- By Prof. Ayub N. Gitau

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Seed Drying Principles, Moisture Management and Storage

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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.

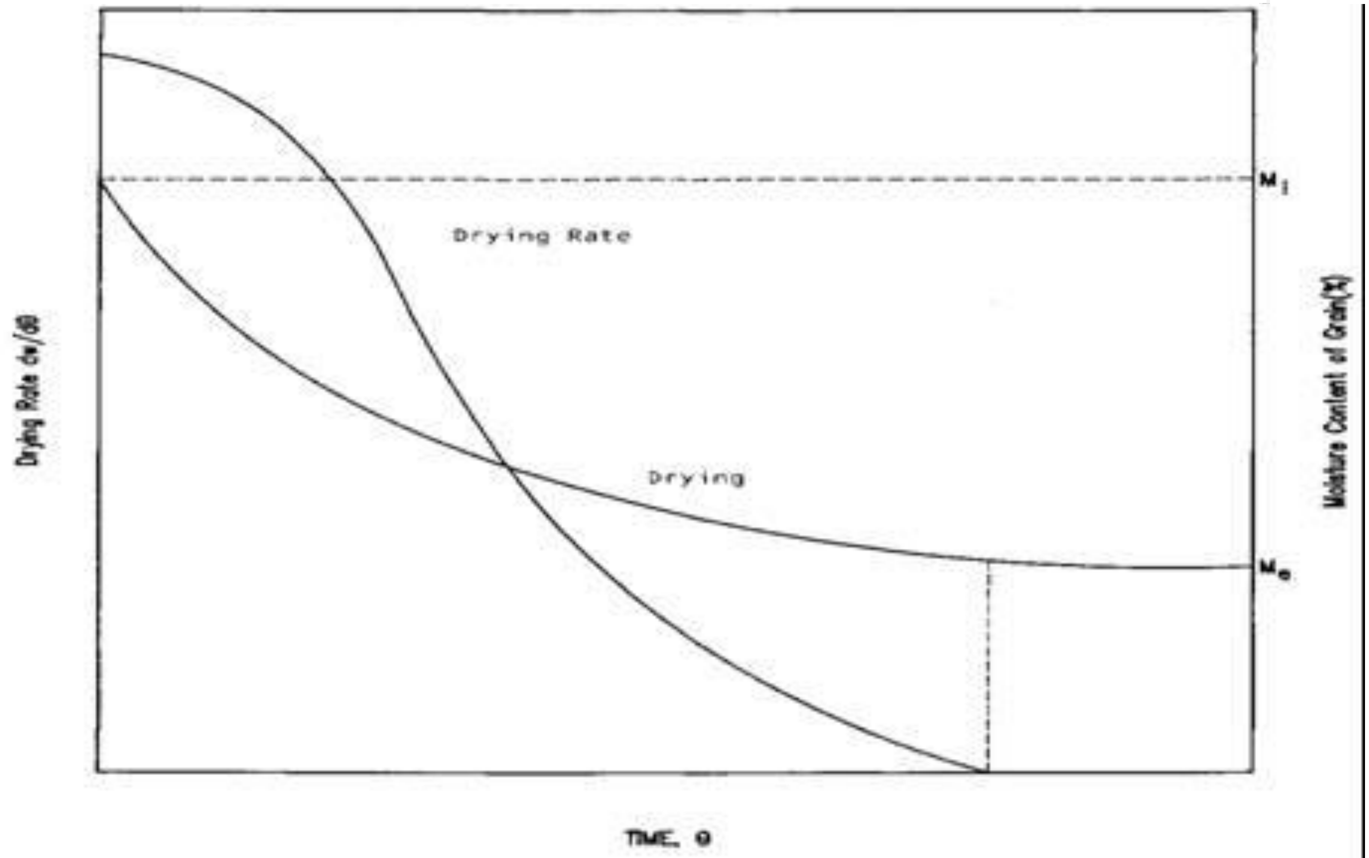
- The drying of grains in thin layers where each and every kernel is fully exposed to the drying air can be represented in the form:
- MR = f (T, h, t)

- Where:
- MR is the moisture ratio;
- MC is the moisture content of th… evel and at any time, % dry basis (%db);
- MCe is the equilibrium moisture …);

$$MR = \frac{MC - MC_e}{MC_0 - MC_e}$$

- 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

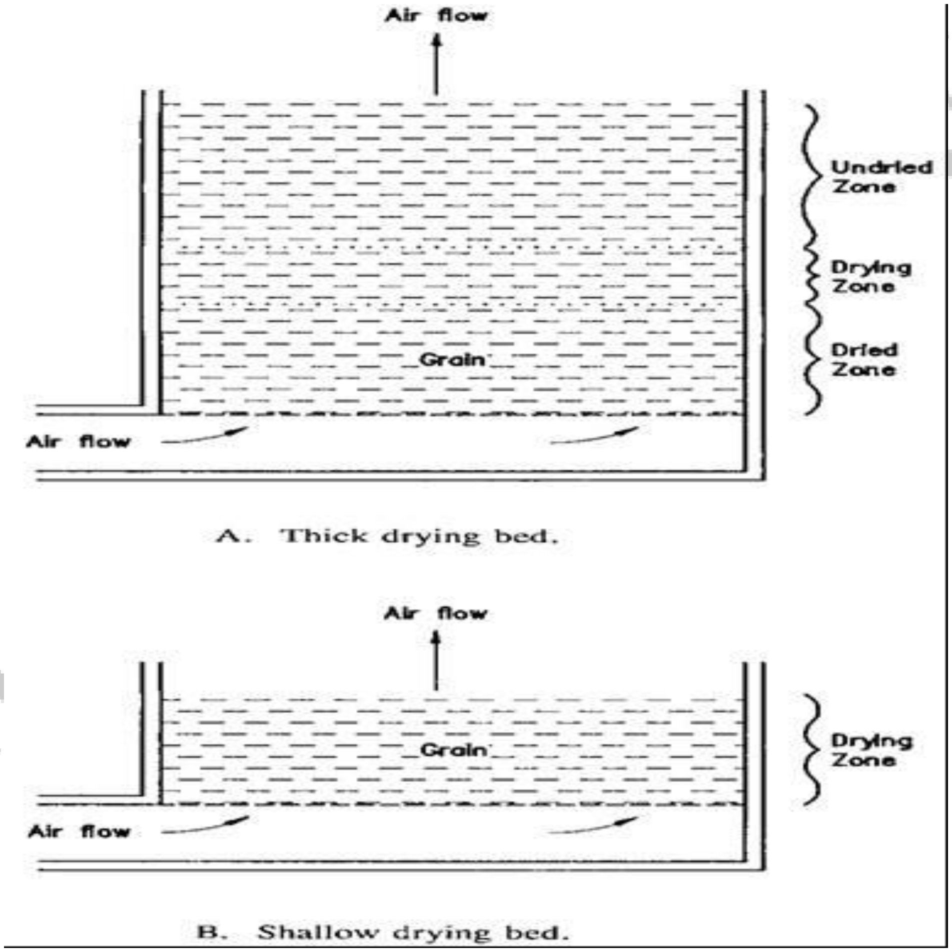
Grain Equilibrium Moisture Contents

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

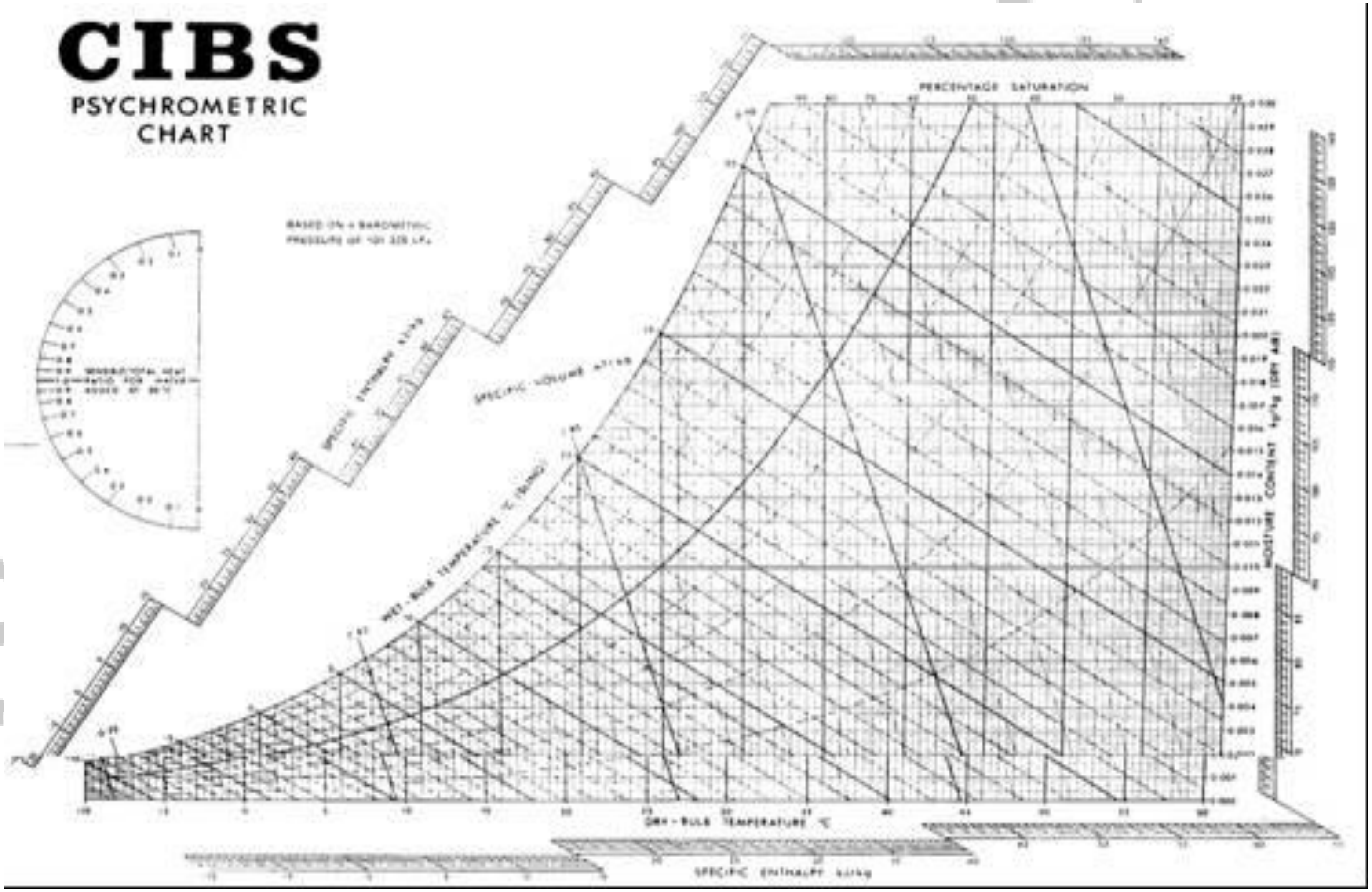
* wet basis

Source: Brooker *et al.* (1974)

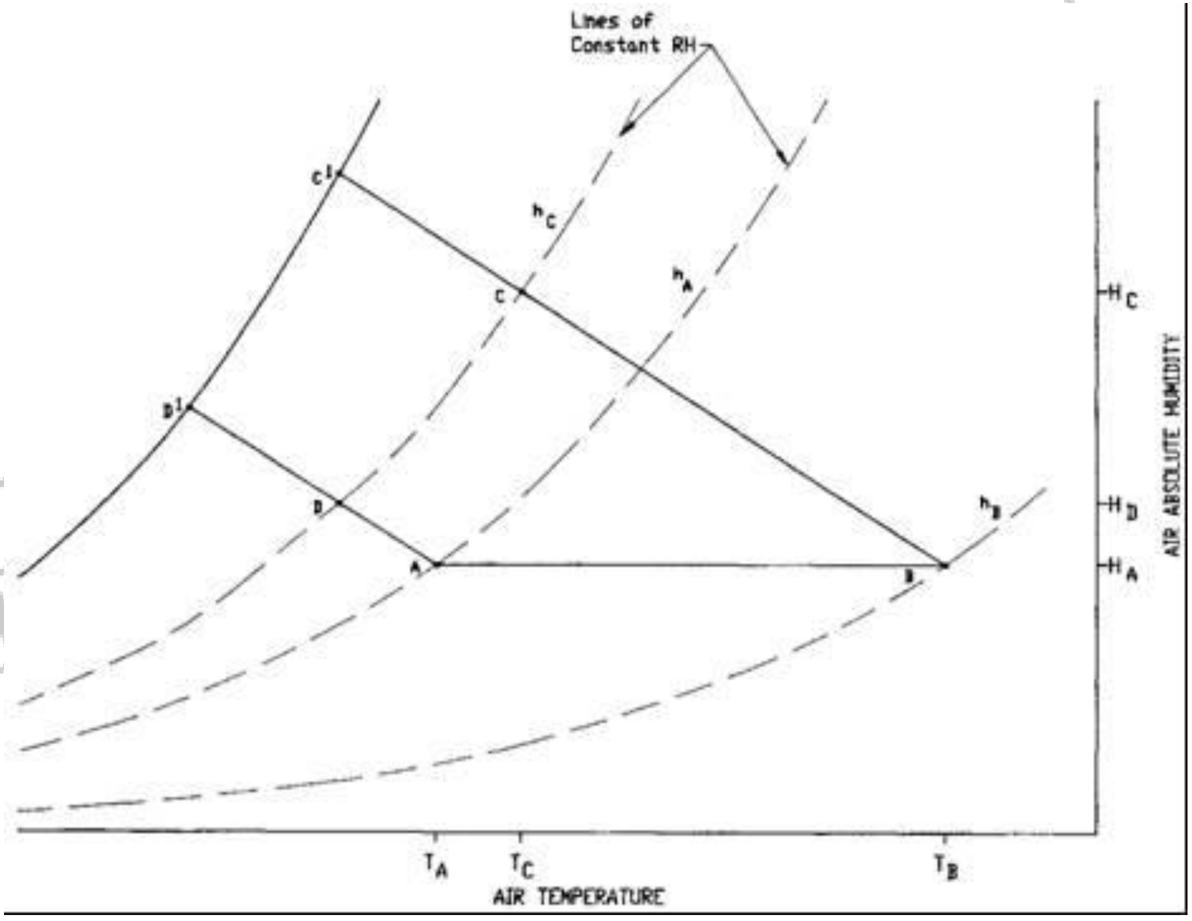
Drying Zone in Fixed-bed Drying



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

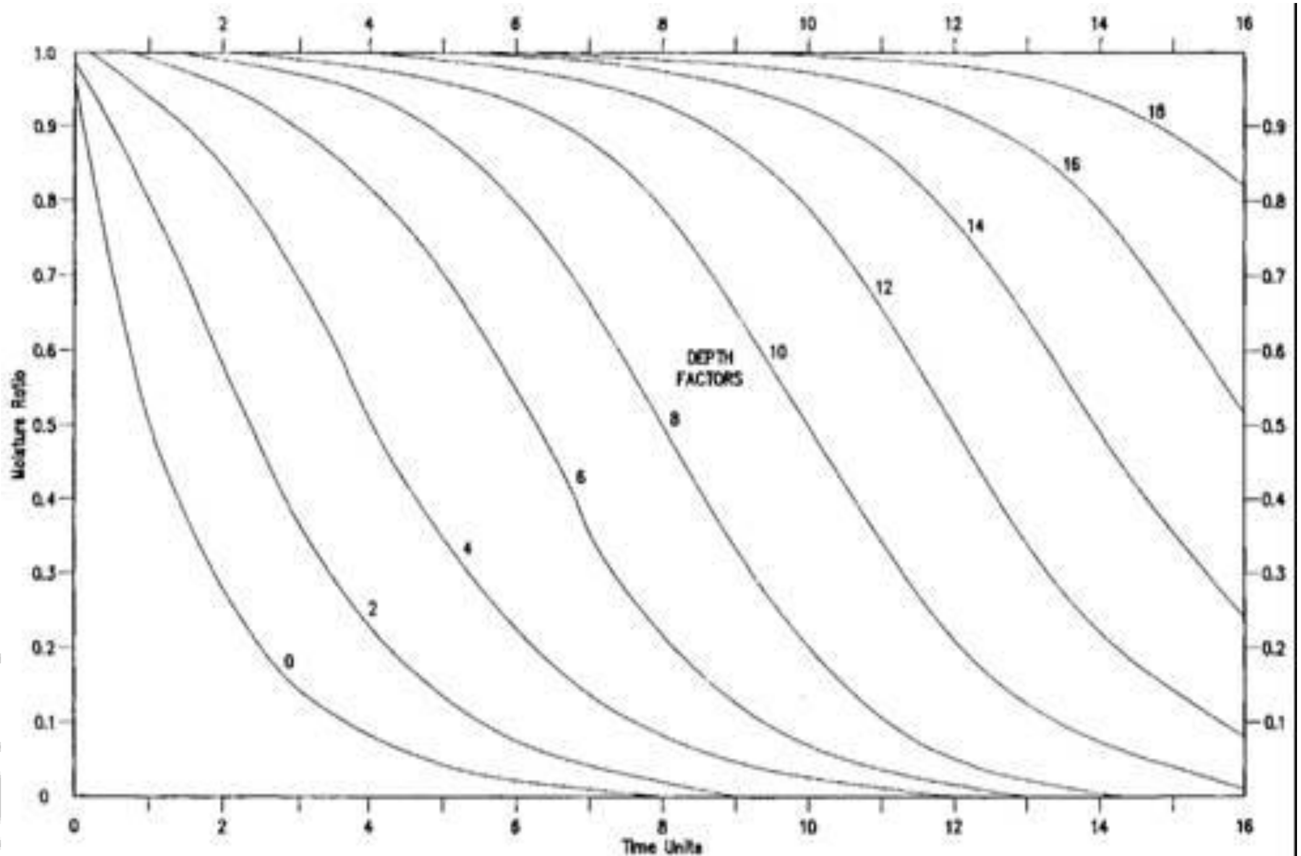


FIGURE 6: DIMENSIONLESS DRYING RATE CURVES

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

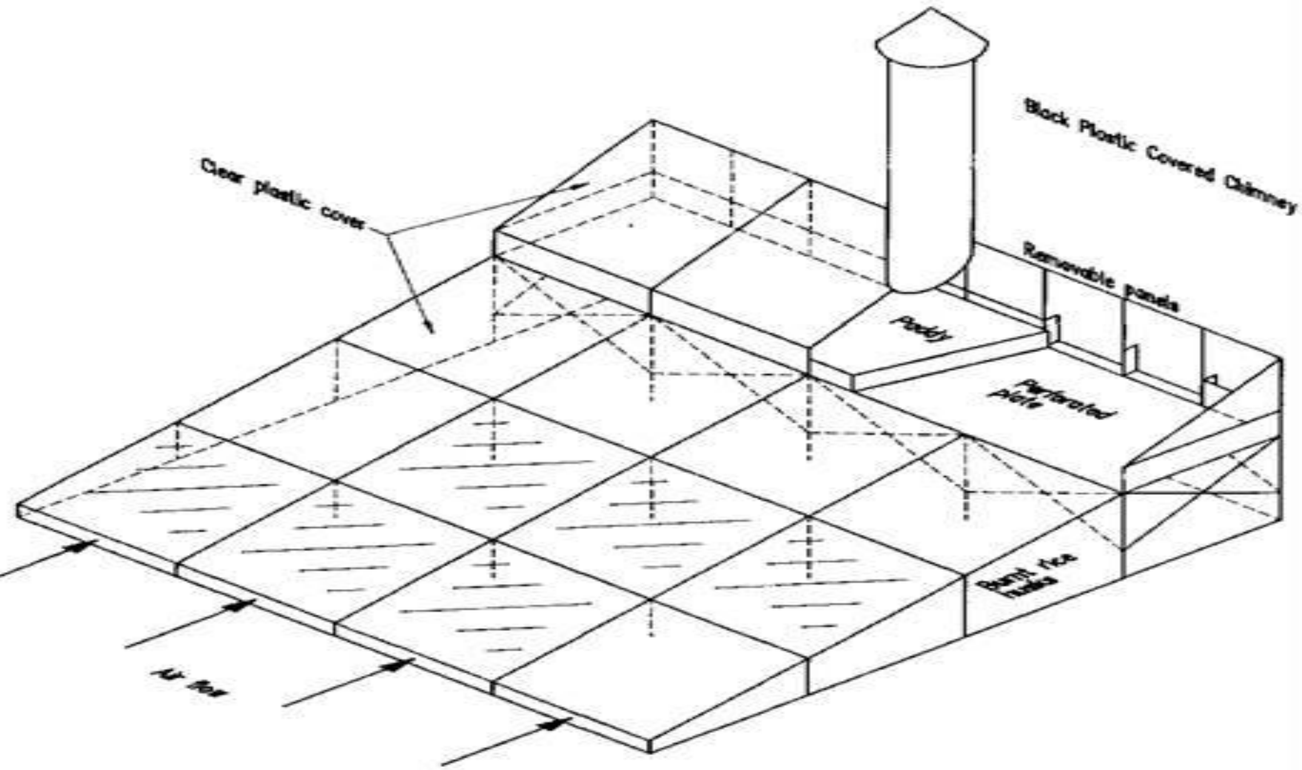
Mechanical Dryers

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

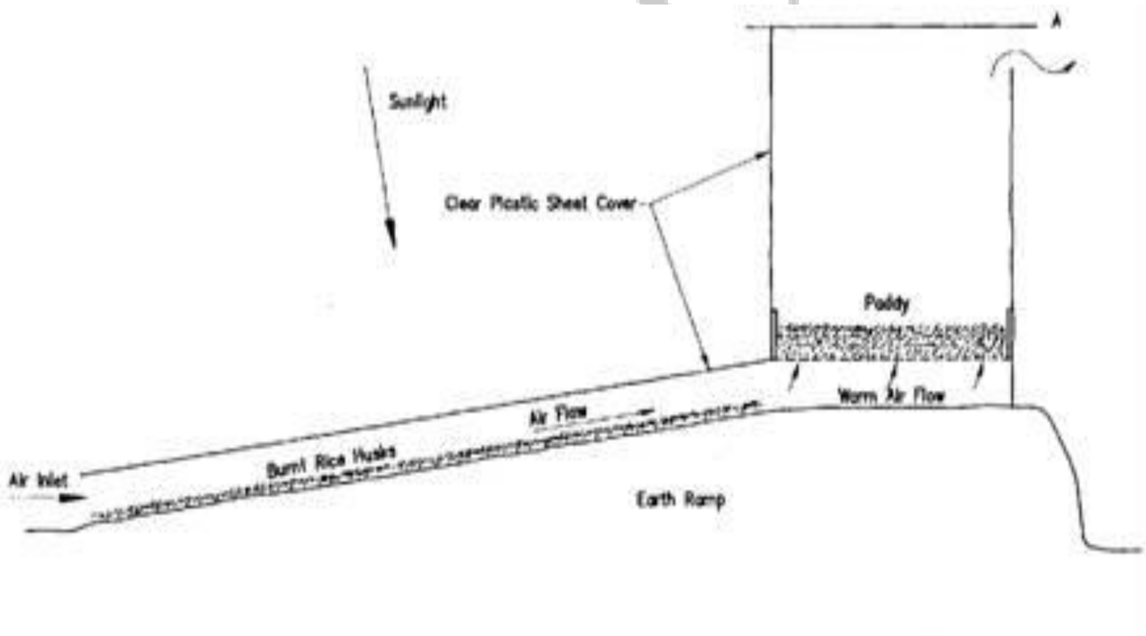
Drying Process and Equipment

Drying Process and Equipment Cont.

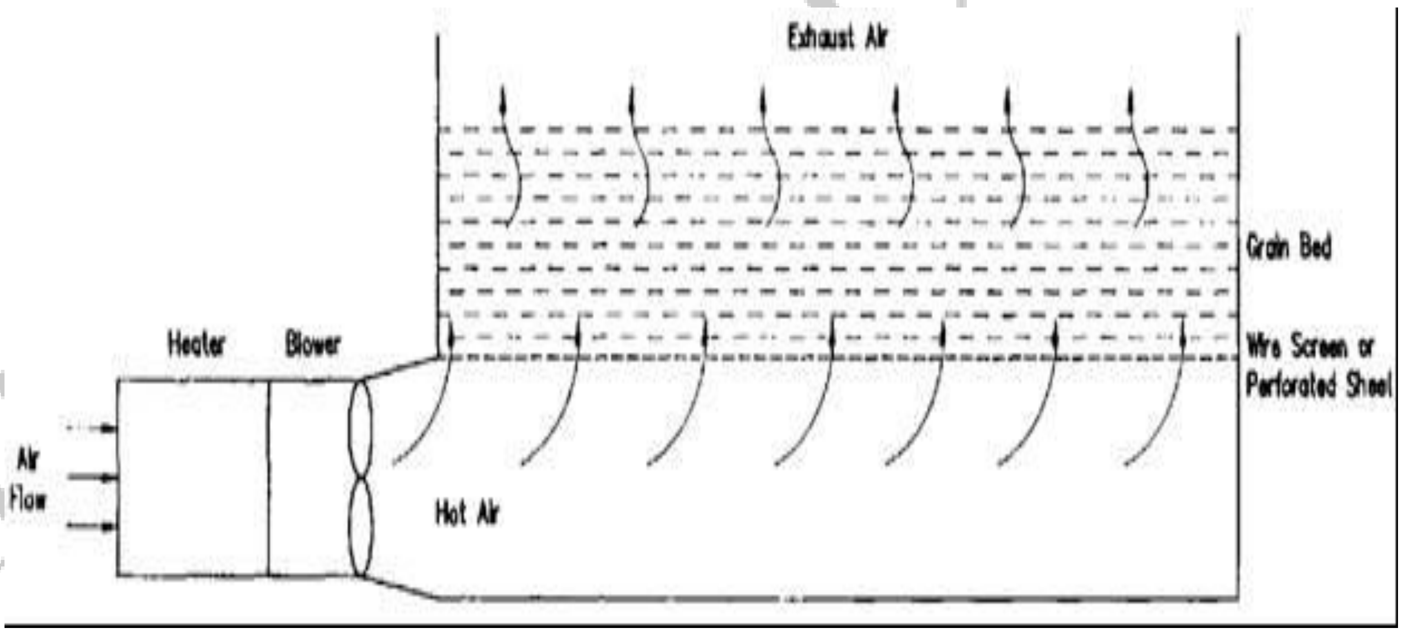
Natural Convection Solar dryer



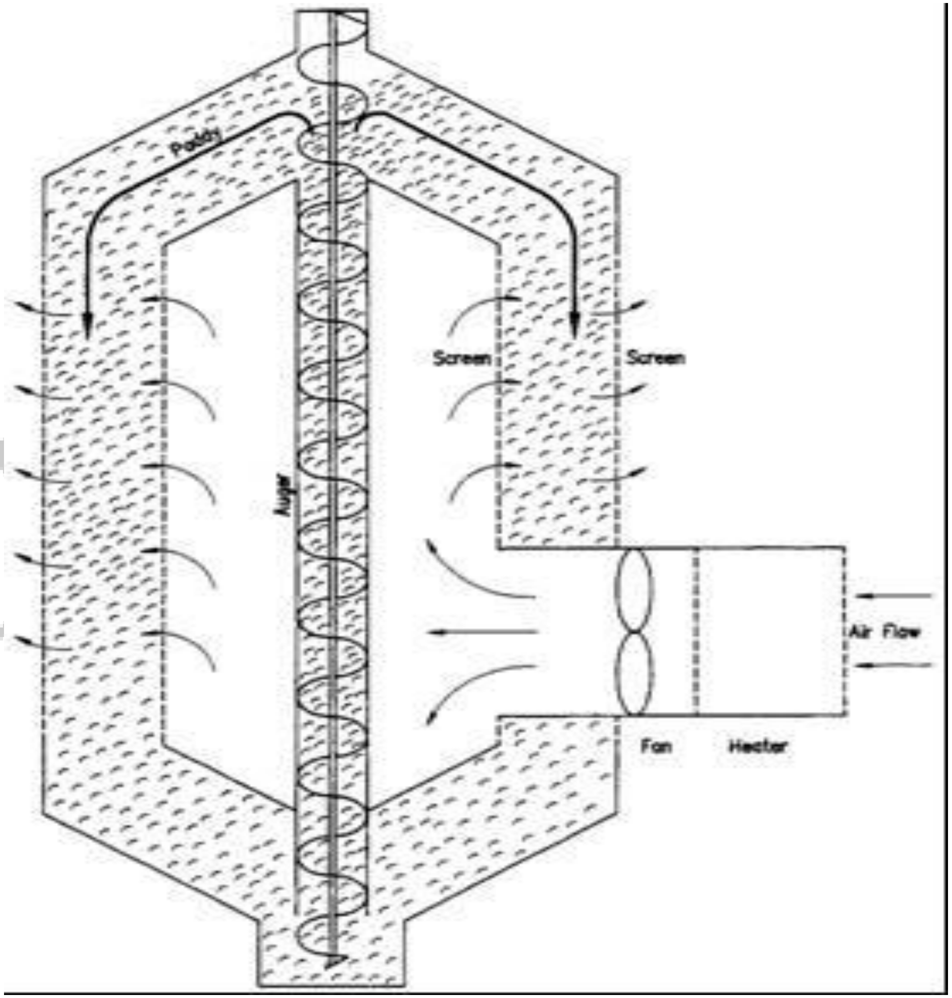
Small Scale Solar Dryer



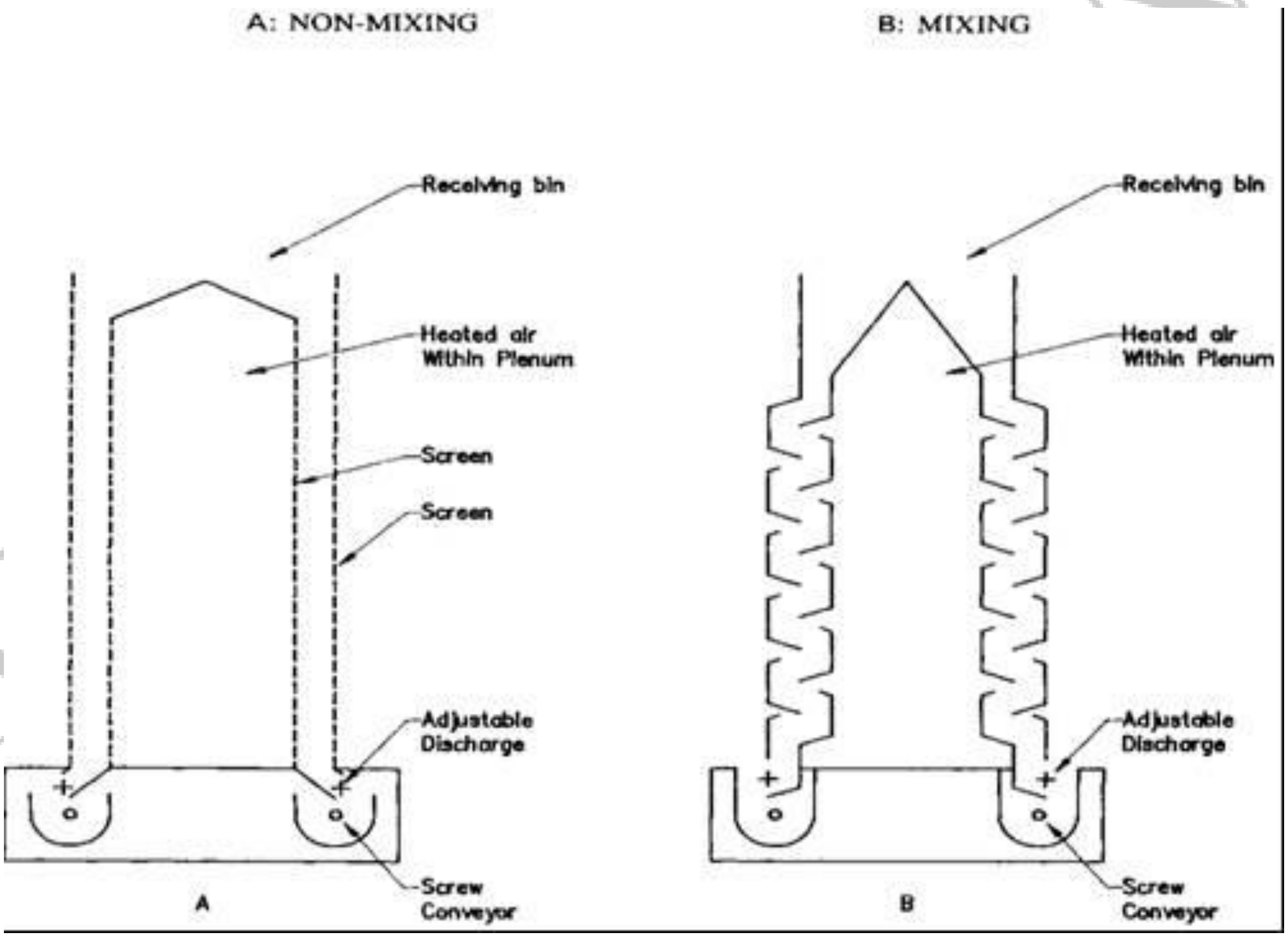
Flat Bed Dryer



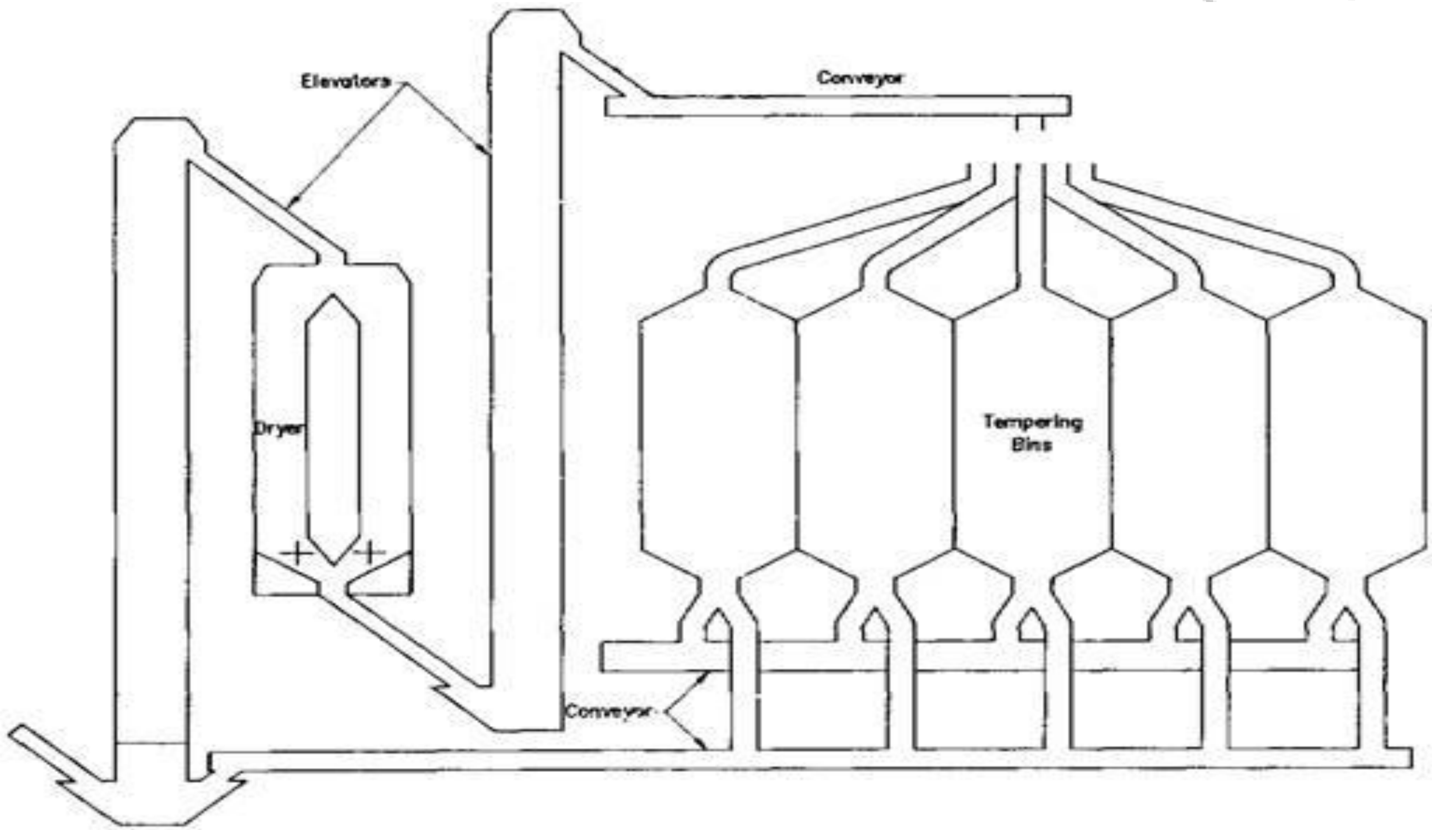
Re-circulating Batch Dryer



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 20° 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 5° C to -18° 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 -10° to -20° 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

SEED TREATMENT, PACKAGING AND PALLETIZING PROCESSES AND EQUIPMENT

By

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1. Seed Treatment

Seed treatments are defined as chemical or biological substances that are applied to seeds or vegetative propagation materials to control disease organisms, insects, or other pests

Merits

- Seed treatments is used on many crops to control a variety of pests. They are commonly used to ensure uniform stand establishment by protecting against soil borne pathogens and insects.
- Seed treatments have had phenomenal success in eradicating seed borne pathogens, such as smut or bunt, from wheat, barley, and oats.
- Seed treatments can be used to suppress root rots in certain crops.
- Some newer systemic seed treatments can supplement or may provide an alternative to traditional broadcast sprays of foliar fungicides or insecticides for certain early-season foliar diseases and insects.

Limitations

Although seed treatments have important benefits, they also pose certain risks.

- One risk is accidental exposure of workers who produce or apply seed treatments.
- Another risk is contamination of the food supply by accidental mixing of treated seed with food or feed grain.

Cont.

- A third risk is accidental contamination of the environment through improper handling of treated seeds or seed treatment chemicals.

Note: All of these risks can be minimized by proper training and proper use of seed treatment pesticides.

The ideal seed treatment should be:

(1) Very effective against seed-borne pathogens,

(2) Relatively nontoxic to animals and plants, even if misused,

(3) Effective for a long time during seed storage,

(4) Easy to use,

(5) Acceptable and

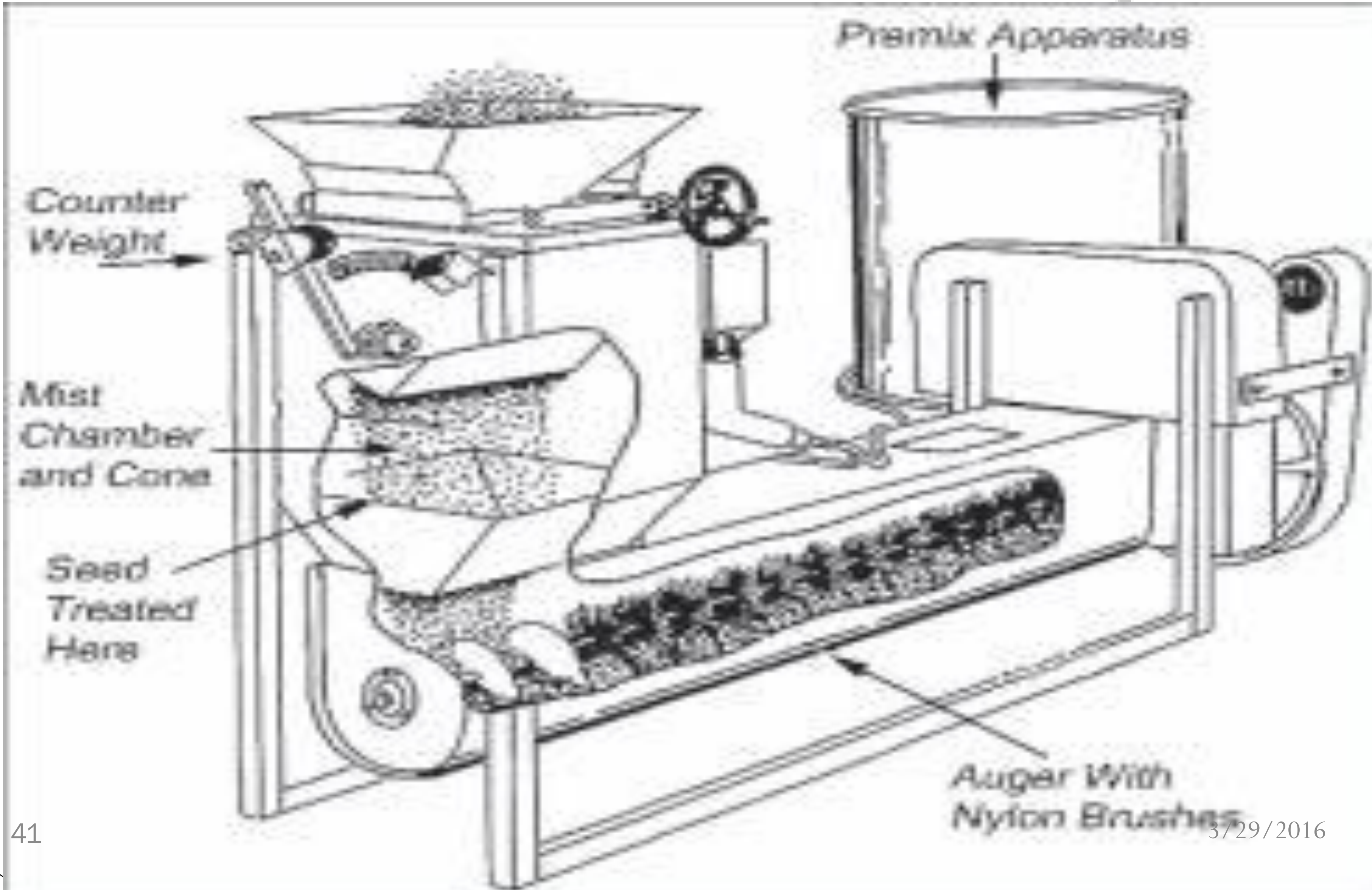
(6) Economical.

Note: The hot water treatment method meets many of these criteria. Though not as easy to use as chemical treatments, it can be more effective and is non-toxic.

Treated Seed

- Pesticide-treated seed must be stored in a dry, well ventilated location separate from untreated seed;
- It should never be stored in bulk storage bins that might also be used for edible grain storage.
- It should be stored in special multiwall (3- or 4-ply) or tightly woven bags. Some polyethylene or foil-lined bags are also good containers for treated seed.

Metered Seed treater



This Seed Treated With POISON
Treatment used: Disulfoton

Do not use for food, feed or oil purposes

2. PACKAGING

After processing and treating are completed, seeds are packaged into containers of specified net weight. Packaging or bagging is essentially the last operation in which seeds are handled in bulk flow.

The packaging consists of the following operations:

- ✓ Filling of seed bags to an exact weight.
- ✓ Placing leaflets in the seed bags regarding improved cultivation practices.
- ✓ Attaching labels, certification tags on the seed bags, and sewing of the bags.
- ✓ Storage/Shipment of seed bags.

PART I: THE PROCESS

What is meant by seed packaging?

- This is the placing of a counted or weighed sample of seeds into a container which is then hermetically (airtight) sealed ready for storage.

Why are seeds packaged?

- Seeds are packaged to prevent absorption of water from the atmosphere after drying, to keep each separate and prevent contamination of the seeds from insects and diseases.
- Other Reasons: Contain products, defining the amount the consumer will purchase; Protects products from contamination, from environmental damage and from theft; Facilitate transportation and storing of products; Carry information and colorful designs that make attractive displays.

When should seeds be packaged?

- The best time to package seeds is directly after the moisture content has been determined and found to be within the required limits for safe storage. Seeds will always show equilibrium between their moisture content and the relative humidity of the environment and therefore, if possible, seeds should be packaged into containers and hermetically sealed in the drying room or without delay on being removed from it.

How should seeds be packaged?

- Different containers and special equipment for sealing are available for the storage of seeds.
- Storage containers for base collections should be hermetically sealed and moisture-proof.
- Cans, bottles, and laminated aluminium foil containers are all acceptable for both base and active collections. The techniques used will vary with the type of container and the equipment that your gene bank is using. The general steps outlined in this section could be followed.
- Moveable racks make the best use of available space and are ideal to store containers in walk-in stores. Small containers or aluminium foil packets can be filed in boxes for ease of locating individual accessions. Coding systems by number or colour are also helpful in exactly locating accessions.

Types of Packaging

- Packaging materials are classified as rigid, semi-rigid and flexible, according to their consistency.
- Those that present some specific characteristic due to the type of product it contains or on its applications, are considered special packs.
- Rigid packs are produced in metal (steel and aluminum), glass, cardboard (flat

  and corrugated), wood, rigid plastics or ceramics, with the addition in some cases, of materials such as tinfoil, resinous or synthetic oils, paints and glues.
- Semi-rigid packs are plastic bottles and containers and mixed laminated materials.

With no reuse, discarded packs have an undesirable impact on the environment

THE PACKAGING PROCESS

- Prepare for Packing
- Package the Seeds
- Enter the data into the Data Files
- Check the Quality of the Containers

Step 1. Prepare for Packaging

- 1. Work in the drying room or, if not possible, expose the seeds to the ambient relative humidity for the shortest possible time.
- 2. Write on the outside of each container or on an adhesive waterproof label. Also prepare a label for inclusion with the seeds. Record the accession number, date of storage, genus and species if required. Use permanent markers for this.

Notes and Examples

- Adhesive labels can be used for the outside of containers, but they must be waterproof and remain adhesive for long periods at low temperatures.
- **Equipment**
- Labels
  Permanent markers
  Laminated aluminium foil containers, cans or bottles
  Machines for sealing
  Coarse balance
  Scoop/spoons

Step 2. Package the Seeds

- 1. Weigh out or count samples of seeds to fit the containers used in your gene bank.
- 2. Fill the labelled containers with the seeds. Add the label prepared for the inside.
- 3. Seal immediately, so that the moisture content of the seeds does not increase due to equilibration with ambient relative humidity.
- 4. Note the weight or number of seeds in each container.

Notes and Examples

- It is important that the containers used should be moisture-proof and sealed. The exact sealing technique will depend on the type of containers and sealing methods that are available.
- **Laminated aluminium foil bags** are easy to package, can be cut to size to save space and can be sealed again after use. However, they are difficult to stack and must be made of good quality material and have good seals or leakage may occur.

Step 2 Cont.

- **Cans** are rigid and easy to stack and usually will not break open if dropped. However, some types of cans are not resealable and therefore are expensive to use. A standard size can with only a few seeds inside wastes space in the store.
- **Glass bottles** can usually be sealed again and the amount of seed left is visible. However, a standard size will waste space and bottles are easily broken.
- Seeds can be packaged in bulk into **large containers and/or sub-samples** can be packaged separately into smaller containers. Although the initial packaging period is longer, sub-samples can then be removed quickly without having to remove the bulk of the accession from the store.

Step 3. Enter the Data into the Data Files

- 1. Enter the relevant data about each accession into the data file.

- 2. The data should include number of containers per accession, number or weight of seeds per container, type of container (if not standard) and the date of packaging.

Step 4. Check the Quality of the Containers

- 1. After sealing, make a visual examination of each container to make sure that there is no obvious damage and that the seals do not leak.
- 2. Any containers that are below standard should be replaced immediately.
- 3. At regular intervals the containers should be checked to see that they remain in good condition. It is suggested that this check should be carried out routinely once a year and that individual containers should also be checked whenever they are removed from the genebank.
- 4. If containers are found to have been leaking and the relative humidity of the store was not controlled, determine the seed moisture content.
- 5. If the moisture content has risen, dry the seeds back to the required moisture content level.
- 6. Enter the value of the new moisture content into the data files. Make a note that the seeds in that container have been held at increased moisture content for a limited period and dried again.
- 7. Check the inventory data file for the descriptor 'date of packaging' and make a list of any other accessions which were packaged in similar containers on the same day or one day before or after.

Step 4 Cont.

- 8. Check the containers on this list for leaks and poor condition and replace any that are faulty using the methods described above.
- 9. Remember that any containers removed from the cold store should be allowed to warm to room temperature before opening. This may take several hours especially with large volumes of seeds.
- **Notes and Examples**
- If any defective containers are found, it may indicate that containers made or sealed at the same time are also faulty or it may just be one faulty container or seal. Checking those packaged at the same time will show if the problem is widespread.

Summary of seed packaging in your gene bank

Fill in this table for your future reference:

Species	Type of container	Optimum number or weight of seeds/container	Sealing method

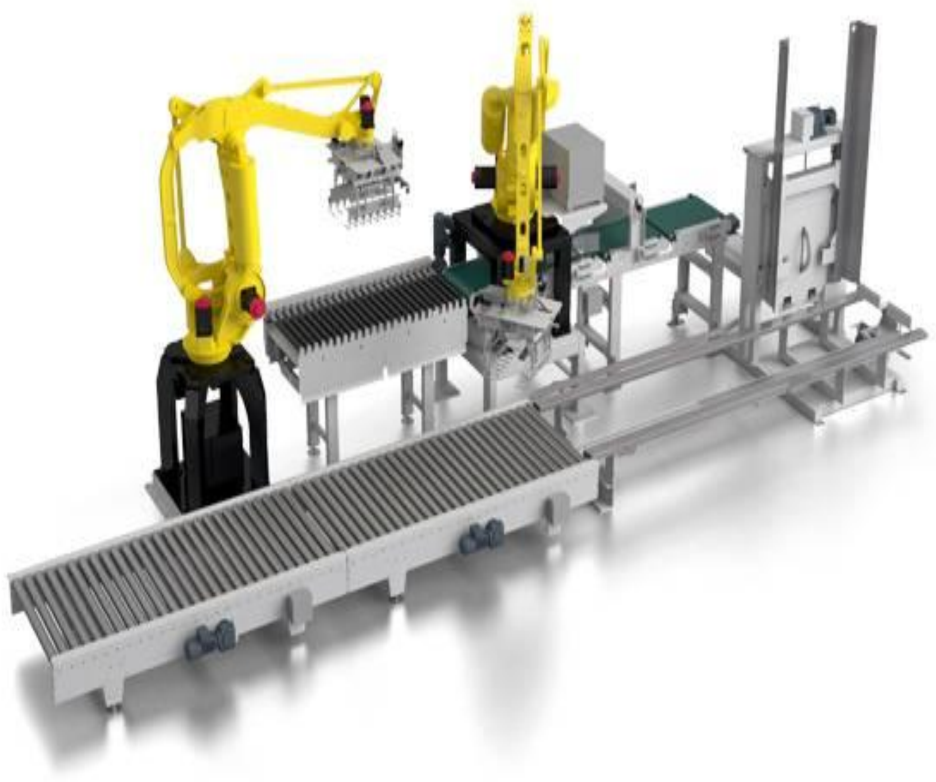
PACKAGING / BAGGING EQUIPMENT

- 1. **Bagger weigher**: These are small machines which when properly mounted beneath a bin will fill and weigh a bag accurately in a single operation. Bagger weigher and bagging scales used in seed packaging may be manual, semi-automatic or automatic.
- 2. **Bag sewing machine**: After an open-mouth bag is filled the bag top must be sewed with a bag sewing machine. Bag sewing machines are precision, high speed machines and must be operated and maintained properly to prevent frequent breakdowns and short operating life.
- 3. **Elevating and conveying equipment**: Several types of conveyors are available for moving seed into, through, or away from the processing plant in vertical, horizontal or inclined directions. Selection of conveyors that have adequate capacity, do little damage to seeds and are easy to clean and can have an important influence on processing effectiveness and efficiency.
- Conveyors used at processing plants can be classified as:
- 1. Bucket elevators 2. Belt conveyors
- 3. Vibrating conveyors 4. Pneumatic conveyors
- 5. Screw conveyors 6. Chain conveyors
- 7. Lift trucks.

Manual Bagger (by weight)

Open mouth bagger

HIGH SPEED ROBOT PALLETIZER



ATTACHING LABELS

- At the time of placing seed into bags, a label must be placed on each bag to maintain positive identity of the seed. When bags are closed with a bag sewing machine, a label or tag can be sewn to the bag.
-
- **Maximum lot size**: The maximum size of seed lot shall not exceed the limits. Each seed lot will be assigned a seed lot no. as specified in the Minimum Seed Certification Standards (MSCS).

The Steps / Parts

- ✓ Month-Year Code
- ✓ Production Location Code
- ✓ Processing Plant Code
- ✓ Seed Produce Code

FIRST PART

- This shall be called the "**Month-year code**" and will indicate the month and year in which the concerned seed crop was harvested. The month will be represented by its abbreviated form and the year will be represented by the last two digits of the calender year, such as 89 for 1989 A.D., 90 for 1990 A.D., 00 for 2000 A.D., 01 for 2001 A.D. and 10 for 2010 A.D.. The abbreviated form to be used each month is given as under:

Month	Abbreviated form
January	JAN
February	FEB
March	MAR
April	APR
May	MAY
Etc.	

SECOND AND THIRD PARTS

Second Part

- This shall be called the "**Production Location Code**" and will indicate the State, District, Sector, Territory, Province etc where the concerned seed field(s) was/were located.
- For this purpose, each State, District, Sector, Territory, Province etc is allotted a permanent numerical as shown below.

Numerical	Sector / District
01	Ngoma
02	Arusha
03	Kitale
04	Jinja
05	Mugesera

Third part

- This shall be called the "**Processing Plant Code**" and will indicate the seed processing plant where the relevant lot was processed. For this purpose, the certification department shall allot a number to each approved seed processing unit.

FOURTH PART

- This shall be called the "**Seed Produce Code**".
- It will indicate ultimate serial number of an individual lot.
- The procedure for assigning this code will be based on unit of certification.
- For this purpose, the Certification department shall allot a number commencing from 01 to each unit of certification.
- The seed produce code shall be commenced from 01 with effect from 01-04-2002 and it shall be continued for THREE financial years.

All the four parts of the lot number shall be written in series with a "dash (-)" between first, second, third and fourth parts to distinctly indicate the code number of each part.

AN EXAMPLE

Lot No: MAR11 – 22 – 10 – 01

- MAY 11 Seed harvested in May.2011
- 22-Seed crop raised in Nyanza
- 10- Seed processed in a processing plant identified as number 10 by the Nyanza District Certification Department.
- 01- Seed Produce Code that will trace to the particular unit of certification.

Note: Each seed lot under Certification shall be assigned a distinct number so as to facilitate in:

- Maintaining its identity
- Tracing back to its origin
- Handling in stores, transit etc.
- Accounting and inventory maintenance
- Referring / communicating about a certain quantity of seed.