Seed Drying

The process of elimination of moisture from the seed is called drying. Seed drying should reduce the seed moisture content to safe moisture limits to maintain its viability and vigour during storage, which may otherwise deteriorate quickly owing to mold growth, heating and enhanced microbial activity. Seed drying also permits early harvesting, long term storage of seeds, more efficient use of land and manpower, the use of plant stalks as green fodder and production of high quality seed.

Depending upon the climate and method of harvesting adopted the threshed seed may or may not be dry enough for safe storage. Under less favorable conditions, threshed seed needs further drying.

Stage of moisture elimination

The moisture from the seed is eliminated in 2 stages

1. Surface moisture of the seed that initially removed by the drying air.
2. The removal of the moisture in the surface cause an imbalance in the moisture potential in the surface of the seed and the inner portion of the seed which leads to the migration of moisture from the inner organ to the surface.

The migration of moisture to the surface is slower than the evaporation and a moisture gradient is developed in the kernal.

Elimination of moisture from the seed depends upon the relative humidity and temperature of the environment surrounding the seed. When RH of the atmosphere is less than the seed, moisture is eliminated from the seed. While drying, care should be taken to minimize /prevent oxidation and decomposition and volatilization. In this process there will be loss of dry weight of seed which is widened when the processes take place at high temperature. Hence, high moisture seeds should be dried at low temperature.

Equilibrium moisture content

A seed is in equilibrium with the environment when the rate of moisture loss from the seed to the surrounding atmosphere is equal to the rate of moisture gained by the seed from the atmosphere.

Drying temperature

Greater the seed moisture content lesser should be the drying temperature and vice versa.

10%	MC and below	110 ^{o} F (43.3^{o} C)
10-18 %	MC	100 ^{o} F (42.2 ^{o} C)
18-30 %	MC	90 ^{o} F (32.2 ^{o} F)

The rate of drying depends on

- Initial seed moisture content
- Size of the bin and capacity
- Depth of spread of seed
- The rate of air blow
- Atmosphere air temperature and relative humidity
- Static pressure
- Drying temperature

Methods of drying

I. Physical drying (or) natural drying (or) traditional sun drying

II. Mechanical (or) artificial drying

a) Drying with forced natural air

b) Drying with forced artificially heated air

c) Drying with desiccants

d) Drying with infrared rays

I. Physical drying / Natural drying / Traditional Sun drying

This is the common conventional method in which drying of the harvested crop is carried out in the field or threshing floor by the radiant energy of the sun. This does not involve any expenditure. To achieve uniform drying, the seed should be spread in thin layer. High moisture content seed with a moisture content of more than 17% should be dried first under shade / light to reduce the moisture content less than 17% and then dried under heavy sun i.e. noon drying. Sun dried seeds should not be allowed to remain open in the floor during night, since seed will absorb moisture from air. 2-4 days are needed to reduce the moisture content to 10-12%. Direct sunlight also can adversely affect seed germinability owing to high temperature and ultraviolet radiation, especially if the moisture content of the seed is high.

Advantages

1. Easy and cheap

2. Does not require any expenditure or fuel.

Disadvantages

1. The rate of drying is slow

2. Loss due to attack by insects, birds and animals

3. Large floor area is required

4. Involves extra labour for collecting and exposing during the day

5. Sun drying cause sun checks or hot spots due to variation in temperature from time to time. This checks or spots induce high amount of breakage while processing

6. mechanical admixtures are possible

7. Dust, dirt and other foreign materials get admixed

8. High weather risks and damage by heavy wind and rains

II. Mechanical drying or artificial drying

Forced air drying

In forced air drying, natural air or air supplemented with heat is blown through a layer of seed until drying is completed.

Generally ordinary seed godowns are provided with two types of ventilators for free movement of air circulation. In modern godowns, provisions are to be made for forcible circulation of air with the help of an electronic blower. The outside air which is comparatively dry is circulated in the godown and thereby the seed get dried up in this process. This is possible only in dry months.

Two types of driers are used: batch and continuous flow driers.

a) Batch dryers

In batch drier, relatively dry air is blown through a layer of seed until the seed is dried completely, after which it is removed and replaced by another batch of seed. The method is simple and well suited to small quantities of seed, allows easy cleaning and is recommended for farm drying.

In horizontal drier, the seed is contained in a box or chamber with a perforated floor through which the air is blown. Air ducts can be installed in a barn floor and the seed to be dried piled over them.

In a modified sack drier, seed contained in a woven sack is placed on a grid through which air is blown. A cylindrical storage bin with raised perforated floor arranged to blow air underneath the floor can also be used.

A vertical batch drier consists of two concentric perforated cylinders. The space between the two cylinders is filled with seed and air is blown into the inner cylinder from where it passes outward the seed. The size of the batch determines the drying rate.

In horizontal batch drier, the seed at the bottom dries first, with the dry zone extending gradually upward. The drying of the uppermost seed may be delayed unduly if the seed layer is too thick or the airflow is inadequate. The seed layer should not exceed a depth of 3m and for high moisture forage seed, it should be reduced to 1m or less. If the seed is dried in a storage bin, a layer of undried seed can be added on top of the dried batch and drying continued, but only if the seed is already fairly dry and air is not too hot. Seed loss also can be avoided by drying in

two stages. After the first batch has partially dried, the emerging air is passed through a second batch held in another chamber, repeating the process with second batch and so on.

The air blown through a batch must not be too hot, because the seed at the bottom may be overheated by direct exposure to the entering hot air. It is often not necessary to heat the air at all, and heating to less than 10^{o} C above the ambient temperature can be very effective, but on a hot humid day in the tropics even a few degrees above ambient temperature can harm the seeds. Dehumidifiers may need to be used under these circumstances.

An appropriate drying rate is very important. Too rapid drying may harm the seed because of the high drying temperature or a quick loss of water from the seed. Slow drying may mean maintaining a high moisture seed at a higher temperature for a prolonged time, resulting in deterioration of seed.

2) Continuous flow dryers

In this type of drier, the seed moves horizontally or vertically through a stream of hot air and then into a cooling chamber. These driers are however difficult to clean when there is a change of cultivar. These driers can use air temperature higher than those of batch dries, because the seed is heated for a much shorter time.

i) L.S.U. dryers (Louisiana State University dryers)

This is a continuous column heated air drier largely used for paddy. The paddy seeds are fed from the top with the help of gravity force in zig zag manner and heated air is blown from the bottom usually at right angles to the direction of seed motion. The falling seeds get dried up by the heated air and this process is repeated till to get a reduction of moisture content to the expected level.

ii) Non mixing column dryer

These dryers consist of a tall vertical column through which paddy flows by gravity. No provision is made for agitating the paddy as it flows and hence there is no attempt to drive the paddy from a straight path. Paddy descends gradually between two parallel screens and heated air is forced through the screens.

Advantages over bin dryers

1. Short drying period

2. Less damages or spoilage during wet weather

3. Drying is more uniform.

Advantages of mechanical drying

1. Quick method, timely and uniform drying is possible

2. Makes early harvest possible

3. It reduces the chances of losses due to over ripening and shattering of seed

4. Losses due to rodents and birds are prevented.

5. Less damage during processing operation.

6. Permits long time storage by preventing sun checks and other damages.

Disadvantages

1. Initial cost of drying the equipment is high

2. Fuel is expensive

3. It produces possible fire hazards

4. Considerable supervision is necessary.

Storage structures for Seed drying

Building requirements for a seed drying system depend upon the size of operation, the number of different seeds to be dried, the level of mechanization desired and future expansion. Different types and forms of storage structures can be built for handling seeds to be dried with forced air. These may be made of steel, wood, plywood or concrete and they may be cylindrical or rectangular in shape.

Regardless of the type of structure, all storage bins used for forced air drying in storage of seeds must have the following features.

1. Small grain seeds in bulk exert large pressures against the sidewalls. The side pressures are converted to a vertical load on the foundation, which should be strong enough to hold the seed lots.
2. The roof and walls of bins must be airtight for drying to proceed satisfactorily.
3. The openings for filling and removal of seed should be large and convenient to use. A full size entrance door is desirable.
4. A hand space about 1 m should be provided for easy inspection of seed. Cleaning and spraying operations should be convenient. For fumigation, the structures should be airtight, with a provision for temporary sealing of all openings.
5. The structure should be able to dry and store more than one kind of seed.
6. The dryingair should be uniformly distributed through all portions of the seed lot for efficient drying.
7. Theflow of air leaving the seed should proceed rapidly so that back pressures do not hinder the flow of drying into the seed.

Air-Distribution Systems

Agrawal described three types of air-distribution systems used for seed drying.

a) The main and lateral duct system b) a single central perforated duct and c) the perforated false floor system.

Multiple bin storage structures for drying can be built so that they are arranged to enable the drying of several seed lots simultaneously using the same drying fans. Alternatively, different seed lots can be dried successively with sliding air gates controlling the flow of air to the respective bins. A multiple bin arrangement is particularly useful to dry more than one kind of seed simultaneously.

Heated air drying system

Heated air driers consist of (a) a heater unit where fuel is burned and (b) a

fan to force the heated air through a canvas connecting duct into the air distribution system of the drying bin. Safety features such as automatic thermostatic high limit temperature control, which cuts off the burner flame if the air temperature exceeds a certain safe maximum and flame failure control, which automatically cuts off fuel flow to the burner if the flame goes out are provided. A thermostat can also automatically maintain the air temperature at a desired setting. In many driers, such thermostats are provided as a standard feature.

Two main types of driers are available, which differ in the manner heat is supplied to the air. Direct fired and indirect fired. In a direct fired drier, the fuel is burned and the hot combustion gases are thrown directly into the air distribution system. Although the heat is used very efficiently, there is possibility of blowing soot, unburned fuel and objectionable fumes into the seed. The burner, therefore, needs to be adjusted properly to burn the fuel completely. With certain fuels, there is also a danger of blowing small sparks into the seed.

In indirect fired driers, the hot combustion gases pass into a chamber. The drying air circulates around this chamber and picks up heat as in a hot air furnace. The drying air thus does not include combustion gases, sparks, soot or fumes. These driers are less efficient in the use of heat, but are safer than direct fired types.

The driers are designed to burn various types of fuels (eg. liquid propane or butane, natural gas, fuel oil and coal. Both liquid propane and natural gas burn readily with minimum soot and are the best fuels for direct driers and kerosene oil is better for indirect fired driers.

Two important aspects that must be considered while calculating the requirements of a suitable to crop drier are the required air flow volume and the heat capacity (BTU/hr) for drying seeds at the specified desired rate. The fan requirements can be computed by knowing the total air flow at the static pressure of the seed at a given drying depth and heater requirement are estimated by calculating the amount of water to be removed from the seed per hour. Based on these calculations, a suitable crop drier can be selected to provide a minimum required airflow volume(bin capacity x air flow rate) and heat capacity in BTU/hr.

Agrawal categorized types of heated driers as layer-in -bin, batch-in-bin, batch and continuous driers and described their functions.

Stirring devices keep the seed in a loose fill condition, allowing easy airflow through the bottom layers. Such mechanisms alleviate the problems of uneven drying (or over drying) by breaking up pockets of fires and trash and blending the seed by constant mixing.

Large differences in the degree of drying between the top and bottom layers of seed have been noticed during drying by heated air. It is therefore, advisable to dry seed at shallow depths to minimize these differences and avoid overheating of the bottom layer. Agrawal recommended maximum seed depths and temperatures for batch drying of seeds of different crop species in bins.

Crop seed	Maximum depth (cm)	Recommended maximum temperature (^{0}C)
Shelled corn	50.8 (20 in)	43.3 (110 ^{o} F)
Wheat	50.8 (20 in)	43.3 (110 ^{o} F)
Barely	50.8 (20 in)	40.4 (105 ^{o} F)
Oats	91.4 (36 in)	43.3 (110 ^{o} F)
Rice	45.7 (18 in)	43.3 (110 ^{o} F)
Soyabean	50.8 (20 in)	43.3 (110 ^{o} F)
Peanuts	152.4 (60 in)	32.2 (90 ^{o} F)
Grain Sorghum	50.8 (20 in)	43.3 (110 ^{o} F)

Heated air drying requires higher rates of airflow, because water is evaporated faster and more air is needed to carry it away. The higher air flow rate also ensures more uniform drying of the top and bottom layers of the seed, completing the drying much faster at the recommended temperatures.

The general procedure for bin drying of seeds with heated air consists of charging seed into the bin to the recommended depth. The drier is operated at the recommended temperature of the seed using either manual or thermostatic controls to set the desired temperature. After drying is completed, blowing of the air

through the seed is continued for sometime without heat to bring the seed to an ambient temperature.

Some variations of batch drying with heated air include wagon drying, bag drying and box drying. In wagon drying, the seed is loaded directly onto a wagon especially constructed for drying. The wagon is then drawn to the drier unit and connected with a canvas distribution duct. Forcing the air up through the perforations in the wagon floor dries the seed. After drying, the wagon is disconnected from the canvas duct and the seed is cooled with a fan towed to the storage bins. Wagon drying provides continuous drying, vwrsatality, easy cleaning and low initial cost.

Bag drying is another suitable variation to handle several varieties of smaller quantities of seed simultaneously. Seed received in jute bags is exposed to airflow with minimum static pressure, because the drying bed is only one sack deep. Typical design criteria provide 25 - 40m^3 of air/min/m^3 seed at a static pressure of 3cm less. The construction is simple and inexpensive.

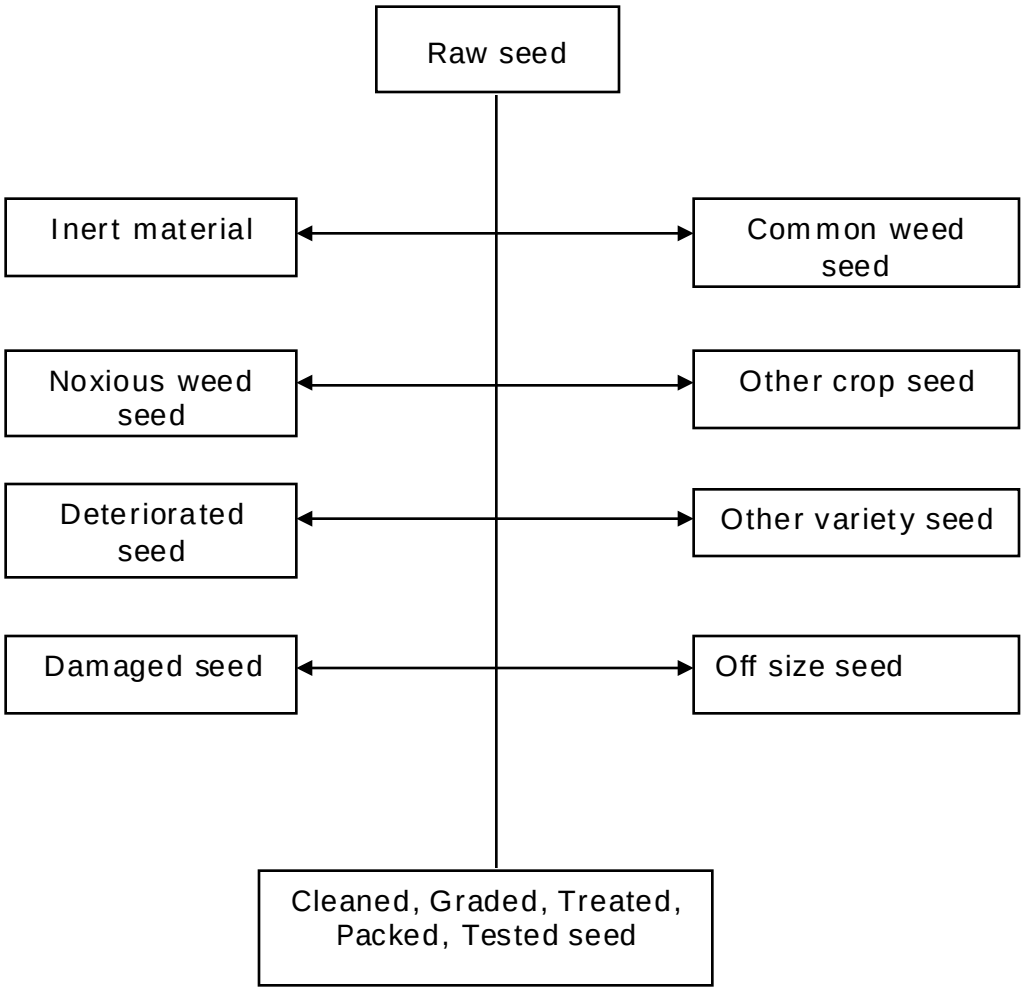
A box drier is modified bag drier well adopted to dry smaller quantities of basic or foundation seed. With box driers, it is possible to maintain the identity of small seed lots despite handling. The boxes can be constructed of locally available materials, which are fitted with perforated metal or woven wire bottoms.

Tempering

Seed is usually dried in stages with heated air each stage consisting of a pass through the drier. Between passes the seed is stored in bins for an equilibrium period known as tempering period. This period of tempering shortens the total drying time. During drying, surface moisture is removed and internal moisture moves towards the surface are slower than evaporation, and a moisture gradient develops in the kernel. The outside becomes drier than the inside and evaporation rate decreased. During tempering moisture concentration equalizes in the kernel and then evaporation of surface moisture is nearly as rapid as at the start of drying.

SEED PROCESSING

Seed lots received from the field are often at high moisture content and contain trash and other inert material, weed seeds, deteriorated and damaged seeds, off-size seeds, etc. Seed processing is necessary in order to dry the seeds to safe moisture level; remove or reduce to the extent possible the various undesirable material, weed seeds, other crop seeds, deteriorated or damaged seeds.



Other than this the seed lot heterogeneity in its physical characters like size, colour, shape etc. The seed lot is heterogeneous due to the following reasons

1. The soil is heterogeneous and there is a lot of variability in the fertility status of the soil due to the availability of nutrients, physical, chemical and biological properties.
2. Variability is introduced due to the position of seed set on the plant/fruit , time of pollination and fertilization over a period of time
3. Variability is created by biotic factors like pest and variability infestation.
4. Variability is also due to the management practices like water, land preparation, leveling, staggered sowing, and uneven distribution of fertilizer and irrigation water, uneven plant protection sprays and uneven maturity at harvest.

The inherent qualities such as germinability and vigour are exemplified by certain physical characteristics of the seed i.e., large size, a denser seed, optimum length etc., So, if grading is done to obtain a particular range of size, shape, length and density of the seeds, the quality of the lot is upgraded.

In its common usage in India, seed processing refers to all the steps necessary for preparation of harvested seed for marketing, namely, handling, drying, shelling, preconditioning cleaning, size grading, treating and packaging, etc.

Seed Processing Plant Layout Planning

Layout plan for construction of a seed processing plant should be carefully planned to ensure that the thorough seed cleaning, upgrading, seed treatment and other seed processing operations are carried out efficiently, without mixing and damaging seed lots, with a minimum of equipment, personnel, time and at minimum cost. The following factors should be considered in planning and designing a seed processing plant:

1. Kinds of crop seeds to be handled and kinds of contaminating crop and weed seeds usually present in the seed lots
2. Size of operation
3. Whether drying facilities should be required
4. Selection of suitable equipment
5. Location of the plant
6. Source of power for running machinery
7. System of seed delivery to processing plant and
8. Availability of labour

The key to efficient plant layout is a thorough knowledge of what needs to be done, and sound planning. First, the general sequence of processes involved between the time seeds enter the processing plant and the time they are cleaned, packaged and ready for shipment, must be charted. The sequence of operations depends upon the kind of crop and the initial quality of seed lot, type of contaminants, moisture content of the seed lot, etc. The layout planner must have an intimate knowledge of the seed to be processed, its physical characteristics, the contaminants in it, and also of the selection of machines used to bring the seed to acceptable marketing standards.

Seed Processing Plant Building Layout

Seed processing plant building will comprise of following components:

1. Receiving-cum-drying platform
2. Processing area
3. Auxiliary building

Receiving-cum-drying platform

This area will be utilized to receive the raw seed and to sun dry small lots of crop seeds. This area can also be utilized for storage of seeds on wooden

palettes. The platform will be connected to processing shed through a rolling shutter.

Processing area

The processing area should be situated between the shed and ventilated storage building. The hall should be connected to ventilated flat stores through a covered gallery for easy movement of processed and packaged seed to seed stores. The hall should have a big rolling shutter in the processing plant to permit entry of seed processing equipment into the hall for installation.

Height will be kept to facilitate installation of the seed processing equipment and machinery. A sequence of processing machines to be installed is shown in Fig. 1. Floor of the processing hall should be above the ground level.

The shed should have sufficient provision for natural as well as forced ventilation in order to maintain congenial atmosphere inside the shed. The shed should accommodate seed scalping, seed processing and packaging equipment and will have sufficient space for weighing and packaging.

Auxiliary building

In addition to building discussed above, a provision should be made for generator room. Sufficient length of road should be provided to connect various functional buildings with each other and main highway. Boundary wall should be provided all around the complex for security reasons. Entire complex should have a good drainage system.

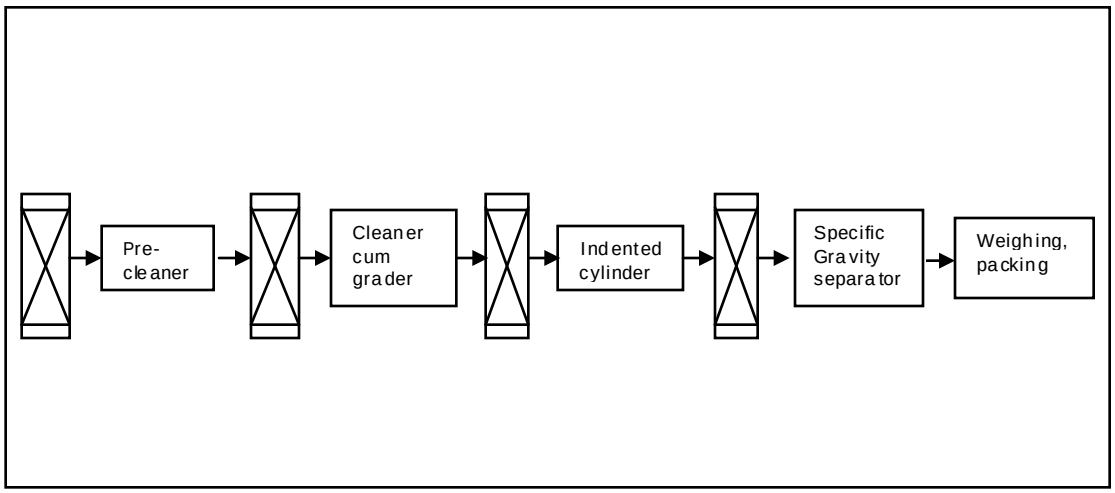
Provision for firefighting equipment such as extinguishers, water buckets, sand buckets etc. should be made to fight minor fire hazards.

The processing plant building should be constructed as per CPWD/PWD norms. It should have tubular trusses, AC sheets pitched hole roof, cement concrete flooring finished with water-proofing cement paint, aerated, ventilated, rat proof and bird protection. Sealed doors should be provided in

these buildings. Buildings will be suitably planned to have interconnection for movement of seeds and materials.

Analysis of Operation

a) Processing sequence: After the machines needed have been identified, the next step is to determine the proper processing sequence. The seed separators, elevators, conveyors and storage bins should be so arranged that seeds flow continuously from beginning to end, and yet be flexible enough to bypass a machine or return to a part for re-cleaning.



b) Matching capacity: Equipment size of capacity must be carefully planned to prevent bottlenecks. When the overall operating capacity needs have been determined, all machines must be able to handle that capacity with some reserve capacity for problem lots. Surge bins can handle variations in individual machine capacities. But when differences are great, either larger models, or more than one machine installed in parallel flow, must be used to maintain uninterrupted flow.

c) Conveying: The type of conveying system is also a very important factor. The conveying system must be able to handle the capacity needed in a particular spot. And it must be carefully adapted to the seed handled.

Type of Layouts

There are three main types of processing plant layouts: multistorey, single level and combination.

Multistorey: In this system, seed is carried by elevators to the top floor and emptied into large bins. Cleaning machines are then arranged in a vertical series on the lower floors. Seed flows from one machine down into the next by gravity.

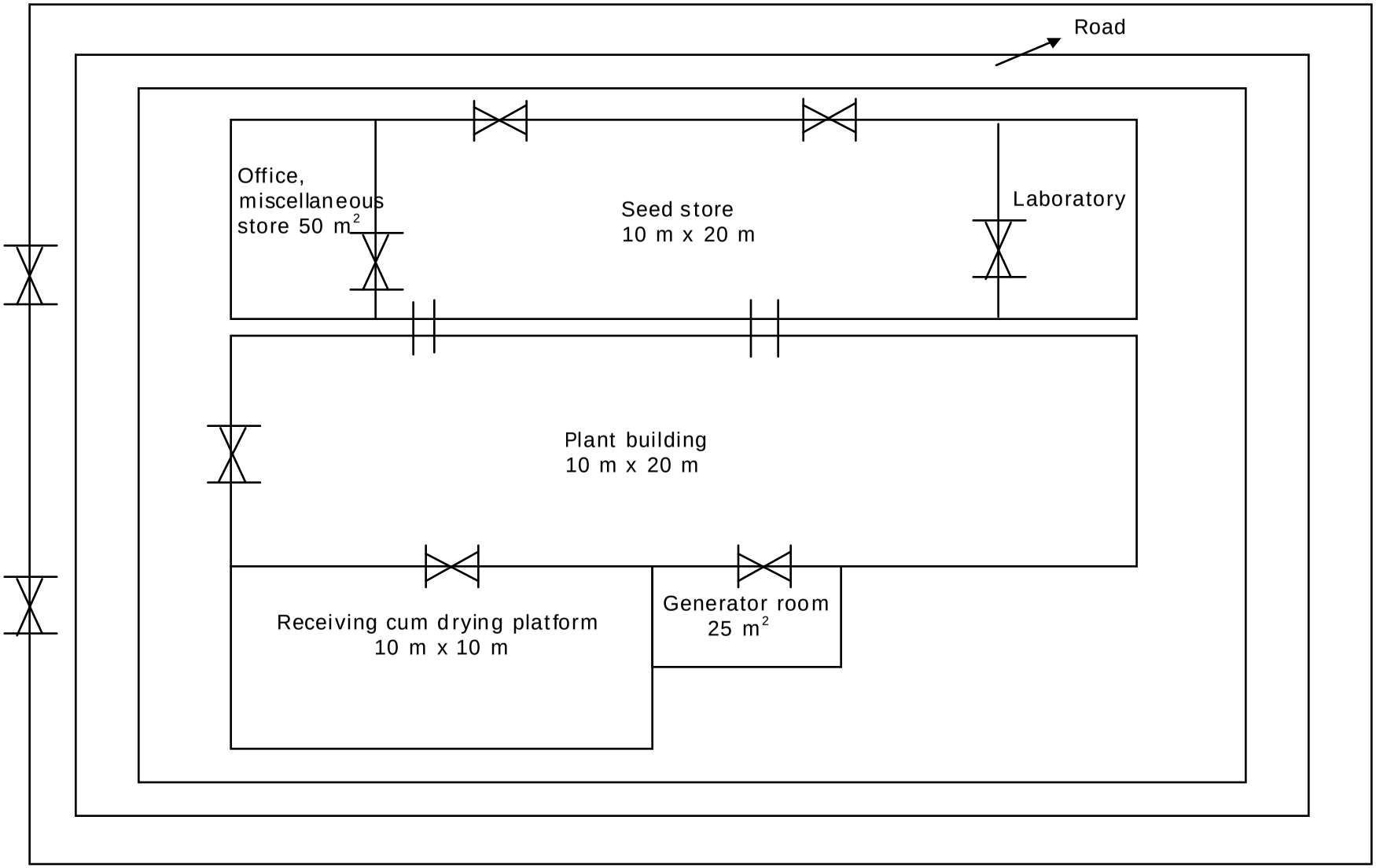
Single level: In the single storey plant, seed is moved from one machine to the next by elevators placed between the machines. A great advantage of the single level system is that one man can supervise the processing line without running up and downstairs. He can thus maintain closer supervision of all operations.

Combined designs: A compromise between the single and multistorey system could also be adapted.

Planning

After the proper machines, elevator capacities, cleaning sequences, and lay out design have been selected, detailed layout planning can begin. Careful layout planning can identify and remedy bottlenecks and trouble spots before the plant is built, and thus prevent trouble later.

As the lay out or design develops, it should be drawn on paper. A good method is to draw lines of flow first and then convert these flow lines into machine lines. After appropriate revisions, detailed drawings can be made to show exact locations of equipment and distances. Scale drawings are the most widely used method of layout planning. Scale models and scale templates are also very effective, but are more expensive.



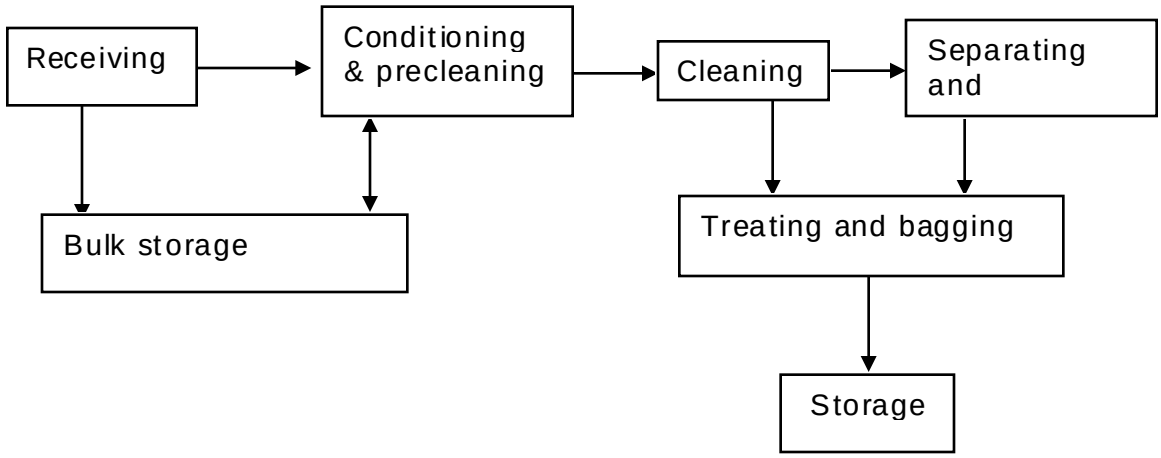
Building layout plan

Requirements in seed processing

1. There should be complete separation
2. Minimum seed loss
3. Upgrading should be possible for any particular quality
4. Efficiency
5. It should have only minimum requirement

Movement of seed in a processing plant

Handling of seed at the processing plant adheres to a definite path irrespective of crop for easy management of seed which is sensitive at each and every step of handling and ready to lose or gain its quality all through the steps.



Physical characteristics used to separate seeds are

1. Size grader : Based on size it can be separated with air screen cleaner cum
2. Length : Disc or indented cylinder separator
3. Weight : Specific gravity separator
4. Shape : Spiral separator or draper separator for round and flat seeds
5. Surface texture : Rough from smooth surface seed- dodder mill

6. Colour : Electronic colour separator

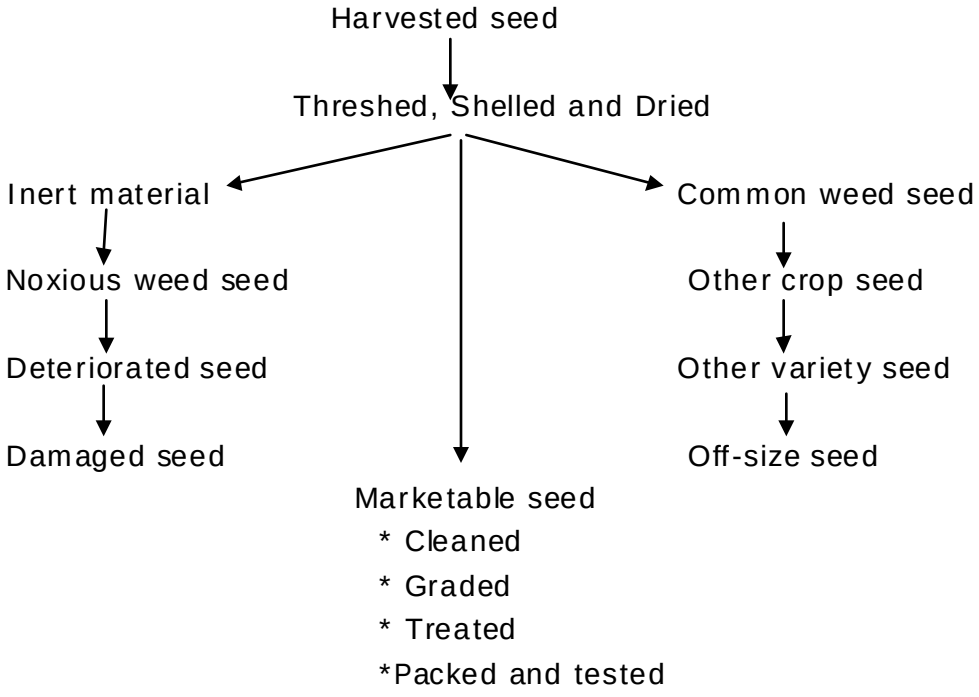
7. Electrical conductivity

Seed differing in their ability to conduct electrical charge can be separated with electronic separator.

8. Affinity to liquid

The seed coat of seed will absorb water, oils etc., which provides a means of separating seed on the magnetic separator.

The flow charts illustrating the types of materials removed from harvested produce during processing.

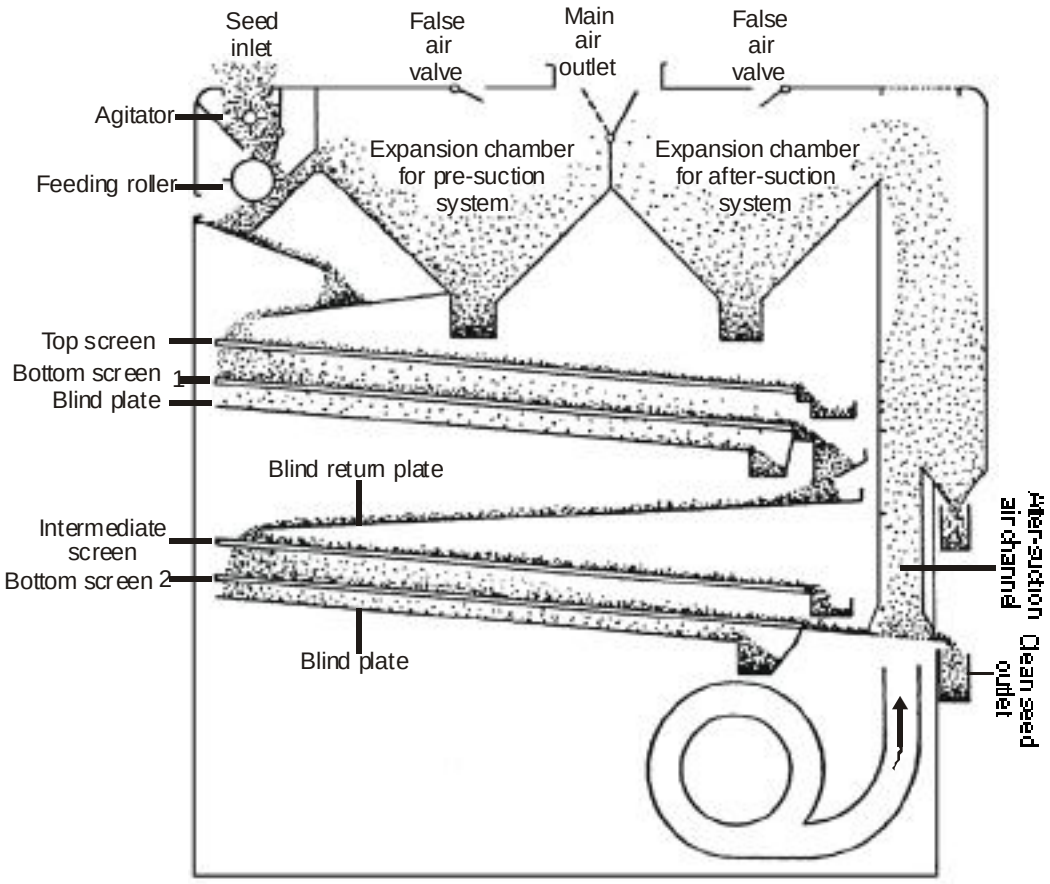


Seed processing equipments

I. Air screen cleaner

This is the most important machine of every cleaning plant. It uses screens and aspiration (air blow) for two separations (Fig.6). A coarse upper screen removes larger material, a lower fine screen stops the seeds and lets through fine matter and then the seed fraction passes through a transverse or nearly vertical air stream which can separate light impurities such as

empty or partly filled seeds, husks and glumes from the seed. In most cases a number of sieves with different sized perforations are used and the cleaning is a process of gradually shifting out smaller particles. Factors which determine the quality and quantity of seed cleaned include (i) size of the perforations, (ii) the precision of the perforation, (iii) the angle at which the sieves operate, (iv) the amplitude and speed of movement of the sieves and (v) correct cleaning and maintenance of the equipment.



II. Cleaner cum grader

The dried seeds should be cleaned and graded with help of a cleaner cum grader. For large scale cleaning and grading the commonly available machine is the “Crippen Model Seed Cleaner cum Grader”.

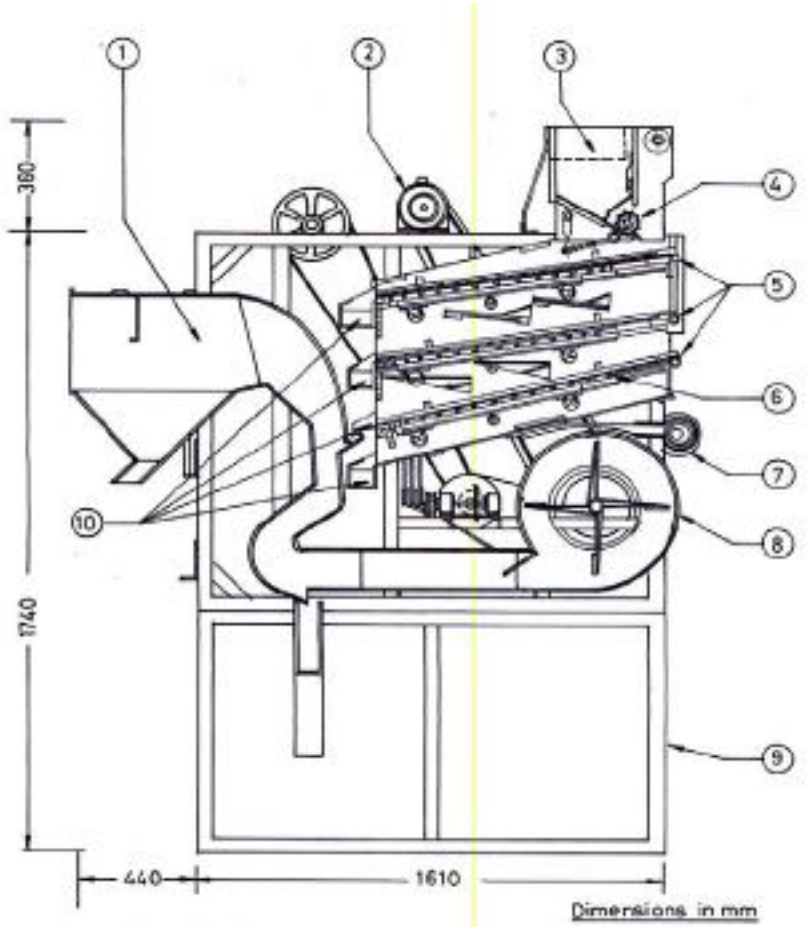
It consists of the following parts

- A hopper in the top for seed filling

- A flutted roller below the hopper to regulate the seed flow to the screen.
- Screen (or) sieves: Perforated metal sheet with specific size of perforation in which there are two types.
  - Rectangular perforations for paddy and
  - Round perforations for seed other than paddy
- Screen shaking unit : for oscillating the sieves to move the seeds on the screens
- Screen brushes to remove the blocked seeds
- Air blower with adjustments for air outlet
- Collecting outlet
- Air duct for directing the blown up light particles to outside
- Collecting bins.

Working principle

The seeds are fed into the hopper and they are guided to fall on the first sieve. The first sieve is a scalping screen which scalps all the foreign materials larger and heavier than seed and the entire quantity of seed passes through the first sieve. The second sieve is a cleaning sieve which removes all the unwanted particles larger in size than the seed. The third sieve is actually the grading sieve which size grade the seed lot and bring into a uniform size and which also screen the undersized, shriveled and immature seed, dust and dirt. The seeds are then rolled and passed through air column, where they are relived of the light chaffy and other materials by the blowing air.



Adjustments

Flutted roller

The speed of this roller can be adjusted so as to increase (or) decrease the flow of seeds to the hopper of the sieves.

Slope (or) inclination of the screen

The angle of inclination of the screens can be adjusted according to the nature of seeds.

Rate of vibration of sieve

This can be adjusted either to increase or to decrease the speed of the rolling seeds on the screen.

Volume of air flow: By increasing (or) decreasing the air inlet.

Choice of screens: According to variety we have to change the screen

Screen dams

Small check dams, which can be provided here and there on the screens so that the seeds can be stopped a while and takes the charge either to pass or to roll.

Types of seed cleaner cum grader

I) Crippen model cleaner cum grader

ii) Clipper model cleaner cum grader

iii) Petkas cleaner cum grader

III. Disc separator

It consists of a series of discs, which revolve together on a horizontal shaft inside the cylindrical body. Each disc contains many under cut pockets. The seed enter the intake end of the separator and move through the open centers of the discs towards the discharge end of machine. As the discs revolve through the seed mass the pockets lift out short seed but rejects longer seed. Longer seeds are conveyed by flights on the disc spokes towards the discharge end of the machine where they go out through the tailings gate. The rate of seed travel through the open disc centers is controlled by conveyor or blades attached to the spokes of the discs. The disc separator makes a very precise separation. No factor other than seed length and shape affects its separation. Flexibility is obtained by varying size of the pockets.

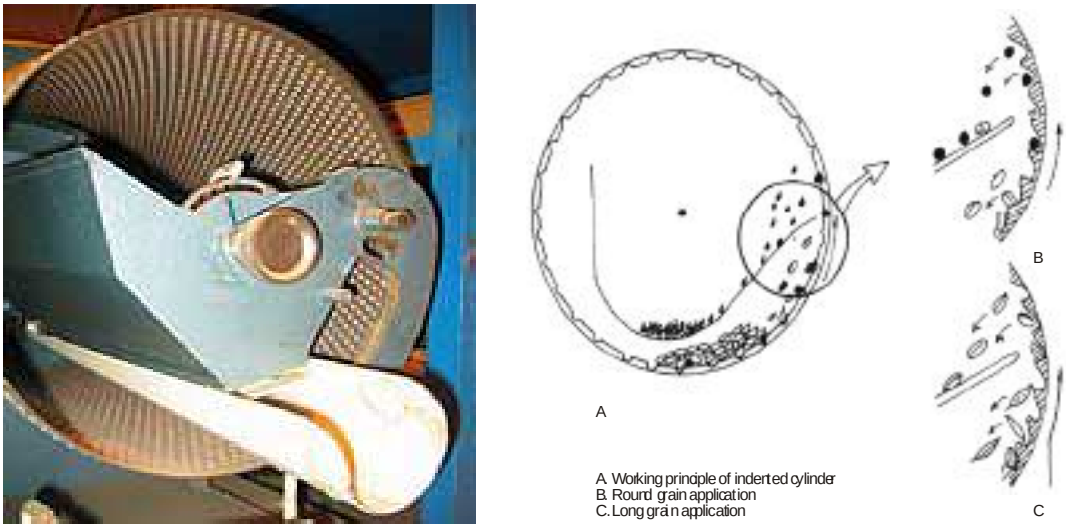
IV. Indented cylinder separator

The indented cylinder separator is a rotating, almost horizontal cylinder with movable, horizontal separating adjustments which are mounted inside it. Indent lines are there inside the surface of the cylinder. The

indented cylinder revolves, turning the seed mass to give each seed a chance to fit into indent. Short seeds are lifted out of the seed mass and are dropped into the lifting and long seeds remain in the cylinder and are discharged out via., a separate spout at the end of the cylinder.

Lab Model

As the cylinder revolves, it creates centrifugal force which helps to hold the seed in the indent. Short seeds are held in the indent until the cylinder turns to the point where the indent is inverted enough for gravity to cause the seed to fall out of the indent. The length, surface texture and size of seeds determine how they fit into the indent, so that it can be lifted out of the seed mass. The speed of the cylinder creates centrifugal force which holds the seeds in the indent as it are lifted upward. Thus the shape and size of the seed to cause some seeds to fall out after being lifted only a short distance, while other seeds are lifted closer to the top of the cylinder before they fall out.



Working principle of the indented cylinder separator

As the seeds enter the cylinder, the small, short, easy to separate seeds are quickly removed. The center cylinder section removes the intermediate sizes of seeds still in the cylinder. All indents in a cylinder are the same size, only the progressively declining amount of material to be lifted causes this difference in separating action.

Adjustments

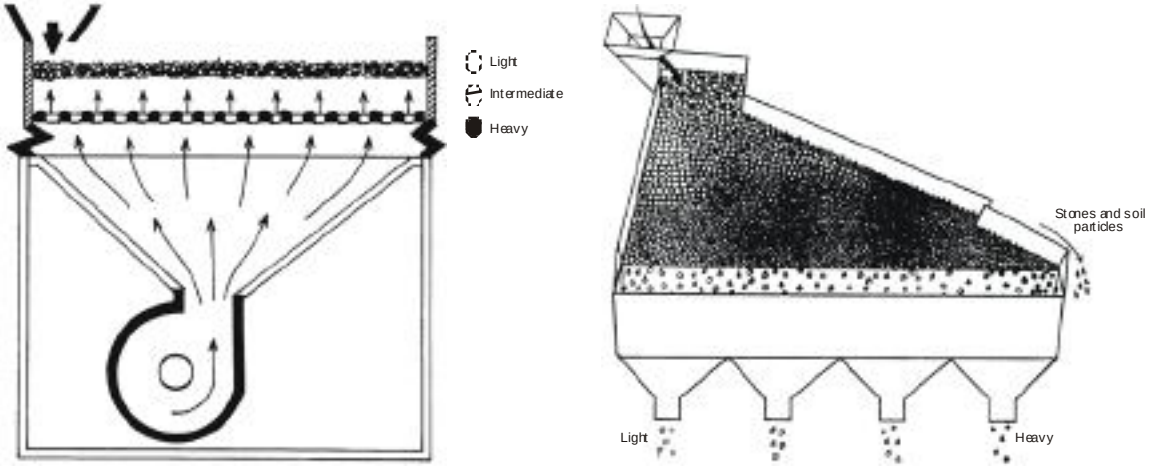
1) Cylinder speed 2) Size of the indent 3) Trough setting 4) Tilt of the cylinder 5) Adjustable retarder.

V. Specific gravity separator

Seeds of the same size and general shape can often be separated because they differ in specific gravity or relative weight. This difference is very useful in removing light, immature seeds or heavy sand and rocks to improve the purity and germination of crop seeds.

Lab Model

If seeds which differ in specific gravity (relative weight / unit of volume) are placed on substrate of intermediate density, seeds of higher specific gravity will fall down through the substrata, while seeds of lower specific gravity will be buoyed up the substrata. Here air is used as separation substrata.



Working principle of the specific gravity separator

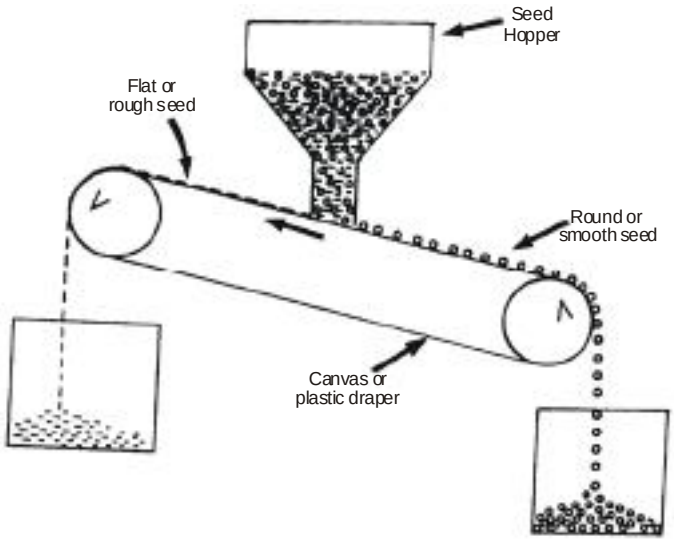
As seeds flow on the deck of the gravity separator, they enter a column of air coming up through the porous surface of the deck. The pressure of terminal velocity of the air rising through the deck can be controlled very closely to separate two kinds of seeds differing in specific gravity, the air is adjusted so that only the lighter seeds are lifted up off the deck surface. These lighter seeds are held up by air pressure and tend to float on the deck surface. The heavier seed possess a velocity greater than that of the air columns so they are not lifted and so will lie on the deck surface. The air column thus stratifies the seed mixture into vertical zones of relative weight with the heavier seed lying on the deck and the lighter seeds lifted up to the top of the seed mass.

Adjustments

1. Feed rate 2) Air flow 3) End slope 4) Side slope 5) Deck oscillation speed 6) Deck speed.

VI. Roll mill or dodder mill or velvet roll mill

It is used to separate the seeds based on surface texture and shape. This separator should be used only after the seed has been carefully cleaned and separated from the chaff. These are effective in separating seeds with a rough seed coat or shape angles from smooth seeds.



Working principle of the roll mill

The roll mill consists basically of two roller, covered with flannel or velvet, placed side by side, so that they touch each other down their entire length. The rollers are mounted on an incline and they turn in opposite directions. A curved adjustable shield is mounted above the rollers.

Separating action

The mixture of smooth and rough seeds is fed into the place, where the rollers touch each other, at the high end of the machine. As the rollers turn up and out, seeds that are rough or have sharp or broken edges are caught by the nap of the fabric covering the rollers. These seeds are thrown up against the curved shield. They strike the shield at an angle, bounce back down to the roller and are again thrown up against the shield. Smooth seeds bounce down the inclined position forward between the rollers, and discharge at the lower end of the machine. They are not affected by the fabric roller covering, and are not pitches over the side of the rollers.

Adjustments

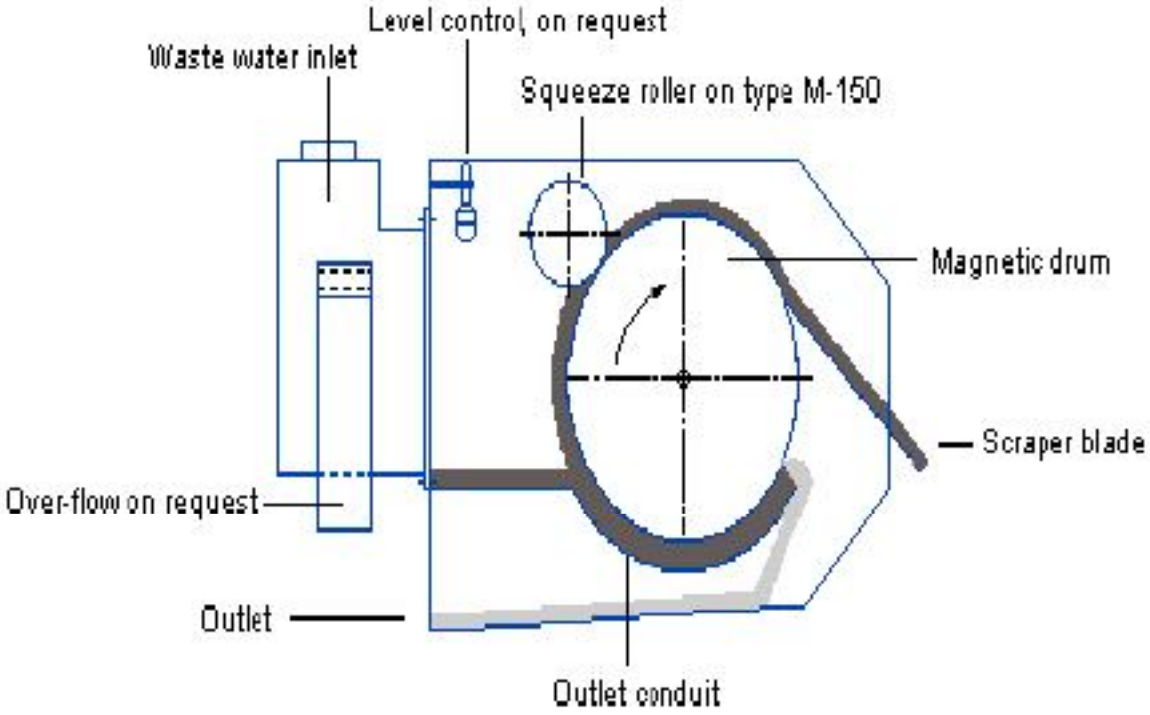
1) Rate of feed 2) Speed 3) Clearance between shield and rolls 4) The angle of inclination of rolls.

VII. Magnetic separator

The separation is mainly based on the affinity for liquids which is used for separation. Since seeds contains no free iron and are not attracted by a magnet they must be selectively pretreated with a magnetic material such as finely ground iron powder. Rough seed coats, cracked or broken seed coats, dirt lumps, chaff or seed with a sticky residue on the surface will hold the liquid and become sticky, so that iron powder will adhere to them. Smooth coated seeds will not absorb liquid. So no iron powder will adhere to them.

The seed are then discharged from mixing chamber and brought into contact with a powerful magnet, which removes the iron coated seeds. Most magnetic cleavers pass the seeds over a revolving drum which has a high intensity magnetic field. Seeds with an affinity for liquids which are now

coated with iron powder are attracted by the magnet and adhere to the drum until they are removed by a brush or scraper. Seeds which are relatively free of iron powder are not attracted by the magnet and will fall into a separate discharge spout.



The first requisite of magnetic seed separation is that the seed to be separated must possess different seed coat characters. Crop seeds should have a smooth surface, while the seeds to be removed should have a rough surface which will retain liquid and can accept the iron powder. Success in separating the components depends upon the magnitude of seed coat differences and thoroughness with which the moistened seeds and the iron powder are blended.

VIII. Colour separator

Many large crop seeds such as peas and beans differ in colour between varieties. Colour variation may also occur due to immaturity or disease. Electronic colour sorting machines can separate such seeds by difference in

colour and also remove mud balls and discoloured seeds in the same operation.

The electronic colour sorter views each seed individually with photo electric cells. The seed is compared with a selected back ground or colour range and is discharged from the machine according to its colour. If it is the great desired colour, the seed is discharged through the good seed spout. If its colour or shade falls within the reject range, a blast of compressed air deflects the seed and sends it in to the reject discharge spout. These are highly sensitive. Since the machine views each seed individually, capacity is low, but the initial cost is high and operating cost is less. The usefulness of machine is greater with large seeded crops.

IX. Spiral separator

The separator, which classifies seed according to its shape and rolling ability, consists of sheet metal strips fitted around a central axis in the form of a spiral. The unit resembles an open screw conveyor standing in a vertical position. The seed is introduced at the top of the inner spiral. Round seeds roll faster down the incline than flat or irregularly shaped seeds, which tend to slide or tumble.

The orbit of round seed increases with speed on its flight around the axis, until it rolls over the edge of the inner flight into the outer flight where it is collected separately. The slower moving seed does not build up enough speed to escape from the inner flight. Most spirals have multiple inner flights arranged one above the other to increase the capacity.

Processing equipments used for improving the quality of the seed

From harvest upto final stage of seed storage, the seeds are to pass through various seed proessing equipments depending upon the speciality and specificity. But some equipment like driers and seed cleaner cum graders are common for all types of seed. The processing machineries and equipments used in the seed handling are as hereunder.

S.No.	Processing equipments	Usage with reference to specific seed management
A.	Threshing with extraction equipments	
1.	Thresher	To remove the seeds from the inflorescence especially in cereals
2.	Ginning machine	To separate the lint and seed from kapas in cotton
3.	Maize sheller	To shell the seed from the cobs
4.	Pulse thresher	To remove seed from the pods
5.	Tomato seed extractor	To extract tomato seed from fruit without wasting the pulp
6.	Chilli seed extractor	For easy removal of seed from chilli fruits
7.	Groundnut decorticator	To shell the kernel (seed from the pods
8.	Sunflower thresher	For removal of seeds from the head
9.	Debearder	To remove the awns form (Barley) the seed
10.	Mechanical scarifier	To scarify the hard seed mechanically to improve the germination of seeds
11.	Pebble mill	To remove webby hairs from grasses
12.	Timothy bumper mill	To remove weed seed from timothy seed
13.	Hammer mill	To remove the hook or appendages from the seeds (i.e. Stylosanthus)
B.	Driers	To reduce the moisture content to lower or needed level for safe handling both for processing and for storage at the final stage

C.	Grading equipments	
14.	Cleaner cum grader	This homogenize the precleaned seed based on size and is known as basic grading in seeds. The sieve sizes requirement vary with crop
15.	Precleaner and aspirator	This remove the inert material and dust particles from seed and improve the grading efficiency
D.	Upgrading machines	
16.	Specific gravity separator	Improve the quality of graded seed further using its weight or specific gravity. Heavier seeds are good storers and expresses maximum field establishment
17.	Indent cylinder	In lengthier seeds it maintains the size of seed (breadth and length). The broken / damaged are removed and good seeds are selected
18.	Disc separator	It is for removal of weed seeds and to improve the general appearance of seed
19.	Roll mill	To separate smooth seed from rough seed based on the surface texture especially the weed seed
20.	Magnetic separator	Removal of weed seed from clovers, alfalfa, trefoils and vetch
21.	Inclined draper	Separation of smooth or round seeds from rough, flat or elongated seeds
22.	Electronic colour sorter	Separation of off-coloured seed
23.	Electrostatic	Based on electrical properties removes

	separator	Johnson grass from sesamum seeds (Specific utility)
24.	Spiral separator	Separation of seeds based on shape (eg.) separation of rape, vetch and soybean seed form wheat, oat or rye grass
25.	Polishers	To improve the luster of seed
26.	Picker belts	To remove undesirable ears / pods from shelled seeds (eg.) Groundnut, Corn
27.	Vibratory separator	Removal of weed seed
28.	Seed treater	To treat the seed with fungicide and pesticide
29.	Seed packing machine	To easier the work and to avoid human error of mixing
30.	Conveyors / Elevators (Belt , Bucket)	Easier the transfer of seed from machine to machine and avoids the contamination of seed at various level.

Though all the machines are highly useful in improving the seed quality, specific machines are utilized for specific crop. The sequential usage of machineries varies with crop seeds (Gregg, 1967).

Precautions in handling processing equipment

All machine adjustments like the speed, oscillation and duration should be perfect. Otherwise, it will result in mechanical damage of seed which reduces the quality of seed in terms of vigour, viability, storability and field stand. Drying of seed should be designed properly as the moisture content needed for threshing; grading, treating and bagging vary with operations. Dosage, exposure period and choice of chemical are important in mechanical seed treatment.

SEED TREATMENT

Maintaining the quality of seed is dependent on many environmental factors, some of which are moisture, temperature, humirlity, and storage conditions. Even though these factors are properly accounted for, seed quality may still be reduced by certain seedborne diseases or destroyed by insects and other pests. Research has shown that treating seed with one or more pesticides is the most economical and efficient way to protect seed from these pests and improve seed quality. Since pesticides are poisonous, extra care and safety precautions must be taken when applying them and in handling seed after it has been treated.

Definition of treated seed

The term "treated" means "to give an application of a pesticide or subject seed to a process designed to reduce, control or repel disease organisms, insects, or other pests which attack the seed or seedlings."

Types of Seed Treatment

A. Pre sowing seed treatments

It is the treatments given to the seeds before sowing to improve the germination and vigour potential and as well as to maintain the health of the seed.

Pre sowing seed treatments includes the following

I. Chemical treatments to improve germination and vigour potential.

II. Insecticidal and fungicidal treatment.

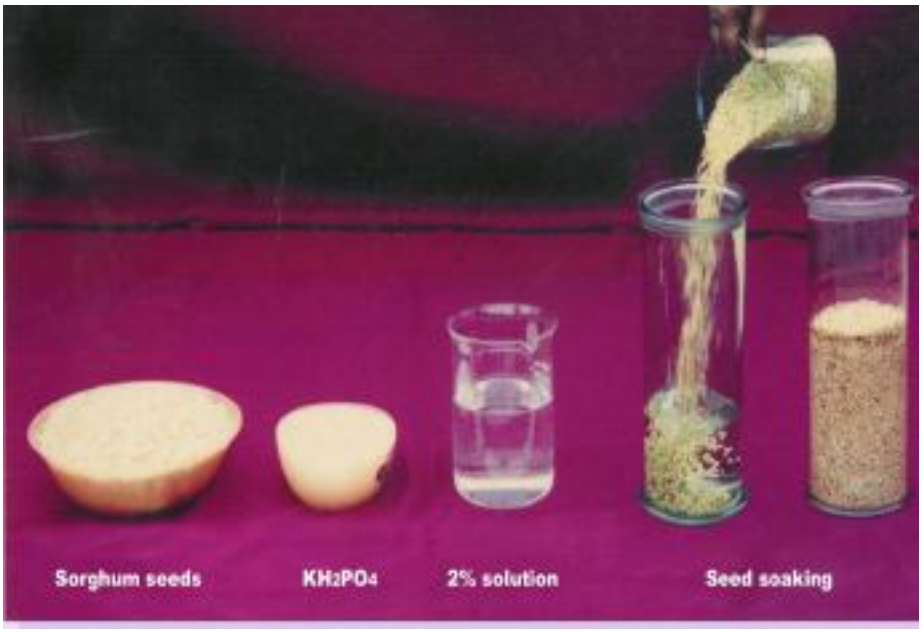
III. Special treatments

I. Chemical treatments to improve germination and vigour potential

Soaking / treating the seeds with nutrients vitamins and micronutrients etc.

Paddy: Seeds can be soaked in 1 % KCl solution for 12 hours to improve the germination and vigour potential.

Sorghum: Seeds could be soaked in $NaCl_2$ (1 %) or KH_2PO_4 (1%) for 12 hours for improving the germination and vigour potential.



Pulses : Seeds can be soaked in $ZnSO_4$, $MgSO_4$ and $MnSO_4$ 100 ppm solution for 4 hours to improve the germination and vigour potential.

II. Insecticidal and Fungicidal treatments

Seed health: It is an important attribute of quality seed. Though a seed lot that meets high standards of germination, vigour and purity if it is contaminated with seed borne pathogens and insect pests, may be useless to farmers because it may result in severe yield loss or even crop loss in an entire area.

Benefits of the insecticidal and fungicidal treatments:

1. Prevents the spread of plant diseases
2. It protects the seed from seed rot and seedling blights.
3. It improves the seed germination
4. It provides protection from storage insects.

5. It controls the soil insects.

Seed may be affected by viruses, bacteria, fungi, nematodes and insects. Seed pests and diseases of which the seed is a victim (e.g., grain weevils, Tricoderma spp., and storage pathogens such as Aspergillus flavus) should be distinguished from seed-borne diseases of which the seed is the vehicle of pest and pathogen dissemination (e.g., bunt of cereals, Tilletia spp.)

Seed Treatment Fungicides

Fungicides are applied to seed prior to planting to provide effective protection against many seed and soil-borne plant pathogens. Chemical (fungicide) treatment guards against the various seed rots and seedling blights that occur during storage or after planting. It is not usually a "cure-all" and will not provide disease protection throughout the growing season after the plants become self-sufficient. (An exception to this would be the control of loose smut by seed disinfection).

Fungicidal seed treatment may be divided into three categories, depending on the nature and purpose of the treatment. These categories are: (1) seed disinfection, (2) seed disinfestation, and (3) seed protection. A given fungicide may serve in one or more of these categories.

Seed disinfection - Disinfection is the elimination of a pathogen which has penetrated into living cells of the seed, infected it and become established-for example, loose smut of barley and wheat.

Seed disinfestations - Disinfestation is the control of spores and other forms of pathogenic organisms found on the surface of the seed.

Seed protection - Seed protection is chemical treatment to protect the seed and young seedling from pathogenic organisms in the soil.

Seed treatment materials are usually applied to seed in one of four forms: dust; slurry (a mixture of wettable powder in water); liquids; and planter-box formulations.

Based on composition, seed treatment fungicides may be organic or inorganic, metallic or non-metallic, and, until recently, mercurial or non-

mercurial. Before the cancellation of the 'volatile mercurials, fungicides for treating seed were generally classified as volatile and non-volatile. Vlith the elimination of the volatile mercurials, most fungicides now approved for use on seed are classified as non-volatile. When using this type material, complete coverage of the seed is necessary to obtain effective control.

Some of the systemics, a fairly new class of pesticides, may now be used as seed treatment materials. The desirability of having materials that would move inside the seed or plant and control the pest has long been recognized. Such materials are called "systemic." When used according to the manufacturer's recommendation (see label), a systemic moves through the host plant and controls or retards the growth of certain fungi and insects without affecting the host's metabolic system.

Seed Treatment Insecticides

Insecticides are often applied to seed to control or reduce insect damage to seed during storage and, to a lesser degree, to prevent damage from such insects as wireworms and seed corn maggots in the soil.

Combinations

Since some pesticides are selective in their control of pests, many times two or more compounds are combined in the treater tank, or an extra tank may be used, to give the spectrum of control needed.

The manufacturers of pesticides are now making combinations available to seed processors, but should a processor blend two or more pesticides, the compatibility of the materials must be determined, since some combinations of materials may seriously reduce seed germination. Also, when applying two or more pesticides, even at different times, the sequence of application may be very important. Whether a single pesticide or a combination is to be applied to the seed, read the label and follow the manufacturer's directions carefully.

Formulation of fungicides /insecticides

Fungicides / insecticides are available in the form of dusts, wettable powders and liquids.

1. Dusts : It is usually applied @ 200-250 gms / quintal of seed. Main dis-advantage is dusty condition will prevail during the seed treatment and after handling.
2. Slurry : This type of fungicide is applied to the seed along with soap like water suspension which can be mixed with seed by using special slurry treater.
3. Liquids : The use of liquid solution is known as the "quick wet ' method. Here a volatile fungicide is applied to the seed and it throughly mixed with them.

   e.g. Chemicals like panogen, mercuran, etc. can be applied by this method.

Safety

There is a general tendency to use chemicals that are safe for user and environment. Very toxic substances, such a organic mercurials (Ceresan and others) and very persistant fungicides, such as Hexachlorobenzene ((HCB), are being replaced by new chemicals, In the past, these chemicals have caused severe cases of poisoning, some resulting in death. Most if not all occurred because treated seed was used for human consumption or livestock feeding instead of for planting. Even with the new, less toxic chemicals, the following safety precautions must be taken.

- Treated seed must be clearly labelled and under no circumstances be used for feed or food.
- Seed treatment should be carried out in a well-aerated area. Contact with chemicals through breathing of dusts and skin contact must be avoided. Protective clothing should be worn.
- As with all pesticides, empty containers should be properly disposed of and never reused in a household or on the farm.

III. Special treatments

i) Seed hardening treatment

Seeds can be hardened for 2 purposes I) Drought tolerance ii) Cold tolerance

The treatments are imposed to the seeds mainly to tolerate initial drought and cold. Cold tolerance treatment is given to germinated seeds, such treatments are given only to temperate crop and tree seeds.

The most important factors to be considered while seed hardening are

- Seed : solution ratio (1:1)
- The duration of soaking
- Method of drying.

The effectiveness of the treatment depends upon the conduct of seed hardening process. The solution amount never be higher than the amount of the seeds. All solution added should be imbibed by the seeds. There should not be any leftover solution as it causes leaching effect. Once the seeds imbibe water, the germination process takes place. At the end of soaking period the seeds should be dried back to its original moisture content. These seeds when sown the germination will be completed earlier whereas in non hardened seeds the process germination takes a longer period.

Chemicals used : $CaCl_2$, KCl, KH_2PO_4,

ii) Seed fortification

Main aim is to supply nutrients to seeds. The main objective is to achieve the high vigour to overcome unfavourable soil reactions. eg.) seed fortification with $MnSO_4$ @ 0.5 to 1 %. will improve oxidation - reduction potential of seeds, which ultimately leads to higher germination.

iii) Moist sand conditioning

It is a need based treatment the concentration can be increased upto 2-4 %. Amount of solution should be 1:1 ratio or slightly excess amount of water can be used. Protinaceous seeds should not be soaked in water (e.g) soybean, etc. for these seeds, mix the seeds with moist sand @ 5 to 10% MC. It should be kept for specified period of time. The method is known as moist sand hydration.

iv) Seed pelleting

Here the nutrients are coated on the seeds. This technique is very much adopted in forest tree seeds.

Importance

- Normally in small seeds this technique is adopted .
- By pelleting we can increase the size of sees and we can make it free flowing one.
- Through this we can able to reduce the seed rate.
- It is also important for aerial sowing (gum arabica) in tree seeds.

Materials used : Nutrients , adhesive, filler material.

Inert materials: Lime, $CaCO_3$, Chalk powder.

Plant products : Neem, Notchi, Arappu, Arappu (Albizia amara) is found good contains a susbstance saponin (growth promoter) which is similar to GA in action.

v) Seed infusion

Infusion of nutrients and growth promoting substances with organic solvents like acetone and dichlormethane.

The organic solvents, slowly increase the chemicals in to the seed. In this method there is no need for drying the seed materials to bring back the original moisture content of seed. The organic chemicals are evaporative in nature, after infusion is over, just we have to keep the seeds as such for 5 to 10 minutes in dry condition the organic solvents will evaporate during this time and we can perform sowing. Seed infusion can also be used for breaking the seed dormancy.

vi) Osmotic priming

It is a very expensive but it is a required process, particularly for large seeded legumes like peas, beans etc., They have high protein content and large embryo and are susceptible to soaking injury. High protein seeds are hygroscrpic and hydrophilic.

Osmotic priming is nothing but making the seeds to imbibe water very slowly. Osmotic solutions used are (PEG) (poly ethylene glyster). Maintol is highly toxic. PEG is inert and will increase very slowly the water in to seeds. By preconditioning through osmotic priming, the seeds are invigourated which results in uniform, early and higher field emergence and higher seedling vigour.

vii) Fluid drilling

This is a technology evolved for mechanical sowing of seeds particularly the germinated seeds. The seeds are coated with a jelly material

called guar gel. It is to have a buffer action to avoid damage of the germinated seeds during sowing.

viii) Separation of viable seeds

It is a new concept particularly for groundnut. This is a good method to get desired seed germination and plant population. Incase of groundnut the actual population requirement is 30 plants / m2. Actual seed multiplication rate in groundnut is 1:8 . There are about 30-40% of dead seeds and of such dead seeds are eliminated, and then we will be able to maintain the required plant population in the field. This is the base for evolving this technology.

This can be done in 2 ways

1. Manual separation based on radicle emergence (groundnut)

2. IDS (Incubation - Drying and Separation) method.

B. Pre storage treatments

Prestorage treatments of harvest-fresh seed are primarily aimed towards protection against deteriorate senescence during storage. Seed storage which is again threatened by insect and pathogen attack, can also be taken care of by prescribed prestorage seed treatments.

i. Halogenation

ii. Antioxidant treatment

iii.Seed sanitation

C. Mid storage treatments

Seeds in storage accumulate damage to cell membranes during senescence. Mid storage seed treatments are capable of reducing the age induced damages and restoring the seed vigour to a certain extent besides, the seed viability and productivity of stored seeds are also improved.

i) Hydration – Dehydration

It is the process of soaking the low and medium vigour seeds in water with or without added chemicals usually for short durations to raise the seed moisture content to 25 – 30% and drying back the seeds to safe limits for dry storage.

The hydration – dehydration treatments

1. Should be given only to stored seeds.
2. Is effective in low and medium vigour non- leguminous seeds,
3. The moisture equilibration and moist sand conditioning treatments in which moisture is taken up by the seed in a slow and progressive manner, are recommended for relatively high- vigour seeds and seeds of pulses and leguminous vegetable crops
6. Direct soaking of leguminous seeds should be avoided.
7. Would not make a seed germinable, which has already lost viability.

Types of H-D treatments

The wet treatments include soaking-drying, dipping-drying, spraying-drying, stepwise hydration-drying, moisture equilibration-drying, moisture equilibration soaking-drying, moist and conditioning-drying, etc. The choice of the treatment depends upon the characteristics of seed and initial vigour status of the seeds.

Soaking – Drying (S-D)

Stored seed is soaked in water or solution of chemicals sufficient to cover it and kept at room temperature for 2-6 hour depending on the material with occasional stirring. The soaked seed is taken out and after surface drying in the shade for some time, dried back to the original moisture content Dilute solution of chemicals such as sodium or potassium phosphate (di and mono basic), sodium chloride, p-hydroxy benzoic acid, p-amino benzoic acid, oxalic acid, potassium lodide,

etc can also be used at 10^{-4} to 10^{-3} M concentrations. Fungicidal and insecticidal formulations can also be incorporated in the soak water.

Dipping – Drying (D-D)

Seeds are dipped in water or solutions of the aforesaid chemicals for only 2-5 minutes and the wet seed is taken out immediately and kept covered for 2 – 6 hours depending on the material, for absorption of surface water followed by drying back in S-D. This treatment is effective in most high and high-medium vigour seeds of rice, wheat, jute, summer and winter vegetables

Spraying – Drying

Seeds are spread in a thin layer and then an amount of water (approximately 1/5 to ¼ of the seed weight) is sprayed on to it in two equal installments (turning over the seed layer after the first spray) and then kept covered by a polythene sheet for 2-4 hours before drying back. This treatment is similar to D-D in its efficacy and suitability.

Moisture equilibration – drying (ME – D)

Here, the seeds are placed in thin layers on trays kept on a raised platform in a closed moisture saturated chamber lined internally with moist blotters giving nearly 100% RH at room temperature. After 24-48 hours, depending on the material and ambient temperature, the seed is dried back in the usual way. For soaking injury prone seeds this treatment, which gives a slow and progressive rise in moisture content, is very effective. ME-D, however, difficult to practice on a large scale and is not advocated for low vigour non leguminous seeds because of possible aging effect of the treatment especially when given for prolonged periods.

Moist sand conditioning – drying (MSC-D)

This treatment is similar to the moisture equilibration treatment but easier to practice. For slow and progressive moisture uptake, the seed is thoroughly mixed with pre-moistened sand, using 3 times the amount of air dry sand than seed. Moisture content of sand is adjusted to 5-10 by adding the requisite amount of water or solution of chemicals to previously washed and dried fine grain building grade sand. The addition of water should be so adjusted as to get the required hydration effect without initiating the germination process. After mixing the dry seed with the premoistened sand, the mixture is kept at room temperature for 16 – 36 hours depending on the material and sand moisture content. The seed absorbs moisture from sand and after incubation the hydrated seed is separated from sand by sieving and dried back to the original weight.

Mode of Action The main purpose of hydration is to raise the seed moisture content to 25 –30% (wet weight basis) before drying back to safe limits for dry storage. The hydration - dehydration treatment may improve the vigour by controlling free radical reactions and consequent peroxidative damage to lipoprotein cell membranes.

SEED TREATING EQUIPMENT

Commercial seed treaters are designed to apply accurately measured quantities of pesticides to a given weight of seed. Basically, there are three types of commercial seed treaters on the market: dust treaters, slurry treaters, and direct treaters-the Panogen and Mist-O-Matic treaters are examples of direct treaters.

1. Dust Treater *(Gustafson XL Dry Powder Seed Treater)*

Controlling the Flow of Seed:

The amount of seed which flows into the weigh pan (which is just beneath the feed hopper on top of the treater) is controlled by opening or closing the gates of the feed hopper by means of the hand wheel on the side of the hopper. The scale on the hopper shows how far the gates are open (in inches). Gates should be open to whatever number of inches it takes to keep

the weigh pan filled to the required number of pounds per dump as it tilts in either direction. The number of pounds per
dump is adjusted by correctly setting the counterweight up or down on the counterweight arm.

Powder Application:

To be sure that the correct amount of powder is being applied to the seed flow, a preliminary test must be made in which a given number of pounds of seed (such as 100 lbs) is run through the feeder.

During this run, the measuring cup provided with the feeder should be used to catch the powder as it comes off the vibrator. After the given amount of seed has run through, the powder should be weighed in order to determine how much is being applied to that amount of seed. The vibrator speed can then be adjusted accordingly. Then a second or more tests should be run until proper setting of the vibrator speed is determined for correct coverage.

Approximate Setting

No. Dumps	Powder Scale Opening	Syntron Setting	Oz. Produced / 100 lbs.
25	1/2	60	2
25	3/4	60	5
25	3/4	70	6
25	3/4	80	7
25	1	60	10

Number 4 on counterweight arm gives five pounds per dump.

2. Slurry Seed Treater

The slurry treatment principle involves suspension of wettable powder treatment material in water. The treatment material applied as a slurry is accurately metered through a simple mechanism composed of a slurry cup and seed dump pan. The cup introduces a given amount of slurry with each dump of seed into a mixing chamber where they are blended.

While operation of the slurry treater is relatively simple, the various operation procedures must be thoroughly understood.

1. The metering principle is the same in direct, ready-mix or fully automatic treaters-i.e., the introduction of a fixed amount of slurry to a given weight of seed.

2. To obtain a given dump weight, slurry treaters are equipped with a seed gate that controls seed flow to the dump pan. With the proper seed gate setting, a constant dump weight for a given can be obtained.

3. The amount of treatment material applied is adjusted by the slurry concentration and the size of the slurry cup or bucket. As the dump pan fills, a point is reached where it over-balances the counter weight and dumps into the mixing chamber. This brings the alternate weighing pan in position to receive the inflow of seed and activates a mechanism to add a cup of slurry to the mixing chamber. Thus, one cup of slurry is added with each dump of seed.

4. The mixing chamber is fitted with an auger type agitator that mixes and moves seed to the bagging end of the chamber. The speed of the auger is important, because at slow speeds more uniform distribution is obtained.

Slurry tanks have 15 to 35 gallon capacities, depending upon the size of the treater. They are equipped with agitators that mix the slurry in the tank and keep it suspended during operation. It is important that the powder be thoroughly suspended in water before treating. If the treater has been idle for any period of time, sediment in the bottom of the slurry cups must be cleaned out.

The proper size slurry cup must be used. Most machines now have cups with ports and rubber plugs for 15 cc, 23 cc, and 46 cc quantities. Some users prefer to mix the slurry in an auxiliary tank and then transfer to the slurry chamber as needed.

DIRECT TREATERS

Direct treaters are the most recent development and include the Panogen and Mist-O-Matic treaters. These two were initially designed to apply undiluted liquid treatment. Instead of applying 23 cc of material per 10 pounds of wheat, as in slurry treaters, they apply 14 to 21 cc (1/2 to 3/4 ounces) per bushel of "wheat. This small quantity of material is suitable only with liquid materials which are somewhat volatile and do not require complete, uniform coverage for effective action.

Later modifications for direct treaters include dual tanks that permit simultaneous addition of a fungicide and an insecticide, and adaptations for the application of slurries. The metering device used in both types of direct treater is similar to that of the slurry treater, since it is attained through synchronization of a treatment cup and seed dump. Otherwise, the two direct treaters differ decidedly from the slurry treater and from each other. Both of these direct treaters have an adjustable dump pan counter weight to adjust the weight of the seed dump. This is not practical with slurry treaters.

3. Panogen Seed treater

The operation of the Panogen treater is relatively simple. A small treatment cup, operating from a rocker arm directly off the seed dump pan and out of a small reservoir, meters one cup of treatment with each dump of the seed pan. Fungicide flows through a tube to the head of the revolving drum seed mixing chamber. It flows in with seed from the dumping pan and is distributed over the seed by

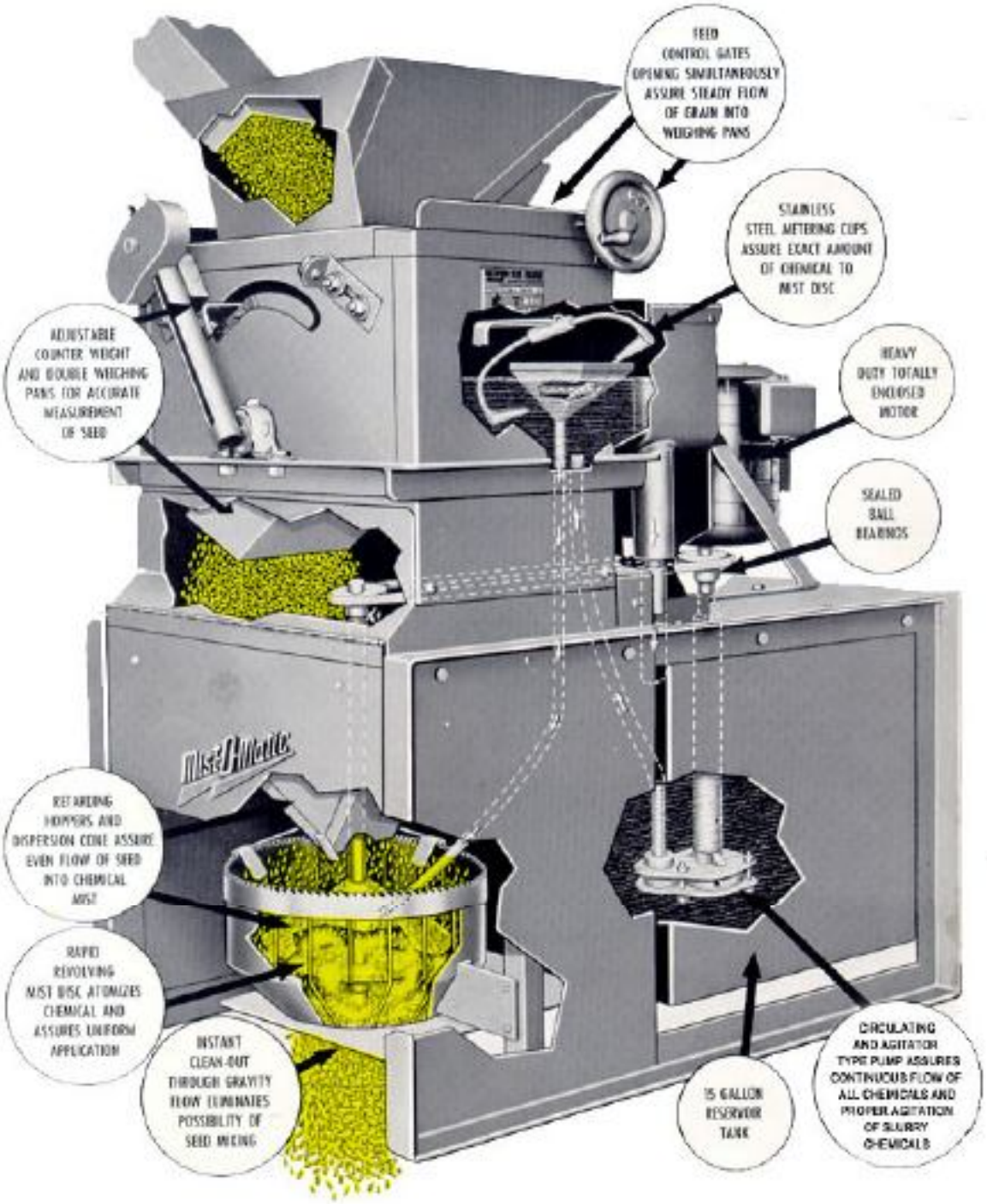
the rubbing action of the seed passing through the revolving drum.

The desired treating rate is obtained by the size of the treatment cup and by adjusting the seed dump weight. Treatment cup sizes are designated by treating rate in ounces and not by actual size-e.g., the 3/4 ounce cup applies 3/4 ounce (22.5 cc) of treatment per bushel with six dumps per bushel. The actual size of this cup is approximately 3.75cc.

4. Mist-O-Matic Seed Treater:

The "mist-o-matic" treater applies treatment as a mist directly to the seed. The metering operation of the treatment cups and seed dump is similar to that of the "Panogen" treater. Cup sizes are designated by the number of cc's they actually deliver-e.g., 2 ½ , 5, 10, 20 and 40. The treater is equipped with a large treatment tank, a pump and a return that maintains the level in the small reservoir from which the treatment cups are fed.

After metering, the treatment material flows to a rapidly revolving, fluted disc mounted under a seed-spreading cone. The disc breaks droplets of the treatment solution into a fine mist and sprays it outward to coat seed falling over the cone through the treating chamber. Just below the seed dump are two adjustable retarders designed to give a continuous flow of seed over the cone between seed dumps. This is important since there is a continuous misting of material from the revolving disc. The desired treating rate is obtained through selection of treatment cup size and proper adjustment of the seed dump weight.


SEED CONTROL GATES OPENING SIMULTANEOUSLY ASSURE STEADY FLOW OF GRAIN INTO WEIGHING PANS
STAINLESS STEEL METERING CUPS ASSURE EXACT AMOUNT OF CHEMICAL TO MIST DISC
ADJUSTABLE COUNTER WEIGHT AND DOUBLE WEIGHING PANS FOR ACCURATE MEASUREMENT OF SEED
HEAVY DUTY TOTALLY ENCLOSED MOTOR
SEALED BALL BEARINGS
REFARDING HOPPERS AND DISPERSION CONE ASSURE EVEN FLOW OF SEED INTO CHEMICAL MIST
RAPID REVOLVING MIST DISC ATOMIZES CHEMICAL AND ASSURES UNIFORM APPLICATION
INSTANT CLEAN-OUT THROUGH GRAVITY FLOW ELIMINATES POSSIBILITY OF SEED MIXING
15 GALLON RESERVOIR TANK
CIRCULATING AND AGITATION TYPE PUMP ASSURES CONTINUOUS FLOW OF ALL CHEMICALS AND PROPER AGITATION OF SLURRY CHEMICALS

Seeds Act and Rules

Introduction

The seed is an important agricultural input and it plays vital role in increasing production and productivity. There is a need to safeguard the farmers with the supply of genetically pure and quality seeds. Any new variety produced by the Scientist has to be multiplied many times to meet the needs of the farmers. In order to ensure the availability of quality seeds, Government of India have enacted Seeds act, 1966 and Seed rules, 1968. The seed (Control) order, 1983 was promulgated under essential commodities act, 1955 in order to ensure the production, marketing and equal distribution of the seeds.

Seeds Act, 1966

The object of Seed Act is to regulate the quality of certain notified kind / varieties of seeds for sale and for matters connected therewith. The seed act passed by the Indian Parliament in 1966 was designed to create a 'Climate' in which the seeds man could operate effectively and to make good quality seed available to cultivators. Seeds rule under the act were notified in September 1968 and the act was implemented entirely in October, 1969. This act extent to the whole of India and it has 25 sections.

Seed legislation could broadly be divided into two groups

1. Sanctioning legislation

Sanctioning legislation authorizes formation of Advisory bodies, Seed Certification Agencies, Seed Testing laboratories, Foundation and Certified Seed Programmes, Recognition of Seed certification Agencies of Foreign countries Appellate authorities etc.

2. Regulatory legislation

Regulatory Legislation controls the quality of seeds sold in the market including suitable agencies for regulating the seed quality. On quality control basis, the Seeds Act could conveniently be divided into the following:

I. Minimum limit and labeling of the notified kind / varieties of seed

a. Power to notify the kind / variety

b. Labeling provisions

c. Seed testing

d. Seed analyst

e. Seed inspectors

f. Penalty

g. General provisions

II. Seed Certification

III. Restriction of Import and Export of Seeds

I. Minimum limits and labeling

Quality control as envisaged in the Act is to be achieved through pre and post marketing control, voluntary certification and compulsory labeling of the seeds of notified kind / varieties.

(a) Power to notify the kind / varieties

New varieties evolved by the State Agricultural Universities and ICAR institutes are notified and released /notified respectively under section 5 of the seeds act in consultation with the central seed committee and its sub committees constitute under section 3 and 3(5) of the Seeds Act. As on date more than 2500 varieties and 130 varieties were notified and denotified under this section. List of varieties notified and denotified from 1969 to 2005 are compiled and made available in the form of a book called catalogue of varieties notified and denotified under section 5 of the Seeds Act. Functions of the Central Seed Committee and its sub-committee are defined in Clauses 3 and 4 of part II of seed rule.

(b) Labeling provision

Minimum limits for germination, physical purity and genetic purity of varieties / hybrids for crops have been prescribed and notified for labeling seeds of notified kind / varieties under section 6(a) of the Seeds Act. Size of the label, colour of the

label and content of the label were also notified under sub clause (b) of Section 6 of Seeds Act. Colour of the label is opel green and size of the label is 10 cm x 15 cm or proportionate thereof. Responsibility for making labeling content of mark or label, manner of marking, false / misleading statement on label etc., are defined under clause 7,8,9,10,11 and 12 of part V of seeds rule.

Section 7 of the act regulates the sale of notified kind or varieties. Accordingly no person shall keep for sale, offer to sell, barter or otherwise supply any seed of any notified kind or variety, after the dates recorded on the container mark or label as the date unto which the seed may expected to retain the germination not less than prescribed under clause (a) of section 6 of the Act.

(c) Seed Testing

There is a provision to set up a central seed laboratory and state seed laboratory to discharge functions under section 4(1) and 4(2) of the Seed Act, In the year 1968 there were 23 state seed testing laboratories in the country. At present there are 86 Seed testing laboratories functioning in the country. During 1995-96 these laboratories tested about 5 lakh samples. Seed testing laboratories have been assigned certain important functions under part III (5) of Seed Rule.

(d) Seed Analysts

State Government could appoint the Seed Analysts through notification in the Official Gazette under Section 12 of the Seed Act defining his area and his jurisdiction. Seed Analyst should posses certain minimum qualification as prescribed under clause 20 part IX of Seed Rule.

(e) Seed Inspectors

Classes of seed

The State Government, under section 13 of the Act may appoint such a person as it thinks fit, having prescribed qualification (Clause 22 part IX of Seed Rule) through notification, as a Seed Inspector and define the areas within which he shall exercise jurisdiction for enforcing the seed law. He will be treated as a public servant within a meaning of section 21 of the I.P.C. (45 of 1860). He has power to examine records, register document of the seed dealer. He will also exercise such

other powers as may be necessary for carrying out the purposes of this Act or rule made there under. Duties of Seed inspectors are defined in clause 23 of part IX of Seed rule. He can issue, stop sale order in case the seed in question contravenes the provision of relevant Act and rules for which he can use form No.III. When he seizes any record, register documents or any other material , he should inform a magistrate and take his order for which he can use form No.IV.

(f) Penalty

If any person, contravenes any provision of the Act or Rule, or prevents a seed inspector from taking sample under this Act or prevents a Seed Inspector from exercising any other power conferred on him could be punished under section 19 of the act with a fine of five hundred rupees for the first offence. In the event of such person having been previously convicted of an offence under this section with imprisonment for a term, may extend to six months or with fine, which may extent to one thousand rupees or with both.

II. Seed certification

The object of the Seed Certification is to maintain and make available to the public through certification high quality propagating material of notified kind / varieties so grown and distributed as to ensure genetic identity and genetic purity. The certified standards in force are Indian Minimum seed certification standards and seed certification procedures form together for the seed certification regulations. Seeds of only those varieties which are notified under section under Section 5 of the seeds act shall be eligible for certification.

- Breeder seed
- Foundation seed
- Certified Seed

Breeder seed

- Breeder seed is a seed directly controlled by the breeder.
- Breeder seed should be genetically so pure as to guarantee that in the subsequent generation.

- Breeder seed could not come under the perview of seed certification as it is not meant for public sale.
- Breeder seed should be packed and supplied with breeder's golden yellow stag as per the guideline given in Indian Minimum Seed Certification standards. It is also the fact that no standard for breeder seed have been prescribed.

Foundation seed

- Foundation class of seed and certified class of seed are to be certified by the Certification Agencies as per the Indian Minimum Seed Certification Standards.
- Section 8 of the Seeds Act provide state government or the Central Government consultation with State Government may be notification in official gazette, established certification agencies for the state to carry out the functions entrusted to certification agency by or under this Act (Part IV, clause 6, part VI clause 14 of Seeds Rule).

Certified seed

- Seed act section 9 provides any person desires of producing certified seed shall register his name with concerned seed certification agency duly remitting the prescribed fee in form No.1 for grant of certificate. Certificate could be granted in form No.11 after meeting the requirement of certification agency prescribed under Part VII clause 15,16 and 17 of Seed rule.
- It should have the minimum genetical purity of 99%
- Certified seed may be the progeny of certified seed , provided this reproduction does not exceed two generations beyond foundation seed and provided that if certification agency determines the genetic and physical purity, if not be significantly altered
- In case of highly self pollinated crops certification of one further generation may be permitted

- Certified seed produced from certified seed ,shall be eligible for further seed increase under certification, except in case of highly self pollinated crops, where certification of one further generation may be permitted
- Certification tags issued once for certified seed not eligible for further seed increase under certification
- For paddy and wheat, certified seed produced from certified seed is eligible for certification by NSC up to two generations from foundation seed

Seed (Control) Order, 1983

III. Restriction of Export and Import of Seeds

There is a provision to restrict export and import of seeds of notified kinds or varieties. The **section 17** defines as under "No person shall for the purpose of sowing or planting by any person (including himself) export or import or cause to be exported or imported any seed of any notified kind or variety unless.

- It conforms to the minimum limits of germination and purity specified for that seed under clause (a) of Section 6 and
- Its container bears in the prescribed manner the mark or label with the correct particular thereof specified for that seed under clause (b) of section 6.

Background of the case

The Ministry of civil supplies through an order dated 24.4.1983 had declared the seed for sowing or planting materials of food crops, fruits, vegetables, cattle fodder and jute to be essential commodities in exercise of power conferred by Section 2(a) (viii) of Essential Commodities Act, 1955. It was followed by the issue of Seed (control) order dated 30th December, 1983 by the Ministry of Agriculture, Dept. of Agriculture and Co-operation in exercise of powers contained in section 3 of Essential Commodities Act, which deals with Central Governments power to control, and regulate production, supply and distribution of essential commodities.

The Seed (control) order, 1983 had been notified as per Gazette notification, G.S.R 832(E) dated 30. 12.1983. The notification under reference holds good and remains operative. Joint Secretary (Seeds), Government of India, Ministry of Agriculture, Department of Agriculture and Cooperation has been appointed as Seed Controller for implementation of seed (control) order.

Gist of the Seed (Control) order, 1983

Issue of License to dealers

All persons carrying on the business of selling, exporting and importing seeds will be required to carry on the business in accordance with terms and conditions of license granted to him for which dealer has to make an application in duplicate in Form 'A' together with a fee of Rs.50/- for license to licensing authority unless the State Government by notification exempts such class of dealers in such areas and subject to such conditions as may be specified in the notification.

Based on such enquiry as it thinks fit for licensing authority may grant in form 'B' or refuse in provisions of the Order. The refusal to grant license shall be accompanied by clear recording of reasons for such refusal.

Renewal of License

A holder of license shall be eligible for renewal upon and applicable being made in the prescribed form 'C' (in duplicate) together with a fee of rupees twenty before the expiry of license or at the most within a month of date of expiry of license for which additional fee of Rs.25/- is required to be paid.

Appointing of Licensing authority

The state government may appoint such number of persons as it thinks necessary to be inspector and define the area of such Inspector's jurisdiction through notification in the official gazette.

Time limit for analysis of samples by Seed testing lab

Time limit for analysis of samples by seed testing lab and suspension / cancellation of license may be done by Licensing authority after giving an opportunity of being heard to the holder of license, suspend or cancel the license on

grounds of mis-representation of a material in particular or contravention in provision of the order.

Suspension / Cancellation of license

The Licensing authority may after giving an opportunity of being held to the holder of license, suspend or cancel the license on grounds of mis-representation of material in particular or contravention in provision of the Order.

Appeal

The state government may specify authority for hearing the appeals against suspension / cancellation under this order and the decision of such authority shall be final. Any person aggrieved by an order of refusal to grant or amend or renew the license for sale, export / import of seed may within 60 days from the date of Order appeal to the designated authority in the manner prescribed in the Order.

Miscellaneous

The licensing authority may on receipt of request in writing together with Rs.10/- can amend the license of such dealer. Every seed dealer are expected to maintain such books, accounts and records to this business in order and submit monthly return of his business for the preceding months in Form 'D' to the licensing authority by 5th day of every month

The Seeds Act, 1966

(Act No.54 of 1966) [29th December, 1966]

An Act to provide for regulating the quality of certain seeds for sale, and for matters connected therewith.

It is enacted by Parliament in the Seventeenth Year of the Republic of India as follows:

Short Title, Extent and Commencement

1. (1)This Act may be called the Seeds Act, 1966.

(2)It extends to the whole of India.

(3) It shall come into force on such date as the Central Government may, by notification in the Official Gazette, appoint, and different dates may be appointed for different provisions of this Act, and for different States or for different areas thereof.

Definitions

2. In this Act, unless the context otherwise requires,

1. "Agriculture" includes horticulture;
2. "Central Seed Laboratory" means the Central Seed Laboratory established or declared as such under sub-section (1) of section 4;
3. "Certification agency" means the certification agency established under Section 8 or recognised under Section 18;
4. "Committee" means the Central Seed Committee constituted under sub-section (1) of Section 3;
5. "Container" means a box, bottle, casket, tin, barrel, case, receptacle, sack, bag, wrapper or other thing in which any article or thing is placed or packed;
6. "Export" means taking out of India to a place outside India;
7. "Import" means bringing into India from a place outside India;
8. "Kind" means one or more related species or sub-species of crop plants each individually or collectively known by one common name such as cabbage, maize, paddy and wheat;
9. "notified kind or variety" , in relation to any seed, means any kind or variety thereof notified under Section 5;
10. "Prescribed" means prescribed by rules made under this act;
11. "seed" means any of the following classes of seeds used for sowing or planting-

    I. seeds of food crops including edible oil seeds and seeds of fruits and vegetables;

II. cotton seeds;

III. seeds of cattle fodder;

and includes seedlings, and tubers, bulbs, rhizomes, roots, cuttings, all types of grafts and other vegetatively propagated material, of food crops or cattle fodder;

12. "Seed Analyst" means a Seed Analyst appointed under section 12;
13. "Seed Inspector" means a Seed Inspector appointed under section 13;
14. "State Government", in relation to a Union territory, means the administrator thereof;
15. "State Seed Laboratory", in relation to any State, means the State Seed Laboratory established or declared as such under sub-section (2) of section 4 for that State; and
16. "Variety" means a sub-division of a kind identifiable by growth, yield, plant, fruit, seed, or other characteristic.

Central Seed Committee

3. (1) The Central Government shall, as soon as may be after the commencement of this Act, constitute a Committee called the Central Seed Committee to advise the Central Government and the State Governments on matters arising out of the administration of this Act and to carry out the other functions assigned to it by or under this Act.

2. The Committee shall consist of the following members, namely:-

i. a Chairman to be nominated by the Central Government;
ii. eight persons to be nominated by the Central Government to represent such interests that Government thinks fit, of whom not less than two persons shall be representatives of growers of seed;
iii. One person to be nominated by the Government of each of the States.

(3) The members of the Committee shall, unless their seats become vacant earlier by resignation, death or otherwise, be entitled to hold office for two years and shall be eligible for renomination.

(4) The Committee may, subject to the previous approval of the Central Government, make bye-laws fixing the quorum and regulating its own procedure and the conduct of all business to be transacted by it.

(5) The Committee may appoint one or more sub-committees, consisting wholly of members of the Committee or wholly of other persons or partly of members of the Committee and partly of other persons, as it thinks fit, for the purpose of discharging such of its functions as may be delegated to such sub-committee or sub-committees by the Committee.

(6) The functions of the Committee or any sub-committee thereof may be exercised notwithstanding any vacancy therein.

(7) The Central Government shall appoint a person to be the secretary of the Committee and shall provide the Committee with such clerical and other staff as the Central Government considers necessary.

Central Seed Certification Board

"8A. ,(1) The Central Government shall, by notification in the Official Gazette, establish
a Central Seed Certification Board (hereinafter referred to as the Board) to advise the Central
Government and the State Governments on all matters relating to certification and to co-ordinate
the functioning of the agencies established under section 8.

(2) The Board shall consist of the folJowing members, namely:-

(i) a Chairman, to be nominated by the Central Government;

lii) four members, to be nominated by the Central Government from out of the persons employed by th~ State Governments as 'Directors 'of Agriculture;

(iii) three members, to be nominated by the Central Government from out of the persons employed by the Agricultural Universities as Directors of Research;

(iv) thirteen persons, to be nominated by the Central Government to represent such interests as that Government thinks fit, of whom not less than four persons shall be representatives of seed producers or tradesmen.

(3) A member of the Board shall, unless his s~at becomes vacant earlier by resignation or otherwise - be entitled to hold officefor two years from the date of his nomination:

Provided that a person nominated under clause *(if)* or clause *(iii)* of sub-section (2) shall hold office only for so long as he holds the appointment by virtue of which his nomination was made.

Central Seed Laboratory and State Seed Laboratory

4. (1) The Central Government may, by notification in the Official Gazette, establish a Central Seed Laboratory or declare any seed laboratory as the Central Seed Laboratory to carry out the functions entrusted to the Central Seed Laboratory by or under this Act.

(2) The State Government may, by notification in the Official Gazette, establish one or more State Seed Laboratories or declare any seed laboratory as a State Seed Laboratory where analysis of seeds of any notified kind or variety shall be carried out by Seed Analysts under this Act in the prescribed manner.

Power to notify kinds or varieties of seeds

5. If the Central Government, after consultation with the Committee, is of opinion that it is necessary or expedient to regulate the quality of seed of any kind or variety to be sold for purposes of agriculture, it may, by notification in the Official Gazette, declare such kind or variety to be a notified kind or variety for the purposes of this Act and different kinds or varieties may be notified for different States or for different areas thereof.

Power to specify minimum limits of germination and purity, etc.

6. The Central Government may, after consultation with the Committee and by notification in the Official Gazette, specify-

a. the minimum limits of germination and purity with respect to any seed of any notified kind or variety;
b. the mark or label to indicate that such seed conforms to the minimum limits of germination and purity specified under clause (a) and the particulars which such mark or label may contain.

Regulation of sale of seeds of notified kinds or varieties

7. No person shall, himself or by any other person on his behalf, carry on the business of selling, keeping for sale, offering to sell, bartering or otherwise supplying any seed of any notified kind or variety, unless-

a. such seed is identifiable as to its kind or variety;
b. such seed conforms to the minimum limits of germination and purity specified under clause (a) of section 6;
c. the container of such seed bears in the prescribed manner, the mark or label containing the correct particulars thereof, specified under clause (b) of section 6; and
d. he complies with such other requirements as may be prescribed.

Certification agency

8. The State Government or the Central Government in consultation with the State Government may, by notification in the Official Gazette, establish a certification agency for the State to carry out the functions entrusted to the certification agency by or under this Act.

Grant of certificate by certification agency

9. (1) Any person selling, keeping for sale, offering to sell, bartering or otherwise supplying any seed of any notified kind or variety may, if he desires to have such seed certified by the certification agency, apply to the certification agency for the grant of a certificate for the purpose.

(2) Every application under sub-section (1) shall be made in such form, shall contain such particulars and shall be accompanied by such fees as may be prescribed.

(3) On receipt of any such application for the grant of a certificate, the certification agency may, after such enquiry as it thinks fit and after satisfying itself that the seed to which the application relates conforms to the minimum limits of germination and purity specified for that seed under clause (a) of section 6, grant a certificate in such form and on such conditions as may be prescribed.

Revocation of certificate

10. If the certification agency is satisfied, either on a reference made to it in this behalf or otherwise, that-

a. the certificate granted by it under section 9 has been obtained by misrepresentation as to an essential fact; or
b. the holder of the certificate has, without reasonable cause, failed to comply with the conditions subject to which the certificate has been granted or has contravened any of the provisions of this Act or the rules made thereunder;

then, without prejudice to any other penalty to which the holder of the certificate may be liable under this Act, the certification agency may, after giving the holder of the certificate an opportunity of showing cause, revoke the certificate.

Appeal

11. (1) Any person aggrieved by a decision of a certification agency under section 9 or section 10, may, within thirty days from the date on which the decision is communicated to him and on payment of such fees as may be prescribed, prefer an appeal to such authority as may be specified by the State Government in this behalf:

Provided that the appellate authority may entertain an appeal after the expiry of the said period of thirty days if it is satisfied that the appellate was prevented by sufficient cause from filing the appeal in time.

(2) On receipt of an appeal under sub-section (1), the appellate authority shall, after giving the appellant an opportunity of being heard, dispose of the appeal as expeditiously as possible.

(3) Every order of the appellate authority under this section shall be final.

Seed Analysts

12. The State Government may, by notification in the Official Gazette, appoint such persons as it thinks fit, having the prescribed qualifications, to be Seed Analysts and define the areas within which they shall exercise jurisdiction.

Seed Inspectors

13. (1) The State Government may, by notification in the Official Gazette, appoint such persons as it thinks fit, having the prescribed qualifications, to be Seed Inspectors and define the areas within which they shall exercise jurisdiction.

(2) Every Seed Inspector shall be deemed to be a public servant within the meaning of section 21 of the Indian Penal Code (45 of 1860) and shall be officially subordinate to such authority as the State Government may specify in this behalf.

Powers of Seed Inspector

14. (1) The Seed Inspector may-

a. take samples of any seed of any notified kind or variety from-

   i. any person selling such seed; or
   ii. any person who is in the course of conveying, delivering or preparing to deliver such seed to a purchaser or a consignee; or
   iii. a purchaser or a consignee after delivery of such seed to him;

b. send such sample for analysis to the Seed Analyst for the area within which such sample has been taken;
c. enter and search at all reasonable times, with such assistance, if any, as he considers necessary, any place in which he has reason to believe that an offence under this Act has been or is being committed and order in writing the person in possession of any seed in respect of which the offence has been or is being committed, not to dispose of any stock of such seed for a specific period not exceeding thirty days or, unless the alleged offence is such that the defect may be removed by the possessor of the seed, seize the stock of such seed;
d. examine any record, register, document or any other material object found in any place mentioned in clause (c) and seize the same if he has reason to believe that it may furnish evidence of the commission of an offence punishable under this Act; and
e. exercise such other powers as may be necessary for carrying out the purposes of this Act or any rule made thereunder.

(2) Where any sample of any seed of any notified kind or variety is taken under clause (a) of sub-section (1), its cost, calculated at the rate at which such seed is

usually sold to the public, shall be paid on demand to the person from whom it is taken.

(3) The power conferred by this section includes power to break-open any container in which any seed of any notified kind or variety may be contained or to break-open the door of any premises where any such seed may be kept for sale:

Provided that the power to break-open the door shall be exercised only after the owner or any other person in occupation of the premises, if he is present therein, refuses to open the door on being called upon to do so.

(4) Where the Seed Inspector takes any action under clause (a) of sub-section (1), he shall, as far as possible, call not less than two persons to be present at the time when such action is taken and take their signatures on a memorandum to be prepared in the prescribed form and manner.

(5) The provisions of the Code of Criminal Procedure, 1898 (5 of 1898), shall, so far as may be, apply to any search or seizure under this section as they apply to any search or seizure made under the authority of a warrant issued under section 98 of the said Code.

Procedure to be followed by Seed Inspectors

15. (1) Whenever a Seed Inspector intends to take sample of any seed of any notified kind or variety for analysis, he shall-

a. give notice in writing, then and there, of such intention to the person from whom he intends to take sample;
b. except in special cases provided by rules made under this Act, take three representative samples in the prescribed manner and mark and seal or fasten up each sample in such manner as its nature permits.

(2) When samples of any seed of any notified kind or variety are taken under sub-section (1), the Seed Inspector shall-

a. deliver one sample to the person from whom it has been taken;
b. send in the prescribed manner another sample for analysis to the Seed Analyst for the area within which such sample has been taken; and
c. retain the remaining sample in the prescribed manner for production in case any legal proceedings are taken or for analysis by the Central Seed Laboratory under sub-section (2) of section 16, as the case may be.

(3) If the person from whom the samples have been taken refuses to accept one of the samples, the Seed Inspector shall send intimation to the Seed Analyst of such refusal and thereupon the Seed Analyst receiving the sample for analysis shall divide it into two parts and shall seal or fasten up one of those parts and shall cause it, either upon receipt of the sample or when he delivers his report, to be delivered to the Seed Inspector who shall retain it for production in case legal proceedings are taken.

(4) Where a Seed Inspector takes any action under clause (c) of sub-section (1) of section 14:

a. he shall use all despatch in ascertaining whether or not the seed contravenes any of the provisions of section 7 and if it is ascertained that the seed does not so contravene, forthwith revoke the order passed under the said clause or, as the case may be, take such action as may be necessary for the return of the stock of the seed seized;
b. if he seizes the stock of the seed, he shall, as soon as may be, inform a magistrate and take his orders as to the custody thereof;
c. without prejudice to the institution of any prosecution, if the alleged offence is such that the defect may be removed by the possessor of the seed, he shall, on being satisfied that the defect has been so removed, forthwith revoke the order passed under the said clause.

(5) Where as Seed Inspector seizes any record, register, document or any other material object under clause (d) of sub-section (1) of section 14, he shall, as soon as may be, inform a magistrate and take his orders as to the custody thereof.

Report of Seed Analyst

16.(1) The Seed Analyst shall, as soon as may be after the receipt of the sample under sub-section (2) of section 15, analyse the sample at the State Seed Laboratory and deliver, in such form as may be prescribed, one copy of the report of the result of the analysis to the Seed Inspector and another copy thereof to the person from whom the sample has been taken.

(2) After the institution of a prosecution under this Act, the accused vendor or the complainant may, on payment of the prescribed fee, make an application to the court for sending any of the samples mentioned in clause (a) or clause (c) of sub-section (2) of section 15 to the Central Seed Laboratory for its report and on receipt of the application, the court shall first ascertain that the mark and the seal or fastening as provided in clause (b) of sub-section (1) of section 15 are intact and may then despatch the sample under its own seal to the Central Seed Laboratory which shall thereupon send its report to the court in the prescribed form within one month from the date of receipt of the sample, specifying the result of the analysis.

(3) The report sent by the Central Seed Laboratory under sub-section (2) shall supersede the report given by the Seed Analyst under sub-section (1).

(4) Where the report sent by the Central Seed Laboratory under sub-section (2) is produced in any proceedings under Section 19, it shall not be necessary in such proceedings to produce any sample or part thereof taken for analysis.

Restriction on export and import of seeds of notified kinds or varieties

17. No person shall, for the purpose of sowing or planting by any person (including himself), export or import or cause to be exported or imported any seed of any notified kind or variety, unless-

a. it conforms to the minimum limits of germination and purity specified for that seed under clause (a) of section 6; and
b. its container bears, in the prescribed manner, the mark or label with the correct particulars thereof specified for that seed under clause (b) of section 6.

Recognition of seed certification agencies of foreign countries

18. The Central Govt. may, on the recommendation of the Committee and by notification in the Official Gazette, recognise any seed certification agency established in any foreign country, for the purposes of this Act.

Penalty

19. If any person-

a. contravenes any provision of this Act or any rule made thereunder; or
b. prevents a Seed Inspector from taking sample under this Act; **or**
c. prevents a Seed Inspector from exercising any other power conferred on him by or under this Act;

he shall, on conviction, be punishable-

i. for the first offence with fine which may extend to five hundred rupees, and
ii. in the event of such person having been previously convicted of an offence under this section, with imprisonment for a term which may extend to six months, or with fine which may extend to one thousand rupees, or with both.

Forfeiture of property

20. When any person has been convicted under this Act for the contravention of any of the provisions of this Act or the rules made thereunder, the seed in respect

of which the contravention has been committed may be forfeited to the Government.

Offences by companies

21. (1) Where an offence under this Act has been committed by a company, every person who at the time the offence was committed was in charge of, and was responsible to the company for the conduct of the business of the company, as well as the company, shall be deemed to be guilty of the offence and shall be liable to be proceeded against and punished accordingly:

Provided that nothing contained in this sub-section shall render any such person liable to any punishment under this Act if he proves that the offence was committed without his knowledge and that he exercised all due diligence to prevent the commission of such offence.

(2) Notwithstanding anything contained in sub-section (1), where an offence under this Act has been committed by a company and it is proved that the offence has been committed with the consent or connivance of, or is attributable to any neglect on the part of, any director, manager, secretary or other officer of the company, such director, manager, secretary or other officer shall also be deemed to be guilty of that offence and shall be liable to be proceeded against and punished accordingly.

Explanation. – For the purpose of this section,-

a. "company" means any body corporate and includes a firm or other association of individuals; and
b. "director", in relation to a firm, means a partner in the firm.

Protection of action taken in good faith

22. No suit, prosecution or other legal proceeding shall lie against the Government or any officer of the Government for anything which is in good faith done or intended to be done under this Act.

Power to give directions

23. The Central Government may give such directions to any State Government as may appear to the Central Government to be necessary for carrying into execution in the State any of the provisions of this Act or of any rule made there under.

Exemption

24. Nothing in this Act shall apply to any seed of any notified kind or variety grown by a person and sold or delivered by him on his own premises direct to another person for being used by that person for the purpose of sowing or planting.

Power to make rules

25. (1) The Central Government may, by notification in the Official Gazette, make rules to carry out the purpose of this Act.

(2) In particular and without prejudice to the generality of the fore-going power, such rules may provide, for-

a. the functions of the Committee and the travelling and daily allowances payable to members of the Committee and members of any sub-committee appointed under sub-section (5) of section 3;
b. the functions of the Central Seed Laboratory;
c. the functions of a certification agency;
d. the manner of marking or labeling the container of seed of any notified kind or variety under clause (c) of Section 7 and under clause (b) of section 17;
e. the requirements which may be complied with by a person carrying on the business referred to in section 7;
f. the form of application for the grant of a certificate under section 9, the particulars it may contain, the fees which should accompany it, the form of the certificate and the conditions subject to which the certificate may be granted;

g. the form and manner in which and the fee on payment of which an appeal may be preferred under section 11 and the procedure to be followed by the appellate authority in disposing of the appeal;
h. the qualifications and duties of Seed Analysts and Seed Inspectors;
i. the manner in which samples may be taken by the Seed Inspector, the procedure for sending such samples to the Seed Analyst or the Central Seed Laboratory and the manner of analyzing such samples;
j. the form of report of the result of the analysis under sub-section (1) or sub-section (2) of section 16 and the fees payable in respect of such report under the said sub-section (2);
k. the records to be maintained by a person carrying on the business referred to in section 7 and the particulars which such records shall contain; and
l. any other matter which is to be or may be prescribed.

(3) Every rule made under this Act shall be laid as soon as may be after it is made, before each House of Parliament while it is in session for a total period of thirty days which may be comprised in one session or in two successive sessions, and if, before the expiry of the session in which it is so laid or the session immediately following, both Houses agree in making any modification in the rule or both Houses agree that the rule should not be made, that rule shall, thereafter have effect only in such modified form or be of no effect, as the case may be; so however, that any such modification or annulment shall be without prejudice to the validity of anything previously done under that rule.

New seed policy {1988}

The Government of India evolved a New seed policy implemented **from October 1, 1988.**

The policy laid special emphasis on

- Import of high quality of seeds

- A time bound programme to modernize plant quarantine facilities

- Effective implementation of procedures for quarantine /post entry quarantine and

- Incentives to encourage the domestic industry

- Import of quality seeds.

1. Bulk import of seeds of coarse cereals, pulses and oil seeds may replace (or) displace the local productions.
2. Transfer of technology may not be actual one, because due to bulk import of seeds or import of technology, instead we can import the germplasm of superior variety if any and could be developed locally to meet the demand (i.e.,) incorporate the advantages of exotic variety to the local types(or) even direct multiplication's after adaptive trials.
3. As we have superior varieties of international standard (e.g.) Maize, Sorghum, Bajra, or even in oil seeds like groundnut etc., the bulk import is not necessiated. Instead we need varieties suitable to agroclimatic zones besides higher yields.
4. Import of flower seeds could be encouraged in order to earn foreign exchange through export of flowers and it can be imported under (OGL) open general license. But there is a fear of introduction of new pest and diseases as they are coming without post entry quarantine checkup.

Strengthening of quarantine

Since, 1st October 1988 only bulk import of seeds was under taken without any progress either in the strengthening of quarantine facilities.

Threat of pest and disease

Introduction of new pest and disease would pose a new problem due to bulk import due to lack of post entry quarantine. To avoid this threat, the imported seeds should be subjected to testing and it should be done by one person from ICAR. Entry of exotic variety without proper field testing may change the disease pattern if that particular strain is becoming susceptible to existing pathogens.

(e.g.) Kernal burnt - which was not noticed in the previous years is now a major disease on wheat after the introduction of Kalyansona.

Genetic erosion

It is another danger, due to introduction of similar strains there is a danger of genetic uniformity and eliminates local diversified strains which leads to problem of non-availability of improved strains if there is any outbreak of disease.

Incentives to domestic seed industry

Indigenous seed production / seed industry will be affected because of the entry of multi nation diseases. Since the policy is allowing indiscriminate bulk imports through private sectors at the same time the import duty on seeds has been reduced to 15 per cent. Import duty on advanced machines and equipment used in seed production or processing has also been reduced and interest on post shipment credit has also been slashed down to help importers. Income tax rebate and deduction are available to the taxpaying units on the revenue expenditure or in house research and development. Incentives are also being provided to seeds located in backward areas and growth centers.

Application of biotechnology in agriculture

The multination would prevent the III world countries in enjoying the full benefit of biotechnology. The bulk import of seed indicates accepting the monopoly rights and the limitation of potential bio-technology in agriculture.

Advantages of biotechnology in agriculture

Certain plants fertilize themselves through nitrogen fixation, which is one of the most promising areas of genetic engineering. Bacterium on the roots of plants like groundnut, and soyabean take nitrogen from the air and transform it into nitrates. Scientists are studying the possibility of transforming the genes responsible for nitrogen fixation in wheat, rice, and maize (in which nitrogen fixation doses not occur). They feel new strains can be grown without expensive chemical fertilizers.

Plant variety protection (PVP) and the Indian agriculture (Protection of Plant Variety & farmers right Bill,2001)

The Intellectual Property Rights (IPRs) are generally being applicable to industrial property only. The patent laws of India did not provide for IPRs on living organisms including plant varieties. The question of plant variety protection has been brought in to sharp focus by Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) which is a part of Agreement establishing World Trade Organization (WTO). India is a signatory to TRIPS agreement, which casts an obligation on member countries to provide for a system of plant variety protection either through patents or through a *sui generis* legislation framework or a combination thereof. Under these agreements, a legislative framework for plant variety protection has to be provided by member countries within a specified time period. While this has lent some urgency to the question of plant variety protection, the question of plant variety rights, even independent of the obligations posed by TRIP's agreement, has been under active consideration in view of our strong agricultural research system. The plant breeding programmes have become more sophisticated and high input based. The extent of investment by the State on public research, in evolving varieties of commercial significance, is coming down with responsibility of evolving new varieties of crops of commercial significance being left to the private sector commercial organisations. There is also a move on the part of the international research institutions, who at one time played a pioneering role in plant breeding and genetic work, to focus on pure or strategic research. In the

wake of the global economic liberalization, it is only expected that agriculture is accorded the status of an industry and given all incentives and impetus, normally required for a fast developing, competitive business. To meet our food demands, as well as to exploit our export potential in agricultural commodities, development and use of new plant varieties having specific agronomic nutritive or market preference characteristics are essential. New varieties may be bred for higher yields, greater resistance to biotic and abiotic stresses, longer shelf life, better consumer preference, higher industrial value, low input requirements and so on. To meet these demands the variety improvement activities based on conventional as well as biotechnological methods requires heavy investments both in scientific, man power and economic terms. It is therefore, understandable that the fruits of such intensive efforts will have to be protected from misuse, and also ensuring an appropriate incentive (reward) to the breeder.

The following are the plant variety protection steps:

1. Historical developments of plant variety protection

For over 60 years, different forms of protection of new plant varieties through the system of Plant Breeders' Right (PBR's) have been in existence in industralised countries which essentially means that the holder of the PBR can prevent others from producing propagating material of the protected variety and / or marketing the same. In order to coordinate inter country implementation of PBR a " Union Internationale Pour La Protection Des Obtention Vegetables" (UPOV) was established by International Convention for Protection of New Varieties of plants (the UPOV convention), which was signed in Paris in 1961. The convention entered into force in 1968. It was revised in 1972, 1978 and 1991. The 1978 Act entered into force in 1981. The 1991 act has not yet entered into force.

The purpose of UPOV convention is to ensure that the member States of the Union acknowledge the achievements of breeder of new plant varieties by making available to them exclusive property rights, on the basis of a set of uniform and clearly defined principles. To be eligible for protection, varieties have to be (I) distinct from existing known varieties (ii) sufficiently homogenous (uniform) (iii)

stable and (iv) new in the sense that they must not have commercialised prior to certain dates established by reference to the date of the application for protection.

2. Scope of protection of plant varieties under UPOV convention

Both the 1978 and 1991 conventions set out a minimum scope of protection offer to member states for the possibility of taking national circumstances into account in their legislation. Under 1978 Act, the minimum scope of the Plant Breeders' right requires that the holders' authorization for the production for purposes of commercial marketing, the offering for sale and marketing of propagating material of protected variety.

The 1991 Act contains more detailed provision defining the acts concerning propagating material in relation to which holders' authorization is required. Exceptionally, but only where the holder has no reasonable opportunity to exercise his right in relation to the propagating material, his authorization may be required in relation to any specified acts done with harvested material of the variety.

3. Duration of plant breeder's rights

Like all intellectual property rights, plant breeder’s rights are granted for a limited period of time (15-20 years) at the end of which varieties protected by them pass into public domain. The rights are also subject to controls, in the public interest, against any possible abuse.

4. Exemptions

It is also important to note that authorization of the holder of plant breeders' rights is not required for the use of his variety for research purpose, including its use in the breeding of further new varieties.

From the inception of UPOV in 1961, farmers have been allowed to use their own harvested material of protected varieties for the next production cycle on their own farms. On farm saving is still a practice in UPOV countries. The 1991 UPOV convention contains an "Optional exception" which provides that it is unto the national government to decide whether to permit farmers to use the seed of a PBR protected variety for propagation purposes on their own holdings or not.

5. Sovereign rights on biological resources

Another major development, which has taken place along with India signing the World Trade Agreement, is global Biodiversity Convention. India is a signatory to this convention, which became operational on December 29, 1993. Among other things it reaffirms that "the states have sovereign rights over their own biological resources" and that states are responsible for conserving their biological diversity and for using their biological resources in a sustainable manner".

6. Suggestions for a SUI system of plant variety protection

The proposal of 1991 UPOV convention which extents plant breeders rights to the harvested material, is not appropriate for our country. The frame work for plant variety protection has to be evolved in a manner that prevents situations where repeated imports of improved varieties are not required so as to avoid dependence on foreign sources of supply.

While, finalizing legislation on PVP, the government needs to strike a balance between its commitment under WTO, growth of the seed sector and their interests of the farmers, which through a difficult task, is not impossible to achieve.

7. Seed Industry Development in Post PVP period

In the post PVP period, we anticipate fairly high investment in seed research from private sector and healthy competition with public sector in crop breeding and seed production and distribution. However, public sector institutions will continue to play major role in developing varieties of wheat rice, chick pea, pigeon pea, mungbeans, urdbeans, groundnut, sugarcane, jute, potato and millets. The continued improvement of these crops is most vital for our food security system. The public sector will have to continue to develop varieties for rainfed, salt affected, hilly and low lying flood prone regions. In export potential of food grains and other agricultural commodities, breeding for quality of produce will have to be given priority. We may also tailor varieties suited to the needs of the importing countries. Since there is growing concern about the use of chemical pesticides in crop production, the present research programme of breeding for resistance against the pests and diseases will have to be strengthened further. **Strategic research on**

breeding for research against pests and diseases will be priority areas of research of a public institution. We anticipate that the material generated from these research programmes will be made available to the private sector.

Seed industry both in public and private sector is likely to develop at a fast rate after the legislation on plant variety protection is enacted. The recent experience shows that contribution of both public and private sector in Seed industry development is complimentary. While private sector seed companies are concentrating on hybrids of millets, oil seeds, cotton and vegetables, the public sector seed corporations are engaged in seed production and distribution of self-pollinated crops. It has also been observed that due to competition among the seed companies, the farmers have been benefited not only in respect of stability in prices of hybrid seeds but also better quality of seeds. It is expected that with programmatic policy planning, faster growth of both public and private sector in seed research and development will be ensured so that they can play important role in improving the incomes and standards of living of our farmers.

Seed Certification

It is a legally sanctioned system for quality control and seed multiplication and production. It involves field inspection, pre and post control tests and seed quality tests.

Purpose of seed certification

To maintain and make available to the farmers, through certification, high quality seeds and propagating materials of notified kind and varieties. The seeds are so grown as to ensure genetic identity and genetic purity.

Eligibility for certification of crop varieties

Seeds of only those varieties which are notified under section 5 of the Seeds Act, 1966 shall be eligible for Certification.

Breeder seed is exempted from Certification. Foundation and Certified class seeds come under Certification.

Breeder seed is produced by the plant breeder which is inspected by a monitoring team consisting of the breeder, representative of seed certification agency (DDA), representative of NSC (Deputy Manager) & nominee of crop co-ordinator (s – 11). The crops shall be inspected at appropriate stage.

Phases of seed certification or Seed certification procedures

1. Receipt & Scrutiny of application
2. Verification of seed source
3. Field inspection
4. Post harvest supervision of seed crops
5. Seed sampling & testing
6. Labelling, tagging, sealing and grant of certificate.

1. Receipt & scrutiny of application

a. Application for registration

Any person, who wants to produce certified seed shall register his name with the concerned Assistant Director (AD) of seed certification by remitting Rs. 25/- per crop, per season. There are 3 seasons under certification viz., kharif (June-Sep), Rabi (Oct. – Jan.) & Summer (Feb-May).

The applicant shall submit two copies of the application to the ADSC 10 days before the commencement of the season or at least at the time of registration of sowing report.

On receipt of the application, the ADSC will verify the time limit, variety eligibility & its source, the class mentioned, remittance of fee etc.

The application, if accepted will be given an application no (e.g. Paddy / K / 01- 05-06, where Paddy refers the crop to be registered, K-the season, 01-the application no & 05-06 -the financial year). The original application is retained and the duplicate is returned to the applicant.

b. Sowing report: (Application for the registration of seed farm)

The seed producer who wants to produce certified seeds shall apply to the ADS.C, in the prescribed sowing report form in quadriplicate with prescribed certification fees along with other documents such as tags to establish the seed source.

Class of seed	**Source of seed**
1. Foundation class	Breeder seed
2. Certified class	Foundation seed
3. F. Class stage II	Foundation class stage – I
4. C. Class stage II	Certified class stage - I

Separate sowing reports are required for different crop varieties, different classes, different stages and if the seed farm fields are separated by more than 50 metres.

Separate sowing reports are also required if sowing or planting dates differ by more than 7 days and if the seed farm area exceeds 25 acres.

The sowing report shall reach the concerned ADAS.C within 35 days from the date of sowing or 15 days before flowering whichever is earlier. In the case of transplanted crops, the sowing report shall be sent 15 days before flowering.

The producer shall clearly indicate on the reverse of sowing report, the exact location of the seed farm in a rough sketch with direction, distances marked form a permanent mark like mile stone, building, bridge, road, name of the farm if any, crops grown on all four sides of the seed farm etc, to facilitate easy identification of the seed farm by the seed certification officer.

The AD S.C, on receipt of the sowing report, scrutinizes & register the seed farm by giving a S.C number for each sowing report. Then he will send one copy of the sowing report to the S.C officer, one to the D.D.S.C & the third to the producer after retaining the fourth copy.

2. Verification of seed source

During his first inspection of seed farm the S.C officer, will verify whether the seed used to raise the seed crop is from an approved source.

3. Field Inspection

Objective

The objective in conducting field inspection is to verify the factors which can cause irreversible damage to the genetic purity or seed health.

Inspection Authority

The seed certification officer authorized by the registering authority shall attend to field inspections.

Crop stages for inspection

The number of field inspections and the stages of crop growth at which the field inspections should be conducted vary from crop to crop. It depends upon duration, and nature of pollination of the seed crop.

If the crop is grown for hybrid seed production, the no. of field inspections during the flowering stage should be more than in the case of self-pollinated / cross/ often cross pollinated varieties.

In hybrid seed production and variety seed production of cross pollinated crops, the inspection during flowering should be made without any prior notice of the seed grower to judge the quality of operation undertaken by him to maintain the genetic purity of the crop. But in the case of self-pollinated crops the seed grower may be informed about the date of inspection.

In the former case if prior notice is given to the seed grower, it may not be possible to detect the damage by the contaminants, whereas in the latter case prior notice will lead to improvement of the quality of the seed production work and thus the quality of seed.

The key points to be observed at each stage of inspection are

Stage of crop	Key points to be observed at Inspection
I.Pre-flowering stage (Vegetative stage)	Verification of seed source
	Confirmation of acreage given in the report
	Land requirement to keep check on genetic as well as physical contamination and spread of disease inoculums.
	Planting ratio
	Border rows
	Isolation distance
	Guide the grower in identification of Off-types, pollen shedder, diseased plants, shedding tassels etc.
II. Flowering Stages: (May be II & III inspections, When 5% of plants begin to flower)	Confirm the observation of plants inspection were correct.
	Confirm whether grower had continued thorough roguing, after the previous inspection.
	Verify the removal & occurrence of Off-types, pollen shedders, shedding tassels, objectionable weed plants & diseased plants.

III. Inspection during post flowering and pre-harvest stage	Confirm the correctness of observations, made in earlier inspections
	Guide the grower on roguing, based on pods, earhead, seed & chaff characters such as colour, shape & size
	Explain to the grower when & how to harvest the crop & process
IV. Inspection during harvest (This is the last inspection conducted on a seed crop)	Verify that male parent rows have been harvested separately.
	Ensure complete removal of off-types, other crops, weeds & diseased plants etc.
	Seal properly by the certification agency of the threshed produce after initial leaning & drying.
	Instruct the seed growers for safe storage & transportation.

MINIMUM NUMBER OF FIELD INSPECTIONS REQUIRED

FOR DIFFERENT CROPS FOR CERTIFICATION

Crop	Minimum no. of inspection	Stages of crop
Paddy & Wheat	2	Flowering to harvest
Sorghum Hybrid	4	Ist before flowering, II nd & IIIrd during flowering, IVth prior to harvest.
Varieties	3	Ist before flowering, II nd during flowering and IIIrd prior to harvest

Maize Inbred lines, Single crosses, Other hybrids	4	Ist before flowering Rest during flowering
Varieties	2	I st before flowering IInd during flowering
Bajra Hybrids	4	Ist before flowering II nd & IIIrd during flowering, IVth prior to or during harvest
Varieties	3	Ist before flowering IInd during 50% flowering IIIrd prior to harvest
Green gram,Black gram, Red gram **Cowpea**	2	Ist before flowering II nd at flowering & fruiting stage
Ground nut	2	Flowering to harvest
Sesame **(Gingelly)**	3	Ist before flowering II nd during flowering IIIrd from fruit maturity to harvest
Sunflower	2	Flowering to harvest
Rape & mustard	3	Ist before flowering II nd from flowering to fruiting IIIrd from fruit maturity to harvest
Soyabean	2	Flowering to harvest
Castor	2	Flowering to harvest
Cotton (Varieties) (Hybrids)	2 4	Flowering to harvest Ist before flowering II nd & IIIrd during flowering IVth during harvest

Brinjal, Tomato Chilli, Bhendi	3	Ist before flowering IInd from lowering to fruiting IIIrd during maturity
Carrot	3	Ist early (20-30 days after sowing), IInd when lifted & re-planted, IIIrd during flowering.
Cabbage	3	Ist before marketable stage IInd when the heads have formed IIIrd during flowering
Cauliflower	4	Ist before marketable stage IInd during curd formation IIIrd when most plants have formed curds IV th during flowering
Onion (seed to seed)	3	Ist during early vegetative stage IInd during bulb formation IIIrd during flowering

Field Counts

The purpose of field inspection is to find out field standards of various factors in the seed farm. It is impossible to examine all the plants in the seed farm. Hence, to assess the field standards of various factors random counting is followed.

The number of counts taken and the method employed in taking counts vary from crop to crop. It is necessary to take a minimum of 5 counts upto 5 acres & an additional count for every 5 acres or part thereof as given below:

Area of the field (in acres)	No. of counts to be taken
Upto 5	5
6-10	6

11-15	7
16-20	8
21-25	9

Double Count

In any inspection, if the first set of counts shows that the seed crop does not confirm to the prescribed standard for any factor, a second set of counts should be taken for that factor. However, when the first set of counts shows a factor more than twice the maximum permitted, it is not necessary to take a second count.

On completion of double count, assess the average for the two counts. It should not exceed the minimum permissible limit.

NO. OF PLANTS FOR A COUNT

S.no.	Crop	No. of plants / heads per count	Remarks
1.	Soyabean, Jute, Lucerne, Mesta, Berseem	1000 plants	Closely planted crops
2.	Beans, Cluster beans, Cowpea, Peas, Green gram, Blackgram, Mustard,Niger, Sesame, Bengal gram, Safflower	500 plants	Medium spaced crops
3.	Bhendi, Brinjal, Chilli, Castor, Cole crops, Cotton, Cucurbits, Maize, Potato, Groundnut, Redgram, Tomato & Sunflower	100 plants	Wide spaced crops
4.	Bajra, Barley, Oats, Paddy, Wheat, Ragi, Sorghum	1000 heads	Tillering crops

Points to be observed before counting

1. All plants falling in each count must be examined for each factor
2. In hybrid seed field, the prescribed number of the field counts should be taken in each parent separately.

Sources of contamination or factors to be observed

The contaminants are

1. Physical contaminants
2. Genetical contaminants.

- Physical contaminants are inseparable other crop plants, objectionable weed plants and diseased plants.
- Genetical contaminants consist of off-types, pollen shedders and shedding tassels.

a. Off Type

Plant that differs in morphological characters from the rest of the population of a crop variety.

Off-type may belong to same spp. or different spp. of a given variety. Plants of a different variety are also included under off-types.

Volunteer plants & mutants are also off-types.

b. Volunteer Plant

Volunteer plants are the plants of the same kind growing naturally from seed that remains in the fields from a previous crop.

c. Pollen Shedders

In hybrid seed production involving male sterility, the plants of 'B' line present in 'A' line are called Pollen shedders.

Sometimes 'A' line tends to exhibit symptoms of fertile anthers in the ear heads of either on the main tiller or side tiller and these are called Partials. These partials are also counted as pollen shedders.

d. Shedding Tassels

These are plants which shed or shedding pollen in female parent rows. When 5 cm or more of the entire spike shed pollen they are also counted as Shedding tassels.

e. Inseparable Crop Plants

These are plants of different crops which have seeds similar to seed crop.

Crop	Inseparable crop plants
Wheat	Barley, oats, gram, & Triticale
Barley	Oats, gram, wheat & Triticale
Oats	Barley, gram, wheat & Triticale
Triticale	Wheat, barley, oats, gram & Rye

f. Objectionable Weed Plants

These are weeds

1. Whose seeds are difficult to be separated once mixed
2. Which are poisonous
3. Which have smothering effect on the main crop
4. Which are difficult to eradicate once established.
5. Difficult to separate the seeds. These seeds cause mechanical admixtures

S.No	Crop	Common name of the weed	Botanical name
1.	Paddy	Wild rice	*Oryza sativa var fatua*
2.	Wheat	Wild morning glory	*Convolvulus arvensis*
3.	Sunflower	Wild sunflower	*Helianthus spp*

4.	Bhendi	Wild okra	*Abelmoschus spp*
5.	Rape, mustard	Mexican prickly poppy	*Argemone mexicana*
6.	Lucerne	Dodder	*Cuscuta spp*

g. Designated Diseases

The diseases which may reduce the yield and quality of seeds are termed as Designated diseases.

S.No	Crop	Name of the Disease	Casual organism
1.	Wheat	Loose smut	*Ustilago tritici*
2.	Sorghum	Grain smut Head smut	*Sphacelotheca sorghii*
3.	Pearl millet	Ergot Grain smut Downy mildew	*Claviceps microcephala* *Tolyposporium pencillariae* *Sclerospora graminicola*
4.	Cowpea	Anthracnose	*Colletotrichum lindemuthianum*
5.	Green gram	Halo blight	*Pseudomonas phasiolicola*
6.	Gingelly	Leafspot	*Cercospora sesami*
7.	Sunflower	Downy mildew	*Plasmopara halstedii*
8.	Brinjal	Phomopsis blight	*Phomopsis vexans*
9.	Chilli	Leaf blight Anthracnose	*Alternaria solani* *Colletotrichum capsici*
10.	Tomato	Early blight Leaf spot Tobacco mosaic virus	*Alternaria solani* *Stemphylium solani* *(TMV)*

Land Requirement

The field offered for certified seed production should not been grown in the previous season with the same crop. If it was grown, the variety should be the

same. In that case, the field should be irrigated at least 3 weeks before sowing and ploughed just prior to sowing, in order to destroy germinating seeds.

Isolation

Separation of seed fields from fields of other varieties of the same crop, same variety fields not conforming to varietal purity requirements, and other related species fields and fields affected by diseases to prevent genetic & disease contamination.

The minimum distance to be maintained between the seed crop and the contaminant is called Isolation distance.

Crop	F.S (m)	C.S (m)
Self pollinated crops		
Cereals and Millets		
Paddy	3	3
Wheat	3	3
Pulses		
Green gram	10	5
Black gram	10	5
Soya bean	3	3
Bengal gram	10	5
Cowpea	10	5
Lab lab	10	5
Oil Seeds		
Groundnut	3	3
Vegetables		
Tomato	50	25
Cluster beans	10	5
French beans	10	5
Peas	10	5
lettuce	50	25

Potato	5	5
Often Cross Pollinated crops		
Millet		
Sorghum Variety	200	100
Sorghum hybrid	300	200
Pulses		
Red gram	200	100
Oil Seeds		
Sesame	100	50
Cotton (variety)	50	30
Vegetables		
Brinjal	200	100
Chillies	400	200
Bhendi	400	200
Cross Pollinated Crops		
Millets		
Maize (varieties)	400	200
Inbred line	400	-
Single cross hybrid	400	-
Double cross hybrid	-	200
Bajra variety	400	200
Bajra hybrid	1000	200
Sun hemp	200	1000
Castor	300	150
Sunflower variety	400	200
Sunflower hybrid	600	400
Cabbage	1600	1000
Beetroot	1600	1000
Radish	1600	1000
Cauliflower	1000	500
Onion	1000	800

Carrot	400	200
Amaranthus	1000	500
Gourds		

Inspection Report

The seed certification officer after taking field counts and comparing them with the minimum field standards, the observations made on the seed farm field should be reported in the prescribed proforma to

1. Deputy Director of S.C
2. To the Seed producer
3. AD, S.C
4. Retained with him.

Assessment of seed crop yield

It is necessary to avoid malpractices at the final stage during harvest operation.

The seed certification officer is expected to fix the approximate seed yield.

L.F.R REPORT (Liable For Rejection Report)

If the seed crop fails to meet with any one factor as per the standards, L.F.R report is prepared & the signature of the producer is obtained & sent to D.DSC within 24 hrs.

RE-Inspection

For the factors which can be removed without hampering the seed quality, the producer can apply for re-inspection to the concerned D.D,S.C within 7 days from the date of F.I rejection order. For re-inspection half of the inspection charge is collected.

4. Post Harvest Supervision Of Seed Crop

The post harvest inspection of a seed crop covers the operations carried out at the threshing floor, transport of the raw seed produce to the processing plant, pre-celeaning, drying, cleaning, grading, seed treatment, bagging & post processing storage of the seed lot.

Pre-requisites for processing

1. Processing report should accompany the seed lot
2. ODV test for paddy should be done at the time of sealing & issue of processing report or before processing. If the result exceeds 1% the produce may be rejected.
3. It should correlate with the estimated yield.
4. Seed should be processed only in approved processing unit.
5. Field run seed should be brought to the processing unit within 3 moths from the date of final inspection. Processing & sampling should be done within 2 months in oil seed crops & 4 months for other crops from the date of receipt in the processing unit. In cotton, the kapas from the passed lot should be moved to the ginning factory within 5 days from the date of issue of processing report. The ginning should be done within 3 months from the date of final harvest inspection report. Ginned seeds should be moved to seed processing unit within 5 days of ginning. Inspection and sampling should be done within 3 months after ginning.

Intake of Raw Produce & Lot Identification

The seed certification officer in-charge of the seed processing plant may, after verification of the above stated documents and total amount of seed accept the produce for processing.

After verification he should issue a receipt to the seed grower. Each seed lot has to be allocated a separate lot number for identification.

Processing of seed lot

1. It is done to remove chaff, stones, stem pieces, leaf parts, soil particles etc from the raw seed lot.
2. Grading to bring out uniformity in the seed lot.
3. Seed treatment to protect it from storage pests & diseases.

Processing Inspection

1. The processing should be done in the presence of concerned seed certification officer.
2. The recommended sieve size should be used for grading.
3. While processing of paddy, the work of perfect processing has to be evaluated then & there.This is done by conducting a **float test**. Take 400 seeds from the processed seed & put into a tumbler of water. Count the floating paddy seeds. Maximum float admissible is 5%. If the float seeds exceed the limit, adjust the air flow or feeding to perfect the processing.
4. In maize, before shelling, the cobs should be examined for off-type and off - coloured kernels. Individual cobs should be examined with reference to its Varietal characters. The cobs of off-types and off-coloured kernels should be rejected.
5. Seed Sorting in Cotton.

   The ginned seeds will be evaluated for its quality. A maximum of 3% for the following factors can be taken into account.

   1. Immature seeds
   2. Ill-filled seeds
   3. Broken seeds
   4. Stained seeds &
   5. Over fuzzy seeds.

Groundnut Pod Verification

- In groundnut 4% of ill-filled pods can be allowed.
- After processing, the seeds may be treated, packed, weighed & sealed before the SCO.
- The unit of packing may be equal to the seed rate of 1/2 or one acre or ha

5. Seed Sampling & Testing

During packaging S.C officer will draw samples according to ISTA Procedure & send the sample to ADSC concerned within a day of sampling. The ADSC will inturn send the sample to the STL within 3 days of receipt of the sample for testing seed standards viz. physical purity, germination, moisture content & seed health as prescribed. The STO will communicate the result to the ADSC concerned within 20 days.

On receipt of the analytical report, the ADSC will communicate the result to the producer & SCO.

6. Labelling, tagging, sealing and grant of certificate

After receiving the seed analytical report, the SCO will get the tag from the ADSC & affixes labels (producer's label) and tags **(Blue for C.S & White for F.S)** to the containers & sealed to prevent tampering and grant certificate fixing **a validity period for 9 months.**

Tagging should be done within 60 days of testing.

Resampling & Reprocessing

When a seed lot does not meet the prescribed seed standards in initial test, on request of the producer SCO may take resample.

If the difference in germination analysed & required is within 10, then straight away re-sampling can be done. If it is > 10, reprocessing & resampling may be done.

The producer should request the SCO concerned in writing within 10 days from the receipt of the result. No charge is collected for resampling.

When a seed lot, fails even after free sampling, reprocessing can be taken upon with special permission from D.S.C. For such reprocessing a fee of Rs. 20/- Q and lab charges of Rs. 10/- Q is collected.

Lecture No. 26 **Seed testing**

Importance

- Quality control of seed depends on the different seed testing protocols which determine the genuine of cultivar.
- Testing of seed evaluate the planting value and the authenticity of the certified lot.
- Seed testing has been developed to aid agriculture to avoid some of the hazards of crop production by furnishing the needed information about different quality attributes viz., purity,moisture,germination,vigour and health.
- The importance of seed testing was realized more than 100 years ago for assured planting values. The adulteration of vegetable seeds by stone dust which was practiced in some parts of the world particularly in Europe.

SEED SAMPLING

Seed sampling is to draw a portion of seed lot that represents the entire seed lot.

Introduction

Seed lot - It is an uniformly blended quantity of seed either in bag or -in bulk.

Seed Size	Maximum quantity per lot
Larger than wheat and paddy	20,000 kg
Smaller than wheat and paddy	10,000 kg
Maize	40,000 kg

Sampling intensity

a. For seed lots in bags (or container of similar capacity that are uniform in size)

I.	up to 5 containers	Sample each container but never, < 5 Primary sample
	6-30 "	Sample atleast one in every 3 containers but never > than 5 P. S.
	31-400 "	Sample atleast one in every 5 containers but never < 10 P. S.
	401 or more	Sample atleast one in every 7 containers but never < 80.

II. When the seed is in small containers such as tins, cartons or packets a 100 kg weight is taken as the basic unit and small containers are combined to form sampling

units not exceeding this weight e.g. 20 containers of 5 kg each. For sampling purpose each unit is regarded as one container.

b. For seeds in bulk

Up to-500kg	-	Atleast 5 Primary sample
501 - 3000 Kg	-	1 Primary sample for each 300 kg but not less than 5 Primary sample
3001-20,000 Kg	-	1 Primary sample for each 500 kg but not less than 10 Primary sample
20,001 and above	-	1 Primary sample for each 700 kg but not less than 40 Primary sample

PRINCIPLES OF SAMPLING

Sample is obtained from seed lot by taking small portion at random from different places and combining them. From this sample smaller samples are obtained by one or more stages. In each and every stage thorough mixing and dividing is necessary.

Methods of sampling

a. Hand sampling

This is followed for sampling the non free flowing seeds or chaffy and fuzzy seeds such as cotton, tomato, grass seeds etc., In this method it is very difficult to take samples from the deeper layers or bag. To overcome this, bags are emptied completely or partly and then seed samples are taken. While removing the samples from the containers, care should be taken to close the fingers tightly so that no seeds escape.

b. Sampling with triers

By using appropriate triers, samples can be taken from bags or from bulk.

1. Bin samplers

Used for drawing samples from the lots stored in the bins.

2. Nobbe trier

The name was given after Fredrick Nobbe- father of seed testing. This trier is made in different dimensions to suit various kinds of seeds. It has a pointed tube long enough to reach the centre of the bag with an oval slot near the pointed end. The length is very small. This is suitable for sampling seeds in bag not in bulk.

3. Sleeve type triers or stick triers

It is the most commonly used trier for sampling : There are two types viz.,

1. With compartments 2. Without compartments.

It consists of a hollow brass tube inside with a closely fitting outer sleeve or jacket which has a solid pointed end. Both the inner tube as well as the outer tube have been provided with openings or slots on their walls. When the inner tube is turned, the slots in the tube and the sleeve are in line. The inner tube may or may not have partitions.

This trier may be used horizontally or vertically. This is diagonally inserted at an angle of 30^0C in the closed position till it reaches the centre of the bag. Then the slots are opened by giving a half turn in clockwise direction and gently agitated with inward push and jerk, so that the seeds will fill each compartment through the openings from different layers of the bag, then it is again closed and with drawn and emptied in a plastic bucket. This trier is used for drawing seed samples from the seed lots packed in bags or in containers.

TYPES OF SAMPLES

1. Primary sample

Each probe or handful of sample taken either in bag or in bulk is called primary sample.

2. Composite sample

All the primary samples drawn are combined together in suitable container to form a composite sample

3. Submitted sample

When the composite sample is properly reduced to the required size that to be submitted to the seed testing lab, it is called submitted sample. Submitted sample of requisite weight or more is obtained by repeated halving or by abstracting and subsequently combining small random portions.

4. Working sample

It is the reduced sample required weight obtained from the submitted sample on which the quantity tests are conducted in seed testing lab.

Weight of submitted sample

The minimum weight for submitted samples for various tests are as follows

1. Moisture test

100 gm for those species that have to be ground and 50 gm for all other species. 2. For verification of species and cultivar

2. For verification of species and cultivars

Crop	Lab only (g)	Field plot & Lab (g)
Peas, beans, maize, soybean and crop seeds of similar	1000	2000
Size	500	1000
Barley, oats, wheat and crop seeds of similar size	200	500
Beet root and seeds of similar size	100	250
All other genera		

3. For other tests like uri and count of other species

Crop	Size of seed lot (kg)	Size of submitted sample	Size of working purity	Sample count of other species
Paddy	25,000	400	40	400
Wheat	25,000	1000	120	1000
Maize	40,000	1000	900	1000
Sorghum	10,000	900	90	900
Bajra	10,000	150	15	150
Red gram	20,000	1000	300 .	1000
Green gram	20,000	1000	120	1000
Black gram	20,000	1000	150	1000
Bengal gram	20,000	1000	1000	1000
Cowpea	20,000	1000	400	1000
Soybean	20,000	1000	500	1000
Groundnut (pods)	20,000	1000	1000	1000
Groundnut (kernels)	20,000	1000	600	1000
Gingelly	10,000	70	7	70
Sunflower (variety)	20,000	1000	250	1000
Sunflower (hybrid)	20,000	1000	125	250
Cotton linted (variety)	20,000	1000	350	1000
Cotton de-Tinted	20,000	350	35	350
(variety)	20,000	350	35	350
Cotton linted (hybrid)	20,000	250	25	250
Cotton de-Tinted	10,000	150	15	150
(hybrid)	10,000	150	15	150

Brinjal	20,000	1000	140	1000
Chillies	10,000	70	7	70
Bhendi	10,000	7	7	7
Tomato (variety)	10,000	100	10	100
Tomato (hybrid)	10,000	100	10	100
Cabbage	10,000	100	10	100
Cauliflower				
Knolkhol				

The samples taken may packed in bags, sealed and marked for identification. For moisture testing the samples should be packed separately in moisture proof polythene bag and kept in the container along with the submitted samples.

Information to accompany the sample

Date Kind Variety

Class of seed Lot No.

Quantity of seed in lot (kg)

Tests) required (1) Purity (2) Germination (3) Moisture

Senders Name and Address

Types of sample used in Seed Testing Laboratory

Service sample *- Sample received from the farmers*

Certified sample *- Sample received from certification agencies or officers*

Official sample - Sample received from the seed inspectors.

Mixing and dividing of seeds

The main objective of mixing and dividing of seeds is to obtain the representative homogenous seed sample for analysis by reducing the submitted sample to the desired size of working sample.

Method of mixing and dividing

1. Mechanical dividing
2. Random cups method
3. Modified halving method
4. Spoon method
5. Hand halving method

1. Mechanical method

The reduction of sample size is carried out by the mechanical dividers suitable for all seeds except for chaffy and fuzzy seeds.

Objective of mechanical dividing

- To mix the seed sample and make homogenous as far as possible
- To reduce the seed sample to the required size without any bias
- The submitted sample can be thoroughly mixed by passing it through the divider to get 2 parts and passing the whole sample second time and 3rd time if necessary to make the seeds mixed and blended so as to get homogenous seed sample when the same seeds passed through it into approximately equal parts.
- The sample is reduced to desired size by passing the seeds through the dividers repeatedly with one half remain at each occasion.

TYPES OF MECHANICAL DIVIDERS

1. Boerner divider

It consists of a hopper, a cone and series of baffles directing the seeds into 2 spouts. The baffles are of equal size and equally spaced and every alternate one leading to one spout. They are arranged in circle and are directed inward. A valve at the base of the hopper retains the seeds in the hopper. When the valve is opened the seeds fall by gravity over the cone where it is equally distributed and approximately equal quantity of seeds will be collected in each spout. A disadvantage of this divider is that it is difficult to check for cleanliness.

2. Soil divider

It is a sample divider built on the same principles as the Boerner divider. Here the channels are arranged in a straight row. It consists of a hopper with attached channels, a frame work to hold the hopper, two receiving pans and a pouring pan. It is suitable for large seeds and chaffy seeds.

3. Centrifugal or Gamet Divider

The principle involved is the centrifugal force which is used for mixing and dividing the seeds. The seeds fall on a shallow rubber spinner which on rotation by an electric motor, throw out the seeds by centrifugal force. The circle or the area where the seeds fall is equally divided

into two parts by a stationary baffle so that approximately equal quantities of seed will fall in each spout.

II. RANDOM CUP METHOD

This is the method is suitable for seeds requiring working sample upto 10 grams provided that they are not extremely chaffy and do not bounce or roll (e.g.) Brassica spp.

Six to eight small cups are placed at random on a tray. After a preliminary mixing the seed is poured uniformly over the tray. The seeds that fall into the cup is taken as the working sample.

III. MODIFIED HALVING METHOD

The apparatus consists of a tray into which is fitted a grid of equal sized cubical cups open at the top and every alternate are having no bottom. After preliminary mixing the seed is pouted evenly over the grid. When the grid is lifted approximately half the sample remains on the tray. The submitted sample is successively halved in this method until a working sample size is obtained.

IV. SPOON METHOD

This is suitable for samples of single small seeded species. A tray, spatula and a spoon with a straight edge are required. After preliminary mixing the seed is poured evenly over the tray. The tray should not be shacked thereafter. With the spoon in one hand, the spatula in the other and using both small portions of seed from not less than 5 random places on the tray should be removed. Sufficient portions of seed are taken to estimate a working sample of approximately but not less than the required size.

V. HAND HALVING METHOD

This method is restricted to the chaffy seeds. The seed is poured evenly on to a smooth clean surface and thoroughly mixed into a mound. The mound is then divided into 1/2 and each half is mound again and halved to 4 portions. Each of the 4 portions is halved again giving 8 portions. The halved portions are arranged in rows and alternate portions are combined and retained. The process is repeated until the sample of required weight is obtained.

SEED PURITY ANALYSIS

The purity test is the first test to be made. Seed samples can contain impurities such as weed seeds, seeds of other crop species, detached seed structures, leaf particles and other material. The object of purity analysis is to determine the composition of the sample being tested by weight. To do this, a purity test is conducted, in which the working sample is separated into the following component parts:

i) **Pure seed** refers to the species under consideration. In addition to mature, undamaged seed, it includes, undersized, shriveled, immature and germinated seeds, provided they can be definitely identified as the species under consideration, more over it includes pieces resulting from breakage that are more than one half their original size Pure seeds includes the following:

A. Intact seeds

B. Achenes and similar fruits like caryopsis, schizocarpand mericarp with or without pedicel, perianth and whether they contain true seed unless it is apparent and when difficult to identify.

C. Pieces of seeds, achenes, mericarp and caryopsis resulting from breakage that is more than half the original size (Half seed rule). However, seeds of Leguminosae, Cruciferae and Coniferae are considered as inert matter if their seed coat is removed.

D. Clusters of Beta or pieces of such clusters with or without seeds that are retained by 200 x 300 mm sieve.

E. Florets and caryopsis of Grammae.

* florests and one flowered spikelets with an obvious caryopsis containing endosperm provided also that the caryopsis of particular genera and species have attained minimum sizes.

* Free caryopsis

* All florets and caryopsis (except broken florets and caryopsis half or less than half the original size and in the case of *Dactylis glomerata* excluding one-fifth of the weight of multiple floret in which the sterile floret extends to or beyond the tip of the fertile floret) remaining in heavy protein after blowing at an uniform blowing speed.

With reference to specific species:

Allium sp., ***Capsicum*** sp., ***Cucumis*** sp., ***Lycopsersicon*** sp., : Seed with or without seed except pieces of seed more than 1/2 the original size with or without seed coat.

Arachis sp., ***Cicer*** sp., ***Glycine*** sp., ***Vigna*** sp. : Seed, provided a portion of testa is attached, pieces of seed more than 1/2 the original size with or without seed coat.

Daccus sp**. :** Schizocarp with or without pedicel unless it is obvious that no seed is present Mericarp with or without pedicel unless it is obvious that no seed is present. Pieces of mericarp more than 1/2 the original size unless it is apparent that no seed is present. Seed with pericarp partially or entirely removed. Pieces of seed larger than 1/2 the original size with the pericarp partially or entirely remove.

Gossypium sp**.:** Seed with or without lint, pieces of seed more than 1/2 the original size.

Helianthus sp**. :** Achene unless it is obvious that no seed is present. Pieces of achene larger than 1/2 the original size unless it is obvious no seed is present. Seed with the pericarp partially or entirely removed. Pieces of seed large than 1/2 the original size partially or entirely removed.

Oryza sp**. :** Spilelet with lemma, palea and sterile glumes enclosing a caryposis. Floret with lemma palea enclosing a cryopsis. Free caryopsis.

ii) **Other seeds** shall include seeds and seed like structures of any plant species other than that of pure seed. iii) **Inert matter** includes seed units and all other matters and structures not defined as pure seed or other seed. It includes, seeds and seed like structures eg., achenes , caryopsis , mericarp and seeds of leguminosae less than ½ the original size with no seed coat.

To perform purity analysis, the working sample is kept over the purity work board at the base end. A small quantity of sample is brought to the middle of the board and split into two basic components as pure seed and inert matter. The inert matter is further divided as pieces of seeds less than 1/2 the original size, stones, pieces of leaves, weed seeds, other crop seed etc. The pure seed is further divided into pure seed and other distinct variety (ODV) etc. The pure seed and inert matter are weighed upto three decimals and percentage worked out. The weed seed, OCS, ODV are counted and reported as number per kg.

Instruments

1. Seed blower

It is used to remove the light weighted inert matter from the seeds. Working sample is kept at the lower portion of the tube and the required uniform upward flow of air is regulated upto prescribed period of time. Lighter matter is separated from the sample by air flow and settle down in the partition provided in the tube of the blower. The tube is removed and inert matter is collected.

2. Diapanascope

The purity work board is provided with light source in the background which facilitates easy separation of different component. It also helps better distinguishing of red pericarp from white percarb and short bold grains long slender grains from medium types.

The percentage by weight of each of the component parts shall be calculated to one decimal place. Percentage must be based on the sum of the weight of the components not on the original weight of the working sample, but the sum of the weights of the components must be compared with the original weight as a check against loss of material or other error. The result shall be reported to one decimal place and the percentage of all components must total 100. Components of less than 0.05% shall be reported as Trace. If the purity is less than the standard retirement the certification department will reject the seed.

Seed Moisture Estimation

The moisture content of a sample is the loss in weight when it is dried in accordance with the rules. It is expressed as a percentage of the weight of the original sample. The submitted sample shall be accepted for moisture determination only if it is in intact, moisture - proof container from which as much air as possible has been excluded. The determination shall be started as soon as possible after receipt.

Procedures

Weighing shall be in grams to three decimal places. Seeds of larger size are ground before drying unless its high oil content makes it difficult. After grinding, the sample is passed through different sizes of sieves. Pre-drying before grinding is required for samples having

moisture content more than 17%. After pre-drying, the sub-damples are reweighed in their containers to determine the loss in weight.

I. Low constant temperature oven method

The working sample must be evenly distributed over the surface of the container. Weigh the container and its cover before and after filling. Place the container rapidly, on top of its cover, in an oven maintained at a temperature of 103 ± 2°C and dry for 17 ± 1 hours. The drying period begins at the time the oven returns to the required temperature. At the end of the prescribed period, cover the container and place it in a desiccator to cool for 30-40 minutes. After cooling, weigh the container with its cover and contents. The relative humidity of the ambient air in the laboratory must be less than 70% at the time of final weighing. ISTA prescribes the low constant temperature oven method, for all tree species. Normally oilseeds are subjected to low constant temperature oven method while cereals and pulses are subjected to high constant temperature oven method.

II. High constant temperature oven method

The procedure is the same as above except that the oven is maintained at a temperature of 130-133°C, the sample is dried for a period of four hours for tree species and no special requirement pertains to the relative humidity of the ambient air in the laboratory during determination.

The moisture content as a percentage by weight shall be calculated to one decimal place by means of the following formula:

$$(M_2-M_3) \times \frac{100}{M_2 - M_1}$$

Where

M_1 - is the weight in grams of the container and its cover,

M_2 - is the weight in grams of the container, its cover and its contents before drying and

M_3 - is the weight in grams of the container, cover and contents after drying.

If the material is pre-dried, the moisture content is calculated form the results obtained in the first (pre-dried), the second stages of the procedure. If S_1 is the moisture lost in the first stage, and S_2 is the moisture lost in the second stage, each calculated as above and expressed as a percentage, then the original moisture content of the sample calculated as a percentage is

$$S_1 + S_2 - \frac{S_1 \times S_2}{100}$$

Grinding requirements

Crop	Grinding	Mesh size	
Paddy, wheat, maize, sorghum, cotton	Fine	50% ground material is passed through 0.5 mm mesh	10% ground material remain on 1.00 mm mesh
Pea, chickpea, soybean, lathyrus	Coarse	50% ground material is passed through 4 mm mesh	

Pre-drying requirements

Crop	Moisture content	Temperature required for drying °C	Duration
Maize	>25%	>0	2 - 5 hrs
Rice	>13%	130	5 - 10 min
Soybean	>10%	130	5 - 10 min

III. Universal moisture meter

Moisture estimation is made quick by the advent of digital moisture meters. The principle involved is that electrical conductivity of moist material is directly proportionate to the amount of moisture content in it.

Universal moisture meter is a popular and most dependable instrument for moisture estimation. The following are its essential parts:

(i) Compression unit (ii) Moisture meter dial

(iii) Thermometer (iv) Compression knob

(v) Cups of different volumes

A representative sample of prescribed weight or volume (Table) is obtained and placed in the sample cup. It is fixed in the lower house of compression unit.

Meter is calibrated by pressing the button "CAL" and "BELL" with the help of calibration knob. Sample is compressed as per requirement with the help of compression knob and scale. At required compression the meter dial (M) is read by pressing the knob "Read" and bell. Temperature (T) is observed by the thermometer fixed in between meter dial and compression chamber. The reading M and T are intercepted on the corelator dial (moisture meter dial) by turning the temperature dial. On adjustment of both the reading mark of arrow on the outer reading of temperature dial indicates the moisture percentage. For some crops factor is also considered for estimation of moisture content.

Determination of moisture content by universal moisture meter

Crop	Sample size		Compression	Factor
	Weight (g)	Volume*		
	FIELD AND FODDER CROPS			
Barley	50	B	0.600	
Maize	60	B	0.560	
Oat	30	B	0.400	
Pearl millet	60	B	0.500	
Rice	50	B	0.550	
Sorghum	50	B	0.675	
Wheat	30	A	0.275	Add 1%
Moong and urid		A	0.275	Add 1.5%
Chickpea		C	0.500	Subtrat 1%
Horsegram		A	0.275	
Lentil		A	0.250	x 0.7 + 3.5%
Pigeonpea, fieldpea		C	0.450	
Castor		C	0.500	Multiplied by 0.5

Groundnut	25		0.300	Multiplied by 0.6
Groundnut (kernel)	26		0.450	Multiplied by 0.56
Safflower	15		0.450	Multiplied by 0.66
Sesame			0.550	Subtract 0.5%
Soybean	60	C	0.575	Subtract 2.5%
Sunflower	30	B	0.500	Multiplied by 0.6
Rape seed and mustard			0.450	Multiplied by 0.6
Cotton (linted)	30	C	0.360	Subtract 5%
	VEGETABLES			
Kidneybean	50	B	0.400	
Okra		C	0.425	
Cabbage		A	0.260	Multiplied by 0.6
Cowpea		A	0.325	Multiplied by 0.8
Cucumber		B	0.525	Multiplied by 0.8
Lettuce		B	0.500	Multiplied by 0.9
Onion		A	0.250	Subtract 2.5%
Tomato	25	B	0.250	Multiplied by 0.8
Turnip	25		0.200	Multiplied 0.8
Watermelon		B	0.425	Subtract 3.5%
Coriander		C	0.325	Multiplied by 0.6

* A,B and C - Container size

The moisture content must be reported to the nearest 0.1% in the space provided on the Analysis Certificate. Seed lot with moisture content more than the minimum seed certification standards (Table) are recommended for drying

Minimum seed certification standard for moisture percentage

Crop	Sample in vapour proof container	Sample not in vapour proof bag
FIELD AND FODDER CROPS		
Castor, mustard, taramira	5	8
Groundnut, niger, sesame	5	9
Cotton	6	10
Rape seed	7	8
Linseed, horsegram, rajmash, safflower, sunflower, jute	7	9
Berseem, lucerne, Indian clover	7	10
Soybean	7	12
Moong, urid, chickpea, fieldpea, pigeonpea, lentil, lathyrus, kidneybean, ricebean	8	9
Buffel, Dharaf, Dinanath, guinea, marvel, setaria and stylo grass	8	10
Wheat, maize, sorghum, pearl millet, barley, triticale, oat, minor millets, teosinte, forage sorghum	8	12
Rice	8	13
VEGETABLES		
Rat tail radish, radish, turnip	5	6
Cole crops	5	7
All cucurbits	6	7
TPS, brinjal, tomato, chilli, capsicum, onion, fenugreek, lettuce, amaranth, asparagus	6	8
Carrot, celery, parsley	7	8
French bean	7	9
Cowpea, Indian bean, clusterbean, spinach, sugarbeat	8	9
Okra	8	10

SEED GERMINATION TEST

Principles

Germination tests shall be conducted with a pure seed fraction. A minimum of 400 seeds are required in four replicates of 100 seeds each or 8 replicates of 50 seeds each or 16 replicates of 25 seeds each depending on the size of seed and size of containers of substrate. The test is conducted under favourable conditions of moisture, temperature, suitable substratum and light if necessary. No pretreatment to the seed is given except for those recommended by ISTA.

Materails required

A. Substratum

The substratum, serves as moisture reservoir and provides a surface or medium for which the seeds can germinate and the seedlings grow.The commonly used substrata are sand, paper and soil.

I. Sand

a. Size of sand particle

Sand particles should not be too large or too small. The sand particles should pass thorough 0.80 mm sieve and retained by 0.05 mm sieve.

b. Toxicity

Sand should not have any toxic material or any pathogen. If there is presence of any pathogen, found, then the sand should be sterilized in an autoclave.

c. Germination Tray

When we use the sand, germination trays are used to carry out the test. The normal size of the tray is 22.5 x 22.5 x 4 cm. They tray may either zinc or stainless steel.

B. Method of seed placement

1. Seeds in sand(s)

Seeds are planted in a uniform layer of moist sand and then covered to a depth of 1 cm to 2 cm with sand.

2. Top of sand (TS)

Seeds are pressed into the surface of the sand

C. Spacing

We must give equal spacing on all sides of facilitate normal growth of seedling and to avoid entangling of seed and spread of disease. Spacing should be 1-5 times the width or diameter of the seed.

D. Water

The amount of water to be added to the sand will depend on size of the seed. For cereals, except maize, the sand can be moistened to 50% of its water holding capacity. For large seeded legumes and maize sand is moistened to 60% water holding capacity.

II. Paper

Most widely used paper substrates are filter paper, blotter or towel (kraft paper). It should be have capillary movement of water, at vertical direction (30 mm rise / min.). It should be free from toxic substances and free from fungi or bacteria. It should \ hold sufficient moisture during the period of test. The texture should be such that the roots of germinating seedlings will grow on and not into the paper.

A. Methods

a. Top of Paper (TP)

Seeds are placed on one or more layers of moist filter paper or blotter paper in petridishes. These petridishes are covered with lid and placed inside the germination cabinet. This is suitable of those seeds which require light.

a. **Between paper (PP)**

The seeds are placed between two layers of paper

b. Roll towel method

The seeds are placed between two layers of paper and rolled in towels. The rolled towels are placed in a water source and kept in germinator or germination room

c. Inclined plate method

Germination on glass plate with germination paper and kept at an angle of 45^{0}

III. SOIL

Should be non-caking, free from large particles. It must free from weed seeds, bacteria, fungi, nematode and other toxic substances. Soil is not recommended for reuse.

B. TEMPERATURE

Normally most of the seeds germinat between 20-30^0 C

C. LIGHT

Light required seeds provided with light eg. Lettuce

GERMINATION REQUIREMENTS FOR DIFFERENT CROPS

Crop	Substratum	Temp ^{0} C	First count (Days)	Final count (days)	Pre - treatment
PAddy	BP,TP,S	20-30	5	14	Pre heat (50^0 C) soak in water for 24 hours
MAize	BP,S	20-30	4	7	-
Bajra	TP,BP	20-30	3	7	0.2% KNO_3 92-3 hrs) /prechill
Sorghum	TP,BP	20-30	4	10	-
Redgram	BP	20-30	4	6	-
Blackgram	BP	30	4	7	-
Greengram	BP	20-30	5	8	-
Bengalgram	BP	20-30	5	8	-
Cowpea	BP	20-30	5	8	--
Peas	BP	20	5	8	-
Castor	BP	20	7	14	-
Groundnut	BP	20-30	5	10	-
Sunflower	BP	20-30	4	10	-
Sesame	TP	20-30	3	6	-
Cotton	BP,S	20-30	4	12	Reithove shells
Brinjal	TP,BP	20-30	7	14	EthreI (25 ppm) 48 hrs.
Tomato	TP,BP	20-30	5	14	
Chillies	TP,BP	20-30	7	14	(Hot water 85° C 1 min)
Bhendi	BP,S	20-30	4	21	
Onion	TP,BP	15-20	6	21	KN03
Carrot	TP,BP	20-30	7	14	KN03
Radish	TP,BP	20-30	4	10	Prechill
Cabbage					prechill
Cauliflower	TP	20-30	5	10	Prechill, KN03
Ash gourd	S	30-35	5	14	light
Biter gourd	BP,S	20-30	4	14	
Bottle gourd	BP,S '	20-30	4	14	-

GERMINATION APPARATUS

1. Germination Cabinet / Germination

This is called chamber where in temperature and relative humidity are controlled. We can maintain the required temperature

2. Room germinator

It works with same principle of germinator. This is a modified chamber of larger one and the worker can enter into it and evaluate the seedlings. Provisions are made to maintain the temperature and relative humidity. This is used widely in practice.

3. Counting Board

This is used for accurate counting and spacing of seeds. This consists of 2 plates. The basal one is stationary and top one is movable. Both top and basal plates are having uniform number of holes viz., 50/100, when the plates are in different position. After taking the sample, the top plate is pulled in such a way that the holes are in one line so that the fixed number of seeds fall on the substratum.

4. Vacuum Counter

Consists of a head, pipe and wall. There are plates of 50 or 100 holes which can be fitted to the head. When vacuum is created the plate absorbs seeds and once the vacuum is released the seeds fall on the substrate.

5. Impression Board

Made of plastic / wood with 50 or 100 holes/pins. Here the knobs are arranged in equal length and space. By giving impression on the sand it makes uniform depth and spacing for seed.

D. Seedling Evaluation

ISTA classified the seedlings into different categories based on the development of essential structures

CATEGORIES OF SEEDLINGS

1. Normal seedlings
2. Abnormal seedlings
3. Hard seeds
4. Fresh ungerminated seeds
5. Dead seeds

1.Normal seedlings

Seedlings which show the capacity for continued development into normal plant when grown in favorable conditions of soil, water and temperature.

Characters of normal seedling

1. A well developed root system with primary root except in certain species of graminae which normally producing seminal root or secondary root
2. A well developed shoot axis consists of elongated hypocotyls in seedlings of epigeal germination.
3. A well developed epicotyl s in seedlings of hypogeal germination.
4. One cotyledons in monocots and two in dicots
5. A well developed coleoptile in graminae containing a green leaf
6. A well developed plumule in dicots
7. Seedlings with following slight defects are also taken as normal seedlings. Primary root with limited damage but well developed seminal root system in leguminosae (Pisum), graminae (maize), cucurbitaceae (cucumis) and malvaceae(cotton)
8. Seedlings with limited damage or decay to essential structures but no damage to conducting tissue
9. Seedlings which are decayed by pathogen but it is clearly evident that the parent seed is not the source of infection.

II. Abnormal Seedlings

Seedlings which do not show the capacity for continued development into normal plant when grown in favorable conditions of soil, water and temperature

Types of abnormal seedling

A. Damaged seedlings

Seedlings with any one of the essential structures missing or badly damaged so that the balanced growth is not expected. Seedlings with no cotyledons, with splits, cracks and lesions or essential structures and without primary root.

B. Deformed seedlings

Weak or unbalanced development of essential structures such as spirally twisted or stunted plumule or hypocotyls or epicoptyl, swollen shoot, stunted roots etc.

C. Decayed seedlings

Seedlings with any one of the essential structures showing diseased or decayed symptoms as a result of primary infection from the seed which prevents the development of the seedlings.

III.Hard seeds

Seeds which do not absorb moisture till the end of the test period and remain hard (e.g.) seeds of leguminosae and malvaceae

IV.Fresh ungerminated seeds

Seeds which are neither hard nor have germinated but remain firm and apparently viable at the end of the test period.

V. Dead seeds

Seeds at the end of the test period are neither hard nor fresh'or have produced any part of a seedling. Often dead seeds collapse and milky paste comes out when pressed at the end of the test.

Retesting

If the results of a test are considered unsatisfactory it shall not be reported and a second test shall be made by the same method or by alternative method under the following circumstances.

1. Replicates performance is out of tolerance
2. Results being inaccurate due to wrong evaluating of seedlings or counting or errors in test conditions.
3. Dormancy persistence or phytotoxicity or spread of fungi or bacteria. The average of the two tests shall be reported.

Use of tolerances

The result of a germination test can be relied upon only if the difference between the highest and the lowest replicates is within accepted tolerances.

To decide if two test results of the same sample are compatible again the tolerance table is used.

Reporting results

The results of the germination test is calculated as the average of 4 x 100 seed replicates.It is expressed as percentage by number of normal seedlings.The percentage is

calculated to the nearest whole number. The percentage of abnormal seedlings, hard, fresh and dead seeds is calculated in the same way. These should be entered on the analysis of certificate under appropriate space. If the result is nil for any of these categories it shall be reported as '0'.

Seed standards for germination

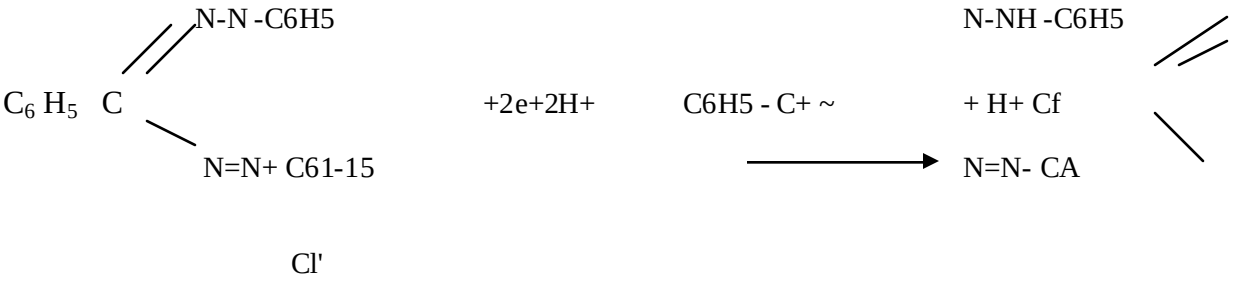
S.No.	Crop	Class of seed	
		Foundation Seed	**Certified seed**
1	Paddy	80	80
2	Maize (inbreds)	80	-
	Single cross	80	80
	Double cross	-	90
	Variety	90	90
3	Sorghum (variety)	75	75
	Hybrids	75	75
4	Cumbu	75	75
5	Ragi	75	75
6	Black gram	75	75
7	Bengal gram	85	85
8	Green gram	75	75
9	Horse gram	80	80
10	Peas	75	75
11	Pigeon pea	75	75
12	Castor variety	70	` 70
13	Ground nut	70	70
14	Sesame	80	80
15	Soybean	70	70
16	Sunflower	70	70
17	Cotton	65	65
18	Jute	80	80
19	Gourds	60	60
20	Brinjal	70	70
21	Chillies	60	60
22	Bhendi	65	65
23	Tomato	70	70
24	Cabbage	70	70
25	Cauliflower	65	65
26	Carrot	60	60
27	Radish	70	70
28	Beet root	60	60

Lecture .No. 28 QUICK VIBILITY TEST

The relative long periods of time required for completion of germination tests delays the seed marketing. This necessitated the development of rapid methods for estimating the germination capacity of seeds. This test was developed by Lakon (1942) in Germany.

Principle

It is a biochemical test, in which living cells are made visible by reduction of an indicator dye. The indicator used is 2,3,5 triphenyl tetrazolium chloride. Within the seed tissues, it interferes with the reduction processes of living cells and accepts hydrogen from the hydrogenases. By hydrogenation of the 2,35 - tri phenyl tetrazolium chloride; a red stable and non difficusable substance, triphenyl formazan is produced in living cells. The reaction is as follows.



2,3,5 triphenyl tetra zolium chloride Triphenyl formazon

This makes it possible to distinguish red coloured living parts of seeds from the colourless dead ones. Staining of seeds determines whether seeds are to be classified as viable. Completely stained seeds are viable partially and completely unstained seeds are non-viable

Field of application

This test is not valid for previously germinated seeds

Method of Tetrazolium testing

A. Testing sample

A representative sample of 50(or) 100 seeds is usually sufficient. l lowever, 200 seeds, in replicates of 100 seeds is recommended.

B. Preparation of solutions

1% solution is used for seeds that are not bisected thro' the embryo, while 0.1% solution is used for seeds in which the embryo is bisected.

The pH of the solution should be between 6 and 8 for best staining. If the pH of the water is not in the natural range, the TZ salt should be dissolved in a phosphate buffer solution. The buffer solution is prepared as follows

Solution -1- Dissolve 9.078 g of KH2 P04 in 1000 ml of water

Solution -2- Dissolve 11.876 g of Na2HP04. 2H20 in 1000 ml water.

Take 400 ml of solution 1 and 600 ml of solution 2 and mix them together. In litre of buffer solution prepared as above, dissolve 10 gms of TZ salt. This gives 1% TZ solution of pH 7.0. This may be further diluted to give lower concentrations. The solution should be stored in brown bottle to prevent deterioration from light.

Methods of preparation for tetrazolium testing

The seeds are first prepared for staining then stained and evaluated for viability.

Method 1 : Bisect longitudinally

(e.g) maize, sorghum, small grains, large seeded grasses. Soak the seeds in water for 3 to 4 hours. Bisect the seeds by cutting longitudinally thus exposing the mains structures of the embryo. Use one 1/2 of each seed for testing.

Method 2 : Bisect laterally

(e.g.) Small seeded grasses

The seeds are cut laterally near the centre of the seed above the embryo. Place embryo end in TZ solution.

Method 3 : Pierce with needle

(e.g.) Small seeded grasses

Puncture the seeds by piercing thro' the seed into the endosperm near the embryo, but avoid injury to the embryo.

Method 4 : Remove seed coat (e.g) seeds with seed coats impermeable to tetrazolium.

Soak the seeds in water for 3-4 hours and then the seed coats and place the seeds in the TZ solution. In some crops like cotton a thin membrane adhering .to the cotyledons is also removed in addition to the seed coat.

Method 5 : Conditioning only
(e.g) Large seeded legumes

Seeds of soybeans and other large seeded legumes may swell so rapidly and irregularly when placed directly in water or TZ solution that the seed coats burst. Hence, it is preferable to condition these seeds slowly in moist paper towels ovemight before staining, so that they absorb moisture slowly without any damage to the seed.

METHOD 6 : NO CONDITIONING OR PREPARATION
(eg.) Small seeded legumes

Seed coats of these seeds are permeable to TZ and embryos usually will stain without conditioning.

Staining

The prepared seeds should be placed in suitable container (small beakers, petridishes etc.,) and covered with TZ solution. Place the containers in an incubator at dark warm conditions of 40°C.The staining time varies for different kinds of seeds, different kinds of seeds, different methods of preparation, and different temperatures (< 1 hr to 8 hrs).

When the sample has stained sufficiently the TZ solution should be discarded and the seed sample covered with water immediately. Seed samples can also be kept for 3 days at 10°C for interpretation.

Evaluation of Samples : A normal TZ stain appears cherry red.

MONCOTS

Non-Viable

1. All structures unstained
2. Shoot largely unstained
3. Scutellar node unstained
4. Major areas of coloeptile unstained
5. Central area of scutellum unstained
6. Insect, mechanical or other injuries causing essential structures non functional.

DICOT SEEDS

Non-viable

1. Embryo completely unstained

2. More than extreme tip of radical unstained

3. More than 1/2 of cotyledon tissue unstained.

4. Deep - seated necrosis at cotyledon and embryonic axis juncture or on radicle

5. Fractured radical.

Advantages of TZ test

I.Quick estimation of viability

2.When the seed is dormant, the TZ test is extremely useful

3. Seeds are not damaged (in dicot) in anlaysis therefore they could be germinated.

Disadvantages of TZ Test

1. It is difficult to distinguish between normal and abnormal seedlings.

2. It does not differentiate between dormant and non- dormant seeds.

3. Since the TZ test does not involve micro organisms harmful to germinating seedlings are not detected.

9. SEED HEALTH TESTS : SEEDBORNE DISEASES

V.K. AGARWAL & ASHOK GAUR

Many high yielding varieties have shown susceptibility to different diseases and many of these diseases are seedborne. The seed primordium or the maturing seed may be infected either (i) directly from the infected plant through the flower or fruit stalk and the seed stalk or directly from the seed surface, or (ii) infection from outside may be introduced through stigma or ovary wall or pericarp, and the flower or fruit stalk, and later through the seed coat. A pathogen may penetrate several of these parts of the seed and in turn infect them. The infestation/contamination of the seed may occur during harvesting, threshing and processing. The pathogen may, thus, be carried with the seeds in three ways.

(i) *Admixture* : Pathogens are independent of seeds but accompany them. Ergot sclerotia are mixed with healthy seeds during threshing.

(ii) *External* : The pathogen may be present on seed surface as spores, oospores and chlamydospores as in case of karnal bunt of wheat, covered smut of barley, downy mildew of pearlmillet etc.

(iii) *Internal* : Pathogens establish within the seed with definite relationship with seed parts.

The seedborne pathogens may result in (i) loss in germination (ii) discolouration and shrivelling (iii) development of plant diseases (iv) distribution of pathogen to new areas (v) introduction of new strains or physiologic races of the pathogen along with new germplasm from other countries (vi) toxin production in infected seed etc. Visualising the importance of seedborne diseases the Central Seed Certification Board has prescribed certification standards for foundation and certified seed for several diseases (Table 9.1).

The methods as approve by the Central Seed Certification Board as well as

suggestive methods for additional diseases have been described. The number of seeds to be tested is based on the presence of atleast one infected seed per replication as per certification standards for foundation seed and certified seed (Table 9.2).

I. Karnal Bunt of Wheat and Triticale, Causal Organism : *Neovossia indica.*

Procedure : Sodium hydroxide (NaOH) seed soak method.

(i) Wheat seeds are soaked in a flask/beaker containing 500 ml of 0.2 per cent sodium hydroxide solution (2 g NaOH/1000 ml water for 24 hr at 20-30°C.

(ii) After 24 hr the solution is decanted.

(iii) Seeds are thoroughly washed in tap water.

(iv) Seeds are spread over a blotter paper so that excess water on the surface of seed is absorbed.

(v) Seeds are examined visually aided with light.

(vi) The seeds exhibiting jet black shiny appearance with hollow or without hollowness are separated.

(vii) Such collected seeds are ruptured separately in a drop of water and observed visually for the release of stream of fungal spores.

(viii) The number of seeds releasing stream of fungal spores are counted as infected seed.

(ix) Result is reported in percentage.

The Karnal bunt infection can easily be differentiated from black point which is mainly caused by *Alternaria alternata*. The seeds affected by black point or black tip exhibit dark brown to blackish discolouration which is mostly restricted to embryo tip. In this case internal tissue of seed is not converted into black powdery mass. These seeds on rupturing do not release stream of fungal spores.

The above procedure is applicable to both chemically treated as well as

untreated seed lots.

II. Bunt of Paddy, Causal Organism : *Neovossia horrida*

Procedure : Sodium hydroxide (NaOH) seed soak method

(i) Paddy seeds are soaked in a flask/beaker containing 250 ml of 0.2 percent sodium hydroxide solution (2g NaOH/1000 ml water) for 24 hr at 20-30°C.

(ii) After 24 hr the solution is decanted.

(iii) Seeds are thoroughly washed in tap water.

(iv) Seeds are spread over a blotter paper so that excess water on the surface of seed is absorbed.

(v) Seed are examined visually aided with light.

(vi) The seeds exhibiting shiny jet black are separated.

(vii) Such shiny jet black seeds are ruptured separately in a drop of water by puncturing and observed visually for the release of stream of fungal spores.

(viii) The number of seeds releasing stream of fungal spores are counted as infected seed.

(ix) Result is reported in percentage.

The seeds looking only shiny jet black have been found to contain bunt infection whereas those with brown to dull black discolouration do not reveal bunt infection. This is a symptom of brown spot or brown discolouration of rice.

III. Ergot of Pearlmillet, Causal organism : *Claviceps fusiformis, (=Claviceps microcephela)*

Ergot of sorghum, causal organism : *Sphacelia sorghi* and *Claviceps* spp., and ergot of triticale, causal organism : *Claviceps purpurea.*

Procedure : Visual observation of dry seeds.

(i) Seeds are examined visually aided with light in dry state for the presence of ergot sclerotia. These sclerotia are purplish brown in colour, irregular in shape, hard structures and these may be two to three times bigger than healthy seeds.

A seed lot of sorghum mixed with well developed and broken sclerotia is called an ergotted seed lot. However, a seed lot mixed with honey dew lumps containing mycelial mat with conidia should not be called an ergotted seed lot.

(ii) The sclerotia are separated and counted.

(iii) Result is reported in percentage (by number).

IV. Loose Smut of Wheat, Causal organism : *Ustilago tritici*

Procedure : Embryo count method.

1. Soak 2000 seeds in 5.00 per cent sodium hydroxide and 0.02 per cent trypan blue solution (one liter) for 24 hr at 25-30°C.

2. Pass the soaked material through 10 mesh sieve and retain the material in a 20 mesh sieve along with showers of tap water.

3. Collect the extracted embryos in a beaker.

4. Dehydrate the embryos in rectified spirit for 5-10 min.

5. Take the dehydrated embryos along with chaff etc. in a beaker containing 50 ml lactophenol.

6. Add to above beaker 100 ml water and stir it.

7. Allow the material to stand for 5 min to settle the chaff at bottom.

8. Collect the floating embryos in another beaker containing 25 ml fresh lactophenol.

9. Boil the above material for 2 min.

10. Pour the embryos in petridishes and arrange in lines along with some lactophenol.

11. Observe the embryos under stereobinocular microscope for the presence of mycelium.

12. Mycelium appears as blue thread like knotted structure in the scutellum portion of the embryo.

13. Total number of embryos and infected embryos are counted.

14. Result is reported in percentage.

It is a suggestive procedure for the detection of loose smut of wheat. At the moment there are no certification standards for loose smut of wheat based on seed infection.

Potato

Procedure : Visual observation of tubers.

Observations : Count infected tubers based on symptoms described below.

1. Late blight of Potato : *Phytophthora infestans*

The tubers exhibit brown to purplish discoloration of the skin, followed by a brownish dry rot which extends to about 1/2 inch below the surface. Sections cut through tubers show brown and necrotic tissues.

2. Dry rot of Potato : *Fusarium caeruleum*

The surface of infected tuber is wrinkled and may be sunken, and the rotted tissues may turn brown, grey or black. Cavities frequently develop in affected tubers, which may become more or less filled with yellow, pink or red mycelium. After prolonged storage, a black, blue or violet fungal growth develops on the surface. The margin of the rot is clearly defined. Typical concentric rings appear on the tuber surface and external mycelium is evident. The tuber dries and hardens.

3. Charcoal rot of Potato : *Macrophomina phaseolina*

On tubers, lesions appear as somewhat softened and blackened areas. The decayed tissue is dark coloured and usually confined to the outer zone of the tuber.

4. Wet rot of Potato : *Sclerotium rolfsii*

Lesions develop on the surface of the tuber. They are yellow to tan in colour and noticeably sunken. Later, these lesions become darker in colour. The tubers decay and the entire tuber becomes slimy. Sclerotia about the size of mustard seeds appear in the decayed tissue and in the cavities. They are white at first and become dark brown with age.

5. Common scab of Potato : *Streptomyces scabies*

Two types of symptoms called shallow and deeper pitted scab may appear on tubers. *Shallow scab consists of a superficial roughened area, sometimes raised* above, and often slightly below the plane of the healthy skin. The lesions consists of corky tissues. The lesions vary in size and shape, sometimes darker than the healthy skin. Deep pitted scab consists of lesions which are 1 to more than 3 mm deep. They may be darker than the shallow lesions. The tissue around the interior of the pits is corky as in shallow scab. These lesions may join together so that entire tuber surface is affected.

6. Black scruf of Potato : *Rhizoctonia solani*

The tuber infection appears hard, superficial, black crust on the skin due to formation of sclerotia of the fungus. Tubers are often rough. The sclerotia are more conspicuous when tubers are wet.

Multiplier Onion

Procedure : Visual observation of onion bulblets.

Observations : Count infected onion bulblets based on symptoms described below.

1. Basal rot of Onion (Bulblets) : *Fusarium oxysporum* f. cepae

On the base of the bulb whitish moldy growth of the fungus appear on the surface of the decayed portions of the scale. On sectioning in the bulbs longitudinal-

ly, ascmiwatery decay is found to be advancing from the bases of the scales upward. Infections occuring about harvest time may continue in transit and storage until only dry shrivelled 'mummies' remain.

2. Soft rot of Onion (Bulblets) : *Erwinia carotovora*

One or two outer scales of the onion rots completely. The diseased bulbs can be detected by gently pressing them, whereupon the watery fluid is extruded through the neck. The slimy decay is usually accompanied by a foul sulfurous odor. The scales outside the rooting ones slip off readily in handling.

Sweet Potato

Procedure : Visual observation of roots.

Observations : Count infected roots based on symptoms described below.

1. Black rot of Sweet Potato : *Ceratostomella fimbriata*

Dark circular depressed spots of varying size appear on the fleshy roots. The spots are grey-black when dry and dark greenish-black when moist. In the center of these spots or in the older portion of the lesions small black fruiting bodies of the fungus also develop. A shallow, dry decay extends below the surface lesion, usually not beyond the vascular ring.

2. Scurf of Sweet Potato : *Monilochaetes infuscans*

Fleshy roots are discoloured. The lesions may be in the form of spots or may cover a considerable area. The roots shrink during storage due to loss of water.

3. Wilt of Sweet Potato : *Fusarium oxysporum* f. batatas

The internal tissue of the roots become discoloured. On the surface of roots shallow, sunken spots appear which finally shrink.

4. Internal cork of Sweet Potato : A virus disease.

Dark brown to blackish, hard corky spots which vary in size upto 3 cms. across and 5 cm long appear in the fleshy portion of the root. These corky areas increase in size and number, the longer the root are held in storage.

Table 9.1 Seed standards for foundation and certified seeds based on maximum percent seed infection (Tunwar and Singh, 1988)

Crop Species	Disease	Causal organism	Certification standards % (by number)	
			Foundation seed	Certified seed
1	2	3	4	5
Pearl millet	Ergot[b]	*Claviceps fusiformis*	0.02	0.04
Paddy	Bunt	*Neovossia horrida*	0.01	0.50
Sorghum	Ergot[b]	*Sphacelia sorghi*	0.02	0.04
Wheat	Ear cockle	*Anguina tritici*	None	None
	Karnal bunt	*Neovossia indica*	0.05%	0.25%
	Tundu	*Corynebacterium michiganense* pv. *tritici* and *Anguina tritici*	None	None
Triticale	Karnal bunt	*Neovossia indica*	0.05%	0.25%
	Ergot		0.02	0.04
Potato	Late blight	*Phytophthora infestans*	1.0	1.0
	Dry rot	*Fusarium caeruleum*	1.0	1.0
	Charcoal rot	*Macrophomina phaseolina*	1.0	1.0
	Wet rot	*Sclerotium rolfsii*	None	None
	Common scab[c]	*Streptomyces scabies*	3.0	5.0

	1	2	3	45
	Black scurf[d]	*Rhizoctonia solani*	5.0	5.0
	Total Diseases[e]		5.0	5.0
Multiplier Onion	Basal rot	*Fusarium oxysporum* f. cepae	None	None
	Soft rot	*Erwinia carotovora*	None	None
	Brown rot	*Pseudomonas aeruginosa*	None	None
Sweet Potato	Storage rot		None	None
	Black rot	*Ceratostomella fimbriata*	None	None
	Scurf[f]	*Monilochaetes infuscans*	None	None
	Wilt	*Fusarium oxysporum* f. batatas	None	None
	Internal cork		5.0	5.0

[b]Ergot sclerotia seed entirely or partially modified as sclerotia, broken sclerotia or ergotted seed.

[c]Even if a single tuber infected with common scab is detected on a seed lot, entire seed lot shall be treated with 0.5% solution of Agallol-3 or Emisan-6 or Aretan-6 for 30 minutes, before seed lot is declared fit for certification. Seed lots having infected tubers more than the prescribed limits will not be certified even after treatment.

[d](i) A tuber carrying 10.0% or above scurfed surface will be considered as one infected unit.

(ii) Seed lots having black scurf infection more than the prescribed limits could be certified after treatments with approved chemical/fungicide.

[e]For all diseases, the higher disease percentage will be considered for the purpose of the specified limits of tolerance.

[f]A root carrying 10.0% or above scurfed surface would be considered as one infected unit.

Table 9.2 Number of seeds to be analysed for different seed certification standards*.

Percent	Seed Infection	No. of seeds to be analysed/ replication
1.	None	5000
2.	0.02	3000
3.	0.04	2500
4.	0.05	2000
5.	0.1	1000
6.	0.25	400
7.	0.5	200
8.	1.0	100
9.	3.0	33
10.	5.0	20

*The number of seeds to be tested is based on the presence of atleast one infected seed in the working sample. Each sample will have two replications. The size of the working sample has been derived from 4 × n, where n = standard specified.

15. SEED VIGOUR TESTING

P.C. GUPTA

Seed vigour is an important quality parameter which needs to be assessed to supplement germination and viability tests to gain insight into the performance of a seed lot in the field or in storage. Several definitions have been offered to explain seed vigour. Looking into the complexity of the situation, the ISTA congress in 1977 adopted the definition of seed vigour as " the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence". Although differences in physiological attributes of seed lots can be demonstrated in the laboratory, it was recommended that the term should be used to describe the performance of seeds when sown in the field (Perry, 1984a).

As the germination test is conducted in an optimum condition specific to different species, it is not always possible to get an idea of the performance of a seed lot in the field on the basis of germination test in the laboratory. It is mainly because of the reason that field conditions are seldom optimum and the emerging seeding suffers from one or the other kind of stress. In many cases seed lots having similar laboratory germinations may give widely differing field emergence values. Similarly, two seed lots having the same germination percentage in the laboratory may age differently when stored under ambient condition. These two situations indicate the incompletences of germination test in assessing the performance of a seed lot in the field or storage. This offers scope and possibility to determine vigour of a seed lot so that its field and storage performance can be assessed.

Seed vigour is still a concept rather than a specific property of a seed or seed lot. Several factors like; genetic constitution, environment and nutrition of mother plant, maturity at harvest, seed weight and size, mechanical integrity, deterioration and ageing and pathogens are known to influence seed vigour (Perry, 1984a). Therefore, care has to be exercised in selecting a seed vigour test to do the job. Two criteria have been employed by the ISTA seed vigour committee to evaluate the performance of seed vigour test methods for different crops :

(i) Reproducibility of vigour method

(ii) The relationship between vigour test results and seedling emergence in field soil.

There is no universally accepted vigour test for all kinds of seeds. The determination of following vigour tests will be useful in gaining additional information on seed quality.

1. Growth Tests

Principles : Growth tests are based on the principle that vigorous seeds grow at a faster rate than poor vigour seeds even under favourable environments. Vigorous seeds rapidly germinate, metabolize and establish in the field. Therefore, any method used to determine the rapidity of growth of the seedling will give an indication of seed vigour level.

Apparatus and equipment : All the equipments and materials needed to conduct a germination test are required. Additionally, a top loading balance and an air oven are also required.

Procedure

(a) First count : The test is done along with the regular germination test. The number of normal seedlings, germinated on the first count day, as specified in the germination test for each species, are counted. The number of normal seedlings gives an idea of the level of seed vigour in the sample. Higher the number of normal seedlings greater is the seed vigour.

(b) Seedling growth rate and dry weight : The seedlings are grown either in laboratory, green house or field. In laboratory, in between rolled towel paper method should be followed. Ten seeds are planted in the centre of the moist towel papers in such a way that the micropyles are oriented towards bottom to avoid root twisting. The rolled towel papers are kept in the germinator maintained at a temperature recommended for crop in reference. After a specified period of time (5-10 days) towel papers are removed and five seedlings are selected, their length is measured and mean seedling length is calculated. Seed lots producing the taller seedlings are considered more vigorous than the seed lots producing shorter seedlings. For dry weight determination, the seedlings are removed and dried in an air oven at 100°C temperature for 24 hours. The seedling dry weight provides additional information for assessing seed vigour.

(c) Speed of germination : One hundred seeds each in four replications are planted in recommended substratum for germination. The substratum is kept in a germinator maintained at recommended temperature for the crop in reference (Table 5.1). Number of seedlings emerging daily are counted from day of planting the seeds in the medium till the time germination is complete. Thereafter a germination index (G.I.) is computed by using the following formula :

$$G.I. = \frac{n}{d}$$

where, n = number of seedlings emerging on day 'd'

d = day after planting

The seed lot having greater germination index is considered to be more vigorous.

Example

Seed lot A — No. of seedlings= 0,0,0,40,30,12,7, counted

Day of counting = 1,2,3,4,5,6,7

Seed lot B — No. of seedlings =0,0,0,0,30,42,21 counted

G.I. of Seed lot A

$$\frac{0}{1}+\frac{0}{2}+\frac{0}{3}+\frac{40}{4}+\frac{30}{5}+\frac{12}{6}+\frac{7}{7}$$

$$= 10 + 6 + 2 + 1$$

$$= 19$$

G.I. of Seed lot B

$$\frac{0}{1}+\frac{0}{2}+\frac{0}{3}+\frac{0}{4}+\frac{30}{5}+\frac{42}{6}+\frac{21}{7}$$

$$= 6 + 7 + 3$$

$$= 16$$

In this example seed lot A has greater G.I. (19) than seed lot B (16), so seed lot A is more vigorous than seed lot B.

(d) Seed vigour index (S.V.I.) : This is calculated by determining the germination percentage and seedling length of the same seed lot. Fifty seeds each in four replications are germinated in towel papers as prescribed for the crop species in germination test. While evaluating the number of normal seedlings at the time of final count, the seedling length of 5 randomly selected seedlings are also measured. Seed vigour index is calculated by multiplying germination (%) and seedling length (mm). The seed lot showing the higher seed vigour index is considered to be more vigorous (Abdul-Baki and Anderson, 1973).

Example

Seed lot	% germination	Seedling length, mm	Vigour index
A	96	85	8160
B	95	76	7220
C	94	71	6674

In this example seed lot A is the most vigorous and seed lot C the least vigorous as they have the highest and the lowest values of seed vigour index, respectively.

2. Conductivity Test

Principle : Weakening of cell membrane in poor vigour seeds causes leakage of water soluble compounds like sugars, amino acids, electrolytes etc. when immersed in water. On the other hand, fresh seeds having intact membrane leach less quantity of these chemicals. The measurement of electrical conductivity (EC) of the leachate by a good and sensitive conductivity meter gives an accurate estimation of membrane permeability. The EC has been positively correlated with the emergence percentage of peas and broad beans (Mathews and Bradnock, 1968). The value of this test appears to be restricted to the large seed species of the Leguminoceae (Perry, 1984b).

Apparatus and equipment : Conductivity meter, beaker, 0.1% mercuric chloride, distilled water, seed sample, wash bottle an tissue paper.

Procedure : A seed sample of 2-5 gram is weighed and surface sterilized with 0.1% $HgCl_2$ for 5-10 minutes. The sample is washed thoroughly in distilled water. The clean seeds are immersed in 100 ml of water at 25 ± 1°C temperature for 10-12 hours. After this the seeds are removed with a clean forcep. The steep water left is decanted and is termed as leachate.

The conductivity meter is warmed for about 30 minutes before testing. First the conductance of distilled water is measured in a beaker. The electrode is then cleaned with a tissue paper and conductance of the leachate is read. The electrode is thoroughly washed using a wash bottle and wiped with a clean tissue paper before reusing. While recording the conductance, the lower bulb of the electrode should be fully emerged in the leachate. To get the EC of leachate the reading of distilled water is substracted from the sample reading. The value is then corrected for the temperature and multiplied by the cell constant factor. The reading is expressed as mu mhos/cm/g of seed. Lower the value of EC greater is the seed vigour.

3. Hiltner Test (Brick gravel test)

Principle : The test was developed by Hiltner in Germany in 1917. He observed that the seeds of cereal crops affected by Fusarium disease were able to germinate in regular test but were not able to emerge from brick gravels of 2-3 mm size. Compared to this, healthy seeds were able to emerge from the brick gravel (Robersts, 1972). The principle is that the weak seedlings are not able to generate enough force to overcome the pressure of brick gravels, so this method can be used to differentiate vigour levels in cereal seeds. Perry (1984b) found this method reproducible and associated with field emergence in case of wheat.

Apparatus and equipment : Germination box, aluminium tray, sand, sand marker brick gravel of 2-3 mm size, germinator, seed sample.

Procedure : The sand is seived, moistured and filled in the germination box leaving about 3 cm empty at the top. One hundred seeds are placed in each box in the impressions made by a sand marker. After this 2-2.5 cm of porous brick gravel is spread over the seeds. The box is kept in the germinator at appropriate temperature. After the period required for germination, the box is removed and the seedlings which have emerged through the brick gravel layer are counted. The percentage of emerged seedlings are used to compare seed vigour of different lots. The test should be repeated 3-4 times to get authentic value.

4. Paper Piercing Test

Principle : The principle of paper piercing test is similar to that of brick gravel test. High vigour seed lots are expected to produce strong seedlings which can pierce a particular type of paper while seedlings of poor vigour lots may not be able to pierce the paper. Therefore, the seedlings which emerge by piercing the paper

are more vigorous than those which are not able to emerge through the paper.

Apparatus and equipment : All the material required for conducting germination test in sand boxes or trays plus the special paper which should have the following characteristics :

(a) Basic weight = 90 g/m^2

(b) Thickness = 0.4 mm

(c) Bulk = 4

(d) Dry bursting strength = 0.3 kg/cm^2

(e) Breaking length = 1000-5000 mm

(f) Filtering speed = 500 ml/minute

(g) Wet bursting strength = 150 mm

(h) Ash content = 0.1%

(i) Fibre composition = Chemical wood pulp with high alpha percentage

Procedure : The cereal seeds are placed on 1.5 cm moist sand in a tray or sand box. The seeds are covered with specially selected dry filter paper, which is then covered with 2 cm of moist sand. After this, the sand boxes/trays are kept in a germinator maintained at 20°C temperature for 8 days. After 8 days sand boxes/trays are taken out and seedlings emerging above the paper are counted. A seed lot having maximum number of seedlings coming out of paper is considered to be most vigorous. *The test is highly dependant on the quality of paper and should be used when such papers are available.*

5. Cold Test

Principle : The cold test has been developed in USA to evaluate the seed vigour of maize (corn). In USA when the corn is planted in late spring, the soil is humid and cold. The weak seeds do not germinate and establish. Therefore, to simulate the actual field conditions witnessed at the time of corn planting, cold test

has been developed. The test aims to differentiate between weak and vigorous seed lots by subjecting them to low temperature prior to germination at optimum temperature. The test has been criticized for using field soil which greatly varies from place to place.

Apparatus and equipment : Aluminium tray, field soil, sand marker, germinator, seed sample.

Procedure : After grinding and properly sieving the soil is filled in tray upto 2 cm depth. Fifty seeds are placed over the sand and covered with another 2 cm thick layer of soil. The soil is compacted and enough water is added to make the soil about 70% of its water holding capacity. The temperature of the water should be 10°C. After watering the trays are covered with polythene bags and placed in the refrigerator maintained at 10°C temperature for one week. After one week the trays are removed and placed in the germinator at 25°C temperature. The seedlings emerged after 4 days are counted. The germination percentage is computed by counting the number of normal seedlings as in germination test. Higher the germination percentage greater is the vigour.

6. Accelerated Ageing Test

Principle : The accelerated ageing test has been developed at the Seed Technology Laboratory, Mississippi State University, USA for determining the storage potential of seed lots. The ageing process is accelerated by subjecting the seeds to high temperature and relative humidity in a chamber before standard germination. The seed lots that show high germination in accelerated ageing test are expected to maintain high viability during ambient storage as well. Thus, ageing test gives an indication of the performance of the seed lot during ambient storage. Tests conducted at Pantnagar with Bragg soybean seeds have shown positive relationship between 3 days accelerated ageing test (42- 45°C temperature, 95-100% R.H.) and viability after 6 months of ambient storage (Gupta, 1980). However, Perry (1984b) reported inconsistency in accelerated ageing test results and not well related to field emergence of maize and soybean. The test also suffers from fungal growth on seeds at high temperature and humidity (Agrawal, 1987). This test is recommended for soybean seeds.

Apparatus and equipment : Acceleratged aging chamber, equipment for germination test, seed samples, tight jar, muslin cloth, wire mesh etc.

Procedure : One hundred seeds each in four replications are tied in a fine muslin cloth. The tied seeds are placed in jar on a wire mesh. The lower part of the jar is filled with water. There should not be a direct contact between water and the seed. The jar is covered with the lid and sealed with parafin wax to make it air tight. The jar is then placed in the accelerated aging chamber maintained at 45 ± 2°C temperature for 3-5 days. The jar is removed after this period and the seeds are cooled in a dessicator. The seeds are then tested in a normal germination test specific to different crops. The percent germination gives level of seed vigour. Higher the germination percentage greater is the vigour of the seed.

Future Role of Seed Vigour Testing

Seed vigour is an important component of seed quality and satisfactory levels are necessary in addition to traditional quality criteria of moisture, purity, germination and seed health to obtain optimum plant stand and high production of crops. As agricultural and horticultural techniques become progressively more sophisticated, the need for high vigour seeds will increase and testing standards, similar to those reconginzed for germination will be required (Perry, 1984b). The technology of seed vigour testing has not been perfected so far, so much so that there is not a single universally accepted seed vigour test method. Research is needed to further refine the current seed vigour test methods and to develop new methods which are more related to field/storage conditions.

VARIETAL IDENTIFICATION

1. Grow - Out Test

Objective

To determine the genetic purity status of a given seed lot of the notified cultivar / hybrid and the extent to which the sample in question conforms to the prescribed standards.

Field of applicability

Grow-out Test is the official measure for controlling the genetic purity of the seed lot. It serves as a pre-control as well as a 'post-control' test for avoiding genetic contaminations. According to the official regulations in India, it is pre-requisite for seed certification of hybrids of certain species such as **cotton, castor, musk melon and brinjal**.

The test is required to be conducted for checking the sellers label with respect to genetic purity status of the seed lot **under the provisions of the seeds Act 1966**. In addition grow-out test can also be used as a measure to judge the efficacy of the certification agency or the inspector.

Sampling

The samples for 'Grow-out test shall be drawn simultaneously with the samples for other seed quality tests in accordance with the prescribed sampling procedures.

Size of submitted sample

The size of submitted samples shall vary according to the species as exemplified in this Table.

Recommended size of submitted sample for Grow-out Test

1,000 g	-	for maize, cotton, groundnut, soyabean and species of other genera with seeds of similar size;
500 g	-	For sorghum, wheat, paddy and species of other genera with seeds of similar size;
250 g	-	Beta and species of other genera with seeds of similar size;
100 g	-	For bajra, jute and species of all other genera;
250 tubers / planting stakes / roots/ corms	-	Seed potato, sweet potato and other vegetatively propagating crops.

Size of working sample

The working sample for grow out test shall be obtained through subsequent mixing and dividing of the submitted sample in accordance with the prescribed procedure for seed sampling.

The minimum population required for taking the observations shall be 400 plants; however, it will also depend on the maximum permissible off-type plants prescribed for the species under consideration in the Indian Minimum seed Certification standards

The number of seeds required for raising the crop to obtain the required number of plants shall depend on the germination percentage of the seed sample and hence seed rate should be adjusted accordingly.

Number of plants required per sample for grow out test

Maximum permissible off types (%)	Minimum genetic Purity (%)	Number of plants required per sample
0.10	99.9	4,000
0.20	99.8	2,000
0.30	99.7	1,350
0.50	99.5	800
1.00 and above	99.0 and below	400

Procedures

To achieve the accuracy and reproducibility of the grow out test results, the procedures provided hereunder must be followed:

Location of the grow out test

The grow out test shall be conducted in specified areas recommended for the cultivar / hybrid or in off-season nurseries.

Standard sample

The standard sample of a cultivar (control) is the official standard against which all other samples of the seed of the cultivar will be judged.

The standard sample must not differ significantly in any character and be obtained from the originating plant breeder / breeding institute and be stored under controlled temperature and humidity conditions so as to use it each year to sow control plots for cultivars under test. Further quantities of sample must be obtained from the originating plant breeder as and when required. A comparison must be made between the two lots of the standard sample before changing from one standard sample to other.

Method of raising the crop

Standard and recommended agronomic / cultural practices such as field preparation, size of the plot, row length, distance between the rows, distance between the plants, irrigation and fertilization, etc., in respect of the specific crop shall be followed both for the sample in question and its control (standard sample).

The germination percentage of the sample (s) in question and the standard sample must be determined to adjust the seed rate. The sowing should be done by dibbling or small plot drill. Seed drill must be carefully checked to ensure its cleanliness. Subsequent thinnings is not recommended. The samples of the same cultivars must be sown in succession and the standard samples are sown at suitable intervals. (one standard sample for every ten sample to be tested).

The size of the plot, row length and spacing shall differ according to the crop. Recommended specification for the above variables are provided in Table mentioned below which can suitably be modified if considered essential.

Recommended row length, distances, spacing for some important crops

S. No.	Crop	Row length (m)	Plant to plant distance (cm)	Space between rows (cm)	Space between plots (cm)
1.	Wheat, barley oats	6	2	25	50
2.	Pea, Cowpea	6	10	45	90
3.	Chickpea, green gram black gram	6	10	30	60
4.	Maize	10	25	60	90
5.	Hybrid cotton	5	10	45	45
6.	Paddy: a) Very early to medium b) Late and very late	 6 6	 15 25	 20 30	 45 60
7.	Pearl millet	6	10	60	90
8.	Sorghum	6	10	45	60

The field plots should be grown in two replicates to guard against failure in one part of the field and to reduce environmental and soil fertility variations.

Methods for taking observations

Grow-out test plots must be examined throughout the growing season with emphasis on the period from the flowering to ripening. All plants must be examined keeping in view the distinguishing characters described for the cultivars both in the test crop as well as the control. While taking the observation, the plants showing deviations in characters against the control should be tagged and examined carefully at a later stage to confirm whether they are off-types or not. The number of the total plants and the off-type plants found should be recorded.

Calculation and interpretation of the results

Percentage of other cultivars, species or aberrants found must be calculated upto first decimal place. While interpreting the results, tolerances should be applied by using the reject number for prescribed standards with reference to sample size as provided in Table.

Reject number for prescribed standards and sample size

	Reject numbers for sample size of	
	800	400
99.5 (1 in 200)	8	*
99.0 (1 in 100)	16	8
95.0 (5 in 100)	48	24
90.0 (10 in 100)	88	44
85.0 (15 in 100)	128	64

** indicates that the sample size is too small for a valid test.*

Reporting of results

- The results of the grow-out test shall be reported as percentage of other species, cultivars or off-type plants.
- If the sample is found to be a cultivar other than stated by the sender, the results shall be reported as such.
- If plants of other cultivars are more than 15 per cent, the report shall state that the sample consists of mixture of different cultivars.
- If nothing worthy of special comments is found, the report shall state that the results of the grow-out test of the sample in question revealed nothing to indicate that the name of the cultivar or species stated by the sender is incorrect.

2. Electrophoresis

It is the latest method of cultivar identification based on protein banding and isoenzyme activity. Here single seeds are defatted and extracted for protein and esterases. The extracted proteins or esterases are separated by polyacrylamide gel electrophoresis. Based on the banding pattern of protein and esterase's the varieties can be differentiated and identified.

Electrophoresis for proteins and enzymes: Seeds, seedlings or mature leaves etc. of a crop plant have a specific mix of proteins which are not only crop specific but also variety specific (genotype specific). The electrophoresis in a suitable medium separates the mixture of proteins extracted from seeds, seedlings or mature leaves into distinct bands. Each variety (or genotype) thus has a specific "banding pattern" on the basis of which admixtures of other varieties, differing in "banding pattern" could be detected. This is done by comparing the banding pattern of analysed sample with the standard banding pattern of that variety. The electrophoresis is now being increasingly used for determining the genetic purity of seed samples.

Principle: The term 'electrophoresis' refers to the migration of a charged particle under the influence of an electric field. The movement of ions takes place in a suitable medium, such as, polyacrylamide gel, which acts as a molecular sieve and

cut down convection currents and diffusion, so that the separated components remain as sharp zones with maximum resolution. The separation into distinct bands is due to,

1. differences in the size of molecules (molecular weight) of various proteins. Particles with smaller molecular weights migrate faster than those with higher weights, and

2. differences in charge. The molecules with the higher charge migrate faster than those with a lower charge.

Since proteins carry a net charge at any pH other than their isoelectric point, they migrate in an electric field, the rate of which depends on the charge density (that is, the rate of charge to mass of the molecule). Proteins with higher charge density will migrate faster, thus resulting in differential rates of movement of proteins when a mixture of different proteins is subjected to an electric field. By altering the gel pore size (using polymers at different concentrations) and the charge on the protein molecule (by changing the pH of the system) a high degree of resolution can be achieved for separation of protein molecules in a mixture.

SEED STORAGE

Maintenance of seed vigour and viability in terms of germination from harvest until planting is of the utmost importance in any seed production programme. Care should be taken at every stage of processing and distribution to maintain the viability and vigour. The harvested seeds of most of the orthodox crop seeds are usually dried and stored for atleast one season until the commencement of the next growing season, except those of the recalcitrant seeds which require high moisture content for safe storage (once dried the viability will be lost. E.g. – Jack, Citrus, Coffee, Cocoa, Polyalthea, etc.,). In such recalcitrant seeds senescence starts in the mother plant itself. The dry weather alters moisture content of the seed, thereby reducing the viability. Some seeds require an after ripening process as in Pinus and Fraxinus. In most of the Agricultural crops ageing starts at physiological maturity, which is irreversible. Hence seeds become practically worthless if they fail to give adequate plant stands in addition to healthy and vigorous plants. Good storage is therefore a basic requirement in seed production.

Purpose of seed storage

Seeds have to be stored, of course, because there is usually a period of time between harvest and planting. During this period, the seed have to be kept somewhere. While the time interval between harvest and planting is the basic reason for storing seed, there are other considerations, especially in the case of extended storage of seed.

The purpose of seed storage is to maintain the seed in good physical and physiological condition from the time they are harvested until the time they are planted. It is important to get adequate plant stands in addition to healthy and vigorous plants.

Seed suppliers are not always able to market all the seed they produce during the following planting season. In many cases, the unsold seed are “carried over” in storage for marketing during the second planting season

after harvest. Problems arise in connection with carryover storage of seed because some kinds, varieties and lots of seed do not carryover very well.

Seeds are also deliberately stored for extended periods so as to eliminate the need to produce the seed every season. Foundation seed units and others have found this to be an economical, efficient procedure for seeds of varieties for which there is limited demand. Some kinds of seeds are stored for extended periods to improve the percentage and rapidity of germination by providing enough time for a "natural" release from dormancy.

Regardless of the specific reasons for storage of seed, the purpose remains the same maintenance of a satisfactory capacity for germination and emergence. The facilities and procedures used in storage, therefore, have to be directed towards the accomplishment of this purpose.

STAGES/SEGMENTS OF SEED STORAGE

In the broadest sense the storage period for seed begins with attainment of physiological maturity and ends with resumption of active growth of the embryonic axis, i.e., germination.

The entire storage periods can be divided into:

1	**Post maturation / Pre harvest segment**	Period from physiological maturity to harvest (seed in field).
2	**Bulk seed segment**	Period from harvest to packaging (bulk seed in aeration drying bins, surge bins, etc.).
3	**Packaged seed segment**	Period from packaging to distribution (seed in Packages in warehouse).
4	**Distribution / Marketing Segment**	Period during distributing and marketing (packaged seed in transit and / or retailer's storehouse).
5	**On-farm segment**	Period from purchase to planting of seed (seed in on-farm storage).

Seeds are considered to be physiologically and morphologically mature when they reach maximum dry weight. At this stage dry-down or dehydration of the seed is well underway. Dry-down continues after physiological maturity until moisture content of the seed and fruit decreases to a level which permits effective and efficient harvest and threshing. This stage can be termed as harvest maturity. There is usually an interval of time between physiological maturity and harvestable maturity, and this interval represents the first segment of the storage period. Any delay in harvesting the seed after they reach harvest maturity prolongs the first segment of the storage period – often to the detriment of seed quality.

The second segment of the storage period extends from harvest to the beginning of conditioning. Seed in the combine, grain wagon, and bulk storage or drying bins are in storage and their quality is affected by the same factors that affect the quality of seed during the packaged seed segment of the storage period. The third segment of the storage period begins with the onset of conditioning and ends with packaging. The fourth segment of the storage period is the packaged seed phase which has already been mentioned. The packaged seed segment is followed by storage during distribution and marketing, and finally by storage on the farm before and during planting.

The seed quality can be considerably be affected at any of the stages or segments mentioned above unless sound principles involved in seed storage are practiced and the seeds are properly handled.

Types of storage

The types of storage needed can be related to the time of storage expected. Broadly this can be classified into 4 types.

a) Storage of commercial truthfully labelled and certified seed.

b) Storage of carry over seeds.

c) Storage of foundation seed stocks and enforcement seed samples.

d) Storage of germplasm seeds.

a) Storage of commercial seeds

This storage of commercial seed requires the largest storage need from harvest until planting. The storage period ranges from 8-9 months. Seed must be dried to 14 per cent moisture content for starchy seed and 11 percent for oilseeds.

b) Carryover seeds

About 20-25 per cent of stored seed may have to be carried over through one season to the second planting time. The storage period may range 1-1½ year. Storage of seeds in metal bins with tight fitting lids or in a moisture proof bag will solve the problems of moisture penetration, provided the seeds are already dry enough for sealed storage.

c) Foundation stock and enforcement seed sample

It is desirable to store foundation and enforcement seeds for several years since genetic drift are minimized by reproducing foundation or stock seeds. Since the quantity of seeds involved is not large, the storage room is only a small part of the total storage area and in fact, is often a small room within a large warehouse. Relative humidity and temperature combination has to be provided for maintaining the viability. A combination of 25 per cent RH at 30^{o}C temperature or less or a RH of about 45 per cent at 20^{o}C or less will be ideal. The required RH can be achieved by making the room moisture proof and by using a dehumidifier.

d) Germplasm seed storage

Germplasm seeds are required to be kept for many years, perhaps very long periods. Basic requirements for such long term storage are the coldest temperature economically possible and seed moisture is in equilibrium with 20-25 per cent RH. Germplasm storage built up so far have rooms which can be maintained at 5^{o}C to 10^{o}C and 30 per cent RH. In addition, the stored samples are dried to perfect moisture level.

PRINCIPLES OF STORAGE

a. Seed storage conditions should be dry and cool

b. Effective storage pest control

c. Proper sanitation in seed stores

d. Before placing seeds into storage they should be dried to safe moisture limits.

e. Storing of high quality seed only i.e., well cleaned treated as well as high germination and vigour.

FACTORS AFFECTING SEED LONGEVITY IN STORAGE

1. Kind (or) variety of seed
2. Initial seed quality
3. Moisture content
4. Relative humidity and temperature during storage
5. Provenance
6. The activity of organisms associated with seeds in storage.

1. Kind or variety of seed

Seed storability is considerably influenced by the kind or variety of seeds. Some seeds are short lived. E.g.: Onion, Soybean and Groundnut. As a general rule starchy seeds can be stored considerably for a longer period compared to proteinaceous or oily seeds because of their hygroscopic nature.

2. Initial seed quality

Seed lots having plumpy, vigorous undamaged seeds store longer than that of deteriorated. Even seed lots having good germination at the beginning of storage period, may deteriorate at a faster rate depending upon the severity of weathering damage, mechanical injury or otherwise in the field. The low quality seeds should invariably be rejected. Even at best storage conditions, the initial quality of the seed cannot be improved (except for the dormant seed) but can only be maintained.

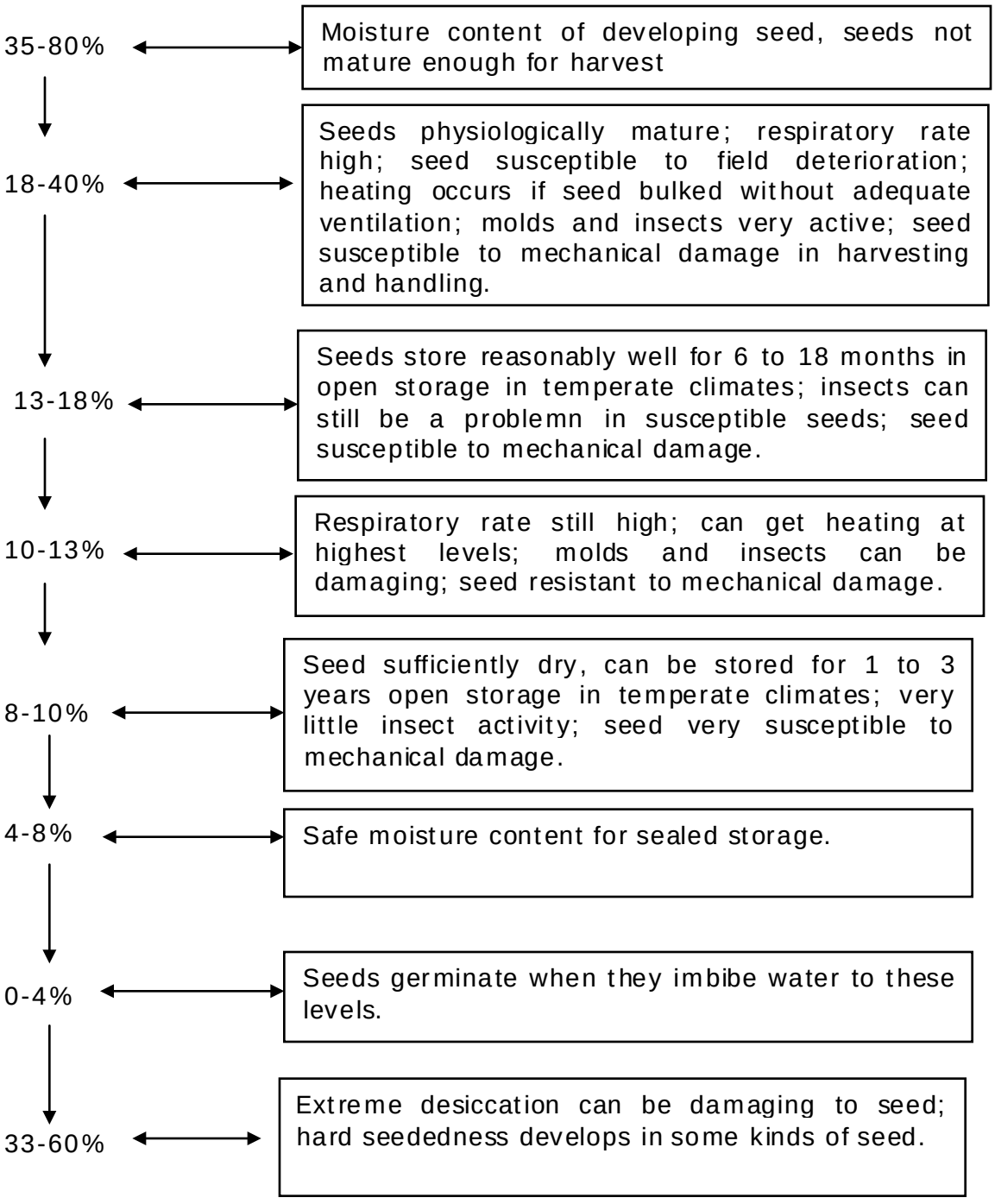
3. Moisture content

The most important factor influencing seed viability during storage is the moisture content and the rate of deterioration increases, as the seed moisture content increases. The drier the seed the higher will be the storage life.

Seed moisture content (%)	Storage life
11-13	½ year
10-12	1 year
9-11	2 years
8-10	4 years

It is well known that higher moisture content enhances the biological activity in the seeds and causes excessive heating, besides promoting mould and insect activities. The relationship of moisture content of seeds during post harvest stages furnished below would clearly indicate the role of moisture in the life of seeds in storage.

Role and importance of moisture content in the life of seeds



The importance of seed moisture content in extending the shelf life of seeds under ideal storage conditions can be well known and understood from the Harrington's thumb rule, that one per cent decrease in seed moisture

content nearly doubles the storage potential of the seed. Again this rule is applicable only at a moisture range of 5-14 per cent because, moisture content below 5 per cent the physio chemical reaction may take place and at above 14 per cent fungi and insects become active. Another rule given by Harrington states that for every 5^{o}C decrease in storage temperature, the seed life will be doubled. Again this can hold good only in the temperature range of 0-50^{o}C. There are exceptions in this rule in a few crops like chillies, brinjal and bhendi. The safe moisture content again depends upon the period of storage, storage structures, kind and variety of seed and the packaging materials used. For cereals under open storage, seed drying upto 10 per cent moisture content appears quite satisfactory. The storage in sealed containers during upto 4-8% moisture content depending upon the particular kind of seed may be necessary.

Use of desiccants

Desiccant like silicagel can maintain the moisture content in equilibrium with the Relative Humidity of 45%. It is kept @ 1kg/10 kg of seeds. When the silicagel turns to pink colour it should be dried at 175^{0} in oven and then again placed in the container.

4. Relative humidity and temperature during storage

Seeds are hygroscopic. They attain rather specific and characteristic moisture content when subjected to given level of atmospheric humidity at a particular temperature (equilibrium moisture content). The equilibrium moisture content for a particular kind of seed at a given relative humidity tends to increase as temperature decreases and the deterioration starts.

Equilibrium moisture content varies among seed kinds. In general, the equilibrium moisture content of “oily” seed is lower than that of “starchy” seed at the same relative humidity and temperature. This phenomenon can be accounted for by the fact that fats and oils do not mix with water. Thus, in a seed with 50% oil content, the moisture has to be concentrated in half the seed, while in a seed containing 10% oil, the moisture is distributed throughout 90% of the seed.

Thus the maintenance of moisture content of seed during storage is a function of RH and to a lesser extent of temperature. At equilibrium moisture content there is no net gain or loss in seed moisture content when seed is placed in a new environment with RH higher or lower than that of the seed, the seed will gain or lose moisture till it reaches a new equilibrium moisture content at this particular new environment.

Dry, cool conditions during storage

The general prescription for seed storage is a dry and cool environment. At this point, the question naturally arises: How dry and how cool? It is difficult to answer this question unless three factors are known: (1) kind(s) of seed to be stored; (2) desired period of storage and (3) physiological quality of the seed.

Seed of most grain crops, e.g., corn, wheat, sorghum, barley, rye, oats, rice, will maintain germination for the 8-9 months period from harvest to planting at moisture content of 12-13% and normal warehouse temperature except possibly in Southern coastal areas. For maintenance of vigour as well as germination, moisture content should not exceed 12% (relative humidity below 60%) and temperature in the warehouse should not exceed 65^0 F. In the case of carry-over seed, which means a storage period of 20-21 months, the moisture content of seed of grain crops should be less than 11% and temperature should not exceed 65^0 F. Since the period of carry-over storage encompasses atleast one summer period, temperatures and humidity control during the period is most important.

Cotton seed stores about as well as seed of grain crops, and the conditions mentioned above are applicable.

Soybeans and peanut seed are poor storers. For one year's storage (actually 8-9 months), moisture content should be 11 to 12% and the warehouse temperature should not exceed 65^0F. Shelled peanuts may have to be stored in a cold room. Carry-over storage should not be attempted unless conditioned storage facilities are available: 65^0F and 50% relative humidity or better.

Seed of most forage grass and legume crops will store well for one year at moisture content of 10-11% at normal warehouse temperatures. When "carried-over", moisture content should be about 10% and temperature should not exceed 65%.

Vegetable seed vary considerably among kinds in their storage requirements. Generally, however, most kinds will store well for one year at a moisture content of 9-11% and a temperature that does not exceed 65^0F.

When a storage period longer than 19-21 months is required, conditioned storage is essential for all kinds of seed. Most kinds of seed will maintain quality for 2-3 years when stored at 60^0F and 50-55% relative humidity or better. For storage longer than 3 years, conditions should be 50^0 F and 50% relative humidity or better.

5. Provenance

The seeds harvested in different climates (or) at different times show differences in viability. Because they would have been subjected to different pre harvest conditions which will have caused different amounts of deterioration by the time, the seeds are harvested.

6. The activity of organisms associated with seeds in storage

The bacteria, fungi, mites, insects, rodents and birds may do harm to seeds in storage. The general limits of temperature and relative humidity for the multiplication of the various biological agencies infesting stored seeds are,

Organism	Temperature		Relative humidity
	Range for multiplication	Optimum range	
Insects	21-42°C	27-37°C	30-95%
Mites	8-31°C	19-31°C	60-100%
Fungi	8-80°C	20-40°C	60-100%
Microbes	8-80°C	26-28°C	91-100%

It is also interesting to note that the favourable limits of temperature and RH for germination are 16-42^{o}C and 95-100 per cent respectively.

Sanitation in storage

There are several other recognized procedures for good seed storage that most seeds men already know. Seeds should be stored in a seed warehouse, not a fertilizer, chemicals, herbicide, or feed warehouse. Good sanitation should be a continuous practice. It will minimize storage insect infestations. If storage insects are a problem, the judicious use of insecticides and fumigants, combined with sanitation, will alleviate the problem. The best procedure is not to place insect infested lots in storage with other lots unless all the insects have been killed by fumigation or insecticide treatment.

In warehouse with concrete floors, seed bags should be stacked on wooden pallets to keep them from contact with the floor as considerable moisture can be transmitted through concrete floors. Seed warehouses should also be adequately ventilated (unless they are conditioned) and protected against rodents.

Storage Conditions

Since seed moisture content and ambient relative humidity are in equilibrium during storage, maintenance of a “safe” moisture content requires an average level of relative humidity in the storage environment no higher than that in equilibrium with the “safe” or desired moisture content. This favorable situation can be achieved in only three ways: (1) location of the storage facility in a region where relative humidity does not rise – on the average – above the critical level; (2) maintenance of the relative humidity at the desired level by packaging seed in moisture vapor proof containers; or (3) dehumidification of the storage room atmosphere to the desired level. The desired level of relative humidity for successful storage of seed depends, of course on the kind of seed, the duration of the storage period, and the temperature.

SEED PACKAGING IN RELATION TO SEED STORAGE

In reality the seed package is a small storage container. The kind of container needed is affected by several factors including :

a) The quantity of seed desired in each package

b) The protection desired

c) The cost of the package

d) The value of the seed

e) The storage conditions into which the container is to be placed and

f) The facilities for drying the seeds

Depending upon the cost availability and the period of storage, the packaging materials are to be selected. Normally cereal seeds are being packed in cotton, jute and paper bags. Moisture vapour penetrates in these containers and they offer no protection against high relative humidity. In high humidity locations with inadequate seed storage facilities, consideration should be given to methods of packaging which can protect the seed from moisture vapour. Such moisture vapour proof containers include paper aluminium foil pouches, polyethylene bags of over 700 gauge thickness, sealed tins and gasketted rigid plastic containers. The costs of these are high, for the package of cereal seeds. Polyethylene bags have been regarded as the most attractive, because of their relatively low cost, compared to other kinds of sealed containers. Rigid plastic containers and sealed tins offer some possibility for hybrid seeds of cotton and vegetables, if the quantity needed is not great.

Classification of packing materials or containers

1. Moisture and vapour pervious containers

These containers allow entry of water in the from of vapour and liquid. These are suited for short term storage. The seeds in these containers will attain seed equilibrium moisture with the surrounding atmosphere (eg) cloth bags, gunny bags, paper bags etc.



2. Moisture impervious but vapour pervious containers

These allow entry of water in the form of vapour and not in liquid. The seeds in the containers can't be carried over for long period in hot humid conditions (.g.) polythene bags of <300 gauge thickness and urea bags.


3. Moisture and vapour proof containers

These containers will not allow entry of moisture in the form of liquid or vapour. These are used for long term storage even in hot humid conditions if the seeds are sealed at optimum m.c. eg. Polythylene bags of >700 gauge thickness, aluminium foil pouches, rigid plastics etc.

Certified seeds of cereals, pulses and oil seeds are normally packed either in gunny bags or cloth bags. However, paper bag, aluminium foil pouches and polyethylene bags are used for packing flower and vegetable seeds.

Seed storage in relation to seed deterioration

The Purpose of seed storage has been previously stated, ***viz.***, to preserve or maintain the physiological quality of seed for the period desired through minimization of the rate of deterioration. Since seed storage is basically concerned with "control" of deteriorative processes, some knowledge of these processes is essential for successful seed storage operations.

Deteriorative changes in seed and their consequences

In our consideration of some of the characteristics of deterioration in seed, another might have been added that deterioration is characterized by change. Indeed, in our context, deterioration and change – detrimental change – are almost synonymous. For deterioration is identifiable only in

terms of observable or measurable changes in the response reactions of the seed. Conversely, detrimental changes, e.g., loss of germination or vigour, are said to be the result of deterioration.

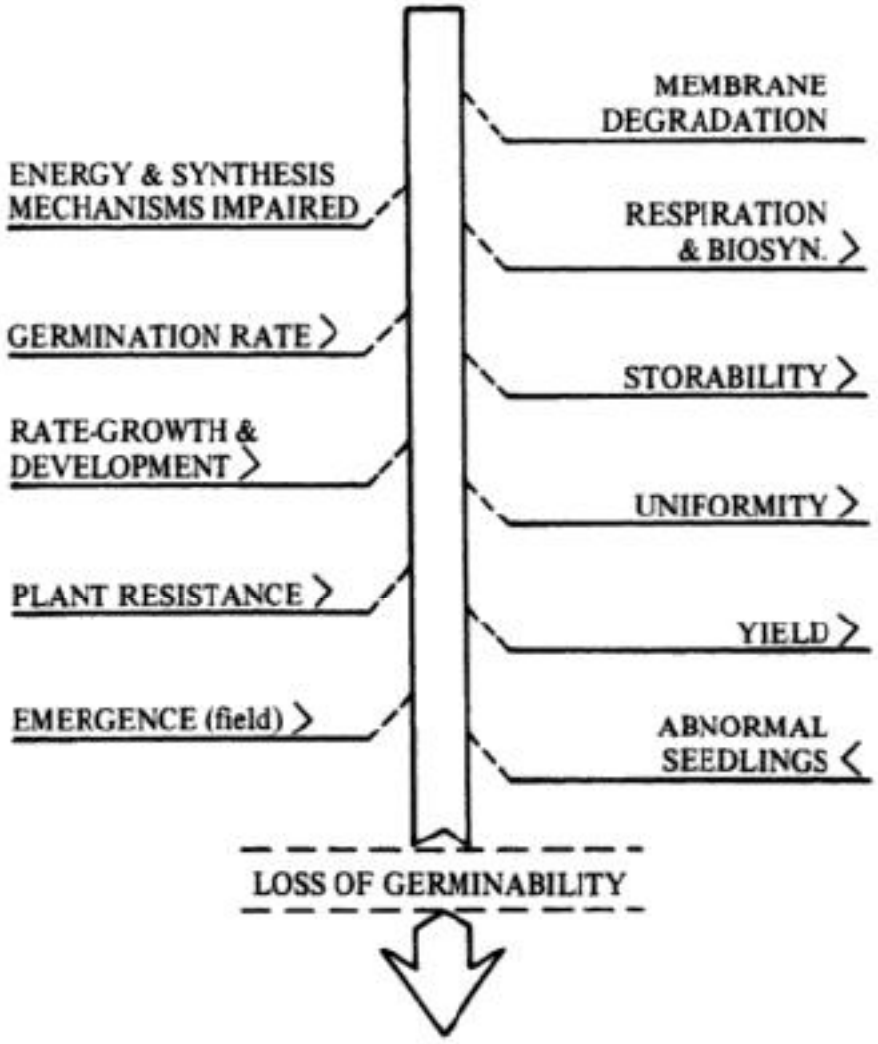
In the sequence of deteriorative changes postulated in figure 1, it can be readily seen that during deterioration, the "performance potential" of seed becomes progressively impaired (reduced) until they lose their capacity to germinate, at which time "performance potential" is zero. Since loss of the capacity to germinate is the last practically significant consequence of deterioration, the design and evaluation of storage conditions only in terms of "maintenance of germination" is not sufficient. The "lesser consequences" of deterioration must also be considered because collectively they determine the "vigour" level of the seed. And, the vigour of seed determines how well they germinate, emerge, grow, and develop in the farmer's field.

Longevity of seed is a characteristic of the species or variety

Some kinds of seed are inherently long-lived, others are short-lived, while others have an "intermediate" life span. Differences in storability extend even down to the variety level. It has been known, for example, the certain inbred lines of corn are "poor storers" and that this characteristic is inherited.

Inherent differences in seed longevity are facts, the seeds man must accept and contend with as best he can. Among the vegetables, onion seed are notoriously short-lived, radish seed are intermediate in longevity, and watermelon seed are relatively long-lived. Soybean and peanut seed do not store well as compared to seed of wheat, corn, cotton, sorghum and rice. In some cases, seed kinds which have very similar chemical and physical properties differ substantially in longevity. Tall fescue and annual ryegrass seed are similar in structure, chemical composition, and yet, ryegrass seed store better than tall fescue seed.

Possible Sequence of changes in seed during deterioration



Seed selection for extended storability

- Store well mature seeds.
- Store normal coloured seeds
- Seeds should be free from mechanical injury
- Seeds should not have met with adverse conditions during maturation
- Seeds should be dried to optimum moisture content.
- Seeds should be treated with fungicides before storage.
- Suitable packaging materials should be used for packing.

High quality seed store better than low quality seed

The storage potential of seed is greatly affected by their quality at the time they enter storage, or their pre-storage history. The pre storage history of a seed lot encompasses all the "events" in the "life" of the seeds from the time functional maturity is reached until they are placed in storage.

Seeds are highest in quality at the time functional maturity is attained. Since most kinds of seed reach maturity at moisture contents too high for mechanical harvest, the seeds are subjected to the field environment from maturation to harvest. The post-maturation pre-harvest period normally ranges from 1 to 4 weeks for the different kinds of seed. Adverse climatic conditions can result in rapid and severe deterioration of the seed, and so on. The degree of deterioration that occurs in seed prior to harvest determines their quality at harvest and conditions their performance in storage.

In like manner, mechanical, abuse to seed associated with harvesting, handling and processing operations, and damage caused by inadequate or improper aeration or drying can have both immediate and residual effects, i.e., performance of the seed might be affected at the time of injury or not until some later time during storage.

In characterizing seed deterioration, we pointed out that the rate of deterioration of seed in storage varies among seed lots of the same kind and among individual seeds within a lot. These variations in storability are, of course, related to the pre-storage history of seed lots. Seed lots with a "good" pre-storage history (minimal field deterioration, mechanical damage, etc.) store well, while those with a "bad" pre-storage history store poorly.

STORAGE GODOWNS AND THEIR MAINTENANCE

Seeds undergo deterioration due to aging in storage. This is accelerated by climatic factors and external biotic factors like insects and pathogen. In addition to seed borne pathogen and storage insects, seeds are damaged by birds and rats for their feed. Clean and hygienic godowns protect the seed from

external insects and preserve the seed. Hence care should be taken in construction of godown. The points to be noted are as follows.

- Seed godown should be in a place where transport facilities are easily available.
- Seed godowns should not be constructed in areas near seashore. Since the high RH of atmospheric air accelerate the deterioration of seed.
- Seed godown should not be constructed in low lying water stagnating areas.
- Seed godown should be constructed in places where atmospheric RH is low, free circulation of air is possible, sunlight is adequate and elevated in nature.
- The ventilators should be at bottom for free air circulation.
- Ground moisture should not reach the floor.
- Should be rat proof with wire mesh
- Should not be near industries as smoke is injurious

In maintenance of seed in godown following points are to be considered.

1. Godown should be clean and dry

2. Seed bags should not be stacked directly on floor. Should be stacked on wooden ballets.

3. The height of the stack should not be more than 6-8 bags.
4. Different seed lot should be kept separately.
5. Godown should be sprayed periodically once in a week or fortnightly with Malathion 50 EC (1 : 300 Chemical : Water) @ 5 lit. sq. m-1 or 0.25% Nuvan @ 1 lit. 100 m^{3-1}.
6. Altering the chemicals at weekly intervals will give better control.
7. Seed lots can be fumigated with Aluminium phophide @ 3 gm/cu.m in air tight condition for 7 days. This can be done as propylatic measure and on minimum infestation by insects.
8. Seed lots should be periodically (once in month) tested for seed quality.
9. Based on seed testing result, seeds can be dried under sun for the removal of moisture. It reduces insect and pathogen infestation.
10. New seed lots should be kept away from old seed lots to avoid secondary infestation of insects.
11. Seeds should be treated with combination of fungicide and insecticide (eg.) Thiram @ 2 g kg-1 + carbaryl @ 200 mg kg-1.
12. Frequent supervision of each and every lot is must.
13. Seed bag should be restacked once in 3 months for free aeration.

14. Instead of gunny bags low cost interwoven polythene bags should be used to prolong the life of seed.

15. Pesticides, fungicides, fertilizers, rejects should not be stored with seed.

16. Each lot should be labeled accurately and registers for stocks should be maintained.

17. Per acre or per hectare packing (small) is preferable for easy handling and effective supervision.

STORAGE INSECT MANAGEMENT

Maintenance of store house hygiene

1. Cracks and crevices around corners have to be brushed to eliminate hiding pests. All debris should be removed. Provision of wire meshes to windows, ventilators, gutters, drains to prevent entry of rats, squirrels, birds, etc.
2. Reduce the moisture content of seed to prevent insect build up (usually below 10%). Previously used bags, bins, etc. should be dried in the sun repeatedly.
3. Elimination of conditions which favour storage pests. Uniformly graded seeds should be used, broken seeds should be removed before bagging since they favour pest build up. Stitching of all torn bags, filling bags up to the brim, no loose packing.
4. Surface treatment of storehouse before storage with malathion dust 4% @ 25 g/sq m or malathion 50% EC spray @ 10 ml/lit of water and 3 lit of solution per sq. metre.
5. Good dunnage by arranging wooden planks or bamboo poles or spreading thick polythene sheets on the floor. Treatment of dunnage materials with malathion as specified, arrange the bags in criscross pattern with a maximum of 15 bags and provide adequate space between the roof and the seed bags.

Prophylatic treatment of seeds

Application of malathion 4 per cent dust 25 g/sq metre or malathion 50 per cent EC 10 ml per litre of water and 3 litres of spray solution for 100 sq.m. The chemicals have to be sprayed on the walls and floors and the treatment has to be repeated based on the extent of flying and crawling insects.

Chemicals

Two chemicals are widely used : Phosphine and Methyl Bromide. Others are dichlorvos, Carbondioxide, Ethylene oxide and HCN.

Phosphine : Available in a solid form (0.6 g pellets, 3 g tablets). The active ingredient is Aluminium phosphide mixed with Ammonium carbonate and Paraffin. After exposure to the atmosphere, the pellets decompose and release the active substance, hydrogen phosphide (PH_3), which has the same specific weight as air, and is thus evenly distributed in the fumigated material or chamber. Phosphine is also able to penetrate bags, carton boxes and other containers.

It must be borne in mind that fumigation particularly repeated fumigation, may seriously reduce the vigour and viability. This is particularly true for seeds with a higher moisture content of 14 per cent. Seeds with moisture content above 14 per cent should be dried, before fumigation.

Samples of seeds have to be drawn at fortnight intervals and the infestation can be classified as follows based on insects found per kg of sample.

When there is no pest	Free
Upto 2 insects	Mild
More than 2 insects	Severe

The fumigant has to be chosen and the requirement worked out on the following guidelines :

Aluminium phosphide: Three tablets of 3 g each per ton of seed for cover fumigation (only selected blocks of bags)

Twenty one tablets of 3g each for 28 cubic metres, for shed fumigation (entire godown). Period of fumigation - 5 days. The major advantages of Phostoxin are that it lacks residues and does not affect flavor or germination and is easy to handle.

Methyl bromide: Above 5.6°C, methyl bromide is in the gas phase and is available in cylinders similar to those used for cooking gas. Since, it is odorless, other gases such as chloropicrin are sometimes added to facilitate detection of leaks. Because methyl bromide is 3.5 times heavier than air, care has to be taken that it is properly distributed within the goods to be fumigated (fan can be used). The recommended dosage is 20 g/m^3 for 24-48 hrs.

Special safety measures are required, since methyl bromide is absorbed through the skin. It tends to accumulate in commodities which are important whenever repeated fumigation is necessary.

Equipment

Gas-proof plastic sheets with at least 50 cm overlap firmly pressed to the ground with sand, iron bars, or other weights are frequently used. Gas escape results in reduced insecticidal effect and is a hazard to users. A cement floor is necessary to prevent gas escape through soil. Care must be taken that the fumigation area is properly aerated and fans sometimes help.

If a store's door and windows can be hermetically sealed, fumigation of the entire store is possible. Most stores, however, allow gas to escape through other openings. Silos are usually good fumigation facilities. When large quantities must be fumigated within a short time, a vaccum fumigation chamber is appropriate. These chambers are available in sizes between 1 and 50 m^3, and sometimes as a plant of upto 6 x 50 m^3, equipped with common fans, pumps and other equipment. The insecticides used are methyl bromide or ethylene oxide.

Safety

Face masks with a proper canister should be used, especially during the aeration process. When handling Phostoxin, cotton gloves should be worn. Gas concentration can be checked with a Halide gas detector for methyl bromide and with a tube detector (Draeger) for Phostoxin. A warning

sign should be clearly visible to prevent people from inadvertently removing plastic sheets or entering a building under fumigation.

Rodent Management in Store Houses

Provide of wire mesh to windows, ventilators, drains and leave no gaps to doors. Use rodent baits with multi dose or anticoagulant rodenticides. The bait may be prepared as follows:

Cereal flour	450 g
Any edible oil	10 g
Powdered jaggery	15 g
Anticoagulant or rodenticide such as coumarin	25 g

Replace the consumed bait daily. If needed the single dose or acute poison bait may be prepared as follows :

Food material	97 g
Edible oil	1 g
Zinc phosphide	2 g

Before providing the poisoned zinc phosphide bait, the plain or non-poisoned bait are to be provided for two or three days to make the rats accept the bait.

SEED MARKETING

A definition of seed marketing

Seed marketing should aim to satisfy the farmer's demand for reliable supply of a range of improved seed varieties of assured quality at an acceptable price.

- To the retailer in the agricultural sector, for example, it is selling seed along with other inputs to the farmer.
- To the farmer it is simply selling what he produces on his farm. However, whatever the circumstances, a well-defined sequence of events has to take place to promote the product and to put it in the right place, at the right time and at the right price for a sale to be made.
- Too many people think of marketing solely in terms of the advertising and selling of goods, whereas in reality marketing starts long before the goods exist and continues long after they are sold. Therefore, for the marketing process to be successful: the farmer consumer's needs must be satisfied; the seed company's objectives must be realized.

MARKETING STRUCTURE

Seed distribution systems

Seed distribution can be carried out by government, public sector agencies, co-operatives and the private sector or, as is often the case, by a combination of all of these. Channels for seed marketing may be described as:

Direct

The seed producing organization supplies the farmer directly. Some features of direct channel distribution are:

- the supplier has direct contact with the consumer
- a high level of service and customer support can be maintained
- direct control is maintained over the quality of the product

- the upkeep of such a system can be expensive, with high fixed costs if a sales force is employed
- a responsive management structure and well-motivated staff are required where there are many staff involved in a direct sales organization there can be an inbuilt inertia to change so the system may lack flexibility.
- the revenue necessary to pay for the high fixed costs will only come from having a wide product range and achieving good market shares or selling high value products such as horticultural seeds.

Single level

The seed producing organization supplies the farmer through independent retail outlets. The main features of this system are that:

- the seed supplier relies on the retailer for contact with the consumer
- retail networks require strong service and support from the supplier
- good administrative control must be provided by the sales management
- the supplier's distribution system must be well organized and responsive
- product quality at the retail level must be monitored for deterioration and adulteration and a return system should be considered
- although the products may be well promoted, the supplier relies on the retailer to make the final sale.

Multilevel

The seed producing organization supplies a national distributor, wholesalers or regional distributors who, in turn, supply sub-distributors or the retail outlets.

This system is characterized by:

- the supplier having no direct contact with the consumer
- products being strongly promoted in order to create demand
- supplying seed to the distributors in sufficient time to achieve timely availability at the retail level

- management ensuring that there is a good system of monitoring sales and obtaining feedback from the consumer
- the distributor being interested only in the strongest selling lines.

If neither infrastructure nor the economy are well developed, national distributors may simply not be available and the seed producer will have to supply seed to regional wholesalers or distributors.

Sources of seed available to farmers

For farmers there are a number of sources available for the purchase of seed. These are:

Direct sales

The seed producer supplies the farmer directly from central seed stores and a network of his/her own supply points

Farmer producers

Farmers with seed production contracts are licensed to supply other farmers within their zone of influence

Cooperatives

Cooperatives act as 'farmer producers' and/or as suppliers of inputs to members

Farmer dealers

Farmers act as dealers, supplying their neighbours; this can evolve into a highly developed system

Commission agents

These work directly with the producer or his/her intermediaries, passing on orders from the farmers

Grain merchants

Traders involved in the seed and grain business who are also licensed seed producers

Crop buyers

Collectors and crop or commodity traders who provide a point of contact with farmers and can be used to market seed

Retail store dealers

Town and village dealers who retail a range of agricultural inputs, with the larger operators possibly having sub-dealers

Industrial processors

Processors interested in specific crops including oilseed crushers and vegetable canners, who may have an interest in supplying seed as part of a growing contract or integrated production system

Cold store operators

Potato cold store operators trade potato seed since they deal directly with the growers and have the appropriate storage

Consumer outlets

Garages, shops and supermarkets (are best suited to display small packets of seed)

Mail order

Suitable for low volume, high value products such as vegetables and flowers.

Although government extension outlets are not strictly retail outlets, seed is sometimes supplied to the farmer through government sponsored agencies and departments which administer crop or regional development and credit programmes.

ORGANIZATIONAL CHART

1. **Product management**

   Concentrates on developing and implementing marketing policy for a seed product or range of products

2. **Advertising, promotion and public relations**

   Aims to create product awareness, influence farmers' buying decisions, (PR) and build up a positive perception of the company

3. **Sales order administration and dispatch**

   Involves receiving and processing orders, allocating stock and dispatching orders, and maintaining stock records

4. **Stock control and quality assurance**

   Involves managing the inventory for each class of seed, crop and variety, to ensure maintenance of germination and vigour

5. **Distribution and transport**

   Entails moving the seeds from the point of production to the point of sale

6. **Sales and invoicing**

   The process of making the actual sale and receiving payment for it, i.e. the end result of the marketing activity

7. Management information

Involves collating and interpreting sales information and other information as a basis for monitoring operations and planning future activities

8. Customer care

Involves after-sales service, dealing with complaints and maintaining customer loyalty

THE PROMOTIONAL ACTIVITIES

Resources invested in variety development and seed production will be wasted if farmers are not persuaded to use the improved varieties. All promotional activities involve sending messages to the distributors and consumers in order to inform them about a company's products and help them to make their decision to buy a particular variety or brand of seed.

- **Advertisements**

  Messages sent via the media to inform and influence the farmer

- **Sales promotions**

  Specific techniques designed to increase sales of particular seeds

- **Personal selling**

  The importance of salesmanship

- **Publicity and public relations**

  Generalized communication which is designed to promote the company's image rather than that of specific seeds

- **Extension**

  Farmers in developing countries have certain characteristics:

  - They have low purchasing power coupled with a low rate of return from farming.
  - They are generally conservative and therefore are slow to adopt new products.
  - They may not be well informed.
  - They often lack mobility and the means to transport goods.

It should also be recognized that educational and literacy standards will not always be high in rural communities. The use of visual material will help to overcome some communication problems. In all forms of communication, companies should always try to make the subject of seeds interesting and relevant to the consumer.

Advertising

The published print media

This includes newspapers, periodicals, magazines, trade and professional journals. There may be both advantages and disadvantages when advertising in this manner.

Some advantages of the printed media are that:

- good coverage can be obtained and, by using the local press and specialist papers, accurate targeting can also be achieved
- it is relatively cheap and immediate
- complex messages can be given in print; these can be read again and again
- reply and cut-out coupons with an exchange value can be used to encourage farmers to request further information and buy the product.

Some disadvantages of the printed media are:

- the text, and therefore the message, may not be well understood due to language and literacy problems
- only limited space may be available
- printed text has limited impact and colour does not always reproduce well in newspapers
- a daily paper has a limited life and the advertisements will have to compete for attention with stories and other information.

As well as placing advertisements, press releases can be given to newspapers or features written that carry the name of the company and its products.

The broadcast media: This includes television, radio and cinema.

Television

Some advantages of television are:

- the impact will be greater as both sound, colour and movement can be used to convey the message

- massive coverage can be achieved and some local targeting may be possible.

Some disadvantages of television are:

- it can be very expensive and is only suitable for simple messages
- the exposure time is short and the advertisement may miss the target audience
- TV reception may be poor and if local targeting is not possible the message will not be relevant to many viewers
- there may not be any related interest programmes that will be viewed by the target audience

- in many countries farmers cannot afford television, although televisions are often available in clubs, bars and other public places.

Radio

Some advantages of radio are:

- good coverage is achieved; this is not confined to the home as people listen to the radio everywhere, including when they are working on the farm
- it is relatively cheap to broadcast on radio compared to television and advertisements are easier to prepare
- the incidence of local broadcasting, in local languages, is greater than with television
- related interest programmes and farming information spots are usually more frequent.

Some disadvantages of radio are:

- reception may be poor in certain areas
- people don't always listen closely and consequently may have poor recall of the message.

Language problems can be overcome through local broadcasting and there is always the possibility of involving local personalities to add interest and relevance to the area. Radio is useful for making announcements, such as the availability of seed in the area. Another form of broadcasting is the loudspeaker van which can be used to tour villages or towns to make similar announcements, particularly on a market day.

Cinema

In rural locations where cinema is the main entertainment a high proportion of the audience will be involved in farming so this medium could be considered for advertising. Advertising slides are not expensive to prepare and these can be shown during the show.

The outdoor media

Outdoor media include posters, signs and advertising on transport, bus shelters, walls and buildings. These forms of advertising can be used to increase the visibility of the company and its products. Outdoor advertising may have considerable and lasting impact at a low cost if it is well situated and if there is not too much competition for the available space. Exclusive arrangements can always be made for the use of space.

In addition to commercial advertising, retailers should be supplied with signs and crop boards. It is important that good sites are chosen which are highly visible and strategically placed to ensure maximum exposure.

Packaging design

Packaging is a form of advertising. Clear printing, the use of colour, brand or company logo and well reproduced photographs or images are all important components of design.

PRICING POLICY

Seed pricing involves setting prices when a new product is launched or a new distribution channel is used. Also, decisions may need to be taken to change the price in response to competition and to the general market situation.

In the public sector prices are often based on an economic pricing policy. Economic pricing considers the effect of seed price on the economy, taking into account the amount officials think farmers can afford to pay and the role of the seed industry in the development of agricultural production. Ideally, however, the public sector should follow a more commercial pricing policy which accounts for all costs and allows for an element of profit.

Some objectives in government seed pricing could be:

- to induce farmers to use certified seed of improved varieties in order to increase national production
- to provide adequate incentives to seed producers to supply seed in sufficient quantity to meet demand
- to encourage the development of private distribution channels
- to implement government agro-economic policies.

Some objectives in private sector seed pricing are likely to be:

- props maximization which will be the long-term target although there may be many other shorter term considerations which will influence pricing policy, such as increasing market share and gaining acceptance of new products
- price competition, may be achieved by setting a price that gives a competitive edge in the market place but may not be lower than that of a rival because other factors, such as service, will be contributing to a company's competitive advantage
- a yield 01? investment which must be at least as good as other uses for investors' funds.

Pricing strategies

Once a company's seed pricing objectives have been established, different pricing strategies must be considered. These include:

Low price strategy

Low price strategies are used where consumers respond very positively to small downward changes in price, but a company may not always gain from setting low prices as more efficient competitors may respond with similar price cuts. If the product is not particularly price sensitive then the net effect of a price reduction can simply mean a reduction in revenue. A company may be tempted to reduce its price where similar or substitute products are also sold or when there is an oversupply. However, seeds can become devalued by selling them cheaply especially where there are real benefits associated with the product. Imported vegetable seeds are often chosen by farmers in preference to locally produced varieties in the belief that they are better because they are more expensive. It is therefore critically important to understand the likely response of the farmer when adopting a low price strategy.

Market price strategy

Where a few large companies dominate supply, products tend to be similar (known in the seed industry as "me-too" varieties) and the role of price tends to be neutral, i.e. a market price is established.

High price strategy

This strategy can be used as a long- or short-term policy. In the case of the long-term policy the company will have identified a market segment for a high quality, value-added product such as graded and treated seed for precision drilling. A high price will reflect the exclusive image or added value of the product. A short-term, high-price policy takes advantage of a new product introduced onto the market, as may be the case with a new high-yielding variety where supply is limited.

Pricing techniques

The important influences on pricing are cost, demand, prices of the product's main competitors and short-term sales targets.

Cost-plus pricing

This method involves calculating the unit cost of a product and adding the appropriate profit margin to give a base price which might then be altered in relation to prevailing market conditions. While this seems a simple approach the fact that such pricing is production oriented and may therefore not reflect what is happening in the market place, makes it risky. A rigid application of cost-plus pricing may lead to price increases when demand is lower and reductions when demand is strong. This is the opposite of what should normally be done.

Contribution pricing

This is a form of cost-plus pricing which involves separating the different products that make up the product portfolio and allocating to them the direct costs associated with their production. The price is determined at a level which will generate revenues in excess of these costs, thereby contributing towards meeting business overheads. Individual products can be analysed in terms of their ability to cover their direct costs and contribute to overheads.

Competitive pricing

Where there is market competition, costs cannot always be the determining factor in pricing. Here the nature and extent of competition will have a major influence on the price. If a product is faced with direct competition from similar products the price will be restrained. In contrast, when a product is faced by indirect competition from products in different sectors of the market there will be more scope to vary the price. This provides the possibility of using different strategies.

Short-term pricing techniques

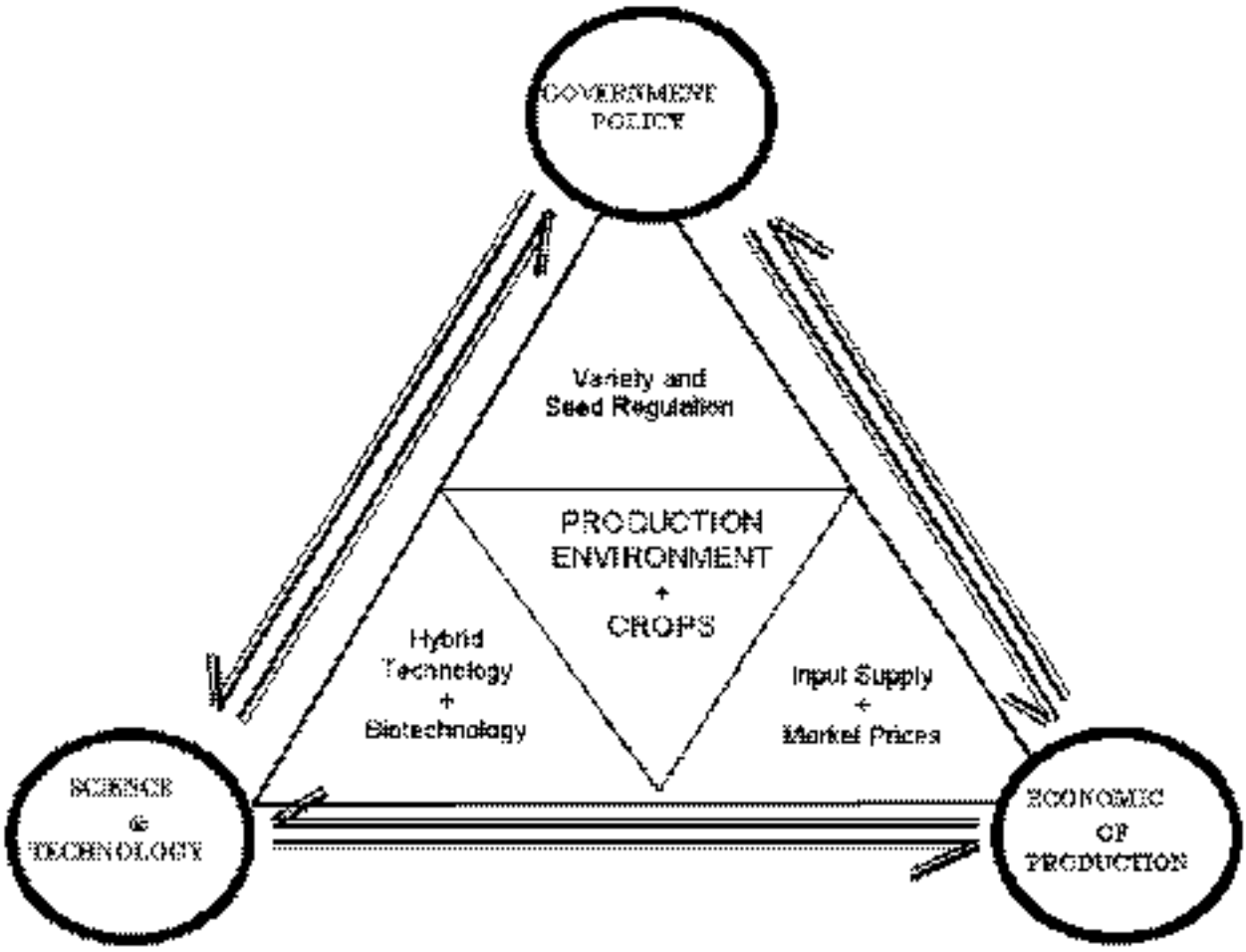
Pricing can be a useful tool for pursuing short-term marketing and sales targets. When a new variety is launched higher prices can be set, providing the opportunity of earning higher returns from those farmers willing to pay the higher prices before seed becomes more widely available. Lower prices may be linked to promotional activities such as boosting sales of established varieties, creating interest in new ones, reducing high stocks and encouraging farmers to buy early.

An overview of factors affecting the seed industry

Three broad influences determine the development and status of the seed industry, namely:

- Technology - especially the flow of new varieties from research;
- Economics - both of seed production itself and of the agricultural sector generally; and
- Policy - creates the commercial and financial environment.

All of these factors can be modified and there are many interactions between them that ultimately determine the size, viability and other characteristics of the seed industry. Figure 1 provides a diagrammatic representation of this analysis, in which various influences on the seed sector are represented within the triangle formed by these three primary elements. Policy has been placed at the top because of the major impact it can have on technology and economics. At the centre lies the production environment, which forms the basis for agriculture, and which cannot be substantially modified, except by irrigation or protected cultivation.



We should recognize seed policy as a major tool for change, but also accept that it cannot alter certain physical and environmental factors and, in a free market, it will always interact with technology and economics. In addition to the policy designed specifically for seeds, wider social and environmental policies may also have an impact on the seed sector and these may be driven by public awareness. For example, the current debate in Europe about the use of genetically-modified crops is not primarily conducted on technical issues about seeds but on wider environmental and food safety concerns. It has nonetheless had a major effect on the seed industry.