POST-HARVEST LOSS OF WHEAT AND ITS IMPACT ON FOOD SECURITY: A STUDY OF RAIKWAR VDC, KANCHANPUR, NEPAL

A Dissertation

Submitted for the partial fulfillment of Master's Degree in Botany

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RECOMMENDATION

This is to certify that Mr. Suresh Raj Paneru has completed this dissertation work entitled **"POST-HARVEST LOSS OF WHEAT AND IT'S IMPACT ON FOOD SECURITY: A STUDY OF RAIKWAR VDC, KANCHANPUR, NEPAL"** as a partial fulfillment of Masters of Science Degree in Botany under our supervision with special paper "Plant Pathology and Applied Mycology". This is his original research work and has been carried out under our supervision. To the best of our knowledge, this dissertation work has not been submitted for any other degree in any institution.

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LETTER OF APPROVAL

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ABSTRACT

A considerable amount of cereals produced in developing countries is lost due to improper post-harvest operations leading to a considerable gap between the gross production and availability. Minimizing these losses can increase their supply without bringing additional land under cultivation. In this research, we assessed the post harvest management practices of wheat and its post-harvest losses in Raikwar VDC of Kanchanpur district, Nepal. Prevalence of stored seed borne fungi in different containers and status of wheat availability for a yearly consumption among farmers of different ethnic groups were assessed. Assessment of wheat grain loss during harvesting, threshing, and winnowing were carried out according to the Global Strategy working paper 2015. Out of 258 households growing wheat, about one third (83 households) were interviewed for post-harvest management practices and status of food security. Among them 35 households were selected for seed sample collections based on the types of containers and treatments applied to minimize the loss during storage. These seed samples were used to assess fungal prevalence. Post-harvest loss was found about 12% that includes storage loss (8.%), harvesting(3 %) and winnowing loss (1%). About 57% farmers used metal drums for storage of grains; the other means of storage were traditional *Kothia, Dheri, Bhakari*, and Plastic sac. The loss was higher in the traditional containers than in metal drums. Eight types of fungi (*Aspergillus flavus, Rhizopus* spp., *Penecillium* spp., *Bipolaris sorokiniana, Alternaria alternata, Chaetomium* spp., *Aspergillus niger* and *Fusarium* spp.) were prevalent in different types containers. Eighty two percent of the farmers had sufficient availability of wheat grain for yearly consumption. The *Janajati* households had sufficient availability of wheat grain followed by *Brahmin-Chhetri* and *Dalits*. It was estimated that 12% of the grain was lost during post-harvest operation which can support the food for ca.2.8 person/year. Overall, technology intervention and improved storage structure can play a positive role in reducing post harvest loss and reduction in prevalence of the storage fungi which will maintain grain quality for long-time storage and improve food security of the farmers.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURE

LIST OF ABBREVIATIONS

APHLIS	African Post Harvest Losses Information System
Bio.	Biological
Bio.+Che.	Biological and Chemical
B+C	Brahmin-Chhetri
Che.	Chemical
DAL	Dalit
FAO	Food and Agriculture Organization
Ha.	Hectare
H.H.	Household
IFPRI	International Food Policy Research Institute
ISTA	International Seed Testing Association
JAN	Janajati
Km	Kilometer
Kg	Kilogram
M	Meter
MoAC	Ministry of Agriculture and Co-operation
NARC	Nepal Agriculture Research Council
NMRP	National Maize Research Program
PHL	Post Harvest Loss
Qt.	Quintal
SDC	Swiss agency for Developing and Cooperation
US	United State
VDC	Village Development Committee

CHAPTER ONE
INTRODUCTION

1.1 Background

Wheat (*Triticum aestivum* L.) is the second most produced crop on earth, lagging behind corn. It is originally from the Levant region of the Near East and Ethiopian high land, but now grown all over the world in a wide variety of climates. Wheat provides 21% of the food calories and 20% of the protein for more than 4.5 billion people in 94 developing countries (Braun *et al.,* 2010). Wheat accounts for around 30% of global grain production and 44% of the cereal used as food of which 18% is traded internationally (Joshi *et al.* 2011). After the development of semi-dwarf wheat by Norman Borlaug (during the mid-twentieth century) and production of wheat was dramatically increased and improved the food security status in many countries especially Mexico, India, Pakistan and Nepal (*https://en.wikipedia.org/wiki/Norman_Borlaug*).

In Nepal, wheat is the third largest cereal crop after rice and maize and cultivated in a wide range of geographical areas from the low land Terai (100 m.a.s.l.) to the high mountains (2200 m.a.s.l.) as a winter crop. In the year 2012/2013 total wheat production was 1727346 Tons in 754243 hectares in Nepal (MoAD, 2013). The present national wheat productivity is 21.56 quintal/hectare. Wheat is cultivated in 20% of total cultivated land area and contributes 18.8% to the total national cereals production. Out of the total wheat cultivated area and production in the country, mountains, hills and Terai represent 7.3%, 37.57%, and 55.09% of land and contributes 5.5%, 33.0% and 61.5% of production respectively (NARC, 2003). However, in the Far western region of Nepal, wheat is the second most important crop after maize in mid hills. The whole region can be characterized on a tract of intensive wheat cultivation in the existing cropping pattern in upland (Bari) as well as lowland (Khet) and farmers cannot give up this crop due to their chapatti (Roti) as a major consuming food habit. More than 95% of the cultivated area of these regions comes under wheat cultivation during winter season (NARC, 2011).

Harvesting practices are found different in different places. Agricultural commodities produced on the field have to undergo series of operation such as harvesting, threshing, winnowing, transportation, and storing, which are in combination known as post-harvest management practices (US Department of state, 2013). Several authors have presented a strong argument in favor of devoting more resources to post harvest research and development effort in developing countries (Bourne, 1983). Although minimizing postharvest losses of already produced food is more sustainable than increasing production to compensate for these losses, less than 5% of the funding for agricultural research is allocated to postharvest areas (Kader, 2003).

Significant volume of grain in developing countries are lost after harvest aggravating hunger and instead of minimizing loss peoples were given emphasis on increasing production by extensive inputs-such as fertilizer, irrigation, water and human labor. During post-harvest operation there is loss of both cereal quality and quantity. Qualitative post-harvest loss (PHL) can lead to a loss market opportunity and nutritional value; under certain condition, these may possess a serious health hazard if linked to consumption of aflatoxin (a toxic chemical produced by fungus) contaminated grain. However, the causes of quantitative loss are many and varied. The technical cause may include harvesting method; handling procedure, drying technique and moisture levels of grain, storage and types of storage; attacks by rat, pests, insects damage and infestation by seed borne pathogen (Neetirajan *et al.,* 2007; Bhandari, 2012; US Department of state, 2013). Post-harvest practices include all processes that occur from time of harvesting until the foodstuff reaches to the final consumers.

Post-harvest management is one of the most important parts after harvesting for the proper maintains of crop without being any losses. The study on post-harvest losses in food grain at different stages of their handling would help to assess the extent and magnitude of losses and identify factors responsible for such losses. This in turn would help to develop proper measures to reduce these losses. According to estimates provided by the African Postharvest Losses Information System (APHLIS) physical grain losses (prior to processing) can range from 10 to 20 percent. However, post-harvest losses for teff were estimated 12.3%, for sorghum 11.6%, for wheat 9.9%, and for maize 16.8%. Other data source showed that post-harvest loss for pulses is 19.6% due to insect and mould alone (Zorya *et al*., 2011). A recent study conducted by Swiss Agency for Developing and co-operation (SDC) in the East Gojam zone of the Amhara showed that the post-harvest losses can be as high as 30% to 50%. UN Food and Agriculture Organization estimates total post-harvest losses at 2.04 million tons of grain whereas the cereal import requirement was roughly 1.16 million tons (US Department State, 2013).

Quality seed is considered as the basic, critical and cheapest input for enhancing productivity (Rana & Raut, 1997). Seed is not only input but also dynamic instrument for increasing agriculture production (Jha & Rai, 2001). Use of quality seed can increase crop yield up to 15-20% (Kshetri, 2013). Use of other inputs such as fertilizer, irrigation, plant protection, does not yield good economic return without use of quality seeds (Thapa, 2005**).** Seed quality is judged by its genetic purity, vigor and germination, analytical (physical) purity, contamination seed borne pathogen and higher yielding ability (Rana & Raut, 1997). Thus, seed is biological basis of the world food security and directly or indirectly supports the livelihood of every people on earth.

The association of pathogens in seed was reported over 200 years ago and doubtlessly by the farmer for long before that. The scientific evidences regarding association between seed and fungi causing anthracnose disease was reported firstly by Frank in 1833 (Shrestha, 1980). About 90% food crops suffer by devastating seed borne diseases which plays eminent role in loss of yield. Understanding the complexity of seed health, international seed testing association (ISTA) was established in Rome in 1924. Noble (1957) which states “the object are to further all matters connected with accurate of uniform method in testing and evaluating seed in order to facilitate and utilization of seed to be used for snowing”. Christensen (1957) grouped fungi that invade cereals in to two categories, field and storage fungi. This division is not taxonomically valid but based primarily upon moisture requirements. The seed-borne pathogens may be externally or internally seed borne, extra or intra embryonal or associated with the seeds (Neergard, 1977; Singh *et al.*, 1977). The seed-borne fungi including saprophytes and weak parasite may lower the quality of seed by causing discoloration, thus reducing the commercial value of seed (Neergaard, 1977; Rees *et al.,* 1984; Christensen & Kaufmamm, 1969).

The majority of research carried on seed borne disease show clearly that they are clearly mycological in character (Wallen, 1964). As a result hundreds of seed borne fungi both pathogenic and saprophytic have been isolated and identified. Various aspects of seed borne disease have been described by Noble (1957).

The storage of grain by farmers is the most important and critical post-harvest operation in which crop products are eventually stored for a varied period of time depending on market demand. Deterioration of the grain quality during storage can be due to improper storing conditions, which lead to contamination with fungi or insect infection. Seed are stored in different storage containers and there is a relation between fungus and storage type. Storage containers that cannot stop moisture absorb greatly influenced by storage fungi decreasing seed germination (Christensen & Kaufmann, 1965; Gupta *et al.*, 1973; Cook & Veseth, 1991).

The World Food Summit (1996) defined food security as “when all people at all times have access to sufficient, safe, nutrient food to maintain a health and active life”. Generally, the food security is built on three pillars.

- Food availability : sufficient quantities of food available on a consistent basis
- Food access: having sufficient resources to obtain appropriate food for a nutrients diet.
- Food use: appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation.

There are millions of people that currently do not have an acceptable level of food security. Furthermore, there are serious challenges involved in feeding more than 9 billion people by 2050 and for that food production will be needed to grow by 70% (FAO, 2009). Therefore, today, one of the main global challenges is how to ensure food security for a world's growing population whilst ensuring long-term sustainable development.

Food insecurity and hunger remain pervasive in Nepal, not only in food deficit districts but also within marginalized communities in district with surplus food production. According to the report prepared by the International Food Policy Research Institute (IFPRI) the Global Hunger Index of Nepal in the year 2013 is 17.3 indicating the serious problem of food security.

Waste reduction is often cited as a way of reducing food security concerns (Godfray *et al.,* 2010; Foley *et al.,* 2011; Foresight, 2011). About 30-40 % of food in both developed and developing countries is currently wasted; in developing countries this is dominated by pre-consumer losses whilst in developing in developed countries food waste is dominated by post-consumer losses. Globally about 1.3 billion tons of food is wasted each year (Gustavsson *et al.*, 2011). How much food is lost and wasted in the world today and how the foods losses can be prevented are the questions hard to give precise answer due to insufficient research data. This issue has not been focused seriously and not much attention has been paid to the chain of loss in global food supply. Thus, reduction in post-harvest losses could have an immediate and significant impact on overall food security.

It is well known fact that food insecurity is either due to low productivity or in case of high productivity the post-harvest loss is major. Post-harvest loss is high in developing countries due to lack of proper methods of harvesting, processing and storage. Therefore, the hypothesis proposed here is that reduction of post-harvest losses of wheat in different stage of harvesting and proper storage can enhance food security.

1.2 Objectives

The main objective of the study is estimation of post-harvest loss of wheat and its impact on overall food security in Raikwar VDC of Kanchanpur district, Nepal. Following are the specific objectives:

- To identify the post-harvest management practices of wheat grain in Raikwar VDC of Kanchanpur.
- To estimate the post harvest losses of wheat in the farm and storage level.
- To determine the fungal prevalence in seeds stored in different containers and treatments.
- To document the status of food security of wheat in Raikawar VDC, Kanchanpur.

1.3 Justification of the study

It has been estimated that more than half of the districts of Nepal are under food deficit condition. Food Aid, mainly through WFP programmers has played an important role but cannot expected to overcome the large and growing food-deficit situation. Particularly 179 VDCs of Mid and Far-Western development regions of Nepal are moderately food insecure (Nepal Food Security Bulletin, 2014). A considerable amount of cereal produced in Nepal has been lost due to improper post-harvest operations as a result there is considerable gap between the gross production and availability. Minimizing these losses can increase their supply without bringing additional land under cultivation. Improper handling and storage cause physical damage, mechanical losses and physiological losses. Post–production operation plays an important role in creating a staple food supply. It is estimated that about 25.0 million tons of wheat is lost during post-harvest stage and about 46 % of this loss is recorded in developing countries (Baloch, 1999). Thus, determination of the post-harvest loss of wheat would have great importance in terms of food security both in national and local level in the country.

In Nepal, poor agriculture management including lack of quality seeds, fertilization dose, weedicide use and irrigation are believed to be responsible for low yields. In spite of these factors, post-harvest management practices may additionally cause significant grain loss. Therefore, present study aimed to determine the post-harvest loss of already produced grain that will support the livelihood of people and ultimately enhance food security.

1.4 Limitation of the study

- ❖ Study of post-harvest losses and post-harvest management practices was concentrated to Raikwar VDC Kanchanpur.
- ❖ Post-harvest losses were estimated only during harvesting, threshing, winnowing and storage.
- ❖ Blotting paper method was applied to isolate the seed fungi.

CHAPTER TWO

LITERATURE REVIEW

2.1 Post-harvest management practices

Boxall & Gillett (1982) conducted a study in the Eastern Hills of Nepal on storage practices of wheat and found that different containers ranging from small pots and sacks to large basket-type containers **(Bhakari)** and mud bins **(Dhikuti)** built inside the dwelling house were used for storage of wheat. They also found that wheat was generally stored unthreshed and bundle of straw being hung under the eaves of the house but occasionally unthreshed ears were stored in *Bhakari*.

Dhaliwal & Singh (2010) investigated on traditional methods of food grain storage practices in Panjab and found that match box was kept in the storage bin to protect wheat grains from insect pest like *Khapara bettle* and *Dhora*. Farmers were well aware about insecticidal properties of **Neem** (*Azadirachta indica*) and **Aak** (*Calotropis procera*). The Neem leaves were also rubbed on the wall of the *Bhakhari* before storage of wheat. Practice of use of Neem leaves, husk, salt, and camphor was also reported to prevent the grains from insect infection and damage.

Silva *et al.* (2011) conducted a study on storage of Swingle citrumelo seed in different maturation stages by using fungicide. The seeds from green fruits deteriorated less than those from mature fruits and treatment with the Tecto+Captan mixture gave effective pathogen control and maintained seed quality during storage.

Tefera *et al.* (2011) suggested that traditional storage practices in developing countries cannot guarantee protection against major storage pests of staple food crops like maize leading upto 20-30% grain losses particularly due to post harvest insect pests and grain pathogens. Additionally, they reported that, apart from causing quantitative losses, pest in stored grain are also linked to aflatoxin (a toxic chemical) contamination and poisoning. To address this problem a metal silo was developed as a valid option and proven effective in protecting stored grains from attack by storage insect pest.

Mehta *et al.* (2012) studied indigenous method of seed conservation and protection in Uttrakhand Himalaya, India and found two stages of seed/ grain protection measure; at the first stage the storage bins were plastered with the paste of cow dung, mud, mustard cake and carbon from ***Tawa*** mixed with cow urine. The cow urine acts as a repellant of storage insect pest. At the second stage the farmers use different medicinal plant parts, ash, mustard oils etc. which were mixed with grains during storage.

Matsa & Mukoni (2013) surveyed on traditional science of seed and crop yield preservation in Metabelel and South province of Zimbabwe. The study revealed that the people of that province have practiced to process and preserve grains by traditional means. Smoke coating and ash mixture were used to preserve most seeds and crop grain for long term use. Also women played the dominant role in seed and crop yield processing, preservation and storage.

Bhandari *et al.* (2015) surveyed on management practices of wheat in western hills of Nepal and found that about 73% of farmers had stored maize in the form of grain in Baglung where as in Gulmi and Syangja about 77% farmer had practiced of storing maize with husk for 5-7 month. Approximately 40% respondents were found using open floor in upper stair '*Aanti'* as a major maize storage. However, in Palpa, Gulmi, and Syangja almost 79% of respondents were using sacks to store shelled grains.

Kumar *et al.* (2015) conducted a study on indigenous technology to protect the storage life of seed in India and suggested that chemical seed treatment was effective to protect and prolong the storage life of seed but certain toxicity created for beneficial microbes so botanical seed treatment is beneficial for sustainable agriculture and to minimize storage loss. The application of *Neem kernel*, *Karanj kernel*, *Sitafal* seed extract and onion, garlic and earthern pots are easily adoptable, cost effective, save biodiversity and prolong storage life of seed.

Sharma *et al.* (2015) suggested that biological seed treatments are expected to be one of the fastest growing seed treatments methods. Physical and biological seed treatment alternative to chemical or in combination with chemical treatment is being used worldwide because of their environmental safety and socioeconomic aspect. They suggested that lack of awareness on seed treatment at farmers' level is one of the limiting factors of disease management and hence effort should be made at farms level to adopt the technology.

2.2 Post-harvest loss and fungal incidence in storage seeds

Ahmed (1983) studies on losses caused by the insect on major food grains commodities i.e. wheat, rice, maize, and other cereals and pulses in Pakistan and reported that 10% loss of grain among which storage losses due to insect pest, rodents, moulds etc. contributed about 5% and as remaining 5% due to loss in harvesting, threshing, winnowing, transportation etc.

Paders *et al.* (1997) carried out a study on influence of moisture content and length of storage on fungal invasion of paddy rice and found that various fungal species predominated at different moisture condition and storage period. The observed fungi were: *Aspergillus flavus-oryzae, A. glaucus, A. mdulans, A. candidus, A. versicolor, A. terreus, and A. niger*, and unidentified species *of Penecillium, Trchoconiella, Curvularia, Fusarium, Syncephalastrum* and *Verticillium.* Study also reflects that the numbers of field fungi were decreased and increase in the number of storage fungi with storage time.

Boxall (1998) under took a project of grain post-harvest loss assessment of five main crops: maize, sorghum, wheat, barley, and beans in Ethiopia and found that the cereals was adversely affected by unusual rain-fall pattern and shortage of rain during the growing period resulted crop failure and reduced yield; Heavy unseasonable rain during crop maturity led to problem during harvesting time and further resulted loss. The study identified post-harvest constraints and to assess their importance in relation to constraints in the total agricultural system and identified insect infection in storage was an important problem (i.e.4% due to insect damage and 5% due to mould damage).

Rajput *et al.* (2005) collected wheat seed sample from Sindh province of Pakistan and tested for fungal seed borne pathogen by using the standard blotter method. A total of five seed borne fungi viz.*Alternaria tenuis, Aspergillus niger, Fusarium moniliforme, Curvuluaria lunta, and Stemphylium herhurum* were isolated from twelve wheat varieties. Among all the fungus *Alternaria tenuis* was predominant fungus (22.5-47.5%), followed by *Aspergillus niger* (3.5 - 15%), *Stemphylium herhurum* (2.5 - 14%), *Fusarium moniliformae* (1.5 -7.5%), and *Curvuluaria lunata* (1 - 3.5%).

Kumar *et al.* (2006) attempted to estimate post-harvest losses of two major vegetables; onion and potato in Karnataka, India and observed that the loss in field level was 6.21 kg/qt and 7.34 kg/qt. Further, the output losses at the wholesale level were 1.85 kg/qt and 2.22 kg/qt respectively. They concluded that about 60% of total post-harvest losses occur at the retailing level. The storage loss at different stages added up to about 38% of the total loss which on farm harvest operation accounted for about 17% of total loss. Also the transit loss was another important component of post-harvest loss contributing about 25% of the total loss.

Brick *et al.* (2006) worked on fungus and mycotoxin in wheat grain at and assessed the fungi and mycotoxin contamination during 180 days of storage. Five samples were taken at 30 days interval during six month of storage period assessing fungus were *Aspergillus* spp., *Penicillium* spp., and *Fusarium* spp. Also the mycotoxin like aflatoxin (AFB_1,AFB_2 AFG_1,and AFG_2), Zearalenone (ZON), deoxinivialenol (DON) and fumonisins (FB_1 and FB_2) were assessed and concluded that the influence of grain fumigation during the storage period reduce the percentage of fungus in the grain and reducing the storage temperature, moisture content and pest contamination help to reduce the mycotoxin in the grain.

Basappas et al. (2007) conducted a study in Karnataka, India for estimating the post-harvest loss of maize at a different stage and estimated that about 3.02 Kg per quintal loss at the farm level, and maximum loss was noticed about 0.68 Kg/qt at the storage level. Similarly, at drying level, transportation, threshing, packing, and cleaning the losses were found to be 0.49 Kg, 0.44 Kg, 0.34 Kg, 0.15 Kg, and 0.10 Kg/qt respectively. They concluded that improper post- harvest handling leads to a considerable loss in maize.

Basavaraja *et al.* (2007) found that the post-harvest loss of rice at farm level was 3.82 Kg/qt. and of wheat was 3.28 Kg/qt. The loss was the highest during storage in both of the crops. Also, the factors that influence the post-harvest losses significantly at the farm level have been identified and some policies were highlighted.

Sharma & Gautam (2010) conducted a study on maize variety Arun-2 and yield loss was estimated by obtaining the yield difference between chemically protected and unprotected maize. They found that the yield difference was significantly less by 28% in unprotected maize as compared to the protected maize and number of stands, number of ears harvested, and 1000 grains weight were also recorded which were found to be 8.5%, 14% and 16% less respectively. Number of stem breakage, number of poor cobs, length of per plant and tunnel length were also recorded and found to be higher by 16%, 6%, 30% and 24% respectively.

Hodges *et al.* (2011) stated that in less developed countries inefficient post-harvest agricultural system leads to loss of food. They also stated that poor post-harvest handling can lead to both weight and quality loss. However, they add that most efforts to reduce PHL have been made toward crop storage aspect for food security.

Rehman *et al.* (2011) collected freshly harvested three and six months old stored wheat grains from various part of Pakistan. They observed the most prevalent seed-borne mycoflora and their effect on seed nutritional value. *Alternaria alternata* was found to be the most prevalent fungus. The carbohydrate, fats and ash content of stored grains was lower as comparison to freshly harvested seed and concluded that growth of *Alternaria alternata* on seed during storage might have caused low nutritional content.

Shamabadi (2012) measured wheat loss during harvesting stage and found that 6.88% loss at harvesting stage. The crop loss of combine end and natural loss were 1.24% and 0.49% respectively. Harvesting delay and unadjusted combines were the major causes of crop loss. The result also showed that old combines had loss amount lower than newer combines.

Senbeta & Gure (2014) isolated the fungi associated with stored wheat grains in Shashemene and ArsiNegella district of Ethiopia and found that a total of 898 fungal isolates belonging to five genera. The isolated mycoflora were dominated by the morphotaxa of *Aspergillus* (45.54%), followed by *Penicillium* (29.18%). The other associated morphotaxa were *Altarnaria* (12.14%), *Fusarium* (9.69%), and *Bipolaris* (1%).

Ali & Khalid (2015) studied the grain loss of wheat in different harvesting and threshing techniques. Three method of harvesting and threshing were considered in the study. The harvesting losses with manual plus thresher and reaper plus thresher at the field level were observed to be 164.37 kg ha^{-1} and 142.93 kg ha^{-1} accounting for 3.16% and 2.76% respectively. Total grain losses during harvesting and threshing process with manual plus thresher, reaper plus thresher, and combine harvester were 222.63kg ha^{-1}, 199.41 Kg ha^{-1}, and 149 kg ha^{-1} which were 4.28%, 3.85%, 2.92% of the total yield. These data revealed that different harvesting and threshing technique had considerable impact on grain loss of wheat.

Bhandari *et al.* (2015) assessed the loss of maize under farmers' storage condition in western hills of Nepal among the heterogeneous group of the farming communities and revealed that about 61% respondents reported storage pests as the major pests and about 12% respondents reported that field pests as the major pests for damaging. Maize weevil and Angoumois grain moth were found as the major storage insect pests in the surveyed areas.

2.3 Food Security

Maharjan & Khatri (2006) conducted a study on food security status and relationship between socioeconomic characteristic and house hold food security in the remote western mountain of Nepal. They found that majority of households were food insecure and severity of food insecurity varies according to socioeconomic characteristic of the households. The resources were disproportionately distributed on favor of higher castes and these groups were more food secure as compared to lower cast people.

Pyakuryal *et al*. (2010) studied on trade liberalization and food security in Nepal. They found that aggregate indictors of food sufficiency and security (per capita food availability, extent of malnourishment) show improvement in Nepal since liberalization. Relative to other south Asian countries, Nepal is doing better on some indicators like the extent of undernourishment population, while in other indicators like stunting of children the condition of Nepal is the worst.

Shively *et al.* (2011) reviewed on food security and human nutrition issue in Nepal and the study revealed that Nepal faces multiple challenge including chronic and wide spread food insecurity and malnutrition in both adults and children. Population growth, agricultural stagnation and a range of institutional failures are responsible causes of serious food crisis in Nepal.

Bista *et al*. (2013) conducted a study entitled food security scenario, challenges and agronomic research of Nepal and concluded that the country is experiencing decline in food security situation due to collision of domestic, national and international crises viz. poor agriculture growth, decline national agricultural priority, global climate change, global food crises and political instability. And, they suggested that adaptive measure on climate change; food distribution policy, crop and livestock insurance, subsidies on fertilizers and seed, research and development activities on food grain crops and biodiversity conservation, food and seed buffer stock and institutional capacity building would be the viable options to maintain food security in Nepal.

Krishnamurthy *et al.* (2013) studied about the climate risk and food security in Nepal analyzing climate change impact on food security and livelihood. They found that the food security in Nepal is highly sensitive to climate risk. Climate related events such as the flood of 2008 and the winter drought of 2008/2009 were highlighted as the factors affecting on food production, access to market and income from agricultural activities due to which livelihood and other vulnerabilities are linked to climate.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Different materials were used for the laboratory experiments and field study which are listed in Appendix - I.

3.2 Methods

3.2.1 Study area

The study area lies in Kanchanpur district of Mahakali Zone in far western Nepal. The Kanchanpur district is boarded on the west and south by Uttarpardesh India, whereas two districts; Kailali and Dadeldhura border to the east and north. The population of the district is 171304 (CBS, 2011).

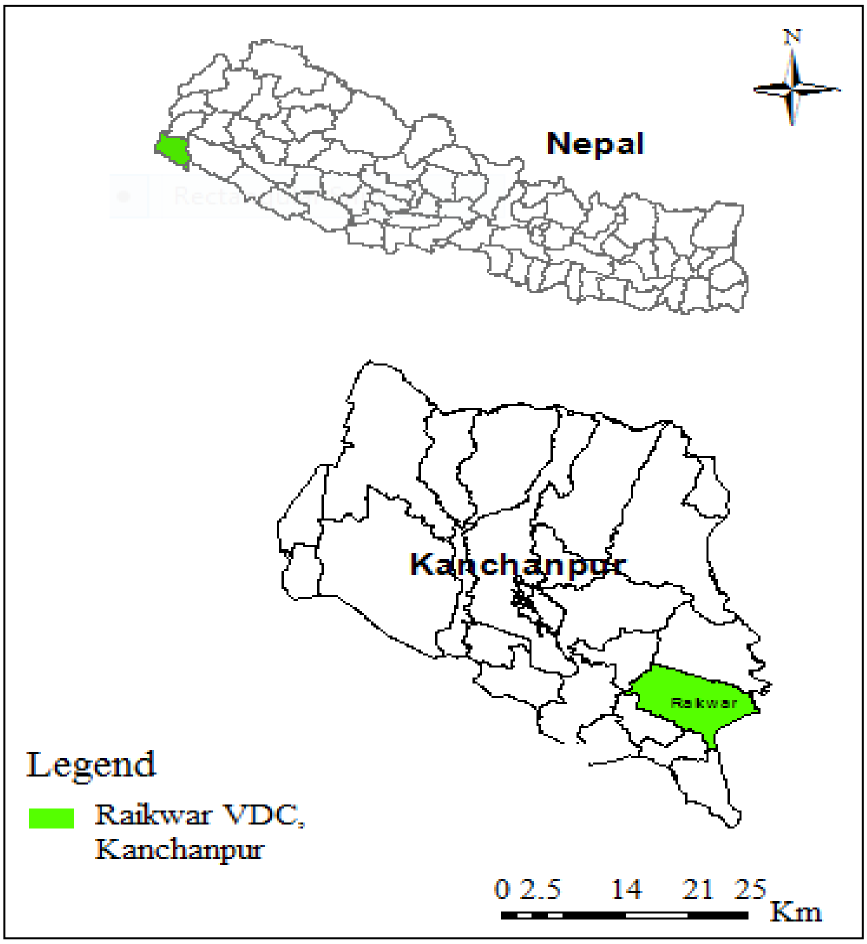

Figure 1: Map of the study site

Raikwar Bichuwa, one of the Village Development Committee (VDC) of Kanchanpur district located at east side broader of Kanchanpur was the VDC selected for the current study (Figure 1). The VDC covers an area of 81 Sq. Km and has population 9136 (CBS, 2011). The climate is subtropical and temperature varies between maximum 43°C and minimum 4°C. The land of Raikwar VDC for agriculture occupies 2580 hectares (ha.). The main occupation of people at the study site is agriculture and domesticating livestock (84.18%) for their livelihood. The people are also involved in labor (6.08%); business (2.47%); government and non-government organization employment (7.23%) and small industry (0.04%) (Data obtained from VDC).

A total 83 households (HH) were selected for survey from 258 household of ward no. 3 of the VDC. The selection of HHs was done by following systematic sampling method. The selected HHs were categorized into different ethnic groups like Brahmin-Chhetri, Dalit, and Janajati (Table 1). The Janajati were represented by *Tharus* and *Rana Tharus*.

Table 1: Total households and number of sampled households in the study area

Ethnic group	Total households	Sample selected	Percentage
All ethnic groups	258	83	32.0 %
Brahmin-Chhetri	90	23	25.0 %
Janjati	120	39	32.5%
Dalit	48	21	43.0 %

3.2.2 Data collection

3.2.2.1 Status of wheat cultivation and management practices

Sampled households were surveyed for collecting the data on wheat cultivation and post-harvest management practices adopted by farmers. The information was collected using semi structured questionnaire include farmer’s practice of wheat cultivation, harvesting, drying, refining, place of drying, storage system, treatment during storage, insect pest attack and losses during post-harvest operations (Annex-II).

3.2.2.2 Assessment of current post harvest loss of wheat

3.2.2.2.1 Production and losses during harvesting

The cropping plot of wheat of an area of 4994 m^2 (½ hectare) was selected for estimating production and losses during harvesting time. Just before harvesting 11 quadrats of size 10×5 m^2 were laid randomly along transects made at the study plot. The distance between two quadrats was 20 m and distance between two transects was 10 m. The area of sampled quadrats covers 10% of the study plot (i.e. 550 m^2). Wheat crop was harvested according to usual farmers' practices and the yield was determined. After harvesting, produce was collected from study plots; all grains shed or missed and then carefully picked up for estimating harvest losses. The data were collected by using the method described in "Global Strategy working paper" (2015).

3.2.2.2.2 Losses during threshing

The loss was assessed by spreading a large sheet on threshing floor to capture the scattered grains. After threshing the produce was removed from the threshing sheet. All grains shed or missed were then carefully picked up for estimating threshing loss (Global Strategy working paper, 2015).

3.2.2.2.3 Losses during cleaning/winnowing

Losses during cleaning/winnowing occur as the result of edible grains passing in to chaff. Initially, the total grains of the study plot were collected at one place after threshing. Then, 5 Kg grain was taken and subjected to winnowing process to separate the chaff from the grain and final weight was recorded. The lost grains were isolated from a sample of chaff and measured and the percentage of loss was calculated. The same process was repeated 5 times for more accuracy.

3.2.2.2.4 Losses during storage

Altogether 35 households were selected for the collection of seed samples stored for one year. Based on the survey it was found that the farmers were using 3 different types of storage containers (metal drum, *Kothiya*, and plastic sac) and 4 different types of treatments applied (chemical, biological, in combined chemical-biological, and no treatment) to minimize the loss during storage. For each storage and treatment type, 5 different samples were collected from the households. Assessment of storage loss caused by insects was carried out following the method of Harris and Lindblad (1978). In short, determination of weight loss was carried out by the 1000 grain count and weight method.

The weight loss percentage was calculated by using the formula as given below:

$$\% \text{ of weight loss} = \frac{(Und) - (DNu)}{U\,(Nd + Nu)} \times 100$$

Where, U = weight of undamaged grains

Nu = no of undamaged grains

D = weight of damaged grains

Nd = No of damaged grains

3.2.2.2.5 Fungal Prevalence

(i) Blotter method

The blotter method is one of the incubation methods where seeds are placed on socked blotter (filter paper), and incubated usually for 7 days at 22^0C under 12h cycles of light and darkness. After incubation, fungi developed on seed were identified under different magnification of microscope. The identification of fungus is based on the way they grow on the seeds "habit characters" and the character of fruiting bodies, spores/conidia observed.

(ii) Preparation of Petri dishes

The petri-plates were washed, dried and sterilized in a hot air oven at 160^oC for 2 hours. Three layers of blotting paper were moistened with sterilized distilled water. Four hundred seeds were taken from each sample from which 150 seeds were selected for plating through repeated halving method. Twenty five seeds were placed per plate at equidistance and there were six replicated plates. Seed plated in petri-dish were incubated at $25\pm1^{\circ}$C for seven day under alternating cycle of 12 hrs light and darkness as some of the fungi need light for spore germination.

(iii) Examination of incubated seeds

A small line was drawn from the centre of the dish to the rime of the dish with the help of a colored pencil. The first examined seed was the one which lies right hand side of line in the outer circle. Once a thorough examination of the first seed is completed the dish is gently rotated in anti-clock wise direction while still looking into microscope. Examination of second seed was started when it came under focus. This procedure was followed in moving one seed to another. Identification and characterization of fungus was carried out following the method described by Mathur & Kongsdal (2003).

(iv) Recording of prevalence

The different fungi grown on the petriplates after incubation were counted by crossing abbreviations, one by one. Crossing of abbreviations by another colour facilitates final checkup which ensures that all marked abbreviations have been counted.

3.2.2.3 Assessment of wheat food security

Information on wheat food security of wheat were collected using semi structured questionnaire including farmers practices on land used for wheat cultivation, total grain production, grain kept for house hold consumption, grain they sold, additional amount of grain they consume, wheat they consume per day, times of wheat consuming/day, total amount of food consumed/day (i.e. rice and wheat), and other main crops they used for consumption.

3.2.2.3.1 Total loss of wheat per hectare and its impact on food availability

Total loss of wheat per ha was calculated by using unitary method as following

Total loss percentage =(x), it means

In 100 kg the loss = (x) kg, Then, loss in 1 kg = (x)/100

Loss per ha (y) kg = total loss percent (x)/100 x field production per ha.

Again, Consumption per year per person = (a) kg

By unitary method, kg of wheat was consumed by = (z) people

1 kg of wheat was consumed by = 1/(z) people

Loss per ha (y) kg of wheat was consumed by = 1/(z) x (y) people

3.2.2.4. Data analysis

The obtained data was compiled and analyzed using Microsoft Excel 2013.

CHAPTER FOUR

RESULTS

4.1 Status of wheat cultivation and management practices

Almost all farmers including different ethnic groups were involved in wheat cultivation using same types of cultivation practices although variation exists in terms of post-harvest management practices. Farmers start harvesting by observing the crop yellow and used sickle as harvesting tool. After that they leave the crop for drying usually up to 3-5 days and the duration may varied due to weather and availability of threshing equipment. Majority of farmers used thresher as threshing tool and threshing is done either in field or in a separate place called threshing yard. After threshing, refining was done either in home or threshary yard. Majority of farmers used winnowing trays as refining tool. Refined cereals were dried up to 1 to 3 days in front of home either on tent or floor. Rainfall or damp cloudy weather affects the drying. Treatment of seed was done chemically or biologically and some farmers were found practicing combine seed treatment (biologically + chemically) and some of them had no practices of any treatment.

4.1.1 Socio economic profile of surveyed farmers

Among the 258 households 83 farmers selected in the survey includes almost equal percentage of male (48%) and female (52%), of them majority of the farmers were illiterate (57%). The literacy status of the respondent farmers based on ethnic community showed high percentage in Brahmin-Chhetri (65%) followed by Janjati (49%) and Dalits (14%) (Figure 2a). The average family size was around 7 individuals per family, although the family size ranged between 3 individuals to 26 individuals per family. The highest number of individuals/family belongs to the joint family group. However, the average family size based on ethnic community is higher in Janjati (9 individuals/family) followed by Dalit and Brahmin-Chhetri (7 individuals/family) (Figure 2b).

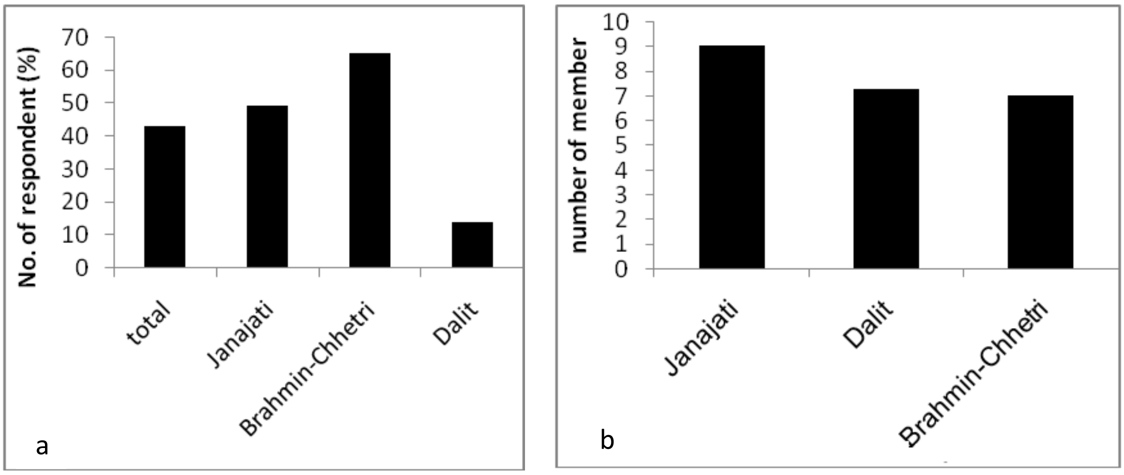

Figure 2: (a) Education status of the farmer (b) Family size

4.1.2 Distribution of land among households

Households were divided into four categories according to their land size to observe the overall land distribution among them as well as within different ethnic groups. Among surveyed households 43.4% had less than 0.5 ha, 19.3% hold between 0.5 to 1 ha, 21.7% had 1-2 ha, and rest of the households (15.7%) had more than 2 ha land area. However, within different ethnic groups, it was found that 86% of Dalit and 61% of Brahmin-Chhetri and 10% of Janjati had less than 0.5 ha land. Likewise, 18% of Janajati, 26% of Brahmin-Chhetri and 14% of Dalit had land size between 0.5-1.0 ha. Similarly, highest percentage of Janjati (43%) and lowest percentage of Brahmin-Chhetri (4%) hold 1-2 ha land. While the farmers those holds more than 2 ha land were belongs to Janjati (28%) followed by Brahmin-Chhetri (9%). In case of Dalit no farmers belonged to the category having land more than one hectare (Figure 3).

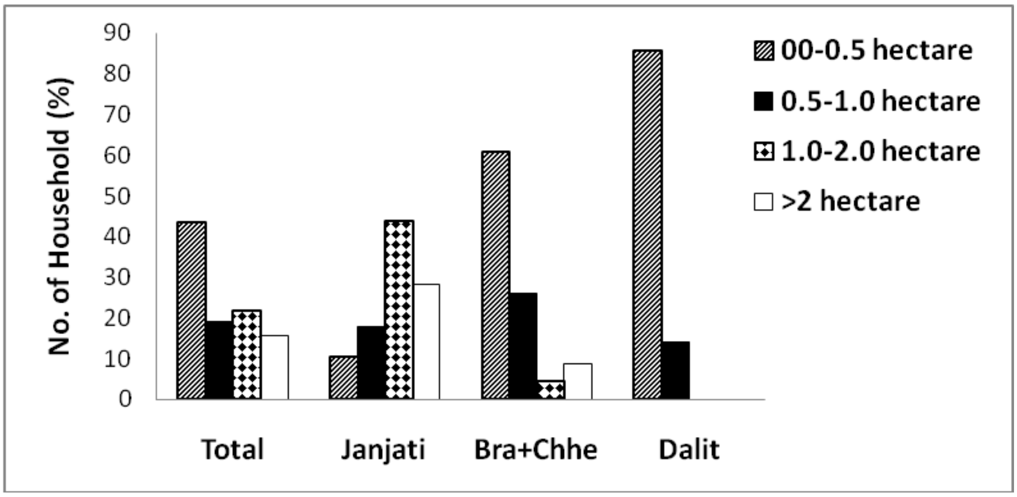

Figure 3: Land holding status of farmer

(Bra+Chhe = Brahmin and Chhetri)

4.1.3 Land holding and wheat cultivation

The average land holding of the farmer was found 1.0 hectare (ha) (total land area; 85.11 ha which ranged from 0.02 to 5.25 ha) of which the average land used for wheat cultivation was 0.52 ha (ranged from 0.2 to 2.03 ha). However, the average land holding belongs to different ethnic group showed that Janjati were rich in average land hold (1.61ha.) and used 0.73 ha land for wheat cultivation. The second largest community was Brahmin-Chhetri in which an average land hold and land used for wheat cultivation was 0.66 and 0.45 ha, respectively. Dalits belonged to the category with small average land holding (0.34 ha) and area used for wheat cultivation (0.21 ha) as well. In general, the farmers were found to use more than half of their total land for wheat cultivation. Among the total surveyed households, the average wheat production was found 19.31 quintal/ hectare.

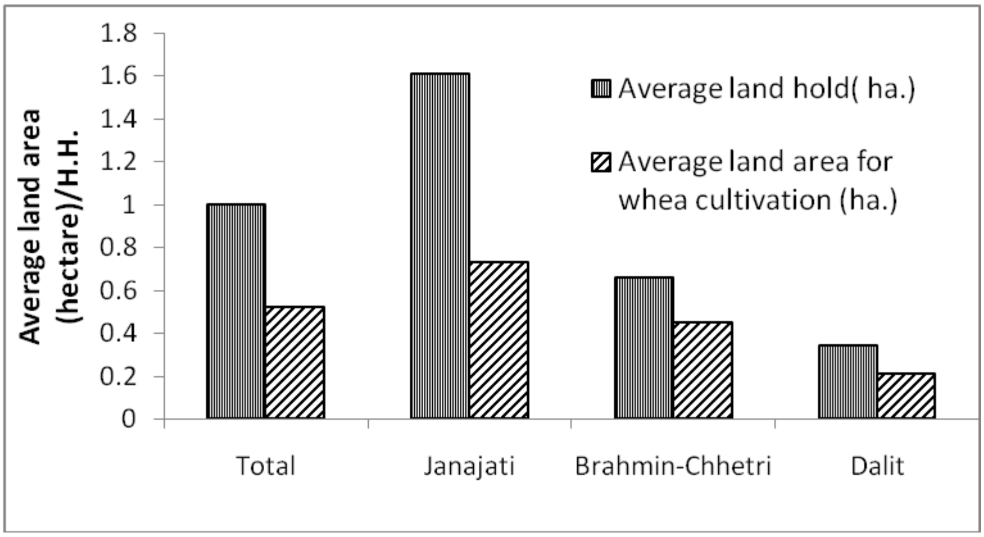

Figure 4: Wheat cultivated land among ethnic groups

4.1.4 Seed treatments

Farmers used to treat seed biologically and chemically during storage; 58% of farmers treated seed with aluminium phosphide while 6% of farmer treated seed biologically with Neem leaves, Citrus leaf, ash, and oil cake, and 5% were treated both chemically and biologically in combine form. Seed treatment practices were not found in 31% farmer before storing. Among them some farmers used aluminium phosphide (54%) and other (56%) treated biologically by direct sun drying process if found insect problem (Figure 5).

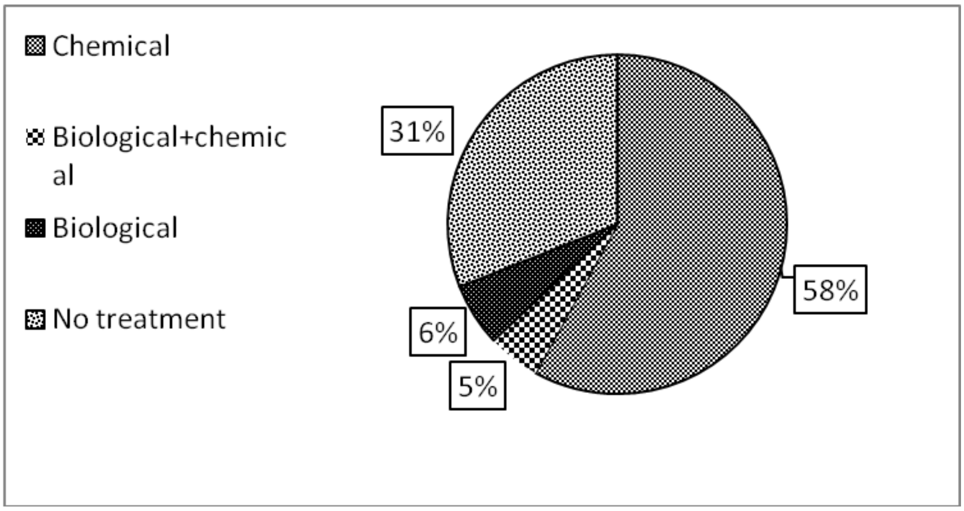

Figure 5: Seed treatment system

4.1.5 Storage system

Farmers use different types of storage system including modern as well as traditional containers. The majority of farmers (57%) stored wheat in metal drum while some of them used drum, *Kothiya, Dheri, Bhakari* (21%), and 15% were used drum and sacks, 7% farmer were used sac as their storage system. *Kothiya, Dehri,* and *Bhakari* were the traditional storage container. Most of the storage containers were placed indoor in the first floor.

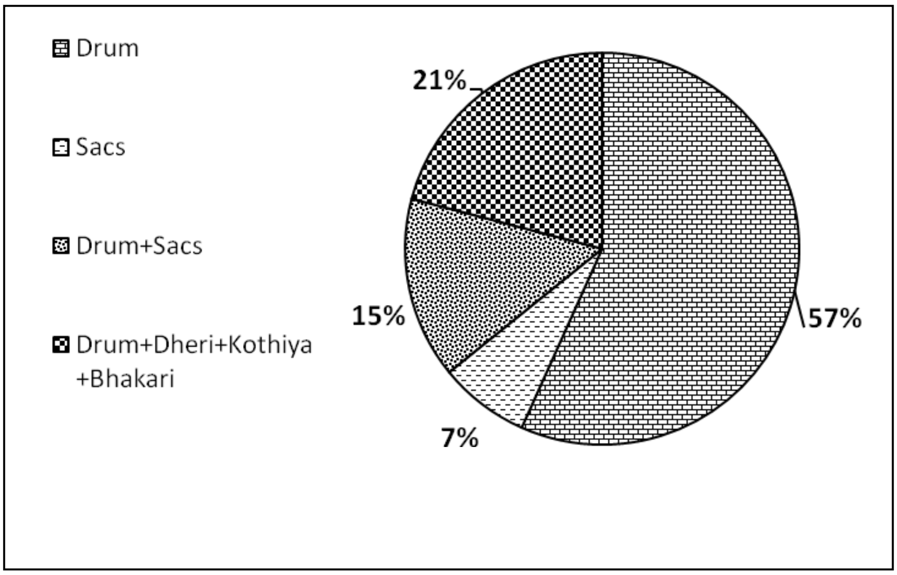

Figure 6: Storage system of wheat grain

4.1.6 Insect pest of wheat

Farmers mentioned various insect pest of wheat namely *Sitophilis oryzae* **(Ghun)** and *Corcyra cephalonica* **(Putala).** Among them *Sitophilis oryzae* was mentioned as the major insect pest of wheat as reported by the majority (99%) of farmers.

4.1.7 Factors affecting post-harvest management

About 99% of farmers mentioned different problems like rainfall or damp cloudy weather at harvest, lack of threshing equipment in time, poor storage facilities, in adequate technical support, lack of awareness and training program on post-harvest management.

4.2 Post-harvest loss of wheat

4.2.1 Loss in the farm level

Total post-harvest loss in farm level includes field loss, threshing and winnowing loss. The amount of loss in the field was 2.94 Kg/qt. out of total production; and 21.78 quintal/per hectare. However, the loss was not observed during threshing due to the use of tent, which was spread over the threshing yard before threshing. Unthreshed spike and scattered grain during threshing remained in the tent were collected at the end of the process. Grains in the husk during threshing were not observed. Although, the farmer's have minimized the threshing loss, but the loss was observed during winnowing process was found to be (0.80 Kg/qt.).

Figure 7: Post-harvest loss of wheat grain in farm level

4.2.2 Storage loss

Storage losses of wheat grain were the major problem of the farmers. Grain with different treatment, stored in different types of containers differs in loss amount. Grains kept in the drum without treatment showed maximum weight loss (6.46%). In the drum, the loss in chemically and biologically treated grain was 2.31% and 2.5% respectively. However, the loss in both chemically and biologically treated grains was 5.45%. Interestingly, the grains stored in metallic drums treated either with chemical or biological means showed less and almost same amount of loss.

Among Kothiya and sac, maximum loss was found in the Kothiya with biological and chemical treatments. The loss in chemical treatment was found 14.79% while in biological treatment it was 13.19%. Both the treatments were not effective for the storage type Kothiya. Grains stored in plastic sac treated with chemical also showed high percentage (11.7%) of loss. The total average loss of stored grain in different storage containers and treatments was 8.05%, higher than the loss at farm level.

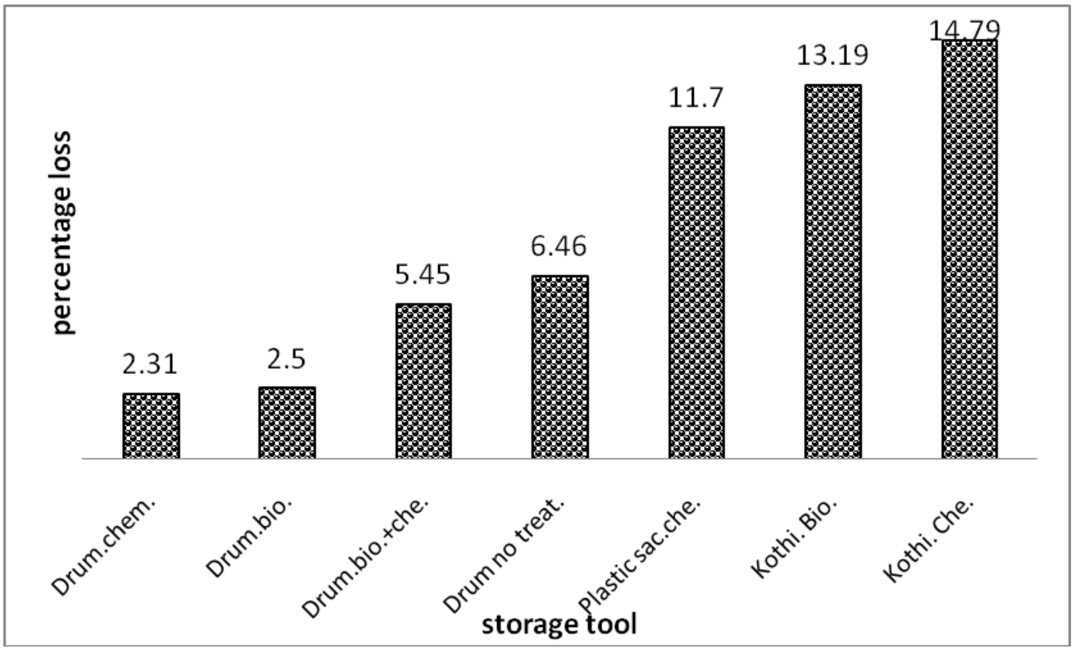

Figure 8: Weight loss of the wheat grain in different storage systems and treatments

(Che.– chemical, Bio.–biological, Treat.- treatment, Kothi.- Kothiya)

4.2.3 Total post-harvest loss in different stages

Post-harvest loss in different stages harvesting, threshing, winnowing and storing are tabulated below (Table 2).

Table 2: Loss of wheat in different stages

Post-harvest loss at	Process	Loss percentage
Farm level	Field loss (harvesting loss)	2.94%
	Threshing	0.00%
	Winnowing	0.80%
Storage	Storage	8.05%
	Total	**11.79%**

4.2.4 Fungus prevalence

4.2.4.1 Fungal frequency in seeds stored in different containers

Frequency of fungus was calculated using seven types of seed samples from 3 different types of containers (Sac, Drum and Kothiya) and 4 types of treatments (chemical, biological, chemical+biological combine and no treatment). The frequency of *Aspergillus flavus* and *Rhizopus* sp. was the highest (100%) and the lowest frequency was recorded of *Fusarium* sp. (14.25%). Frequency of other species ranged between 29-71 % (Figure 9).

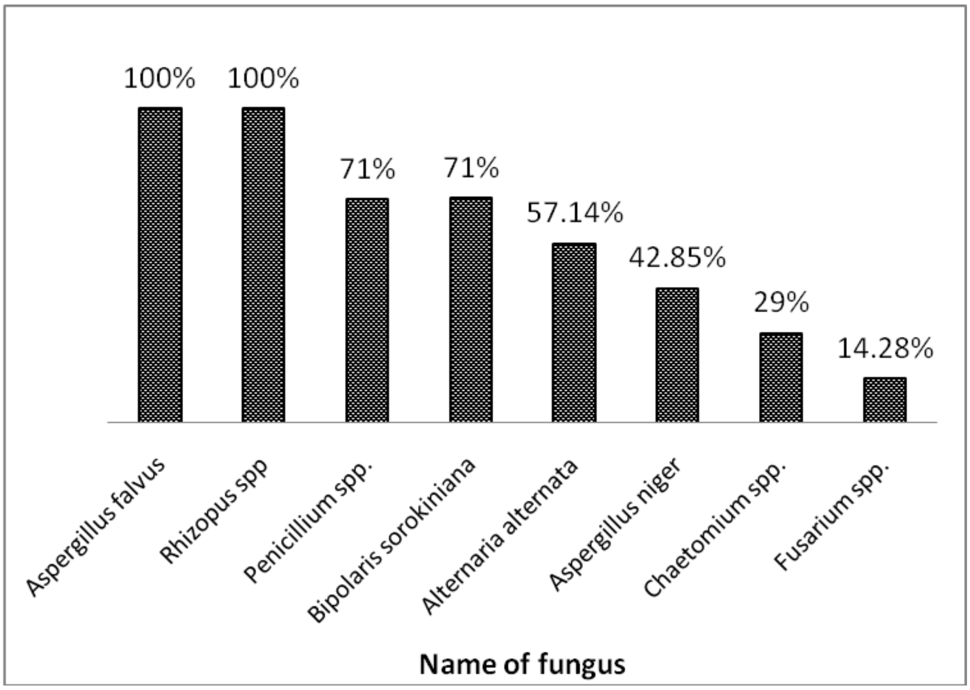

Figure 9: Fungal frequency in grains stored in different containers

4.2.4.2 Prevalence of seed borne fungi in different storage type

Two distinct types of fungi were found namely field fungi and storage fungi. Eight different types of fungi were isolated from the wheat seeds, among them majority of the fungi belongs to family Trichomaceae and Pleosporaceae. Least number of fungi belongs to family Mucoraceae, Chaetomiaceae and Nectriaceae (Table 3). Seven different types of fungi were observed in Kothiya type of storage container in which seeds were biologically treated, and followed by 6 different types in Kothiya with chemical treatment, 5 types in sac with chemical treatment and drum with no treatment, 4 types in drum with biological and combined treatments, and 3 types of fungi were found in drum with chemically treated seeds. Numbers of fungi were higher from modern to traditional containers (Figure 10).

Table 3: Name of fungus

S N	**Organism**	**Storage type**							**Family**	**Colony Colour**
		A	**B**	**C**	**D**	**E**	**F**	**G**		
1	*Aspergillus niger*	-	-	+	-	+	+	-	Trichocomaceae	Black
2	*Aspergillus flavus*	+	+	+	+	+	+	+	Trichocomaceae	White
3	*Penecillium* sp.	-	+	-	+	+	+	+	Trichocomaceae	Gray to yellow
4	*Alternaria alternata*	-	-	-	+	-	+	+	Pleosporaceae	Black
5	*Bipolaris sorokiniana*	-	+	-	+	+	+	+	Pleosporaceae	Black
6	*Rhizopus* sp.	+	+	+	+	+	+	+	Mucoraceae	Dark gray
7	*Chaetomium* sp.	-	-	+	-	+	-	-	Chaetomiaceae	Gray to olivaceous
8	*Fusarium* sp.	-	-	-	-	+	-	-	Nectriaceae	White cottony mass
Total		3	4	4	5	7	6	5		

Index: + Presence of pathogen, - Absence of pathogen, A: Drum with chemical treatment, B: Drum with biological treatment, C: Drum with combine treatment, D: Drum no treatment, E: Kothiya with biological treatment, F: Kothiya with chemical treatment, G: Sac with chemical treatment

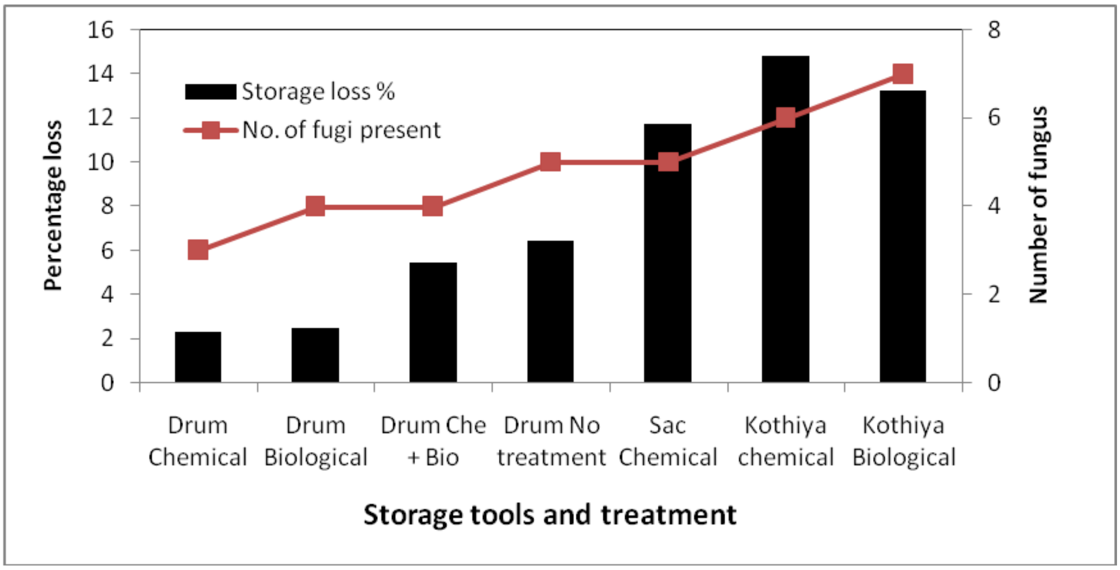

Figure 10: Relationship between fungal prevalence and storage type

4.3 Food security status of wheat

4.3.1 Status of wheat production, consumption and selling

In this study the total average production, amount of grain required for consumption and selling of wheat per household per year was calculated and found 8.98 qt., 6.94 qt, and 2.83 qt. respectively. Among the ethnic groups, Janajati have great contribution on production and selling of wheat. In Janajati the average wheat production, amount of grains required for consumption and selling was found 13.81 qt., 5.97 qt. and 6.88 qt., respectively.

The wheat production (8.52 qt.) and grain required for consumption (7.17 qt.) was found almost equal for Brahmin-Chhetri which results less amount of wheat for selling (1.57 qt.). However, the Dalit community has low contribution in the production of wheat (4.60 qt.), but they required 6.38 qt for consumption/household in a year. Their own production is not enough to feed them annually (Figure 11).

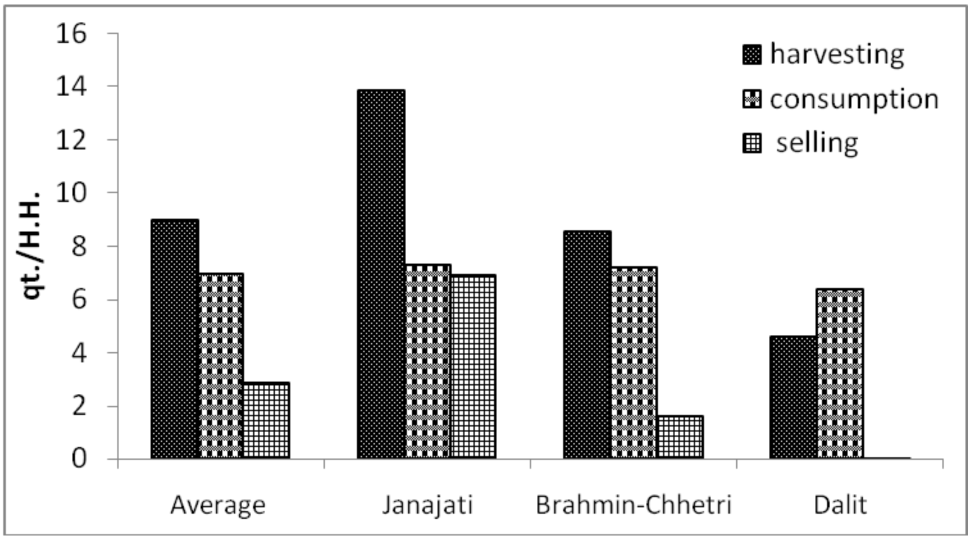

Figure 11: Grain harvesting, selling and consumption of different ethnic group

4.3.2 Food consumption pattern

Average food consumption (i.e. rice and wheat) and only wheat consumption per household/year were calculated as 1361.7 Kg and 711.6 Kg respectively. Among different ethnic groups average food consumption of Janjati was 1695 Kg followed by Dalit 1328 Kg and Brahmin-Chhetri 1062 Kg/household/Year. However, average wheat consumption per household/year was higher in Dalit (781.2 Kg), followed by Brahmin-Chhetri (756 Kg) and Janjati (597.6 Kg/household/year). The average wheat consumption of Brahmin-Chhetri and Dalit was almost similar.

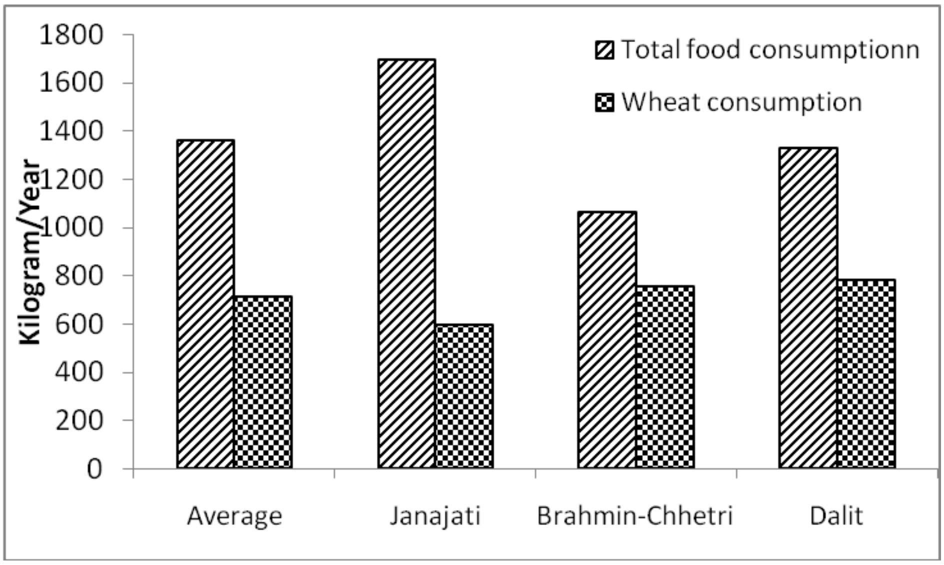

Figure 12: Food consumption pattern based on ethnic group (household/year)

4.3.3 Wheat availability among the households

Availability of wheat among the surveyed households showed that the highest percentage (81.9 %) of households had enough wheat while small percentage (18.1 %) of households depends on external supply of wheat for consumption. Among the ethnic groups, wheat sufficiency for yearly consumption from their own production was found in the Janajati households (97.4%) followed by Brahmin-Chhetri (82.6%) and Dalits (52.4%).

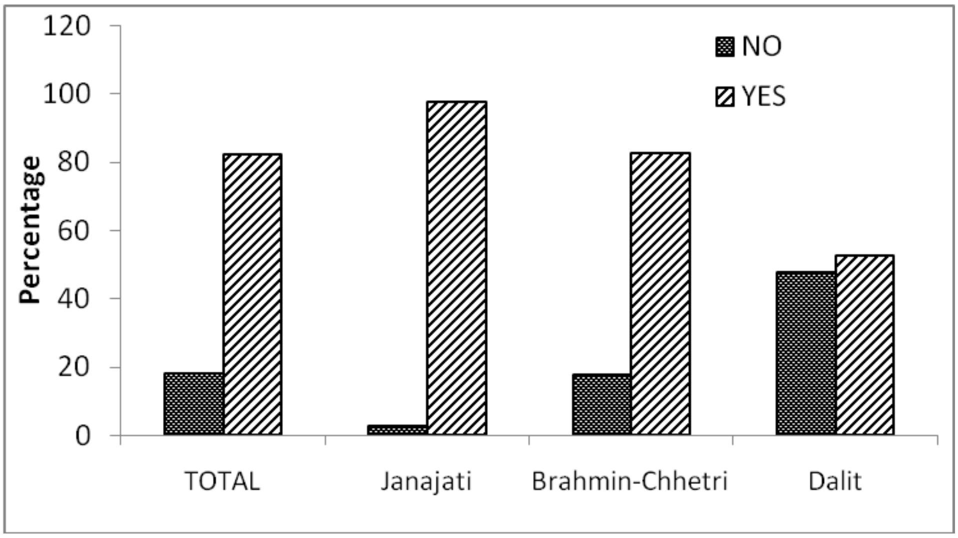

Figure 13: Wheat availability among the households

4.3.4 Wheat consumption

Total average food (rice and wheat) and wheat consumption per person/day was found 0.48 Kg, 0.26 Kg respectively. However, the pattern was different among ethnic groups. Among the Janajati average total food consumption per person/day was 0.52 Kg. and average wheat consumption was only 0.18 Kg. In Dalit community the average food and only wheat consumption was 0.5 Kg. and 0.3 Kg. respectively .Likewise, total average food and wheat consumption was found 0.42 Kg. and 0.29 Kg. respectively for Brahmin-Chhetri community.

4.3.5 Loss of wheat and its impact on food availability

Total wheat loss per ha and wheat consumption per person/year was calculated and the impact of loss in wheat availability per year was estimated. It was found that 11.79% of grain/ha was lost during post-harvest operation which is enough for *ca.* 2.8 person per year.

CHAPTER FIVE

DISCUSSION

5.1 Post-harvest management practices

Almost all farmers including different ethnic groups were involved in wheat cultivation using same types of cultivation practices although variation exists in terms of post-harvest management practices. These practices are more or less similar in south Asia where farmers lack modern equipments and limited irrigation facility. Another similarity exists among the farmers of developing countries is distribution of land. The land distribution of Raikwar VDC was not uniform; majority (83%) of the farmers holds less than 2 hectare land. This result is consistent with the results obtained from other countries. In India about 78% of the farmers hold less than 2 hectare land (Singh *et al* 2002). Similarly, 98% of the farmers in China and 90% of the total farms in Ethiopia and Egypt (Rapsomanikis, 2014) belonged to this group. In spite of unequal distribution of land, farmers used almost half of their land for wheat cultivation in the study site of current study. This may be due to flexibility of wheat plants which may even grow in areas without irrigation facilities.

In developing countries storage of grain is another major challenge after production. Improper storage not only causes the loss of grains but also facilitates insect infestation. In this study, farmers reported loss of storage grain due to insect pest *Sitophilis oryzae* in all type of traditional and modern storage structures. This pest has been reported to cause major grain loss in storage worldwide (Trematerra & Gentile, 2006). The common practice exercised by the farmers of Raikwar VDC was use of chemicals such as insecticides and fumigation against infection, however, some of the farmers used some traditional insect control methods (biological method: use of leaves of *Azadirachta*, *Calotropis* and ash etc.).

As the biological treatment majority of farmers used dried neem leaf, and citrus leaf while some uses ***Bojho, Bokaino*** **and ash.** Usually, 2-3 days dried leaves were mixed with grains (250 grams per 2-3 quintal grains) during storage. Ash can also be mixed with grains during storage. The chemical generally used by farmers was **Aluminium phosphide,** also called as celophos, which contains fumigant tablets. Majority of farmers used three tablets per container by wrapping with cotton clothes and kept in three different layers. Some of the farmers also notified that they use 5 to 6 naked tablets per container and have to practice to wash the grains in tap water for 2-3 times before consumption to remove toxicity of chemical. Combined treatment practices (chemical+biological) were also reported by some of the farmers. In combined treatment practices half dose of the chemical and biological materials were used. Similar types of practices have been conducted by Indian farmers.

The farmers of Panjab, India, used plant leaves such as **Neem** (*Azadirachta indica*),**Oraak** (*Calotropo sprocera*), husk, salt and Camphor to protect the wheat grains from attack of storage insect pest (Dhaliwal *&* Singh, 2010). Similarly, other farmers were reported to protect their grains at two different stages; at the first stage the storage bins were plastered with the paste of cow dung, mud, mustard cake and carbon from **Tawa** (an iron pan used to prepare Chapati) mixed with cow urine, and at the second stage the farmers use plant parts, ash, oils etc. which were mixed with grains during storage (Mehta *et al.,* 2012).

Farmers usually stores their grains in different types of containers; traditional or modern, depends on the availability and cost. In this study, farmers were found to use four different types of containers to store their dried and treated seeds namely; Metal drum, *Kothiya*, *Dehri*, or *Bhakari* and Sac. Among these, majority of farmers used Metal drum (57%) followed by traditional and modern storage type i.e. drum+*Kothiya* or *Dheri* or *Bhakari* (21%), drum and Sac (15%), Sac (7%). Similarly, Boxall & Gillett (1982) reported that farmers of Eastern Nepal used different containers for the storage of wheat which ranged from small pots and sacs to large basket type containers (*Bhakari*) and mud bins *(Dhikuti*). Likewise, the farmers of Bangladesh were found to use six different types of containers namely; Tin Kouta, Earthen pot or Motka, Iron or Metal container, Plastic container, Gunny bag and thick Polythene bags (Ali et al, 2009).

Farmers mentioned different issues related to post harvest like lack of infrastructure, technical support, and storage facilities. It seems that farmers are adopting different post-harvest practices since many years. It is obvious that neither they avoided such practices completely nor accepted modern agriculture. Lack of enough land and above mentioned limitations restricts the farmers being a professional which impacts on insufficient food production and ultimately lowers the income.

5.2 Post-harvest loss

5.2.1 Loss in the farm level

This study revealed that about 21.78 quintal of wheat grain was produced per hectare which is slightly less than the average grain production (22.90 qt/ha) in Nepal (MoAD, 2013), India (26.96 qt/ha) and world (27.0 qt/ha), although, the average wheat production in China is higher (38.0 qt/ha) (Bonfil *et al.*, 1999).

The post-harvest loss was found the major loss of the grain and was the serious problem of the farmers of this region. Result from the present study showed that out of total production about 3.74 % of wheat has been lost in the field during the process including harvesting, threshing and winnowing. In Karnataka of India, the post-harvest loss was reported 3.28 Kg/qt and 3.82 Kg/qt of wheat and rice respectively (Basavaraja *et al.,* 2007). However, "Government of India New Delhi 1971" estimated 8% loss of wheat grains of the total production. Ali & Khalid (2015) found that the harvesting losses with manual plus thresher and reaper plus thresher at the field level were 164.73 kg $ha^{-1}$and 142.93 kg ha^{-1} accounting 3.16% and 2.76% respectively of wheat grain yield, in Pakistan. In this study harvesting loss in the field was 2.94% while threshing loss was not observed. This was minimized by the framers using tent in the threshing yard. The scattered or shattered grains of the wheat remains in the tent and are collected at the end of the threshing. Unthreshed spikes and kernels were also collected at the end of the threshing. The grains passing through husk were not observed because of well-equipped modern machine. This was the positive result achieved by the farmers.

Present study showed that winnowing losses were not the major loss of grain because only 0.8% loss was recorded. Light and small grains were passed along with husk and shattered long distance by the air current from the grain mass. Later these grains were not used for the consumption and selling purpose. Kumar & Kalita (2017) reviewed that the grain losses during winnowing can be as high as 4% of the total production. This value is significantly higher than the present study. The low percentage of loss in this study may be due to use of electric fans which generate the air current for the winnowing and the process were carried out on winnowing trays.

5.2.2 Storage loss

The result of the present study suggested that losses due to insect pest of wheat grain stored in different types of container with various types of treatments were different. The grain stored in metal drum shows lesser degree of weight loss than *Kothiya*, *Dheri*, *Bhakari* and sacs. This may be due to the high moisture content, small cracks and porous nature on the wall of these containers. Tefera *et al.* (2011) reported that metal silo is an effective grain storage technology for reducing post-harvest insect and pathogen losses in maize. In general, storage loss is directly related to structural design and structural materials of store rooms/place or containers. Under bad hygiene and poorly designated stores the absorption of moisture would be higher which results considerable damage of the grains.

In this study, the maximum loss was observed in traditional containers such as *Kothiya*, *Dheri* and *Bhakari*. The *Kothiya* are cylindrical containers made up of mixture of husk and mud with permanently plastered lower and upper surface with the mud and dry grasses. *Dheri* and *Bhakari* are also the traditional containers slightly different in their structure. *Dheri* is square shaped and made up of wooden frame and later wall is plastered with mud leaving small opening at the lower while *Bhakari* is cylindrical structure made up of linear bamboo strips and plastered with mud. These container were immovable and kept at fixed place about 25-30 cm above the ground lower floor for several years and grains are kept directly without any treatment due to which the old grains may remain inside the container and insect get easy entry and multiply rapidly. These insect may remain hidden in the small cracks on the wall of container after the removal of grain and get multiply within favorable condition.

The mouth of sacks may not be sealed with air tight after grain packed. The sacks are placed over the wooden pieces or bricks while its side has wall of mud or cement due to which high moisture was absorbed by the grain which favors suitable condition for insect entry and their multiplication. The seed treatments applied to these containers were observed less effective it may be due to the passing out of the fumigation chemicals and botanical insecticidal properties through the pores.

In contrast, the grains stored in metal drum treated with biological or chemical treatment showed less degree of weight loss than biological-chemical combined treatment and grain kept without treatment in the drum. It may be due to air tight nature of the container in which chemical or biological means are more effective. However, higher weight loss in case of combined treatment is due to use of less amount of treating material (i.e. one fourth of the material) as compared to their single treatment, thus is not effective against insect repellent. The grains stored in drums without any treatment were sun dried for 2-3 days due to which the moisture content in the grain may remain high which provide favorable environment for insect infestation.

Farmers have knowledge on conservation and utilization of natural resources. Even though, chemical method of management of stored grains pests are highly successful and they leave behind toxic residue. But traditional method of storage of traditional wisdom might protect stored grains from insect infection for considerably longer period. So that it is recommended to the farmer for use of metal or tin drum as their storage tool and apply the biological seed treatment during storage.

Birewar (1982) notified that in India post-harvest losses accounts for 9.5 % of total pulses production. Among post-harvest operation storage is responsible for the maximum losses (7.5%), followed by processing, threshing and transport causes 1%, 0.5%, and 0.5% respectively. This loss was reported highest in African countries where the loss up to 25% has been estimated for total crop harvested (Voice newsletter, 2006). The average post-harvest loss in present study is similar to the India while less than African countries, although, the loss can be minimized by using effective containers and treatment types.

5.2.3 Fungus prevalence

For this research work, whole seed were unsterilized in order to find out internally as well as externally borne fungus prevalence. For this, standard blotter method was adopted for fungal isolation which provides excellent condition for mycelia growth and conidial sporulation. This method was found excellent for seed fungi in wheat (Agarwal *et al.,*1972), in rice (Shrestha, 1971), in soybean (Singh *et al.*, 1973), in barley (Bharat & Singh, 1976), in sorghum (Rai & Gupta 1978), and in fenugreek (Elwakil & Ghoneem, 2002). Altogether eight species of fungi were isolated which includes *Aspergillus falvus, Rhizopus sp., Penicillium sp., Bipolaris sorokiniana, Alternaria alternata, Chaetomium sp., Aspergillus niger,* and *Fusarium sp.*

Two distinct ecological groups of fungi viz. field fungi and storage fungi were recorded from wheat seed during storing in different types of container with different treatment. The field fungi were *Alternari alternata, Bipolaris sorokiniana*, and *Fusarium* sp. the storage fungi were *Aspergillus flavus, Aspergillus niger, Chaetomium* sp., *Penecillium* sp., and *Rhizopus* sp. Among the field fungi *Bipolaris sorokinia* appeared to be the most predominant which was followed by *Alternaria alternata*, and *Fusarium* sp. In case of storage fungi *Aspergillus flavus* and *Rhizopus* sp. appeared to be most predominant which was followed by *Penecillium* sp., *Aspergillus niger* and *Chaetomium* sp. were more prevalent than the others.

Prevalence of both field and storage fungi associated with wheat seed varied among different types of containers; the population of storage fungi were highest in *Kothiya* type of container followed by sacs and drum. Results of the present study showed agreement with the study conducted by Senbeta & Gure (2014) and Lohar & Sonawane (2013), in which *Aspergillus* sp. were found more dominant in stored wheat grains. Malaker *et al.* (2008) reported similar results in Bangladesh by taking five different storage containers i.e. Dole, Earthen pitcher, Tin, Polythene bag and Refrigerator.

The prevalence of field fungi were highest in refrigerator, which were followed by Polyethylene bag, Tin container, and Earthen pitcher, while the lowest prevalence of these fungi were observed when the seed were stored in Dole. On the other hand, the highest populations of storage fungi were observed in Dole, followed by Earthen pitcher, Tin container and Polyethylene bag and lowest incidence of these fungi were recorded in case of seed stored in refrigerator. Chowdhury *et al.* (2016) also conducted similar study in rice seed stored in 10 different types of indigenous storage containers and reported that *Aspergillus* sp., *Penicillium* sp., *and Fusarium* sp., were more dominant.

The result of present study indicates that the prevalence of field fungi decreased and that of storage fungi were increased in different container after about one year of storage wheat grain. Similar findings of prevalence in these two groups of fungi during storage of wheat seed have also been reported by other workers (Christensen and Kaufmann, 1965; Golzar, 1989; Gooding & Davies, 1997). The activity of storage fungi was the lowest in drum it may be due to the lowest moisture absorption from the outside and effect of insecticide chemical used in seed treatment during storing. Drum was air tight container so moisture was not absorbed by seed and activity of the storage fungi was not high.

Various techniques are required for managing stored grains to ensure the grain quality. These technique include; the proper sanitation, temperature management and aeration, use of chemical protectants, grain drying, regular sampling, and use of fumigation. Storage bin and storage facilities also play an important role in the quality determination of seed grain. The wheat and other cereals like maize, rice, sorghum etc. were affected by the major aflatoxin producing species which are *Aspergillus flavus* and *Aspergillus parasiticus* (Cotty, 1997; Kabak *et al*., 2006). Therefore, fungal prevalence and their impact in wheat seed is one of the major issues to be considered for post harvest management and food security concerns.

5.3 Food security

The purpose of this study was to assess the extent of wheat production, consumption, selling, and wheat insufficiency per year among the house hold of ethnic groups. The result of this study shows that total food consumption rate per year was highest in the Janjati ethnic group as compared to the Brahman-Chhetri and Dalit. This may be due to their large family size. This result was correlated with family size and showed that rate of food consumption was higher with the family size.

The wheat consumption rate was found highest in the Brahmin-Chhetri and Dalit household as compared to the Janajati. It may be due that wheat was major food of the

Brahmin-Chhetri and Dalit whereas rice was the major food among Janajati. Farmers of Brahmin-Chhetri and Dalit notified that maximum wheat food items were used in their daily life, occasional festival and other ceremonies. Farmers also notified that wheat food items called *Roti* were used two times in their daily life. Janajati farmer's mentioned that rice was consumed two times per day and maximum food items of rice were used in their different ceremonies, cultural programmers, festivals, and also rice is used for production of alcoholic beverage. This could be also due to food habit according to the region i.e. rice is the major crops of low land and the Janajati (Tharu) people are living since ancient time to Terai whereas the Brahmin-Chhetri and Dalits are migrated from hills and in the hills the wheat is the major food crops.

Result of this study shows that Janajati have great contribution on wheat production and selling in comparison to other two groups. It may be due to the large land holding size of Janajati. Large number Dalit farmers have small land holding i.e. 86% of the farmers have less than 0.5 ha. Concerning Brahmin-Chhetri, about 61% have less than 0.5 ha land. But the Janjati farmers only 10% have less than 0.5 ha land. 59% of Janajati have between 0.5 to 2ha land and remaining 31% have more than 2 ha land. Where 30% Brahmin-Chhetri farmer have 0.5 to 2 ha land and only 9% have more than 2 ha land. In case of Dalit 14% farmers have 0.5 to 2 ha land and no Dalit farmer have more than 2 ha land. This result was also correlated with wheat cultivated land and shows that production of wheat were higher with increasing cultivated land.

This study found that about 28% of wheat was insufficient for yearly consumption in Dalit households, which they fulfill from the market through purchase. Result of the survey shows that about half percent (52.4%) of Dalit household have sufficient wheat for yearly consumption where as in Bramin-Chhetri (82.6%) and Janajati (97.4%) households have adequate amount of wheat for yearly consumption. This may be due to unequal distribution of the land among the farmers.

The present study deduced that about 20% of household in the study area were insecure of wheat availability. Land distribution is a major factor to maintain the household availability of wheat. The average land holding size of sufficient wheat availability household is almost double that of wheat availability insecure house hold. It was also found that large number of Dalit households is small holders of land as compared to Janajati and Brahmin-Chhetri households. All the households regardless of caste/ethnicity are more dependent on agriculture production to fulfill their household demand. About 80% of house hold food demand is fulfilled by own production. Similar study was conducted by Maharjan & Khatri-Chhetri (2006) in rural household of remote western mountain of Nepal on food security status among different caste/ethnicity and found that majority household of lower cast was food insecure as compared to the household of higher caste. The land holding size and other resource were disproportionately distributed in favors of higher cast.

In current situation for food security, the major emphasis has to be given to the production of food grains, controlling strategy of post-harvest losses, fisheries, and livestock product through sustainable use of resources. The agriculture has several benefits and it occupies as a major sector contributing to economic growth, agriculture has to transform form traditional to a vibrant commercial and competitive one.

5.4 Overall post-harvest loss and its impact on food security

Analysis of overall post-harvest loss (PHL) in terms of quantity showed that loss at experimental farm represents the total farm loss in the surveyed households. It is due to same type of cultivation and harvesting practices in the study area. However, loss at storage level was found different and depends on storage and treatment types. Three types of field fungi and 5 types of storage fungi were isolated from one year old stored seeds.

Among the five types *Aspergillus flavas* is known for producing mycotoxin in the stored grains. The total loss of grain per hectare was reached about 11.79%. This study shows that 11.79 kg out of every 100kg of grain produced were lost during post-harvest operation (i.e from harvesting to storing per year). This weight loss or grin loss is enough to feed about 2.75 people for a year. This means that a reduction in grains losses could have significant impact on people’s livelihood or food availability. Effective post-harvest management practices can contribute to conservation of scarce resources while minimizing the need to produce more food to cover the losses caused by lack of appropriate post- harvest technologies and strategies.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Post-harvest loss is complex problem and its scale varies for different practices and condition. Storage losses accounts for the maximum fraction of all post-harvest losses for wheat and negatively affect the farmer’s livelihood. Harvested grain stored in traditional storage structure (Kothiya and plastic sacks) which are inadequate to avoid the insect infection and growth of storage fungi during storage and lead to high amount of losses. Technology interventions and improved storage structure i.e. metal drum can play a critical role in reducing post-harvest losses and increasing farmer’s revenues. Use of properly sealed hermetic storage structure with chemical or biological treatment of seed during storing has resulted in up to about 98% reduction in storage losses, and reduction in prevalence of storage fungi which improve its quality for long time storage. Using better agricultural practices and adequate storage technologies can significantly reduce the losses of wheat and help in strengthening food security of the farmers.

6.2 Recommendations

Based on the study following recommendation are made

1. Farmers should be encouraged to accept the modern technology of agricultural practices and post-harvest management practices
2. Training, awareness programs about post-harvest loss are needed at farmer’s level for better management.
3. Metal drum storage container should be preferred to the farmer’s for storing.
4. Non-toxic biological seed treatment method is preferred to the farmers during seed storing.
5. Storage container should be sampled time to time to check insect pest infection.
6. Storage container should be properly sealed hermetic condition and placed in dry condition.

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ANNEX I

Materials used in the field

Measuring tape | Rope
Long iron needle | Weighting baance
Sample collecting bags | Questionnaire

Materials used in the laboratory

Seed sample | Petri plate
Blotter paper | Distilled water
Slide/ cover slip | Forceps
Camera

Table A: Status of land holding size of the ethnic group

Ethnicity	Land holding by farmers				
	Small (< 0.5 ha.)	Medium (0.5-1 ha.)	Medium (1-2 ha.)	Large (> 2 ha.)	Total no. of farmers surveyed
Janjati	4	7	17	11	39
Brahmin, Chhetri	14	6	1	2	23
Dalit	18	3	0	0	21
Total	36	16	18	13	83

ANNEX II

Research Questionnaire

POST HARVEST MANAGEMENT PRACTICIES OF WHEAT

S.N…….

A. FARMERS DETAILS

District :…………………　　　VDC: ………………

Tole: ………………Ward No: ………Contact No: …………..

Name of respondents: …………………………….. Age:…………

Occupation: ………………….

Family size　　　　　　　　Education status:………………….

Male	Female

Land Ownership

SN	Type of land	Self ownership land		Taken as rent (Kattha)	Total land
		Self farming (kattha)	Given to other for farming(kattha)		
1	Khet				
2	Bari				

Total land used for cultivation of wheat crop : ……………………….(kattha)

B. FARMERS POST HARVEST ACTIVITIES

1. Method of decision, harvesting tool used for harvesting and harvesting age of crop.

Cereal	Decision Method	Harvesting Tool	Harvesting time (Month)	
Wheat				

2. Harvesting process

	Wheat
Drying duration	
Seed separation tool	

3. Refining process

Cereal	Winnowing tools	Drying duration
Wheat		

4. How do you dry your grain?

Yield drying method Where, how long	

5. Detection of storing

	Method to detect seed storing time
Wheat	

6. Storing process

Cereal	Storing tool		
	Name	Amount	Location
Wheat			

7. Treatment during storing

Chemical or biological treatment		Method of treatment
Name	Amount	

8. Do you found loss of cereals at these links harvesting / field drying, transporting, to thrashing place, threshing, winnowing, drying, transporting, to store room? If yes then which links loss is significant.

…………………………………………………………………………………

…………………………………………………………………………………

9. Did you apply control method to prevent loss at those links? If yes what you did? Among the method that you used which one is most appropriate?

………………………………………………………………………………………

………………………………………………………………………………………

10. Have you experienced the loss during seed storage?

11. What are causes of loss?

12. If yes, can you tell how long storage initiates loss by which factor?

13. What is the cause of losses and method applied to control the loss during storing?

Cause of loss	Control
1.	
2.	
3.	
4.	
5.	

14. What kinds of insect /pest attack your stored grain?

………………………………………………………………………………………

15. What you did to protect it against insect /pest?

What you add	
When you add	
How you add it	
How much of it you add	
Whether it works	

16. What kind of disease attacks your stored grain? What do you do to protect against it?

…………………………………………………………………………………………
…..

…………………………………………………………………………………………
…..

17. Did you sell some of this crop harvested in this season? (Yes /No)
18. How many bags if grain were sold after harvest? […………] bags
19. How many bags of wheat will be kept for the household consumption?[………..] bags
20. It is sufficient or not for your household consumption?
21. If more than enough, what do you do for additional amount?........... How much? ……………
22. What do you do if your storage food is damaged enough by insects or other factors?
23. If less than enough, what do you do to for consume additional amount? How much (Kg)? From where? Cost estimation.

………………………………………………………………………………

24.What are the main crops for HH?

a) Paddy (Ranks)

b) wheat

c) Maize

d) Potato

e) Others

25. How much food is consumed in your daily life (kg) ?...

26. How many times did you use the wheat in your daily life? how much (kg)?.........

C.FARMERS PERCEPTION OF CROP POST HARVEST LOSSES

1. Have you heard about post harvest losses?..
2. Have you got any awareness training on this topic?................................
3. Did you think it is necessary to give awareness on post harvest losses?
4. What types of problems are you facing during harvesting?..
5. Are you changing your harvesting and storing practice time to time?

What type of help do you need from government?..

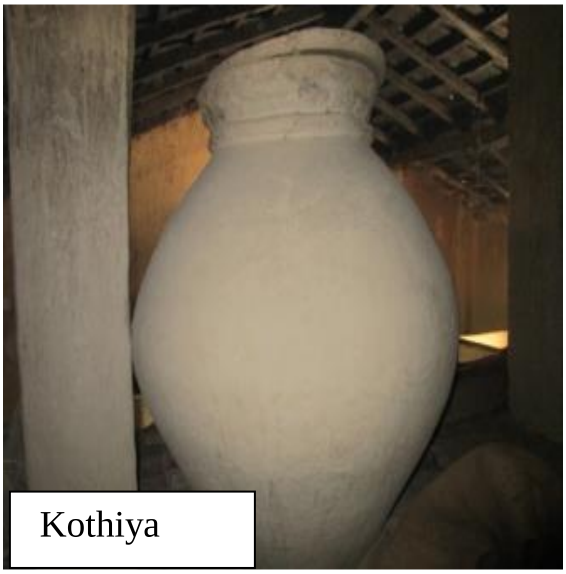
PHOTO PLATES

Plotting quadrate

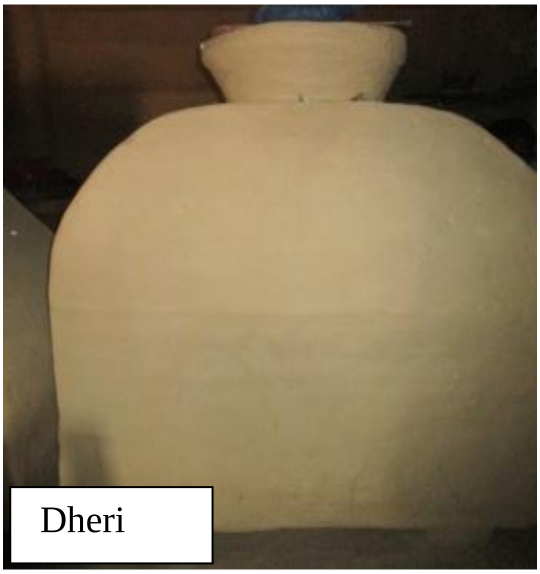
Grain Harvesting

Threshing

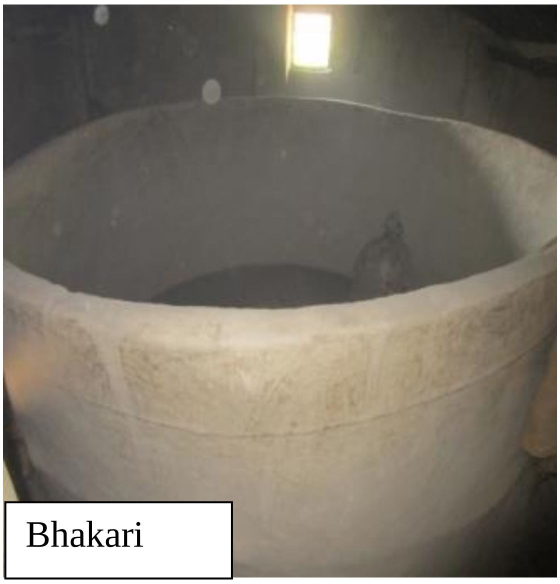
Winnowing



Kothiya

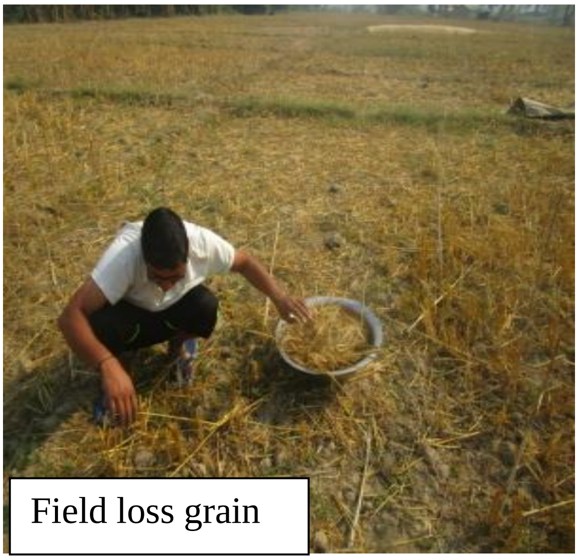


Dheri


Bhakari


Sacks


Drum


Field loss grain


Questionnaire survey


Sample collected

Seed counting

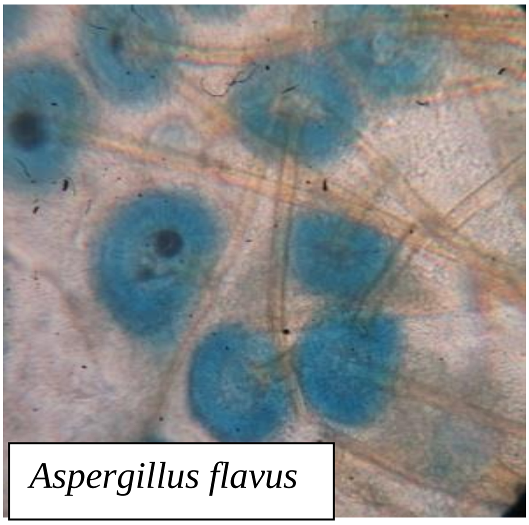
Seed plating

Seed in blotter

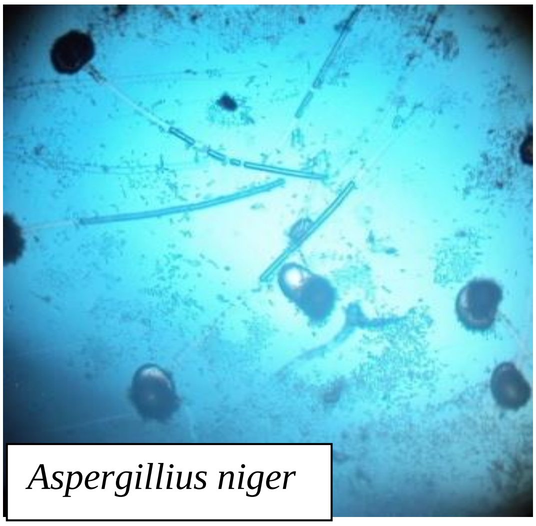
Examination of seed

Rhizopus sp.

Altanaria sp.

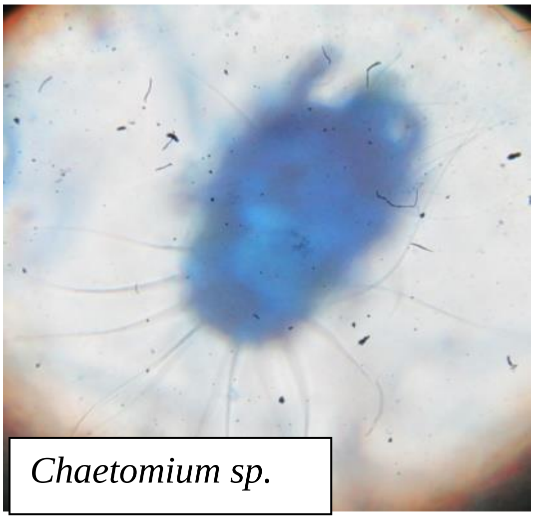


Aspergillus flavus



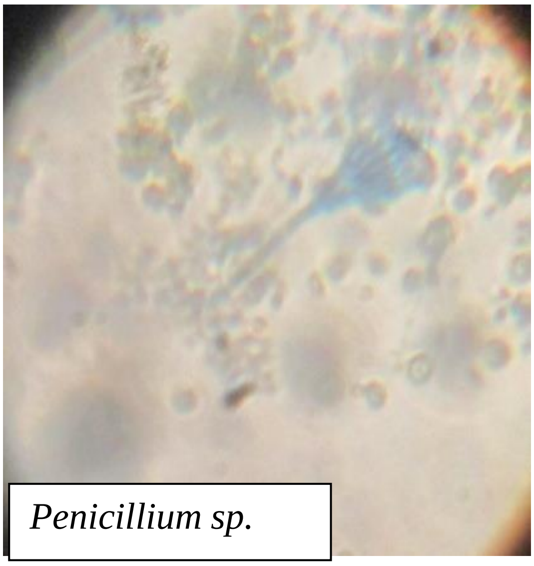
Aspergillius niger

Bipolaris sorokiniana



Chaetomium sp.

Fusarium sp.



Penicillium sp.