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HASSAN II INSTITUTE FOR AGRONOMY AND VETERINARY MEDECINE

MANUAL FOR

PLASTIC LINERS FOR UNDERGROUND GRAIN STORAGE PITS

GERS

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Background

The use of underground pits for grain storage is a traditional technic extensively used in many places around the world such as in Morocco where the total capacity estimated is close to 1 million metric tons. This type of storage is also used in other places such as in the Middle East, North Africa, South America and Asia. Advanatges of this technic include its low cost; grain protection against temperature fluctuations as well as insect and fungi control. However, this type of storage may be compromised by losses du to underground water contamination of grain. The objective of this manual is to indicate how to improve the usage of underground pits for on farm grain storage, particularly how to achieve a sealed plastic lining of such pits.

Preparation of grain for storage

Moisture content of grain at harvest time is an important factor to take into account before grain is stored. A safe storage requires a relatively low moisture content, less than 13%. Metabolic activity decreases substantially in grain kernels when moisture content of grain goes below this level. This activity practically ceases for moisture content less than 8%. Grain drying may therefore be needed in some cases prior to storage. When grain is harvested manually, harvesting takes place when grain kernels are not completely dry in order to reduce grain loss during handling. Grain harvested in such situations is usually sun dried. It is left to dry in the fields for a few days and continues to dry on the winnowing area.

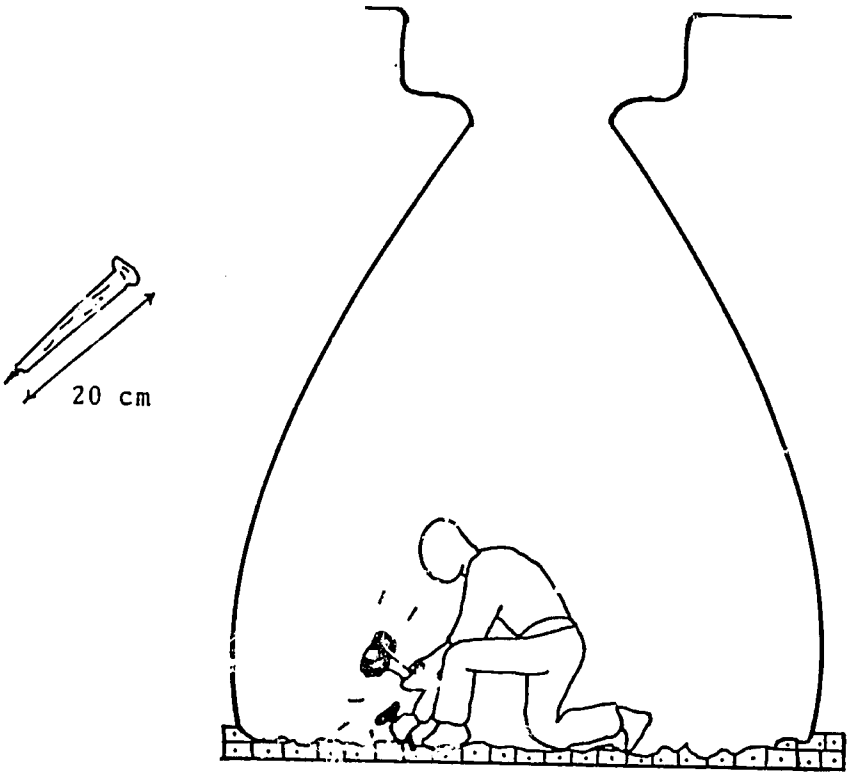
Underground pit preparation

Site selection

The site is selected according to various criteria. It is generally located near the farm dweling in order to secure the stored product and to facilitate grain transport. Topography and soil permeability also influence the site selection. One needs to avoid places with poor drainage conditions. Places where ground water level is close to the surface should be disregarded. These precautions are taken into account in order to prevent underground water from reaching the stored grain. Subsoil geology affects the storage structure stability and the cost of digging of pit. Existence of rocks offers greater stability to the structure but makes manual digging difficult to acheive. However, in case large cracks exist in the rocks, they can allow underground water to contaminate grain and thus make the site inadequat for underground storage. Farmers usually pay attention to most of the criteria listed above.

The digging of the pits

This operation is carried out mannually on farm (fig. 1). Pits capacity is limited and can go up to .4 metric tons. Digging



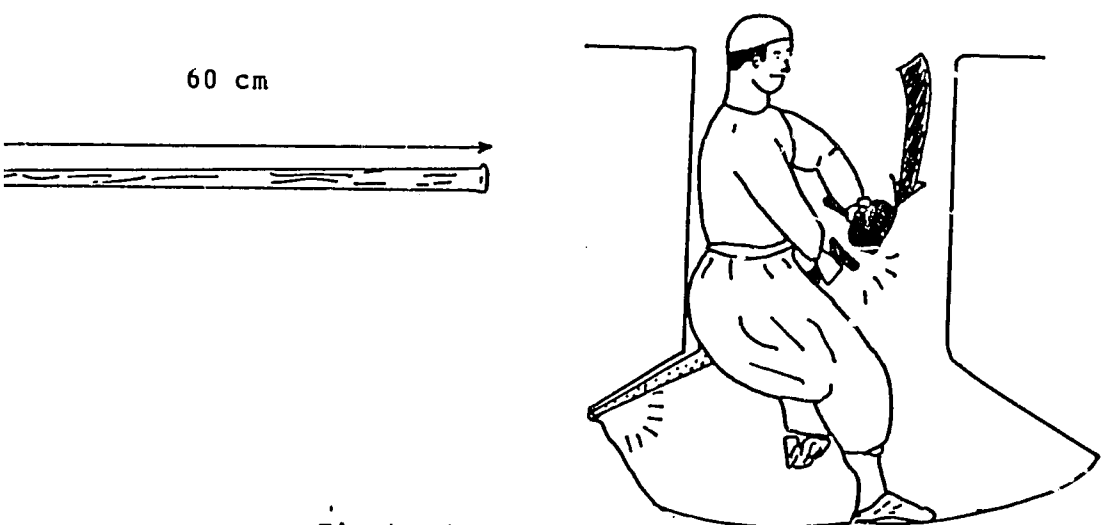


Fig.1 : Manual digging of pits (excavation)

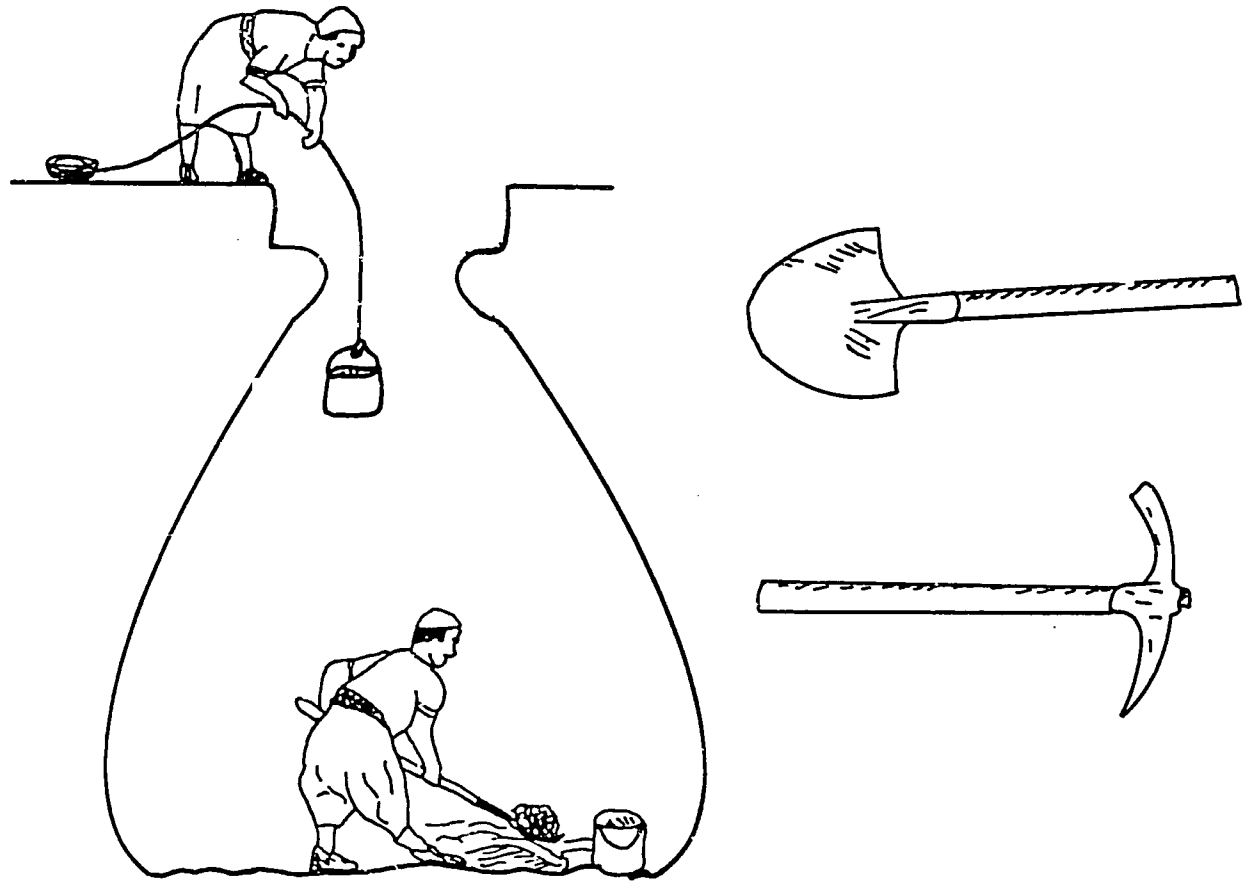


Fig.2 : Digging operation
(earth evacuation)

usually takes place at the end of spring and the number of workers depends on the size and the depths of the pit. Usually two workers are carrying out the work, one takes care of the digging and the other, one of earth evacuation using a rope and a bag. Equipment used for this purpose comprise a shovel, a pickaxe and a steel bar (fig. 2).

Pit Shape

The most common shape encountered for underground pits is the conical shape. This shape is the most stable for underground structures particularly when no reinforcement is used. The mouth of the pit is 0.50 m in diameter and is located about 1 m below ground level. These two precautions help acheive pit sealing.
Depth of the pit usually varies from 2.5 m to 5 m according to the nature of soil and the capacity. When the upper surface layers are sandy, opening walls need to be stabilized with bricks or stones and cement (fig. 3).

Interior lining of pits

Most of deteriorations observed in grain stored inderground seems to come from humidity. This factor is responsable for direct or indirect spoilage of grain and needs to be carefully considered. Permeability of underground pit wall particularly for those exposed to water seepage, represents a vulnerable aspect for underground grain storage. One method to avoid this problem is the interior lining with a sealed plastic bag. Some precautions need to be taken however in order to avoid plastic sheet puncture. This may happen when plastic comes into contact with sharp points of the pit wall. One has to ensure that the interior wall surface is smooth enough. Interior wall surface may be manually lined with clay, to smoothen it, because clay is a construction material easily found on many farms. It presents the advantages of being plastic, low cost material that binds to the wall surface of pit.
Clay is mixed with chopped straw and water in proportions such that adequate plasticity and resistanse are reached.

Plastic lining

Interior lining of pits must be carried out with great care in order to acheive adequate storage. Plastic sheets are commonly found on markets and are accessible costwise. Among various plastic materials found on the market, polyethylen sheets are most common. Sheets available in rolls offer thicknesses varying from .15 to .4 mm. Lining experiment was carried out successfully with .18 mm sheets. The plastic sheets can be used for two or three years for underground pit lining. Maximum width of plastic sheets found in the market is 4 m. For an underground pit 2.3 m diameter at the bottom, that is to say 7.2 m circumference, and 2 to 2.5 m depth, one can use two plastic strips 5m long and 4 m

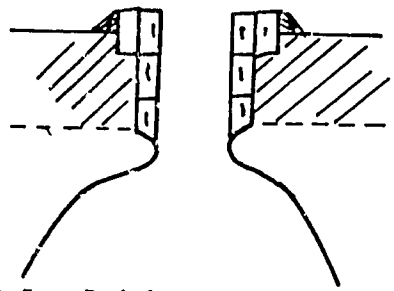


FIG.3 : Bricks of stones cimented to stabilize opening

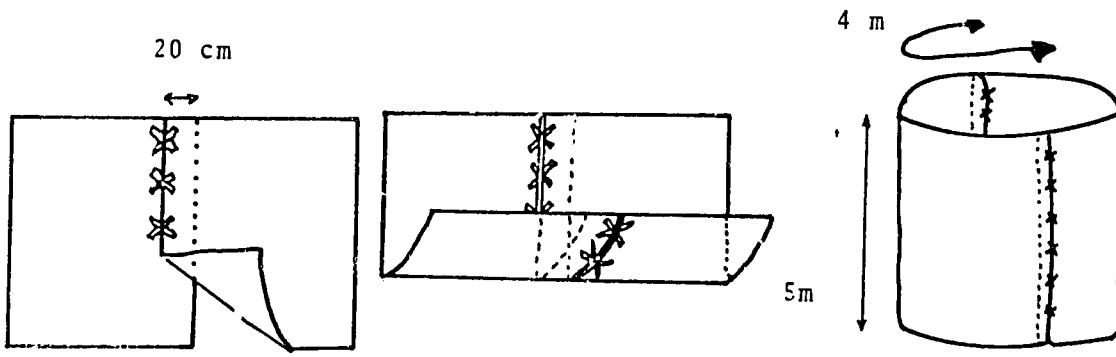


FIG.4 : Plastic bag confection

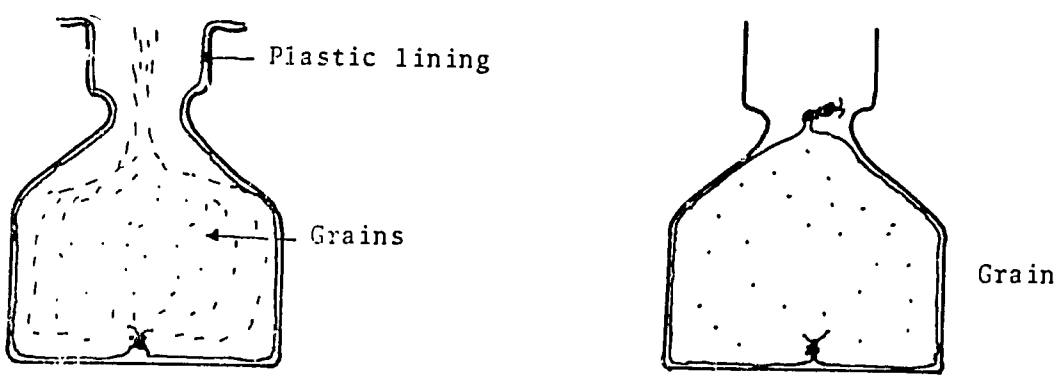


FIG.5 :Closing of plastic bag

wide each. The two strips will be attached together to form a cylinder 5m high and 2.3 m in diameter. The two plastic strips are overlapped over a 20 cm wide area using tape in order to make the intersection resistant and watertight (fig. 4).
The upper part of the plastic cylinder must be closed using a rope in order to reduce as much as possible the volume of air left with the grain within the plastic bag. This is an important step in acheiving oxygen starved atmosphere in underground pits, an essential means to control insect and grain respiration (fig. 5).

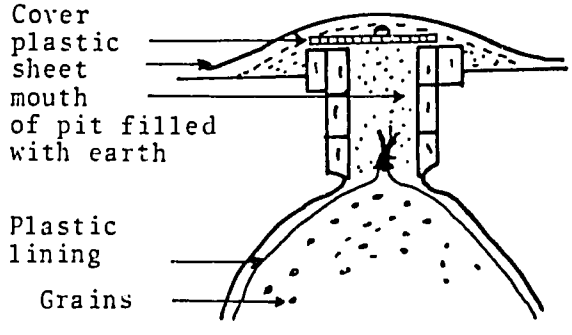
Underground pit filling

Before installation of plastic sheet lining, a layer of chopped wheat straw or other cereals straw is deposited on the bottom of the pit. Grain is then poured in bulk from the top. Some farmers tend to add at the moment of pouring grain some inecticides or fumigants pills to help protect grain from infestation. This is not necessary given the performances obtained with a plastic lining carefully carried out according to the instructions included in this manual. When the frequence of pit reopening increases, it leads to the reintroduction of oxygen inside the pit and thus makes the use of inscticides helpful.

Closing underground pits

When the plastic bag has been filled with grain and carefully closed, operation of pit sealing is acheived. A layer of earth around .5 m thick is placed on the top to cover and protect the stored grain. A round stone or wooden plate is used to close the pit opening. On top of it a straw layer and plastic sheet are placed. The objective of using plastic, straw and earth layers is to achieve heat insulation and waterproofness of the pit opening (fig. 6).

FIG.6 :Pit sealing



Grain recovery

High CO_2 levels are reached in underground pits after several months of storage. This requires some precaution when recovering of grain is needed. The pit must be left open for aeration for a few hours before one can penetrate the pit in order to avoid accidents. Also, the more one opens a pit, the more oxygen enters the pit and may reactivate biological activity. Thus its prefered to reduce the number of openings as much as possible. Grain is recovered manually by ropes and bags. Mecanisation of the unloading operation is possible with pneumatic systems.

Physical parameters and grain characteristics

Grain bulk temperatures reach high levels when nonwaterproof lining material such as polyethylen bags are used in underground pits. A diffrence of 6 to 10 degrees between straw pits and plastic pits was noticed. This indicates grain kernels, insects, fungi respire and transpire more actively within a non waterproof lining material. This is so because water and air can cross the lining. Straw lining has another disadvantage, it traps any heat generated from biological activity within the grain bulk because it is a heat insulating material. Plastic lining makes good use of temperature reduction offered by soil layers between the atmosphere and grain. The grain temperature remains constant year round and generally inferior to 20 C.

Also nonwatreproof lining material leads to relative humidity levels in the pits near 90 % for example with straw. Plastic lining keeps the R.H levels lower near 65 %. Moisture contents of grain reaches 18 % in straw pits after a storage period of 15 months, whereas it stays at 12.5 % in plastic pits for the same period. Germination capabilty drops to 60 % after a storage period of 3 months when straw lining is used and stays around 90 % if sealed plastic bags are used. Therefore, with plastic lining, grain stays within a safe zone in the temperature/moisture content diagram.

Sealed atmosphere

Environment provided by plastic lined pits is characterized by a relatively high content in carbone dioxide reaching 14 %. This level obtained naturally in matmoras is used in artificially controlled atmosphere for grain storage.

Losses

Percentage of damaged grain are three times as much with a nonwaterproof material compared to plastic bags. With straw lining damaged grain is concentrated along walls and at the bottom of pits where grain is caking. Dry weight loss for grain stored in straw pits was nearly 20 % and around 3 % for that

stored in plastic. Grain stored in plastic pits keeps its orginal color and odor. Grain stored in straw exhibits a dark color and mold odor.

Conclusion

To summarise, the use of plastic pits as a lining material in underground pits:

-protects grains from moisture uptake,
-stops microbial growth
-reduces chemical changes (lipid degradation)
-preserves the technological quality (bread-making quality) of grains.
-preserves germination capablity of grain stored in underground pits: After 3 months of storage, percentage rate of stored wheat is 97 % with plastic lining and 67 % with straw lining.
-reduces the rate of dry weight loss of 20 % compared to other lining materials such as straw.
-extra cost generated by the purchase and installation of plastic bags is negligible compared to the losses it prevents from taking place.

It is strongly recommended to use sealed plastic bags for underground grain storage.

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