# Seed Drying Principles, Moisture Management and Storage



**Ayub N. Gitau – PhD, Reg. Eng.**

gitauan@yahoo.co.uk; ayub.gitau@uonbi.ac.ke

**Department of Environmental and Biosystems Engineering**

University of Nairobi – Kenya

6/12/2019

## Components of a seed processing plant

- Reception
- Seed laboratory
- Pre-drying
- Storage and Drying
- Processing
- Packaging
- Warehousing

## Definitions:

- **Drying:** Removal of moisture to moisture content in equilibrium with normal atmospheric air or to such moisture content that decrease in quality from moulds, enzymes action or insect will be negligible. Normally to 12 to 14% m.c. for most materials/products
- **Dehydration:** Removal of moisture to a very low moisture content, nearly bone-dry condition (all moisture removed)
- **Equilibrium Moisture Content (EMC):** Moisture content of the material after it has been exposed to a particular environment for an infinitely long period of time or the m.c. that exist when the material is at vapour pressure equilibrium with its surrounding. EMC depends on; humidity, temperature, species, variety, maturity of grains etc.

## Merits of seed drying

- Early harvest (at high m.c.) minimizes field damage and shatter losses and facilitates tillage operations for products.
- Long storage period is possible without product deterioration
- Viability of seeds is maintained over long periods
- Products with greater economic value are produced
- Waste products can be converted to useful products
- Production operations are facilitated for products.

# Part I
# DRYING MECHANISMS



Knowledge of the effect of grain moisture content, other grain properties (surface shape factors, kernel size, grain depth, quality, nature of contamination), the temperature, humidity and flow rate of the air upon fully exposed kernels is essential to an understanding of how drying would proceed within a bed.

- Air Properties:
- Physical properties (mc, BD)
- LHV
- Drying time
- Drying efficiency

## DRYING MECHANISMS



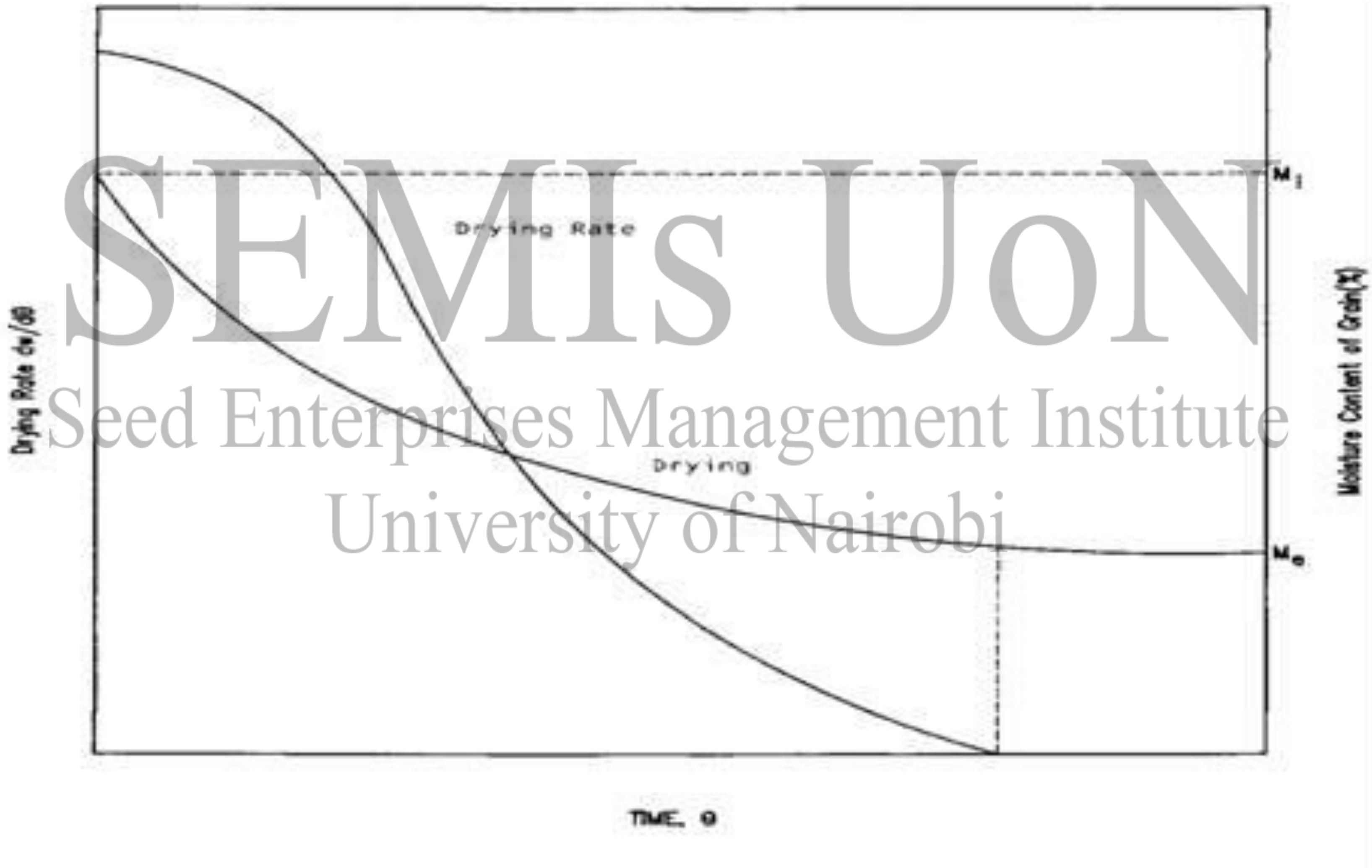
- In the process of drying heat is necessary to evaporate moisture from the grain and a flow of air is needed to carry away the evaporated moisture.
- There are two basic mechanisms involved in the drying process; the migration of moisture from the interior of an individual grain to the surface, and the evaporation of moisture from the surface to the surrounding air.
- The rate of drying is determined by the moisture content and the temperature of the grain and the temperature, the (relative) humidity and the velocity of the air in contact with the grain.

- The drying of grains in thin layers where each and every kernel is fully exposed to the drying air can be represented in the form:
- MR = f (T, h, t)

$$MR = \frac{MC - MC_e}{MC_o - MC_e}$$

- Where:
- MR is the moisture ratio;
- MC is the moisture content of the grain at any level and at any time, % dry basis (%db);
- MCe is the equilibrium moisture content (%db);
- MCo is the initial moisture content of the wet grain (%db);
- T is the air temperature (°C);
- h is the air relative humidity; and
- t is the drying time.

# Drying and drying Rate curves




$M_i$ = Initial Moisture content, and $M_e$ = Equilibrium Moisture content

## Grain Equilibrium Moisture Contents



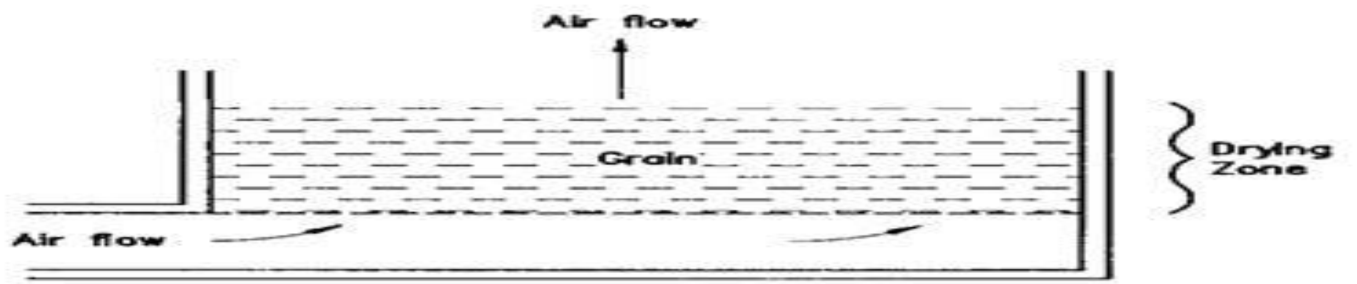
| Grain | Relative Humidity (%) 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|
| | Equilibrium Moisture Content (%wb*) at 25°C | | | | | | | |
| Barley | 8.5 | 9.7 | 10.8 | 12.1 | 13.5 | 15.8 | 19.5 | 26.8 |
| Shelled Maize | 8.3 | 9.8 | 11.2 | 12.9 | 14.0 | 15.6 | 19.6 | 23.8 |
| Paddy | 7.9 | 9.4 | 10.8 | 12.2 | 13.4 | 14.8 | 16.7 | - |
| Milled Rice | 9.0 | 10.3 | 11.5 | 12.6 | 12.8 | 15.4 | 18.1 | 23.6 |
| Sorghum | 8.6 | 9.8 | 11.0 | 12.0 | 13.8 | 15.8 | 18.8 | 21.9 |
| Wheat | 8.6 | 9.7 | 10.9 | 11.9 | 13.6 | 15.7 | 19.7 | 25.6 |

* wet basis

Source: Brooker *et al.* (1974)

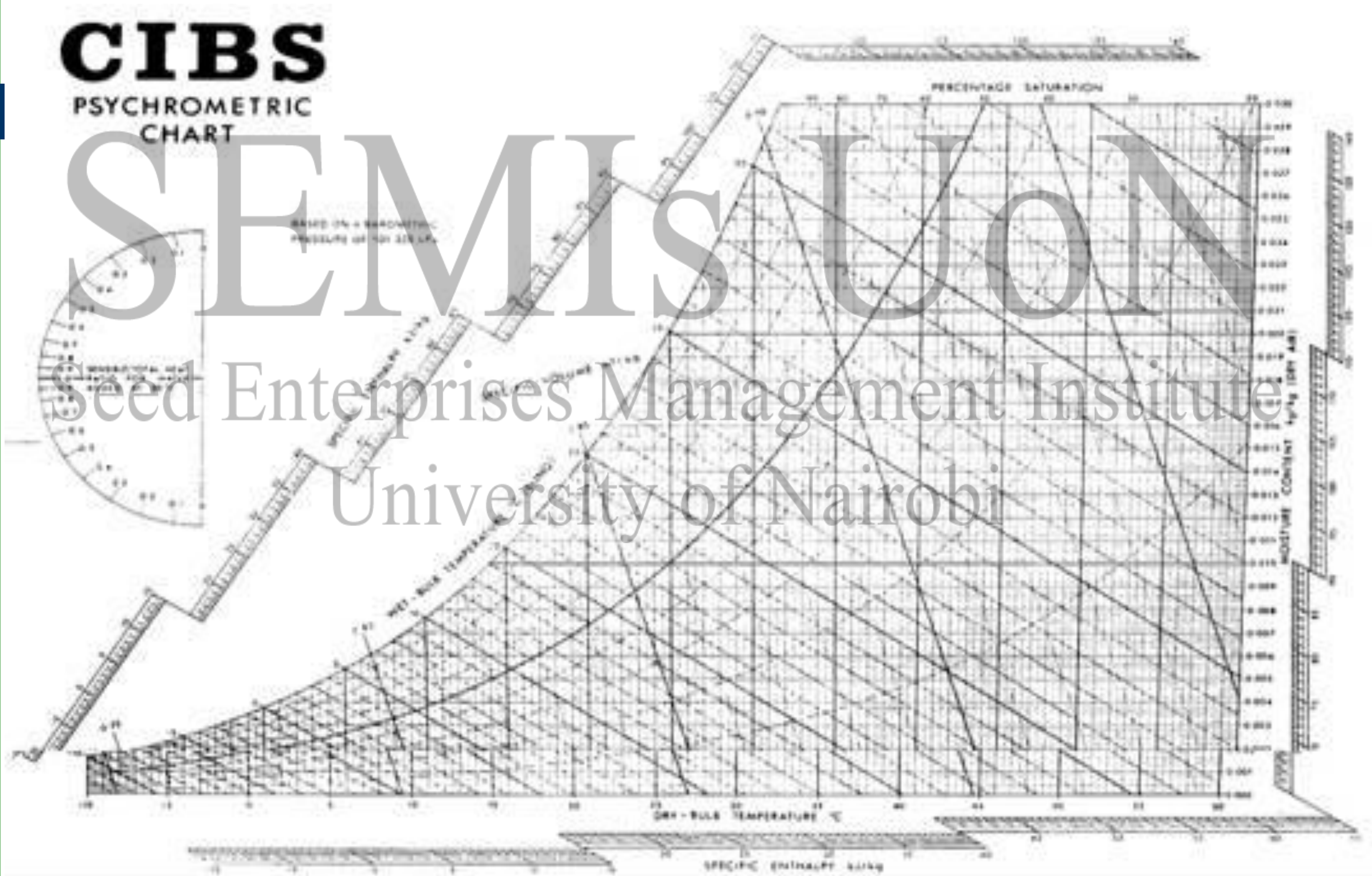
# Drying Zone in Fixed-bed Drying


A. Thick drying bed.

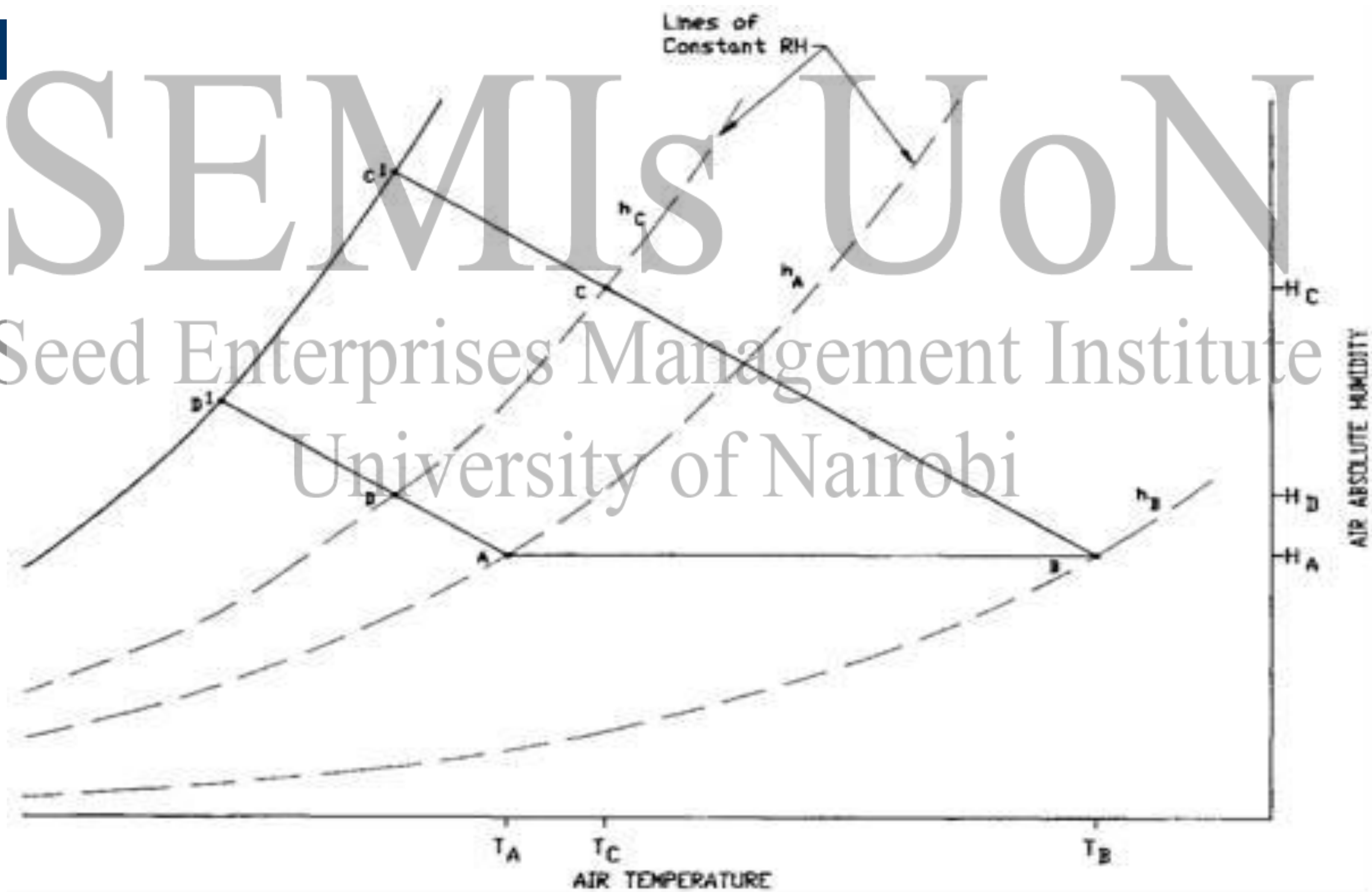



B. Shallow drying bed.

# CIBS Psychrometric Chart



## Representation of the Drying Process



$$MC_{db} = \frac{100MC_{wb}}{100 - MC_{wb}} \quad (3)$$

**Table 2. Conversion of Moisture Contents.**

| **Wet Basis %** | **Dry Basis %** |
|---|---|
| 10.0 | 11.0 |
| 11.0 | 12.3 |
| 12.0 | 13.6 |
| 13.0 | 15.0 |
| 14.0 | 16.3 |
| 15.0 | 17.6 |
| 16.0 | 19.0 |
| 17.0 | 20.5 |
| 18.0 | 21.9 |
| 19.0 | 23.5 |
| 20.0 | 25.0 |

# Moisture Loss during Drying



| Initial Moisture Content % (wb) | Final Moisture Content % (wb) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 19 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 |
| | Moisture Loss (kg/tonne) | | | | | | | | |
| 30 | 136 | 146 | 157 | 167 | 176 | 186 | 195 | 205 | 213 |
| 29 | 125 | 134 | 145 | 155 | 165 | 174 | 184 | 193 | 202 |
| 28 | 111 | 122 | 133 | 143 | 153 | 163 | 172 | 182 | 191 |
| 27 | 99 | 110 | 120 | 131 | 141 | 151 | 161 | 170 | 180 |
| 26 | 86 | 98 | 108 | 119 | 129 | 140 | 149 | 159 | 169 |
| 25 | 74 | 85 | 96 | 107 | 118 | 128 | 138 | 148 | 157 |
| 24 | 62 | 73 | 84 | 95 | 106 | 116 | 126 | 136 | 146 |
| 23 | 49 | 61 | 72 | 83 | 94 | 105 | 115 | 125 | 135 |
| 22 | 37 | 49 | 60 | 71 | 82 | 93 | 103 | 114 | 124 |
| 21 | 25 | 37 | 48 | 60 | 71 | 81 | 92 | 102 | 112 |
| 20 | 12 | 24 | 36 | 48 | 59 | 70 | 80 | 91 | 101 |
| 19 | | 12 | 24 | 36 | 47 | 58 | 69 | 80 | 90 |
| 18 | | | 12 | 24 | 35 | 47 | 57 | 68 | 79 |
| 17 | | | | 12 | 24 | 35 | 46 | 57 | 67 |
| 16 | | | | | 12 | 23 | 35 | 45 | 56 |
| 15 | | | | | | 12 | 23 | 34 | 45 |

## Latent heat of Vaporization



| Temperature °C | Latent Heat of Vaporization (kJ/kg) | | | | | |
|---|---|---|---|---|---|---|
| | Free Water | Moisture Content %(wb) | | | | |
| | | 14 | 16 | 18 | 20 | 22 |
| 25 | 2,443 | 2,605 | 2,518 | 2,483 | 2,464 | 2,453 |
| 30 | 2,431 | 2,593 | 2,506 | 2,471 | 2,452 | 2,441 |
| 35 | 2,419 | 2,580 | 2,493 | 2,458 | 2,440 | 2,429 |
| 40 | 2,407 | 2,567 | 2,482 | 2,447 | 2,428 | 2,417 |
| 45 | 2,395 | 2,555 | 2,469 | 2,434 | 2,416 | 2,405 |
| 50 | 2,383 | 2,542 | 2,456 | 2,422 | 2,404 | 2,393 |
| 55 | 2,371 | 2,529 | 2,444 | 2,410 | 2,391 | 2,381 |
| 60 | 2,359 | 2,516 | 2,432 | 2,398 | 2,379 | 2,369 |

# Dimensionless Drying Rate Curves

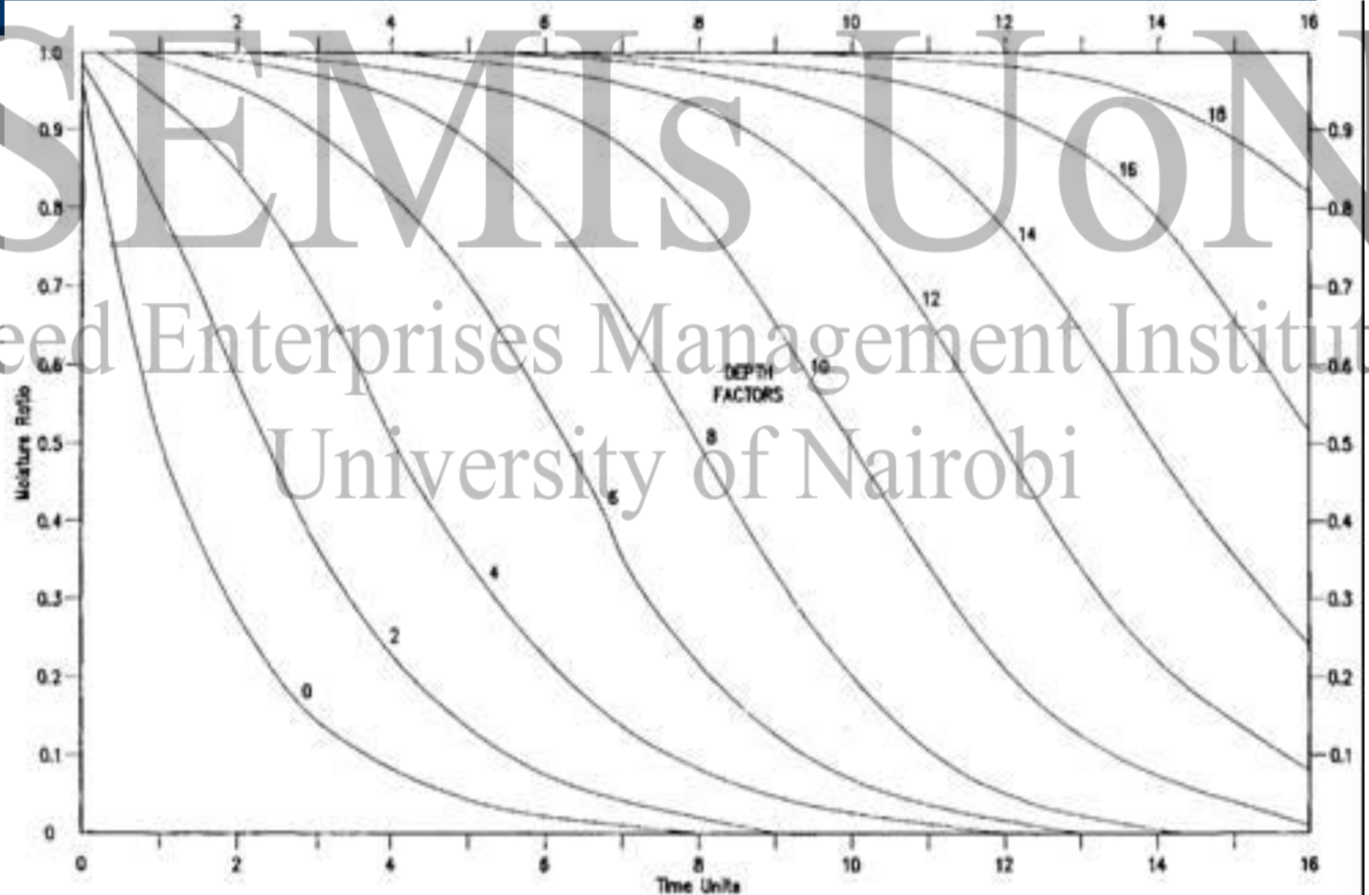



FIGURE 6: DIMENSIONLESS DRYING RATE CURVES

## Drying Efficiency

- **Sensible Heat Utilization Efficiency (SHUE) = (Heat utilized for moisture removal)/ (Total sensible heat in the drying air)**
- **Fuel efficiency = (Heat utilized for moisture removal)/ (Heat supplied from fuel)**
- **Drying efficiency = (Heat utilized for moisture removal)/ (Heat available for moisture removal)**

# Effect of Drying on Seed Quality

The drying operation must not be considered as merely the removal of moisture since there are many quality factors that can be adversely affected by incorrect selection of drying conditions and equipment.

The desirable properties of high-quality seeds include:

- low and uniform moisture content;
- minimal proportion of broken and damaged seeds;
- low susceptibility to subsequent breakage;
- high viability;
- low mould counts;
- high nutritive value;
- consumer acceptability of appearance and organoleptic properties.

# Part II
# Seed Drying Methods and Equipment



- **Sun Drying**
  - The traditional practice of grain drying is to spread crop on the ground, thus exposing it to the effects of sun, wind and rain.
  - The logic of this is inescapable; the sun supplies an appreciable and inexhaustible source of heat to evaporate moisture from the grain, and the velocity of the wind to remove the evaporated moisture is, in many locations, at least the equivalent of the airflow produced in a mechanical dryer
  - Although not requiring labour or other inputs field drying may render the grain subject to insect infestation and mould growth, prevent the land being prepared for the next crop and is vulnerable to theft and damage from animals.

## Crib Dryers

- The maize crib in its many forms acts as both a dryer and a storage structure.
- The rate and uniformity of drying are controlled by the relative humidity of the air and the ease with which air can pass through the bed of cobs.
- The degree of movement of air through the loaded crib is largely attributable to the width of the crib

## Solar Dryers

- Natural Convection dryers
- Forced Convection Dryers

## Mechanical Dryers

- Flat Bed dryers
- Re-circulating Dryers
- Continuous Flow Dryers (Cross-Flow, Counter flow and Concurrent-Flow)

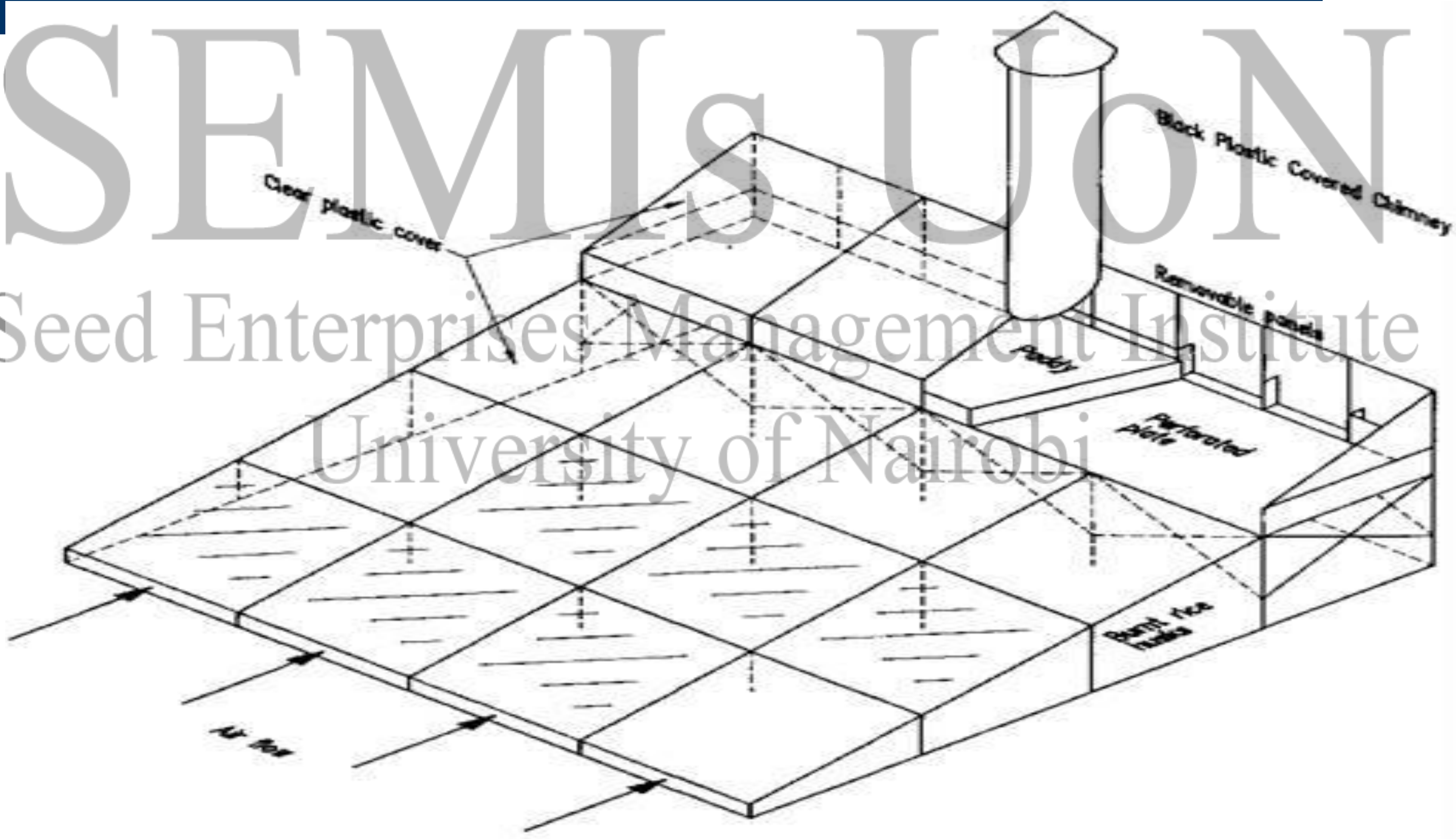
# Drying Process and Equipment



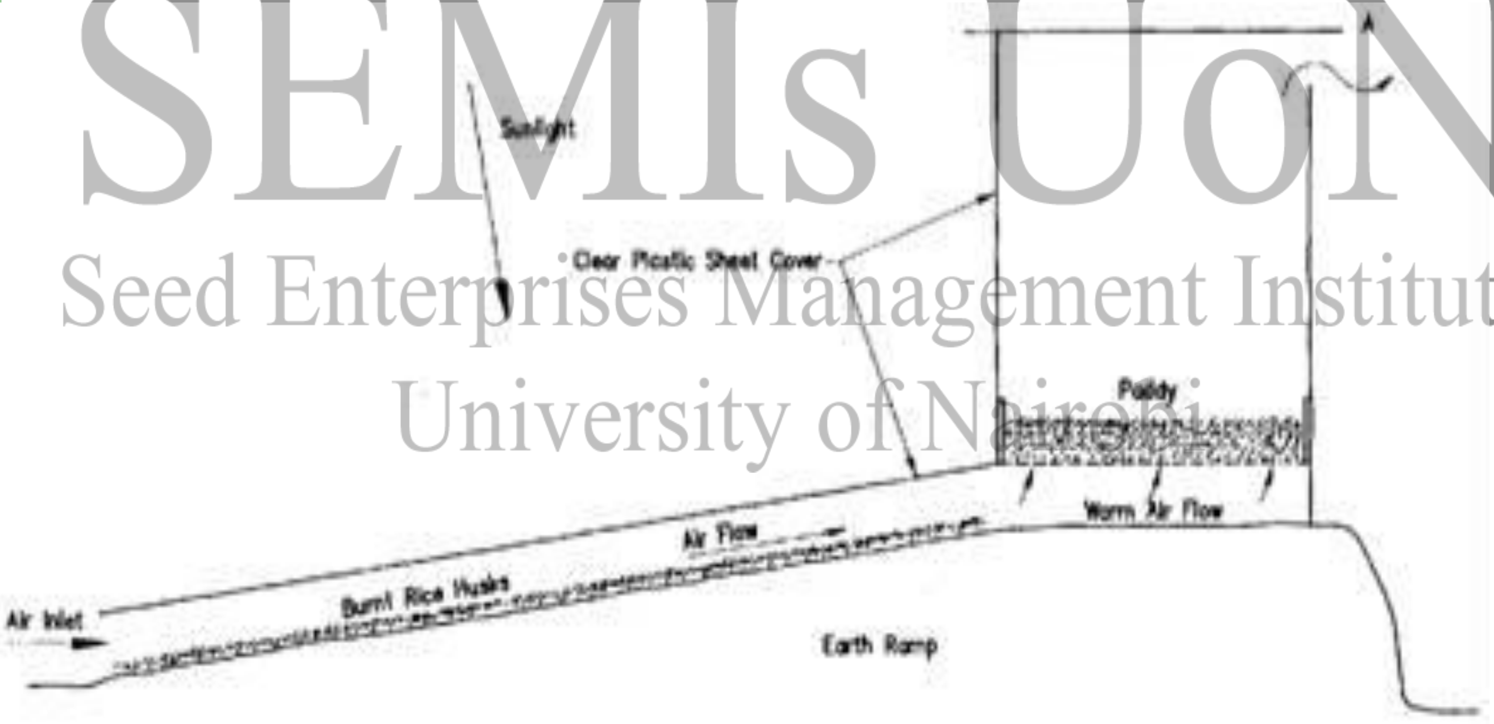

# Drying Process and Equipment Cont.



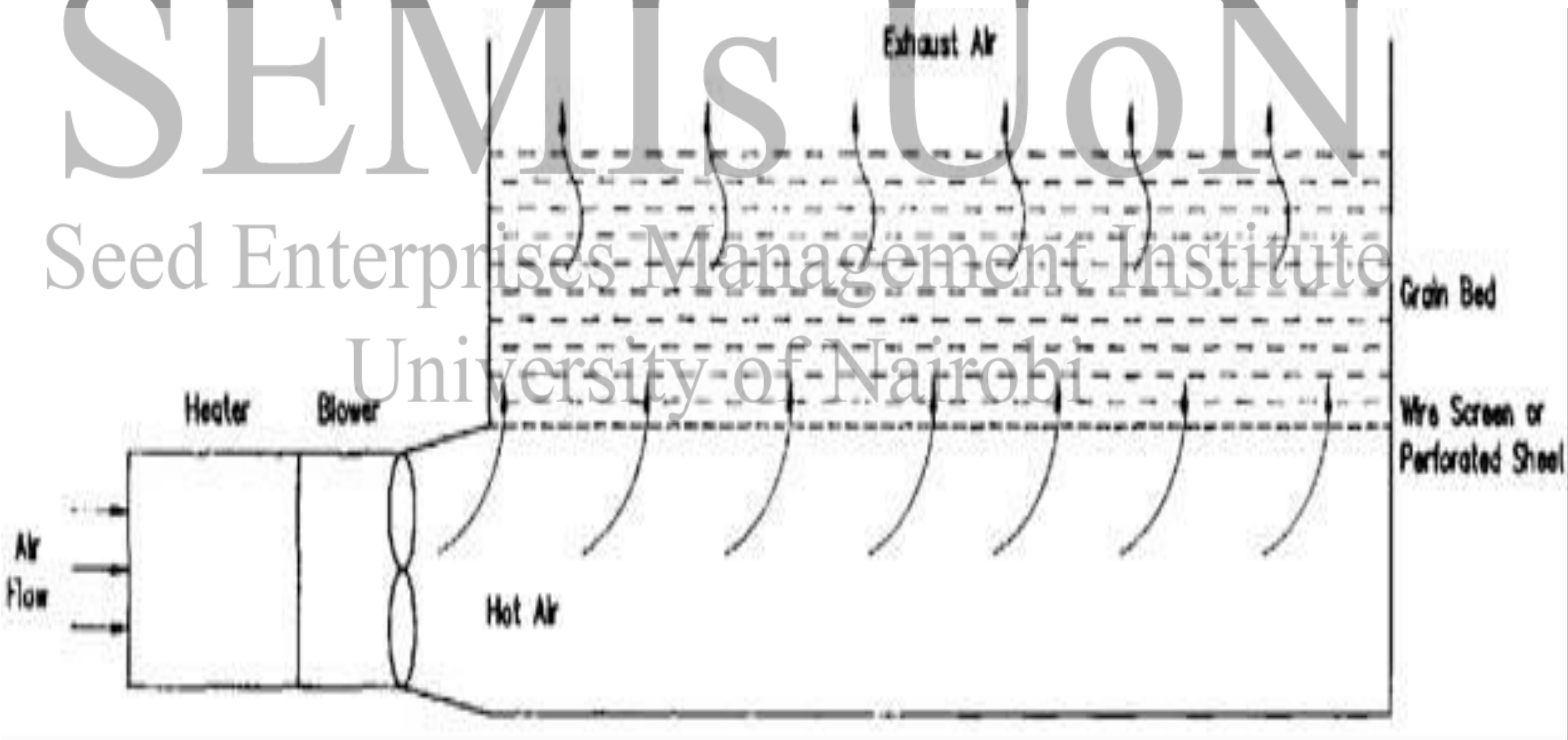

## Natural Convection Solar dryer



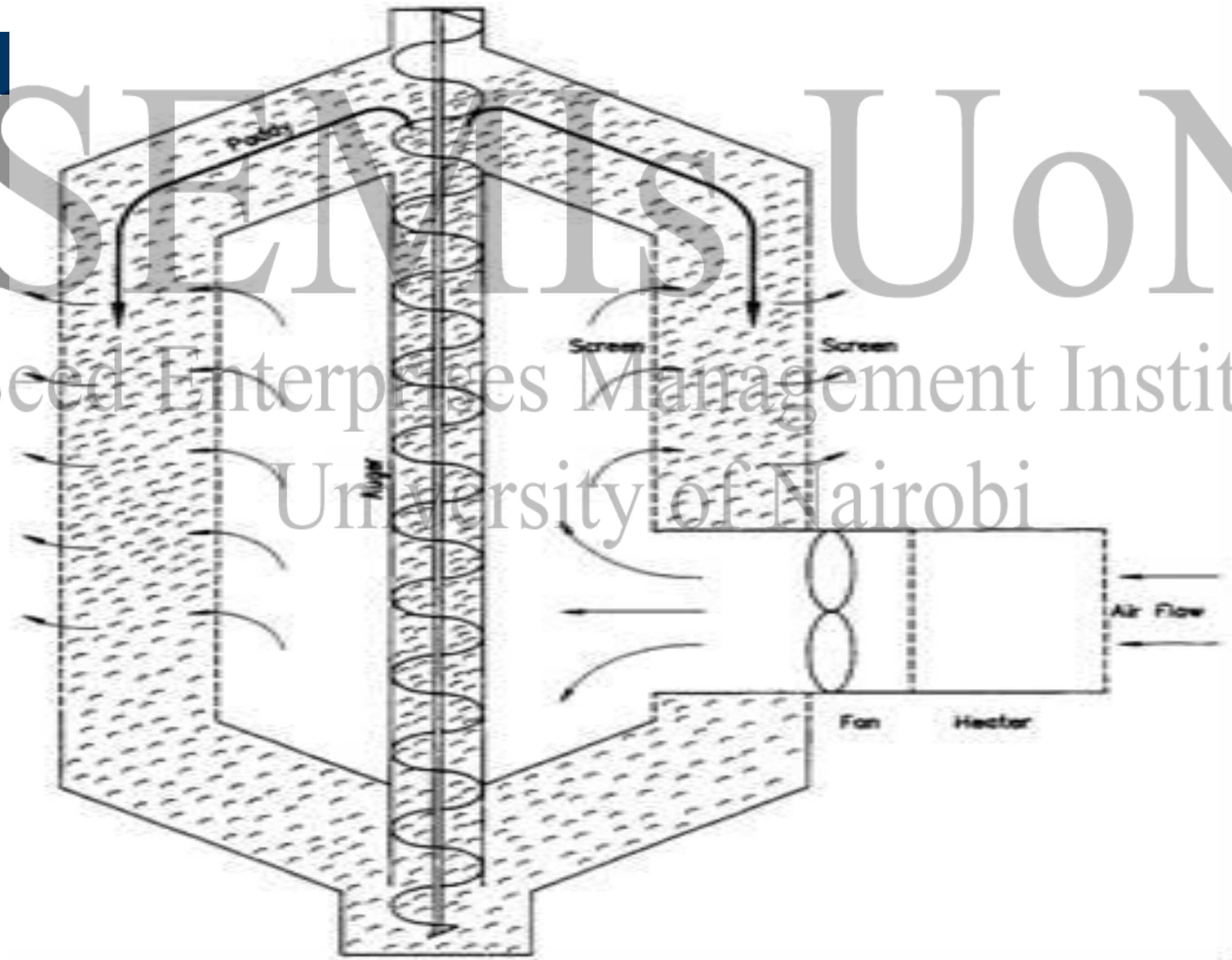
# Small Scale Solar Dryer



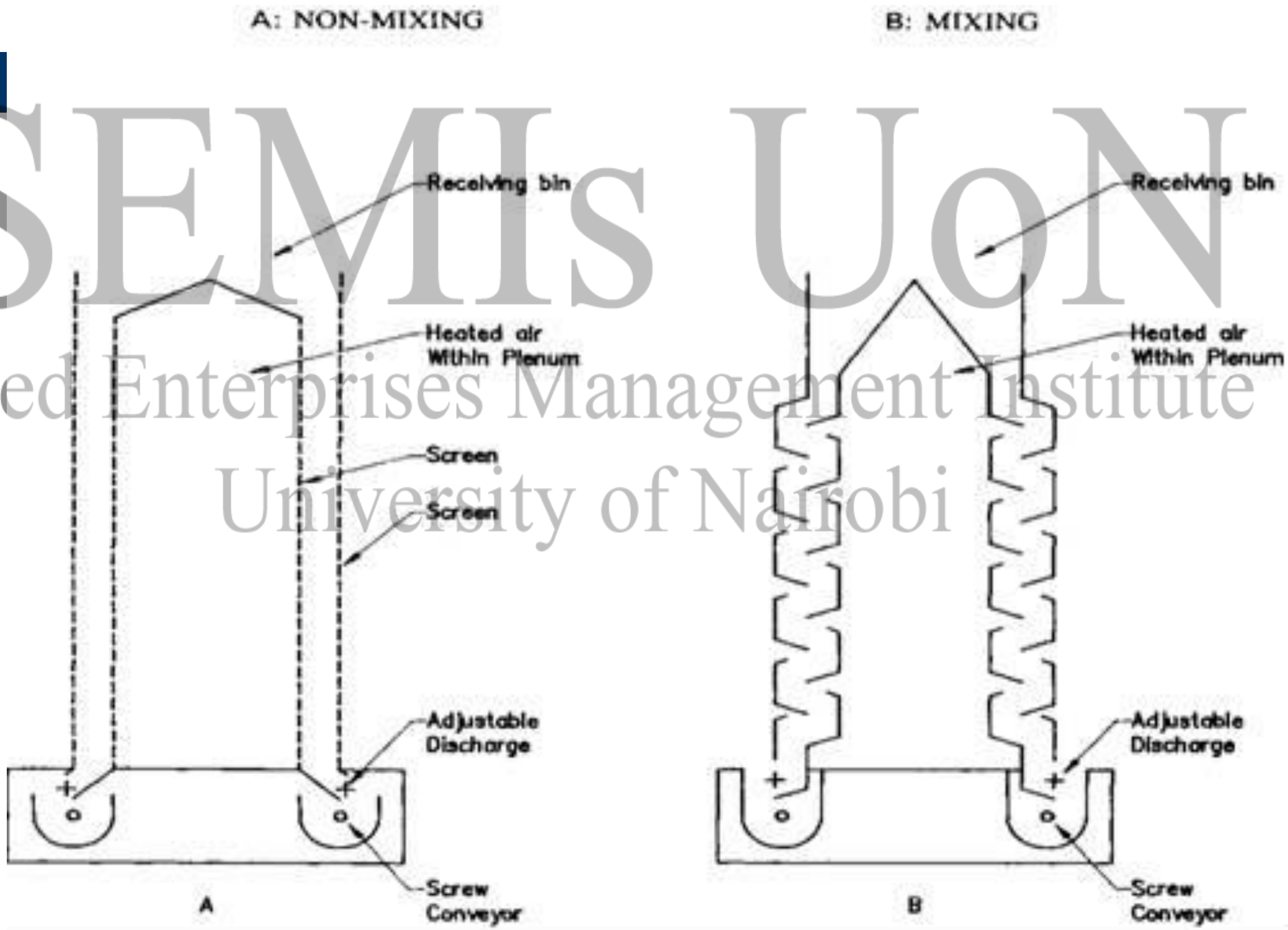
## Flat Bed Dryer



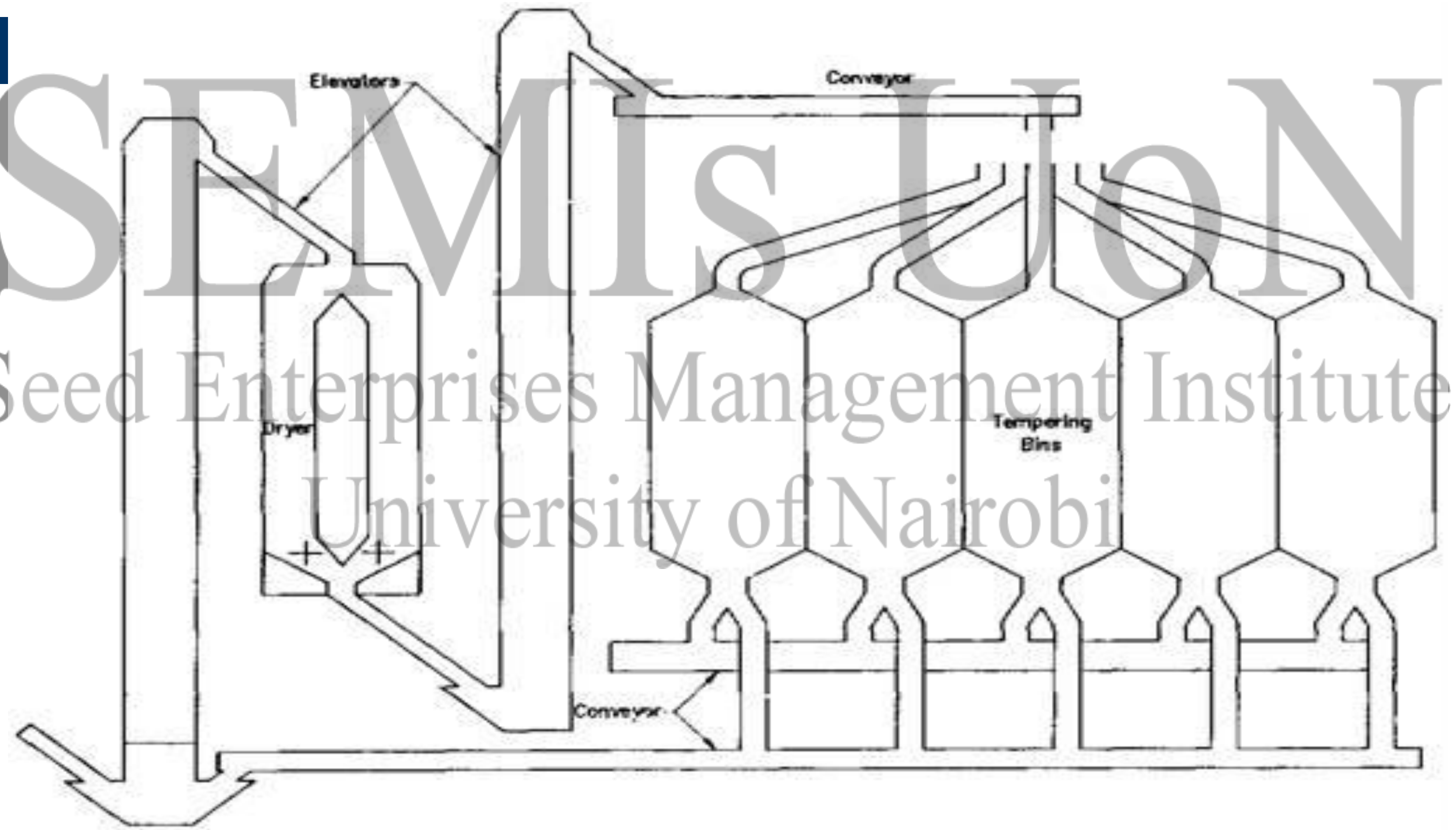
## Re-circulating Batch Dryer



# Continuous Flow Dryer



# Large Drying System using Continuous Flow Dryer



- **Drying of Seed Grain**
- If grain is destined for use as seed then it must be dried in a manner that preserves the viability of the seed. Seed embryos are killed by temperatures greater than 40-42°C and therefore low temperature drying regimes must be used.
- It is essential that batches of grain of different varieties are not mixed in any way and therefore the dryers and associated equipment used must be designed for easy cleaning.
- In this respect simple flat-bed dryers are more suitable than continuous-flow dryers.
- Cross-mixing between batches of different varieties can be avoided by drying in sacks in a flat-bed dryer although care must be taken in packing the loaded sacks in the dryer to ensure reasonably even distribution of airflow.

## Seed Storage

According to Harrington's rule of thumb for storage,

- For every one percent increase in moisture content, the seed life is halved for seeds of moisture content of 5 - 14%.
- For temperature, every 5º C rise in temperature, between 0 - 50º C, the seed life is halved.
- Moisture content of seeds is the most important determinant of the life span of seeds. In addition, low moisture content will not favour the growth of fungi nor insect pests.
- Hence it is of vital importance to dry seeds to low moisture level of 6 - 8% and to store them at low temperature ie. at 20º C for short term storage and 5º C or -20º C far very long term storage.

## Types of Storage for Seed



1. ***Ordinary storage for short periods***

- For short term storage in crops for the next season, an air-conditioned room at 20º C will be sufficient provided the seeds are properly dried and packed in bags preferably moisture proof containers.
- During storage, if the moisture content is too high, the problem of fungal growth is inevitable and also there will be insects which can breed at a faster rate in moist seeds.
- The pests will eat up the seeds or bore invisible holes which affect the vigor and quality of seeds. Too high moisture in stored seeds will lead to heating of the seeds and high rate of respiration leading to loss of viability.

## Cont.

***2. Cold Storage for Breeder Seed***

- In case of breeders seed or seeds for genetic conservation then a higher standard is required. Seeds have to be dried to 6 - 8% moisture content sealed in airtight moisture proof containers and stored in cold rooms of 5º C to -18º C and 50% relative humidity. This is the case in a seed or gene bank, where genetic materials in small samples are stored in cans or aluminium foil packets.
- The temperature is often sub-zero at -10º to -20º C. The latest form of storage is cryogenic storage mainly for genetic resources as smaller samples are involved and stored in liquid nitrogen tanks at temperature of -196 C. Cryogenic storage has certain advantages in that no electricity is required. There is no mechanical breakdown and maintenance cost is low.

***3. Storage with Drying Component***

- In some cases, the storage facility may double up as the drying facility. In this case the silo takes the form of the deep layer dryer as elaborated earlier.

Thank you
for
your Attention