Post-harvest Pest Management
Research, Education and Extension in Ethiopia: The Status and Prospects

Proceedings of the 22\textsuperscript{nd} Annual Conference of Plant Protection Society of Ethiopia

Edited by
Belay Habtegebriel (PhD)

Plant Protection Society of Ethiopia
The Plant Protection Society of Ethiopia is a society formed by plant protection professionals in the country and is licensed and registered by the Charities and Societies Agency of the Ministry of Justice. The society has been in existence for more than two decades and has been conducting annual conferences every year by picking up a key plant protection issue of a year as a theme. The theme of the 22nd annual conference of the society was “Post-harvest Pest Management Research, Education and Extension in Ethiopia: The Status and Prospects”. Invited papers and discussion are compiled into this proceedings.

The 22nd annual conference was organized by the 2014 and 2015 PPSE executive committee members:

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Note from the Editor

The cover page of the proceedings of the 21st annual conference of the Plant Protection Society of Ethiopia (PPSE) published in 2014 incorrectly reads as the “Proceedings of the 22nd annual conference of the Plant Protection Society of Ethiopia”. Readers are politely asked to read it as “Proceedings of the 21st annual conference of the Plant Protection Society of Ethiopia”.

# Table of Contents

**Welcome Address**  
*Ermias Shonga*  
*i*

**Opening Speech**  
*His Excellency, Ato Wondirad Mandefro*  
*ix*

**Crop Postharvest Pests as Human and Animal Health Concerns**  
*Tariku Hunduma*  
*1*

**Role of Mechanization in Reducing Post-Harvest Losses: Challenges and the Way Forward**  
*Bisrat Getnet and Laike Kebede*  
*9*

**Reducing Post-harvest Losses and Increasing Food Availability**  
*Tadele Tefera*  
*23*

**The Political Economy of Post-Harvest Losses in Ethiopia: Historical Counts, Current Status, Policy Implications**  
*Dawit Alemu*  
*31*

**Sustainable Agricultural Intensification in Sub-Saharan Africa and the Role of Nematodes**  
*Danny Coyne*  
*61*

**Minute for Plenary Session: 22nd Annual Conference of the Plant Protection Society of Ethiopia, March 10-11, 2016**  
*69*

**Summary of the deliberations from 22nd PPSE Annual conference**  
*73*

**Dates and Themes of Annual Conferences of the Plant Protection Society of Ethiopia**  
*77*
Welcome Address

Ermias Shonga
President, Plant Protection Society of Ethiopia

Your Excellency, Ato Wondirad Mandefro,
State Minister,
Minister of Agriculture and Natural Resources

Dr. Fentahun Mengistu,
Director General,
Ethiopian Institute of Agricultural Research (EIAR)

Dear Honorable guests,
Conference participants,
Ladies and gentlemen,

On behalf of the Executive Committee and on my own behalf, it gives me a great honor to welcome you all to the 22nd Annual conference of the Plant Protection Society of Ethiopia. I would like to thank you all for honoring our invitation and coming here from various institutions and long distance to attend this timely event.

At the beginning of this year, we lost unexpectedly one of our senior Entomologist and mentor, the founders of PPSE, “life time honored” and active member of the society, Dr. Tadesse G/Medhin. Dr. Tadesse has served our society by taking different responsibilities and with strong dedication until his retirement. May I ask you all, for a moment of silence in remembrance of Dr. Tadesse G/Medhin.
Your Excellency,
Distinguished guests,
Ladies and gentlemen,

As you notice, we selected the theme for this year’s conference entitled as “POSTHARVEST PEST MANAGEMENT RESEARCH, EDUCATION AND EXTENSION IN ETHIOPIA: THE STATUS AND PROSPECTS”. We realized the topic is so catchy and essential for ensuring our future food security. We have made a consultation and circulated the theme among the senior PPSE members and got a wide acceptance. The Executive Committee has selected this theme for this year due to the following main reasons:

1. For more than the last two decades, our government policy is “Agricultural Development Lead Industrialization (ADLI)” and has given much emphasis for the agricultural sector to ensure food security. However, Ethiopia has experienced a food deficit for the last five decades. Therefore, a substantial amount of food is imported every year (on purchase or donation) to alleviate the deficit. On the other hand, tremendous amount of food is lost to a number of factors during the food production chain, including harvesting, handling, storage, processing, packing and transportation of the produce.

2. On the contrary, less attention was given to post-harvest pest management and a national figure for post-harvest losses is not available in most cases. However, estimations based on limited observations put the grain losses in cereals and pulses due to insect pests alone at about 10 to 21%. Similarly, Post-harvest loss of horticultural crops ranging from 20% to 50% was recorded in between marketing and consumption.
Besides, losses caused by storage fungi and mycotoxines especially in underground pits storages are tremendous.

3. In Ethiopia, there was no research work on stored product pest management (except a few preliminary studies) until the late 1980s, when some graduate students took the problem as their thesis research topic. Since then very limited PHL research have been covered by different researchers in different institutions.

4. Similarly, the issue of PHL has got minimum emphasis in agricultural training and extension sector.

5. According to the United Nations population projections released in March, 2013, the current world population is expected to reach 10.5 billion by 2050. This further adds up to global food security concerns and translated into 33% more human mouths to feed in the future,

6. Similarly, a report by the Population Reference Bureau says, Ethiopia's population will reach 174 million by 2050 to become the 9th largest country in the world. Ethiopia's current population is estimated at 95 million, the second most populous country in Africa, faces increasing food insecurity unless it can dramatically boost agricultural productivity.

7. According to some scholars study, analysis of food aid, food import and food security figures versus post-harvest losses suggest that addressing postharvest losses could have a significant impact on food security and farm-income without increasing pressure on land.

8. Significant postharvest loss, up to 50%, has been attributed to the lack of adequate knowledge and implementation of sound grain storage management.

9. Key stakeholders of Post Harvest Pest Management are: civil society, academic institutions, farmer organizations, trade
associations and ministries (Ministry of agriculture & Natural Resources and Ministry of trade, etc).

Your Excellency,
Distinguished guests,
Ladies and gentlemen,

Allow me to say this boldly, “In a civilized world, when millions go hungry, it would be a crime to allow postharvest losses and wastage to continue”.

Currently, a number of deficiencies exist in the post-harvest pest management and processing of agricultural produces in Ethiopia. **Action must be taken** in order to upgrade systems, in order to reduce the levels of post-harvest losses. “It is unfortunate that in Ethiopia, policy makers and planners set targets for increased production without making any effort to reduce postharvest losses.”

To compare and contrast the benefit,

- Expenditure on crop production is **required on an annual basis**,  
- While the establishment of infrastructural facilities for postharvest operations are **a onetime capital investment** which must be undertaken and compensated for by the annual savings from reducing postharvest losses.  
- Proper infrastructure, logistics management and human resources are essential to improving postharvest management and marketing of agricultural produces.

Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security.

The current challenges ahead of us are:
• Rapid population growth, increased food demand and consumption habit change with urbanization;
• Recurrent climate shock on agricultural productivity;
• Occurrence of new exotic quarantine pest such as LGB; and
• The outdated storage structures used by farmers and traders such as: Gotera, Gota, Dibignit, Underground Pits, Sacks, Barrel, Clay-Pots or Jars and Small Stores, which are exposing the produce for damage by pest and micro-organism.

Therefore, the EC of PPSE has recognized the issues and took the responsibility to bring all the principal stakeholders on board and sensitize the agenda of PHL and PH pest management. In effect, this conference aims to show the gaps in the post harvest pest management with regard to research, extension and education.

In this conference, at least five themes related plenary papers will be presented and all the necessary understanding will be created among all the stakeholders and remedial measures will be recommended.

Hence, this Annual Research Conference is unique and has attracted a number of policy makers. We have some issue to address and in turn, we hope the policy makers will address it from policy perspectives. We have also some important issues which will be directed to the researchers, technocrats and academicians for their actions. I would like to emphasize that every one of us has an issue to take home and play our role accordingly.

Therefore, there is a huge work up on us, as plant protection professionals to keep our plants safe from the emerging ravages of pests and reduce post harvest losses of crops in orders to ensure food security and feed the future generation.
Distinguished conference participants,
It is a pleasure to have with us our Guest of Honor, H.E Ato Wondirad Mandefro to give an opening speech to this national event and to encourage the efforts of our society, despite all his tight programs and official engagements. We are also pleased to have many distinguished and prominent guests attending this conference. Therefore, the EC of PPSE is highly delighted with all of you coming to this national conference and requests your active participation and fruit full deliberations.

Distinguished conference participants,
On behalf of the EC, I would like to thank all of those who contributed to the success of convening this annual conference. First, I would like to express my gratitude to the DG of EIAR for taking time to be with us this morning to make an introductory remarks and chairing the opening session. We are sincerely grateful to our donors for their generous financial support. These are:

- Ministry of Agriculture and Natural Resources (MoANR),
- Ministry of Science and Technology (MoST),
- Ethiopian Institute of Agricultural Research (EIAR),
- Lions International,
- Chemtex PLC,
- General Chemicals and Trading PLC,
- Adami Tulu Pesticide Processing Share Company
- B-NYSE General Trading PLC

We are also grateful to different EIAR Research Centers such as Debere Zeit, Melkassa, Holetta, Ambo and Kulumsa Research Centers, for provision of vehicles and other facilities to the Executive and Editorial Committee members.
Finally, I acknowledge also all who have devoted their time and energy to make this conference successful. With these brief remarks, may I take the honor to request the Director General of EIAR, Dr. Fentahun to make a keynote remark and invite the Guest of honor H.E Ato Wondirad Mandefro to officially open the 22nd annual conference of PPSE.

Thank you!
Opening Speech

His Excellency, Ato Wondirad Mandefro
State-Minister, Ministry of Agriculture and Natural Resources

Mr. Chairman,
Distinguished Conference Participants,
Invited Guests,
Ladies and Gentlemen
On behalf of the Ministry of Agriculture and Natural Resources of the Federal Democratic Republic of Ethiopia and on my behalf, I would like to extend to all of you my respectful congratulations for successfully organizing this important gathering, the 22nd Annual Conference of the Plant Protection Society of Ethiopia under the theme “Postharvest Pest Management Education, Research and Extension in Ethiopia: the Status and Prospects”

Distinguished Conference Participants,
Agriculture is the backbone of the Ethiopian economy, with 85% of the population living in the rural areas and depending on this sector for livelihood. The agricultural sector accounts for more than 40% of national GDP, 90% of exports and provides basic needs and income to more than 90% of the poor. There is no doubt for the economic importance of agriculture for sustainable development and poverty reduction in Ethiopia. Currently, the agriculture sector is performing better and has provided growth to the overall economy, improved the food security and reduced poverty. It accounts for the lion's share of the total GDP, in foreign currency earnings and in the employment creation. Both industry and services are dependent on the performance of agriculture, which provides raw materials, generates foreign currency for the importation of essential inputs and feeds for the fast growing population.
Unfortunately, the constraints those threatening this important sector of the economy are many and diverse. First and foremost threatening factors, includes the use of traditional farm tools and implements; the low level use of improved agricultural inputs such as fertilizers, improved seeds and pest control technologies; the inadequate level of post-harvest technologies; the natural resource degradation; the population pressure; and the biotic factors like insects, diseases, weeds, rodents, birds and other vertebrate pests. Besides, the recurrent climate shock is the most important factor severely affecting the sector. These factors slow the growth of agricultural production in general and of food grain production in particular. Thus, they greatly contribute to food insecurity.

**Distinguished Conference Participants,**

At the national level, efforts are underway to increase agricultural productivity through the endeavour to food security, to supply enough raw materials to domestic industries and to produce export commodities for foreign exchange earnings. The government has also introduced specific policies and provided technical and institutional support to farmers, in its drive to increase food production through intensive cultivation.

The most important development strategy of the Ethiopian government is the adoption of Agriculture Development Led Industrialization (ADLI), which has been a central plank of the EPRDF government's development program until recent years. The ADLI focuses on productivity growth on small scale farms as well as labour-intensive industrialization.

Consistent with the ADLI, the government focus shifted from policy reforms designed such as:
• Public investment in agricultural extension aimed at boosting productivity through the widespread introduction of modern technology.
• An extensive extension program called the Participatory Demonstration and Training Extension System (PADETES).
• The government also revisited the program and formulated an integrated rural and agriculture development strategy that was launched in 2002.
• Sustainable Development and Poverty Reduction Program (SDPRP).
• After the continuing evidence of widespread food insecurity in the drought of 2002/03, the government also initiated a strong focus on safety nets, programs to build the assets of food insecure households, resettlement and soil - water conservation (especially water harvesting).
• Poverty Reduction Strategy Paper (PRSP) developed and implemented by the Ethiopian government. It was followed by the second PRSP titled “Plan for Accelerated and Sustained Development to End Poverty (PASDEP)”.
• The Plan formed Ethiopia’s guiding strategic framework for the five-year period; MDG; GTP-I and GTP-II.

In the recent years, the policy reforms, agricultural investments and public service provision have provided a boost to agricultural production, primarily on cereals. Therefore, the Ethiopian agriculture has witnessed the most rapid growth in its history.

**Mr. Chairman,**

**Distinguished Conference Participants**

This conference is timely and a landmark in the history of plant protection society in Ethiopia. Because, this year, we have experienced a lot of noticeable events that happened. To mention these, it was the time we successfully completed our first GTP-I and launched the GTP II; the EIAR has celebrated its 50th anniversary
or the golden jubilee with so many successes and great contribution to agricultural productivity and ensuring food security. On the other hand, we have challenged with “Ei Nino” caused climate variability and have affected more than 12 million peoples who are largely dependent of rainfall based agriculture. Therefore, strong commitment and much work are expected from the policy makes, professional societies, researchers and extension agents to make the agricultural sector development sustainable. In order to feed our growing population, ensure food security, and reduce poverty and malnutrition boosting agricultural productivity is not the only solution; but the reduction of Post-Harvest food loss and wastage must be the integral part in our future actions.

**Distinguished Conference Participants,**

In Ethiopia, it is estimated that about 60 to 90% of the produce is retained by the farm household and stored for 6 to 12 months. However, they are subject to post-harvest losses and deterioration due to biotic and abiotic factors. Insect pests, fungi and rodents constitute the major biotic agents that cause serious problems in storage. Moreover, the severe post-harvest loss and quality deterioration of crops mainly occurred during harvesting followed by marketing, transporting and storage.

Despite the limits, information on post-harvest losses of food grains in Ethiopia is scarce and there is considerable debate over the importance of such losses at the farm level. Therefore, reduction of post-harvest losses and quality deterioration are essential in increasing food availability from the existing production. Minimizing this loss has a great significance for food security, economic growth and welfare of the society.
Mr. Chairman,  

Distinguish members of the Crop Protection Society of Ethiopia  

It is well established fact that, Professional Societies play a multi-faceted role in the national development effort. They constitute a vital portion of the scientific and technical infrastructure of a country. Professional societies are a collection of individual scientists and technologists with specialized knowledge, experience and expertise that can be mobilized to accomplish specific tasks. Professional Societies like yours, hold their respective annual conference with a specific theme in their field of specialization. In this context, it is necessary for your Society to play a pivotal role in the process of identifying research and development needs and priority areas of national development programs and strategies.  

The theme of your conference being “Postharvest Pest Management Education, Research and Extension in Ethiopia: the Status and Prospects”, a timely concern of the country, is appreciated very much and is a testimony of a growing social concern of your Society in Food Security. I am full confident that your deliberations today and tomorrow will be able to build a rational and objective analysis of all plant protection issues associated with Food Security to the benefits of agricultural economic development endeavor.  

Taking this opportunity, I would like to extend my sincere thanks to the organizers of this conference, who have contributed their time and energy to bring about the realization of this conference. I wish you all the success in your deliberations and hope your discussions will be enjoyable and fruitful.  

Finally, I declare the 22nd Annual Conference of the Plant Protection Society of Ethiopia is open and wish you all the best in your deliberations.  

Thank you all!

[xiii]
Crop Postharvest Pests as Human and Animal Health Concerns

Tariku Hunduma
Ambo Plant Protection Research Center, EIAR, E-mail: tarikuh2012@gmail.com

Abstract

Crop postharvest pests are both an economic and health concerns. In addition to direct economic considerations, a number of crop postharvest pests are known to cause a potential health risk both to human and animals. This paper addresses how crop postharvest pests impact on human and animal health with some historical happenings to briefly show the scenario.

Keywords: crop, postharvest, pests, health, risk.

Introduction

The primary role of an effective postharvest system is to ensure that the harvested food reaches the consumer, while fulfilling customer satisfaction in terms of quality, volume and safety (Adebayo et al. 2014). However, large quantities of agricultural commodities produced on the farm never reach the consumer as a result of postharvest losses (Malcolm 1977) due to physiological crop perishability, mechanical damage, environmental causes such as excessive exposure to high ambient temperature, relative humidity, rain and pests (diseases, rodents, insects and other pests) (Adebayo et al. 2014). Losses may be qualitative or quantitative, or a combination of both (Kader 2005). Crop postharvest pests are both an economic and health concerns. In addition to direct economic considerations, a number of crop postharvest pests are known to cause a potential health risk both to human and animals.
Rodents (Vertebrate pests)

Rodents, in addition to causing considerable qualitative and quantitative losses of agricultural commodities, are important vector for zoonosis, and can act as reservoirs for more than 60 different diseases which can affect people (RatZooMan 2006). Some of these diseases are caused by viruses (e.g. Lassa fever, hantavirus disease, tick-borne encephalitis, Argentine and Bolivian hemorrhagic fever), bacteria (e.g. plague, leptospirosis, lyme disease, relapsing fevers), protozoans (e.g. leishmaniasis, toxoplasmosis) or helminths (e.g. trichinellosis, echinococcosis, capillariasis) (RatZooMan 2006).

“The Black Death” (Plague)

Let us have look at the history of “The Black Death”, just to understand how sylvatic (wild) disease get transmitted to human and human vicinity and become new serious disease.

“The Black Death”, now known as the plague, is spread by a bacillus called *Yersina pestis*, an obligate pathogen and does not exist freely in the environment. It is unable to replicate outside a host (flea or mammal) in natural conditions, and plague is maintained in foci in mammals, mainly rodents, with transmission between individuals via fleas. Human plague occurs when wild rodents encroach on human habitat because of food and various reasons; commensal rodents are then at risk for infection. Alternatively, humans may encroach on rodent habitat because of agriculture, hunting, or residence. Humans’ domestic animals can also intrude into rodent habitat, get infected, and be a source of human infection (RatZooMan 2006). According to “The Black Death 1348”, the plague presented itself in three interrelated forms. The bubonic variant (the most common) derives its name from the swellings or buboes that appeared on a victim's neck, armpits or groin. Infected fleas that attached themselves to rats and then to humans spread this bubonic type of the plague. A second variation - pneumatic plague - attacked the respiratory system and was spread by merely breathing the exhaled air of a victim. It was much more virulent than its bubonic cousin - life expectancy was measured in one or two days. Finally, the septicemic version of the disease attacked the blood system (Figure 1).
Historically the first recorded pandemic, the Justinian Plague occurred between 542-546 AD, causing epidemics in Asia, Africa and Europe. It is estimated to have claimed nearly 100 million victims (WHO/CDS/CSR/ISR/2000.1).

The second pandemic, widely known as the "The Black Death" or the Great Plague of the fourteenth century (1347–1350), originated in China in 1334 and spread to Constantinople and then to Europe, where it claimed an estimated 60% of the European population (WHO/CDS/CSR/ISR/2000.1). Entire towns were wiped out until no survivors remain to bury the dead (WHO/CDS/CSR/ISR/2000.1).

The third pandemic began in Canton and Hong Kong in 1894 and spread rapidly throughout the world and caused approximately 10 million deaths (WHO/CDS/CSR/ISR/2000.1). In India, there were over 6 million deaths from 1898 to 1908. It was during this last pandemic that scientists identified the causative agent as a bacterium and determined that plague is spread by infectious flea bites.

Recently the plague is widely distributed in the tropics and subtropics and in warmer areas of temperate countries; and in 2015 there were 320 cases reported worldwide, including 77 deaths (http://www.who.int/csr/disease/plague/en/). According to Stenseth (2008), Plague is now commonly found in sub-Saharan Africa and Madagascar, areas which now account for over 95% of reported cases.
Figure 1. Transmission of plague from wild to human and human vicinity.

**Source:** Rats and Human Health in Africa: Proceedings of an international workshop on rodent-borne diseases and the RatZooMan research Project. 3-6 May 2006, The Pestana Kruger Lodge, Malelane, Mpumalanga Province, Republic of South Africa
In general, rodent infestation is present throughout the food chain and implicated in various important food-borne diseases. Humans possibly become infected by eating food contaminated with infected rodent urine and/or faeces and also by inhaling pathogen-laden dust particles (Meerburg et al. 2009) (Figure 2). Studies indicated that the worst scenario of some disease transmission to human appear when rodents are used as food source in some African and Asian countries (Assogbadjo et al. 2005; Lynwood 1990). It is reported that rodent infestations can create microclimates that facilitate mold invasion of some stored commodities (Grants et al. 2003).

Figure 2. Grains contaminated with rodent faeces and possibly be source of pathogenic organisms

occur in a wide variety of foods and feeds and have been implicated in a range of human and animal diseases. Mycotoxigenic postharvest fungi contaminating various agricultural food commodities have been considered major economic and health threat (Phelix et al. 2007). In Ethiopia such toxic effects has been recognized when mycotoxins responsible for gangrenous ergotism broke out in 1977-78 with 93 cases and 47 deaths (Kelbessa Urga et al. 2002). Recent outbreak of ergotism was also reported in Tijo-Digelu woreda, Arsi zone, Oromia in 2001 (Kelbessa Urga et al. 2002). Exposure to mycotoxin occurs through consumption of contaminated food products (Figure 3) and can produce both acute and chronic toxicities ranging from death to deleterious effects upon the central nervous, cardiovascular and pulmonary systems, and upon the alimentary tract. Mycotoxins may also be carcinogenic, mutagenic, teratogenic and immunosuppressive (Wayne 2007). Works done in Africa indicated that majorities of farmers use moldy grains in one or another way. In Ethiopia about 52% and 46% of Shewa and Hararghe farmers, respectively feed the deteriorated grain to animals whereas 37% and 42% of them respectively consume the spoiled grain by themselves (Habtamu and
In another study, cattle and poultry fed on mycotoxin contaminated feed produced milk with aflatoxins $B_1$ ($M_1$) and food products from such poultry lead to human health risks (Phelix et al. 2007).

Insect pests (invertebrate pests)

Studies indicated that postharvest insect pests cause indirect health risks. Insects have a profound effect on the spread of fungal diseases through transmitting the spores and increasing the surface area susceptible to fungal infection, which eventually increases the production of mycotoxins (www.icipe.org). In general, it is reported that insects contribute to mycotoxin contamination and play major roles in cross contaminating other disease causing organisms (CAST 2003).

Poisonous weeds

Weed, mostly called “a plant out of place” often get harvested along with grain crops and feeds (UoF). Unfortunately, some weeds contain alkaloids, glucosides, irritant oils, organic acids, minerals, resins and phytotoxins are potentially toxic to man and domestic animals (List and Spencer 1979). Different works elsewhere in the world showed weeds such as jimsonweed ($Datura stramonium$), nightshade ($Atropa belladonna$), crotalaria ($Crotalaria spectabilis$) and others pose toxic effect on human and livestock (Lee 2007; Mukul et al. 1998).
**Recommendation**

A wide variety of crop postharvest pests cause product losses. Most agricultural researchers consider those pests from product loss point of view. But, crop postharvest pests are not only the issue of product loss but also are the issue of both human and animal health risk. As the case of “The Black Death” crop postharvest can lead to the transmission of new wild disease to human and domestic animals leading to high heath risks that probably become deadly disease. Hence research on crop postharvest pests needs (1) to focus not only on product loss but also on health risks, (2) to raise the awareness of consumers on the health risks of the pests and (3) to focus on developing management options of the pests.

**Reference**


LIST GR and SPENCER GF. 1979. Toxic Weed Seed Contaminants in Soybean Processing.


Role of Mechanization in Reducing Post-Harvest Losses: Challenges and the Way Forward

Bisrat Getnet and Laike Kebede
Ethiopian Institute of Agricultural Research, Melkassa Agricultural Research Center, Agricultural Mechanization Research Directorate, P.O.Box 436, Adama, Ethiopia

Abstract

This paper reviews the role of post-harvest mechanization and the attempts made in the Ethiopian post-harvest mechanization research. Quality and safe produce is very important to consumers and retailers. To satisfy the demands and prepare the market for foreign countries, post-harvest mechanization technologies are very important for Ethiopia. Research results show that post-harvest mechanization technologies can contribute to the food security of a country. According to different literatures, it is difficult to get the exact information on post-harvest losses of food grains in Ethiopia but the frequently used figure ranges from 20-30 percent. The figure increases up to 50 percent for perishable crops. Therefore, reducing the post-harvest loss is as equal as increasing crop productivity. This paper focuses on post-harvest-loss interventions through mechanization and the way forward to address the challenges.

Introduction

Current world population is expected to reach 10.5 billion by 2050 (UN March 2013), further adding to global food security concerns. This increase translates into 33% more human mouths to feed, with the greatest demand growth in the poor communities of the world. According to Alexandratos and Bruinsma (2012), food supplies would need to increase by 60% (estimated at 2005 food production levels) in order to meet the food demand in 2050. Food availability and accessibility can be increased by increasing production, improving distribution,
and reducing the losses. Thus, reduction of post-harvest food losses is a critical component of ensuring future global food security. Food and Agriculture Organization of U.N. predicts that about 1.3 billion tons of food are globally wasted or lost per year (Gustavsson et al. 2011). Reduction in these losses would increase the amount of food available for human consumption and enhance global food security, a growing concern with rising food prices due to growing consumer demand, increasing demand for biofuel and other industrial uses, and increased weather variability (Mundial 2008; Trostle 2010). A reduction in food loss also improves food security by increasing the real income for all the consumers (World Bank 2011). In addition, crop production contributes significant proportion of typical incomes in certain regions of the world (70 percent in Sub-Saharan Africa) and reducing food loss can directly increase the real incomes of the producers (World Bank 2011).

It is an established fact that no nation can gain international recognition and respect without achieving technological advancement. More importantly, a country which cannot feed its citizens using local technologies that can be adapted for her own raw materials, cannot achieve meaningful industrial progress. The need for postharvest loss prevention of primary agricultural products has been of great concern to past and present governments in Ethiopia. It is a problem that needs to be addressed at both on-farm and industry levels. To this end, the Agricultural Mechanization Research has been involved in initiating various applied and adaptive research projects in post-harvest activities aimed at improving postharvest handling and processing, processing and preservation of food crops and livestock products in the country.

**Food Losses and Food Waste Concepts**

Post-harvest loss (PHL) which presents one of the main problems in all agricultural production is a measurable qualitative and quantitative food loss along the supply chain, starting at the time of harvest till its consumption or other end uses (De Lucia and Assennato 1994; Hodges et al. 2011). According to Harries and Linblad (1976), it is defined as any change in the ability, edibility, wholesomeness or quality of food that prevents it from being consumed by people. PHLs can occur either due to food waste or due to inadvertent losses along the way. Thus, food waste is the loss of edible food due to human action or inaction such as throwing away wilted produce, not consuming available food before its expiry date, or taking serving sizes beyond one’s ability to consume. Food loss on
the other hand, is the inadvertent loss in food quantity because of infrastructure and management limitations of a given food value chain.

Agriculture in Sub-Saharan countries currently suffers from a huge post-harvest loss (PHL) through inefficiency and mismanagement of harvested crops. Food losses can either be the result of a direct quantitative loss or arise indirectly due to qualitative loss. Losses can also be economic, resulting from low prices and lack of access to markets for poor quality grain. The direct or quantitative loss is the reduction in weight or volume of grain or food by spillage, or consumption by insects, rodents and birds and also due to physical changes in temperature, moisture content and chemical changes (FAO 1980). The same report pointed out that, although drying, a necessary postharvest process, involves considerable reduction in weight, there is no loss of food value, and therefore, should not be counted as loss. Reducing these losses, especially those caused by insects, microorganisms, rodents and birds can increase the available food provisions.

The indirect or qualitative loss on the other hand is the lowering of nutrient value and unwanted changes to taste, color, texture, or cosmetic features of food to the point where people refuse to eat it (Buzby and Hyman 2012). It can occur due to incidence of insect pest, mites, rodents and birds, or from handling, physical changes or chemical changes in fat, carbohydrates and protein, and by contamination of mycotoxins, pesticide residues, insect fragments, or excreta of rodents and birds and their dead bodies. When this qualitative deterioration makes food unfit for human consumption and is rejected, this contributes to food loss.

Food waste, as earlier mentioned, is a subset or sub-category of the food losses (Buzby and Hyman 2012). Food waste occurs when the an edible food item goes unutilized as a result of human action or inaction and is often the result of a decision made farm-to-fork by businesses, governments, and farmers (Buzby and Hyman 2012; Bloom 2010). The definitions of food waste and food losses are not consistent worldwide. For e.g., Buzby and Hyman (2012) and Waarts et al. (2011) report that Dutch Ministry of Economic Affairs, Agriculture, and Innovation defines food waste to include quality considerations and residual and waste flows in addition to the food loss (). Wastes & Resources Action Programme (WRAP) final report in 2009 defines waste as ‘any substance or object
Role of Mechanization in Reducing Post-Harvest Losses

which the holder discards or intends or is required to discard’ (Quested and Johnson 2009). Different studies use appropriate definitions for their needs.

Need For Mechanization Technologies for Post-Harvest Loss Interventions.

1. Improvement of post-harvest technology to reduce losses, ensure quality and food safety.
2. Technology and equipment for diversification of agro-products.
3. Complete technology and equipment for traditional food processing in order to improve quality, extend storage life and ensure food safety in localities. As some types of cakes, fermented rice noodle, fruit dehydration, fruit and vegetable fermenting, salting …
4. Utilize waste from processing and storage for food and animal feed in order to increase high efficiency in manufacture and good waste management.
5. Technology and equipment for pre-processing, storage, and transportation. Research, design, manufacture and transfer to production comprehensive lines of pre-processing and storage vegetable and fruits at the scale of 1-2 tons, serving gathering markets and exporting bases with the products of good quality, hygiene and safety.
6. Manufacture specialized containers for far-away transportation of fresh vegetable and fruits.
7. Transfer to production models of cold stores at different scales, for fresh vegetable and fruits and aqua-products preservation.
8. Agro-product preservation to reduce losses.
9. Research and development on technology and equipment of grain, fruits and vegetables drying in household and industrial scale (of 0.1-40 tons per batch).
10. Research and development on Cooling and Frozen technology by Individual Quickly Frozen (IQF) of fruits and vegetable at industrial scale.
11. Research and development on preservation and processing technologies and equipment of multi-year crops, including tea, coffee, cashew nut and cashew apple in household and industrial scale.
12. Research and development on horticulture crop preservation technology, including Modified Atmosphere Packaging (MAP) in order to export at National level.
13. Research and development on new materials used for preservation, coating, waxing of fruits and vegetables.
14. Research and development on indigenous knowledge for Agro-food preservation and processing in different regions.

**Nature and Magnitude of Harvest and Post-Harvest losses**

According to FAO (2011) loss of produced food accounts for one third (1.3 billion tons) of the annual global food production. Worldwide post-harvest food losses have been quoted as being 15-50% for horticultural products and 10-20% for grains and oil seeds (Okezie 1998). Based on questionnaire survey results relating to cereals, non-storage postharvest losses of up to 19% (5% from harvesting/field drying, 6% from threshing/shelling, 5% during winnowing and 3% for transport from field to store) are incurred in Ethiopia (Vervroegen and Yehwola 1990). Storage losses then again in traditional on-farm bulk grain stores in Ethiopia are reported to be high. Anon as cited by Abraham (1991) reported 16-20% of the already harvested crop is lost due to the poor storage system. According to 2013 estimates of African Postharvest Loss Information System (APHLIS), in Ethiopia, postharvest weight loss is about 18 percent for maize, 14 percent for wheat and 12 percent for teff, sorghum and barley. According to Boxal (1998), 11 percent of grains produced in Amhara, Oromiya and Southern regions are lost; more than half of it is loss at storage. Another report also indicated the estimated weight losses of 17.5, 11.8, 11.7, 11.5, 13.0 and 9.9 for maize, sorghum, millet, rice, wheat and barley respectively for Eastern and Southern Africa (including Ethiopia) based on annual production for the year 2005–2007. Abraham and Senait (2013) made an assessment in two Woredas in Amhara Regional State and suggested alarmingly high level of loss that could amount from 30 to 50 percent of the production.

Estimates of postharvest losses of fruits and vegetables vary widely both in the developed and developing countries (Paull 1993). A comprehensive statistics for such losses is not available for Ethiopia; however, in horticultural state farms of Ethiopia like the Upper Awash Agricultural Development Enterprise post-harvest losses of horticultural commodities vary, depending on commodities, from 10 to 49%, and includes losses encountered between harvesting and marketing only. In the peasant sector, they are believed to be a more serious problem and it is possible to find individual cases with losses even reaching up to 100%. The main factors responsible for postharvest losses were lack of proper packaging, no
Role of Mechanization in Reducing Post-Harvest Losses

precooling, no proper transportation, and lack of good storage techniques. As noted by Tyler (1982) postharvest losses may be due to a variety of factors, the importance of which varies from commodity to commodity, from season to season, and to the enormous variety of circumstances under which commodities are grown, harvested, stored, processed and marketed.

Generally the available too few information indicates that the levels of post-harvest losses of agricultural products vary according to crop type, climate and storage type. Climate is a key determinant of storage losses, since the biodeterioration factors that are the main agents of loss are dependent on conditions of temperature and humidity.

As in most food insecure low income countries, in Ethiopia where food insecurity is a serious threat, PHL in all agricultural produce shall not be taken lightly. The causes varied including harvesting methods, handling procedures, types of storage, attacks by rats, birds, and other pests damage including infestation by storage insect pests and food-borne pathogens. The Significant volumes of grain lost after harvest in developing countries, aggravating hunger and resulting in wastage of expensive inputs such as fertilizer, irrigation water, and human labor (World Bank 2011).

According to MoFED, during the years 2010/11, 2011/12 and 2012/13, agricultural production has registered a yearly growth of nine, five and seven percent, respectively. Though the country puts every effort to boost production in a sustainable manner to enhance food security; prevailing facts are explicitly pressing the need for corresponding attention and actions towards the PH sector in order to maximize gains from the increase.

Current Harvest and Post-Harvest Practices

In Ethiopia, traditionally harvesting cereal and pulse crops is merely done manually using sickle. Drying the harvested crop is almost exclusively done with a combination of sunshine and movement of atmospheric air. Threshing of cereal and pulse corps is done by traditional animal threading and manual beating/rubbing. Winnowing and cleaning is done traditionally using natural wind with the help of forks, shovels and baskets. These traditional methods of harvesting and post-harvest activities are time consuming, give reduced quantity and quality of produce, induce human drudgery and are inefficient during
operation and moreover result in high percentage of quantitative and qualitative losses.

**Agricultural Mechanization Post-Harvest Research in Ethiopia: A Review**

To overcome farmers harvest and post-harvest problems, different technologies were developed and tested by different organizations. Arsi Rural Development Project (ARDP) took the first initiative and developed engine (8 hp) driven non cleaning type wheat and barley thresher (Seyoum et al. 2007). Later in 1985-1989 the former Bako Rural Technology Promotion Centre (Now named Bako Agricultural Engineering Research Center) designed and developed Power Take Off (P.T.O.) and engine (12 hp) driven maize sheller with the shelling capacity of 50-60 qt.hr\(^{-1}\) with good cleaning and shelling efficiency and no breakage and loss. Later on, Agricultural Implement Research and Improvement Center (AIRIC) of EIAR redesigned and developed the ARDU non-cleaning barley and wheat thresher to come up with cleaning type multi-crop thresher keeping the basic mode of operation of the original ARDU developed thresher. AIRIC also took over the Bako’s thresher and improved the concave assembly and managed to reduce grain breakage. AIRIC also tested and evaluated four different threshers namely IAR non-cleaning thresher, Chinese thresher, Assela maize sheller and IITA thresher on maize and Assela thresher was found superior in capacity (61 qt.hr\(^{-1}\)) with minimum breakage followed by IAR thresher (54 qt.hr\(^{-1}\)) (Seyoum et al. 2007).

Based on the good design features of the tested thresher, new multi crop thresher was developed by AIRIC and managed to get some advantages over the previous threshers including lower cost, better straw chopping, avoiding interchangeable concave, better threshing efficiency for *tef* and better cleaning.

For farmers who have no access to engine or tractor, hand (manual) and pedal operated IAR maize sheller were also developed. Bako Mechanization Research Center modified and evaluated the IAR hand operated maize sheller by redesigning the flywheel and concave arc length and clearance and achieved shelling capacity of 690±76 kg.hr\(^{-1}\) and a shelling capacity of 99.3±19% (Zelalem et al. 2007).

Recently AIRIC is doing research to improve votex thresher, Bako thresher and IITA thresher to improve their capacity and threshing efficiency and also to address different crops. However, the different manual and engine driven
threshing/shelling equipment that can successfully be used in cereal and pulse production have not been adequately promoted for wider use in the country yet.

Demonstrations and participatory field experiments were carried out with farmers to promote storage technologies and processing techniques. Among improved grain storage technologies, participatory field demonstration and promotion of metal silo household grain storage facility has been in Ethiopia by EIAR in collaboration with SG 2000 and CIMMYT. In 2012 about 50 metal silos were fabricated and distributed to selected farmers. As a result farmers gave very positive response regarding overall performance of the metal silo compared to the traditional stores. On all participating farms, without exception, the new technology enabled farmers to safely keep their grain with zero loss. The metal silo technology can also be efficiently used for other crops such as beans, sorghum, millet, cowpeas and pigeon peas, and provides good business opportunities for local artisans.

Furthermore some studies on improving underground grain storage methods, evaluating and promoting above ground storage structures, developing small scale milk churning equipment, evaluating processing and preservation of milk and meat, testing evaporative cooling and solar drier technologies of fruits and vegetables were conducted at different local Universities and agricultural research Centers. An experiment carried out to develop a naturally ventilated onion store achieved an up to two months increased shelf life with a loss of 17.9% and 22.4% during dry and wet season respectively (Laike and Shemelis 2007). Studies on processing of soybean milk, mechanical oil extraction, composite flour were handled and generated vital information at ENI. Enset processing devices, above ground storage structures were also developed at Melkassa research center and primary coffee processing at Jimma. These efforts though deserve some appreciation, but are very far from giving backstopping to the current target of export oriented agricultural production. A strong support is needed both in the development of human power and facility to build a viable post-harvest technology research program.

**Attempts at Loss Reduction Using Post-Harvest Mechanization Technologies**

There have been numerous attempts by donors, governments and technical assistance agencies over the years to reduce post-harvest losses in developing
countries. Despite these efforts, losses are generally considered to remain high although, as noted, there are significant measurement difficulties. One problem is that while engineers have been successful in developing innovations in drying and storage, these innovations are often not adopted by small-scale farmers. This may be because farmers are not convinced of the benefits of using the technology. The costs may outweigh the perceived benefits and even if the benefits are significant the investment required from farmers may present them with a risk they are not prepared to take. Alternatively, the marketing chains may not reward farmers for introducing improvements. While good on-farm drying will lead to higher milling yields or reduced mycotoxin levels this means nothing to farmers unless they receive a premium for selling dry grains to traders and mills. This is often not the case.

More positive achievements have been recorded in the Central African Republic, using a simple 1-tonne capacity structure that was found by farmers to be easy to construct and proved popular even without donor subsidies. Considerable success has been reportedly achieved with metal bins over the last 20 years in Central America (Shepherd and Andre 2012; FAO 2008). Metal bins have been widely used for grain storage in Swaziland for half a century, drawing on the availability of local entrepreneurs who had been supplying metal water tanks. Replication of this success in other parts of Africa is very much in the pilot stage. Difficulties include the lack of local craftsmen to fabricate the bins; the need for grain stored in such bins to be dried to 14 °C, and problems with carrying out the necessary fumigation. Small-scale bins for use inside the home appear to be having more success than larger bins for outside use. A relatively new development is hermetically sealed bags, which appear to offer good possibilities to store a variety of quantities, although further socio-economic evaluation is still required. The Purdue Improved Cowpea Storage (PICS) bags are hermetically sealed bags that allow small-scale farmers to store cowpea without any use of chemicals.

**Challenges**

As there is limited or no reliable source of measured data on magnitude of postharvest losses in Ethiopia, a systematic research is needed to correctly estimate the levels of postharvest losses, both quantitative and qualitative (nutritional), of the commercially important commodities. Identification of technological and knowledge gaps existing in the entire postharvest value chain of both durable and perishable crops is also a critical research question.
The post-harvest problem has been a problem for years for most of African counties and it is of an issue that can be tackled by a developing nations in particular as food security is currently not yet achieved due to climatic and soil degradation factors. However, it is a concern that how post-harvest loss can be partly reduced if not totally reduced. The main challenge for developing nations like Ethiopia is lack of awareness on the existence of post-harvest loss and the interventions that exists to reduce the post-harvest loss using appropriate technologies.

The second challenge is that even if there exists some knowledge among farmers who opt to use the technologies, there is limited access to the technologies in their localities. These issues can be addressed by the intervention of actors who are involved in the post-harvest sector. There are three critical success factors that need to be implemented in the sector to get a desired outcome. The first factor is training. When we say training, farmers are always struggling to grow crops and get a better yield, not knowing that most of their produce is wasted prior to consumption. Having the knowledge of what is happening to their produce, they will be aware of it and try to search for technologies that can be appropriate to their socio-economic situations. The second factor is to improve the access of post-harvest mechanization technologies through incentivizing the private manufacturers and local artisans so that they can make the technologies available to the farmers with a price that can be affordable. This also involves so many actors along the chain. Importers who are importing the technologies and manufacturers who are producing technologies locally have their own share in the post-harvest reduction process. The third factor is to strengthen the national post-harvest research which can have an impact on making research on post-harvest and recommending possible solutions depending on the situations.

**Way forward**

From the foregoing, mechanization of post-harvest activities essentially involves the evolution, application, management and maintenance of technologies and other engineering principles to reduce or eliminate post-harvest food losses, process various forms of food products, and add value to the products. When there are precision, standardization and quality control in the processes, post-harvest food losses will be greatly reduced and optimally controlled.
The role of agricultural mechanization which spans the whole area of post-harvest mechanization of all agricultural operation in Ethiopia cannot be underestimated. Such roles include the development of appropriate technologies and systems for post-harvest processing and storage, handling, and preservation of agricultural products in order to prevent food losses, add food values, generate economic activities and above all ensure continuous supply of many food items which otherwise would have been seasonal. With approach to agricultural mechanization development, Ethiopia can develop her own indigenous technologies for processing, preservation and storage of her many tropical root crops such as cassava, potato, ginger, cocoyam; cereals crops such as maize, rice, sorghum, soya beans; oil crops such as groundnut and sunflower; fiber crops such as cotton and animal products such as livestock and fishery.

There is indeed a great need to conduct adaptive and innovative research to develop appropriate technologies for the processing, handling, preservation and transportation of our locally produced food products, to meet the retailing market system of our communities. It is disheartening to observe the colossal waste of our perishable food items such as fruits and vegetables in our market system due to deterioration in transit. EIAR and other related research institutes on post-harvest activities should tackle this problem as part of the mechanization strategy for the nation.

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Role of Mechanization in Reducing Post-Harvest Losses


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Reducing Post-harvest Losses and Increasing Food Availability

Tadele Tefera
International Center of Insect Physiology & Ecology (ICIPE)
ILRI Campus, Gurd Shola, PO Box 5689, Addis Ababa, Ethiopia;
E-mail: ttefera@icipe.org; tadeletefera@yahoo.com

Abstract
One of the key constraints to improving food and nutritional security in Ethiopia is the poor post-harvest management that leads to 20-30% loss of grains. It also has an impact on the nutritional value of grains, adversely affecting the health of populations consuming unsafe food, notably those contaminated with aflatoxins. Post-harvest losses contribute to high food prices by removing part of the supply from the market. Reducing post-harvest losses in grains is an essential component in any strategy to make more food available without increasing the burden on the natural environment. Solving the post-harvest management problems in grains will require cooperation and effective linkage among the following: research, extension, agro-industry, marketing system and favorable policy environment. Factors causing post-harvest losses and ways of managing postharvest losses are discussed.

Keywords: Ethiopia, food security, grains, postharvest loss

Introduction
Declining per-capita food availability, hunger, malnutrition and degradation of natural resources are the critical challenges currently confronting many countries in Sub-Saharan Africa. These have contributed to cycles of poverty and environmental degradation, exposing many farm households to market and agro-climatic shocks (World Bank 2015). One of the key constraints to improving food and nutritional security is the poor post-harvest management that leads to 8-40% loss of grains, with an estimated monetary value of more than US$4 billion annually (FAO 2010). It also has an impact on the nutritional value of grains, adversely affecting the health of populations consuming unsafe food, notably those contaminated with aflatoxins (PACA 2016). Farmers compensate for high post-harvest losses by clearing new fields where land is available, intensifying
production without capital inputs where land is scarce and/or selling grains immediately after harvests, when supply is high and prices are low (Tefera 2012). In addition to intensifying food insecurity and vulnerability, these measures lead to a cumulative expansion of the agricultural frontier and intensification of land degradation, weakening the agro-ecosystem’s ability to provide goods and services.

World population has been predicted to reach 9.1 billion by 2050 and this will require a 70 per cent increase in food production. Almost all of this growth will have to occur in less developed countries including Africa (FAO 2010). Two-thirds of the people in eastern and southern Africa (ESA) live in rural areas where they make a living from agriculture, often from degraded and marginal lands, with little opportunity to diversify incomes through additional employment in non-farm activities. Addressing rural poverty and food insecurity is, therefore, central to any efforts to improve human wellbeing and livelihoods.

Cereal grains constitute bulk of crop production in Ethiopia. One of the key constraints to improving food and nutritional security in Ethiopia, however, is the poor postharvest management that leads to 20-30 per cent loss of grains. Postharvest losses contribute to high food prices by removing part of the supply from the market; as a consequence, high food prices (Tefera 2012; Tafesse et al., 2011). It is, therefore, important and timely to implement strategies to minimize post-harvest food losses, help conserve valuable resources, and improve the livelihoods of the resource-poor.

Postharvest losses, caused by insect pests, fungal pathogens, rodents, or birds, vary extensively in different areas, particularly with respect to grains. Insect pests, pathogens and rodents are the principal causes of losses of stored grains in Ethiopia. The most economically important post-harvest pests of cereal grains include the maize weevil (Sitophilus zeamais), the larger grain borer (Prostephanus truncatus), the Angoumois grain moth (Sitotroga cereallela) and the lesser grain weevil (Sitophilus oryzae), and Callosobruchus spp. for grain legumes. These pests are widespread in Ethiopia and co-occur in the field and in storage (Demissie et al. 2008). Fungal pathogens in particular attack grain and contribute to both quantitative as well as qualitative losses to food value and a decrease in the monetary value of grains (Tefera 2012). Another serious concern is that certain species of fungi produce mycotoxins; for example the aflatoxin
produced by *Aspergillus flavus* renders a product unsafe for both human and animal consumption (PACA 2016).

**Posthavest losses and food security**

Food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (http://www.fao.org/spfs/en/, accessed in April 2016). Several people in the developing countries, including Ethiopia, however, are food insecure. Despite significant advances in food storage methods, many smallholder farmers in developing countries still rely on traditional storage methods for storing grain. Although relatively simple and inexpensive to construct and maintain, traditional storage systems lead to substantial post-harvest losses (Mughogho 1989). Inadequate post-harvest storage contributes significantly to food insecurity.

Effective grains storage plays an integral part in ensuring domestic food supply, and in stabilizing food supply at the household level by smoothing seasonal food production (Tefera 2012).

Improved storage structures are useful food security element in the grain storage and distribution chain. Smallholder farmers with a metal silo, for example, could feed their family year round and free to decide when to bring surplus harvest to market. Grains, particularly maize and beans can be stored in the metal silo for up to three years without any problem (SDC 2008). This helps schools, urban dwellers and smallholder farmers to set aside the reserves needed when changing climate conditions or natural disasters lead to crop failure (CIMMYT 2009)

**Factors affecting posthavest losses**

While the national agricultural research and extension system recognizes the importance of the postharvest losses and reducing post-harvest losses as part of a wider agricultural strategy, the wide scale adoption of the postharvest management strategy is hampered by several technical, financial, policy, skills and market barriers. While the technology for pest and disease proof post-harvest management practices is emerging slowly, particularly in Ethiopia, grain handling in the majority of rural areas is still by ‘traditional methods’ characterized by the granaries or simply any large empty rooms infrequently supplemented by pesticides (Chameda *et al.* 2007). Research on post-harvest technologies has been
limited, and the few innovations have been poorly disseminated. Private sector involvement in market development for post harvesting technologies has been limited, compounding the inaccessibility of the technologies by farmers, which further reduces the demand for the technologies. This in turn keeps the supply low, which consequently keeps the cost of production (and prices) relatively high. These barriers are compounded by the lack of policy based incentives for both research and private sector involvement in the post-harvest technology development, dissemination and adoption of post-harvest management processes (Tefera 2012). Although Ethiopia is increasing investments in grain production, indeed, there are several disincentives to the adoption of post-harvest management technologies such as taxes on materials, and consequently high prices.

**Relationship of post-harvest technologies, markets and policy environment**

Post-harvest loss has important impacts on markets and income opportunities for the poor. Storage losses drastically reduce the surplus available for markets and cut the incomes for many smallholder producers. This happens both from deterioration of quality and loss of quantity as result of pest and pathogen contamination. The risk of post-harvest loss also reduces the income opportunities as most farmers avoid storage and try to sell the surplus immediately after harvest, leading to surging supply and falling prices (Chapoto and Jayne 2010). Despite the significance of the problem for food security, income growth and adaptation to climate change in the region, many governments have emphasized policies targeting heavy investment in production subsidies with little attention to investments on the reduction of post-harvest losses. In the context of the high post-harvest losses especially for cereals and legumes, there is a distinct need to catalyze evidence-based policy dialogues for addressing this investment imbalance. The existing best-bet post-harvest technologies need to be scaled up and disseminated in the region. In addition to this, markets for post-harvest management options and storage systems need to be catalyzed so that private and public institutions and agencies can expand their availability and positively influence their adoption across the grain value chain (production to processing and storage). Producers also need to have access to equitable and efficient value chains to sell their produce at the time of their choosing without the risk of high storage losses (Tafesse *et al.* 2011). Utilization of such technologies is influenced by the prevailing policy environment; hence concerted efforts are required to develop institutional innovations and enabling policies to ensure adoption of effective post-
harvest management practices, and bring the benefits to both producers and consumers.

**Markets for adoption of postharvest technologies**

Improved storage will increase availability of grain for local consumption while also making it possible for surplus producing farmers to sell it when prices are attractive in local markets. Fear of loss due to storage pests is one of the major reasons why grain farmers want to sell the grain right after harvest – leading to excess supply and collapsing local markets (Mylene et al. 2002). This undermines the incentive for farmers to increase production and invest in new postharvest technologies. In recognition of this challenge, there has to be improvement in both the commercialization of improved postharvest management technologies as well as the market options for farmers to sell the surplus stored grain. One without the other option will fail to support farmer investments in storage and adoption of improved postharvest management technologies (Ferris and Wheatley 2001). This approach will further generate local employment and income growth that will reduce poverty in the Ethiopia.

**Managing postharvest losses**

Grain must be dried to a recommended moisture level as soon as possible after harvesting to minimize the risk of mold growth and mycotoxin contamination. To control storage pests, improved storage technologies have been developed, including actellic super (a mixture of pirimiphos-methyl and permethrin), super grain bags, and the metal silo (De Groote et al. 2013). Metal silos are made of galvanized flat iron sheets; it is a cylindrical container with grain holding capacity from 50 kg to 3000 kg. Metal silos provide a strong barrier against insect pests and rodents and are hermetically sealed, killing any remaining insects through oxygen depletion (Tefera et al. 2011). They are durable, allow for long storage periods, and are therefore an important storage technology in the fight against hunger and food insecurity in developing countries.

Hermetic bagging and insect resistant maize variety is just such an extension of the choice of technologies available to farmers to explore to lever food security and sustain livelihoods (Likhayo et al. 2016). Hermetic bags are airtight containers which prevent oxygen and water movement between the outside atmosphere and the stored grain or product. The respiration by the grain and insect
inside the bags changes inter-granular atmosphere consuming oxygen and producing carbon dioxide (Baoua et al. 2012). Depending on the type of the container and insect population, oxygen levels is reduced (hypoxia) from 21 to below 10% and carbon dioxide levels increased (hypercarbia) within a short period of time (Mutungi et al. 2014). However, the attainment of high enough carbon dioxide level to kill all the insects in hermetic bags is a challenge. PICS® and SuperGrain II™ bags are type of multi-layer co-extruded tougher plastics with low permeability in which oxygen is depleted fast. Big storage facilities such as cocoons and grain safe are long-term safe storage for large scale agricultural community or community food reserve are available from Grain-Pro for most farmers in the developing areas of the world (http://grainpro.com/gpi/index.php?option=com_content&view=article&id=231&Itemid=1644; accessed on June 2016).

References


Reducing Post-harvest Losses and Increasing Food Availability


The Political Economy of Post-Harvest Losses in Ethiopia: Historical Counts, Current Status, Policy Implications

Dawit Alemu
Ethiopian Institute of Agricultural Research;
E-mail: dawit.alemu@eiar.gov.et/dawit96@gmail.com

Abstract

The paper presents the analysis of the political-economy processes governing the importance of PHL and prevailing estimates in Ethiopia. It does this by analysing (i) the overall post-harvest systems recognized along with their respective key elements in the research, development and policy arenas, (ii) the historical and current counts of PHL consideration in the agricultural R&D in the country, (iii) the main interests of the different actors/networks driving the policy formulation and implementation of PHL issues and the roles and interaction of these actors, and (iv) the most common estimates being quoted today, the methods used, and also the sources of these PHL figures. The analysis is based on an extensive literature review and primary information generated through key informant interviews (KII) and focus group discussions (FGD).

Key words: post-harvest systems, PHL, political-economy, Ethiopia
Introduction

Postharvest losses have never attracted as much attention as they do now days in Ethiopia where cereals were traditionally handled by feudal Landlords under the traditional share tenancy system. During the Socialist regimes, storage and marketing of grains was centralized and the assumption may have been that government systems were more efficient (Rashid et al. 2009) and hence experienced low postharvest losses. The agricultural policies in that period served the interests of huge state farms and urban consumers. Even after the overthrow of the Derg regime, Ethiopia’s agricultural policies mostly focused on aspects of production and marketing and less on what happens in between production and consumption (Gabriel et al. 2006) even though some targets of reducing post-harvest losses are indicated.

Estimates suggest that the magnitude of post-harvest loss in Ethiopia was tremendous ranging from 5% to 26% for different crops (Dereje 2000). Reduction of food waste in general and post-harvest losses in particular is considered as one of the avenues for ensuring food security mainly in developing countries especially following the 1974 first World Food Conference that identified reduction of post-harvest losses as part of the solution in addressing world hunger (Parfitt et al. 2010). Accordingly, in many Sub-Sahara African countries, measures for estimating the postharvest losses and with set targets how to reduce them were put in place, including Ethiopia.

Addressing the issues of post-harvest loss (PHL) in the public programs in Ethiopia has been historically capricious. The institutional setup and the attention given along with the actors involved have been continuously changing, which has resulted in inconsistent estimates of PHLs and emphasis given. Studies that remotely touch on post-harvest aspects focus on marketing only without interrogating the veracity of figures quoted. Understandably their policy recommendations do not go beyond the improvement of transportation, storage and information infrastructure and/or regulatory frameworks (see, for example, Alemayehu 1993; Wolday 1994; 1998; Bekele and Mulat 1995), with little mention of processing as an important post-harvest grain management activity.
This paper analyses the political and economic processes governing the importance of PHL in Ethiopia. These include: (i) the post-harvest systems recognized in the country, (ii) the most common estimates quoted, the methods used and the sources of these PHL figures, (iii) the main interests of the different actors/networks driving the policy formulation and implementation of PHL issues, the roles and interaction of the actors, and, (iv) the overall post-harvest system and along with its key elements in the research, development and policy arenas. The analysis was based on an extensive literature review and primary information generated through key informant interviews (KII) and focus group discussions (FGD).

**Recognized post-harvest systems and their elements**

The definition of PHL in the context of developing and developed countries seems to be different. In developing countries, postharvest loss is often used to describe losses within agricultural systems and the process of supply of produce to markets, whereas PHL in developed countries is used in relation to the food supply chain associated with post-harvest processing, large retail sectors, and post-consumer losses. Post-consumer losses include food wasted from activities and operations at the point of food consumption (Parfitt *et al.* 2010).

Furthermore, as Grolleaud (2002) indicated, the discussion about PHL estimation starts from the very basic definition of PHL associated with the question of which of the different elements of post-harvest system should be included. Specifically, the discussions are related with what operations are included in the post-harvest system. What is its starting point and where does it end? On what basis are losses to be calculated or estimated? Do we work from the theoretical or recorded yield per hectare? Are post-harvest operations only part of the production cycle, or the processing and distribution sector? In addition, due to the variations in the post-harvest systems, the discussions are different for crop, livestock, and forestry sectors (Parfitt *et al.* 2010; Lore *et al.* 2005; Grolleaud 2002; Dereje 2000; Harris and Lindblad 1978). With different importance, the available literature and PHL estimates in Ethiopia recognize post-harvest systems for crop, livestock, and forest products along with the key elements for each post-harvest system. The key elements of PHL recognized for crops, livestock and forestry sector are as follows:
• Harvesting: this is related to the timing of harvesting in relation to the physiological maturity of the crop and method of harvesting. Late harvesting results in extended pre-harvest field drying, which may ensure good preservation but also heightens the risk of loss due to attack (birds, rodents, insects) and harvesting before maturity entails the risk of loss through moulds and the decay of some of the seeds. Dereje (2000) reports that commonly Ethiopian farmers harvest after the physiological maturity of most of the crops and the moisture content reaches up to 13% or below during harvesting. This may cause seed shattering and insect attack. For crops like sesame, the time of harvesting is very critical due to the shattering of pods at the time of full maturity. In terms of method of harvesting, the common practice of harvesting of grain crops by small-scale Ethiopian farmers is using sickles, which predisposes them to shattering of matured grains.

• Transport: this is related with the loss that may occur during transporting a mature harvest on the road before reaching the storage or threshing place or during stacking.

• Post-harvest drying: this is related with loss that may occur due to improper drying of ears and grains which depends on the weather and atmospheric conditions.

• Threshing: loss could occur during threshing due to the use of improper threshing methods, and/or due to threshing before the harvest is dry enough. The common methods of threshing under small-scale farmers' condition are (i) manually using hands mainly for maize (shelling), (ii) manually using steaks (beating), and (iii) animal trampling. However, the most common method is animal trampling.

• Storage: loss during storage may occur due to inadequate facilities, poor hygiene and lack of monitoring especially in closed structures like granaries, warehouses, and other traditional storage structure. Loss occurs due to lack of cleanliness, high temperature and humidity. The extent of storage losses is important as studies document that 60 to 90% of the total grain produced by Ethiopian small-scale farmers is retained by the farm households for subsistence and is stored for 6 to 12 months (Abraham et al. 2008). Farmers use different traditional storage structures including gotera, gota, underground pit and bags or sacks,
• Processing (primary): grain losses occur due to excessive threshing or hulling, which is common for crops like rice.
• Marketing: this is the final and decisive element in the post-harvest system and loss can occur during packaging, transporting, and market level storage.

Post-harvest losses in the livestock sector are related with intertwined factors: (i) poor skill of value chain actors in handling livestock products (ii) poor infrastructure, (iii) poor marketing system, and (iv) socio-cultural factors (Lore et al. 2005).

The key effects of these factors vary with different livestock products. For example, farm-level milk losses are largely in form of spoilage, spillage, and “forced home consumption” (including by calves and humans); whereas, milk losses along the marketing chain are mainly due to spillage and spoilage.

The PHL equivalent in the forestry sector is wood waste, which is defined as wood material from the forest, which does not appear finally in marketable products other than fuel wood regardless of whether it is economically or technologically feasible to utilize it (Panshin et al. 1962). In Ethiopia, a large amount of waste of forest products occurs during harvesting, primary conversion, secondary processing and during utilization (WUARC 1985; 1995; Wubalem and Getachew 2011).The major sources of residual and waste wood are: (i) Wood left in the forest after logging: this includes high stumps, long butts, trees not cut because of poor form, mechanical defects and decay, large tops and limbs, trees damaged in logging and residual trees destroyed during slash disposal; (ii) Residual and waste wood generated in the manufacturing of primary products such as lumber, veneer and shingles: this include coarse material such as slabs, endings, trimmings from sawmills and veneers mills, culled stave bolts; and fine materials such as saw dust and shavings from sawmills and other plants; fibres and chemical components lost in making pulp and paper; (iii) Residual and waste wood generated in the secondary manufacturing operations of all kinds (furniture and particleboard plants), materials unutilized during building construction and many minor sources.
PHL considera
tions in the agricultural R&D

Historical counts of PHL

PHL reduction as a formal R&D intervention area is an endeavour aimed at increasing agricultural production and productivity for food security. In Ethiopia it was recognized in the late 1970s following the worldwide recognition of the importance of post-harvest losses in developing countries by the United Nations General Assembly (1975) which passed a resolution committing member states to reduce post-harvest food losses by 50% by 1985 (Girma et al. 2012; Harris and Lindblad 1978). The earliest information relied by FAO and the government of Ethiopia was from the report by McFarlen (1969) which quoted postharvest losses of 15% for stored cereals. Therefore, the 1977 FAO project on PHL was implemented in collaboration with the Ministry of Agriculture and targeted reduction of PHL through crop protection measures mainly by building human capacity and introduction of improved post-harvest technologies for storage.

PHL data and its sources

A review of subsequent data generated on postharvest loss figures shows high variations in numbers quoted by different experts in different organizations over time (Table 1). It is well recognized that there is no a national figure for post-harvest loss that is based on well-established methodology and national coverage (Abraham et al. 2008). The figures commonly cited at national level are from studies that are limited in area coverage and based on rapid appraisal approaches. Specifically, the method of assessment and whether the figures refer to amount of damage, the total amount of grain lost, or a reduction in quality are not always clear in the available PHL estimates.
Table 1. Grain crops PHL estimates in Ethiopia

<table>
<thead>
<tr>
<th>Source</th>
<th>Estimated PHL (% of quantity)</th>
<th>PHL coverage</th>
<th>area coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CADU¹, 1969</td>
<td>10</td>
<td>Improper threshing (animal trampling)</td>
<td>Project area (Arsi area)</td>
</tr>
<tr>
<td></td>
<td>3-4</td>
<td>Animals eating the grains during trampling</td>
<td></td>
</tr>
<tr>
<td>McFarlane, 1969</td>
<td>15</td>
<td>storage</td>
<td>National</td>
</tr>
<tr>
<td>FAO, 1977</td>
<td>10 - 20</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td>Kashi, 1985</td>
<td>13.20</td>
<td>storage</td>
<td>National</td>
</tr>
<tr>
<td>Boxall, R.A., 1998</td>
<td>9</td>
<td>Storage</td>
<td>Amhara, Oromia, SNNPR</td>
</tr>
<tr>
<td>Dereje Ashagari, 2000</td>
<td>20</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td></td>
<td>7 - 10</td>
<td>Improper harvesting</td>
<td></td>
</tr>
<tr>
<td>Kasahun Bedada, 2000</td>
<td>3-5</td>
<td>Harvesting, stalking, and threshing</td>
<td>National</td>
</tr>
<tr>
<td></td>
<td>2-3</td>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15 - 25</td>
<td>storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11 - 19</td>
<td>Total PHL</td>
<td></td>
</tr>
<tr>
<td>Duressa Chibsa, 2000</td>
<td>10</td>
<td>Crop harvesting</td>
<td>Southern Nations, Nationalities, and Peoples Region, Ethiopia</td>
</tr>
<tr>
<td></td>
<td>10 - 15</td>
<td>Threshing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 - 10</td>
<td>Transportation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20 - 25</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Abebe H. Gabriel and Bekele Hundie, 2006</td>
<td>12</td>
<td>Total PHL</td>
<td>Major grain producing three areas Hetosa (wheat), Ada’a (teff), and Bako (Maize)</td>
</tr>
<tr>
<td>Abraham Tadesse, 2005</td>
<td>10-21</td>
<td>Storage</td>
<td>National</td>
</tr>
<tr>
<td>MoFED, 2006</td>
<td>15</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td>MoARDb, 2010</td>
<td>30</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td>MoA, 2010</td>
<td>25</td>
<td>Total PHL</td>
<td>National estimate by referring to FAO</td>
</tr>
</tbody>
</table>

Experts’ opinion suggests that the attention given to post harvest issues by the then Ministry of Coffee and Tea Development (1974 -1991) was instrumental in promoting the initial institutional setup as a department with considerable number of trained experts dealing with postharvest matters. Accordingly, the PHL issues in coffee and tea sub-sectors in the country were relatively well addressed and

¹ CADU (Chilalo Agricultural Development Unit) was a Swedish Government supported project implemented in the former Arsi area designed to promote integrated rural development by linking agricultural development to credit facilities, extension support, even education and health services.
followed. However, following the reorganization of the Ministry, the attention on PHL eroded and the experts were re-allocated to different departments of the Ministry of Agriculture. The PHL interventions of the then Ministry of Coffee and Tea Development had a spill over effect in the promotion of PHL agenda in the other sub-sectors of agriculture.

The specific consideration of PHL in the agricultural R&D in the country emanated generally from conferences and workshops that dealt with post-harvest issues in relation to increasing agricultural production and productivity to ensure the national food security. The key events that were undertaken in the country in this regard are: (i) the national conference on the food and nutritional strategy for Ethiopia held in 1986, (ii) Annual Crop Improvement Conferences held 21 times until 1989, (iii) the national conference on Post-harvest and storage technologies research and extension held in 2000, (iv) the different research based crop national workshops that are commonly undertaken every decade, for example, the National Maize Workshops, the National Barley Workshop etc, and (v) annual conferences of Crop Science Society of Ethiopia (CSSE) and Plant Protection Society of Ethiopia (PPSE).

In the efforts made to develop the food and nutritional strategy for Ethiopia, the issue of PHL was duly considered during the conference organized by the then Office of the National Committee for Central Planning (the current Ministry of Finance and Economic development) in Dec 1986 (ONCCP 1989). Though the focus was on grain PHLs due to storage, it has been influential in setting the issue of PHLs as an agenda at higher policymaking level (Yemane and Yilma 1989).

There used to be National Annual Crop Improvement Conferences (NCIC) organized by the then Institute of Agricultural Research and the PHL issues mainly in relation to crop protection were presented and discussed. The last NCIC, the 21st conference was held in 1989, where the nature and extent of crop post-harvest losses in Ethiopia was also presented (Berga et al. 1990). The results and discussions in these conferences were important inputs in the planning of interventions for the Ministry of Agriculture.

Another key milestone was the relatively comprehensive and high level national conference on post-harvest and storage technologies research and extension in the country that was conducted in 2000 jointly by the Ministry of Agriculture and the
then Ethiopian Agricultural Research Organization now the Ethiopian Institute of Agricultural Research (EIAR). The conference reviewed (i) the overall concept of post-harvest losses, (ii) the status of PHL at national level and regional, (iii) existing technologies along with the role and capacity of the rural technology centers that are responsible in demonstration and multiplication post-harvest technologies such as shellers and threshers, and (iv) the existing extension support along with the challenges it faces.

The different research based crop national workshops that are commonly undertaken every decade generally generate information on PHLs mainly related with crop protection. The three national maize workshops that have were held in the last three decades have documented the importance of different pests inducing PHLs in maize. Similarly, there have been two National Barley Workshops, eleven regional wheat conferences, and two national sorghum workshops where the importance of different pests in inducing PHLs along with coping strategies and available technologies have been reviewed.

Similarly, the issues of PHLs with a focus on grain PHL have been presented and discussed during annual conferences of CSSE and PPSE. These societies in general bring together all professionals from different public, private and non-governmental originations and generally the results and discussions serve as inputs directly or indirectly into the program designs related to PHL.

The Medium Term National Statistical Program for Ethiopia jointly developed by the Central Statistical Agency (CSA) and the Ministry of Finance and Economic Development (MoFED) was mainly designed to align the development of national database according to the priority accorded to sectors in line with the adopted development strategies. It recognizes the need to have information about pre- and post-harvest grain losses. Accordingly, the plan is to have every five-year a national Pre and Post-harvest Grain Losses Survey and the first survey was planned to start for 2005/06 production season (CSA 2012). However, due to the difficulties in the methodology, the survey was not undertaken. There is a plan to undertake these surveys regularly in collaboration with FAO and EIAR in the future once feasible assessment methods are agreed.

The trajectory of generation and use of PHL figures continued to ignore the disparities in figures quoted even in peer reviewed papers and government funded
programmes. Apparently, every expert or group or organization was not willing to reconcile the quoted figures because of methodological differences and the research objectives which were targeting different pre-conceived policy interventions. This

**PHL and government programs**

The Plan for Accelerated and Sustained Development to End Poverty (PASDEP) of Ethiopia, which was implemented from 2005/06 to 2009/10, recognized the importance of post-harvest loss in relation to the national strategy in pest management. The average estimate for crop loss due to pests was considered 45% of which 30% is accounted for by pre-harvest loses and 15% by post-harvest loses (MoFED 2006). The document also targeted to reduce pre-harvest crop loss to 25% and post-harvest crop loss to 10%, which is equivalent to a 2% annual reduction of crop loss during the plan period. There is no adequate information as to the level of achievement of the stated target.

In CAADP Post Compact PIF, postharvest management is indicated as one of the strategies under its strategic objective one, which is to attain sustainable increase in productivity and production and it envisages an annual reduction of postharvest loss by 3% for key commodities.

Following the Business Process Re-engineering (BPR) in the agricultural sector in 2008, the explicit interventions/programs in the area of PHL become more implicit and are integrated with the interventions/programs of agricultural mechanization. Accordingly, the issue of PHL is explicitly mentioned only in few of the recent public agricultural documents.

The Growth and Transformation Plan (GTP), which is under implementation since 2010/11 after PASDEP until 2015, gave due emphasis to the development of smallholder agriculture through scaling up of best practices (practices and technologies). Though the issue of PHL was not directly mentioned in the plan, the post-harvest technologies and practices were the key components of the scaling up strategy with considerable variability among regions. On the other hand, the Agricultural Sector Policy and Investment Framework (2010-2020) specifically address the issue of PHL and recognize the limited importance given to post-harvest losses in the country in the past. The estimates of PHLs in the
document are (i) 15-20 per cent of potential grain production due to poor pre-harvest practices and natural disasters, (ii) losses of up to 30 per cent post-harvest due to inappropriate collection, transport, storage, and pest control, and (iii) high post-harvest losses for non-grain commodities. Accordingly, it sets targets by how much the PHL should be reduced each year and the suggested annual reduction is three per cent (MoARD 2010b).

The multi-donor Agricultural Growth Program (AGP) implemented by the MoA since 2011 until 2015 targeted 83 agricultural potential woredas in four regions to ensure improved production and productivity, value addition and market opportunities for smallholder households engaged in the commodities targeted by the AGP (World Bank 2011). The program aimed to ensure these benefits primarily as the result of: (i) increased production and productivity; (ii) reduced post-harvest losses; (iii) improved access to goods, services, markets and information; (iv) reduced transaction costs; (v) improved product quality and increased producer (farm gate) prices; and (vi) improved economies of scale. Though, AGP targeted the reduction of PHLs, the specific interventions that were designed did not address the issue of PHLs mainly due to the lack of expertise at MoA at federal level and at BoA at regional level (even though, three regions namely Oromia, Amhara and Tigray have a PH focal person in their respective regional bureaus of agriculture).

One of the main public investments in the agricultural sector is the public agricultural extension program. Following the implementation of the first post-harvest extension activities in 1995 and the achievements made in the subsequent two years, a national extension package on PHL was developed and implemented nationally since 1997 production season (Yonas 2000). In general, the main contents of the PHL extension package are small-scale machines for threshing (shellers for maize, teff, barley and wheat, small-scale combiner for teff, barley and wheat), transport equipment (animal drawn carts, carts), and storage structures (above and below ground storage structures, potato seed storage structure, enset squeezer).

Recent trends however seem to indicate a recognition of PHL given the specific PHL reduction targets set in the GTP II plan (2015 – 2010) of the renamed Ministry of Agriculture and Natural Resources (MoANR). The plan targets to reduce post-harvest loss of major crops from 5-25% to 5% by the end of the GTP,
The Political Economy of Post-Harvest Losses in Ethiopia

(by 2020) and the main activities identified to achieve this goal are related with promotion of use of mechanical and modern technologies in: (i) harvesting, threshing and shelling operations by mechanical technologies; (ii) transportation and storage, and (iii) agricultural value addition (MoANR 2015). This indicates the focus only on addressing PHL issues through mechanization aspects.

Similarly, the research aspect of the PHL has received due attention following the development of a research strategy on PHL and the establishment of a PHL research team within the crops research program and also within the Agricultural Mechanization Research program of the Ethiopian Institute of Agricultural Research.

These trends indicate the revival and reconsideration of PHL issues in Agricultural Research and Development. However, still there will be a need in making available qualified human resources both in the research and development efforts of addressing the challenges of PHLs in the country.

**Actors, roles and linkages in post-harvest education, research and development in Ethiopia**

In general, PHL related issues in agricultural research and development endeavours are related mainly with the grain sector specifically in relation to crop protection and mechanization (post-harvest technologies). The different endeavours of addressing the PHL issues in the country emanates from the recognition of PHL as one of the key measures to ensure food security by reducing losses (Abraham *et al.* 2008 and from the 1975 UN General Assembly resolution to reduce post-harvest loss by 50% by 1985 (Harris and Lindblad 1978). However, the interventions were more focused on the crop sector, though the limited research available shows there are considerable losses in the livestock sector and forest products in the country.
Table 2 Actors, roles and linkages in post-harvest education, research and development in Ethiopia

<table>
<thead>
<tr>
<th>Subsector</th>
<th>Institution</th>
<th>Specific responsibility</th>
<th>Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>Haramaya University</td>
<td>Institute of Technology</td>
<td>M. Sc. in Post-harvest Technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>College of Agriculture</td>
<td>M.Sc. in PH and food science</td>
</tr>
<tr>
<td>Jimma University</td>
<td>College of Agriculture and veterinary Medicine</td>
<td>MSc in Post-harvest Management</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc in Post-harvest Management</td>
<td></td>
</tr>
<tr>
<td>Hawassa University</td>
<td>College of Agriculture</td>
<td>MSc in Food Science and Post-harvest Technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>BSc in Food Science and Post-harvest Technology</td>
<td></td>
</tr>
<tr>
<td>Research</td>
<td>Ethiopian Institute of Agricultural Research</td>
<td>Agricultural Mechanization Directorate, Plant Protection Research projects</td>
<td>Adaptation, design, and development of improved post-harvest technologies (storage structures, harvesting tools, threshers, dehullers etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food science research project</td>
<td>Research on crop pest importance and control</td>
</tr>
<tr>
<td></td>
<td>Regional Agricultural Research Institutes</td>
<td>Rural Technology Multiplication centers, Plant Protection Research projects</td>
<td>Adaptation and design of improved post-harvest technologies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Food science research project</td>
<td>Research on crop pest importance and control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plant Protection Research projects</td>
<td>Development of food preservation methods/recipes etc</td>
</tr>
<tr>
<td></td>
<td>Plant Protection Society of Ethiopia</td>
<td>Annual conferences</td>
<td>Research results of the importance of post-harvest pests</td>
</tr>
<tr>
<td>Extension</td>
<td>Federal Ministry of Agriculture</td>
<td>Extension directorate (No expert)</td>
<td>Development of post-harvest extension package</td>
</tr>
<tr>
<td></td>
<td>Regional Bureaus of Agriculture</td>
<td>Extension directorate (Some regions have assigned an expert on post-harvest)</td>
<td>Adaptation and Implementation of the post-harvest extension package</td>
</tr>
<tr>
<td>Marketing/logistics</td>
<td>Federal Ministry of Trade</td>
<td>Agricultural marketing Directorate</td>
<td>Promotion of efficient marketing system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cooperative promotion agency</td>
<td>Promotion of group marketing</td>
</tr>
<tr>
<td>Post-harvest technology</td>
<td>Regional Agricultural Research Institutes</td>
<td>Rural Technology Multiplication centers</td>
<td>Multiplication of available technologies</td>
</tr>
<tr>
<td>technology multiplication</td>
<td>The Swiss Agency for Development Cooperation (SDC)</td>
<td>Funding technology promotion and capacity building</td>
<td>Improved postharvest management</td>
</tr>
<tr>
<td></td>
<td>Canadian International Development Agency and Jimma University</td>
<td>Funding and Research (From 2009)</td>
<td>Develop low-cost technologies to reduce postharvest losses.</td>
</tr>
<tr>
<td></td>
<td>Private Metal workshops</td>
<td></td>
<td>Multiplication of available technologies</td>
</tr>
</tbody>
</table>
Table 2 presents the different actors relevant to PHL in the country along with their roles. The key actors are: (i) higher learning institutes that are engaged in addressing the critical shortage of skilled manpower, (ii) members of the national agricultural system mainly the Ethiopian institute of agricultural research and the regional agricultural research institutes, which are involved in postharvest research; (iii) the Ministry of Agriculture at federal level and regional Bureaus of Agriculture, which are responsible for the design and provision of extension services; (iv) the Ministry of Trade at federal level responsible for promoting efficient agricultural marketing and logistics –(transport, storage and information); (v) private metal workshop like selam PLC that are engaged in the fabrication of postharvest related machines like maize shellers, and (vi) rural technology centers that are under respective regional research institutes and are also engaged in the multiplication of postharvest related machines (vii) donors such as the Swiss Development Cooperation (SDC) and Canadian International Development Agency (CIDA).

Table 3. Farm mechanization actors in post-harvest technology research and multiplication

<table>
<thead>
<tr>
<th>Organization</th>
<th>Directorate</th>
<th>Research centers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oromiya Agricultural Research Institute</td>
<td>Agricultural Mechanization research</td>
<td>Assela Agricultural Mechanization center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Bako Agricultural mechanization center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fedis Agricultural Mechanization center</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jimma Agricultural Mechanization research center</td>
</tr>
<tr>
<td>Tigray Agricultural Research Institute</td>
<td>Agricultural Mechanization and Rural Energy</td>
<td>Mekelle Agricultural Mechanization and Rural Energy</td>
</tr>
<tr>
<td>Amhara Regional Agricultural Research Institute</td>
<td></td>
<td>Bahir Dar Agricultural Mechanization and Post-harvest Research center</td>
</tr>
<tr>
<td>SNNPR BoA</td>
<td></td>
<td>Southern Technology Promotion and Multiplication Center</td>
</tr>
</tbody>
</table>
The donor groups justify their interventions by quoting very high PHL figures in total disregard of available data showing lower figures. SDC in its project brief has quoted postharvest losses of cereals at 30% while the programme director for CIDA, Tessema Astatkie argues that postharvest losses as ranging from 30 – 70% depending on the crop type. Both programmes were set up to contribute to food security through reduction of postharvest losses.

**The history and current status of post-harvest extension and development and estimates**

During the time of the Ministry of Coffee and Tea Development (1974 -1991), due attention was given to post harvest issues that was instrumental in having institutional setup as a department with considerable number of trained experts. This had also an impact in recognizing PHL issues in the institutional and human resource development within the Ministry of Agriculture through a spillover effect in the promotion of PHL agenda mainly related with staff movement. Following the reorganization of the Ministry, the experts were relocated to different departments of the Ministry of Agriculture. Though there is no empirical evidence, expert opinions suggest that still the PHL challenges in coffee and tea sub-sectors in the country are given relatively better attention by both public and private institutions.

The national postharvest technology extension package, developed by the Extension Directorate of the MoA in 2010 is currently serving as guideline for the extension services in the area. The package covers four major categories of commodities: (i) grains (both cereals and pulses), (ii) horticultural crops, (iii) enset, and (iv) livestock products. It also sets the strategy of distribution and implementation of the package along with the strategy for provision of inputs required (MoA 2010). As indicated above, however, the current institutional arrangement does not allow to effectively promote the implementation of the package mainly as the availability of qualified personnel is limited both at federal and regional level and there is a very high tendency of associating PHLs only to farm mechanization.

The results of the extensive literature review, KII, and FGDs with relevant actors reveal that there are different estimates of PHL in the country since the late 60 with a focus on grains. Table 3 presents the estimates of grain PHL with respect to
different sources of post-harvest losses. The estimates of PHL due to the different elements of the post-harvest system differ by author and year. The total PHL for grains was estimated to be 20% by Dereje (2000), 10 to 20% by FAO (1977), and 11 to 19% by Kasahun (2000), which implies the grain total PHL to range from 10 to 20% at national level.

As indicated in Table 4, the post-harvest losses for cereals are relatively high, with estimates varying from 20 to 40% of the gross production (FAO 2009) and from 15 to 30% (IFPRI 2010) and a lower estimate of 6.1% by Yemane and Yilma (1989). The PHL estimates for specific cereal crops ranges from one for teff to about 50% for rice. These studies associate the losses primarily with the timing of harvesting, shelling methods, and the type of storage devises. Poorly managed on-farm storage structures, such as dibignit and gotera, can also make cereal crops susceptible to different types of damages, including weevil and rodent attacks, which cause substantial loss of stored grain. Moreover, harvesting and crop management practices are sub-optimal in the sense that there are losses resulting from improper handling, threshing, and transporting. Crop losses of 2-3%, 1-2%, 4-6%, 2-5% and 1-3% have been reported to occur in cereals during cutting, drying, threshing, winnowing and transporting, respectively (Anon. 1993, cited by Abraham et al. 2008).
### Table 4. Cereal crops PHL estimates in Ethiopia

<table>
<thead>
<tr>
<th>Source</th>
<th>Crop</th>
<th>Estimated PHL (% of quantity)</th>
<th>PHL coverage</th>
<th>Area Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAO, 2009</td>
<td>Cereals</td>
<td>20 - 40</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td>IFPRI, 2010</td>
<td>Cereals</td>
<td>15 - 30</td>
<td>Total PHL</td>
<td>National</td>
</tr>
<tr>
<td>Yemane and Yilma, 1989</td>
<td>Cereals</td>
<td>6.1</td>
<td>Storage</td>
<td>Ankober (highland), Akaki (mid altitude) and central Hararghe</td>
</tr>
<tr>
<td>Dereje Ashagari, 2000</td>
<td>Cereal</td>
<td>9.0</td>
<td>Storage</td>
<td>National</td>
</tr>
<tr>
<td>Abraham Tadesse, 2005</td>
<td>cereals</td>
<td>7.23-14.32</td>
<td>Storage</td>
<td>National</td>
</tr>
<tr>
<td>McFarlane, 1969</td>
<td>Maize</td>
<td>15.0</td>
<td>Storage</td>
<td>National</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barley</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teff</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abraham, 1991</td>
<td>Maize</td>
<td>6.3-7.5</td>
<td>Storage</td>
<td>Western Ethiopia</td>
</tr>
<tr>
<td>Abraham, 1993</td>
<td>Maize</td>
<td>2.1-13.8</td>
<td>Storage</td>
<td>Western Ethiopia</td>
</tr>
<tr>
<td>Abraham, et al, 1993</td>
<td>Maize</td>
<td>0.2-17.9</td>
<td>Storage</td>
<td>Western Ethiopia</td>
</tr>
<tr>
<td>Emana Getu, 1993</td>
<td>Maize</td>
<td>12-18</td>
<td>Storage</td>
<td>Southern Ethiopia</td>
</tr>
<tr>
<td>Boxall R. A., 1974</td>
<td>Sorghum</td>
<td>2-55</td>
<td>Pit storage</td>
<td>Hararghe</td>
</tr>
<tr>
<td>Abraham, 1997</td>
<td>Maize</td>
<td>5-30</td>
<td>Storage</td>
<td>Western Ethiopia</td>
</tr>
<tr>
<td>Abraham, 1997</td>
<td>Maize</td>
<td>16.30</td>
<td>Storage</td>
<td>Western Ethiopia</td>
</tr>
<tr>
<td>SSEAD consultancy, 1997</td>
<td>Maize</td>
<td>2.3-15.9</td>
<td>Storage</td>
<td>Amhara region</td>
</tr>
<tr>
<td>Boxall 1998</td>
<td>Maize</td>
<td>11.20</td>
<td>Storage</td>
<td>National (Amhara, Oromia and SNNPR)</td>
</tr>
<tr>
<td></td>
<td>Sorghum</td>
<td>8.10</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wheat</td>
<td>6.20</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Barley</td>
<td>1.50</td>
<td>Storage</td>
<td></td>
</tr>
<tr>
<td>Abraham Tadesse, 2003</td>
<td>Maize</td>
<td>5.64</td>
<td>Storage</td>
<td>National</td>
</tr>
<tr>
<td>MoARDb, 2010</td>
<td>Rice</td>
<td>~50</td>
<td>Total PHL</td>
<td>National</td>
</tr>
</tbody>
</table>

The available PHL estimates for pulses are related with losses due to storage. The national estimate of PHL of pulses due to storage is about 20% (Table 5). However, the considerable difference in the estimates in specific locations compared to the national estimate implies considerable variability.
Table 5. Pulses and oilseeds PHL estimates in Ethiopia (storage loss)

<table>
<thead>
<tr>
<th>Source</th>
<th>Commodity</th>
<th>Estimated PHL (% of quantity)</th>
<th>Area coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>McFarlane, 1969</td>
<td>Pulses</td>
<td>6.0</td>
<td>National</td>
</tr>
<tr>
<td>McFarlane, 1969</td>
<td>Oilseeds</td>
<td>2.0</td>
<td>National</td>
</tr>
<tr>
<td>Yemane and Yilma, 1989</td>
<td>Pulses</td>
<td>4.0</td>
<td>Ankober (highland), Akaki (Mid altitude) and Central Hararghe</td>
</tr>
<tr>
<td>Tadesse G/Medhin, 1987</td>
<td>Faba bean</td>
<td>14.4</td>
<td>Yerer and Kereyu</td>
</tr>
<tr>
<td>Teshome Lemma, 1990</td>
<td>Chickpea</td>
<td>8.2</td>
<td>Yerer and Kereyu</td>
</tr>
<tr>
<td>Dereje Ashagari, 2000</td>
<td>Pulses</td>
<td>20.0</td>
<td>National</td>
</tr>
<tr>
<td>Abraham Tadesse, 2005</td>
<td>Pulses</td>
<td>12.51-28.35</td>
<td>National</td>
</tr>
<tr>
<td>Boxall, 1998</td>
<td>Beans</td>
<td>19.6</td>
<td>National (Amhara, Oromiya and SNNPR)</td>
</tr>
<tr>
<td>Worku Teka, 2000*</td>
<td>Field pea</td>
<td>12.10</td>
<td>Amhara Region, Ethiopia</td>
</tr>
<tr>
<td></td>
<td>Chickpea</td>
<td>6.37</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Faba bean</td>
<td>1.95</td>
<td></td>
</tr>
</tbody>
</table>

Note: *for grains stored from 6 to 9 months

Though the existence of considerable PHL in the horticulture sector is well recognized, there are very limited estimates about the extent (EHDA and EHPEA 2011). The discussions about PHL in the horticulture sector are related with handling and logistics in the marketing process (EHDA and EHPEA 2011; Joosten 2007). As indicated in Table 6, the available estimates are from 1990 and are related with PHL based on the proportion of rejection that is supplied to markets and for the then horticultural state farms (Berga Lemaga et al. 1990).
Table 6. Horticultural crops PHL estimates in Ethiopia

<table>
<thead>
<tr>
<th>Source</th>
<th>Category</th>
<th>Type</th>
<th>Estimated PHL</th>
<th>Area coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tadesse F. 1991</td>
<td>Horticultural crops</td>
<td>fruits and vegetables</td>
<td>25 - 35</td>
<td>National based on former state farms</td>
</tr>
<tr>
<td>Berga Lemaga et al. (1990)</td>
<td>Fruits</td>
<td>Guava</td>
<td>49.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pineapple</td>
<td>28.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mango</td>
<td>26.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mandarin</td>
<td>17.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Papaya</td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orange</td>
<td>9.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Banana</td>
<td>8.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grape</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grapefruit</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lemon</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Berga Lemaga et al. (1990)</td>
<td>Vegetables</td>
<td>Tomato</td>
<td>19.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Melon</td>
<td>16.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Onion</td>
<td>10.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Potato</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>sweet potato</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>beetroot</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Green beans</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>sweet pepper</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carrot</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cabbage</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

The information available on the PHL in the livestock sector is for dairy products, which is from National study commissioned by the Food and Agriculture Organization of the United Nations (FAO) in 2003 aimed at providing a clear assessment of the types, causes and levels of post-harvest milk and dairy losses (Lore et al. 2005). Farm losses in Ethiopia were quantified at 1.3 per cent and this was mainly due to spillage during milking and transportation, and spoilage caused by poor hygiene and use of inappropriate containers for milk storage (Table 7). Similarly, the estimated 2% Off-farm losses were largely due to spillage during transportation and at retailers’ premises due to poor handling and use of inappropriate containers. In general, Lore et al. (2005) estimates the total value of annual post-harvest milk losses to be 14.2 million US dollars.
Table 7. Dairy product PHL estimates in Ethiopia

<table>
<thead>
<tr>
<th>Source</th>
<th>Estimated PHL (% of quantity)</th>
<th>PHL coverage</th>
<th>Area coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lore et al., 2005</td>
<td>1.30</td>
<td>Total farm level PHL</td>
<td>Major milk shed areas in six regions of the country (Addis Ababa, Amhara, Oromiya, Tigray, SNNP and Afar)</td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>Total off-farm level PHL</td>
<td></td>
</tr>
<tr>
<td>FAOSTAT data, 2004 cited in Lore et al., 2005</td>
<td>2.90</td>
<td>Total PHL</td>
<td>National</td>
</tr>
</tbody>
</table>

The issue of wood waste and estimation of the extent are linked with the establishment of the Wood utilization and Research Center in the country with the Swedish development assistance. Table 8 documents the wood waste estimates by different source of waste. The wastes are mainly associated with the backward methods employed, inadequate number of professionally skilled personnel and old age of sawmills and joineries operating in the country (WURC 1995; Demel Teketay et al. 2010).

Table 8. Estimates of wood waste in Ethiopia (National estimates based on Järvholm and Tivell, 1987)

<table>
<thead>
<tr>
<th>Elements of Post-harvest system</th>
<th>PHL coverage</th>
<th>Estimated PHL (% of quantity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvesting</td>
<td>Improper harvesting</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Waste due to long stumps</td>
<td>15</td>
</tr>
<tr>
<td>Primary processing</td>
<td>Waste as slab</td>
<td>6-8</td>
</tr>
<tr>
<td></td>
<td>waste while edging</td>
<td>4-7</td>
</tr>
<tr>
<td></td>
<td>waste while sizing</td>
<td>4-7</td>
</tr>
<tr>
<td></td>
<td>waste as sawdust</td>
<td>11-12</td>
</tr>
</tbody>
</table>

**Quality of PHL figures and policy narratives**

The importance of PHL as one of the measures affecting food security has been well recognized in the country since late 70 after the preliminary estimates of grain PHL came into picture along with FAO interventions. As indicated in the part presented above, different estimates based on different methods and approaches have been published by different authors. The variability and the limited quality of these estimates have been recognized by different authors and
the government (MoA 2010; Abraham et al. 2008). In response to this recognition, it has been decided to have a national Pre and Post-harvest Grain Losses Survey every five years as one of the key components of the national statistical program of the country through the Central Statistical Agency (CSA), which is accountable to the Ministry of Finance and Economic Development (MoFED). However, the first such survey was to be implemented in 2006, but due to the difficulties in the methodology, it has not materialized until now. There is a plan to undertake these surveys regularly in collaboration with FAO and EIAR in the future.

Though, the different estimations of PHL present different figures, the recognition of the importance of the PHL has led to different public programs that address directly or indirectly the issues of PHL. The PASDEP that has been implemented from 2006/07 to 2010/11 as a national economic development plan had a policy directive to reduce crop post-harvest losses from the estimated 15% to 10% over the planned period through development of extension package (pest control, improved storage structures and practices) and provision of training to pest-control personnel and farmers (MoFED 2006). Similarly, the agriculture sector Public Investment Framework (PIF: 2010 - 2020) clearly indicates the need for intervention in reducing post-harvest losses as one of the measures to improve agricultural production and productivity.

The national extension package on post-harvest technology states the lack of comprehensive and rigorous assessment of the extent of PHLs in the country and recognizes that the available figures are estimates based on old literature, which are mainly linked to estimates from FAO study in 1977 (MoA 2010). However, it recognizes the existence of huge PHLs for grains and even more PHLs for perishable agricultural products like horticultural crops currently. The main outcomes from the extension package are stated to be (i) reduction of PHLs, (ii) improved quality of produce through deployment of improved post-harvest tools, (iii) reduce labor requirement and the saved labor can be used for other productive activity, and (iv) support the marketing system by reducing the pressure on farmers to sale immediately after harvest due to fear of storage loss by providing improved storage structures. The extension package covers interventions for (i) grain technologies and practices for harvesting, drying, threshing, cleaning, grading, storage structures, and transportation; (ii) horticultural crops storage structures for potato and onion and harvesting for mangos and papaya fruits; (iii)
enset processing (decorticator, cornpulverizer, and Bulla squeezer); and (iv) animal products technologies such as the small-scale milk churner and honey squeezer.

The key policy narratives that are guiding the efforts in the PHL R&D are (i) the on-going research focused in the area of post-harvest pest management research, improving the traditional grain storage structures, and small-scale post-harvest machines mainly for harvesting and threshing, which are the responsibility of the National Agricultural Research System; (ii) development efforts focused on crop pest control, which is the responsibility of the Animal and Plant Health Regulatory Directorate, and execution of the national extension package on post-harvest technology under the Extension Directorate of the MoA.

The over-riding narrative has been that postharvest losses are a big problem among smallholder farmers which contributes to food insecurity. The Ministry of agriculture, the universities, research organizations and donors has used varied figures to build consensus around high postharvest losses in order to justify funding development and dissemination of technology to reduce postharvest losses. This has meant that policy is framed in terms of technological and market solutions which do not put into consideration the importance of local postharvest management systems, farming systems, scale of production, subsistence patterns, alternative uses of harvested crops and marketing requirements.

Conclusion

The paper assessed the overall political economy of post-harvest issues with due emphasis on identification of the key elements of the recognized post-harvest systems, assessment of the main interests of the different actors/networks involved in the PHL issues and the roles and interaction of these actors, and the most common estimates being quoted along with their sources. The analysis is based on an extensive literature review and primary information generated through key informant interviews and focus group discussions.

The crop post-harvest systems include losses during harvesting, transporting, post-harvest drying, threshing, storage, processing, and marketing. The livestock post-harvest systems include losses due to spillage, and “forced home consumption”
(by calves and humans) because of the poor skills among the value chain actors in handling livestock products, the poor infrastructure, the poor marketing system, and socio-cultural factors. The PHL for forest products is related with wood waste, which consider the losses during harvesting, primary conversion, secondary processing and during utilization. However, in the systems the role of value chain management and logistics linked with improving marketing systems as one of the key element of PHL have not received adequate emphasis.

SIDA supported integrated agricultural development projects (CADU and WADU in late 60s) and the 1975 United Nations General Assembly resolution committing member states to reduce post-harvest food losses by 50% by 1985 and the subsequent interventions of FAO were instrumental in promoting the issue of PHL in the country during the early years. However, the imperialist regime maintained a feudal system that left smallholder farmers with little of the harvested and it was not important whether they experienced postharvest losses or not.

In Ethiopia, the different public documents recognize that there are no a dependable estimates of PHLs and the existing figures are either very old or are based on assessment that are limited by coverage and methodology and are highly varied. Paradoxically, however, postharvest losses were considered as a very important factor affecting increased agricultural production and productivity and a number of public interventions were put in place to address it since the late 1970s.

The focus of PHL estimates and interventions have been mainly for grains with emphasis on storage. No attempt was made to harmonize the statistics quoted over time. However, there are estimates for livestock and forest products, which were made through externally funded projects. The estimates for horticultural crops were based on the data from the then state farms during the late 1980s while small farms were ignored. The PHL estimate for dairy products were made through a project of the International Livestock Research Institute (ILRI) on milk and dairy products, post-harvest losses and food safety in sub-Saharan Africa and the Near East in 2003. Similarly, Swedish researchers estimated PHL for the forest products during the late 1980s. In general, the PHL estimates for grains vary considerably over the years and by source implying the variability of methods used, which has lead to the use of dubious figures in both the research and development arena in the country.
The current trends indicate that there is re-consideration of PHLs in both agricultural research and development efforts, where the GTP II plan targets reducing PHL at national level to 5% for major crops. Though, the institutional support to address the R&D for post-harvest issues used to be de-emphasized, currently there seems to exist an institutional setup to plan and implement activities to reduce PHLs. The recent interventions in the PHL are highly associated with crop pest control, farm mechanization especially with harvesting and threshing machines, and promotion of improved storage structures with limited scale even though there is a national extension package on post-harvest technologies.

Thus, the following interventions are recommended:

- Design the methodology for assessing PHL in the recognized post-harvest systems (crop, livestock and forest products);
- Support the institutionalization of PHL assessment for better M&E and policy formulation. Key actors in these are the NARS, MoA, CSA, MoFED, and FAO;
- There is need to re-emphasis the role of value chain management and logistics linked with improving marketing systems as one of the key element of PHL the recognized post-harvest systems; and
- There is need to strengthen the institutional support both at federal and regional level along with required human resource development with expertise, which is expected to generate and harmonize data collected on PHL by the research institutions and extension.

References


The Political Economy of Post-Harvest Losses in Ethiopia


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Sustainable Agricultural Intensification in Sub-Saharan Africa and the Role of Nematodes

Danny Coyne
International Institute of Tropical Agriculture (IITA), Nairobi, Kenya, E-mail: d.coyne@cgiar.org

Abstract

Across the globe crop productivity continues to increase, including across the developing world, but not in sub-Saharan Africa. Similarly, agricultural output per capita is increasing across the developing world, but decreasing in Africa. Nine of the 20 fastest growing cities in the world are located in Africa, creating increasing demands on agriculture. In a region of immense biophysical diversity, potential and hope crop productivity in sub-Saharan Africa is currently failing to keep up with demand. The intensification of smallholder agriculture will constitute an important component of any strategy towards improving this situation given that they dominate these agricultural production systems. Intensified cropping systems, however, increase selection pressures for pest and disease emergence, including nematode pests, which, in general, are commonly overlooked and/or misdiagnosed across the globe but especially in developing countries. Consequently, greater capacity in nematological expertise is most wanting where it is most lacking. Attracting interest in nematology as well as other plant health aspects should be key within the overall strategy to increasing agricultural productivity. Heavy reliance on synthetic pesticides will be less of an option for farmers in Africa, particularly for nematode pests, as many nematicides are no longer available. Therefore, building up such a human resource base is important to addressing this issue in the long term. Overcoming production losses will require suitable management options, chemical or otherwise, strong capacity building, and stronger links between the agro-input industry (private) and public sectors.

Key words: agricultural productivity, IPM, nematology, plant parasitic nematodes, smallholder subsistence farmers.

[61]
Introduction

Current projections indicate that half of the world’s population growth will occur in Africa by 2050 resulting in a doubling of its population and a global population of 9 billion. In some countries, the population increase will be dramatic, such as Tanzania, which will have increased by five-fold by the year 2100 (UN-ESA 2015). A critical problem therefore relates to the sustainable increase in agricultural production proportional to the demand. In sub-Saharan Africa (SSA) the situation is becoming critical, as crop productivity remains static at best or declining, unlike the rest of the world (Hazell and Woods 2005; FAO 2014). In particular this has major consequences for the increasing demand from urban centres, as urbanization escalates across SSA, while the effects of climate change further disrupt crop production and exaggerate losses. Urban populations and associated food demands are fast increasing in SSA demanding a sustainable increase in production proportional to this demand. Current increases in agricultural production in SSA have largely been the result of area expansion (Keating et al. 2014). Intensification of agricultural production is consequently essential, in order to improve productivity to feed the rapidly growing and urbanizing population. For areas that contain valuable natural ecosystems, such as the primary forest in the Congo basin, or other areas of natural reserves, intensification of agriculture is a key pillar of the strategy to conserve these reserves but increase the supply of food (UN-REDD 2013). While the concept of intensification is desirable the aspect of sustainability needs to be considered, while also considering that it is becoming increasingly urgent (Vanlauwe et al. 2014). In SSA agriculture is dominated by smallholder subsistence farming systems, which are highly heterogeneous, complex and vulnerable to production risks complicating the intensification process (Cotula et al. 2009). Consequently, the complexity of the prevailing agricultural systems and the impacts of a changing climate require consideration within this intensification process. Intensification of cropping systems however, also increases the selection pressures on pests and diseases, leading to elevated losses and/or requiring the implementation of strategies to avoid these losses. Of the various pest and disease problems, plant parasitic nematodes can be a particularly troublesome problem as systems become more intensified. To maintain the sustainability of crop production intensification in SSA, the changing dynamics of pests and diseases under the more intensified systems requires suitable responses to offset this challenge. At the same time, there needs to be raised awareness of these pests and
diseases, and in particular of nematode issues. And this needs to be created across the agricultural spectrum, from farmers to extensionists to agricultural researchers. The knowledge and understanding of these important pests is necessary to be able to improve our ability to manage them. This will take time, and requires the process to involve awareness creation and capacity building at all levels.

**Nematodes Challenge to Agricultural Intensification**

In the first instance it is important to understand the threat posed by nematodes to crop production, an often understated, overlooked or ignored issue. There are numerous genera of nematodes that parasitize crops, which, depending on conditions differ in the damage they cause. Of all the nematodes that affect crop production, the most economically damaging group is considered to be the root knot nematodes (RKN; *Meloidogyne* spp.) (Jones *et al.* 2013). They are particularly problematic for various reasons, not least due to their highly polyphagous nature and their ability to rapidly multiply under favorable conditions. Under tropical and sub-tropical conditions temperatures, short life-cycles and often consecutive cropping of the same land facilitates their rapid multiplication and population build-up. Their highly polyphagous nature means that they are also particularly difficult to manage through rotation or host resistance. RKN reputedly are hosted by thousands of different plant species of broadly varying botanical groups (Perry *et al.* 2011). Some species are quite host specific but a number of tropical species, occurring in the *Meloidogyne incognita* ‘group’, are extremely polyphagous, such as *M. incognita*, *M. javanica*, *M. arenaria* and *M. enterolobii*. However, RKN species are also well known for being particularly difficult to identify and differentiate from each other, and the diagnostics of these species is fraught with complications. Major efforts are being made to overcome this, with a current focus towards the use of mitochondrial DNA to diagnose the different species (e.g. Pagan *et al.* 2015; Janssen *et al.* 2016). Advances and progress in RKN diagnostics are helping to distinguish species and provide a more solid basis for developing management options, especially where mixtures of species occur. It is furthermore providing a basis for species distribution in SSA where, to date, there is relatively limited knowledge on RKN species occurrence and distribution. For example, in Ethiopia coffee is a major crop for both local and export markets, but there is no documentation as yet on the RKN species occurring on this crop (Abebe *et al.* 2015).
RKN are key pests to crop production. They affect all crops grown in SSA with different species affecting different crops, although the tropical species in the *M. incognita* group have very broad host ranges. Under intensified cropping conditions they build up to highly damaging population levels and need to be considered very carefully within IPM strategies for intensified cropping systems, especially in tropical and sub-tropical conditions. Visible symptoms of their damage are often unspecific in nature and consequently overlooked. By damaging the root system, host plants become stunted and chlorotic, which may be due to a range of ailments. They may wilt under low water availability due to the inefficient and damaged root system and may become infected by secondary or additional pests and diseases, which may then become the focus as the causal agent of the host plants’ demise. If the host is a root or tuber crop or if roots are exposed and unearthed, the symptoms of RKN parasitism are often very obvious. Depending on the host and the RKN species symptoms can differ, but in general roots become swollen, knotted and deformed before eventually deteriorating and decomposing. The ‘knots’ tend to be less obvious on graminaceous hosts, while the level of infection usually indicates the magnitude of the damage. Affected roots however, can be extremely deformed and as such become inefficient, resulting in stunted growth and production, and in the case of root and tubers leads to reduced quality. Deformed tubers are unsightly and less marketable, but also the texture can be altered and is often tougher and less palatable, affecting market value and resulting in discard of tuber crops, especially in the case of processing, such as on potatoes for the crisping and chipping industry.

Although RKN are key focus pests and particularly damaging under more intensified conditions, there are indeed a vast array of nematode pest species. Other key groups of nematode pests include the lesion nematodes (*Pratylenchus* spp.) and cyst nematodes (*Heterodera* and *Globodera* spp.) although there are many others. The reality is that there is often a combination of nematode species occurring in the same situation or on the same host, where one species may be dominant, or where several species may combine to jointly affect the host. The density of the nematodes on the host is usually used as the indicator for the level of infection and damage (potential) by the nematodes. A complex of species attacking the same host, however complicates the situation in terms of determining damage potential and creates difficulties for their management, especially for the identification of host resistance and identifying suitable crop rotations.
Management of Plant Parasitic Nematodes

Traditionally, synthetic chemical pesticides have been relied upon to manage nematode pests in commercial and western cropping systems. With increasing awareness of the detrimental environmental and health implications of these hazardous Class 1 chemical products, the majorities have been removed from use and are now unavailable. Without this previously important tool for nematode pest management, the intensification of cropping systems in SSA will need to rely on alternative management options. This has required a change in direction for the management of these pests, on a global basis, and considerable efforts have been focused on the use of biological control agents, which in general are more environmentally sensitive (Viaene et al. 2013). However, substantial research is required to determine suitable levels of management of new products/agents and ensure there are no side-effects in terms of damage to non-target or beneficial hosts. Progress has been slow in general, but positive, while in SSA developments in this area has been hampered by the slow registration process, as authorities adapt to this new area of pest and disease management. The limited interest to invest in small-holder farming systems by commercial production companies has also reduced potential progress. There is however much growing interest in this area and the progress is gradually improving and moving positively forward.

The improved management of plant parasitic nematodes in cropping systems in SSA is very much dependent upon local expertise and indigenous knowledge and capacity. This area of crop protection science requires substantial support and bolstering in many countries and at all levels. Without this expertise in academic and research institutions, there is little hope for such knowledge and understanding to flow into the wider arena and to farmers. Improved knowledge and expertise in this area, over time will help to provide solutions and implement nematode management options locally. It remains the responsibility of national programs and the academic system to nurture this, but similarly requires the support of the network of nematologists locally, regionally and internationally, in harmony, to make the necessary advancements in SSA.

Intensification of cropping systems and Pests management

In SSA, the intensification of cropping systems is not so much a discussion point but rather an essential ingredient of the agricultural landscape, which is already overdue. A key concern or question revolves around how to incorporate the
complexity of conditions that characterize smallholder cropping systems and ensure suitable, sustainable and environmentally acceptable pest and disease management under increasingly challenging circumstances. This is not to neglect or underestimate the need and contribution of larger scale commercial undertakings, which equally need to consider the implications of pest and disease challenges, including nematodes, under intensified systems. An understanding and local capacity of the various pest and disease disciplines is essential to coping with this challenge. This includes the area of nematology, which will become an increasingly important constraint under more intensively cultivated cropping conditions, but remains by and large, an overlooked and neglected area of crop science – requiring immediate correction.

References


Participants: Plant protection society members and invited guests

Venue: Hiruy Hall, EIAR HQ

Following the opening formalities, the plenary session was held. It was chaired by Dr. Kemal Ali and reported by Dr. Netsanet Bacha. The session featured presentation of the post-harvest losses in four parts:

1. Crop post-harvest pests as human and animal health concerns, by Mr. Tariku Hunduma
2. The political economy of post-harvest losses in Ethiopia: Historical counts, current status, policy implications, by Dr. Dawit Alemu
3. Post-harvest losses in the faces of increasing food shortage, by Dr. Tadelle Tefera
4. Role of mechanization in reducing post-harvest losses: challenges and the way forward, by Mr. Bisrat Getnet.

Participants who commented on the presentations drew attention to the following issues:

1. The need to have updated post-harvest losses estimates for different commodities
2. The need to know losses along the food supply chain: the critical point where the post-harvest losses are high
3. The need to identify the problems related to adoption and promotion of post-harvest mechanization technologies
4. The need to create awareness related to health hazards of rodents among the community

After the plenary discussion of the presentations, the following key messages on post-harvest losses were delivered from the session

1. Since the methodologies used by different researchers were different, the post-harvest losses estimates currently available are inconsistent. Besides some of the estimates are very old and are from 1970’s. Hence, at the moment we don’t have a figure that we can use to inform the policy makers. Moreover physical losses should be converted in to food security as it will be more interesting for policy makers. In 2005 it was decided to take data every five years but the methodology to follow is not yet decided. Hence there should be a way of developing a consistent methodology that should be followed and also multidisciplinary techniques should be formed and economic data on losses should be known. Loss estimates especially on horticultural crops is very limited so attention should be given.

2. Since losses are occurring at different levels of food supply chain, losses all the way should be considered and the solutions identified.

3. Health hazards related to rodents should be included in the 15 years strategy developed for post-harvest pest management.

4. Horticultural crops are very sensitive to post-harvest losses. Hence, attention should be given to post harvest losses on horticultural crops as the country is expanding horticultural crops production through irrigation.

5. Mechanization system is mostly for grains. Mechanization technologies for high value crops like horticultural crops should also be considered. Seed cleaners should also be considered for post-harvest losses management in addition to storage facilities. Technologies developed on seed cleaners so far have to be disseminated. Indigenous knowledge should be exploited in developing hermetic storages.

[70]
6. To minimize the problems related to limited adoption of storage facilities such as cost of the technologies, shortage of galvanized metal sheet to produce the metal silos and lack of knowledge among the farmers on how to determine the moisture content before storing grains in storage; the following solutions should be considered:

   a) Private sectors should be encouraged to involve in producing and commercializing storage facilities
   b) Trainings to farmers how to determine moisture content at farmers’ level should be strengthened and
   c) Small scale farmers, development agents and all concerned bodies should be trained on how to use the technologies.

7. The possible post-harvest losses management options should be identified for different commodities.

8. The community is not aware of health hazards of rodents. Therefore, awareness should be created among the community regarding the health hazards of rodents.

9. Well-focused institutional setup and a multi-disciplinary approach should be developed as effective ways of addressing post-harvest losses of different crops.

**Comments given to the presenters**

1. The presentation on the health hazard of post-harvest pests should include recommendations and the examples in the full write ups should be exhaustive enough. Contaminant weed seeds should be differentiated from poisonous plants.

2. In the second presentation, important symposiums like 1985’s crop production symposium and 2002 crop protection symposium should be included.
Universities like Addis Ababa University who teach post-harvest pest management under the department of insect pest department should also be included in the write up.

**General comment from the presenters to the organizers**

- The presentations were prepared according to the presenters’ interest; there was no consultation with the organizers. But for the future directions should be given to the presenters.
- From the workshop there should be a synthesized document that should come out as a proceeding.
### Summary of the deliberations from 22nd PPSE Annual conference

<table>
<thead>
<tr>
<th>No</th>
<th>Agenda for intervention</th>
<th>MoANR</th>
<th>EIAR</th>
<th>Govt.</th>
<th>PPSE &amp; other Societies</th>
<th>Public Institutes</th>
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<tbody>
<tr>
<td>1</td>
<td>Attention to Postharvest pest management and reduction post harvest food Loss</td>
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<td>2</td>
<td>Increased Attention to Nematology in Ethiopia</td>
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<td>3</td>
<td>Increased efforts for MLND management</td>
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<td>4</td>
<td>The association of barberry plant as alternate host for wheat rust in Ethiopia</td>
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<td>5</td>
<td>Enhancing Integration b/n professional societies</td>
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<td>6</td>
<td>Support for Societies by EIAR and MoANR</td>
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<td>7</td>
<td>Preparation of IPM training manual</td>
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<td>8</td>
<td>Plant Protection professionals Capacity building</td>
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<td>9</td>
<td>Enhancing the focus given to Plant Protection discipline in Agricultural Research, Education and Extension (Reducing System bottle neck)</td>
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<td>10</td>
<td>Encouraging publications on local journals</td>
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[73]
1. Attention to postharvest pest management and decreasing post harvest food loss

The postharvest issues in Ethiopia have got minimum attention in research, extension and education. General information on stored food losses at the farm and village level in developing countries are sparse and poorly documented. Therefore, emphasis should be given to the following activities:

a) Developing refined scientific methodology for estimation of postharvest loss in Ethiopia.

b) Documenting up-to-date postharvest loss estimates for all major crops instead of using out-dated and fragmented information for limited crops.

c) Creating awareness on the human and animal health hazards caused by mayco-toxins, cross contamination of food items with microorganisms, insects and rodents.

d) Creating awareness on the widespread ignorance of the magnitude of the rodent problem on the post harvest loss and of means to control it.

e) Putting an end to the use of outdated storage structures, the high cost of Metal silo and unavailability of sheet metal for making silos and making it available and affordable to small scale famers.

2. Increasing the attention to Nematology research, education and extension in Ethiopia

- Nematodes are important crop pests mostly attacking the underground parts of the crop, causing quantitative and qualitative loss of crops.
- The gall forming nematode reduces the astatic value of the produce and makes it unmarketable.

[74]
There are few nematologists in Ethiopia and training more personals in the field of nematology

3. Increased efforts for MLND management
   • The problem of MLND in Ethiopia is being aggravated and it needs concerted efforts among the different stalk holders

4. The association of barberry plant as alternate host for wheat rust in Ethiopia.

5. Enhancing Integration between professional societies.

6. Support for Societies by EIAR and MoANR

7. Preparation of IPM training manual by PPSE and researchers.


9. Enhancing the focus given to Plant Protection discipline in Agricultural Research, Education and Extension (Reducing System bottle neck).

10. The number of local publications is decreasing in an alarming rate and EIAR must encourage researchers to publish on local journals.
## Dates and Themes of Annual Conferences of the Plant Protection Society of Ethiopia

<table>
<thead>
<tr>
<th>No.</th>
<th>Conference Date</th>
<th>Conference Theme</th>
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<tr>
<td>1</td>
<td>5-6 March, 1992</td>
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<tr>
<td>1(^{st})</td>
<td>14 – 15 April, 1993</td>
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<td>Joint conference of the Ethiopian Phytopathological committee and committee of Ethiopian entomologists</td>
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<td>2(^{nd})</td>
<td>26 - 27 April, 1993</td>
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<td>3(^{rd})</td>
<td>18 – 19 May, 1995</td>
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<td>4(^{th})</td>
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<td>8(^{th})</td>
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<td>9(^{th})</td>
<td>4 – 8 June, 2001</td>
<td>Pests and Vectors Management for Food Security and Public Health in Africa: Challenges for the 21(^{st}) Century</td>
<td>Conducted jointly with the 14(^{th}) African Association of Insect Scientists</td>
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<td>10(^{th})</td>
<td>15 – 16 August, 2002</td>
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<td>11(^{th})</td>
<td>5 – 6 June, 2003</td>
<td>Pest Management in Fruit and Vegetable Crops in Ethiopia: Challenges in the 21(^{st}) Century</td>
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<td>12(^{th})</td>
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<td>13(^{th})</td>
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<td>14(^{th})</td>
<td>19-22 December, 2006</td>
<td>Two decades of Plant Protection Research in Ethiopia and Prospects for the New Millennium</td>
<td>Two decades of Plant Protection Research was published under the title “Increasing Crop Production through Improved Plant Protection” Edited by Abraham Tadesse</td>
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<td>15(^{th})</td>
<td>1 – 2 November, 2007</td>
<td>Challenges of Plant Protection Research and Development in the New Millennium</td>
<td>Dedicated to the late Dr. Dagnachew Yirgu, Pioneer Ethiopian Plant Pathologist, Educator and a Model Citizen</td>
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<td>16(^{th})</td>
<td>13 -14 August, 2009</td>
<td>Food Crisis and Climate Change from the</td>
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<td>17th</td>
<td>25-26 November, 2010</td>
<td>Perspective of Plant Protection</td>
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<td>18th</td>
<td>29–30 December, 2011</td>
<td>Invasive Alien Pests of Plants Threatening Ethiopian Agriculture</td>
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<td>19th</td>
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<td>Biological Control Incorporated IPM for Pests Management in the Growing Protected Agriculture in Ethiopia</td>
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<td>Biotechnology for Plant Protection in Ethiopia: Challenges and Opportunities</td>
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<td>Plant Quarantine: the State of Affairs in Ethiopia</td>
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<td>New Pests Challenging the Current Pest Management Support System and Need of Reinvigorating the System</td>
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<td>Post Harvest Pest Management along the Supply chain of Horticultural crops: Prospects and Challenges in the changing climate</td>
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