GOOD PRACTICES TO MINIMIZE POST HARVEST STORAGE LOSSES OF MAIZE IN BHUTAN

Food and Agriculture Organization of the United Nations

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National Plant Protection Centre
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P.O Box: 670
Phone: +975–2–351–016, Fax: +975–2–351–656
Email: nppcsemtokha@gmail.com
Website: www.nppc.gov.bt
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FOREWORD

Maize farming is the livelihood of the majority of the rural population in Bhutan. In 2017, a total of 94,052 metric tons of maize was harvested from 66,042 acres (DoA, 2017). Serious losses and deterioration of quality occur in maize due to adoption of improper post-harvest practices, particularly in storage. Maize harvest coincides with monsoon rainfall and high humidity which further aggravates the quality of storage maize within short span of time.

In addition to the serious quantitative loss, considerable deterioration in quality occurs in maize due to improper post-harvest practices. Qualitative loss is manifested as damaged and discolored grains due to insect, rodent and mould growth. Incidence of aflatoxins (fungal secretions) in grains is another quality attribute that leads to serious consequences with respect to food safety and health.

The publication of this manual provides the detailed information on good practices that should be adopted and followed throughout the maize post-harvest system, starting from harvesting to storage to minimize serious losses that occur whilst maintaining quality and quantity of maize.

Yeshey Dema
Program Director
National Plant Protection Centre, Semtokha
Department of Agriculture
Ministry of Agriculture and Forests

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Dr. Keerti In Bongo Gewog, Chukha Dzongkhag

ACRONYM

MoAF	Ministry of Agriculture and Forests
DoA	Department of Agriculture
FAO	Food and Agriculture Organization
BHU	Bhutan
TCP	Technical Cooperation Programme
NPPC	National Plant Protection Centre
IPM	Integrated Pest Management

HARVESTING

A major issue in the post-harvest system of maize that has to be addressed is allowing the standing crop after it has attained maturity to remain in the field without harvesting, thus exposing the produce to deteriorative agents such as: adverse weather conditions; heating of grains leading to discoloration; insect infestation; mould damage; damage due to birds, rodents and wild animals causing serious grain losses. Keeping the standing crop after it is matured without harvesting is practiced by farmers mainly to allow the cobs to dry since no other drying operation is performed by them prior to storage of the cobs.

Correct stage of maturity for harvesting of maize is:

- When silks of ears have dried to a golden brown.
- Kernels should be well filled & plump milk stage.
- Cob sheath turn to white color.
- Cobs should be at least 5" long.
- 20 days after the appearance of the first silk strands.
- 90 – 115 days after planting (depends on variety).
- Grain moisture content 18-20%.
- The part of the kernel where it is attached to the cob starts to turn brownish or blackish in 90% of the kernels of the cob. This is called black layer formation.

Early harvesting results in

- High level of immature, unfilled, partly filled cobs
- Low field yield
- High grain moisture
- Poor storage qualities

Late harvesting results in

- Low field yield due to damage by insects, mould, birds, rodents and wild animals
- Exposure to adverse weather conditions such as sudden rains, storms, etc.

Plate 1: Harvesting of maize at the correct stage of maturity

DRYING

Drying involves removal of moisture from the cobs/grains, is an important operation prior to storage because high moisture grain will deteriorate rapidly due to following reasons:

- Grain respiration and heating, causing grain discoloration and dry matter loss
- Germination of grains
- Mould (fungal) growth and subsequent incidence of aflatoxin,
- Insect multiplication and damage,

The moisture content of maize, like in other cereals, has to be brought down to a 14% or less for safe storage.

Sun drying

The survey found that farmers practice many drying methods which are sun drying, smoking and floor drying. Out of these methods, the sun drying was the most common drying method practiced by farmers. Sun drying is a popular method of drying grains where spread grain is exposed to direct sunlight until the desired grain moisture content is achieved. The advantage of sun drying is its low energy cost. In Bhutan even though the harvesting period of July and August coincides with rains, weather data indicate that at least 5 sunshine hours per day prevail during this period. Hence, the farmers could utilize these intermittent dry spells to dry their maize to a level safe for storage.

Good practices that have to be followed in sun drying are as follows:

- De-husked maize cobs should be spread on a ground cover such as a plastic sheet or any other suitable material to prevent seepage moisture from the ground reaching the cobs and also contamination of the produce with foreign matter. If a paved drying yard is used, any cracking or damage to the drying surface should be repaired
- Start the drying operation in the morning to get maximum sun shine hours of the day.
- Clean the drying surface properly before spreading the grain to prevent contamination with impurities
- Spread the cobs as thinly as possible on the drying floor, but not more than 5 cm thick, to achieve faster drying.

- Turn the cobs periodically by feet or any other means to enhance the drying rate.
- Grains absorb moisture during nighttime when the relative humidity (measure of moisture content in the air) of the air increases. In order to minimize this phenomenon, heap the cobs on the drying floor and cover the heaps with plastic sheet or any other protective material such as straw bags until the grains are spread on the following day.
- During sudden rains, heap the cobs or grains on the drying floor and cover the heaps with plastic sheet or any other moisture barrier.
- Ensure the cobs are dried to moisture content of 14% or less; in the absence of a moisture meter, by checking the grain hardness.

The advantage of sun drying is its low energy cost; however, several disadvantages are associated with sun drying such as: slow drying rate and hence, longer drying time; dependence of drying time on prevailing weather conditions; interruption in the drying process during night time when the crop becomes susceptible to microbial damage etc. Therefore, an effective drying system for maize at farm level should include sun drying whenever adequate solar energy is available, particularly for intermittent drying of the maize in storage, as well as the use of a mechanical dryer, on a community basis, during wet weather which usually prevails during harvesting periods of July and August.

Plate 2: Sun drying of dehusked maize cobs in Mongar

On-Farm Storage

The survey found that maize cobs are commonly stored in their unhusked form. To improve their drying, it is often recommended to remove the husks from the cobs. The survey findings also revealed that most of the farmers soon after harvesting the cobs are placed in storage without subjecting to any drying process. Drying of the cobs to a moisture content safe for storage is the single most important factor to minimize deterioration due to: inherent metabolic activities of the cobs, especially respiration and subsequent heating; insect damage; and mould damage.

AGENTS OF GRAIN DETERIORATION

The main causative agents of cob/grain deterioration during storage are as follows:

Internal agents:

a) Grain respiration

Grains are living entities and they respire resulting in loss of dry matter and also temperature build up within the grain mass causing the grains to get discolored. High moisture grains respire rapidly and hence, it is important to store grain dried to a moisture content of 14% or less to minimize deterioration during storage. The other factors affecting the rate of respiration in grains are: high temperature of grain and ambient air; presence of insect pests in the stored grain; presence of micro flora in the grain; physical state of grain; and oxygen supply.

b) Grain germination (sprouting):

Wetting of stored grain due rain water percolating to stored grain through roof or wall leaks and moisture seeping from the ground can cause the grains to sprout, causing serious losses.

External agents:

a) Insects:

The main insects damaging stored grain can be broadly categorized as weevils, beetles and moths. Insects whether adults or larvae feed on the grain and cause serious losses. Insects also contaminate the grains resulting from excrement, empty eggs, larva, empty cocoons and dead adults. Further, the metabolism of insects is accompanied by the production of heat and moisture resulting in the proliferation of toxin producing fungi and untimely rotting.

The causes of insect infestation are:

- Introduction of infested lots to the store.
- Cross infestation from neighboring lots of stores or nearby crop field.
- Migration from wastes or rubbish.
- Hiding places in stores (cracks, fissures)
- Use of infested bags

Plate 3 Maize cob infested by storage insects

b) Moulds (Fungi)

Moulds grow rapidly in stored grains with high moisture content and high levels of impurities causing serious losses due to discoloration and rotting. In addition, mould produce chemical contaminants toxic and hazardous to humans' referred to as mycotoxins.

Plate 4 Damage caused to stored maize cobs by mold

Storage of maize in good condition with minimum deterioration

In order to store maize cobs/grains in good condition, the factors that affect the causative agents of deterioration have to be controlled. These factors can be broadly classified as follows:

a) Grain factors:

- Moisture
- Maturity
- Soundness and
- Cleanliness

b) Environmental factors

- Temperature
- Relative humidity

Grain Moisture:

High moisture in the maize will influence the following:

- Rate of respiration:

  High produce moisture will increase the rate of respiration in the produce, breaking down dry matter and releasing heat. Due to the heat buildup with in the grain mass, the produce tends to get discolored. Increased temperature also results in damage due to increased insect activity.

- Mold growth:

  Above certain moisture content (in equilibrium with a relative humidity of 65-70%) moulds start to multiply rapidly, causing the maize to deteriorate.

- Sprouting:

  At high moisture levels of over 30% the produce will start to germinate, resulting in spoilage.

It is important to store well dried maize cobs or grains at a moisture content safe for storage, that is, at 14% or less.

Grain Maturity:

Immature cobs/grain deteriorate rapidly during storage because of their soft cellular structure and difference in composition to mature ones; they are more susceptible to agents of produce deterioration, especially to insects, molds and respiratory activity. In this context harvesting the maize cobs at the correct stage of maturity assumes importance.

Grain Soundness and Cleanliness:

Maize cobs often get mechanically damaged due to following reasons:

- Use of incorrect harvesting methods and techniques.
- Poor handling, threshing, shelling, cleaning, sorting and drying.
- Bad transport and loading practice.

Since the protective cell wall structure of these cobs is damaged exposing the soft tissue, they are easily attacked by insects and microorganisms thus leading to rapid deterioration during storage. Hence, it should be ensured that sound undamaged cobs or grains go in for storage. Extraneous matter present in cobs or grains harbors insect pests and microorganisms and provides a source of infestation to stored produce. Hence, the storage spaces, structures, bins and sacks should be thoroughly cleaned to remove all impurities before storing the maize. The cobs or grains going in for storage should be clean, free from any extraneous matter and during storage, the inside of the store as well as the surroundings should be kept clean to avoid contamination. Hence, it is important to store sound (undamaged) clean maize cobs or grains free from any extraneous matter in clean surroundings"

Temperature control:

- Respiration:

  Up to 28°C Heat release doubles for every 5°C; At 50°C Grain killed and respiration stops

- Moulds:

  Temperature speeds up life processes of all organisms from 21-43°C; Temperature tolerance: 2 – 65°C depending on spp.

- Insects:

  Development accelerates with increase in temperature and killed at 42°C; Development retarded at < 15°C

Good practices for storage of maize cobs or grains:

- Selection of produce for storage:

  Cobs or grains should be dry, clean, sound, undamaged, free from infestation and mature

- Preparation of store:

  No rain water or seepage water should touch the sored maize

- Sanitary practices:

  Clean storage area, store, bags or sacs and clean surroundings

- Routine inspection:

  To detect any early any damage

- Environmental control:

  On dry, sunny days provide adequate ventilation and on humid, wet days keep the storage closed

- Adopt the practice of "First in first out", that is, cobs or grains stored first should be removed first.

- When using sacs for storage, the grain sacks should be stacked on palates so that they will not touch the ground for seepage water to reach the grains.

- Adopt insect control practices

- Adopt rodent control practices

- Prevent and control mold growth in stored grains

INSECT CONTROL:

Insects in stored maize can be controlled by physical, chemical and biological methods.

Physical methods of insect control:

- Storing clean, dry, sound, un-infested cobs or grains
- Removal of potential sources of infestation: store location to prevent cross infestation, clean surroundings, remove waste and rubbish, close hiding places in store viz. cracks/crevices, un-infested clean sacks/stores
- Admixture of mineral substances with stored maize: wood ash (30-100 volume %), fine sand- (40-100 volume % as top layer 2-7 cm); inert dust (Lateric clay dust, quick lime (0.1- 50 volume %)
- Mechanical methods: Removal of insects by hand, sieving/winnowing,
- Use of heat: Spreading grain in sun, storage above kitchen fire, Smoking
- Air tight storage: At oxygen level of less than 5% insects cannot grow and multiply
- Mixing plant leaves with stored maize such as citrus leaves which have insect repellent properties for insect control

Chemical methods of insect control:

Pesticides can be extremely harmful to both humans and the natural environment. They may represent a chemical hazard for consumers when maize cobs or grains are accidentally contaminated by pesticides. Therefore the use of pesticides is not advocated.

Integrated Pest Management (IPM) for insects of stored grain

Since pesticides can be extremely harmful to both humans and the natural environment, integrated pest management (IPM), where a combination of physical, biological and chemical method of pest control is adopted, is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programmes use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by

the most economical means and with the smallest possible threat to people, property, and the environment.

An IPM programme for control of stored product insect pests will include:

- Adoption of hygienic practices in grain storage
- Use of physical methods such as:
  - Drying
  - Heat Treatment – Insects die at 55 to 60oC in 10 minutes
  - Mixing of inert dusts viz. Clay, Ash etc.
  - Storage of produce at low temperature conditions (below 15oC)
  - Mixing with plant materials which have insect repellent properties
  - Sieving and winnowing of produce

Prevention and control of storage fungi

The causes of mold (fungi) infection are: high moisture content of stored produce, high relative humidity, moisture condensation in stored produce and high insect infestation.

Mold growth and subsequent damage in grains can be prevented by adopting following procedures:

- Proper drying of maize to less than 14% moisture
- Prevent damage cobs/grains during harvesting, handling, threshing and drying
- Keep storage area cool and dry
- Avoid development of high insect population
- Prevent moisture and condensation in the stored maize

Rodent control

The preventive measures that can be adopted to minimize damage of stored maize due to rodents are as follows:

- Storage facility as well as the surrounding areas must be kept clean
- Storage facility must be properly maintained: holes and cracks in the walls, floors, and roofs must be blocked up immediately

- Granaries and platforms should be reinforced with conical rat guards made of 0.5 mm thick metal plates 25 cm in diameter. Rodents must be prevented from climbing along the posts in contact with granaries and guards must be fitted to all
- Trees and branches close to the granary should be cut

Active method for rodent control is the use of traps use of traps

Control of damage due to birds

- In constructing storages no space should be kept between wall and roof. If present should be covered with wire mesh
- All opening for ventilation should be covered with wire mesh
- All other openings through which birds can enter should be closed.

NATIONAL PLANT PROTECTION CENTRE
Department of Agriculture
Ministry of Agriculture and Forests
Post Box: 670
Tel. No. : +975-2-351016/351665
Fax No. +975-2-351656
Email: nppcsemtokha@gmail.com
www.nppc.gov.bt

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