species that are considered pests of maize (Steffey *et al*., 1999), most of these can be considered minor and/or sporadic pests. However, there are several key pests of which all producers must be mindful each year. These include the corn rootworm complex of beetles (*Diabrotica* sp.).

In Gojam and Gondar, it was observed that *B. fusca*, *Rhophalosiphum maidis* are widely distributed ,while the cereal leaf beetle (*Oulema* sp.), termites and African bollworm are also common (Melaku, unpublished). Cobworm (*Eublema gaymere*) and *Cicadulina* sp. were observed at Motta and Li birr, respectively. In south Gondar, *B. fusca* was observed attacking triticale (Birhane Assayehegne, 2001).

Isard (2004) recorded that the damage due to insect pest complex depends upon their population trends in the field which, in turn, rely upon the physical factors of their immediate environment.

Rahman *et al*. (1994) reported that the pests of maize are strongly influenced by weather conditions and are very difficult to predict. A thorough understanding of the exact relationship between the change in environmental factors and those in the pest population may not only help anticipate the pest losses to the crop, but also help avoid them through some well-timed pest control measure.

The presence of insects also raises the product temperature, due to their feeding activity, resulting in "hot spots" (Appert, 1987; Mills, 1989).

Andrews (1921), the beetle can be seen almost throughout the year, the peak occurrence being in March and April and again in September and October.

According to van Huis, 1981 reported the grain productivity in Central America in maize that is cultivated during wet season under natural rainfall.

Dhaliwal and Koul (2010) observed that the various control measures against pests farmers are mainly depend on chemical control which cause consistently increase in crop loss. This is due to misuse and overuse of insecticides which cause resistance and increase the survival rate of insect pests.

In India, Sudesh *et al*. (1996) found that infestation of wheat, maize and sorghum grains with single or mixed populations of *Trogoderma granarium* and *Rhyzopertha dominica* resulted in substantial reductions in the contents of total lipids, phospholipids, galactolipids, and polar and nonpolar lipids, while Jood *et al*. (1995) recorded a significant decrease in essential amino acids in the same crops due to mixed infestation with the same two pests, with maximum reduction found in methionine, isoleucine and lysine. Similarly, Kumar *et al*. (1996) recorded a substantial reduction in starch in parboiled cassava chips due to infestation with *Sitophilus oryzae* and *Rhyzopertha dominica* as compared to the uninfested chips.

In Nigeria, Okiwelu *et al*. (1987) recorded high level of moisture, combined with a decrease in germination ability of maize due to infestation by *Sitophilus zeamais*, while Mbata (1994) showed that infestation of bambarra groundnuts (*Vigna subterranea*) with *Callosobruchus subinnotatus* reduced seed viability and increased free fatty acids and peroxides, which are indices used in measuring biochemical deterioration

Insect pests inflict their damage on stored products mainly by direct feeding. Some species feed on the endosperm causing loss of weight and quality, while other species feed on the germ, resulting in poor seed germination and less viability (Malek and Parveen, 1989; Santos *et al*., 1990)

In Zimbabwe, 9.1 percentage of potential yield of maize was lost due to attack by pests (Mvumi *et al*., 1995).

Prostephanus truncatus (Horn), exotic storage pest native to Mexico has been introduced to Africa (McFarlane, 1988; Pike *et al*., 1992), where it is a more destructive pest of stored maize and cassava than in its native Central America (Dick, 1988). *P. truncatus* attacks maize before and after harvest. Adults bore into the maize cob causing severe damage and weight loss. In Tanzania, maize losses of up to 35 percentage may occur due to *P. truncatus* in 5-6 months if improperly stored (Mallya, 1992), and up to 60 percentage after nine months of storage (Keil, 1988).

The loss incurred by a single insect under field condition is difficult to access, however it has been estimated that the yield loss due to insect pest ranges from 15 to 25 percent (FAO, 1979). It has been asserted that an estimated 35 percent of potential yield in developing countries is lost due to defective and inadequate pest control. The maximum loss was calculated to be 31.5 for Asia (excluding Japan and main land China) followed by 33.7 percent for Africa, 20.5 percent for America and 21.0 percent for North and Central America (Barr *et al.* 1975).

Spodoptera frugiperda, the fall armyworm, has been reported to cause yield reductions of 15-30% in Nicaragua (Obando, 1976; van Huis, 1981; Hruska *et al.*, 1987). *Valbulus maidis*, the corn leafhopper, occurs throughout most of Latin America and is the primary vector of three maize pathogens, one of which is the corn stunt spiroplasm (Gamez, 1969; Davis, 1974; Nault, 1980; Power, 1987). In Nicaragua, Urbina (1982) reported that maize production is severely limited by this pathogen.

2.2 In national context

In Nepal, maize (*Zea mays* L.) is emerging as second most important crop after rice and one of the staple food crops being used mostly for human consumption by hilly populations. With the introduction of new high yielding varieties/hybrids and advancement in farming technologies, the cropping pattern has changed. As a result of this, maize is grown now round the year. This has added new dimensions to the pestilence front (Panwar, 1995).

More than 70 species of insect pest are known to attack maize in Nepal. About 20 species of are identified as the most destructive (Jyoti and Shivakoti, 1992). The major insect pests are in field condition; cutworm (*Agrotis ipsilon*), white grub (Phyllophaga *rugosa*), red ant (*Dorylus orientalis*), termite (*Odontoterm esobesus*), armyworm (*Mythimna separate*), maize borer (*Chilo partellus*), field cricket (*Tarbinkiellus portentosis*), maize shoot fly (*Atherigona* sp.), maize aphid (*Rhophalosiphum maidis*). And storage condition maize weevil (*Sitophilus zeamais*), warehouse moth, grain moth (*Sitotroga cerealella*).

The first paper on the systematic studies of insects from Nepal was written by F.W. Hope in the nineteenth century. During the last few years, some information on various insect groups like butterflies, aphids, dragon flies, weevils, carabids, etc. of Nepal have been reported by members of various scientific expedition as well as by the Entomology section of Agriculture Department, Khumaltar, Lalitpur. The Entomology section of Khumaltar publishes annual reports every year pointing out the status as well as biology and chemical control of important pests of different crops.

Aphids are of great economic importance since they suck up plant sap, hamper plant growth as well as spread several plant virus diseases to floricultural, silvicultural and wild plants. They suck sap, secrete honeydew through anus, which attracts sooty moulds, a fungus. They reproduce by parthenogenesis or by budding. Adult females are viviparous. (Tamrakar *et al*., 2000)

According to Paneru and Giri (2011) cereal crop cover most of the cultivated area of the country. Rice, Maize, Wheat and Millet are major cereals crops and supply major staple food product. The productivity and quality of cereals are greatly influenced by the level of insect pest attack. Through various insect pests have been reported as a problematic biotic factor in cereals crops grown under various locations of Nepal at different levels; stem borers, leaf and plant hoppers, rice gundhi bugs, rice hispa, white grubs and leaf folders are considered to be major insect pests in Nepalese farming system. Stem borers are serious insect pest of rice, maize and wheat. These are chronic insect pest which are present in all rice fields. Yellow stem borer, pale headed stripped borer and pink stem are considered to be the major stem borer in Nepalese context.

About 20 to 80% of plants damaged due to maize stem borer were recorded in various studies (Thakur *et al*., 2013; Neupane *et al*., 1984). Similarly, Sharma and Gautam (2010) recorded more than 28% of grain harvested from stem borer protected field as compared to borer unprotected field. Mainly, the borer complex associated species in Chitwan condition were *Chilo partellus*, *Sesamia inferens*, *Chilo suppersalis* (Jyoti and Shivakoti, 1992).

Pradhan and Manandhar (1992) reported the total loss of cereal grain from rodents is 44.3% on a national basis and in maize alone is about 21.5 % in the mountains, hills and terai regions.

The ecological belt-wise storage loss in maize has been, however, reported by Anon (1982), which indicated total weight loss due to various agents including rodent, insect and mold as 8.0% in the mountain, 7.4% in the hill and 13.0% in the terai.

In Chitwan condition, maize can be grown all three seasons: spring, summer and winter (Nayava and Gurung, 2010); however, both biotic and abiotic factors have played a decisive role for grain production. Of the biotic constraints, stem borer complex: maize stem borer, *Chilo partellus*, pink stem borer, *Sesamia inferens*, and the stripped stem borer, *Chilo suppersalis* are frequently noticeable species (Jyoti and Shivakoti, 1992). Among them, *C. partellus* is most destructive pest in Nepal (Neupane *et al*., 1984). Newly hatched larvae of stem borer migrate to whorl and feed on leaf as a result of damaged leaf appears pin holes and window panes. Subsequently the second generation larvae emigrate inside the collar region of the plant and start making tunnel into stalk. The larvae that feed into stalk may pupate inside the stem or exit out from stem by making a hole, which is called exit hole. In this way, roughly, up to five generations of *C. partellus* recorded in the Chitwan valley of Nepal (Neupane *et al*., 1988). Regarding the destructiveness of maize stem borer in maize can be expressed in terms of leaf feeding, whorl and stalk infestation, tunnel length measurement per plant, and exit holes on stalk in which various studies found 20% to 80% of damage level (Thakur *et al*., 2013; Neupane *et al*., 1984a).

Joshi (1977) reported that the low productivity (2.5 ton/ha) of maize in Nepal is attributed to many reasons. Among them is the attack of various insect pests. The cumulative effect of pests including some other minor insects on maize yield is reported to be 33-41% at Khumaltar. It is experienced that more than 50 percent loss or sometimes even more damage of the production is due to pests and diseases (Yonjon, 2000).

Because of the increased demand with good market outlets and better price, farmers have been using pesticides in the vegetables indiscriminately with frequent and cocktail spray to protect the increasing incidence of insect pests and diseases (Manandhar, 2000).

With the growing trend of commercial production of Nepal, the use of pesticides on crops has increased dramatically in recent years (Maharjan et al. 2004). However, it worths nothing as we glance that the average use of pesticides in Nepal which is 142g/ha (Jha, 2008). According to the latest estimate, the annual import of pesticides in Nepal is about 211ton a.i. with 29.19 percent insecticides, 61.38 percent fungicide, 7.34 percent herbicides and 2 percent others. In Nepal chemical pesticides is the major crop protection inputs and it is used indiscriminately without considering its productivity and its effects on the natural biological resources base of the production system.

As pesticide is the major crop protection input especially for crop production in Nepal and it is used indiscriminately in crop production without considering its effect on the natural biological resource base of the production system. Bio-pesticides are one of the critical inputs for integrated pest management that hold promises as alternative to chemical pesticides to reduce its externalities to environment and human health (Jha, 2008).

In Nepal, use of chemical pesticides in field crops was started during the early 1950s to a limited scale. After the introduction of high yielding varieties and influenced by slogan “produce more compaign”, pesticide use specially in all cash crops gradually increased in terms of quantity and frequency. Pesticide act was enforced only after 1999. Basically the act was formulated to regulate the import and use of pesticides and enable the consumers to be safe from biohazards (SAARC, 2009). The use is higher in areas with intensive commercial farming of crops indicating the need for intensive implementation of IPM-farmers field school (FFS) programmed. About 859 types of formulations by trade name (Insecticides-500, fungicides-229, herbicides-88, rodenticides-10, bactericides-6 and biopesticides-19) and 102 by technical or common name have been registered for use up to date 2071 (PRMS, 2071). Based on WHO risk classification system, all classes of pesticides are available in the market like highly hazardous (Class Ib), moderately hazardous (Class II), slightly hazardous (Class III), low risk (Class U/NH) and unknown (NC). As there is an open and porous border with India, there is a considerable but unknown quantity of trade between farmers to farmers close to the border. Issues like illicit import/smuggled pesticides are of trans-boundary natures which are concern to Nepal in the context of pesticide hazards (GC, 2012).

3. MATERIALS AND METHODS

3.1 Study area

3.1.1 Location Map of study area

The study site was Sipadol village of Kathmandu District which falls under central development region of Nepal and a part of Bagmati Zone. Geographically it lies between 27°38’49.7” North Latitude to 85°26’16.7” East Longitude, at an altitude 1513m from sea level. It has an area of 8.02 square kilometer with an altitude ranges.

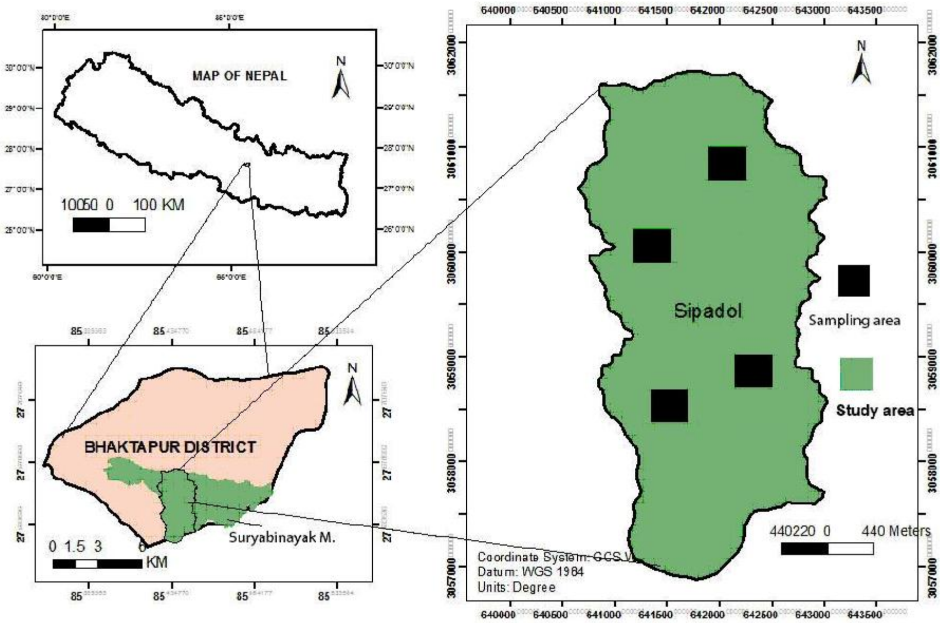

Figure 1: Location map of study area

3.1.2 Status of Sipadol village

The total household of Sipadol is 2278 with the total population 9876 among them, 4862 are male and 5014 are female. Most of the population is literate about 76.4%. There is considered to be the potential area for the agricultural production.

3.2 Study Design

The study was conducted out in four months and started from May–August. Four plots were chosen randomly from Sipadol village. The size of each plots were of 20×20 square meter. From each sites 25 different maize plants were selected randomly and were marked. Then they were checked for the insect pests, by observing all parts of the plants such as stem, leaf, blossoms for four different months. Pests were observed by means of hand lens.

3.3 Equipments

- Vials (70% ethanol)
- Blunt and sharp forceps
- Camel Brush
- 1.1-1.3 mm size of entomological pins
- Paper envelope
- Simple microscope with 10X and 20X
- Sweep net

3.4 Data Collection

The study was based on primary as well as secondary data:

3.4.1 Primary Data Collection

For primary data the study site was observed directly and collected the needed data. The following methods were abided:

a. **Pest collection:**

   The large pests were collected by handpicking method with the help of forceps and camel brush as assessor for collection and preservation of were put inside the vials containing 70% ethanol as preservatives. Sweep net was used for collecting flying insect pests; On the other hand, beating process and aspirator were used for the collection of small and light insects. For collecting the pest a random sampling method was applied which covered 10-15% of the total maize plants of their respective fields.

b. **Preservation:**

   The different processes of dry and wet preservations were applied for the preservation of pests depending upon their nature. Similarly, the winged insect pests were temporarily preserved in envelope and later on pinned in entomological box by spreading their wings.

c. **Questionnaire survey**

   During field, questionnaire survey was carried at the end of July. The semi-structure method was followed for questionnaire survey. The villagers who cultivate maize were chosen. Ten from each plot altogether 40 farmers from surrounding of each plot were sampled.

3.4.2 Secondary Data Collection

The secondary data were collected from both published and unpublished literature from different sources like related to journals, scientific papers, publication, websites, government and non-government institution.

3.5 Identification of pest

The pests were identified with the help of keys and literatures (Borer and Delong, 1971; Gupta, 1985; Sharma, 2000 and Hill, 2012,). Most of the collected species were identified by Entomological section of CDZ, NARC and NHM, Ktm.

3.6 Specimens deposition

The collected specimens were deposited in Central Department of Zoology.

3.7 Data analysis

The collected data were checked, entered and analyzed through Ms. Excel 2010. For the good result Two- way analysis of Variance (ANOVA) was used to test the significance difference in number of pest observed in different sites. This association analysis was performed under R 3.3.2 platform by using multipatt package to see whether there is species associated with particular month or month combination ($\alpha = 0.05$).

Similarly, Species diversity was calculated by Shannon Diversity Index (H) and Community dominance was calculated by Simpsons index (Odum 1996), where:

$$(H) = -\Sigma(ni/N)\log(ni/N)$$

Where,

H= Shannon index of Diversity

ni= Importance value for each species

N= Total no. of importance value

(∴Importance value= number of individual)

In addition to this, the index of dominance (c) was calculated as-

Index of dominance (c) = $\Sigma(ni/N)$

Where,

C= index of Dominance

ni= Importance value for each species

N= Total no. of importance value

4. RESULTS

4.1 Pests of Maize

Altogether 16 species of maize pests belonging to 12 families and 5 orders were observed in the Kathmandu valley during the study. Among them, Family Noctuidae had 5 species, whereas other families were represented by single species (Table 1).

Table 1. Pest species with their order and families:

Order	Family	Species	May	Jun	July	Aug
Lepidoptera	Pyralidae	*Chilo partellus (*Swinhoe, 1885)	37	63	50	32
	Noctuidae	*Helicoverpa armigera* (Hubner, 1808)	19	34	22	13
		Sesamia inferens (Walker, 1856)	28	44	36	22
		Mythmna separate (Walker, 1856)	14	23	16	4
		Spodoptera exampta (Walker, 1856)	13	24	19	5
		Agrotis sp. (Hufnagal, 1766)	17	28	23	9
	Erebidae	*Amsacta moorei* (Butler, 1876)	11	28	20	5
Sub- total individual	659		139	244	186	90
Sub total number of species			7	7	7	7
Coleoptera	Scarabaeidae	*Phyllophaga rugosa* (Harris, 1827)	11	24	18	4
	Meloidae	*Mylabris pustulata* (Thunberg, 1821)	8	21	14	7
	Coccinellidae	*Epilachna* sp. (Heymons, 1915)	10	28	13	4
Sub- total individual	162		29	73	45	15
Sub total number of species			3	3	3	3
Orthoptera	Gryllotalpidae	*Gryllotalpa africana* (Beauvois, 1805)	10	21	14	3
	Gryllidae	*Brachytrupes portentosus* (Lichtenstein, 1796)	4	17	14	1
	Acrididae	*Heiroglyphos banions* (Macleay, 1821)	7	20	13	2
Sub- total	126		21	58	41	6

individual						
Sub total number of species			3	3	3	3
Hemiptera	Aphididae	*Rhopalosiphom maidis* (Fitch, 1856)	26	38	32	18
	Pentatomididae	*Nazara viridula* (Linnaeus, 1758)	3	11	8	3
Sub- total individual	139		29	49	40	21
Sub total number of species			2	2	2	2
Isoptera	Termitididae	*Microtermes* sp. (Holmgren, 1912)	20	36	27	14
Sub- total individual	97		20	36	27	14
Sub total number of species			1	1	1	1
Total individuals (n)	1183					
Total species (S)	16					
eveness (e)	0.935					
Shannon index (H')	2.593					

4.2 Relative abundance

This study had found the following number of species. Generally *Chilo partellus* (Swinhoe, 1885) had ranked at the first or commonly found species followed by *Sesamia inferens* (Walker, 1856) and *Rhopalosiphom maidis* (Fitch, 1856) as maize pest insect in Sipadol village. (Figure 5)

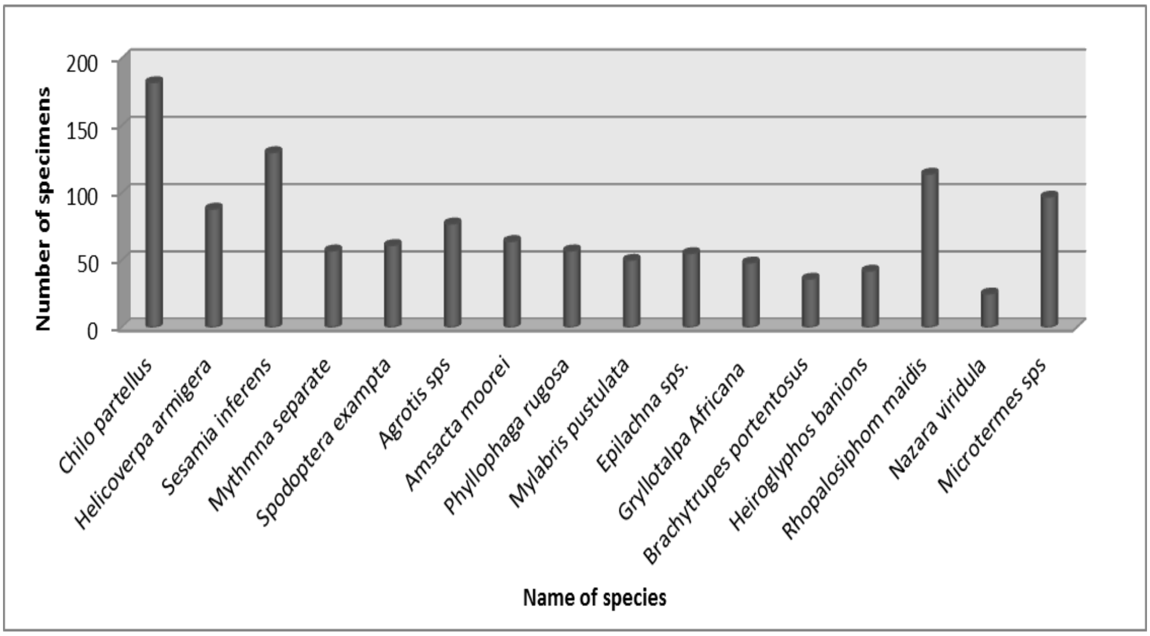

Figure 2: Pest species and their number

Altogether 1183 individuals of pests belonging to five order and 16 species were observed during study. Among them, Maize stem borer *Chilo partellus* (Swinhoe, 1885) was the most common pest of maize followed by Pink stem borer *Sesamia inferens* (Walker, 1856*)* and Aphids *Rhopalosiphom maidis* (Fitch, 1856). Green bug *Nazara viridula* (Linnaeus, 1758*)* showed the least (Table 2).

4.2.1. Nature of Damage:

On the basis of the data collected from the field, the pest damaged on different parts of the maize plant which were categorized into borer, defoliator, and sap sucker and chewing. According to the data, borer and chewing both was found highest with 34%. While defoliator was found in 20 % and sap sucker was found in 12 % (Figure 6).

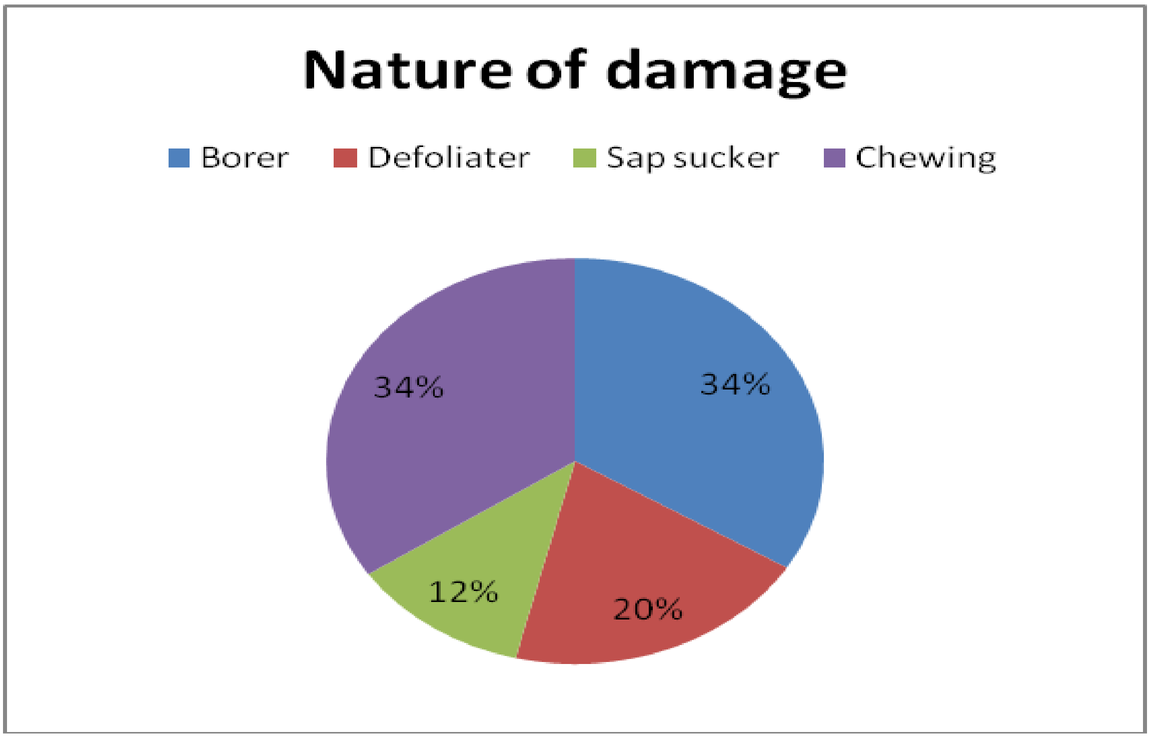

Figure 3: Chart showing nature of damage

4.2.2 Order-wise composition of maize pest

According to the study, most of the specimens were belonging to Lepidoptera, where 7 species and abundance was 659 found in this order. Less number of species was found in the Order of Isoptera in which species and abundance was found to be 1 and 97 respectively. In Coleoptera and Orthoptera no variation in the number of species but abundance was different in two orders as 159 and 121 respectively was recorded. (Figure 7).

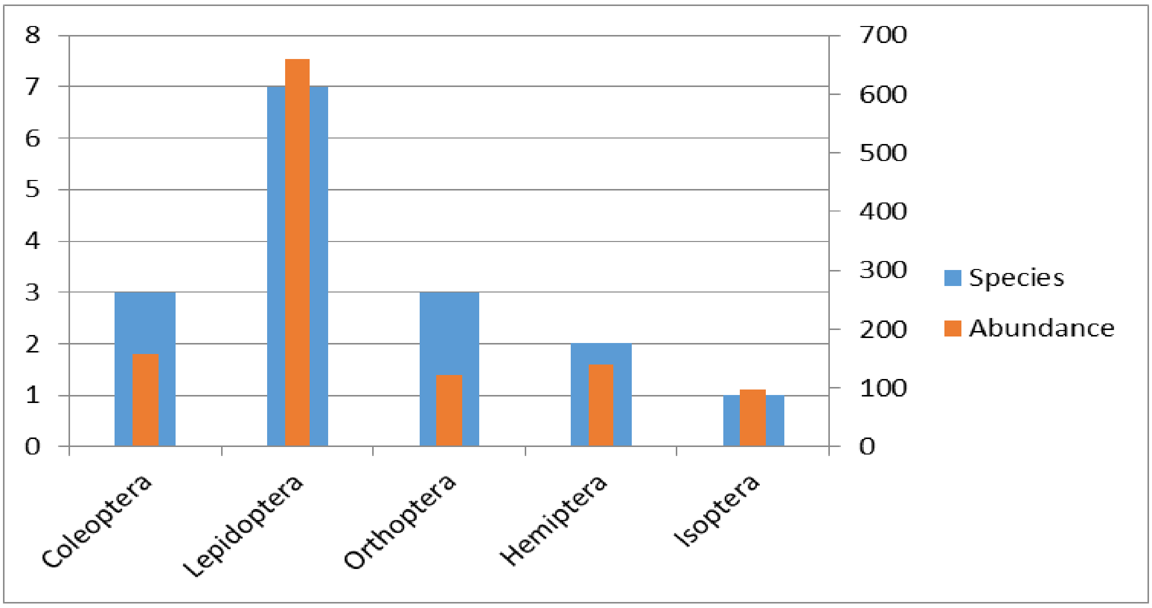

Figure 4: Species and abundances on the basis of order

4.3 Monthly variation of maize pest

On the basis of the study of monthly variation, among 1183 specimens, abundances was found to higher in June (398) which is about 34% followed by July (27%), May (21%) and the lowest in August (18%). Total species of 16 were recorded in four sites where the month June and July had all the species recorded. Regarding specific pests, Maize stem borer *Chilo partellus* (Swinhoe, 1885), Pink stem borer *Sesamia inferens* (Walker, 1856) and Aphids *Rhopalosiphom maidis* (Fitch, 1856)) were most dominant species in June and July. While Green bug *Nazara viridula* (Linnaeus, 1758) were common least species in subsequent months. Data showed that plot C had higher percentage of specimens than other block (Sipadol) in the month of June and lowest is in August. The species number found in four different sites were varied. The data shows the highest number of species during June and July, and lowest number of species during August.

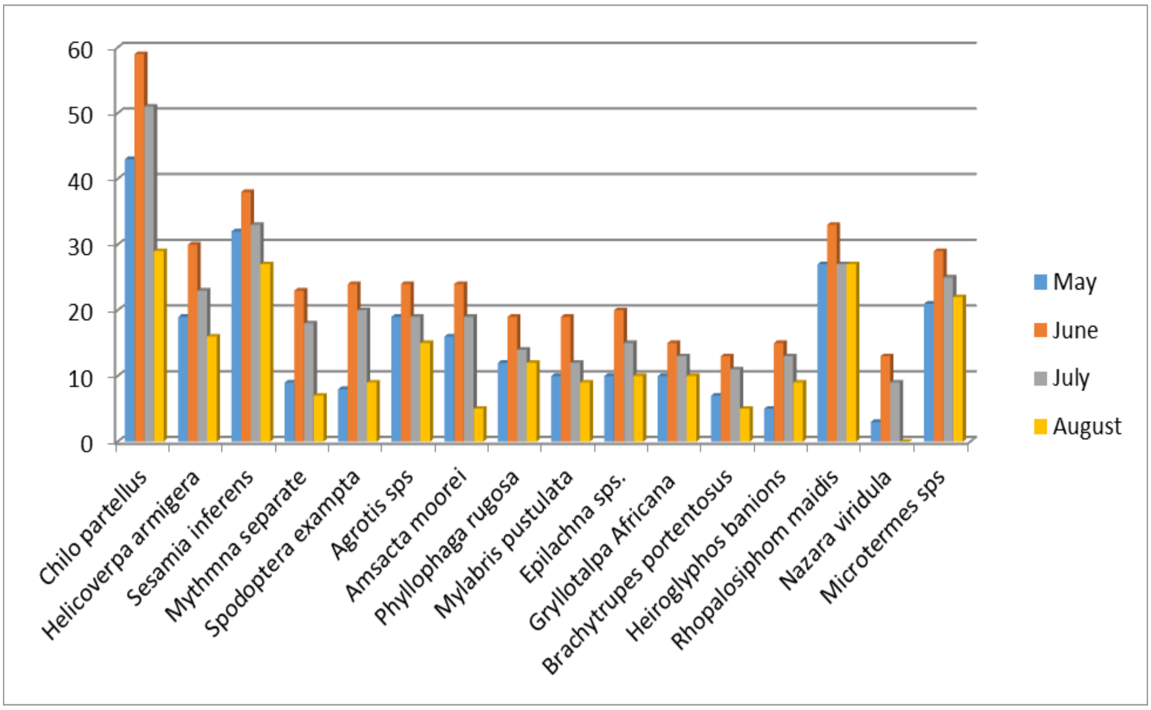

Figure 5: Monthly variation of Maize pests

4.4 Management practices:

4.4.1 Methods of crop pest management:

The methods of crop pest management used by the farmers were cultural, mechanical, biological and use of local pesticides and chemical pesticides. The use of synthetic chemical pesticides is commonly used pest management practice in the area. 70% of the farmers applied chemical pesticides in their field. The use of such pesticides has been effective to manage pest problems in these crops. But pest management in maize has become difficult. The chemical pesticides are also used to manage leaf, weeds as well which has become the serious problem in production. 19% of the respondents were applied mechanical methods and 11% of the respondents were applying cultural methods.

100% were unknown to biological management practices and homemade pesticide. Because of lack knowledge of biological control and others increasing trend of chemical pesticide used day by day in study area of Sipadol (Figure 9).

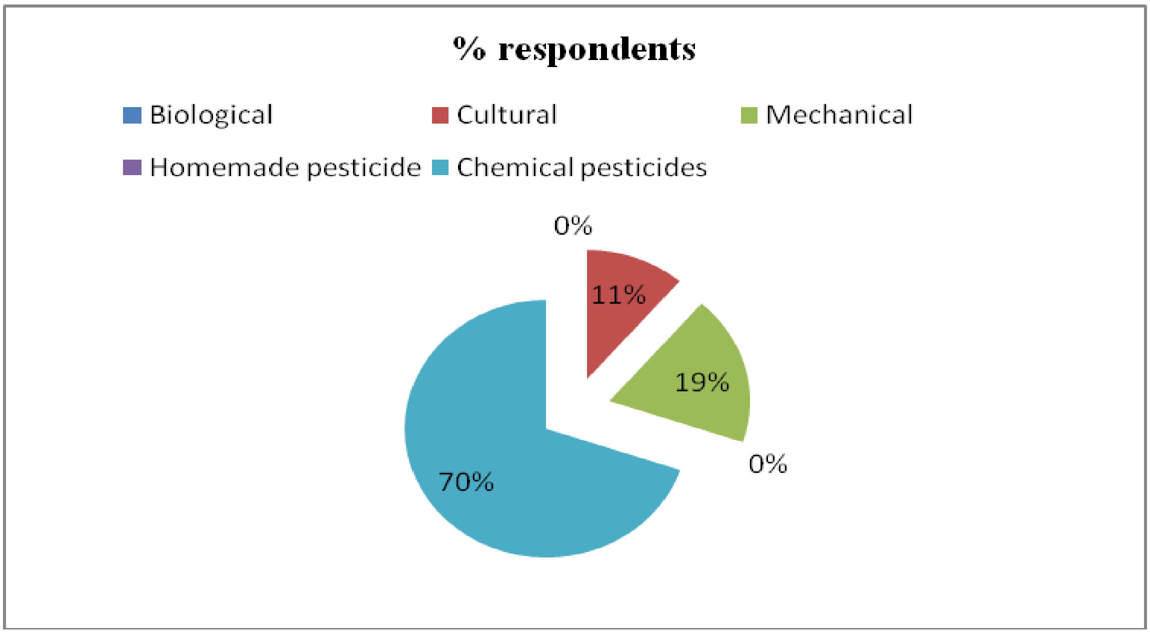

Figure 6: Maize pest control practices used by farmers

4.4.2 Major pesticides used by farmers in Sipadol village, Bhaktapur :

The farmers applied synthetic chemical pesticides in allow amount particularly on the crops to manage insect pests to increase crop productivity. Both male and female are equally involved to purchase, apply, store and dispose the chemical pesticides. Most of the respondents do not know name of the chemical pesticides banned by the government of Nepal to sale and use in Nepal. The name of commonly used chemical pesticides is Chloropyriphos 50% EC and Cypermethrin 5% EC etc (Table 3). It was found that 92% of chemicals were used by farmer of study area and 8% of respondents were no used any type of pesticides for insect pest control. The frequency of pesticide use was 1 times by 27% of respondents and 2 times by 73% of respondents in these study area (Figure 10 and 11).

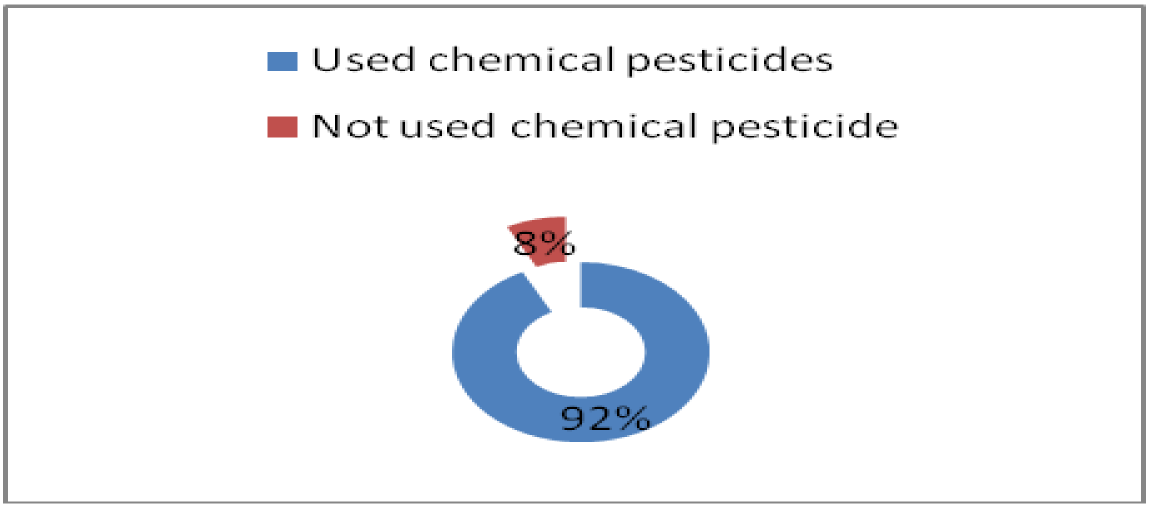

Figure 7: Use and unuse of pesticide by farmer

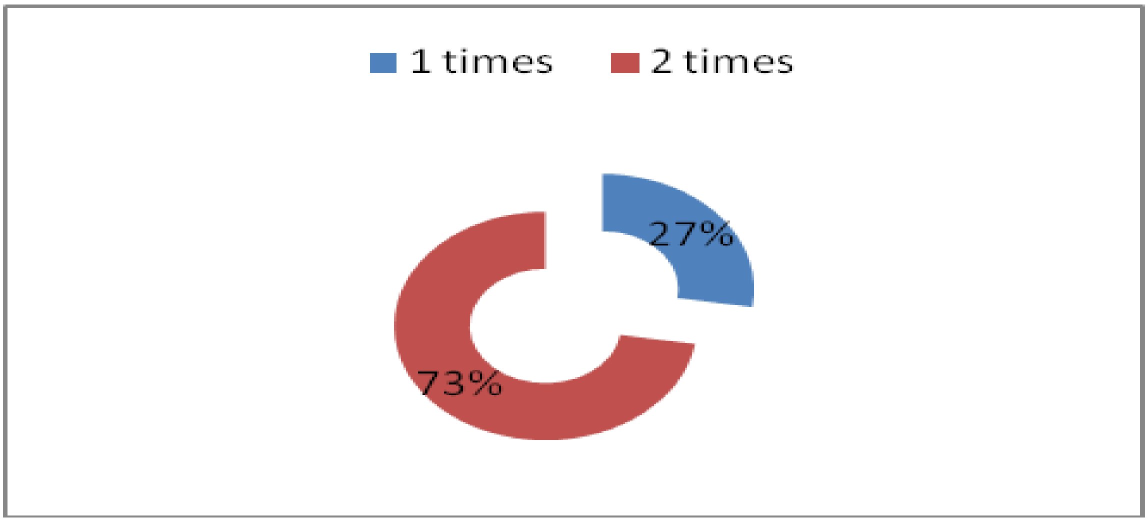

Figure 8: Pesticide often used by farmers

Table 2: Quantity of chemical used

Used chemical	Amount to used
Chloropyriphos 50%EC +Cypermethrin 5% EC	1.5 ml L¯1 of water
Furadon 3Gr	3-4g/whorl
Confidor 200SL	0.5 ml L’1 of water
Chloropyriphos 20% EC	1.5 ml L¯1 of water

4.4.3 Sources of information:

During questionnaire, all farmers seemed to be dependent or purchased pesticide from the shop that is based on agrovet. Eighty seven 87% followed the idea on the procedure about the use of pesticide through agrovet, whereas 13 % from JTA (Figure 12).

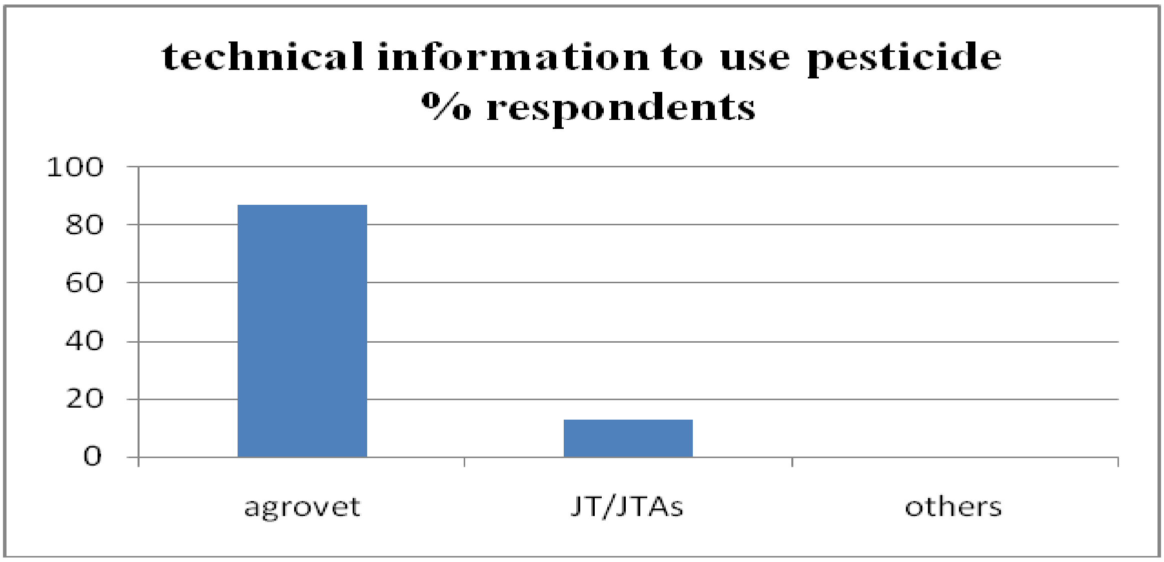

Figure 9: Technical information to use pesticide

4.5 Pest and its abundance in four month

The statistical tool Two-Way ANOVA was used to analyze the data on pest species and abundance in four months and four plots. According to the statistical analysis there was significant difference between pest species and plots (f = 3.76, df =3 p = 0.05). Similar significance difference between pest species and months (f = 324.89, df = 3, p = 1.73E-09) was found. In addition, with regard to abundance and plots, there was no significance difference (f = 1.61, df = 3 and p = 0.25) whereas the variation of months differ with the abundance of the species in different plots (f = 31.38, df = 3, p = 4.27E-05).

4.6 Multilevel pattern analysis

Among 16 species collected in 4 months, no species was found to be significantly associated with single month. One species was found to be significantly associated with two months and 6 species was found to be significantly associated with three months. *Brachtrupes portentosus* (Lichtenstein, 1796) was found to be indicator species of June and July months where *Heiroglyphos banions* (Macleay, 1821), *Gryllotalpa Africana* (Beauvois, 1805), *Epilachna sp*. (Heymons, 1915), *Amsacta moorei* (Butler, 1876) and *Spodoptera exampta* (Walker, 1856) were indicator species of May, June and July months.

5. DISCUSSION

Maize is currently one of the most important crops and is generally cultivated by small holder farmers who save open pollinated seed from one season to the next. Altogether 1183 individuals of pests belonging to 16 species were observed during study. In this study, 16 insect pests were recorded belonging to five orders and 12 families which is similar to the finding of Pollard, 1971; Midega, 2001 in which a total of 12 families from 7 insect orders and 4 families. Similarly Abraham et al., 1993 recorded the more than 40 species of insects as pest on maize and recorded, the maize stalk borer (*Busseola fusca*), spotted stalk borer (*Chilo partellus*), and various termite species (Macrotermes and Microtermes sp.) as the key pests. Finding on Alejandro, 1987 in which Lepidopterous pests (which include cutworms, armyworms, earworms, borers, and grain moths) are the most damaging to maize worldwide, followed by the Coleoptera (root worms, wireworms, grubs, grain borers, and weevils).

It was found that Maize stem borer *Chilo partellus (*Swinhoe, 1885) is the most common pest of maize. Similarly, the other frequently occurring pests were Pink stem borer *Sesamia inferens* (Walker, 1856), Gram stem borer *Helicoverpa armigera* (Hubner, 1808), Aphids *Rhopalosiphom maidis* (Fitch, 1856), Termites *Microtermes* sp. (Holmgren, 1912), Cut worm *Agrotis* sp. (Hufnagal, 1766), Army worm *Spodoptera exampta* (Walker, 1856). Green bugs *Nazara viridula* (Linnaeus, 1758) were the least common species in Maize pest during the study which was comparable with the research work carried out by Santosh et al., 2012 in India the maize is greatly affected by the infestation of two major insect pests, spotted stem borer *Chilo partellus* (Swinhoe) and pink borer *Sesamia inferens* (Walker). Which supported the result of Pingali 2001, Dhaliwal and Arora 2001, Sekhon and Kanta 1997 in which among the serious pests, Maize stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) is one of the major biotic constraints throughout the country and abroad. Similarly in the study of Jyoti and Shivakoti, 1992 the biotic constraints, stem borer complex: maize stem borer, pink stem borer, and the stripped stem borer, *Chilo suppersalis* are frequently noticeable species. The annual report of NARC Annual Report (2014/15) also mentioned Maize stem borer (*Chilo partellus*) as a most common pest of Maize, including other species such as Cutworm (*Agrotis sp.*), Aphids (*Rhopalosiphom maidis*) and White grub (*Phyllophaga rugosa*) which resembles with my study.

On the basis of my study in Sipadol village, the species diversity index (SDI) of overall maize pests was high (2.593), which show stability in pest's ecosystem. On the basis of the data collected from the field, the pest damaged on different parts of the maize plant which were categorized into borer, defoliator, sap sucker and chewing. According to the data, borer and chewing both was found highest with 34%. While defoliator was found in 20 % and sap sucker was found in 12 %. Studies documented by Thakur et al., 2013 and Neupane et al., 1984 showed that the destructiveness of stem borer in maize can be expressed in terms of leaf feeding, whorl and stalk infestation etc has been found 20% to 80% of damage level and other sap sucking, defoliator are nominal damage level.

Different months of maize planting, from May to August, had significantly different on the measured borer damage parameters. It is obvious that almost each month had a wide range of minimum temperatures, maximum temperatures, humidity levels, and rainfall amount. An influence of these weather parameters to regulate growth and development of the larvae as well as adult of maize stem borers would not be beyond the expectation. The result showed that the time of June and July months had the more abundance which may due to temperature and low relative humidity, Similarly Navaya and Gurung, 2010 result showed the increasing trend of annual maximum temperature during the month of June and July. Although the pest population was statistically dependent to months, however, the highest number of pests was observed in June (39%) and gradually increment from May to June and their number gradually dwindled in the subsequent months. This result is in agreement with the finding of Dhooria and Bhutani (1983) and Putatunda and Tagore (2000), in which the pest population peaked during May to June and there was negligible population during August, as a result, their population was peaked in June months. As temperature is generally high in (May and June), this might be another cause for high density of pests in these months because in these months the life cycle of most of the insect pests became functional or more active during day time according to Pedigo (2002). Though there was no statistically variation in pests population due to months, but more number of pests was observed in June (39%) than in other months.

The finding of Tamiru et al., 2012 reported that temperature plays a significant effect for growth and development of pests. Regarding specific pests, Maize Stem Borer (*Chilo partellus*) alone dominated the all months in present study, but its number was higher in month of June which is similar to the study of Portor (2007) and Murray and Alston (2011), where they argued that maize stem borer and their density was high in this period. In support of that Tamiru, Jembere, & Bruce (2012) suggested that Chilo partellus (Swinhoe), one of the important insect species of maize borers. Similarly, Neupane, Chapman, and Coppel (1986) reported that a 30ºC temperature range was an optimum for *C. partellus* development, and the subsequent threshold temperatures for eggs, larval, Pupal and entire life development. On the other hand, there was no significant difference in the number of pests in different sites of Maize pests in Bhaktapur district. In all sites, Maize stem borer *Chilo partellus* (Swinhoe, 1885), Gram stem borer *Helicoverpa armigera* (Hubner, 1808), Army worm *Spodoptera exampta* (Walker, 1856), Hairy caterpillar *Amsacta moorei* (Butler, 1876), Cut worm *Agrotis sp.* (Hufnagal, 1766) Aphids *Rhopalosiphom maidis* (Fitch, 1856) etc were common pests and recorded mostly. These four sites are no more distance from one another. Though there exist of similar temperature, humidity and elevation. As a result, the pest composition seemed to be similar in all sites.

Percentage stem borer infestation was gradually increased toward the progress of weeks and more or less remained constant from 10 to 42 weeks and further start declined gradually. Thus, it is cleared that the above mentioned temperature is most congenial for pests’ growth and development. These finding has confirmed with the work of Tamiru et al. (2012) as most suitable condition for *Chilo partellus Swinehoe* development was 26 to

30°c temperature. Beside maize stem borer, sporadic infestation of some minor insects like Army worm in winter seeding maize, Leaf folder, White grub, Grass hopper in rainy season. Aphids, Field cricket and Cut worm were observed in the field but their damage was nominal. About 20 to 80% of plants damaged due to maize stem borer were recorded in various studies of Thakur, Shrestha, Bhandari, & Achhami, 2013; Neupane, Coppel, & Chapman, 1984. Similarly, Sharma & Gautam (2010) recorded more than 28% of grain harvested from stem borer protected field as compared to borer unprotected field. Mainly, the borer complex associated species in Chitwan condition were *Chilo partellus*, *Sesamia inferens*, *Chilo suppersalis* which is recorded on Jyoti & Shivakoti, 1992.

On the basis of questionnaire survey the methods of crop pest management used by the farmers were cultural, mechanical, biological and use of homemade pesticides and chemical pesticides. The use of synthetic chemical pesticides is commonly used pest management practice in the area. 70% of the farmers applied chemical pesticides in their field followed by mechanical and cultural method. The use of such pesticides has been effective to manage pest problems in these crops. The chemical pesticides are also used to manage leaf, weeds as well which has become the serious problem in production. All respondents were unknown to biological management practices and homemade pesticide. Due to lack of knowledge on biological control chemical pesticide is using which is in increasing order. This study result supported the Poubom et al., 2005 results indicated that only 45.70 % of the farmers used one indigenous method or another, while 54.30 % depended solely on conventional control methods, which are expensive and the indigenous methods were time-consuming and they were not sure of the results. Those who used indigenous methods believed that those methods were cheaper with harmless facing and no problems. Cultural/indigenous practices are not expensive for the farmers and do not necessitate in general, supplementary material investments to control insect pests. Aslam et al., 2002 results showed that very few farmers were using plants as insect pest control methods in their fields. Farmers perceived plant derivatives could not give the desired results achieved when conventional methods are used. Possibly integrating the use of resistant plants with plant derivatives could be a better option for replacing synthetic chemicals, given that they are simple, economical and important strategies in insect pest control. Farmers' knowledge and perception of their use can accelerate and facilitate their adoption in the local communities. The result of Pan 2003 showed that more farmers depended on pesticides than on botanical control, although not adequately informed about their proper use. Similarly Ministry of Agriculture, Cameroon, 2008 studies carried out that more than 42 % of farmers use pesticides.

According to farmers, Chloropyriphos 50% EC and Cypermethrin 5% EC etc were usually used. It was found that most farmer of study area used pesticides in order to yield more production. The study of Emana and Tsedeke, 1999 research results carried at Arsi-Negele indicated that early sowing with cypermethrin treatment doubled the yield of maize grain. The highest economic return with cypermethrin treatment at the rate of 0.30 kg a.i./ ha applied at 4 and 6 weeks after crop emergence was obtained with early sowing, indicating that early infestation of stem borer is very detrimental for maize production.

Tsedeke and Elias (1998) also reported that early sowing had a yield advantage of more than 58.2% over late sowing.

In this study, about 27% of respondent's sprayed pesticide once in growing period while 73% of respondents sprayed the pesticide twice in growing period. Most of the farmers seemed to be dependent on pesticide from the shop that is based on agro vet. 87% followed the idea on the procedure about the use of pesticide through agro vet, whereas 13 % from JTA. The study of Phiri and Otieno (2008) further indicated that adulterated insecticides are often sold to farmers without the farmers' knowledge. Abate et al., 2000, showed that traditionally, farmers have used various forms of cultural practices and local communities still continue to use an array of insecticidal plants for the control of specific pests. Ethnoecology or traditional ecological knowledge (Berkes, 2008) is important for the identification of indigenous practices and for the formulation of sustainable pest management strategies relevant to local conditions. Although Ogendo et al., 2004; 2007 explained that the synthetic pesticides are a vital component of the control of maize pests, their high cost, inaccessibility for resource-poor farmers, their misuse and the accompanying undesired effects could have negative impacts.

6. CONCLUSION AND RECOMMENDATIONS

A total of 16 species insect pests were recorded from the collected specimens during the study period which belongs to five orders Coleoptera, Lepidoptera, Hemiptera, Orthoptera and Isoptera and their families are Scarabaeidae, Meloidae, Coccinellidae, Pyralidae, Noctuidae, Erebidae, Aphididae, Pentatomididae, Gryllotalpidae, Gryllidae, Acrididae and Termitididae of insect pests.

The species diversity of overall maize pest was 2.593 and dominance was 0.087, which show stability in pest's ecosystem. Temperature is one of the most important factors that have great effect on pests (insects) developmental rates primarily because of their poikilothermic adaptation. On the basis of the study of monthly variation, among 1183 specimens, abundances was found to higher in June (398) which is about 34% followed by July (27%), May (21%) and the lowest in August (18%). Total species of 16 were recorded in four sites where the month June and July had all the species recorded. Regarding specific pests, Maize stem borer *Chilo partellus* (Swinhoe, 1885), Pink stem borer *Sesamia inferens* (Walker, 1856) and Aphids *Rhopalosiphom maidis* (Fitch, 1856) were most dominant species in June and July. While Green bug *Nazara viridula* (Linnaeus, 1758) were common least species in subsequent months. The data shows the highest number of species during June and July, and lowest number of species during August.

Among the majority of farmers, the used of pest management option were cultural, mechanical, biological, homemade pesticide and chemical pesticides. The most common used pest management practices option was synthetic chemical pesticides. The use of such pesticides has been effective to manage pest problems in these crops. The chemical pesticides are also used to manage leaf, weeds as well which has become the serious problem in production. Most farmers were unfamiliar with the biological management practices and homemade pesticide. The commonly used chemical pesticides were Chloropyriphos 50% EC and Cypermethrin 5% EC etc. Because of lack knowledge of biological control and others, the use of chemical pesticide is increasing.

On the basis of the investigation it can be concluded that, major problem of Maize cultivation of the study area were increasing infestation of Maize stem borer. Other insect pests are less negligible as compared to borer.

Based on this study, following recommendation is derived:

- Studies relating to Maize pests should be carried out regularly, as it has been seen that research regarding Maize pests had not been done since one decade.
- Farmers must give knowledge about different types of pests and diseases which attack their crops, their biology and their infestation parts. So that farmers themselves can identify the pest 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 doesn't 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 use 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 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 to reduce reliance on pesticides, reduce costs of pest management and to ensure correct choice.

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Appendix 1

Pest species with their order and families:

S.N.	Order	Family	Species	Common name
1	Lepidoptera	Pyralidae	*Chilo partellus (*Swinhoe, 1885)	Maize stem borer
		Noctuidae	*Helicoverpa armigera* (Hubner, 1808)	Gram stem borer
			Sesamia inferens (Walker, 1856)	Pink stem borer
			Mythmna separate (Walker, 1856)	Common armyworm
			Spodoptera exampta (Walker, 1856)	Armyworm
			Agrotis sp. (Hufnagal, 1766)	Cut worm
		Erebidae	*Amsacta moorei* (Butler, 1876)	Hairy caterpillar
2	Coleoptera	Scarabaeidae	*Phyllophaga rugosa* (Harris, 1827)	White grub
		Meloidae	*Mylabris pustulata* (Thunberg, 1821)	Blister beetle
		Coccinellidae	*Epilachna* sp. (Heymons, 1915)	Hadda beetle
3	Orthoptera	Gryllotalpidae	*Gryllotalpa africana* (Beauvois, 1805)	Mole cricket
		Gryllidae	*Brachytrupes portentosus* (Lichtenstein, 1796)	Field cricket
		Acrididae	*Heiroglyphos banions* (Macleay, 1821)	Grasshopper
4	Hemiptera	Aphididae	*Rhopalosiphom maidis* (Fitch, 1856)	Aphids
		Pentatomididae	*Nazara viridula* (Linnaeus, 1758)	Green bugs

5	Isoptera	Termitididae	*Microtermes* sp. (Holmgren, 1912)	Termites

Maximum and Minimum temperature, Annual rainfall and relative humidity record at meteorological station of Kathmandu District during study period in 2016.

Months	Max. temp. (°c)	Min. temp. (°c)	Annual Rainfall(mm)	Relative Humidity(%)
January	17	2	13	79
February	19	4	14	71
March	24	8	10	61
April	28	12	29	53
May	29	15	70	57
June	29	17	129	73
July	27	18	325	81
August	27	18	239	83
September	27	17	175	82
October	25	14	67	79
November	22	9	7	85
December	18	4	8	80

(Source: Department of Hydrology and Metrology, 2016)

Appendix 2

List of Survey questionnaire:

1. How many members in your family?
   ……………………………………….
2. In which section you are employed?
   i. Field ii. Office iii. Factory iv. Others
3. Are your crops damaged by insects?
   i. Yes ii. No
4. Which insects are mostly observed in your farm?
   …………………………………………………….
5. Do you know about major and minor pests? If yes.
   i. Major ii. Minor
6. Which parts of plant is mostly damage?

S.N.	Name of species	Affected part/25 plants				Remarks
		Leaf	Stem	Flower	root	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10	.					
11						
12						
13						
14						

15						
16						

7. In which month did you see the pest?
   i. May ii June iii. July iv. August
8. Do you use any preventive methods of pest?
   i. Yes ii. No
9. Which preventive methods did you use?
   i. Chemical ii. Physical iii. Botanical iv. Others
10. Which chemicals mostly used to prevent the pest in your farm?
    …………………………………………………………………….

S.N.	Name of pesticide	Target pest to reduce	Stage of crop	Effectiveness of crop	Remarks
1					
2					
3					
4					
5					

11. How often do you use these chemicals?
    i. Weekly ii. Monthly
12. Do you any take precautions while using?
    i. Yes ii. No
13. Is there control in the pest after the use of chemicals?
    i. Yes ii. No
14. Is there improvement in your production or not?
    i. Yes ii. No

Appendix 3: Pest species with their damage pattern

Pest	Nature of damage	Seen on plants
Chilo partellus	Borer	Inside the stem around the nodes
Helicoverpa armigera	Borer	Found on tender leaves and stem
Sesamia inferens	Borer	Found on leaf whorl, tender leaves and central shoot
Mythmna separate	Defoliater	Found on tender leaves, central leaf whorl and older leaves
Spodoptera exampta	Defoliater	Found on leaves
Agrotis sp.	Bitting and chewing	Found on young leaf and shoot
Amsacta moorei	Defoliater	Found on the under surface of young leaves
Phyllophaga rugosa	Chewing	Found on roots
Mylabris pustulata	Chewing	Found on flower
Epilachna sp.	Defoliater	Found on surface of leaves
Gryllotalpa Africana	Chewing	Found on roots
Brachytrupes portentosus	Chewing	Found on stem tunnels
Heiroglyphos banions	Chewing	Found on leaves
Rhopalosiphom maidis	Sap sucker	Abundant in developing tassel , flag leaves
Nazara viridula	Sap sucker	Found on tender parts
Microtermes sp.	Chewing	Found on root and stem

Appendix 4: Table of abundance of pest species collected in four months

species name	m/p1	m/p2	m/p3	m/p4	j/p1	j/p2	j/p3	j/p4	ju/p1	ju/p2	ju/p3	ju/p4	a/p1	a/p2	a/p3	a/p4
Chilo partellus	10	8	9	10	16	15	14	18	12	12	12	14	8	7	8	9
Helicoverpa armigera	4	5	5	5	8	9	9	8	5	6	6	5	3	3	4	3
Sesamia inferens	7	6	7	8	12	9	11	12	9	8	9	10	5	5	5	7
Mythmna separate	3	4	5	2	6	5	7	5	3	5	4	4	0	1	2	1
Spodoptera exampta	4	4	2	3	8	5	5	6	6	4	4	5	2	3	0	0
Agrotis sp.	4	4	4	5	6	7	6	9	5	7	5	6	2	2	3	2
Amsacta moorei	3	1	4	3	8	5	8	7	5	4	6	5	0	0	2	3
Phyllophaga rugosa	2	3	3	3	6	6	6	6	4	5	4	5	0	2	0	2
Mylabris pustulata	2	2	2	2	6	4	6	5	4	3	4	3	2	1	2	2
Epilachna sp.	1	3	3	3	9	5	9	5	4	2	5	2	0	2	0	2
Gryllotalpa Africana	3	2	3	2	4	6	6	5	3	4	3	4	1	0	2	0
Brachytrupes portentos	0	0	2	2	3	5	3	6	3	4	3	4	0	0	1	0

us																
Heiroglyphos banions	2	2	2	1	5	5	5	5	3	4	4	2	0	2	0	0
Rhopalosiphom maidis	8	5	6	7	11	8	10	9	9	7	8	8	4	4	4	6
Nazara viridula	0	0	2	1	2	3	3	3	2	2	2	2	0	0	3	0
Microtermes sp.	5	5	5	5	10	8	10	8	7	6	8	6	3	3	4	4
TOTAL	**58**	**54**	**64**	**62**	**120**	**105**	**118**	**117**	**84**	**83**	**87**	**85**	**30**	**35**	**40**	**41**

M=May p1= plot 1

J= June p2= plot 2

Ju= July p3= plot 3

A= August p4= plot 4

Photo 1:
Gram stem borer (*Helicoverpa armigera)*

Photo 2:
Photo 2: Cut worm (*Agrotis* sp.*)*

Photo 3: Army worm *(Spodoptera* sp.)

Photo 4:
Hairy Caterpillar (*Amsacta moorei)*

Photo 5:
Aphid infestation in maize plant

Photo 6:
Common army worm *(Mythimna* sp.)

Photo 7: Green bugs (Nazara viridula)

Photo 8: Collection of pests in vial

Photo 9:
Collection of pest through handpicking

Photo 10:
Questionnaire survey with Farmers

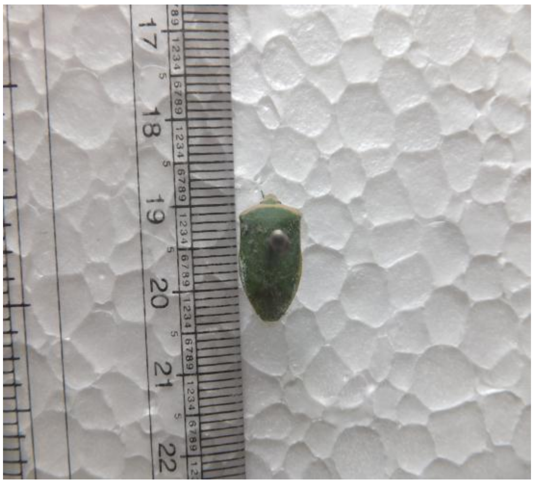

Photo 11:Phyllophaga rugosa

Nazara viridula