

# **PRINCIPLES OF SEED TECHNOLOGY**

Dr. Rudrasen Singh Raikwar  
Assistant Professor  
**College of Agriculture Tikamgarh**

## **Seed and seed technology: introduction, definition and importance**

### **Introduction**

The history of agricultural progress from the early days of man has been the history of seeds of new crops and crop varieties brought under cultivation. In the early days it was achieved through the cultivation of indigenous but useful plants and those taken through introductions. Later through the well known techniques of selection, hybridization, mutation, polyploidization and plant biotechnology the scientists made available many new and better varieties. However, to the farmer all this scientific research would be of little value unless he gets seeds, which are genetically pure, high germination percentage and vigour, high purity, sound health etc., When the farmers do not get seeds possessing these qualities the yields they obtain may not be as expected. The pace of progress in production therefore, will largely depend upon the speed with which we are able to multiply and market good quality seeds of high yielding varieties.

### **Definitions of Seed Technology**

Cowan (1973) identified seed technology as “that discipline of study having to do with seed production, maintenance, quality and preservation”.

Feistritzer (1975) defined seed technology as the methods through which the genetic and physical characteristics of seeds could be improved. It involves such activities as variety development, evaluation and release, seed production, processing, storage and certification.

Thus seed technology is essentially an inter disciplinary science which encompasses broad range of subjects. In its broadest sense,” seed technology includes the development of superior crop plant varieties, their evaluation and release, seed production, seed processing, seed storage, seed testing, seed certification, seed quality control, seed marketing and distribution and research on seed physiology, seed production and seed handling based upon modern botanical and agricultural sciences”.

In a narrow sense “seed technology comprises techniques of seed production, seed processing, seed storage, seed testing and certification, seed marketing and distribution and the related research on these aspects”.

## Concept of seed technology

The distinction between seed and grain is vital, being of seminal importance to agriculture. A seed, strictly speaking, is an “embryo” a living organism embedded in the supporting or the food storage tissue. The seed pertains to material (seed, fruit or vegetatively propagating material) meant for saving for planting purposes, the essential function being the reproduction. The seed when scientifically produced (such as under seed certification) is distinctly superior in terms of seed quality, namely, the improved variety, varietal purity, freedom from admixtures of weeds and other crop seeds, seed health, high germination and vigour, seed treatment and safe moisture content etc. A grain on the other hand, includes cereals and pulses meant for human consumption.

## Differences between scientifically produced seed and the grain (used as seed)

S. No	Seed (Scientifically produced)	Grain (used as seed)
1	It is the result of well planned seed programme	It is the part of commercial produce saved for sowing or planting purposes
2	It is the result of sound scientific knowledge, organized effort, investment on processing, storage and marketing facilities.	No such knowledge or effort is required
3	The pedigree of the seed is ensured. It can be related to the initial breeders seed	Its varietal purity is unknown
4	During production, effort is made to rogue out off-types, diseased plants, objectionable weeds and other crop plants at appropriate stages of crop growth which ensures satisfactory seed purity and health.	No such effort is made. Hence, the purity and health status may be inferior
5	The seed is scientifically processed, treated and packed and labeled with proper lot identity.	The grain used as seed may be manually cleaned. In some cases, prior to sowing it may also be treated. This is not labeled

6	The seed is tested for planting quality namely, germination, purity, admixture of weed seeds and other crop seeds, seed health and seed moisture content.	Routine seed testing is not done
7	The seed quality is usually supervised by an agency not related with production (seed certification agency)	There is no quality control.
8	The seed has to essentially meet the “quality standards”. The quality is therefore well known. The labels, certification tags on the seed containers serves as quality marks.	No such standards apply here. The quality is non-descript and not known.

### **Role of seed technology:**

**Feistritzer (1975) outlined the following roles of improved seed.**

1. Improved seed – a carrier of new technologies The introduction of quality seeds of new varieties wisely combined with other inputs significantly increase yield levels. In India, the cultivation of high yielding varieties have helped to increase food production from 52 million tonnes to nearly 180 million tonnes over a period of 40 years.

2. Improved seed – a basic tool for secured food supply.

The successful implementation of the high yielding varieties programme in India has led to a remarkable increase in production and food imports from other counters have been brought down inspite of rapid increase in population.

3. Improved seed – the principal means to secure crop yields in less favorable areas of production. The supply of good quality seeds of improved varieties suitable to these areas is one of the important contribution to secure higher crop yields.

4. Improved seed – a medium for rapid rehabilitation of agriculture in cases of natural disaster. In case of floods and drought affected areas the Govt. will provide the improved seeds from national seed stocks to rehabilitate the agricultural production of foods grains in the country

### **Goals of Seed Technology:**

The major goal of seed technology is to increase agricultural production through the spread of good quality seeds of high yielding varieties. It aims at the following:

1. **Rapid multiplication:** Increase in agricultural production through quickest possible spread of new varieties developed by the plant breeders. The time taken to make available the desired quantities of seeds of improved varieties to farmers should be considered as a measure of efficiency and adequacy in the development of seed technology in the country
  2. **Timely supply:** The improved seeds of new varieties must be made available well in time, so that the planting schedule of farmer is not disturbed and they are able to use good seed for planting purposes.
  3. **Assured high quality of seeds:** This is necessary to obtain the expected dividends from the use of seeds of improved varieties.
  4. **Reasonable price:**
3. The cost of high quality seed should be within reach of the average farmer.

### **Deterioration causes of crop varieties and their control;**

**Variety:** Is a group of plants having clear distinguished characters which when reproduced either sexually or asexually retains these characters.

The main aim of seed production is to produce genetically pure and good quality seed. But why/how the genetic purity of a variety is lost or deteriorated during seed multiplication. The several factors that are responsible for loss of genetic purity during seed production as listed by Kadam (1942) are:

1. Developmental Variation
2. Mechanical Mixtures
3. Mutations
4. Natural Crossing
5. Genetic drift
6. Minor Genetic Variation
7. Selective influence of Diseases
8. Techniques of the Breeder
9. Breakdown of male sterility
10. Improper / defective seed certification System

1. **Developmental Variation:** When a seed crop is grown in difficult environmental conditions such as different soil and fertility conditions, under saline or alkaline conditions or under different photo-periods or different elevations or different stress conditions for several

consecutive generations the developmental variations may arise as differential growth response. To avoid or minimize such developmental variations the variety should always be grown in adaptable area or in the area for which it has been released. If due to some reasons (for lack of isolation or to avoid soil born diseases) it is grown in nonadaptable areas it should be restricted to one or two seasons and the basic seed i.e. nucleus and breeder seed should be multiplied in adaptable areas.

**2. Mechanical Mixtures:** This is the major source of contamination of the variety during seed production. Mechanical mixtures may take place right from sowing to harvesting and processing in different ways such as;

- a. Contamination through field – self sown seed or volunteer plants
- b. Seed drill – if same seed drill is used for sowing 2 or 3 varieties
- c. Carrying 2 different varieties adjacent to each other.
- d. Growing 2 different varieties adjacent to each other.
- e. Threshing floor
- f. Combine or threshers
- g. Bags or seed bins
- h. During seed processing

To avoid this sort of mechanical contamination it would be necessary to rogue the seed fields at different stages of crop growth and to take utmost during seed production, harvesting, threshing, processing etc.

**3. Mutations:** It is not of much importance as the occurrence of spontaneous mutations is very low i.e.  $10^{-7}$ . If any visible mutations are observed they should be removed by rouging. In case of vegetatively propagated crops periodic increase of true to type stock would eliminate the mutants.

**4. Natural Crossing:** It is an important source of contamination in sexually propagated crops due to introgression of genes from unrelated stocks/genotypes. The extent of contamination depends upon the amount of natural cross-fertilization, which is due to natural crossing with undesirable types, offtypes, and diseased plants. On the other hand natural crossing is main source of contamination in cross-fertilized or often cross-fertilized crops. The extent of genetic contamination in seed fields is due to natural crossing depends on breeding system of the species, isolation distance, varietal mass and pollinating agent. To overcome the problem of natural crossing isolation distance has to be maintained. Increase in isolation distance decreases the extent of contamination. The

extent of contamination depends on the direction of the wind flow, number of insects presents and their activity

5. Genetic drift: When seed is multiplied in large areas only small quantities of seed is taken and preserved for the next years sowing. Because of such sub-sampling all the genotypes will not be represented in the next generation and leads to change in genetic composition. This is called as genetic drift.
6. Minor Genetic variation: It is not of much importance, however some minor genetic changes may occur during production cycles due to difference in environment. Due to these changes the yields may be affected. To avoid such minor genetic variations periodic testing of the varieties must be done from breeder's seed and nucleus seed in self-pollinated crops. Minor genetic variation is a common feature in often cross-pollinated species; therefore care should be taken during maintenance of nucleus and breeder seed.
7. Selective influence of Disease: Proper plant protection measures much be taken against major pests and diseases other wise the plant as well as the seeds get infected.
  - a. In case of foliar diseases the size of the seed gets affected due to poor supply of carbohydrates from infected photosynthetic tissue.
  - b. In case of seed and soil borne diseases like downy mildew and ergot of Jowar, smut of bajra and bunt of wheat, it is dangerous to use seeds for commercial purpose once the crop gets infected.
  - c. New crop varieties may often become susceptible to new races of diseases are out of seed production programmes. Eg. Surekha and Phalguna became susceptible to gall midge biotype 3.
8. Techniques of the Breeder : Instability may occur in a variety due to genetic irregulaeities if it is not properly assessed at the time of release. Premature release of a variety, which has been breed for particular disease, leads to the production of resistant and susceptible plants which may be an important cause of deterioration. When sonalika and kalyansona wheat varieties were released in India for commercial cultivation the genetic variability in both the varieties was still in flowing stage and several secondary selections were made by the breeders.
9. Breakdown of male sterility: Generally in hybrid seed production if there is any breakdown of male sterility in may lead to a mixture of F1 hybrids and selfers.
10. Improper Seed Certification : It is not a factor that deteriorates the crops varieties, but is there is any lacuna in any of the above factors and if it has not been checked it may lead to deterioration of crop varieties.

### **Maintenance of Genetic Purity during seed Production**

**Horne (1953) had suggested the following methods for maintenance of genetic purity;**

1. Use of approved seed in seed multiplication
2. Inspection of seed fields prior to planting

3. Field inspection and approval of the Crop at critical stages for verification of genetic purity, detection of mixtures, weeds and seed borne diseases.
4. Sampling and sealing of cleaned lots
5. Growing of samples with authentic stocks or Grow-out test Various steps suggested by Hartman and Kestar (1968) for maintaining genetic purity are as follows;
  1. Providing isolation to prevent cross fertilization or mechanical mixtures
  2. Rouging of seed fields prior to planting
  3. Periodic testing of varieties for genetic purity
  4. Grow in adapted areas only to avoid genetic shifts in the variety
  5. Certification of seed crops to maintain genetic purity and quality
  6. Adopting generation system

### **Safe guards for maintenance of genetic purity**

The important safe guards for maintaining genetic purity during seed production are;

1. Control of seed source
2. Preceding crop requirement
3. Isolation
4. Rouging of seed fields
5. Seed certification
6. Grow out test

**1. Control of Seed Source :** The seed used should be of appropriate class from the approved source for raising a seed crop. There are four classes of seed from breeder seed, which are given and defined by Association of Official Seed Certification agency (AOSCA).

- a. Nucleus Seed: It is handful of seed maintained by concerned breeder for further multiplication. The nucleus seed will have all the characters that he breeder has placed in it and it is of highest genetic purity. The quantity of nucleus seed is in kilograms.
- b. Breeder Seed : It is produced by the concerned breeder or sponsoring institute or and which is used for producing foundation seed. It is of 100% genetic purity. The label/tag issued for B/s is golden yellow in color. The quality of breeder seed is assured by the monitoring team constituted by the govt.
- c. Foundation Seed: It is produced from breeder seed and maintained with specific genetic identity and purity. It is produced on govt. farms or by private seed producers. The quality of foundation seed is certified by certification agency. It has genetic purity of above 98%. The certification tag or label issued for F/s is white in color.

2. Preceding Crop requirement : This has been fixed to avoid contamination through volunteer plants and also the soil borne diseases.
3. Isolation : Isolation is required to avoid natural crossing with other undesirable types, off types in the fields and mechanical mixtures at the time of sowing, threshing, processing and contamination due to seed borne diseases from nearby fields. Protection

from these sources of contamination is necessary for maintaining genetic purity and good quality of seed.

4. **Rouging of Seed Fields:** The existence of off type plants is another source of genetic contamination. Off type plants differing in their characteristics from that of the seed crop are called as off types. Removal of off types is referred to as rouging. The main sources of off types are
  - a. Segregation of plants for certain characters or mutations
  - b. Volunteer plants from previous crops or
  - c. Accidentally planted seeds of other variety
  - d. Diseased plantsOff type plants should be rouged out from the seed plots before they shed pollen and pollination occurs. To accomplish this regular supervision of trained personnel is required.

**5. Seed Certification:** Genetic purity in seed productions maintained through a system of seed certification. The main objective of seed certification is to make available seeds of good quality to farmers. To achieve this qualified and trained personnel from SCA carry out field inspections at appropriate stages of crop growth. They also make seed inspection by drawing samples from seed lots after processing. The SCA verifies for both field and seed standards and the seed lot must confirm to get approval as certified seed.

**6. Grow-out Test :** varieties that are grown for seed production should be periodically tested for genetic purity by conducting GOT to make sure that they are being maintained in true form. GOT test is compulsory for hybrids produced by manual emasculation and pollination and for testing the purity of parental lines used in hybrid seed production.

## **Seed Quality – Classes of Seed**

**Objective:** Multiplication of quality seed under vigilant supervision of breeder of seed certification agency to distribute quality seed of notified varieties for sowing purpose.

Seed of notified varieties are multiplied in four tier system by the involvement of ICAR Institutes / State Agricultural Universities, State / National Seed Corporation and Seed Certification Agencies.

1. **Nucleus seed:** Nucleus seed: This is cent per cent genetic pure seed with physical purity produced under the direct supervision of the concerned plant breeder.
2. **Breeder's seed:** This is the progeny of the nucleus seed multiplied in large area under the supervision of plant breeder and monitored by a committee. It provides cent per cent physical and genetic pure seed for production of foundation class. Golden yellow coloured certificate is issued for this category by the producing agency.



3. Foundation seed: Progeny of breeder's seed is handled by recognized seed producing agencies in public and private sector under the supervision of Seed Certification Agency in such a way that its quality is maintained according to the prescribed standard. Seed Certification agency issues a white colour certification for foundation class seed. Foundation seed is purchased by Seed Corporation from seed growers. Foundation seed can again be multiplied by Seed Corporation in the events of its shortage with similar seed certification standard.
4. Certified seed: Progeny of foundation seed produced by registered seed growers under the supervision of Seed Certification Agency by maintaining the seed quality as per minimum seed certification standards. Seed Certification Agency issues a blue colour (Shade ISI No. 104, azure blue) certificate.
5. Nucleus seed: is the handful of original seed obtained from selected individual plants of a particular variety for maintenance and purification by the originating breeder. It is further multiplied and maintained under the supervision of qualified plant breeder to provide breeder seed. This forms the basis for all further seed production. It has the highest genetic purity and physical purity.

### **Seed Quality**

Thompson (1979) defined seed quality as a multiple concept comprising several components and their relative importance in different circumstances and laid much emphasis on

1. Analytical purity / physical purity
  2. Species purity / Genetic purity
  3. Freedom from weeds
  4. Germination percentage
  5. Seed vigour and health
  6. Seed Moisture content
  7. Seed size, weight and specific gravity
- Seed quality characters: A good seed should have the following quality characters.

- 1. Improved variety:** It should be superior to the existing variety i.e. the yield should be higher by 20-25% than the existing variety or it should have some desirable attributes like disease resistance, drought resistance, salt tolerance etc., with good yield potential.
- 2. Genetic Purity:** The seed should be true to type. The seed should possess all the genetic qualities / characters, which the breeder has placed in the variety, genetic purity has direct effect on the yields. If there is any deterioration, there would be proportionate decrease in the yield or performance.
- 3. Physical Purity:** Physical purity of a seed lot refers to the physical composition of the seed lots. A seed lot is composed of pure seed, inert matter, broken seeds, undersized

seeds, soil and dust particles weed seeds, OCS etc. Higher the content of pure seed better would be the seed quality. Pure seed together with germination gives the planting value of the seed lot.

- 4. Seed germination and vigour:** Seed germination refers to the ability of a seed when planted under normal sowing conditions to give rise to a normal seedling. Seed vigour refers to the sum total of all seed attributes that give effective plant stand in the field. Higher germination percentage and vigour gives adequate plant population and uniform growth, which have profound effect on, yield and determine the planting value of the seed.
- 5. Freedom from weeds and other crop seeds:** This is an extension of physical purity described earlier. There are certain weed species, which are very harmful to the crop and once established they are difficult to eradicate. An absolute freedom from seed of such species is highly desirable and is one of the important criteria for determining the planning quality of seeds.
- 6. Seed health:** Seed health refers to the presence or absence of disease organisms or insect pests on the seed. The quality of a seed lot depends on its health, hence the seed should be free from seed borne disease and insect pests.
- 7. Seed moisture:** The seed moisture is the most important factor in determining the seed germination and viability during storage. At high seed moisture content there is high incidence of pest attack and at moisture content above 16% seed get heated and the viability is lost. Hence the seed should be stored at safe moisture levels of 11-13%
- 8. Seed size, weight and specific gravity:** Seed size, weight and specific gravity has been found to have positive correlation with seed germination and vigour in many crops. Therefore the seed should be bold with high specific gravity.
- 8. Seed Colour:** The colour of the seed often reflects the condition during seed maturation. The farmers from ancient times have regarded good normal shine as invariable quality guides. The colour and shine deteriorates only when the weather conditions are adverse during maturation or when insects infest the crop or when it is handled badly. The seed lots having high genetic purity, high germination and with a minimum amount of inert matter, weed seeds and other crop seeds and are free from diseases is said to be of high quality and if it is lacking of these it is said to be of low quality.

#### **Maintenance of Nucleus seed and Breeder seed in self and cross pollinated crops**

**Nucleus Seed:** is the handful of original seed obtained from selected individual plants of a particular variety for maintenance and purification by the originating breeder. It is

further multiplied and maintained under the supervision of qualified plant breeder to provide breeder seed. This forms the basis for all further seed production. It has the highest genetic purity and physical purity.

Maintenance of nucleus can be divided into 2 groups

1. Maintenance of newly released varieties
2. Maintenance of established varieties

**Maintenance of nucleus seed of pre-released or newly released varieties:** Harrington 1952 has outlined the procedure for multiplication of nucleus seed which is given below;

1. Sampling of a variety to obtain nucleus seed: In any crop not more than 15 new varieties should be sampled in any research station. Select approximately 200 plants from one of the yield trials. Discard poor diseased and inferior plants. The selected plants should be harvested 4 to 5 days before harvest to avoid shattering. All the 200 plants should be tied individually and wrapped in a cloth bag and stored till the yield results are obtained. The bundles of high yielding varieties are taken for further examination and the inferior varieties are discarded.

2. Table examination of samples: The bundles are threshed separately and the seed should be examined in piles on the purity work board. Piles with undesirable characters (diseased, offtypes etc.) should be discarded. The remaining pure seed of individual plants is sown in a variety purification nursery called as nucleus seed.

3. Location and seeding of nucleus seed: Select clean fertile and in the experimental station in which the same crop was not grown in previous one season. The land should be free from volunteer plants and it should be properly isolated. The 200 or less progenies should be sown in 200 double rows in 4 series of 50 double rows in each plot. Sufficient spacing should be there between and within the rows to facilitate examination of each row during the crop growth.

4. Inspection of nucleus double row plots and removal of offtypes: the double row plots should be critically examined from the seedling stage until maturity. If any plot differ distinctly from that of the nucleus seed variety it should be removed before flowering stage. After flowering and during maturity plots should be examined critically for other characters like flower colour, ear head shape, seed colour etc. and the offtypes should be removed before harvest. When a plant is removed after flowering all the plants or plots within 3 meters should be removed as they may contaminate the surrounding plants.

5. Harvesting and threshing: The remaining plots (between 180-200) should be harvested individually and tied into a bundle. The individual plots are threshed cleaned and dried separately. The seed of each plot should be placed on the purity work board in piles and examined for uniformity of seed characters. If any pile appears to be of off type or diseased it should be discarded. All the remaining plot seed should be mixed together into one lot treated with fungicide and insecticide bagged, labeled and stored as breeder stock seed for next year.

**Maintenance of breeder seed of inbred lines:** for increasing B/s the breeder stock seed obtained from nucleus seed is planted in an isolated field. During increase of B/s adequate attention must be paid to

1. Land requirement
2. Isolation
3. Roughing
4. Field inspection
5. Harvesting and drying
6. Sorting of the ears. Care should be taken on the above points so as to produce breeder seed of maximum genetic purity

## **Seed Certification**

Objectives: Upon completion of this exercise the student should know about

1. The procedure for seed certification
  2. Differentiate between truthfully labeled seed and certified seed
  3. The history of seed certification
  4. Should know the procedure to conduct field inspection in important crops
- Seed certification is a legally sanctioned system for the quality control of seed during seed multiplication and production. As per Indian Seed Act seed certification is voluntary and it is not compulsory. The seed that is sold in the market is of two types certified seed or truthfully labeled seed. The seed, which is being certified by seed certification agency, is called as certified seed. The certification agency is a separate organization meant for certifying the quality of the seed and it has nothing to do with seed production. The seed certification agency maintains certain strict standards before issuing the certification tag or label. Where as truthfully labeled seed is one which is being produced and marketed by the producing company by maintaining the labeling standards. The farmer or the user of the seed does not know the pedigree of the truthfully labeled seed and he has to rely on the seed producing company. Where as the certified seed has to maintain both field and seed standards and if the seed lot meets both the field and seed standards then only the certification tag or label is issued.

### **History of seed certification**

Exactly where and how the concept of seed certification was originated is not clear. But the credit of seed certification goes to Swedish people. In 20th century the newly developed varieties lost their identity due to genetic contamination and mechanical mixtures. To avoid this, Agronomist and breeders started visiting the fields of progressive farmers and educated them to avoid mechanical mixtures and keep the seed genetically pure. This process slowly led to field inspection. The farmers and the scientists thought that field inspection could be useful in maintaining genetic purity of crop varieties. But other problems started like to what extent the mechanical mixtures or genetic contamination should be permitted etc. To overcome these problems representatives from USA and Canada met in Chicago Illinois in 1919 and organised the International Crop Improvement Association (ICIA). The ICIA, which later in 1969 changed its name to Association of Official Seed Certification Agency (AOSCA), laid the beginning of modern day seed certification. Procedure for seed certification: Seed certification is voluntary and that too for the kind and variety notified by the government of India. It can be completed in six broad phases.

1. Receipt and scrutiny of the application.
2. Verification of seed source, class and other requirements.
3. Field inspection should be conducted to see that fields are up to the prescribed field standard.
4. Post harvest inspection, including processing and packing.
5. Seed sampling and testing to confirm that the seeds are up to the prescribed seed standards.
6. Grant of certificate, tagging and sealing.

**1. Receipt and scrutiny of the application:** All those persons who are interested in seed certification should submit an application in Form No 1 to the concerned seed certification officer with the prescribed fees of Rs 25/-. The fee is for one season for a single variety and for an area up to 25 acres (10 ha.) If the area is more than 25 acres or if more than one variety is planted separate applications should be made for each variety. If the area is less than 25 acres under one variety but if the fields are scattered and separated by more than 50 meters separate applications should be made. On receiving the applications the seed certification agency verifies for the following conditions:

1. Eligibility of the variety: Only those varieties that are notified by the central govt. are eligible for certification.

2. Establishing the seed source: The seed producer should submit the tag, invoice, and a copy of Form No2.)
3. There should not be any difficulty in reaching the field for carrying out timely field inspection.
4. Whether the required isolation and land requirement is followed or not.
5. Whether the processing plant facility is available to the applicant.
6. Whether the applicant has paid the requisite registration fee or not. If all the six conditions are fulfilled then the seed producer has to pay the field inspection fees as given below:

#### Various certification Charges

1. Cost of the form No 1 :Rs 2.00
2. Registration fee (per unit) : Rs 25.00
3. Inspection fee (per ha.)
  - a. Self-pollinated Crops :Rs 125.00
  - b. Cross Pollinated Crops :Rs 175.00
  - c. Other than Cotton hybrids/parents :Rs 175.00
  - d. Cotton Hybrids :Rs 800.00
  - e. Vegetable Crops :Rs 150.00
4. Grow Out Test (per sample) : Rs 150.00
5. Seed Testing
  - a. Routine tests :Rs 30.00 per sample
  - b. Health tests :Rs 5.00 per sample
  - c. Revalidation Charges (sample) :Rs 30.00
6. Revalidation fees per quintal and part thereof :Rs 10.00
7. Reprocessing/ Re grading fee :Rs 5.00 (per quintal of part thereof)
8. Cost of Application form for registration / :Rs 5.00 renewal of processing plant

## 9. Processing / Ginning Plants

a. Registration fee :Rs 1000.00

b. Renewal fee :Rs 500.00

10. Repackaging charges per quintal :Rs 10.00

11. Cost of seed certification tags per 1000 nos :Rs 60.00

12. cost of cotton seed tags (with hologram) per 1000 :Rs 80.00

13. Appeal fee per case: Rs. 100.00

2. Verification of seed source, class and other requirements. The seed should be from authentic source and from appropriate class and should be in accordance with Indian Minimum Seed Certification Standards.

3. Inspection of Seed Fields. The certified seed producers should grow and harvest the crop as per the guidelines issued by the seed certification agency. They must carefully and faithfully carry out the roguing and other operations as per the directive of the certification agency. The certification staff conducts field inspections at appropriate stages of crop growth to ensure that minimum standards of isolation, preceding crop requirement, roguing and other special operations are maintained at all times. The inspection of seed crop is done at different stages of crop growth such as at the time of sowing (when new crop is introduced), vegetative stage or preflowering stage, flowering stage, post flowering or preharvest stages and at the time of harvest. The contaminants to be observed during field inspections are offtypes, pollen shedders, shedding tassels, inseparable other crop plants, objectionable weed plants and diseased plants. The field inspections are designated to ensure that the crop is up to the prescribed field standards. All the seed fields, which do not meet the required field standards, are eventually rejected.

### Method of taking field counts

The method of taking field counts involves following steps:

1. Determine the number of field counts. For all crops a minimum of five counts are to be taken for an area up to two hectares, and an additional count is to be taken for each additional two hectares or part thereof as given below.

<b>Area of the field in hectares</b>	<b>Minimum number of counts to be taken</b>
Up to 2	5
2-4	6
4-6	7
6-8	8
8-10	9

In any inspection, if the first set of counts show that the seed crop does not confirm to the prescribed standards for any factor, a second set of counts should be taken for that factor, if the percentage of first set of count for that factor is not more than twice the maximum permissible level. Two sets of counts are called as double counts. In hybrid seed production plots the number of counts must be taken separately for both the parents.

2. Number of plants to be observed for completing one count. The number of plants to be observed for completing a single count varies from crop to crop. The number of plants/heads to be observed for completing a single count is given below.

<b>Crop</b>	<b>Number of plants/heads per count</b>
<b>Wide spaced crops:</b>	
Bhendi, brinjal, Bulb crops, Chillies, Cole crops, Cotton, Cucurbits, Groundnut, Maize, Potato, Redgram, Tomato, root crops, etc.	100 plants
Medium spaced crops: Beans, cowpea, gram, leaf crops, moong, urad, mustard, peas, sesame, sunnhemp, etc.	500 plants
Thickly sown crops: Berseem, jute, lucern, mesta, soybean Bajra, paddy, wheat, sorghum, etc	1000 plants 1000 heads

The required number of field inspections specified in the seed certification standards should be conducted. The purpose of these field inspections is to properly guide and advise the seed producer, but at the same time to do the necessary



inspections so that the ultimate buyer can be assured that the seed crop has met all the necessary standards.

3. Taking of Filed Counts: The procedure for taking filed counts differs for different crops. 4. Rejection of seed fields: All the seed fields, which do not confirm to the required standards for any of the factors should be rejected. The rejection letter should be immediately communicated to the seed grower stating the reasons for the rejection. As far as possible the seed growers should be convinced for rejecting the seed fields by showing the contaminants.

5. Post Harvest Inspection: The personnel from the seed certification agency should inspect the fields during harvesting or post harvesting, so that there are no mechanical mixtures and the seed is not handled badly during threshing or afterwards. Then the seed is sent to seed processing plant with a threshing certificate. The personnel from the seed certification agency will be inspecting the seed processing plant to avoid mechanical mixtures and damage caused to the seed during processing.

6. Seed Sampling and Testing: The representative from seed certification agency draws a representative sample from the seed lot at the time of processing or after processing and sends the sample to official seed testing laboratory for evaluation. In the seed testing laboratory the samples will be evaluated for seed standards such as pure seed, inert matter, other crop seed, weed seeds, germination percentage and moisture percentage etc.

7. Grant of certificate, tagging and sealing. After receiving a satisfactory report from the seed testing laboratory, tagging and sealing of bags will be done under the supervision of seed certification agency. Under special circumstances, advance tags will also be issued to the extent of 75 per cent of the seed lot. Tags and seals should be in accordance with general seed certification requirements. Affixing of tags and seals on the containers completes the process of certification of seeds.

8. Control Plot testing. The seed certification agency should arrange for a postseason grow-out test for all hybrids as prescribed in the standards. Randomly samples should be drawn from certified seed lots and sent to grow-out test to check the efficiency and accuracy of the work done.

9. Validity period. The seed is initially valid for a period of nine months from the date of testing the samples. If the seed is not sold within the stipulated period, it can be revalidated for a period of six months if the seed lot meets the required seed standards. The seed can be revalidated as long as it meets the prescribed seed standards and for each revalidation the validity period will be extended for six months.

10. Revocation of certificate. If the certification agency is satisfied that the certificate granted by it has been obtained by misrepresentation of essential facts, or the holder of the certificate has failed to comply with the conditions subject to which the certificate has been issued, can revoke the certificate. The certificate can be revoked only after giving a show cause notice to the holder of the certificate.

11. Appeal against seed certification agency: If any certified seed grower is not satisfied by the decision taken by the seed certification agency (in rejecting the seed plot), he can make an appeal to the appellate authority specified by the state government. The appeal should be made within 30 days from receiving the rejection letter. The appeal should be made in written along with a copy of the rejection letter and a treasury fee of Rs 100/- (Rupees one hundred only). The application should be submitted personally or it should be sent through registered post. The decision of the appellate authority will be final and it is binding on the seed certification agency and the seed grower. The appellate authority for Andhra Pradesh is Additional Director of Agriculture (inputs).

## **Seed Drying**

Lowering down the seed moisture content to safe moisture limits is very important in order to maintain seed viability and vigor, which may otherwise deteriorate fast due to mold growth and increased micro-organism activity. The advantages of seed drying are it permits early harvest, so that land and manpower can be used efficiently, permit long term storage and maintains the seed quality.

### Methods of seed drying

#### 1. Sundrying

#### 2. Forced air drying

**1. Sundrying:** the moisture of seed is generally reduced in the field before harvest and later by sun drying on the threshing floor. The system involves harvesting of crops when they are fully dried in the field, leaving the harvested produce in the field for a couple of days for sun drying and later spreading the threshed and winnowed produce in thin layer on threshing floors of sun drying. The main advantages of sun drying are No additional expenditure or special equipment is required. The Disadvantages are delayed harvesting, risk of weather damage, and increased possibilities of

mechanical admixtures. If sundrying is done following precautions should be taken.

1. Do not spread the produce on wet, dirty and kaccha, threshing floors.
2. Only one crop variety should be handled at a time and care should be taken to avoid mechanical mixtures.

**Forced Air Drying:** In this system natural air is forced into seeds. The air passing through damp seeds pick up the water. The evaporation cools the air and the seed. The heat necessary for evaporating the water comes from the temperature drop of the air.

### **Principle of Forced Air-Drying**

Seeds are highly hygroscopic living material and their moisture content depends upon temperature and relative humidity of surrounding air. Whenever the vapour pressure in the seed is greater than that of the surrounding air vapour pressure will move out of the seeds i.e. the seeds will loose moisture. If however, the vapour pressure gradient is reversed, the moisture move into the seeds and the seed will gain the moisture. When the two vapour pressures are equal the moisture content of seed is in a state of equilibrium with the surrounding atmosphere. Seed drying takes place when there is a net movement of water from the seed into surrounding air. The rate of seed drying depends on rate of moisture migration from the centre of the seeds to surface and by the speed at which surface moisture is evaporated in the surrounding air. The temperature of the seed, physical structure of the seed, chemical composition of the seed and the seed coat permeability influence the rate of moisture migration from the centre to the surface of the seed. Surface saturation, relative humidity and temperature of drying air influence removal of the moisture from the surface.

### **How Drying Proceeds in the Seeds**

When air is forced through the seed for drying, all the seeds do not dry uniformly at the same time. Actually all the seeds in the drying bin may be considered to be in the three zones a. the dried zone, b. the drying zone and c. the wet zone.

1. The Dried Zone: As the air enters the seeds, the zone nearest to the inlet gets dried first with either natural air or heated air. The seeds will dry below the desired level to some degree. The dried zone will gradually move upwards as drying proceeds.
2. Drying Zone : The air passing through the dried zone picks up moisture in the next region, the drying zone, until it reaches moisture equilibrium or saturation in case of

very wet seeds. How much moisture it can pick up before it reaches equilibrium is determined by the width of the drying zone. The lower edge of the drying zone at the interface with dried zone is called as drying front. 3. Wet Zone: Refers to the region above the drying zone i.e. the seed in-between top of drying zone and the top surface of the seed, which is wet 16-20 % moisture. The top most layer will be wettest and last to dry. The drying front will not always be a parallel plane except when there is parallel airflow from all parts of the perforated floor below the seed. Generally the ducts are very commonly used and hence a covered drying front will be observed surrounding each inlet

The difference in moisture content of the air entering and leaving the seed is known as stratification. The amount of stratification and width of drying zone depends upon the volume of air flowing through the seed and its relative humidity. At high airflow rates or with air of low relative humidity the drying zone may extend the entire bin except at bottom dried zone there will be reduced stratification (ie. Difference between moisture content of upper most and lower most layers). The outlet should be twice the size of the inlet so that backpressure is not exerted.

### **Forced Air Drying**

There are three major drying methods for drying with forced air: 1. Natural air drying – Natural air is used in this type of drying method. 2. Drying with supplemental heat – In this method temperature of the air is raised to about 10 to 20 oF for reducing relative humidity of the air. 3. Heated Air drying – In this method the drying air is heated to 110oF. The first two methods require more than 2 to 3 weeks reducing the moisture content to safe limits. These methods are mostly used in western countries for drying grains

and seeds, which are stored on the farm and these methods, are rarely used in India. Heated air-drying is mostly favored and used for seed drying. In this method the seed is dried in special drying bins or wagons using heated air. After drying the seed is moved into processing assembly or storage bins, if processing is not done immediately.

### **2. Heated Air Drying Systems**

The heated air drying system can be conveniently discussed under following heads:

1. Building requirements: This involves construction of bins/storage structures for drying and air distribution system.
2. Selection of crop dryers and systems of heated air drying
3. Management of seed drying operations.

1. Building Requirements The building for seed drying system depend upon:

1. size of operation

2. Number of different kinds of seeds to be dried
3. Level of mechanization desirable and
4. Future expansion

Different types of structures can be used for storage of seeds to be dried with forced air-drying. The storage structures are made of steel, wood, concrete or plywood and they may be in cylindrical or rectangular in shape.

### **Requirements of storage bin for seed drying**

1. Adequate strength. Seeds of small grains in bulk exert large pressure against the sidewalls. A sound foundation is necessary since, the side pressure of the seed is converted into a vertical load on the foundation
2. Weather tight. The roof and walls must keep out rain and snow, which are important causes for the damage of stored seed. For drying the seeds satisfactorily the walls must be airtight.
3. Easy to fill and empty. The openings for filling and removal of seed should be large enough and so situated that minimum time is lost in filling and unloading the seed. A full size entrance door is desirable.
4. Convenient to inspect, fumigate and clean. For easy inspection there should be 60120 cms. of headspace above the seed. Cleaning and spraying are made comparatively easy if sharp corners are avoided. For fumigation the structure should be airtight, with provisions for temporary sealings of all openings.

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5. Multiple Use. The structure should be usable for drying and storage of more than one kind of crop.
6. Good air distribution system. The air distribution system should be able to carry adequate quantities of air for the drying of seed, and distribute it as uniformly as possible through all portions of the seed bulk.
7. Adequate air venting. Flow of air to the outside, after it leaves the seed should proceed rapidly enough so that back pressure do not hinder flow of drying air into the seed. For this the size of the outlet should be more than twice the cross section area of the main duct of air distribution system.

### **Types of Air distribution systems for seed Drying.**

There are three main types of air distribution systems.

1. Main and lateral duct system
2. Single central perforated duct and
3. Perforated false floor system

**1. Main and lateral duct air distribution system:** In this system the main duct can be located in the centre of the bin, or it can be located at one side of the bin. When the central duct is located outside the bin under the floor it can also serve to empty

the bin. When the main duct is located on the side of the bin it can be located inside the bin or on outer wall of the bin.

**2. Single central perforated duct system:** For this air distribution system there must be equal thickness of seed not exceeding 6 feet, around the duct, which is made of perforated metal. For drying the air should be forced upwards through the seed. The sidewalls of the bin must be perforated so that air can flow laterally through the seed. This type of air distribution system is more commonly used for drying maize cobs.

**3. Perforated false floor air distribution system:** This is most commonly used air distribution system for heated air-drying. In this method the air is introduced under the perforated false floor, the air passes up through the perforations and through the seed. The false floor can be made of hardware cloth, screen or perforated metal sheet. The metal false floors are more durable and convenient to use. It is recommended that this type of flooring must be supported on concrete blocks placed at every 3 to 4 ft. interval. It is followed the floor will support load upto 500 lbs/square ft. The channels and openings for the flow of air must be carefully designed too carry the air stream satisfactorily. When perforated metal

flooring is used the total area of all the openings in the steel sheet should not be less than 8-10 % of the storage floor area. This is important when the drying floor does not extend completely to the sidewalls.

4. Multiple Storage Bins: These are used to dry several types of seeds simultaneously using the same drying fan or fans. In this method sliding air gates are there for controlling the flow of air to the respective bins. Multiple bin arrangements are advantageous when 2 or more kind of seeds are grown.

### **Selection of crop dryers and system of heated air-drying**

Dryers for heated air drying unit consists of a heater unit where the fuel is burned and a fan to force the heated air through a canvas connecting duct into the air distribution system of the drying bin. The drying bin is connected to an automatic thermostat, which controls the temperature at higher limit and cuts off the burner flame if the air temperature exceeds the safe limit. There are two types of dryers according to the manner in which heat is supplied to the air.

1. Direct fired
2. Indirect fired

**1. Direct fired:** In this the fuel is burned and the hot combustion gasses are thrown directly into the air stream which goes into the air distribution system. The fuel used is liquid propane gas, butane gas or natural gas. Advantages of this system are it is

highly heat efficient. The disadvantages are there is possibility of blowing soot entering into the air distribution system. Unburnt fuel and objectionable fumes may enter the seed bin. With some fuels there is also danger of blowing small sparks into the seed, leading to fire hazards.

**2. Indirect Fired:** The hot combustion gasses pass into a chamber. The drying air circulates around this chamber and picks up the heat and enters the air distribution system. The fuel used is kerosine oil or rarely coal. The fan may be driven by either an electric motor or oil engine. The advantages of this system are, there is no possibility of combustion gasses or soot entering the bin and it safe with respect to fire hazards. One of the disadvantage is it is less efficient in use of heat.

### **Types of seed dryers for heated air-drying.**

There are four types of seed dryers

1. Layer in Bin Dryer: In this method the bin is filled to a specific depth depending upon seed moisture, the drying unit and bin sizes. After drying this seed to safe moisture level for storage, next level is added. The diameter of the bin will range from 21 to 40 ft. and requires 5 to 20 HP motors. It is most efficient but slow drying method. The seed is uniformly dried between the top and bottom of the bin.

2. Batch in bin dryer: In this type the high moisture seed is loaded in the drying bin. The seed is dried to safe moisture level, cooled and removed to storage bin. The drying equipment used is similar to that of layer drying but requires high capacity of heater and fan. Seed depths are typically 2.5 to 4.0 ft. the deeper the seed depth lower is airflow and slow is the drying process.

3. Batch Dryer: These are bins with inner air chamber (plenum) surrounded by two parallel perforated steel walls to contain a desired thickness of seed. The fan heater unit is connected to one end or side of the plenum as heated air for drying and natural air for cooling can be forced through the seed. Batch dryers are generally rectangular or cylindrical. Fan power ranges from 3 to 40 HP. The number of batches per day may be 8-10 for small dryers and 2-3 for large units.

4. Continuous Dryers: In this method there is a continuous flow of seed through heating and cooling sections. The flow of the seed can be regulated. Heated air is forced through the upper  $\frac{2}{3}$  or  $\frac{3}{4}$  of the seed column. The dried seed is removed for storage continuously. Recommended temperature and depth for heated air drying of various crop seeds in bins.

### **Procedure for heated air drying in bins**

1. Put the seed into the bin to the recommended depth and there should be uniform distribution of trash and broken seeds.
2. Operate the dryer at recommended temperature for that seed using a thermostat.
3. When drying is completed, continue blowing air through seed without heat to bring the seed temperature down to air temperature or to 50oF if air temperature is

lower. This may require around 30 minutes to 2 hours depending on the quantity being dried and the air temperature. The seed must be dried to safe moisture levels as given below. Wheat, sorghum and rice to 12 % Oats, barley and corn to 13 % Soybeans to 11% **Wagon Drying:** It is a special type of batch drying with heated air. The seed is directly loaded from a combine into a wagon that is specially built for drying. The wagon is drawn to the dryer and connected to the canvass distribution duct. Three to four wagons can be dried at a time. The heated air is forced through the perforations of the wagon floor for drying the seed. After drying is over it is disconnected from the heating system and the seed is cooled with a small fan of half to three and half HP as required. After cooling the wagons are taken to storage bins. Advantages of wagon drying are

1. Drying is continuous
2. It is versatile
3. Low initial cost
4. Saves on seed handling and

5. Can be used for other purpose **Bag Drying:** The drying is carried out in bags when many varieties are to be handled simultaneously or when seed lots are small in size and when the seed is received from the field in jute bags. The drying depth is one sack deep in a typical design of 25-40 cu.m. of air per minute per cu.m. of seed at a static pressure of 3 cm or even less.

**Box Drying:** It is a modified bag drier. The identity of small seed lots can be maintained despite bulk handling. The boxes are made locally with perforated bottoms. Hot air is forced through the bottoms. After drying the boxes are shifted to storage area.

#### **Management of seed drying operations**

1. Dry the seed soon after it is received. If there is any delay aerate the bin by fitting with a fan. Aeration prevents heating of the seed.
2. Care may be taken not to accumulate trash at one place. This problem is more when the seed is discharged through conveyor. Using a spreader can solve it. Small trash has high resistance to air flow.
3. Observe the temperature in different drying zones. When the temperature of the top layer is equal to incoming air, drying of the entire bin is completed. Moisture content should be tested at random through out the bin to ensure that no wet spots are present. If germination percentage falls 1 -2 % during drying check for the following:
  1. Excessive holding time before drying commences
  2. Insufficient air flow
  3. Excessive static pressure
  4. High relative humidity of drying air
  5. Drying air temperature may be more than 43oC



6. Excessive seed depth
7. Uneven air flow through the seeds.

## **Seed Storage**

Seeds are uniquely equipped to survive, as viable regenerative organisms until the time and place are right for the beginning of a new generation. However like other form of life, they cannot retain their viability indefinitely and eventually deteriorate and die. Fortunately neither nature nor agricultural practice ordinarily requires seeds to survive longer than the next growing season, though the seeds of most species are able to survive much longer under the proper conditions.

Depending on the longevity of seeds during storage, seeds can be divided into two categories;

**1. Orthodox Seeds:** Orthodox seeds are long-lived seeds. They can be successfully dried to moisture contents as low as 5% without injury and are able to tolerate freezing temperatures. Most orthodox seeds come from annual temperate species adapted to open fields. At physiological maturity they contain moisture content of 30 – 50%.

**2. Recalcitrant Seeds:** They are short-lived seeds, which cannot be dried to moisture contents below 30% without injury and are unable to tolerate freezing. They are difficult to store successfully because of their high moisture content encourages microbial contamination and results in more rapid seed deterioration. Storage of these seeds at subzero temperatures causes the formation of ice crystals, which

disrupts cell membranes and causes freezing injury. These seeds are from perennial trees in the moist tropics such as coconut, coffee, cacao, citrus etc. These seeds mature and exist in their fruits and are covered with fleshy or juicy ariloid layers and impermeable testa. At physiological maturity they contain more moisture content (50-70%) than orthodox seeds, even though their embryos are only about 15 % of the size of an orthodox seed embryo. In general recalcitrant seeds never go into dormancy but instead continue their development and progress towards germination. Most attempts at storing these seeds have focussed on using endogenous seed inhibitors such as abscisic acid or replacing the high water content with other substances such as sugar or ethylene glycol to permit successful storage even under low temperature without inducing ice-crystal formation and subsequent seed damage.

### **Factors influencing the life span of seeds:**

1. Genetic factors : Seeds of some species are genetically and chemically equipped for longer storability than other under comparable conditions. Most long-lived seeds belong to species possessing hard, impermeable seed coat. Generally seed species possessing high oil content do not store well as those with low oil content. Quantity of oil present in embryo portion of seed is responsible for storability. For eg. Whole seeds contain only about 3 % oil, but their embryo portion has about 27% oil.

Seeds of different species may also be chemically similar but have greatly different storability due to differences in genetic potential. For eg. Chewing fescue and annual

ryegrass seeds are similar in appearance and chemical composition, how ryegrass seeds have much better storability under comparable conditions. These genetic factors affect seed storability and have led to classify the seeds based on their relative storability.

Differences in seed storability may also occur among cultivars. Some cultivars store long than others. Some inbred lines of maize have shown to germinate 90% after 12 years of storage while others were completely dead at the same storage period. Inheritance clearly

**2. Initial seed Quality:** The physical condition and physiological state of seeds greatly influence their life span. Seeds that have been broken, cracked deteriorate more rapidly than undamaged seeds. Several kinds of environmental stresses during seed development and prior to physiological maturity can reduce the longevity of seeds. For example deficiency of minerals (N,K,Ca), water and temperature extremes. Immature small seeds within a seed lot do not store as well as mature and large seeds within a seed lot. Hard seediness also extends seed longevity.

**3. Seed Moisture:** Moisture content of the seed is one of the important factors influencing the viability of seed during storage. Over the moisture range, the rate of

deterioration increases with increase in moisture. In general for every 1% decrease in moisture the store potential of the seed doubles (when the seed moisture is in the range of 4 – 14%). If the seed moisture content is in the range of 12-14 %, losses occur due to increases mould growth and if the moisture content is above 18-20% due to heating of the seed. Moreover within the normal range, biological activity of seeds, insects and moulds further increases as the temperature increases. The higher the moisture content of seeds the more they are adversely affected by both upper and lower ranges of temperature. At very low moisture content of 4 per cent seeds may be damaged due to extreme desiccation, or breakdown of membrane structure hastens deterioration. This probably a consequence of reorientation of hydrophilic cells membranes due to loss of water molecules necessary to retain their configuration. Since the life span of seeds largely depends on the moisture content it is necessary to dry it to safe moisture limits before storage. However the safe moisture content again depends on length of storage, type of storage structure and kind of the seeds to be stored. For cereals in ordinary storage conditions for 12-18 months the seeds should be dried to 10 – 12 % moisture content. However for storage in sealed containers (Hermetic packing) the seeds should be dried to 5 to 8 per cent moisture content.

**4. Relative humidity and Temperature:** the most important factors that influence the life span of seeds are relative humidity and temperature. The effects of R.H. and temperature

of the storage environment are highly interdependent. Most crop seeds loose their viability at R.H. approaching 80% and temperatures of 25-30oC but can be kept for 10 years or longer at R.H. of 50 % or less and a temperature of 5 oC to lower (Toole 1950). According to Harrington, 1973 because of interdependency the sum of the percentage of RH plus temperature in oF should not exceed 100 for safe storage. Harrington suggested the following thumb rules regarding optimum storage conditions.

1. For every 1% reduction in seed moisture the storage life of seed doubles
2. For every 10oF reduction in temperature doubles the life span of the seed .
3. The sum of relative humidity in percentage and temperature in oF should not exceed 100.

The thumb rule applies to only when the seed moisture is in-between 4 and 14 %.

**5. Provenance:** It has already been stated that a number of factors operating before and during harvest can affect seed viability. The samples obtained from different sources may show differences in viability behavior. The seeds harvested from regions of high relative humidity and temperature at the time of maturation or

harvesting store less than the seed harvested from the regions of low relative humidity with moderate temperature.

**6. Pre and post harvest conditions:** Environmental variations during seed development usually has little effect on the viability of seeds, unless the ripening process is interrupted by premature harvesting, weathering of maturing seeds in the field, particularly in conditions of excess moisture or freezing temperature results in a product with inferior storage potential. Mechanical damage inflicted during harvesting can severely reduce the viability of some seeds eg. Certain large seeded legumes. Cereals are largely immune from mechanical injury presumably because of the protective lemma and palea. Small seeds tend to escape the injury during harvest and seeds that are spherical tend to suffer less damage than do elongated or irregularly shaped ones. During storage injured or deeply buried areas may serve as centers for infection and result in accelerated deterioration. Injuries close to vital parts of the embryonic axis or near the point of attachment of cotyledons to the axis usually bring about the most rapid losses of viability. High temperatures during drying or drying too quickly or excessively can dramatically reduce viability.

**7. Oxygen Pressure during storage:** Increase in oxygen pressure during storage tends to decrease the period of viability. Use of antioxidants has increased the storage period in some of the crops. If seeds are not maintained in hermetic storage at low moisture contents or even under conditions of constant temperatures and moisture the gaseous environment may change as a result of respiratory activity of the seeds and associated microflora.

**8. Effect of storage conditions on the activity of organisms associated with seeds in storage:** There are six main types of organisms associated with seeds in storage. They are bacteria, fungi, mites, insects, rodents and birds.

**Bacteria :** Bacteria probably do not play a significant role in seed deterioration. As germination is rarely reduced unless infection has progressed beyond the point of decay. Since bacterial populations require free water to grow, they cannot grow in stored seeds as the seeds are dry.

**Fungi:** Two types of fungi invade the seeds; field fungi and storage fungi. The field fungi invade seeds during their development on plants in the field or following harvesting while the plants are standing in the field. they cannot invade seeds during storage. Field fungi associated with wheat or barley in the field are *Alternaria*, *Fusarium*, and *Helminthosporium* spp. Storage fungi, mostly belong to the genera *Aspergillus* and *penicillium*. They infect seeds only under storage conditions and are never present before, even in seeds of plants left standing in the field after harvesting. Major deleterious effects of storage fungi are to decrease viability, cause discoloration, produce mycotoxins, cause excessive heat and develop mustiness and caking

**Insects and Mites:** Deterioration of seeds by insects and mites is a serious problem, particularly in warm and humid climates. Weevils, flour beetles or borers are rarely active below 8% moisture content and 18-20 °C, but are increasingly destructive as the moisture content rises to 15% and the temperature to 30 – 35°C. Mites do not thrive below 60% RH, although they have temperature tolerance that extends close to freezing. Hence for protecting the seeds from insects and mites the seeds should be stored at a moisture content of less than 10%, at a temperature of less than 20°C and the R.H. of less than 60%.

**Rodents and Birds:** Birds are constant source of seed loss in even small openings exists. All openings should be sealed or screened, if needed for ventilation. Rats and other rodents are more serious problems. Rodents may result into a complete loss of seed. Rodents can be prevented from entering the store by elevating the floor by 90 cm above the ground level, and it should have a lip like structure of 15 cm around the building at 90 cm level. A removable deck should be provided at the entrance for loading and unloading of seeds into the store.

9. **Other factors:** Besides the above factors storage life is affected by number of times and kind of fumigation, effect of seed treatment etc.

### **General principles of seed storage**

1. Seed storage conditions should be dry and cool
2. Effective control of storage pests
3. Proper sanitation in seed stores
4. Before placing seeds into storage they should be dried to safe moisture limits, appropriate for storage system.
5. Store only high quality seed i.e. seeds which are well cleaned, treated, with high germination and vigour.
6. Determine seed storage needs in view of period or length of storage time and prevailing climate of the area during storage period. Long-term storage requires more exacting conditions of seed storage than short-term storage. Similarly, the regions with favourable storage climate, i.e., one where relative humidity is rather low, require less sophistication than areas of high relative humidity.

### **SEED TESTING**

Seed testing is required to assess the seed quality attributes of the seed-lots which have to be offered for sale. These quality attributes are seed moisture content, germination and

vigour, physical and genetic purity, freedom from seed-borne diseases and insect infestation. In India, during seed testing, moisture, germination and physical purity of seeds are generally determined. Standard seed-testing procedures for the evaluation of seeds have been developed by the International Seed Testing Association (ISTA) and the seed scientists from all over the world have played a key -role in these developments. It is obligatory on the part of the seed analysts to follow rules prescribed by the International Seed Testing Association (ISTA, 1985) for seed testing if the seed is moving into the international trade. However, if the sale of the seed is regulated in a country by an Act of Parliament, the testing of seeds for quality-control purposes may be done by the rules prescribed in the country. The science of seed testing, that is, the science of evaluating the planting value of seed has been developed to achieve the following objectives for minimizing the risks of planting low quality seeds:

### **Objectives of Seed Testing**

1. To determine their quality, that is, their suitability for planting
2. To identify seed quality problem and their probable cause
3. To determine the need for drying and processing and specific procedures that should be used.
4. To determine if seed meets established quality standards or labeling specifications.
5. To establish quality and provide a basis for price and consumer discrimination among lots in the market.

### **International Seed Testing Association (ISTA)**

As seed testing developed, it became obvious that cooperation between seed testing stations was imperative for the establishment of common methods of testing that would secure uniformity in evaluation and test results. This need ultimately led to the foundation of the International Seed Testing Association in 1924.

The primary object of ISTA is to develop, adopt and publish standard procedures for sampling and testing seeds, and to promote uniform application of them for the evaluation of seeds moving in the International seed trade. In addition, it also promotes research in all aspects of seed science and technology, including sampling, testing, storing, processing, and distribution, it encourages cultivar certification, participates in conferences and training courses aimed at furthering these objectives and establishes and maintain liaison with other organizations having common or related interests in seeds. The technical and scientific work of the associations is carried out by fifteen special committees (e.g., committee on seed sampling and bulking, purity, germination, vigour, etc). It publishes scientific and technical papers in the Association's journal, Seed Science and Technology. One of the foremost

achievement of ISTA is the adoption of the International Rules for Seed Testing. These rules prescribe testing techniques based upon scientific evidence, which are accurate within stated statistical limits and practicable within the everyday operations. In developing the rules for seed testing (Justice, 1972), the following objectives have served as guidelines.

1. To provide methods by which the quality of seed samples can be determined accurately.
2. To prescribe methods by which seed analysts working in different laboratories in different countries throughout the world can obtain uniform results.
3. To relate the laboratory results, in so far as is possible, to planting value.
4. To complete the tests within the shortest period of time possible, commensurate with the above-mentioned objectives.
5. To perform the tests in the most economical manner.

The ISTA Rules for testing seeds are followed by its member countries, in carrying out seed testing work.

The introduction of the International Seed Analysis Certificate, widely used in the international seed trade, is another important achievement.

#### **Establishment of Seed Testing Laboratory:**

The seed testing laboratory is the hub of seed quality control. Seed testing services are required from time to time to gain information regarding planting value of seed lots. To carry out these responsibilities effectively, it is necessary that seed testing laboratories are established, manned and equipped in a manner such that whatever samples are received could be analysed in the least possible time, so that the seed quality control work and the need of seed industry are effectively met.

Kahre et al., (1975) has listed the following conditions that are essential for ensuring good seed testing work.

1. A highly responsible staff which must continue to work conscientiously when the person in charge is away.
2. Uniformity of equipment, procedures and interpretations. In other words, consistently good facilities and skilled analysts.
3. Good service, that is, prompt analysis and a cooperative spirit among employees.
4. Leaders with a scientific background to give advice to all types of customers and to furnish explanatory remarks in reports, when necessary, to those who submit samples.
5. Promotion to research, leading to improvement of the whole seed programme, especially of testing procedures, with practical questions being submitted for scientific analysis.

#### **Plan for Seed Testing Laboratory and General Principles**

1. The physical-infrastructure and facilities should be planned on the basis of average expected workload during the peak season, so as to permit efficient handling of seed samples without undue delays. The working space should be adequate. This is

important since the time taken in reporting results is of crucial importance. There should be sufficient space left for any special tests section etc. if the need arises.

2. The kinds of tests to be carried out or likely to be carried out, for examples, routine tests, seed health test, varietal purity tests etc. must be ascertained in advance for making provisions in the plan.
3. The selection and number of the equipment should be such so as to permit efficient handling of work. The equipment must meet requisite specifications.
4. The decent furnishing, light arrangement and other necessities should be provided so as to reduce the strain of otherwise strenuous work. Building A seed testing laboratory can be housed as a separate building or it could form part of a larger building housing a Department. The entire work can be organized in a hall/or in separate rooms. The size of the building or space requirement depends upon the number of samples to be handled and the kind of tests to be done. The following space requirements for testing 10,000 samples per year may serve as a guideline. The purity room, in particular, should have abundant natural non-glare light. It should be preferred to locate window in this section along the north side of the building. It would also be desirable that the bottom window panes open in a horizontal manner so that the air coming through the window will be deflected upward and not blow directly across the working table of the seed analyst. Windows should also be screened on the outside to keep out insects and birds.

**Staff :** The number of workers in the seed testing laboratory should be related to the number of samples, crop species to be handled and kind of tests to be performed. The following criterion may serve as a guideline for a laboratory handling 10,000 sampler per year. The need for additional hands is invariably felt during the peak seasons. This need should be met by employing graduate-students on daily wage basis.

**Equipment :** The Rules for testing seeds includes the type of equipment and its specifications. The equipment for a seed testing laboratory, therefore, should be selected accordingly. Only the best available should be purchased. The following list of equipment may serve as a guideline.

#### **List of equipment for seed testing laboratory**

1. Seed Sampling and dividing equipment Seed triers,
2. Boerner divider,
3. Gamet divider and Soil type divider
4. Sample storage boxes and racks
5. Balances – Single pan (top loading), Analytical Balance
6. Purity work boards
7. Germinators – Cabinet germinators and Walk-in-room germinator
8. Refrigerator
9. Hot Air Oven



10. Grinding mill
11. Incubators
12. Autoclave
13. U.V. Lamp
14. Miscellaneous equipment – Seed blower – Seed Scarifier – Moisture meter (electric), Hand sieves, Petridishes

**Seed Testing Procedures for Quality Assessment:** The following may be used as a guideline for managing the work in a seed testing laboratory for efficient handling of seed samples.

**1. Receipt and registration of seed samples:** The samples received in the laboratory should be entered in a pre-printed register or forms and assigned a test number to be used in all the analysis. The information, namely, name of the sender, type of sample, kind of tests required, crop, variety and class of seed etc. should be properly recorded. The samples especially received for moisture test in the moisture-proof containers should be passed on as such to the moisture test section after assigning the test no. For speedy operation it would be desirable to simultaneously prepare separate seed analysis cards and envelopes for working samples. The test no. would invariably be written on each card and the envelop. These are passed on to the person responsible for preparation of the working samples. The entire work should be so organized that this work is completed in same day.

**2. Moisture test:** The samples intended for a moisture test requires special attention, because it may otherwise either lose or may absorb moisture from outside. These samples after assigning the test no. should be passed on for moisture testing analysis without unnecessary delay.

**3. Working sample:** After entering the samples the next step is to prepare the working sample(s) or various tests. To save time taken in completing the seed tests the first objective should be to prepare a working sample for the germination/viability test so as to limit the seed testing time to the minimum time required to complete seed germination / viability test, as the case may be. Subsequently, if the seed cleaning on laboratory model machines or test weight determination, is desired, the same may be done at this time. The working sample envelopes for the various tests alongwith the corresponding analysis card should be serially placed in sample trays for sending to the concerned section.

**4. Routine Tests:** In a seed testing laboratory, germination test, purity test, test for other seeds and moisture test are known as routing test. For all such crops where the analysis for diseased seeds or other variety seeds is also desired on the routine basis (as in the case of certified seed samples for the issuance of seed certification tags) these tests should also be included in the routine tests. Every effort should be made to analyse the samples

speedily so that there are no undue delays in sending the results. These tests must be done as per rules, that is, rules mentioned in the 'Seed Testing Manual'.

**5. Other tests:** Every effort should be made to complete these tests as quickly as possible. These should be carried out as per available procedures. The name of the procedure adopted should, however, be mentioned while reporting the results.

**6. Reporting of results:** After the tests have been completed the results are reported on a printed form, known as, seed analysis certificate in the requisite manner. One of the common complaint against seed testing laboratories is "length of time", that is, the days taken in sending the report. It is therefore important to ensure that there are no undue delays. The result of seed samples received from seed inspectors under the provision of seeds Act should be communicated within 21 days from the date of receipt but not later than 30 days in any case.

**7. Storage of guard samples:** The submitted samples received by the seed testing laboratory, on which reports are issued, should be stored after analysis for one year from the date of issue of reports, in conditions calculated to minimize any change in quality.

**8. Maintenance of records:** To serve the needs of seed certification, farmers and other applicants, it is essential that records are immediately available for any sample tested during the current year, season or at any other specified time. The records should be maintained in such a manner that any information needed can be traced immediately.

### **Varietal Identification through Grow-Out test and Electrophoresis**

The main aim of grow-out test is to determine the genetic purity of the variety of the given sample. In grow-out test plant characters that are less influenced by the environment and which are highly heritable are observed by growing the plants in the field. The variety, which is to be tested for genetic purity, should be grown in the area for which it has been released so that the characters of that variety are fully expressed. Each sample should be sown with proper spacing by adopting the recommended cultural practices so that the differences between the varieties are fully expressed.

**Sampling:** The sample for grow out test are to be drawn simultaneously with the samples for other quality tests and the standard procedure shall be followed.

**The size of the submitted sample shall be as follows:**

1. 1000 g for maize, cotton, groundnut, soybean and species of other genera with seeds of similar size
2. 500 g For sorghum, wheat, paddy and species of other genera with seeds of similar size.
3. 250 g species of other genera with seeds of similar size.
4. 100 g For bajra, jute, and species of all other genera.
5. 250 tubers / cuttings/ roots etc. Seed potato, sweet potato and other vegetatively propagated crops.

**Procedure** Before sowing the seed in the field the seed should be examined on the diaphanoscope to identify the seeds of other variety. The seeds of other variety should be separated and the percentage should be noted. One may also separate the doubtful seed, which may be sown separately for thorough examination. The various samples of the same cultivar are sown in adjacent plots with standard samples at regular intervals. In case of self pollinated crops the characters are fixed and it is easy to identify the plants of other cultivars. In cross pollinated crops where the variability for characters is more it is essential to sow the authentic samples at regular intervals for comparison between the samples to be tested and the standard sample. The sample plots should be regularly observed during the entire growing period of the crop as some of the characters are expressed at seedling stage while the others are expressed at flowering or at maturity stage. The size of plots, row length etc. will differ from crop to crop.

The seed rate may be adjusted depending on the germination percentage of individual samples and the sowing may be done by dibbling. Subsequent thinning is not recommended.

The test crop may be raised along with the control either in the areas recommended for the variety or in off-season nurseries. The authentic control sample from the originating plant breeder/breeding institute is to be maintained by the testing station/Agency following standard procedures. A minimum of two hundred plants from control sample will be raised along with the test crop.

**Observations**

- a. All plants are to be studied keeping in view the distinguishing characters described for the cultivar both in the test crop as well as the control. Necessary corrections may be incorporated if the control is found to be heterogeneous.
- b. Observations are made during full growing period, or for a period specified by originating breeding Institute and deviations from the standard sample of the same variety are recorded. At suitable development stage the plots are examined carefully

and plants which are obviously of other cultivar are counted and recorded. The specifications of the field plot, row length etc. may be determined from the information given in the table. On the basis of the number of plants required for taking observations is depended on maximum permissible offtypes, which are as follows:

Maximum permissible offtypes %	Minimum genetic purity %	Number of plants required per sample for observation.
0.10	99.9	4000
0.2	99.8	2000
0.3	99.7	1350
0.5	99.5	800
1.00 & above	99.0 & below	400

#### Advantages

1. It is the cheapest way to examine reasonable number of plants.
2. It is possible to examine a large number of plots and for each plot it is possible to check large number of plants.
3. The plants are examined during the whole period of growth. Some characters are more prominent at one time of the year than another, and the samples may therefore, be examined several times during the season.

#### Disadvantages:

1. The results are not available until 4 to 12months after the seed was received for testing.

### **ELECTROPHORESIS**

**Objective:** Verification of variety by electrophoretic mobility of protein on polyacrylamide gel.

**Principle:** Proteins and enzymes are the primary products of genes and hence are most suited for genetic purity determination. Changes in coding base sequence result in corresponding replacements in amino acids and thus in the primary structure of protein and enzymes. They possess ionizable groups and can therefore be made to exist in solution as electrically charged particles either as cations (+) or anions (-). Molecules with similar charge and size will have differential migration in solution with porous support medium in an electric field based upon differences

in net electrical charges as molecules with higher charge migrate faster than those with a lower charge. Particle with smaller molecular weight migrates faster than those with higher weight. This separation of molecules based on their size and net electrical charge is known as electrophoresis.

Interpretation of protein banding pattern After staining of the gel, it is placed over a trans illuminator to see the banding pattern.

Relative mobility of each protein (band) is calculated by the following formula.

$$\text{Relative mobility (Rm)} = \frac{\text{Distance traveled by protein}}{\text{Distance traveled by tracking dye}}$$

On the basis of Rm value and thickness of the band a zymogram is drawn on a paper to show the banding pattern.

The varieties are verified on the basis of banding pattern.

1. By measuring Rm of bands
2. Total number of bands
3. Presence or absence of specific band
4. Intensity of band
5. Difference in banding pattern in comparison to authentic zymogram of the variety under test

## **World Trade Organization – Protection of Plant Varieteis and Farmers Rights Act – Intellectual Property Rights – Plant Breeder’s Rights**

The power of knowledge in the society is truly unimaginable. Gone are the days where wealth is associated with tangible properties i.e., for more than a century, the worlds wealthiest man has been associated with oil, starting with John Rockefeller ending with the Sultan of Brunei in the late twentieth century. But today, for the first time in history, the worlds wealthiest person is a knowledge worker Bill Gates . The paradigm shift in the understanding from “Heritage of Mankind” to the “Sovereign Rights of state” in respect of biological resources as a consequence of

## **Convention on Biological Diversity(CBD) triggered several changes in the International arena.**

CBD is an International Treaty concluded under the auspices of the United Nations Conference (3-14 June 1992) on Environment and Development at Rio de Janeiro, Brazil, On 5th June 1992 and Convention was participated and signed by 168 countries .Currently 188 countries has joined Party to the CBD.CBD came into force on 29 December, 1993.CBD was developed on recognition of the intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity and its components. And the importance of Biological Diversity for evolution and for maintaining live supporting systems of the biosphere.

The setting up of International body-the World Trade Organization (WTO) in January 1995 – was to restructure international institutions in the areas of finance, trade and economic stability. The liberalized trade regime under WTO became operational with the Marrakesh Agreement, ratified in 1994 at the conclusion of 8th Uruguay Round of Trade talks which began in 1986. India was one of the 136 member countries and signatories to the Agreement which altered the whole framework of international trade which has existed under the earlier General Agreement on Trade and Tariffs (GATT). Three-fourths of the member countries are developing countries, and together, they account for over 90% of world trade. The issue of Plant variety Protection has been brought into focus under the provisions of Trade Related Aspects of Intellectual Property (TRIPs) Right which is a part of Agreement on Agriculture (AoA) under World Trade Organization (WTO) for which India is signatory and a founding member. Different forms of Protection of New Plant Varieties have been existing in the developed countries through the system of Plant Breeder's Rights (PBRs). In order to co -ordinate inter-country implementation of PBRs "International Union for the Protection of New varieties of Plants" (UPOV) was established by International Convention for Protection of New varieties of Plants, which was signed in

Paris in 1961. The purpose of the convention is to ensure that the member states of the union acknowledge the achievements of breeder of new plant varieties by making available to him exclusive marketing rights, on the basis of a set of uniform and clearly defined principles. As the existing UPOV models of plant variety protection were not suitable for our requirements, the Government of India enacted our own legislation on the Protection of Plant Varieties and Farmers Rights Act (PPV&FR) In 2001 which is a unique model in the world as it provides equal rights to farmers along with breeders. For the purpose of implementation of this act, central Govt. of India established PPV&FR authority

## **Main objectives of the Protection of Plant Varieties and Farmers Rights Act**

1. Registration of plant varieties,
2. Characterization and documentation of registered varieties,
3. Documentation, indexing and cataloguing of farmer's varieties,
4. Providing compulsory cataloguing facility for all plant varieties,
5. Ensuring that seeds of all registered varieties are made available to farmers,
6. Collection of comprehensive statistics on plant varieties,
7. Maintenance of National Register of Plant variety

**Intellectual Property:** Intellectual property is an idea, a design, an invention etc which can ultimately give rise to a useful product / application. For the development of such intellectual property, requires intellectual inputs, innovativeness, considerable monetary and other resources. Therefore, the inventor would like to ensure a fair reward for his invention. But the major problem with intellectual property is that they can be copied, imitated or reproduced, this minimizes the returns to the original inventor. The right on an invention to derive economic benefits for his invention (i.e. intellectual property) is called as intellectual property rights (IPR). The IPR however is recognized by the govt. only so long as it is not detrimental to the society. Protection of Intellectual Property Rights – The protection of IPR may take several forms depending on the type of intellectual property and the type of protection sought. Each form of protection has its own advantages & disadvantages. The main forms of IPR protection are as follows.

1. Trade secrets
2. Patents
3. Plant Breeder Rights (PBR)
4. Copyright

**1. Trade secret:** When the individual / organization owning an intellectual property does not disclose the property to any one and keeps it as a closely guarded secret to promote his business interests, it is called trade secrets. Trade secret may relate to formulae, processes or parented lines in hybrids, in biotechnology trade secret include cell lines, micro organism strains etc.

### **Advantages:**

1. They are for unlimited duration
2. It is not necessary to satisfy the stringent procedures for patents
3. The cost of facing, contesting & enforcing patents is saved
4. The risk of some one improving upon the product etc is reduced

### **Limitations:**

1. Maintaining a trade secret itself is a costly affair
2. It is not protected from independent innovation /

3. Non-disclosure of the invention does not give others as chance to improve upon the original inventions. This prevents or delays the progress in that particular field.
  4. It cannot be applied to many inventions eg. Equipments designs, plant varieties, books etc.
3. **Patents:** A Patent is the right granted by a government to an inventor to exclude others from imitating, manufacturing, using or selling the invention in question for commercial use during the specified period.

**Patent Requirement:** For granting a patent the main requirements are as follows

- 1) Novelty
- 2) Inventiveness
- 3) Industrial application & usefulness
- 4) Patentability
- 5) Disclosure

**Novelty:** The invention must be new and should not be already known to public.

**Inventiveness:** The invention should represent an innovation

**Industrial Application & Usefulness:** The patent must have an industrial application should be useful to the society/nation.

**Patentability:** It must be patentable under the existing law and its current interpretation. The criteria at present varies from country to country and with time within the same country. The Indian Patent Act 1970 does not allow product patents in pharmaceuticals, food and agriculture. The key element is that substances used as food/medicine/drug and the entire class of materials formed by any chemical reaction do not qualify as patentable subject matter i.e. product patents are not allowed in India. As a result, an antibiotic is not patentable in India, while the process of its production is in contrast; both the product & the processes are patentable in Europe & USA.

**Disclosure :** The inventor has to describe his invention in sufficient detail so that a person of normal skill is able to reproduce it. In case of biological entities already known, organisms may be simply named. But if they have been genetically modified, the nature and the method of modification has to be described fully. A patent may be viewed as a contract between the society and the inventor where in the inventor discloses his intention in return for the protection granted to him by the society to control the commercial aspects of his invention to the extent that is not determined to the society. The disclose of an invention gives an opportunity to other inventors to improve upon the various features of the invention, so that it became more efficient & /or more useful. This in-turn, results in scientific and economic progress of the society/nation.

Limits of a patent: A patent is limited both in time and space



- a) Limitation of Time – A patent is valid for a specified period of time from the date of award in most countries this period is 15-20 years. The Indian patent act (1970) grants protects for 7 or 14 years. However, there is a strong argument for larger protection as it aytakeupto 10 years from the time or patent is awarded to the time the product reaches market. B
  - b) Limitation of Space – A patent is valid only in the country of its Award and not in other countries. A group of nations may agree to honour the patents awarded by any member country eg. European Economic community. WTO has a similar provision that a patent awarded by WTO will be valid in all member countries.
4. Copyright: Certain intellectual properties are not patentable. They are protected by copyright eg: Books, Audio, Video cassettes & Computer software. The copyright is limited both in time and extent.

**Plant Breeder Rights: are the rights granted by the Govt. to plant breeder, or owner of a variety to exclude others from producing commercially the propagating material or that variety for a period of 15-20 years.**

To qualify for PBR protection a variety has to be novel, distinct from existing varieties and uniform and stable in its essential characteristics. A person holding PBR title to a variety can authorize other organizations to produce and sell the propagating material of that variety.

**PBR in India** – India had evolve a sui generis system of PBR. Which means a system of their own. The essential features of UPOV - 1978 act are being considered for adoption. Some important features of the Indian sui generis system are

1. Farmers rights
2. Researchers right to use the material for research
3. Protection period of 15 years for annuals and 18 years for fruit trees
4. Compulsory deposit of the material in national gene bank
5. Establishment of National Authority for the protection of Breeders, farmers and researchers use rights.

**Benefits of PBR –**

1. Profits obtained by breeders through PBR will act as an incentive in promoting Plant Breeder research.
2. It encourages private companies to invest in Plant Breeding Research.
3. It will enable access to varieties developed in other countries & protected by IPR laws
4. Increased competitiveness among various organizations engaged in Plant Breeding is likely to benefit both farmers and the nation

### **Disadvantages of PBR –**

1. PBR will encourage monopoly in genetic material for specific use
2. It suppress free exchange of genetic material and encourage unhealthy practices
3. The PBR holder may produce less seed and increase the price for achieving more profit.
4. Farmers privilege to resow the seed produced by him may be gradually diluted
5. PBR may result in increased cost of seed and may be burden for poor farmers.