National Training

on

POST HARVEST HANDLING & MANAGEMENT OF SEEDS

February 12-16, 2024

Training Manual

Organized by:

Government of India

Ministry of Agriculture & Farmers Welfare

Department of Agriculture & Farmers Welfare

National Seed Research and Training Centre

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POST harvest handling & Management of Seeds
(february 12-16, 2024)

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कृषि एवं किसान कल्याण मंत्रालय
कृषि एवं किसान कल्याण विभाग
जी टी रोड कलेक्ट्री फार्म,
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GOVERNMENT OF INDIA
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FOREWORD

Quality seed is a basic and important input to achieve higher productivity in sustainable agricultural production system. It has been estimated that quality seed alone can contribute up to 15-20% increase in total production, which can be further increased with efficient management of other inputs depending upon the seed crops.

In our country, to tackle the challenges being faced in seed sector, quality seed play key role in improving agricultural output and yield through application of latest technologies. The technological advancement in post-harvest management of seed crops is very important aspect of any quality seed production programme. It is must to have skilled/trained man power with sound knowledge of recent advancement in handling of seed crop/produce for a success of Indian seed industry.

In this context, National Seed Research and Training Centre, Varanasi has organized five days National Training on ***"Post Harvest Handling & Management of Seeds" from February 12-16, 2024.*** The main objective of this National training programme is to update the knowledge and skills of the officials engaged in quality seed production, processing, packaging, labeling, management of seed stores and other associated post-harvest operations.

The training manual contains valuable information on various aspects of seed quality management practices especially post-harvest operations including seed handling, processing and storage. I hope that this training manual will be beneficial to all personnel involved in Post Harvest Handling & Management of Seeds.

Date:16.02.2024

Place: Varanasi

(Manoj kumar)

National Training
On
Post Harvest Handling & Management of Seeds
(February 12 – 16, 2024)
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NSRTC at a glance...

National Seed Research and Training Centre (NSRTC), Varanasi established under Govt. of India, Ministry of Agriculture& Farmers Welfare, Department of Agriculture and Farmers Welfare, during October 2005.

The prime objective of establishment NSRTC is to have a separate National Seed Quality Control Laboratory, which is serving as **Central Seed Testing Laboratory (CSTL)** as well as to act as **Referral laboratory** for hon'ble court of the entire country.

Further, this **CSTL** has to coordinate and monitor the functioning of all the **notified State Seed Testing Laboratories** presently available in our country in order to obtain Uniformity in Seed quality Regulation at National level.

More importantly for facilitating International seed Movement, our CSTL the member laboratory of International Seed Testing Association (ISTA), ZURICH, Switzerland and expected to become accreditated Laboratory very soon and thereafter will be eligible for issuing International seed movement certificates on behalf of Government of India.

NSRTC is the National Centre for Training Human resources for the officials who are all involved in the **Seed Quality Control, Seed Law Enforcement and stake holders of Seed Industry.**

In order to fulfill the mandate, NSRTC organize National trainings, workshops, National seed congress for the benefit of personnel involved in seed development and quality control programme and stakeholders of seed industry for updating their knowledge and skills.

The NSRTC is situated under greater periphery of the Holy city Varanasi, which is located 7 KM away from heart of city towards south – west on Varanasi - Allahabad GT road, Collectry farm, surrounded by Banaras Hindu University (6 km), Indian Institute of Vegetable Research (20kms) and well linked by Air, Train and Road.

PRIME OBJECTIVES:

- To have a separate National Seed Quality Control Laboratory, which is serving as **Central Seed Testing Laboratory (CSTL).**
- To act as **Referral laboratory** for hon'ble court for the entire country w.e.f 1.4.2007 onwards.
- Member laboratory of **International Seed Testing Association (ISTA)**, Switzerland,
- Centre for testing all transgenic crop seeds etc., in future
- **To organize National and International seed related conferences, symposium and trainings** for the benefit of personnel who are involved in seed development and quality control programme and stakeholders of seed industry.

- Centre for training human resource on all seed related aspects.

VISION:

Our vision is to

- Contribute integrated approach towards quality seed availability.
- Have separate National Seed Quality Control Laboratory as CSTL.
- Maintain uniformity in seed testing and seed quality control at National level.
- Make Seed Industry in India globally competitive.

MISSION:

Our mission is to lead and engage in downstream programmes on Seed Science and Quality Control to disseminate the values of seed production and availability of quality seed to the need of National and International seed community.

STRATEGY:

NSRTC pursues its Mission and Goals through

- Integrated approach and system –based programs on seed quality control and act as Referral Lab for the hon'ble Court.
- Strengthening Seed Technological Research in seed production disciplines of major crops.
- Total seed quality management through systemic seed certification and law enforcement process.
- Interaction with stake holders of seed industry, officials of seed certification and law enforcement, seed producers and other seed organizations that share's NSRTC mission.
- Continued efforts in improving / updating knowledge and skill of human resources involved in seed certification and quality control as a training human resource on all seed related aspects
- In order to meet out these visions and mission's strategy the NSRTC is housed in a modern building with all latest infrastructural facilities, equipments and machineries, excellent conference/ seminar hall, workshop /class rooms, exclusive ISTA member laboratories, museum, well stocked library.

Staff strength:

The Ministry of Finance sanctioned of 23 posts for National Seed Research and Training Centre, Varanasi for making the centre functional so as to meet out the mandate.

NSRTC is especially designed for continuous dissemination of knowledge of seed and thereby improve skill, competency and scientific soundness of individuals engaged in seed development programme. NSRTC regularly organizes training on various aspects of seed for the officials working in Seed Certification Agencies (25 in number), Seed Testing

Laboratory (147 in number), Seed Law Enforcement Agencies, Agricultural Universities and other institutes dealing with seeds. The NSRTC, Central Seed Testing Laboratory acts as a referral lab under clause 4(1) of the Seeds Act, 1966. CSTL, NSRTC is testing more than 20,000 samples per year and performs at par with ISTA (International Seed Testing Association) with regard to seed testing net work in the country.

National Seed Testing Laboratory as Central Seed Testing Laboratory

The testing of seed material will be flowing from different State Seed Corporations as well as Seed Producing Organizations for physical purity, seed health and at later stage genetic purity that is mostly required in referral cases. At present the mandate of Central Seed Testing Laboratory (CSTL) is to receive 5% samples from seed producing organizations all over the country. In addition, CSTL act as a Nodal centre for coordinating the activities of Seed Quality Control programmes on behalf of Government of India in accordance with the Act and Rules with the State Notified Seed Testing Laboratories.

Grow Out Test

NSRTC have been allotted 10 hectares of land out of which the office premises have been constructed in about 2.5 hectares of land and remaining land have been kept reserve for organizing Grow Out Test for which Green House/Poly House and other necessary facilities have been created.

NSRTC is geared to go Global

NSRTC is a globally competitive Institute in Seed Science and Quality control, marching ahead with:

- To promote the availability of quality seed to meet the challenges of Science based Agriculture.
- Making of promising Technologies reach the seed entrepreneurs and other stakeholders through innovative Trainings, Conferences, Workshops & Symposia.
- Establishing uniformity in Seed production & Quality Control programmes at National level.
- Innovative curriculum planning and implementation to make Seed Science & Research more vibrant and responsible to match the vision and needs of present and future.

Manoj Kumar, IAS
Director, NSRTC

Assessment of Physiological Maturity for Quality Seed in Vegetable Crops and its effect during Post Harvest Management

Rajesh Kumar
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Introduction:

Time of crop harvest is one of the most important strategy that influences yield, quality and storage of crop. Premature or delayed harvest often adversely affects quality of the produce. Pre-mature or immature harvest is desirable for certain products that are preferred juicy and succulent. Produce may become more fibrous and tough or hard if harvested at full maturity, as in the case of pulse crops for vegetable purpose. There are different stages for various crops, which are demarked as maturity stages; and harvesting in those stages gives high income and good quality produce.Maturity is the stage of fully developed tissues of fruit and vegetables only after which it will ripen normally. During maturation, the fruit receives a regular supply of food material from the plant. Upon maturation, the abscission or corky layer formed at the stem end, stops this inflow of food materials. Afterwards, the fruit depend on its own reserves, carbohydrates are dehydrated and sugars accumulate.

- **Horticultural maturity:**
  It is a developmental stage of the fruit on the tree, which will result in a satisfactory product after harvest.
- **Physiological maturity:**
  It refers to the stage in the development of the vegetables when maximum growth and maturation has occurred. It is usually associated with full ripening in the fruits. The physiological mature stage is followed by senescence.
- **Commercial maturity:**
  It is the state of plant organ required by a market. It commonly bears little relation to Physiological maturity and may occur at any stage during development stage.
- **Physiological Maturity:**
  Crop is considered to be physiologically mature when the translocation of photosynthates is stopped to economic part. It refers to a developmental stage after which no further increase in dry matter in the economic part.

Difference between seed and crop production

Seed production	Crop production
Seed plot should be selected carefully for better performance, as per edaphic and environmental requirement	Can be grown in any area
Needs isolation from other varieties	Isolation is not necessary

Needs technical skill for maintenance of quality	Special technical skill is not required
Roguing is compulsorily practiced	Roguing is not practiced
Harvesting should be done at physiological/ harvestable maturity	Harvested at field/commercial maturity
Resultant seed should be vigorous and viable	Question of viability does not arise

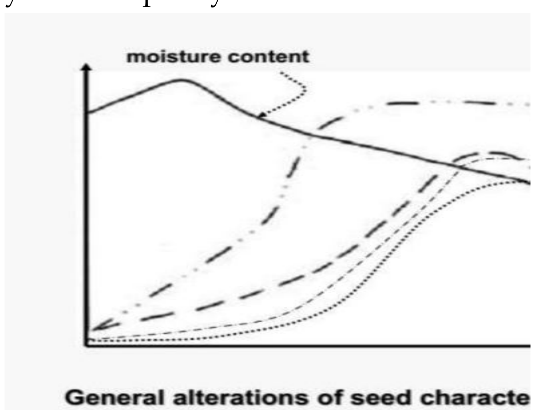
Types of material to be harvested:

The types of vegetable seed material to be harvested can be broadly classified into three groups-

- Dry seeds (e.g. brassicas, legumes and onion).
- Fleshy fruits which are usually dried before seed extraction (e.g. chillies and okra.
- Wet fleshy fruits (e.g. cucumbers, melons and tomatoes)

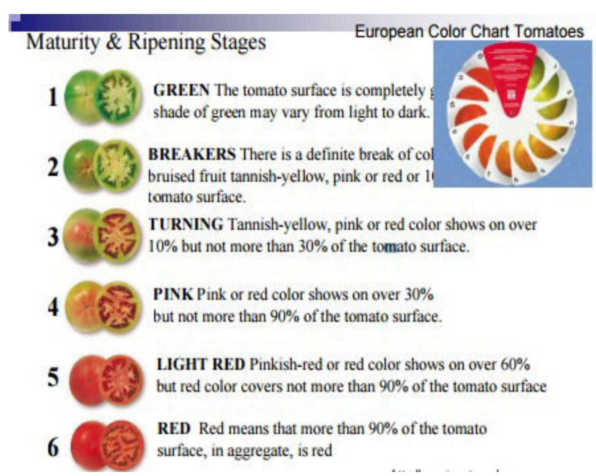
Loss of seeds before and during harvesting:

- Shattering, birds, lodging, vulnerability of seed-laden mother plant from weather conditions or other hazards.
- Lodging, possible effects on seed yield and quality.
- Effect of exact harvest stage.
- Balance between immature seeds yet to ripen against subsequent loss, and reduction in yield and quality to achieve maximum yield of high quality seed.
- Effect of weather on yield and quality.



Tomato:

- Harvesting is done once the fruits are physiologically mature and turns from green colour to orange or red.
- The fruits that should be harvested are those that are ripe just beyond the eating stage.
- Physiological maturity is the stage of development when maximum growth and maturation has occurred in tomatoes.
- There are six maturity stages viz. mature green, breaker, turning, pink, and light red.



Ripening tomatoes **Ripened tomatoes**

Chilli:

Chilli seed crops should be allowed for proper maturity. Later in the season, fertilizer applications should be stopped and irrigation should be reduced. This will stimulate fruit to ripen and partially dry the fruit to a leather like condition. Harvesting only red - ripe chilli is done for seed purposes. Immature, green and diseased fruits should be removed completely. Seeds from immature peppers lack vigour and germinate poorly. Seeds were harvested at different maturation stages from 10 to 90 days after anthesis. Seed quality was assessed according to water content, dry weight, germinability, electrolyte leakage, content of starch, neutral lipids, soluble proteins, total soluble sugars, non-reducing sugars, and total free amino acids.

Physiological maturity was reached at 40 days after anthesis, when seeds displayed maximal dry weight and 60% of water loss; however, harvesting maturity was established 50 days after anthesis, taking into account maximal germinability, minimal electrolyte leakage, reserve deposition, and non-reducing sugar accumulation.

Brinjal:

- ✓ In brinjal, fruits are allowed to mature beyond the edible stage for seed purpose.
- ✓ The physiological maturity of the fruits is identified by change in colour.
- ✓ The mature fruits of different varieties will vary in colour from yellow to dull purple to brown.
- ✓ The matured fruits are harvested by hand picking and hung in sheds until their colour dulls.

Okra:

- The physiological maturity of pods is identified by a change in colour from green to brown and by the drying of the pods.
- Pods should be harvested at the right time, since dried pods tend to dehisce (split open) with very little force.

Cucurbitaceous crops:

- Harvesting fruit for the purpose of seed extraction in cucurbits is normally done when the fruits are ripe, however, it can be performed even before complete maturation, and followed by post-harvest storage
- For cucurbits, the process of seed maturation continues after harvest

- It reaching maximum levels of germination and vigor after undergoing a rest period, which varies among different species

Table: Crop maturity stage for seed purpose

Crop	Maturity symptoms
Cucumber	Dark brown fruits
Bitter gourd	Fully mature fruit of yellow colour
Round melon	Mature fruits
Musk melon	Fruit detachment from dried stem
Watermelon	Dryness of vine, dull sound of fruits, yellowness of fruits touching soil surface
Pumpkin	Colour change – yellowing- drying of fruits
Sponge gourd	Brown dry fruits
Bottle gourd	Colour change –pale green to whitish- drying fruits
Pumpkin	Complete yellowing

Pumpkin:

The physiological maturity can be identified by colour change from green to yellow and drying of the fruit stalks.The matured fruits should be harvested by hand picking and stored for few weeks for further maturation of seeds. Pumpkin fruits can be harvested at 55-65 DAA for obtaining seeds with maximum physiological quality. Pumpkin seeds reach physiological maturity in the period between 55 and 65 DAA, when they have the lowest water content and electrical conductivity practically stable. After harvest, the storage of fruits for a period of 15-20 days is essential to ensure seed quality.

Cowpea:

- The pod length reaches maximum at 12 days after anthesis in both cowpea varieties (bush and pole type) with higher pod weight and hence it is considered as the optimum stage of harvest for vegetable purpose.
- Seed development and maturity takes place in the second phase.
- Seed qualities (germination and vigour) were maximum in pods harvested at 16 days after anthesis in bush cowpea variety "Bhagyalakshmi" and at 18 days after anthesis in pole cowpea variety "Lola" and hence considered as the optimum physiological maturity stage for seed purpose harvesting.

TABLE 2. Seed characteristics of cowpea varieties at different growth stages.

Days after anthesis	Fresh seed weight/pod (g)		Dry seed weight/pod (g)		Germination %		Vigour index	
	Bhagyalakshmi	Lola	Bhagyalakshmi	Lola	Bhagyalakshmi	Lola	Bhagyalakshmi	Lola
2	0	0.00	0	0.00	0	0.00	0	0.00
4	0	0.00	0	0.00	0	0.00	0	0.00
6	0	0.20	0	0.02	0	0.00	0	0.00
8	0.15	0.45	0.01	0.03	25.6	0.00	163.7	0.00
10	2.2	2.77	0.2	0.37	60.1	0.00	419.8	0.00
12	2.9	4.50	0.2	0.77	69.3	44.63	756.7	551.47
14	5.1	5.17	1.5	1.20	80.1	69.30	948.2	848.63
16	3.9	7.42	1.6	2.40	92.6	83.70	1198.9	1510.00
18	3.3	8.33	1.6	2.63	90.2	88.00	1043.2	1552.50
20	2.9	6.58	1.3	2.63	82.1	69.67	947.9	1022.90
CD(0.05)	0.78	1.2	0.1	0.3	7.5	6.3	104.0	89.4

Krishnakumary, 2012. Pattern of fruit and seed development in vegetable cowpea varieties, Legume Research, 35 (1) : 53 – 55.

Onion:

- In a study, seed quality in terms of germination and vigour were maximum at 40 and 45th DAA in ArkaBindu.
- The seed attained physiological maturity between at 45th DAA.
- Seed moisture content of 16.6% was found to be the right stage for harvest.

Table 3. Seed quality as influenced by seed developmental stages in onion cv. Arka Bindu

Treatments	Germination (%)*	First count (%)*	Seedling Root length (cm)	Seedling Shoot length (cm)	Seedling Vigour Index	EC (µs/cm)
15 DAA	0.0 (0.0)	0.0 (0.0)	0	0	0	157.7
20 DAA	1.0 (2.9)	0.0 (0.0)	0	0	0	152.7
25 DAA	7.0 (14.9)	2.5 (8.9)	0	0	0	157.6
30 DAA	10.5 (18.8)	4.0 (11.3)	0	0	0	102.8
35 DAA	45.5 (42.3)	14.5 (22.3)	5.2	6.2	518	134.5
40 DAA	95.0 (76.9)	77.0 (61.2)	6.4	8.9	1456	128.6
45 DAA	96.0 (78.4)	83.0 (65.6)	6.7	8.9	1474	97.3
SEm ±	2.5	1.3	0.3	0.3	50	12.0
CD at 5%	5.25	2.73	0.6	0.6	104	25.8
CD at 1%	7.15	3.72	0.8	0.9	141	35.8

* Figures in the paranthesis are arc sine transformed values.

Lablab bean:

- Pod and seed growth, and seed composition (protein, fat, carbohydrate, ash, total soluble solid, TSS) of two genotypes (DS-52 and DS-106) of Sem (Indian bean) were investigated to assess the stage of physiological maturity, time of harvest of vegetable pod and seed germination at physiological maturity.
- It was found that physiological maturity of seed attained around 40 DAF with standard germination(> 80%) Das and Fakir, 2014.

Peas:

- For table purpose, the high quality of pea is associated with tenderness and high sugar content.

- During maturity sugar content decreases rapidly and there is an increase in starch and other polysaccharides and insoluble nitrogenous components such as protein.
- Harvesting of pea seed crop is done when more than 25% pods are ripe and almost all pods are matured.
- Plants are pulled up for curing for 3-5 days. Delay in harvesting may lead to shattering of pods.

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Seed Sampling: Principles and Procedures

M. P. Yadav
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Seed sampling is the process of obtaining the representative portions of small quantities of the seed from the seed lot. The process itself is a highly technical and it is the pre-requisite of seed testing. The analysis results obtained on the sample tested in the seed testing laboratory may cause the rejection of the seed lot for distribution or further multiplication, certification or may serve as evidence in the Court of Law against the seller of faulty seeds. It is neither physically possible nor practicable to test the entire quantity of the seed lot. Accordingly it is essential that the sample drawn from the seed lot must be representative to avoid problems in seed certification and seed law enforcement. It is customary that the analysis results on the sample tested in the seed testing laboratory should reflect the quality of the whole lot from where the sample was drawn.

Principles of Sampling:

Samples are derived from different portions of a seed lot and mixed to obtain a sample of required quantity representing the seed lot in true sense. From this composite sample, small portion of required quantity is obtained in such a way that even after reduction, it represents the seed lot. In each and every stage thorough mixing and dividing is necessary.

Seed Lot:

A seed lot is a specified quantity of the seed of one cultivar, of known origin and history and controlled under one reference number (lot number). It is an uniformly blended quantity of seed either in bag or in bulk.

Equipment and Materials: Trier, plastic tubs, bags, balance, seed divider, sticker and labels.
Trier: It is required to draw the primary sample from the seed lot stored in bags or containers. Two types of triers are required for sampling *Stick and Nobbe trier.*

Seed divider:

It is equipment used for getting desired quantity of true to the type sample for submission in laboratory for individual test. Three types of divider are used in seed testing Boerner *type divider* (conical divider), *Soil type divider* and *Gamet type divider* (centrifugal divider).

Sampling in processing plant

1) **Primary sample:**

It is a small quantity of seed taken from one point of the processed lot. The seed lot is arranged to approach conveniently up to individual container. Primary samples are drawn from different portions and depth by inserting the stick Trier with the closed slot diagonally in the seed bag or container up to desirable depth with minimum damage to seed. The flow of seed is facilitated in the tube by opening and closing of the slot. Finally, the trier is withdrawn with closed slot and collected sample is transferred to a container.

Stick Trier is inserted into a bag up to a desirable depth at an angle of 30 degree with the hole present at the pointed end facing downwards. The spear is withdrawn gently, so that, equal quantity of seeds enter into the hole from centre to the side of the bag. The point of insertion is closed with the help of a sticker or by running across the trier on the hole a couple of times in opposite direction. Minimum number of primary samples should be taken as per Table 1. and 2. The quantity of seed drawn in one primary sample depends on the sampling intensity, size of submitted sample and seed lot size of crop.

2) **Composite sample:** Primary samples drawn from different places of a lot are mixed and the mixture is known as composite sample. The size of composite sample should be 10 times more than the required submitted sample.

3) **Submitted sample**: The required quantity of seed, which is sent to seed testing laboratory, is known as submitted sample. The weight of the submitted sample varies accordingly to the kind of seed or the kind of test required. (Table 1 and 2). To prepare a submitted sample, the composite sample is mixed thoroughly and reduced up to required quantity with the help of seed divider or by repeated halving method.

Category of seed sample:

Mainly three categories of samples are received in the seed testing laboratory based on their usages. Viz.

a) Service samples
b) Certification samples
c) Enforcement/legal/official samples

Service samples:

These are the samples drawn from the farmer stored stock / dealers by extension workers or by the dealer/farmers themselves to know the quality of the seed for further immediate use. The result obtained on these samples is generally utilized for sowing or labeling purpose. The sample should contain the necessary information for documentation (sample slip). Non notified laboratories can also test these categories of seed samples.

Certification sample:

The samples drawn submitted to the seed testing laboratory by the authorized official from seed certification agency for certification purpose. Such seeds are tested in the seed testing laboratory to know whether they confirmed to the seed certification standard prescribed. Only notified seed testing laboratories are authorized to test the certification samples.

Seed law enforcement sample:

For seed quality regulation at distribution and marketing level these sample are drawn from sale/stock point by the notified seed inspectors in their respective jurisdictions as per the provisions of the section 14 (1) a, b Seeds Act 1966. These samples are also know as quality control samples and are tested only in notified: Seed testing laboratories. These samples are tested by the authorized or notified seed analyst as per the procedure laid down in Seeds Act 1966 and Seed Rules 1968.

Separate sample for determination moisture:

The seeds are hygroscopic in nature and tend to absorb atmospheric moisture when exposed. Therefore when the seed sample is to be taken for moisture content a separate seed sample of 100 gram (for species that require grounding) and 50 gram (for other species) in a polythene bag (700 gauge)/ moisture proof bag is to be apportioned, tightly secured and be submitted along with the submitted sample bag.

Sampling situations:

Seed sample are required to be drawn before or during processing and after bagging or packing operations. Seed may be stored in the form of heaps, in the storage bins/gunny bags / cloth bags, paper packets/pouches or moisture impervious containers such as laminated aluminum foils, sealed tins etc.

General principles of sampling:

1. Sampling should be carried out only by persons trained and experienced in seed sampling.
2. The seed lots shall be so arranged that each individual container or part of the lot is conveniently accessible. Upon request by the sampler, the owner shall provide full information regarding the bulking and mixing of the lot. Sampling may be refused when there is definite evidence of heterogeneity.
3. The size of the seed lot should also not exceed to maximum seed lot size prescribed in the rules, subject to a tolerance of 5%
4. Seed sampler may request the producer to get some bags emptied or partially emptied to facilitate sampling. The bags may then be refilled. This may be necessary since it is impossible to obtain sample deeper than 400 mm, i.e. from the lower layer in bags and bins.
5. The sampler should determine that all seed bags sampled are identified as belonging to a single lot, either by a label or stencil mark on the bag
6. The sampler must sample the minimum requisite number of bags from the seed lot in accordance with the sampling intensity.
7. Care must be exercised in reducing composite samples. Careless splitting of the sample cannot be expected to produce two similar portions.
8. Any seed know to have been treated with a poisonous fungicide should be identified so that the person who subsequently may handle the sample will be informed of the potential hazard.
9. While taking samples from machine sewed cotton bags, a few stitches at one of the top corners can be broken and then this break can be closed with a hand stapling device, after the contents of the bag have been sampled.
10. The sample drawn should not be less than the weight of submitted sample prescribed in the rules.

Table 1: Sampling intensity for a seed lot stored in container

Number of container	Sampling intensity
up to 5	Each container, at least 5 Primary samples
6 - 30	Sample 5 Containers or at least one in every three containers, Whichever is the greater
31 - 400	Sample 10 Containers or at least one in every 5 containers, Whichever is the greater
401 or More containers	Sample 80 Containers or at least one in every 7 containers, Whichever is the greater

Table 2: Sampling intensity for seed stored as bulk

Lot size (Kg)	Sampling intensity
up to 500	At least 5 primary Samples.
501 - 3,000	One primary sample for each 300kg, but not less

	than 5 primary samples.
3,001-20,000	One primary sample for each 500 kg, but not less than 10 primary samples.
20,001 and Above	One primary sample for each 700 kg, but not less than 40 primary samples.

Dispatch of submitted sample:

Sample should be dispatched to the seed testing lab as early as possible providing all the details like date of sampling, number of processing plant, crop, variety, class of seed, lot number, lot size / Quantity of seed in lot (kg) Senders Name and Address etc. and Tests required: 1) Purity (2) Germination (3) Moisture, apart from this sample, two reference samples are also prepared by the same method. One reference sample is stored by the office and second by producer. Office sample of seed lot passed in seed testing is stored for two years.

Sampling in seed testing lab:

The submitted sample received in seed testing lab is registered and designated by a code number. Submitted sample is tested for determination of seeds of other crop, weed, objectionable weeds, objectionable diseases and other distinguishing varieties by number. Three working samples of the submitted sample, which passes the seed certification standard by number are prepared. Each working sample consists of at least 2500 seeds (Table 3).

Preparation of working sample:

Mechanical divider: As described for preparation of submitted sample.

Repeated halving method: As described for preparation of submitted sample or the seed is poured on a clean smooth surface and shaped as a mound after thorough mixing. Mound is divided into two halves, each half is again halved, each portion is again halved giving total 8 portions. Alternate portions are combined i.e. 1st and 3rd of first row and 2nd and 4th of second row. The remaining portion is kept in a pan and the process is repeated to obtain required size of the working sample.

Random cup method: Six to eight small cups of equal size and shape are arranged at random on a tray. The seed is poured uniformly over the tray. The seeds, which fall into the cups, are collected as working sample. This method is useful for the crops with small seed size but not for chaff and round seeds.

Spoon method:

The seeds are poured evenly in one direction over the tray. If required, seed can be poured second time in opposite direction. Shaking of the tray is avoided, small quantity of seeds are collected with the help of spatula from minimum 5 random places to make a working sample of required quantity. The working sample is stored in paper bag marked with code number, name of the crop and purpose.

Table 3: Size of submitted and working samples required for different crops

Crop	**Submitted sample (g)**	***Working sample (g)***
	FIELD AND FODDER CROPS	

Wheat, oat, triticale	1000	0120
Sorghum	0900	0090
Pearl millet	0950	0015
Italian millet	0090	0009
Kodo millet	0080	0008
Linseed, jute, common millet	0150	0015
Fieldpea, maize	1000	0900
Lentil	0600	0060
Chickpea, groundnut	1000	1000
Pigeonpea	1000	0300
Horse gram, moong bean	1000	0400
Grass pea	1000	0450
Castor, soybean	1000	0500
Rice, rajmash, urid bean	1000	0700
Sunflower	1000	0200
Safflower	0950	0090
Cotton	1000	0350
Gueina grass, Setaria grass	0025	0002
Marvel grass	0030	0003
Brassica juncea, taramira	0040	0004
Lucerne, Indian clover	0050	0005
Egyptian clover, finger millet, buffel grass	0060	0006
VEGETABLE CROPS		
Celery	0025	0001
Chinese cabbage, parsley	0040	0004
Carrot, lettuce	0030	0003
Tomato	0015	0007
Turnip	0070	0007
Onion	0080	0008
Brassica olerecea all varieties	0100	0010
Chilli, egg plantl	0150	0015
Cucumber, musk melon	0150	0070
Spinach	0250	0025
Radish	0300	0030
Pumpkin	0350	0180
Coriander	0400	0040
Fenugreek	0450	0045
Sugar beet	0500	0050
Cluster bean, asparagus	1000	0100
Okra	1000	0140
Water melon, sponge gourd	1000	0250
Ridge gourd	1000	0400
Bitter gourd	1000	0450
Bottle gourd	1000	0500
Indian bean	1000	0600
French bean and all squashes	1000	0700

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Seed Extraction Techniques in Vegetable Crops

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Introduction

Raising the crop for good quality seed and method of seed extraction is one of the most important operations to maintain the quality of seeds. Seeds extraction is the separation of seeds from the pulp, gelatinous substance, chaffs, straws, other light materials in pods per fruits. Seeds should be carefully harvested to ensure its high quality. Seeds should possess the qualities of the variety that was planted, as if a long purple eggplant was planted the harvested fruit should possess these qualities.

Seeds should also be harvested at the optimal maturity of the crops. Seeds that are over mature are not recommended since they might have already been infected with pests and diseases. Seeds that are under mature will not produce good seedlings and usually do not germinate. Usually for plants that have greater number of seeds in their fruits, the seeds to be used for planting are collected or extracted from the middle portion of the fruit where the maturity of the seeds is just right and the seeds are the same age. If earliness or lateness of fruiting is not one of your selection criteria it is recommended to get fruits that ripen in the middle of the fruiting season.

Seed extraction methods

Seed separation from fruit is a specialized job. A slight negligence while extracting the seed can considerably damage its viability and vigour besides physical appearance. The in-situ germination can also occur due to improper extraction technique.

The seed can be separated by following method-

(1) Acid Method:

In this method the fully ripened matured fruits are harvested and crushed to pulp. The pulp is taken in plastic container or wooden container or cement tub of convenient size and the commercial HCL added. The acid and pulp are mixed thoroughly and kept for as such time. During this period, corrosiveness of the acid removes the mucilage adhering to the seed and makes the seed free of pulp. Then, the seeds are washed 4-5 times thoroughly with water to make free of acid, otherwise the remnants of the acid spoil the embryo of the seed. The seed extraction is quicker in this method. Seed are also bright in colour with good germinability and free from fungal attack. The different extraction methods found that the seed recovery percentage was higher in acid method irrespective of varieties. Germination was highest in 2.5% HCL with 30 minutes soaking duration. Concentration of HCL was varies from vegetables to vegetables, some examples are given in the following table:

Table: Concentration of HCl for different vegetables for seed extraction

SN	Vegetable crop	Concentration of HCl	Duration
1.	Tomato	25 ml/1 kg of pulp	30 minutes

2.	Brinjal	4 ml/1 kg of pulp 10 ml/1 kg of pulp 30 ml/1 kg of pulp	60 minutes 45 minutes 20 minutes
3.	Water melon	1:6 (Acid: water ratio)	2 hours
4.	Pumpkin	1:6 (Acid: water ratio)	5 minutes
5.	Cucumber	100 cc/1 kg of pulp	30 minutes

(2) Fermentation Method:

The fruits are crushed in a non-metallic container and kept as such for fermentation for 2-3 days. It has been observed that 2 days fermentation of fruits is the best for getting quality seed during normal temperature, the time may decrease at higher and increase at lower temperature regimes. During fermentation the seeds get detached from the adhering pulp and settles to the bottom of the container. The seeds are separated, washed thoroughly and dried under shade to the desired moisture level. The seed recovery is less compared to other method of extraction. The seeds become dull coloured due to fermentation of the pulp and also due to the fungal load in the seeds. In situ germination may occur due to long period of fermentation. These are method used in vegetables like, tomato, brinjal, cucumber, watermelon, muskmelon, etc.

(3) Mechanical Seed Extraction:

This method is mainly used in vegetables like, tomato, brinjal and chilli. In tomato, the known weight of ripened tomato fruits is fed into the pulper machine. The pulp containing the seed is collected separately from the outlet, washed in water and then shade dried. In brinjal, pulpers can also be used for crushing the fruits. Before using pulpers sufficient quantity of water is added and after pulping stirred well. In chilli, dried chilli fruits fed through the feed hopper of seed extractor are subjected to the beating action and thereby the seed are separated and discharge through the outlet. The seed separated from hulls manually. The seed extraction efficiency was is higher.

(4) Alkali Method:

Fully ripened matured fruits are harvested and crushed to make pulp. In tomato, to hasten the fermentation process 0.5% sodium bicarbonate (500 g dissolved in 10 l of warm water) is added to the pulp and allowed to remain for a day. Then, the seeds are separated and washed free of alkali with water.

(5) Citric Acid Method:

In this method for seed extraction using 30 g of citric acid for one litre of pulp with digestion duration of 2 hour removes the gelatinous coating of seed without affecting the germination and vigour of seeds. But this method found to affect the storability of seed and used in only in tomato.

(6) Modified acid Method:
Freshly harvested fruits are pulped using water. The peals and pulp are removed leaving the wet seed with mucilage. Ten kilograms of fruit, yield 1 kg of wet seed. Forty ml of commercial HCL is added to this and allowed to react for 20 minutes with constant stirring. The seeds are then washed and dried. This method saves acid without affecting the seed recovery and seed quality. It's used in tomato, watermelon and muskmelon.
(7) Dry Method:
The fully matured and dried fruits are harvested and dried in the sun for 2-3 days. After extraction of seed, the seed are dried in the sun between 8.00-11.00 Am and 2.00-5.00 Pm to bring out the original moisture content. Example like, Chilli, Okra, Sponge gourd, Ridge gourd, etc.

(8) Directly Harvesting of Matured Pod Method:
The pods are picked at maturity level and dried under sun for 2-3 days to reduce the pod moisture content to 15-16%. Then the pods are beaten with pliable bamboo stick extract the seeds. Excessive drying and heavy beating should be avoided to reduce mechanical injury to the seed. Excessive mechanical injury results in lowering of seed quality. This method mainly used in okra, French bean, Lablab bean, cowpea, cluster bean, etc.

(9) Manually Seed Extraction Method:
In which the fruits are cut into longitudinal bits and seeds are removed manually. Remnants of the pulp are washed and the seed are dried. This method alsogreatly influences seed storability. Example like, water melon, musk melon, pumpkin and bitter gourd.

Seed extraction some of the vegetable crops:

Tomato
Well-matured fruits are crushed and made into pulp. For every 1 kg of pulp 25 - 30 ml of commercial HCl acid should be added, and left for 30 min with constant stirring. At the end of 30 min. the seeds are washed for 3 - 4 times with water and shade dried for one day followed by mild sun drying to reduce the moisture content to 7-8%.

Chilli
Red-ripe fruit is picked, dried under the sun and macerated mechanically to separate the seeds. Early harvest of immature fruits will affect germination. Dried fruits are filled in gunny or cloth bag and threshed with a pliable bamboo stick, or; Chilli seed extractor and seeds are separated from the fruit pulp.

Cauliflower
The harvesting may be done in two lots -generally the early matured plants are harvested first, when the pods turn into brown colour. After harvesting it is piled up for curing for 4 to 5 days and it is turned up-side down and allowed for further curing for 4 to 5 days. Then the pods are threshed with pliable sticks and shifted with hand sifters.

Ash gourd seed extraction
First cut the fruits into two halves by crosswise and length wise. Then remove the seed along with pulp and crush with hand in excess quantity of water. Remove the floating

fraction and collect the seeds settle at the bottom. Seed can also be extracted by acid method. Take the pulp along with seeds and HCl (diluted 6 times with water) at 1:1 ratio and allow it for 30 minutes with stirring. The seeds will settle down, floating fraction is to be removed. Collect the seeds settled at the bottom and wash it with water for 3-4 times.

It is easy to dry the seeds extracted by acid method and also remove the fungal growth over the seed coat, thus seeds possess golden yellow colour and high vigour. The seed extraction by fermentation method may possess poor vigour and off colour due to fungal activity.

Garden Pea Seed Extraction

When almost 90% pods on the plants mature and turn dry, the whole plants are uprooted and collected on the threshing floor. After about a week the seeds are separated out from the pods by threshing and winnowing. Threshing is done by a thresher and extreme care should be taken during threshing to prevent injury to the seed. The ripe and dry pods can also be picked up by hand and threshed on small scale. Usually the moisture content of seeds at this time is higher therefore the drying must be resorted to maintain the specified moisture content of 8% for ordinary pack and 6% for vapour proof pack.

Okra

For okra seed harvesting, the seed pods must dry on the vine and beginning to crack or split. Late maturing fruits contain immature and lighter seeds resulting in less vigorous seedlings and are also associated with seed infections, reducing overall germinability. The position of fruit and size determine the seed filling and conversion of assimilates. The bold seed harvested from middle nodes possess maximum vigour and storability. Good quality seed with satisfactory germination potential could be produced under favourable field and weather conditions if fruit position considerations are taken into cognizance

Curing of Vegetable Seed

The harvested crop is piled up in small heaps for curing either on a tarpaulin or cement floor and covered with a tarpaulin or hay to reduce rapid drying of branches. Curing with branches helps the unripen seed to ripen slowly, improves the colour of seed and also reduced shattering losses in the field. After 4-5 days the heap is turned upside down and allowed to cure for another 4-5 days. Care should be taken if the harvesting is done in wet humid period, the stock should not be kept as such for more than 4-5 days. This method is used in cabbage and cauliflower. Heaps are covered with paddy or wheat straw to protect from direct sunlight. If it rains, the heaps should be provided with tarpaulins. More time for curing may be required in heavy treatment soil as compared to sandy loam.

Drying of Vegetable Seeds

Seeds contain natural moisture, which at harvest time is often higher than the optimum required for the maximum potential life and best germination. The amount of moisture in the seed is probably the most important factor influencing the longevity and germination capacity of the seed. After the seed is detached from the mother plant, its moisture content is a function of relative humidity, and it is at equilibrium with that of the surrounding air. Seeds of fleshy fruits such as, Tomato, Cucumber and Melons, have much higher moisture content at harvest, and may absorb more water during their wet extraction process. On the contrary, seeds formed in fruits, which become desiccated during the ripening process, are relatively dry at the time of harvest, e.g., onion, Amaranthus, Brassicas, etc. Under humid tropical conditions, the freshly harvested vegetable and flower seeds may have a moisture content ranging from 18 to 35%, which must be reduced to a 'safe level', i.e. about 8% in normal packing and 6% for vacuum packing.

Packaging of the seeds

It is very important to choose a right material and a right packaging technique to retain the growing capacity of the seeds. Spending higher costs here is not at all a problem since this is the place which decides profits and loss your company. If the seeds are poorly packed and they get spoiled even before they reach the customers, it is a huge loss. Or say, the seeds reached the customers but haven't germinated due to harmful effects of the material in which they were packed. Your company's reputation will be negative and automatically the next move of the customers will be to choose your competitive seller in the industry. Best material to use for packing is paper. Modulate the paper into any desired way to store your seeds but try not to seal it completely making the seeds inactive.

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Seed Enhancement Techniques: An Overview

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Seed enhancement is a range of treatments of seeds that improve their performance after harvesting and conditioning, but before they are sown. They include pelleting, encrusting, film-coating, priming, hardening, pre germination, tagging and others, but excludes treatments for control of seed borne pathogens (Black & Halmer, 2006).

Objectives:

- To improve germination/seedling growth through manipulation of seed germination / vigour (priming, hardening, pre germination, antioxidants)
- To facilitate seed planting (pelleting, coating)
- To remove weak or dead seeds using 'upgrading' techniques (density, color, sorting, x-ray).
- To deliver materials (other than pesticides) needed at sowing (e.g. nutrients, inoculants)
- Tagging of seeds with visible pigments or other materials / markers for traceability and identity

Priming:

Seed priming is the treatment of seeds in which they are hydrated sufficiently to allow the preparative events for germination to take place but insufficiently hydrated to allow the radicles to emerge followed by drying before actual sowing. The priming of seeds advances and synchronizes germination, resulting in earlier and uniform seedling growth. The optimal priming effect is often obtained at the least negative water potential [ψ] that prevents radicle emergence. The degree of enhancement from priming depends upon following factors:

- Initial quality of the seed.
- Species being treated.
- Treatment conditions such as temperature, water potential (ψ), duration and other conditions specific to the priming medium.

Methods of Priming

1. **Uncontrolled Water Uptake:**
   When water is used, the duration of priming and not the water potential of the solution prevents germination during treatment.

2. **Controlled Water Uptake :**

Osmotic Priming: Seeds are hydrated in liquid solution. A number of osmotica including PEG, Glycerol, Mannitol, KNO_3, KH_2PO_4 and other salt solutions have been successfully used.

Solid Matrix Priming: Seeds, a solid carrier material, and water are incubated together in a sealed container for a prescribed period of time. The mixture is dried and seeds are separated from the media and cleaned. Materials such as vermiculite, synthetic calcium silicate, calcited clay, sphagnum moss, shale and bituminous charcoal have been widely used for SMP.

Drum Priming: Seeds are hydrated to a pre determined water potential over a 24h period by placing them inside a horizontal rotating drum into which water vapour is released. The drum is mounted on an electronic balance connected to a computer to continuously monitor the level of hydration. After treatment the seeds are redried to their original moisture content.

Seed priming virtually arrests the seed germination after phase-II of the triphasic pattern of water uptake. Major metabolic events occur at this time to prepare the seed for radicle emergence. Bringing about all the seeds to a uniform physiological and metabolic state during the phase II enable maximum uniformity among the seedlings. Osmotic potential and duration of the priming contribute to the improved germination performance. Manipulations in metabolic changes during priming play a beneficial role in radicle emergence upon rehydration. The consequences of successful priming treatments show a rapid resumption of growth processes and improved germination.

Drew *et al*. (1997) reported that slow germinating seed lots of carrot, leek and onion primed in PEG, germinated immediately, dried back and stored for 6-12 months, get benefited more due to priming in terms of mean germination rate and time to 50% germination than faster ones. However the storage potential of primed seed is severely limited. Osmo priming with 2% KNO_3 at 20^{O}C for 6 days and hydro-priming (30^{O}C, 18hr) increases germination as well as improved radicle emergence and hypocotyl growth under temperature and osmotic stress in watermelon (Demir *et al*., 1999).

Germination performance is a result of alterations in energy metabolism and various biochemical and molecular processes during priming of seeds. Kang *et al*. (1997) reported that pepper seeds primed with K_3P0_4 showed improved germination rate and reduced days to 50% germination associated with the increased activities of aldolase, isocitrate lyase, isocitrate dehydrogenase and malate dehydrogenase.

Effects of Priming:

- Increased rate of germination.
- Greater germination uniformity.
- Increased germination percentage.
- Wider temperature range for germination.
- Advancement of maturity.
- Weakening of barriers to embryo growth.
- Increased protein synthesis.

How Priming affects Seeds:

- Developmental Advancement.
- Effects on Germination Temperature.
- Metabolic Repair Processes.
- Changes in seed morphology.
- Protein and DNA Synthesis.
- Changes in Seed Water Relations.

Pelleting and Coating:

Pelleting is typically used to round out small or irregular shaped seed, or to make small seeds larger for improving singulation and speed of sowing. Coating (encrusting) applies less material, so the original seed shape (more or less) is still visible. Seed pelleting/coating aims to influence the external physical properties of the seed, affecting the sowing characteristics only. The stress of the coating process should not affect seed quality. By itself an ideal coating would be neutral in its influence on the speed, uniformity and percentage of germination when compared to the original raw seed lot. It would perform in the same manner as the raw seed under a wide range of environmental conditions: light, moisture, temperature, pH, soil type etc.

Method of Coating:

Seed coating relies on technology developed by the pharmaceutical industry to make medicinal pills.

- Seeds in a rotating drum are misted, and blends of powdered materials (e.g. chalk, clays, perlite, lime, peat, talc) are progressively added, along with more water, until desired pellet wt. or size increase is achieved.
- Each misted seed becomes the center of an agglomeration of powder that gradually increases in size. The pills are rounded and smoothed by the tumbling action in the pan.
- Binders are often incorporated near the end of the coating process to harden the outer layer of the pill. Binders can also reduce the amount of dust produced by the finished product in handling, shipping and sowing.
- Tumbling action distributes blending material to give good size distribution and prevents formation of empty (seedless) pellets or seeds sticking together.
- Pelleting increases seed wt by ~2 to 50 times (or more in tobacco seed); compared to an increase of only 0.1 to 2 times for coatings/encrusting, and less than 0.1 times increase for film coating.

Pelleting process can be broadly classified into three parts:

(1) stamping
(2) coating
(3) rolling

Seeds are first mixed with adhesives and then coated with filler material on rolling for uniformity. The major vegetable crop using seed coating / pelleting is lettuce in US. Brassicas, carrot, celery, onion, pepper and tomato are also coated / pelleted to a significant extent, varying with growing season, individual grower preference, the use of direct sowing or transplants, the economics of seed and coating costs etc.

Types of Coats :

Melt Coats:

The melt coats dissolve when wet and gradually wash away from around the seed. The melt coats often require more water to wash the coating material away from the seed, and more time for the oxygen to reach the seed through the saturated coating material. Melt coats may offer advantages when soils are saturated.

Split Coats:

Split coats initially retain their shape when wet and, by capillary action, pass moisture through the pill to be imbibed by the seed. The seed swells and cracks the pill by internal turgor pressure. The split coat often permits germination with less water, as they split, allow uniform, rapid oxygen access to the surface of the seed.

Materials used in pelleting

(i)Adhesives:

Adhesives are gum arabic, methyl ethyl cellulose, gelatin, casein, carboxy methyl cellulose (CMS), methyl ethyl cellulose.

(ii) Coating materials or the filler materials:
Lime, gypsum, dolomite or rock phosphate, charcoal materials commonly used for pelleting. Leaf powder of neem, arappu, pungam etc. are also used.

Advantages:

- Pelleting regulates the size of seeds for precision planting.
- Reduces the amount of seeds required to plant the crop.
- Singling of seeds and prevention of clogging.
- Attraction of moisture.
- Supply or plant growth regulators and micronutrients.
- Saving of chemicals / fertilizers applied to the soil.
- Ensure uniform field establishment.
- Remedy for sowing at problematic soils.
- Protection from birds, animals and insects.

Disadvantages:

- Seed pelleting increases the cost and weight of seeds.
- If proper pelleting techniques / machine is not used, there would be missing of seed during pelleting or some times a pellet may contain more than one seed.
- More moisture is required to germinate since pellet must be dissolved first.
- Delayed field emergence at low moisture level .

Polymer Coating:
A thin polymer film smoothes the surface of the seed for better flow ability. The polymer also influences water uptake and the adherence of chemicals.

Traits of seed coating polymer:

- Water-based polymer
- Low viscosity range
- High concentration of solids
- Adjustable hydrophilic/hydrophobic balance
- Capacity to form a hard film upon drying

Application of seed coating polymer:
Similar to slurry seed treatments including the equipments to be used.

Advantage of film coating:

- Minimal increase in seed weight allows the formulation to be changed several times during spraying and drying process so that the seeds can contain a multilayer film coat
- Absence of "dusting off" problem
- Better seed flow in planting equipment

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SOPs for Seed Drying, Processing, Packaging and Storage for Seed Quality, Up-gradation and Management

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Seed is one of the most important input for sustainable agriculture. Quality of seed affects both yield and credibility in the market. Unlike in grain, extreme care and vigilance is required in seed to avoid mechanical mixing of crop varieties during post harvest stages such as threshing, winnowing, drying, Pre-cleaning, grading, packaging, storage and marketing. Many a time carelessness as well as ignorance at any stage cause colossal loss in seed quality and market value. Hence, in-depth knowledge of post harvest care and improvement in physical purity of seed is most important.

Seeds attains highest level of vigour and viability at the stage of physiological maturity . Moisture content at this stage is very high and unsuitable for successful harvesting and threshing .Thereafter, the seed quality starts deteriorating and there for these operations need to be undertaken at the earliest opportunity to check the rate of deterioration .

In order to maintain the quality of seeds, following post-harvest operations should be undertaken carefully at the appropriate stages with due care;

- ✓ drying, threshing and conditioning
- ✓ Cleaning and grading
- ✓ Separating and upgrading
- ✓ Treatment, Packing, labeling and sealing
- ✓ Storage
- ✓ Transport and distribution

Seed Drying: Principles & Procedures

The most important factor influencing seed viability during storage is the moisture content and the rate of deterioration increases, as the seed moisture content increases. The drier the seed the higher will be the storage life. It is well known that higher moisture content enhances the biological activity in the seeds and causes excessive heating, besides promoting mould and insect activities. The relationship of moisture content of seeds during post harvest stages furnished below would clearly indicate the role of moisture in the life of seeds in storage.

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

Seeds are living hygroscopic materials. Its moisture content depends upon the relative humidity and temperature of the surrounding air. The determining factor in this relationship is the water vapour pressure which exists in the seed and the air surrounding it. Whenever the vapour pressure within the seed is greater than the surrounding air, vapour will move out of the seed. If the vapour pressure gradient is reversed, the movement of moisture is also reversed into the seed. When the two vapour pressures are equal, there is no net movement of vapour; at that point the moisture content of the seed is in the state of equilibrium with the surrounding atmosphere.

Drying takes place when there is net movement of water out of the seed into the atmosphere. The rate at of which seed will dry is determined by how fast moisture migrates from centre to the surface of the seed and by the speed at which the surface moisture is evaporated in the surrounding air. The rate of moisture migration from the centre to the surface of a seed is influenced by seed temperature, physical structure, chemical composition of seed and seed coat permeability.

The rate of moisture removal from the surface of the seed is influenced by the degree of surface saturation, relative humidity and temperature of drying air. It has been well established that drying air temperature higher than 43°C are detrimental to the seed quality.

Why Seed Drying?

At physiological maturity the seed reaches maximum germination capacity and vigour. However at this stage of maturity seed has high moisture content. Therefore, for obtaining good quality seed, it should be harvested soon after attaining physiological maturity and dried to a safe moisture level. Harvesting seed at higher moisture contents (particularly Kharif season crop) poses immediate and serious problem because seed will heat and deteriorate very rapidly. Seed moisture content during storage is the most important factor influencing seed deterioration; mould growth can begin at 13-14 per cent, heating due to increased rate of respiration, micro-organism activity begins at 16 per cent and seed will begin to germinate at 30-35 per cent moisture content. The enormous influence of seed moisture content on longevity makes artificial drying mandatory in the production of high quality seed.

Seed Drying

- ✓ Seed drying is the most important part of seed business.
- ✓ Whether it be farmer retained seed or high value hybrid seeds from a commercial seed company, dry storage of seed is acknowledged as vital to ensure high germination value.
- ✓ With the difficult, hot and humid climatic conditions, it is very important to store seeds at the proper seed moisture content.
- ✓ It is accepted that SMC, above all other controllable variables in seed storage, has the highest impact on successful seed germination and the resulting impacts on profitability.
- ✓ In lack of proper seed drying and storage systems, seeds can rapidly lose viability, resulting in poor crop establishment, lack of uniformity, reduced yields and poor marketability.
- ✓ Seed drying is the process of lowering the moisture content of the seed in order to improve the vigour and viability of the seed and thereby increasing the storage life.

- ✓ It helps to keep the seeds free from pest and disease incidence.
- ✓ Drying should be done at a lower temperature. During drying, first the moisture from the seed surface will be evaporated and the moisture from inner layers of the seed is transferred to the surface for further drying.

Drying refers to the removal of relatively small amount of moisture from solid or material nearly solid material by evaporation and diffusion. The seed drying process is divided into:

1. **Thin layer drying:** It refers to seed drying process in which all seeds are fully exposed to the drying air under constant drying conditions i.e. constant temperature and humidity. Generally, up to 20 cm thickness of bed is taken as thin layer drying. All commercial flow dryers are designed on thin layer drying principle.

2. **Deep bed drying:** In this process, all the seeds in the dryer are not fully exposed to same condition of drying air. The condition of drying air at any point in the seed mass changes with time and at any time, it also changes with the depth of grain bed. The depth of bed in this drying process is more than 20cm. All on farm static bed batch dryer are designed on deep bed drying principle.

Drying seed is similar to the grain drying and grain drying equipment and methods can be used with seed. The type of dryer that is most suited for a particular situation depends upon the volume seed to be dried in a season, the length of drying, the number of varieties to be handled, the size of seed lots and the handling and transportation method to be used.

Seeds may be dried by various methods that includes-sun drying, natural air drying, hot air drying, dehumidified air drying, drying in storage and the use of desiccants in sealed container.

Sun drying can be used to dry the seeds as long as RH of the air is lower than the RH in equilibrium with the moisture content of the seed. For example, seed of 14% moisture is in equilibrium with 70% R. H., Therefore,

- If the RH of the air is 45%, 14% moisture content grain seed will dry further.
- If RH of air is 70%, 14% moisture grain remain at 14%
- If the RH of the air is 85%, 14% moisture grain seed will increase in moisture.

Sun drying can damage the seed if the temperature of the seed rises above 110°F (43°C) for seeds and 90°F (32° C) for vegetable seed particularly when they are high in moisture content. Thus, sun drying should not be attempted when either the RH or the temperature is too high. Natural air drying can be used in areas where the climate is dry and temperature is less than 43°C when drying cereals and 32°C for vegetable seeds.

Hot air drying can be used when the weather is cool because heating air reduces its RH. For example seed lot with 14% moisture content will not sundry, if RH

Mechanical Seed Dryers

is 85% on a day when temperature is 70°F (21° C) but will dry rapidly if the air is heated to 100°F (37.8° C) and blown through the seed because this also reduces the RH of the air to 33% which would be in equilibrium with a grain seed moisture content of about 9%. However, hot air drying is not possible for vegetable seed when the temperature of the day is 90°F(32° C) or above and RH is above the equilibrium moisture content of the seed to be dried.

If hot air drying cannot be used and the seed is too moist to store, dehumidified drying can be done. Here, a closed drying system dryer is used passing the air through the seed to pick up moisture from the seed then through the dehumidifier to remove the moisture from the air. The dried air is blown back through the seed for further drying. The air act as a carrier of moisture from the seed to the dehumidifier until the seed moisture is reduced to the level desired.

Drying in storage with unheated air is a slow process and should only be done when the moisture content is of the seed is lower than 13% moisture content. Drying in storage require ventilating fan and an understanding of when to ventilate.

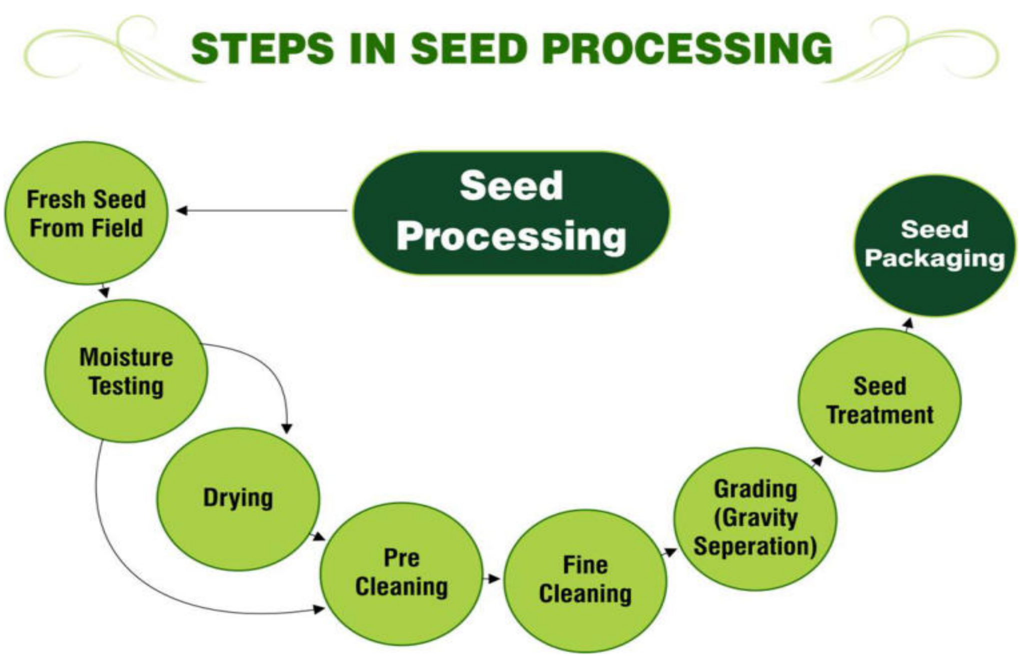
The use of desiccant (Silica gel) in a sealed container to dry seed can also be used. This too is slow way of drying and should not be used to dry seed unless it is already below 13%.

Seed Processing:

The objective of seed processing is to achieve clean, pure seeds of high physiological quality (germinability) which can be stored and easily handled during succeeding processes, such as pretreatment, transport and sowing. Processing includes a number of handling procedures, where applicability differs e.g. according to seed type, condition of the seeds after harvest and potential storage period. Seed cleaning typically consists of a series of processes during which impurities are gradually removed and the seed lot concurrently achieves a progressively higher purity (Fig-1). The type, order, and adjustment of the processes depend on seed type and type of impurities. During seed processing, contaminants are removed to a level that meets the industry wide minimum seed certification standards, failing which, they may be discarded or blended with a relatively better lot of the same variety. Contaminants are removed by procedures utilizing machines which exploit the differences in physical characteristics of the desirable seed and other components in the mixture. These physical properties include but are not limited to length, width, thickness, shape, density, terminal velocity, drag coefficient, reflectivity, surface texture, electrical conductivity and resilience. Seed separators are designed to utilize the difference in a single physical property or a combination of physical properties of the seed.

Concept of Separation Processes

Separation and purification of materials forms an important process in post harvest handling of agricultural products. Naturally occurring processes are inherently mixing processes and have led to the reverse procedure of separation processes which are becoming the most challenging categories of engineering problems. Mechanical separations are applicable to heterogeneous mixtures. Broadly, a separation processes a mixture of substances in two or more products which differ from one another in composition. The separation is caused by the addition of a separating agent which may be in the form of energy. Need for separation accounts for the most of the production cost of a pure substance. Often separation itself can be the key function of the entire process e.g. grain cleaning. To a large extent man's ability to ease food shortage depends upon his technical knowledge and capacity to extract and separate essential food materials from the new or inexpensive sources. From the above considerations, it is apparent that much careful thought and effort must go into understanding and improvement of various separation processes.



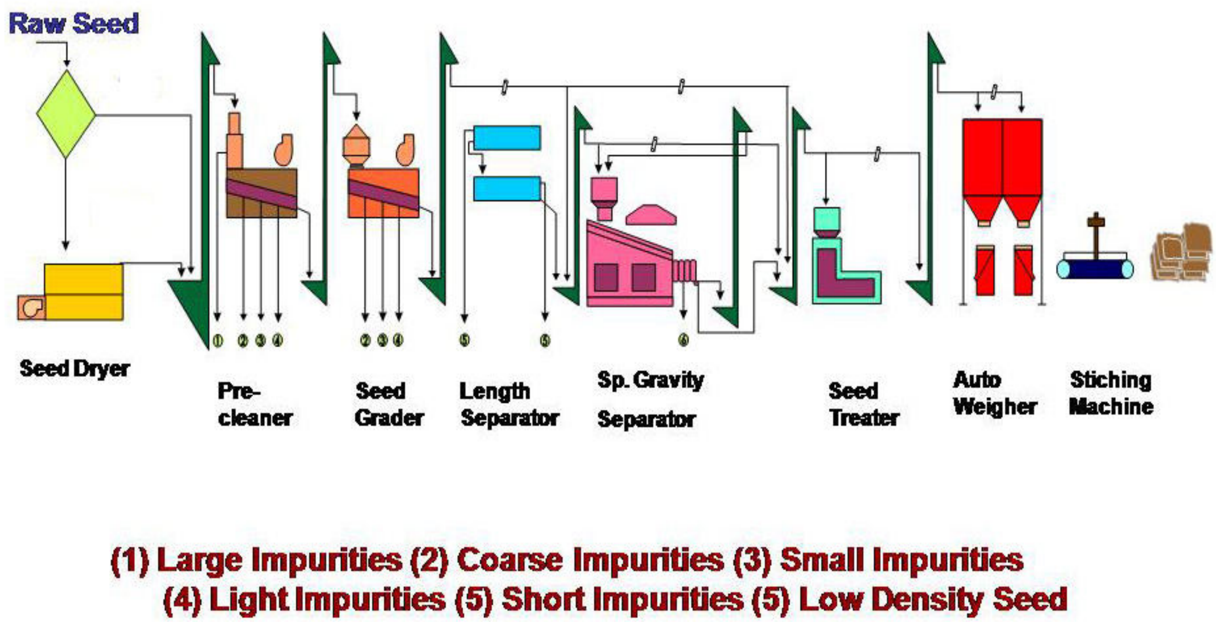


Fig-1: Flow diagram of modern seed processing

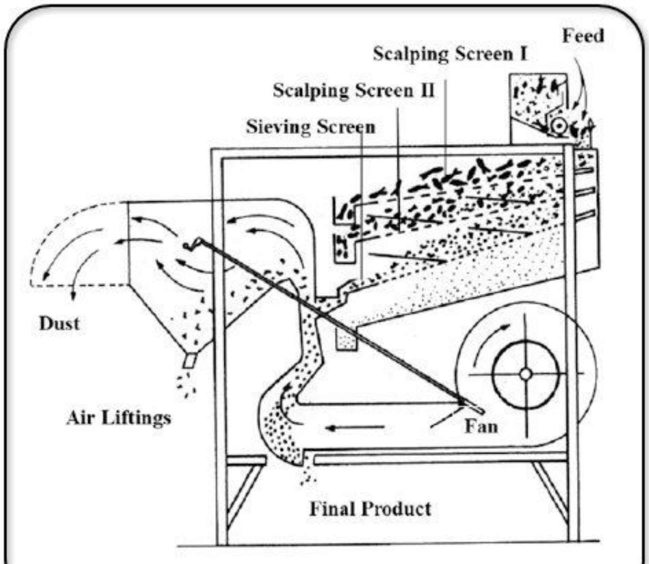
Methods of Seed Separation

Improvement in seed separation technology from simple hand picking and domestic hand screen to present day methods runs parallel to the story of civilization. A modern seed processing involves moving the field produce through a series of machines which perform specific operations and pass on the product to the next machine after discharging the reject. A well designed seed processing plant is laid out to permit by passing any machine without interrupting the product flow. Many types of seed cleaning machines are used to remove contaminants from the harvested-threshed seed.

Air-Screen Cleaner

The air-screen cleaner is the most widely used machine. It is an essential unit operation in seed processing plant. The simplest mechanical method of separating particulate solids, the class to which most agricultural seeds and food grains belong, is by passing than over screens which are stationary or reciprocating and are set at a slight downward slope, so that small particles will pass through and larger materials will tail over them. In combination with air-fans or blowers, the screen machine provides adequate conditioning for some seed crops. Such machines work by taking advantage of dimensional and aerodynamic differences. Agricultural screens are constructed of perforated metal or woven wire mesh. Hole shapes in perforated screens are usually round, triangular, oblong or rectangular, Openings in wire screens are square or rectangular, their size being represented by mesh numbers. Round hole screens are identified by a number denoting diameter of the perforation. In India, these numbers indicate the diameter in millimeters. Rectangular or oblong holes in perforated screens are identified by two numbers describing the width and length of the slot. Selection of the screen depends on the seeds being handled. Screen opening sizes used for different crops have been prepared and are available in literature. Screens with various sizes and shapes of holes drop some particles and retain others depending mainly on the width and thickness of particles and, to a lesser extent on their length. Pneumatic separators or air columns exploiting aerodynamic differences are used to remove dust, chaff or other light contaminants. The air system in air-screen machine operates in this manner. As a finishing machine it can remove light, immature, shriveled or damaged seeds from already cleaned good seed lots. Air screen combinations are extensively used in grain combining and threshing.

The air screen machine in general employs three cleaning elements: aspiration, scalping and grading. The light seeds and chaffy materials are removed from the seed through aspiration. In scalping operation, the good seeds are dropped through top screen opening and the larger materials (trash, clods etc.) are carried over the screen into the rejection spout. In grading operation, the good seed ride over screen openings, while smaller particles (under size, cut shriveled, broken seeds) drop through.



Air Screen Cleaner Cum Grader

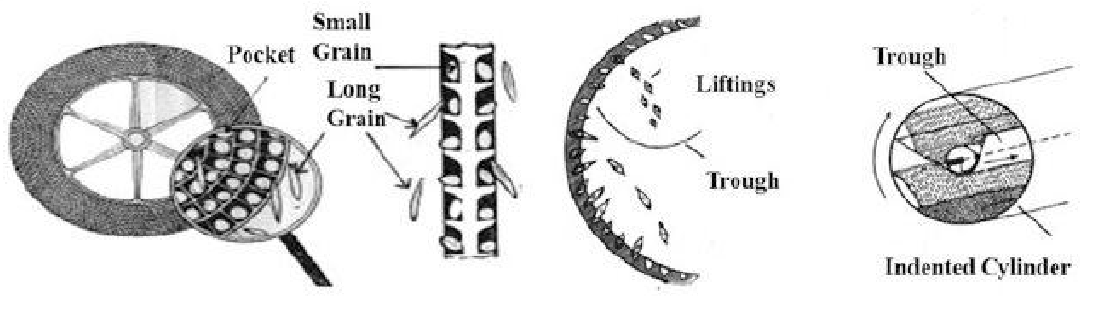
Feed hoppers of air screen cleaner cum grader are of three types: Roll feed hopper consists of a container to receive the seed, hopper flights and auger to spread the seed across the width of the hopper and a revolving fluted roll in the bottom of the hopper that feeds and even steady flow of seed to the top screen and distributes the seed across the full screen width. In roll feed brush hopper a rotating shaft pulls trash of seeds down to the revolving fluted roll and a tough fibre brush to prevent clogging. In the metering hopper a shaft width specially bent rod is used to spread the seed. Other special purpose variants are designed to handle special seeds.

Principles of operation

In a typical two screen seed cleaner cum grader, as the seed is delivered by the feed hopper the air blast removes light weight seed and chaff, scalping screen remove material larger than the crop seed; grading screen dropout material smaller than the crop seed. In a four screen machine, the 4 screen do the following operations: (a) 1st screen- scalping, (b) 2nd screen-grading, (c) 3rd screen- close scalping, (d) 4th fine grading. At the seed drop off the gravity screens they fall through the lower air separation to remove residual light seed and trash.

Length Separator

Length separators are designed to lift and remove the short fraction from a varied length mixture by exploiting the difference in the largest dimension of the product and the reject. These are two types of length separators, the indented disc separators and indented cylinder separators. Both lift out short particles out of a seed mixture with a given pocket or indentation and a relatively cleaned product is pushed further. The indented disc separator consists of a series of indented discs, mounted together on a rotating horizontal shaft. Each disc is designed with an open centre and numerous undercut recesses on each face. The broken seeds and the material shorter than the crop seed are lifted by the indents and are delivered into a trough at the side of the machine. Discs of increasing pocket sizes are normally provided on the shaft so that the particles of increasing lengths are removed selectively. The long seed that does not match the pockets is pushed by the incoming seed through the open centre of the disc and is discharged at the outlet.

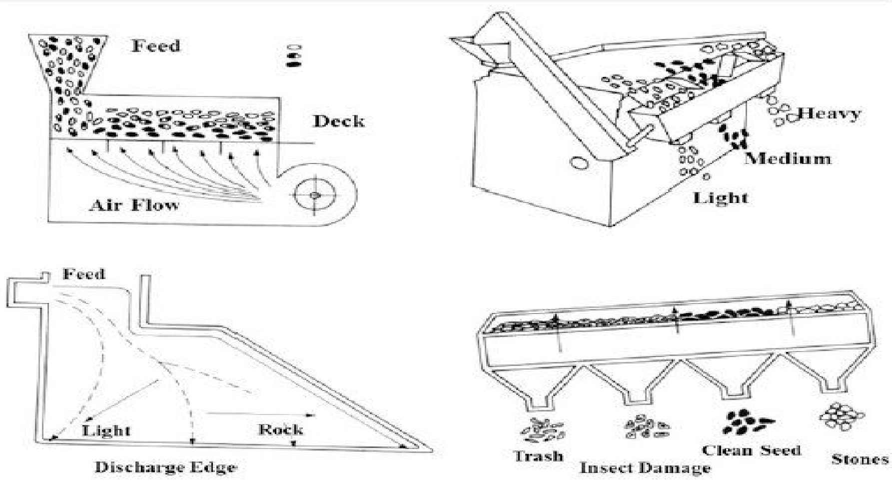


Indented Cylinder Separator

The indented cylinder separator consists of a rotating cylinder and an adjustable trough. The inner surface of the cylinder has closely spaced indents. The seed mass to be handled is fed at one end and lies at the bottom of the cylinder. As the cylinder rotates on its axis the short seeds are lifted from the mixture by indents. Thus at some point before reaching the top of the rotation, the seeds fall out from the indents, because of the tilting of the later. Actually, the seeds resting in the indents lose balance and are eventually received in the adjustable trough from where they are conveyed out by an auger. The long seed which is not lifted by the indents gradually move through the cylinder end are discharged to a separate spout at the other end of the cylinder. The quality of separation depends on the position of the trough and the speed of the cylinder.

Specific Gravity Separator

A specific gravity separator consists of two key components - air chest and the deck. Air chest houses fans and motor. The deck is mounted above the chest. The deck is a rectangular or triangular table covered with a porous cloth or wire mesh and inclined in two directions. The gravity separator classifies components of a mixture mainly according to density. Separation is caused in two steps. Seed mixture introduced at the back of the porous deck is stratified by the low pressure air coming through the deck. Low density particles tend to float and form a layer at the top and the high density particles sink to the bottom layer. Fractions of intermediate density, assume intermediate position. For proper identification of different density fractions, the seed lot must be well screened before hand so that all particles are of the same size. The seed should be dust free. An aspiration canopy is installed above the feed corner to further suck up any residual dust. The oscillating motion of the deck moves the high density particles laterally towards the uphill side at the deck. Simultaneously the floating low density material moves downhill by gravity. As the seed mixture layers travel from the feeding corner to the discharge end of the deck, a continuous gradation of particles takes place ranging from the low density ones at the lower side of the deck to the high density ones at the upper side. Adjustable splitters divide the output into number of density fractions needed. For deck covering a closely woven material for small seeds and a coarse weave for large seeds is used. Typical covering materials are small hole perforated metal and wire mesh. The coverings are supported by a deck frame, which serves as the top of the air chamber and helps to equalize the flow of air through the seed mass. Feed rate, air flow rate, deck angles and frequency of stroke are major adjustments. These adjustments are interrelated.



Specific Gravity Separator

Seed Refining

To further refine the seed, machines have been developed to take advantage from additional differences in physical properties. The electrostatic separator exploits the difference in the electrical characteristics of the seeds and contaminants. The quality of separation depends on the relative availability of the components in the seed mixture to conduct electricity or to hold electrical charge on surface. A spiral separator senses the ability of components to roll. This is very simple machine and operates completely by gravity. It has no moving parts and needs no prime mover. The endless draper belt separator utilizes surface texture differences to separate rough seeds from the smooth ones. A magnetic separator requires certain pre treatment of the feed mixture. Iron power or a magnetic fluid is added. Variation in seed coat characteristics is utilized. The iron is selectively adsorbed by rough, broken, cracked porous or sticky components making them more reactive than the smooth components. A colour separator acts on differences in reflective properties. The components of the mixture must be cingulated for individual sensing by the photoelectric cells. To scale up the throughput multi-channel machines are required.

Seed Treatment

Seed treatment refers to the application of fungicide, insecticide, or a combination of both, to seeds so as to disinfect and disinfect them from seed-borne or soil-borne pathogenic organisms and storage insects. It also refers to the subjecting of seeds to solar energy exposure, immersion in conditioned water, etc. The seed treatment is done to achieve the following benefits.

Benefits of Seed Treatment:

- Prevents spread of plant diseases
- Protects seed from seed rot and seedling blights
- Improves germination
- Provides protection from storage insects
- Controls soil insects.

Types of Seed Treatment:

Seed disinfection: Seed disinfection refers to the eradication of fungal spores that have become established within the seed coat, or i more deep-seated tissues. For effective control, the fungicidal treatment must actually penetrate the seed in order to kill the fungus that is present.

Seed disinfestation: Seed disinfestation refers to the destruction of surface-borne organisms that have contaminated the seed surface but not infected the seed surface. Chemical dips, soaks, fungicides applied as dust, slurry or liquid have been found successful.

Seed Protection: The purpose of seed protection is to protect the seed and young seedling from organisms in the soil which might otherwise cause decay of the seed before germination.

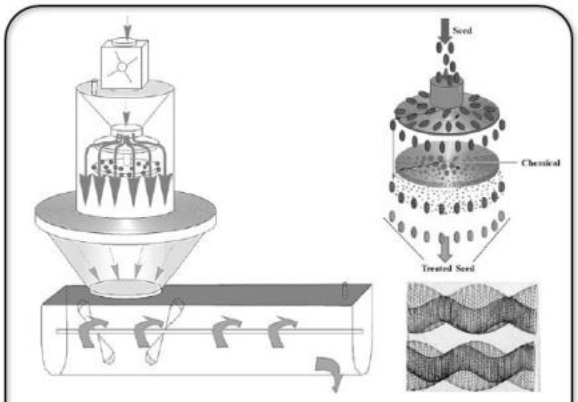
Conditions under which seed must be treated

Injured Seeds: Any break in the seed coat of a seed affords an excellent opportunity for fungi to enter the seed and either kill it, or awaken the seedling that will be produced from it. Seeds suffer mechanical injury during combining and threshing operations, or from being dropped from excessive heights. They may also be injured by weather or improper storage.

Diseased seed: Seed may be infected by disease organisms even at the time of harvest, or may become infected during processing, if processed on contaminated machinery or if stored in contaminated containers or warehouses.

Undesirable soil conditions: Seeds are sometimes planted under unfavorable soil conditions such as cold and damp soils, or extremely dry soils. Such unfavorable soil conditions may be favourable to the growth and development of certain fungi spores enabling them to attack and damage the seeds.

Disease-free seed: Seeds are invariably infected, by disease organisms ranging from no economic consequence to severe economic consequences. Seed treatment provides a good insurance against diseases, soil-borne organisms and thus affords protection to weak seeds enabling them to germinate and produce seedlings.



Mist-O-Matic Seed Treater

Seed Packing:

Packing of seed involves selection of good packaging material, weighing bagging, labeling and sealing .These operations are undertaken manually, semi-manual with help of machines for few operations and fully automatic depending upon the scale and packing requirements . Choice of packing material should be based on following criteria;

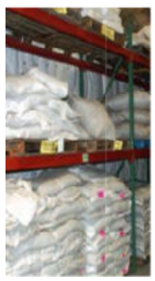
- Quantity in each packet
- Characteristics of seed
- Storage condition where the seed would be stored
- Attractive, appealing and identifiable packaging
- Cost of packaging
- Availability of drying facility
- Availability of packaging equipment and material

Different types of packaging materials

1. **Moisture and vapour pervious containers**

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

2. **Moisture impervious but vapour pervious containers**



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

3. **Moisture and vapour proof containers**

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

Depending upon the size of packing, following packaging material are in use in the seed industry;

Size of packing	Type of packaging
1-500 gm	Packet of paper, plastic, pouches of laminated aluminum foil, cotton and polyethylene bags.
100gm -5 kg	Tins, paper boxes and rigid plastics
1 kg -40 kg	Cotton bags, Jute bags, polyethylene bags
10 kg -100 kg	Gunny bags

Seed Packaging

Weighing is done by weighing balances, automatic weigher-bagger and filler and stitching of bag is done either by hand-held bag closer or bag closing machine with conveyor .While stitching the bags labels and tags are attached depending upon class of seed giving details of seed quality packed in the bag and lot number to ensure traceability.

Management of Seed stores/Godowns

Seed storage management implies the maintenance of the harvested seed mass in good physical and physiological condition from the time of harvesting upto the time of their replanting. Seed ageing and loss of germination during storage can not be checked altogether. However, it could be reduced appreciably by proper pre storage treatment to the product and providing good storage conditions. Seeds should be stored dry and kept dry. Seeds should be handled carefully to avoid any impact damage. The period of time that seed can be stored without decline in viability is a function of their storage environmental variables and initial seed quality. The simplest and the oldest method of storage is to store dry seed in bags near air temperatures. This is termed as ambient storage or normal temperature storage. Many species can be stored in this way for a year or longer. Conditioned storage is necessary for longer periods and for extra sensitive seeds. Seed longevity in storage rooms depends upon a number of factors.

Factors Affecting Seeds in Store

The most important feature of preserving seeds for long periods is based on maintaining viability and other attributes of quality seed above prescribed minimum standards. Therefore, it is important to understand various factors that directly or indirectly influence seed during storage.

Humidity:Like temperature, humidity is also an important ecological factor that influences longevity and pest activity. Most of the seed under tropical environment deteriorates faster due to high humidity coupled with temperature.

Seed Moisture: Moisture content in seed is the most detrimental factor that directly affects seed deterioration and pest multiplication. The safe moisture content however depends upon storage period, type of storage structure, kind / variety of seed, type of packing material used. For cereals in ordinary storage conditions for 12-18 months, seed drying up to 10% moisture content appears quite satisfactory. However, for storage in sealed containers, drying up to 5-8 % moisture content depending upon particular kind may be necessary. Very low moisture content <4% may damage seeds due to desiccation.

It is known that the life span of seed is influenced by storage conditions specifically the temperature and relative humidity (RH). The arithmetic sum of storage temperature in degree Fahrenheit and the RH per cent should be around 100. It holds well only in the range of 5 to 14 % seed moisture. The thumb rule in safe seed storage is that the sum of relative humidity (%) and temperature (^{o}F) should not exceed the value of 100, and with each 1% reduction in moisture content (Range 5-14% M.C.) or 5^{o}C drop in temperature (Range 0-50^{o}C temperature), the storability of seed gets doubled without the loss of germination (Harrington's Rules).

Seed Deterioration:

Deterioration of seed refers to some degree of impairment in functions resulting from changes occurring over a period of time .It is inexorable, irreversible and minimal at the time of maturity and variable in rate among the seed kinds, lots of same kind and individual seed within the lot and is identifiable only in terms of measurable or observable changes in response in terms of abnormal seedling /less germination percentage etc .Vigour of seed declines faster followed by loss of germination, which is the cumulative effect of all deteriorative changes taking place in the seed .

Seed storage

During the period of seed harvest till next sowing, it is subjected to field /threshing yard storage, bulk storage, packed seed storage, transport and distribution storage as well as farm storage before sowing .All the stages of storage are not under the control of seed processor .However, the good store should provide protection from temperature, allow good aeration, should have sufficient light and should be possible to make it airtight for fumigation and should be bird and rat proof besides being economical and ease of operation.

Storage period and conditions needed for storage

Depending upon requirement, seed needs to be stored for varying period .Following conditions for storage period of 1-9 months are adequate;

- 30°C -50 %RH)seed moisture content ranging from maximum of 12 %for cereal seeds to 8 %for oil seeds(
- 20°C -60 %RH)seed moisture content ranging from maximum of about 13 %for cereal seeds to9.5 %for oil seeds(
- Other combinations of temperature and relative humidity as favorable as above.

Some of the carryover seed require storage little longer period .Following conditions can accomplish the storage requirement for 18months storage

- 30°C,40 %RH)seed moisture content ranging from maximum of 10 %for cereal seed to 7.5 %for oil seeds(
- 20°C, 50 %RH)seed moisture content ranging from maximum of about 12 %for cereal seeds to 8 %for oil seeds(
- 10°C, 60%RH)seed moisture contents ranging from maximum of about 12 %for cereal seeds to 9 %for oil seeds(
- Other combinations of temperature and relative humidity as favorable as above.

Further long-term storage for a period of 3 to 5 years of storage is required for costly seeds and breeder seeds .Conditions of 10°C, 45 %RH are satisfactory for most kinds of field crop seeds .Successful storage for a period of 5 to 15 years can be achieved under conditions of 0 to 5°C, 30-40 %RH

These levels of temperature and relative humidity can only be obtained in specially constructed insulated rooms conditioned with refrigeration and dehumidification system . However, it becomes costly to design and install refrigeration system to create such conditions of low temperature and relative humidity .Therefore, better and cost-effective option should is to look for cooling and dehumidification separately.

Seed Storage Structures:

Bag storage is mostly practiced in India due to the reasons of maintaining the identity of small size lots .Based on the structures being presently used, a classification can be done as under:

)1(Rural structures

)2(Modified structure meant for rural areas

)3(Bin/silo storage

)4 Ventilated store with AC sheet roofing

)5 (Flat ventilated seed store

)6 (Seed store with moisture vapour proofing, insulation, dehumidification and air conditioning.

Distribution of Seeds

Following aspect should be taken in view to safeguard the quality of seed during transport and distribution:

- ✓ Producer is responsible for quality during validity period of seed. Therefore, the distributor, dealer and retailer should be properly guided for storage of seeds.
- ✓ In case of unsold seed, he should not sell it without getting revalidated.
- ✓ Seed should be moved for quickest delivery.
- ✓ During transit, the transporter should have proper arrangement for covering to protect from sun and rain.
- ✓ Material requiring cold chain should be shipped with AC trucks only.
- ✓ Material should be insured for transit risk.
- ✓ Dealers should guide farmers for on farm storage
- ✓ Transport with assured fast delivery should only be used
- ✓ Proper dunnage should be used while loading
- ✓ Record should be completed about seed being dispatched and required papers be sent with the truck.

Factors Affecting Seed Longevity in Storage

Initial Seed Quality: Seed lots figuring high in initial seed quality store longer than deteriorated lots. The important implication of this is that only high quality seed should be carried over. The medium quality seed may be retained for the next planting season. The low quality seeds should be normally not considered for storage. Low quality seeds decline rapidly in storage. Initial seed quality reflects pre harvest history of the seed lot and the amount of care during the harvesting, transport, threshing, conveying and processing. Well maintained and adjusted post harvest handling equipment are essential for retaining the highest seed quality.

Moisture content: Life of seed and its span largely revolves around its moisture content and it is essential to dry seeds to safe moisture content. Over the moisture range of about 8 to 12%, the rate of seed deterioration increases as the moisture content increases. At higher moisture contents, the losses could be rapid due to mold growth and/or due to heating. Most seeds are good thermal insulators and, therefore they do not permit heat energy to transmit through them easily. Also, within the normal range, the biological activity of seeds, insect and mold further increase as the temperature increases. However, it is important to note that very low moisture content (< 4%) may also damage seeds due to extreme desiccation or cause hard seededness in some species.

Relative humidity and temperature during storage: Relative humidity and the temperature in the air of the seed storage room are the major environmental factors influencing the storage life of the seeds. Low relative humidity makes the air thirsty of water and it picks up the unwanted moisture from the seed. Hence the seeds are kept dry in low humidity condition. Seeds achieve a rather specific and characteristics moisture content, termed as equilibrium moisture content, when subjected to a given combination of atmospheric relative humidity and the air temperature. This results due to the hygroscopic nature of the seeds. Fortunately, the establishment of moisture equilibrium in seeds is a time dependent process and it does not occur instantaneously. Therefore, the diurnal fluctuations in the relative humidity have little effect on moisture content.

Temperature also plays an important role in life of seed. Within the normal range, insect and molds increase as the temperature increases. Decreasing temperatures, relative humidity and moisture, therefore, is an effective means of maintaining seed quality in storage. Low temperature, low humidity storage of dry, cleaned and healthy seeds is the key to effective seed storage management.

Temperature Control

Temperature is one of the most important environmental factors which influence seed storability. The lower the temperature, the longer the seed maintain good quality. Temperature control may be achieved by ventilation, insulation and refrigeration. These methods are not mutually exclusive and are used in combination.

Ventilation: Ventilation can be used to lower seed temperature and seed moisture control when used judiciously. Ventilation is suitable for minor downward adjustment of temperature (and to a lesser extent the moisture). It can also help to prevent hot spots from developing; the formation of convection air current; and maintenance of uniform seed moisture content and temperature. Right time of ventilation is when the outside temperature and relative humidity are low. At that time the exhaust fan can be put on.

Insulation: The walls, ceiling and floor of a seed storage room must have satisfactory heat insulation and a moisture vapour seal. Floor insulation is frequently installed in a bed of hot asphalt, which provides a good vapour seal. The types of material used may be fiber glass, spray-on-foam, Styrofoam, saw dust, glass wool cork etc. The insulation materials must be kept dry for maximum efficiency. The moisture protection must be provided outside the insulation, if the material does not have a characteristic for dryness naturally built into it. Board type insulation is applied in 2 or more layers. The joints are lapped and/or staggered to minimize heat and moisture penetration at joints. Ceiling insulation can be of many kinds. Ceiling and wall finishes usually consist of one half inch or more cement plaster applied as two coats. Wood, metal, or concrete bumpers are installed on walls where trucks and tractors might accidentally hit them. Low temperature seed storage rooms must have no windows and their doors must be well insulated and well sealed. For large openings, the roller-mounted door (siding door) may be preferred over swinging doors. A relatively novel idea is to use a high velocity stream of cool air across the inner face of the door. Double door air locks and small anterooms also help reduce heat and moisture entering low temperature low humidity seed storage rooms. Adequate measures for checking the leakage of heat and moisture can be provided at the time of planning and building such seed stores. This job is better left to construction consultants and seed technologists should provide the functional requirements.

It is usually desirable to construct several low temperature rooms rather than a single large warehouse. In this ways annual operating costs can be lowered significantly. During the period when only small lots of seeds are stored, one or two rooms rather than the entire warehouse can be kept refrigerated. Most refrigerated seed storage facilities use forced air circulated through a cooling coil and then through the room. For large areas, a duct system distributes the cold air uniformly throughout the room.

Classification of moisture and heat removal systems configuration

System type	Components	Operation
I	Refrigeration compressor, motor and fans, evaporator and condenser coils	System is placed inside the conditioned space. Inside air is re-circulated through the unit until the set relative humidity is reached and the humidistat shut the unit off. It turns the unit on when the RH begins to rise due to product or system variables. Suitable where the sensible heat does not raise the temperatures above safe limits.
II	Desiccant, heater coils, conditioned air blower, and reactivation blower	Desiccant dehumidifier is located outside the conditioned space. Air in the conditioned space through a closed system, is re-circulated through, the unit until the set relative humidity is reached. A humidistat located inside the seed stores controls the running of the plant.
III	Conventional type split air conditioner	Evaporator section of the refrigeration unit is placed inside the conditioned space. Air is recirculated over the cold evaporator coil. Outside air is drawn over the condenser coils releasing the transferred heat to the atmosphere. A thermostat controls the unit. Electrical heater strips are sometimes used to add heat to the system for RH control.
IV	Desiccant dehumidifier with water after cooler	The water cooler reduces the air temperature as it leaves the desiccant dehumidifier. Effective for maintaining low humidities.
V	Refrigeration unit and the desiccant dehumidifier	Air in the conditioned space is cooled by pre-cooling coil before dehumidification. In the dehumidifier, latent heat of condensation is converted into sensible heat. Therefore, the after-cooling coil is provided. Pre-cooling and after-cooling is provided by refrigeration system.
VI	Refrigeration type dehumidifier and cooler	A self-contained refrigeration-type dehumidifier located inside the conditioned space removes the moisture from the air. The sensible heat load is handled by a refrigeration unit that transfers the heat to the outside atmosphere.
VII	Split air-refrigeration and desiccant dehumidifier	A dual system. The refrigeration system independently dehumidifies (within limits) and cools the air. The desiccant dehumidifier has much larger moisture extraction capacity. Offers a factor of safety in extreme conditions.

Refrigeration: Refrigeration is the household term. It is a process by which the heat is made to flow from lower to higher temperature, i.e., against the natural heat transfer process. It is the only method to achieve and maintain low temperature on long term basis. The medium employed to absorb heat is the refrigeration agent or simply refrigerant. Mechanical refrigeration systems are based on the ability of liquid heat as they vaporize. The vaporizing temperature of the liquid can be regulated by controlling the pressure at which the liquid vaporizes. In closed systems, the vapour is condensed back into liquid and thus used over and over again to provide a continuous flow of liquid for vaporization. Of all the fluids currently used as refrigerant, the one nearest to idle general purpose refrigerant is refrigerant-12 or R-12. It has a saturation temperature of –29.8°C. It can be stored as a liquid at ordinary temperature only under pressure in heavy steel cylinders. A typical mechanical refrigeration system contains the following parts: (1) An evaporator to provide heat transfer surface through which heat moves from the space being refrigerated into the vapourising refrigerant; (2) a suction line to convey the refrigerant vapour from the evaporator to the compressor; (3) a compressor to heat and compressor the vapour; (4) a hot gas or discharge line to carry the high-temperature, high-pressure vapour from the compressor to a condensor; (5) a condenser to provide heat transfer surface through which heat passes from the hot gas to the condensing medium; (6) a receiving tank to hold the liquid refrigerant for future use; (7) a liquid line to carry the liquid refrigerant from the receiving tank to the refrigerant metering device; and (8) a refrigerant metering device to control the flow of liquid to the evaporator. The typical vapor-compression system is divided into a low and a high-pressure side. The refrigerant metering device, evaporator, and suction line constitute the low pressure side of the system; the compressor, discharge line, condenser, receiving tank, and liquid line constitute the high pressure side of the system. A mechanical refrigeration system that will cool at a rate equivalent to melting one tonne of ice in 24 hours is said to have a capacity of one tonne refrigeration. The capacity of the compressor must be such that the vapor is drawn from the evaporator at the same rate at which it is produced.

Refrigeration and Humidity Control

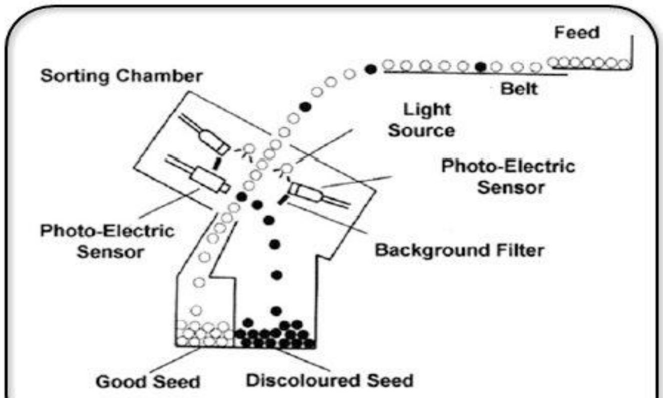
Relative humidity is measured by taking dry bulb and wet bulb temperature reading and finding the relative humidity from psychometric charts. Lower the wet bulb depression (dry bulb temperature – wet bulb temperature) lower is the relative humidity and vice-versa. At 100% relative humidity the wet bulb temperature and dry bulb temperature equalize. Humidity control systems are of two types. These are the refrigeration type and the desiccant type. The refrigeration type dehumidifier draws warm, moist air over a metal coil with fins spaced far enough apart to permit partial frosting and still allow for sufficient air passage. To be effect at low temperatures, a refrigeration type dehumidification system must cool the air below the desired temperature and reheat to the desired temperature. Air handling units are available with built-in refrigeration coils, electric defrosters, and reheat coils. Dehumidifiers using liquid or solid desiccants in conjunction with refrigeration can frequently reduce the cost of maintaining very low relative humilities. The dehumidifier incorporates one or two beds of granulated silica gel or activated alumina, which can absorb much water vapour. Now a days the rotary bed dehumidifiers are in practice. The rotary bed dehumidifiers have one or more beds divided into two air streams. The bed rotates slowly, and while part of each bed is absorbing water vapour from the air stream, the remainder is being recharged.

LTLH Seed Store
(Controlled Condition)

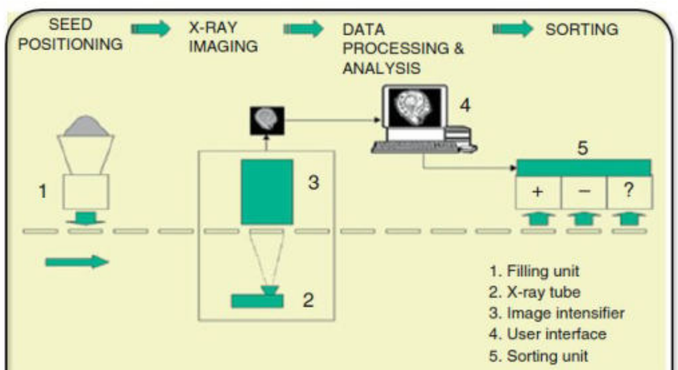
Normal Seed Store
(Ambient Condition)

New Emerging Technologies

Modernization of agriculture causes demand for higher quality seeds and invites application of new technologies to seed conditioning. This needs removal of all contaminants even when the physical property difference is very slight. This emphasis has led to the investigation of measurement system for physical properties and development of systems for improved seed conditioning. With the advent of microprocessors and the rapidly expanding application of technology, seed conditioning is beginning to benefit as the use of computers is integrated into the new equipments. Machine vision system (MVS) is being used for seed conditioning.



Colour Sorter



X-Ray Sorter


Detection of internal damage in seed

The feasibility of the application is shown for identifying seeds of different colour, size and shape. The MVS can also be used to detect stress cracks in certain seeds. By adopting such systems for modern seed processing packaging and storage, the availability of quality seeds to the farming community can be ensured.

Conclusion:

Seed quality upgradation through innovative post harvest operations and the delivery of high quality seeds to growers is necessary for ensuring improved crop production, achieve food security, promote sustainable agriculture & meeting growing environmental challenges. Every Farmers should get sufficient quantity of high quality seeds which are genetically pure, with high seed vigour and good germination percentage, associated with the right farming practices, at the right time and at reasonable costs.

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Seed Drying: Principles & Procedures

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Seeds are living hygroscopic materials. Its moisture content depends upon the relative humidity and temperature of the surrounding air. The determining factor in this relationship is the water vapour pressure which exists in the seed and the air surrounding it. Whenever the vapour pressure within the need is greater than the surrounding air, vapour will move out of the seed. If the vapour pressure gradient is reversed, the movement of moisture is also reversed into the seed. When the two vapour pressures are equal, there is no net movement of vapour; at that point the moisture content of the seed is in the state of equilibrium with the surrounding atmosphere.

Drying takes place when there is net movement of water out of the seed into the atmosphere. The rate at of which seed will dry is determined by how fast moisture migrates from centre to the surface of the seed and by the speed at which the surface moisture is evaporated in the surrounding air. The rate of moisture migration from the centre to the surface of a seed is influenced by seed temperature, physical structure, chemical composition of seed and seed coat permeability.

The rate of moisture removal from the surface of the seed is influenced by the degree of surface saturation, relative humidity and temperature of drying air. It has been well established that drying air temperature higher than 43°C are detrimental to the seed quality.

Why Seed Drying?

At physiological maturity the seed reaches maximum germination capacity and vigour. However at this stage of maturity seed has high moisture content. Therefore, for obtaining good quality seed, it should be harvested soon after attaining physiological maturity and dried to a safe moisture level.

Harvesting seed at higher moisture contents (particularly Kharif season crop) poses immediate and serious problem because seed will heat and deteriorate very rapidly. Seed moisture content during storage is the most important factor influencing seed deterioration; mould growth can begin at 13-14 percent, heating due to increased rate of respiration, micro-organism activity begins at 16 percent and seed will begin to germinate at 30-35 percent moisture content. The enormous influence of seed moisture content on longevity makes artificial drying mandatory in the production of high quality seed.

Seed Drying

Drying refers to the removal of relatively small amount of moisture from solid or material nearly solid material by evaporation and diffusion. The seed drying process is divided into:

3. **Thin layer drying:** It refers to grain drying process in which all grains are fully exposed to the drying air under constant drying conditions i.e. constant temperature and humidity. Generally, upto 20 cm thickness of grain bed is taken as thin layer drying. All commercial flow dryers are designed on thin layer drying principle.

4. **Deep bed drying:** In this process, all the grams in the dryer are not fully exposed to same condition of drying air. The condition of drying air at any point in the grain mass changes with time and at any time, it also changes with the depth of grain bed.

The depth of grain bed in this drying process is more than 20cm. All on farm static bed batch dryer are designed on deep bed drying principles.

Drying seed is similar to the grain drying and grain drying equipment and methods can be used with seed. The type of dryer that is most suited for a particular situation depends upon the volume seed to be dried in a season, the length of drying, the number of varieties to be handled, the size of seed lots and the handling and transportation method to be used.

The way seed may be dried includes-sun drying, natural air drying, hot air drying, dehumidified air drying, drying in storage and the use of desiccants in sealed container.

Sun drying can be used to dry the seeds as long as RH of the air is lower than the RH in equilibrium with the moisture content of the seed. For example, grain seed of 14% moisture is in equilibrium with 70% R. H., Therefore,

- If the RH of the air is 45%, 14% moisture content grain seed will dry further.
- If RH of air is 70%, 14% moisture grain remain at 14%
- If the RH of the air is 85%, 14% moisture grain seed will increase in moisture.

Sun drying can damage the seed if the temperature of the seed rises above 110°F (43°C) for grain seed and 90°F (32° C) for vegetable seed particularly when they are high in moisture content. Thus, sun drying should not be attempted when either the RH or the temperature is too high. Natural air drying can be used in areas where the climate is dry and temperature is less than 43°C when drying cereals and 32°C for vegetable seeds.

Hot air drying can be used when the weather is cool because heating air reduces its RH. For example, 14% moisture grain seed will not sundry if RH is 85%on a day when temperature is 70°F but will dry rapidly if the air is heated to 100°F and blown through the seed because this also reduces the RH of the air to 33% which would be in equilibrium with a grain seed moisture content of about 9%. However, hot air drying is not possible for vegetable seed when the temperature of the day is 90°F or above and RH is above the equilibrium moisture content of the seed to be dried.

If hot air drying cannot be used and the seed is too moist to store, dehumidified drying can be done. Here, a closed drying system dryer is used passing the air through the seed to pick up moisture from the seed then through the dehumidifier to remove the moisture from the air. The dried air is blown back through the seed for further drying. The air act as a carrier of moisture from the seed to the dehumidifier until the seed moisture is reduced to the level desired.

Drying in storage with unheated air is a slow process and should only be done when the moisture content is of the seed is lower than 13% moisture content. Drying in storage require ventilating fan and an understanding of when to ventilate.

The use of desiccant (Silica gel) in a sealed container to dry seed can also be used. This too is slow way of drying and should not be used to dry seed unless it is already below 13%.

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Seed Processing-Principles & Procedures

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New and improved crop varieties becomes an important agricultural input only when seed of such varieties are available to farmers varietal pure in a viable condition free of contaminating weed seed and in adequate quantities at the right place and time. seed processing encompasses all the steps involved in the preparation of harvested seed for marketing, handling, shelling, pre conditioning drying, cleaning, size grading, upgrading, treating and packaging in common seed processing refers to the pre-conditioning, cleaning, size grading and upgrading of seed.

A. Importance of Seed Processing:-

Seed growers and producers are dependent on the seed processor for preparation of their seed for market. The quality of the final product regardless of its inherent capacity to produce is directly related to the processors ability to remove contaminants and low quality seed, to property size grade for precision planting, to treat the seed effectively, and to prevent mechanical mixture of seed with those of other varieties or hybrids. In turn the processors ability to render these services efficiently and effectively is greatly attested by the types of processing equipment available to him his skill to operate them his knowledge of seed characteristics and how they relate to processing.

B. Materials Removed From Seed During Processing:- A variety of contaminants such as inert material, insect infected seed weed seed, other crop/variety seed, can seriously affect production of crops if they are not removed.

Seeds are processed to remove contaminants to size grade for plant ability upgrade quality through removal of damaged or deteriorated seed and to apply seed treatment materials. These objectives are achieved effectively and with minimal damage to the seed.

C. Principles of Seed Processing:-

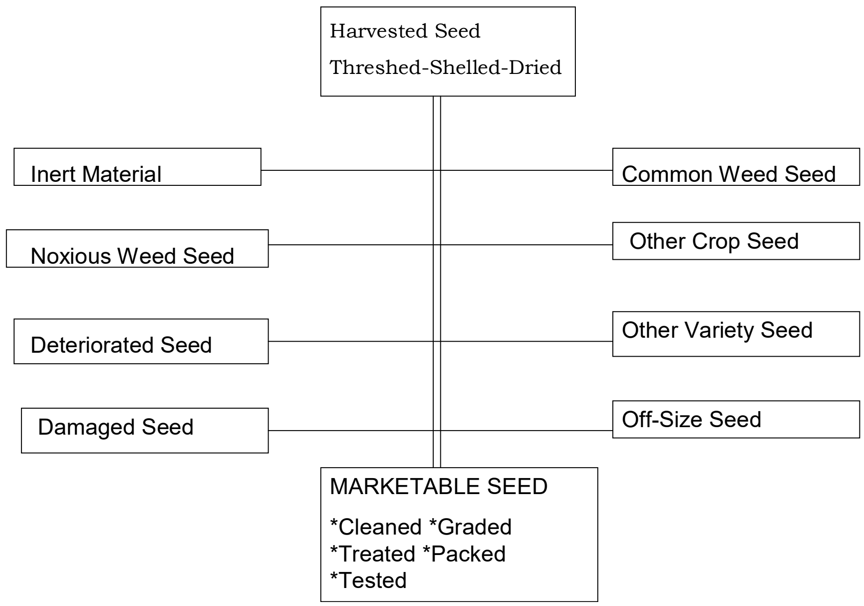
i. Complete separation- removal of all contaminants or undesirable materials.
ii. Minimum seed loss - some good seeds are removed along with contaminants in almost every processing operation be minimum.
iii. Up grading quality – improvement in seed quality by removal of contaminating, rotten, cracked, broken, insect damaged injured, low quality crop seed.
iv. Efficiency – the highest capacity consistent with effectiveness of separation.
v. Minimum labour requirement – labour is a direct operating cost and can not be recovered.

D. Steps in Seed Processing:-

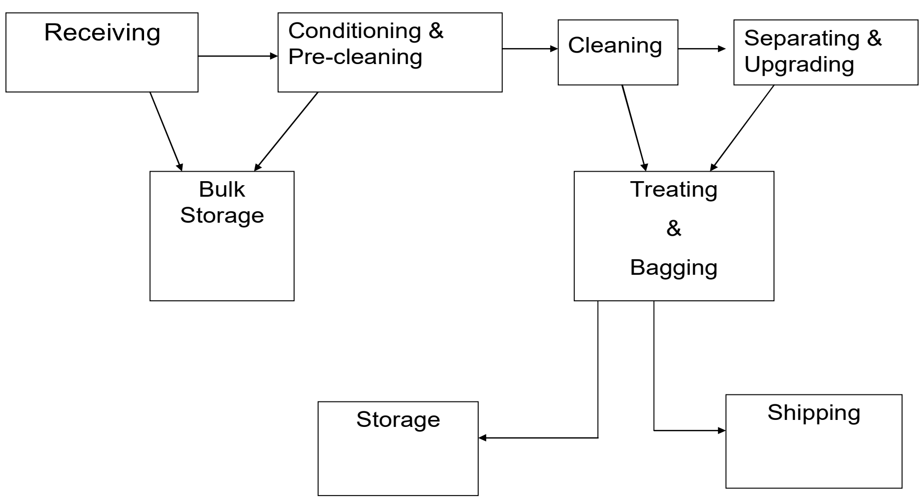
i. Receiving – seed arrives in bags or bulk can go to bulk storage or directly into processing line.
ii. Conditioning or precleaning – This includes removal of appendages, large pieces of trash, debearding to remove awns or bulling of seed.
iii. Basic Cleaning – The air screen cleaner is the most basic cleaner which makes separation and aspirates seed.

iv. Separating and upgrading- To remove specific contaminants special machines separates crop and weed seed by difference in their specific physical characteristics.
v. Bagging – After removal of inert matter weed and other crop seed, seed lot ready for bagging.
vi. Treatment – Treating fungicide or insecticide treatment is applied before they are bagged.
vii. Storage – Storage treated seed may then be sending to market or held in storage.

Materials removed during seed processing



Essential steps for seed processing



E. Basis of Separations: - Seed processing is based on difference in physical properties between the desirable seed and the contaminating weed or other crop seed, seed that do not differ in physical properties used for separation and SIZE LENGTH SHAPE, WEIGHT, SURFACE TEXTUREG, COLOR, AFFINITY FOR LIQUIDS etc.

F. Separation According to Size:-

F-1. Air Screen Cleaner – This separator characteristic of length and thickness of seed that differ from the contaminants. Cleaner is equipped with Scalping Screens having perforations larger than good seed which drops through the screen opening and Grading screen having perforations smaller than seed size, so good seed ride over the screen. A Sevier of scalping and grading operations removes all material larger or smaller than the crop seed.

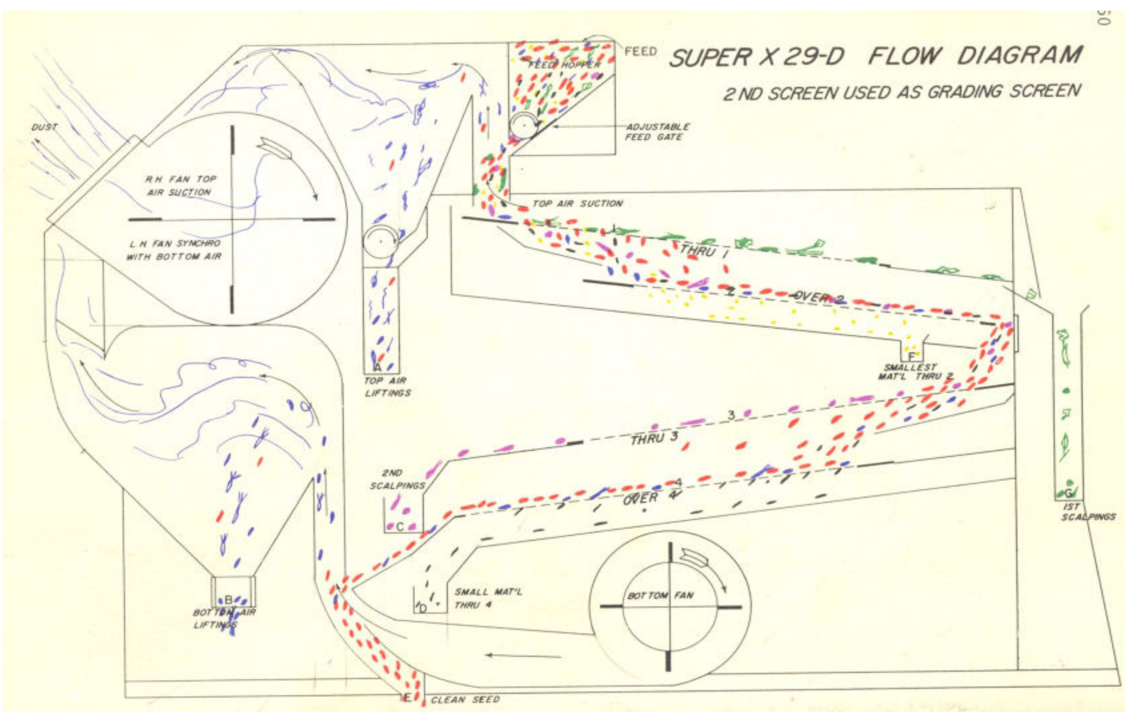
Principles of Operation – In 4 screen cleaner first screens scaling second screen grading third screen close scalping and fourth screen fine grading.

Seed is to be cleaned are fed from hopper by the feed roll where they pass through the upper air which remover light chaff and dust. The top screen is used for rough scalping. Its perforations are large enough to readily drop the crop seed but small enough to scalp off large foreign material such as stems, sticks, dirt or weed seed.

Seed which passes through 1st screen drop on to the 2nd screen having perforations smaller than crop seed which allows trash weed seed and dirt's smaller than crop seed to pass through. Good seed ride over 2nd screen and dropped on to 3rd screen. This screen is a close scalper it removes large foreign material that were small enough to pass through the 1st screen.

The crops seed drop through the 3rd screen go to 4th screen for final close grading. This screen has perforations slightly larger than those in 2nd screen seed or material smaller than crop seed drop through.

Four screen air cleaner

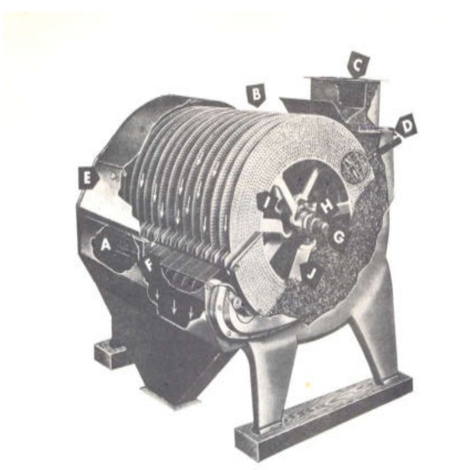


As the crop seed drop off the 4th screen, they fall through lower air separation. This removes the light seed and trash which was not removed by the upper air and the screens for efficient cleaning, the lower air blast should be strong enough to blow out a tend good seed.

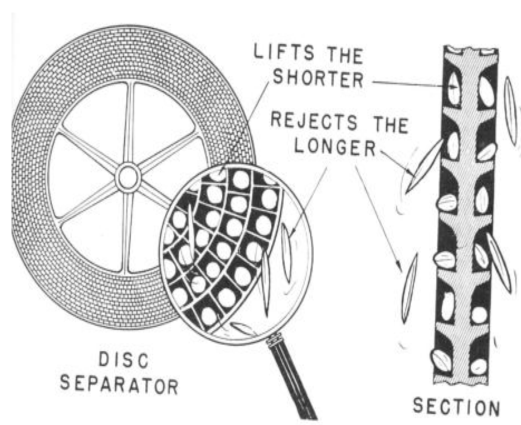
F-2. Disc-Separator: – The disc separator is a length sizing separator which lifts short seeds out of seed mass containing both short and long seed.

Seeds are fed this the separator from the feed hopper. To reach the tail end of the machine they must pass through the eye (open area between disc and shaft) of each disc, In so doing, the spokes and conveyor blades agitate and stir the mass assuring that all seed come in contact with the pockets in each rotating disc. As the disc rotate through the seed mass, short particles are picked – up, held in the disc pocket and lifted out of the seed mass. They are discharged into discharge spout when the trap doors are closed. If the trap doors are open they are discharged into the return conveyer and returned to seed mass. Seed too long to fit securely into the pockets travel the entire length of the machine and discharged through the toiling gate. In a normal arrangement the disc pockets are furnished in progressively larger size from the intake end to discharge end of the machine.

Disc separator



Face & cross-section of disc



F-3. Indented Cylinder Separator:– It is also a length sizing separator which lifts under size or short particles out of a mass of seed.

Cylinder: – The cylinder performs the operations. The walls of the cylinder are lined with indents/pockets which are either conical or hemispherical indents.

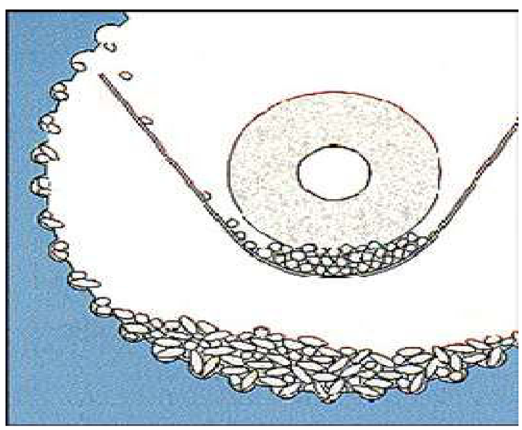
Principle of operation:- Seed to be cleaned are fed into the upper end of rotating cylinder since all indents in a single cylinder and of the same size and type, all indents lift essentially the same size particle.

Short seed or particles drop into indents, as the indents pass under the seeds bank in the cylinder. They are lifted, and hold in the indents until force of gravity over comes centrifugal force and they drop into the receiving trough. From the receiving trough they are discharged out of the machine.

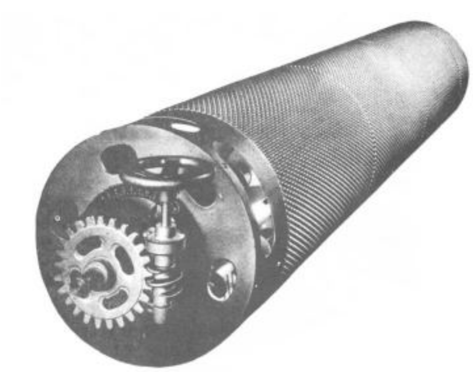
The long seed travel the entire length of the cylinder and are discharged over the retarder into a hopper that removes them from the machine.

Sectional view of Indented Cylinder

Lifting by indented cylinder

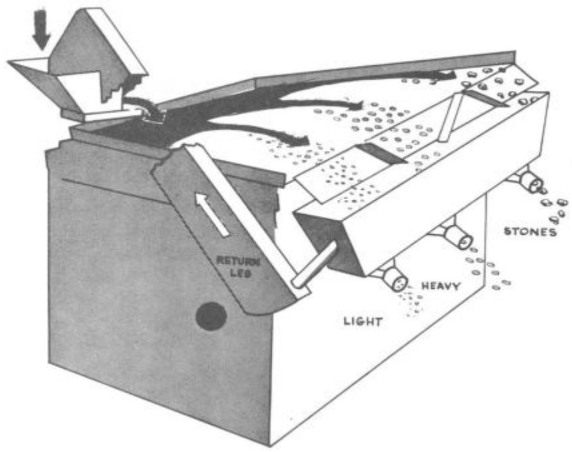


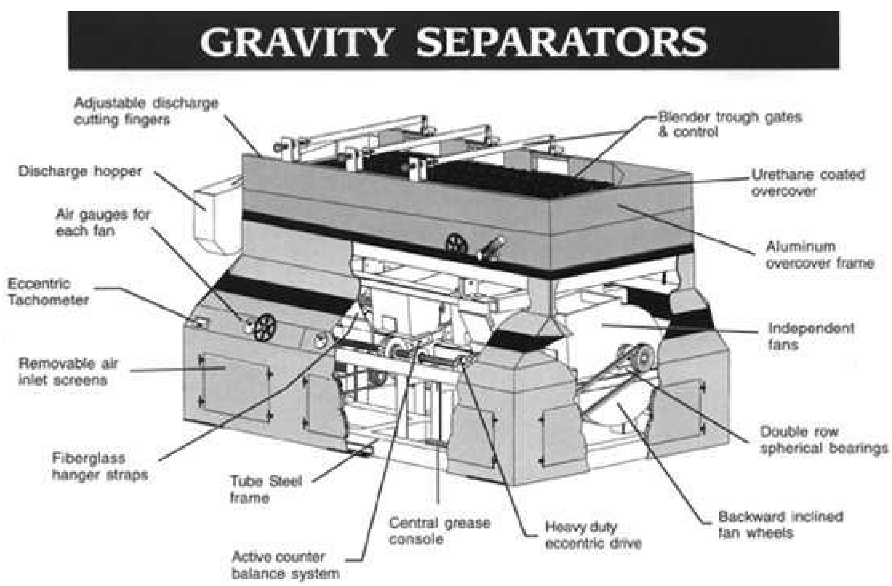
View of indented cylinder



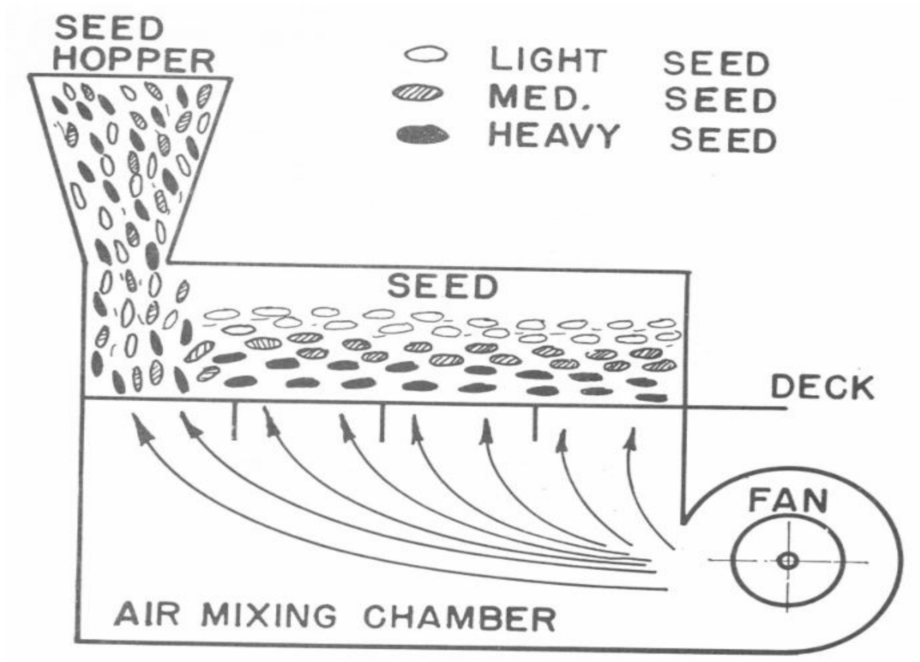
G. Gravity Separator:– Undesirable seed and contaminants are often so similar to the good seed in size shape that efficient separations con not be achieved by air screen magnetic velvet roll or dimensional sizing machines. Those undesirable materials however differ from good seed in unit weight or specific gravity- insect damaged seed often retain the same dimensions as undamaged seed but are much lighter because of interior destruction of the seed by insects, deteriorated, moldy or rotten seed are usually similar in size to good seed, but have a lower specific gravity and consequently are much lighter. Therefore contaminating seeds or materials

Gravity separator

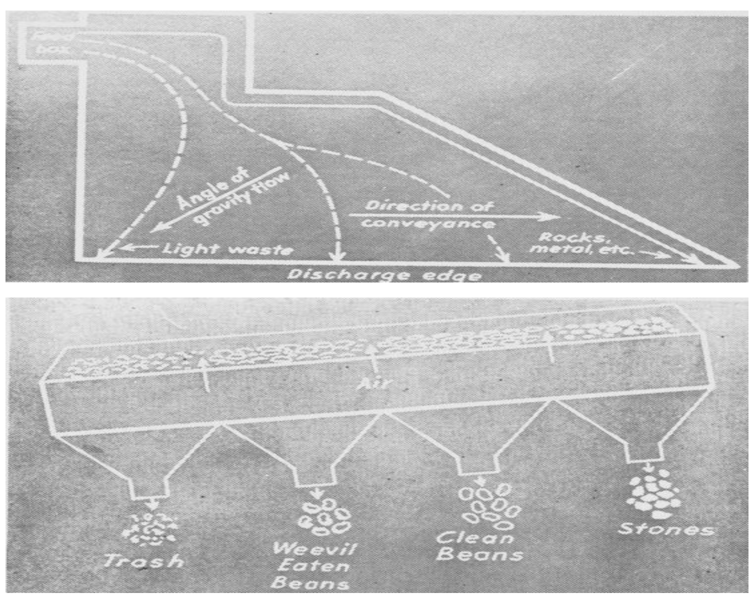




Seed stratification



Flow pattern & discharge of separates



Differing from crop seed in unit weight or specific gravity can be separated with a specific gravity separator (commonly called gravity separator)

Principles of separation: – Separation of seed differing in specific gravity involves two district steps stratification and separation.

Stratification: – seed feed from hopper fall into air stream through porous deck and make them partially fluidized so that they flow almost like a fluid.
The velocity of air stream adjusted to that light seed in the mixture are lifted and float on a cushion of air while heavy seed are not lifted and lie on the deck surface. The seeds are thus stratified in vertical layers of seed of decreasing specific gravity from bottom to top.

Separation: – The stratified seed layers are moved apart and separated so they discharge into different spouts. A combination of deck slope and deck motion is used to separate the layers. The deck slope can be adjusted in two directions from feed end to discharge edge (side slope). End slope influence the speed at which seed move across the deck to the discharge end where as side slope determines inclination across which the seed move as they are separated.
As seed move across the dick side slope forces them to flow across an inclined surface since light seeds are on as air cushion and do not touch the cock they slide down hill across the air cushion towers the lower side of the deck under the influence of gravity.
An eccentric drive causes the dick to oscillate back and forth toward the high side. The oscillating motion pitches the deck up and toward the high end, the drops it down slightly and pulls it back into position for the next up and forward motion. This motion is separated so rapidly that the deck appears to be vibrating.
The oscillation of the deck has no effect on light seeds which float on an air cushion. The heavy seed however in contact with the dick surface as the deck move up and forward, ass deeds lying on the deck move with it. As the deck mover back into position for the next up and forward move it drops slightly clown ward and momentarily causer the seed to lose contact with the dick, consequently, when they regain contact with the deck, they are closer to the high end of the dick.
Since light seeds and fluidized and flow almost like fluid, they flow toward the discharge and because of downhill slope. Heavier seed move uphill with deck motion. The constant addition of seed into the deck forces the entire seed mass to move toward the discharge end. When all adjustment are properly coordinated the stratified layers of seed separate and move to different sides of the deck before the moving seed mass reaches to the discharge end.

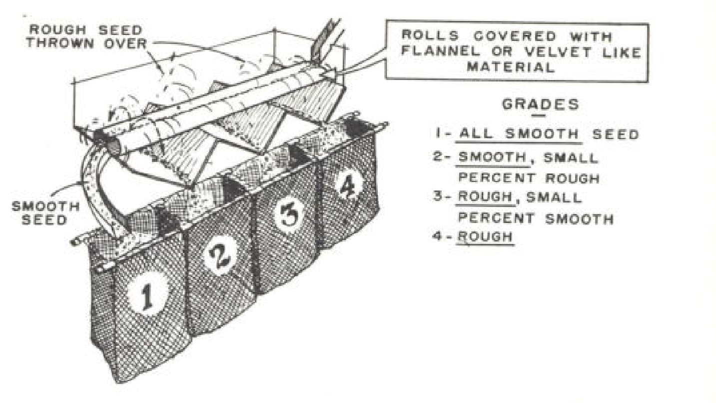
(H) Separation according to surface texture –

H-1. Roll Mill Separator: – It separates the mixture of seed that differ in surface texture.

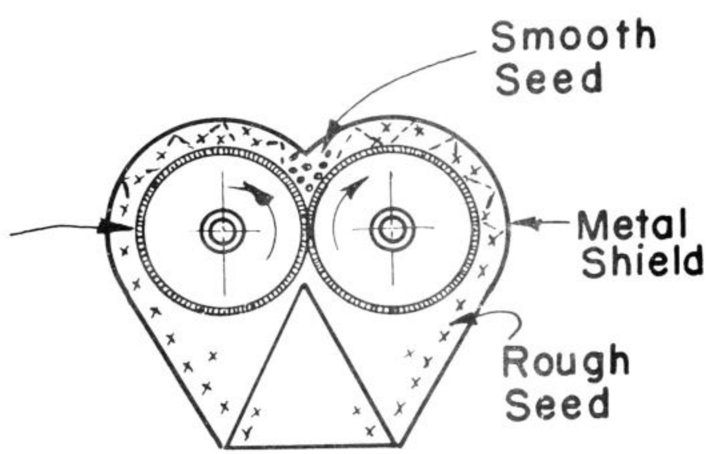
The mixture of seed to be separated is introduced onto the upper or high end of each pass of rolls. As they move down hill in the trough formed by the two rolls rough seed are caught by the raps of the velvet fabric cover of each revolving roll and thrower against the shield above the rolls. The rough seed strike the shield at an angle and are reflected back toward the roll at an apposite but equal angle. This they contact the valvet roll at a higher level along its upper are. Repeated action of this type causer the rough seed to move in steps across the upper arc of the roll until they finally fall over the outer edge of the roll the suck of the smooth and regular shared seed use not affected by the nap of fabric and continue to slide downhill until they discharge at the low end of the machine.

Since seeds are separated along the entire length of the rolls, several grades of seed are produced. The roughest seed are the first to be separated and drop into a hopper positioned beneath the upper one third, of the length of the rolls. A second hopper beneath the middle third of the rolls catches seed that are a mixture of predominately rough but with a small percentage of smooth seed the lower third catches seed with high percentage of smooth and low percentage of rough seed pure seeds are discharged off the lower end of the rolls. Seed discharged into lower one third hopper are usually re-run to recover the large percentage of smooth seed.

Roll mill separator



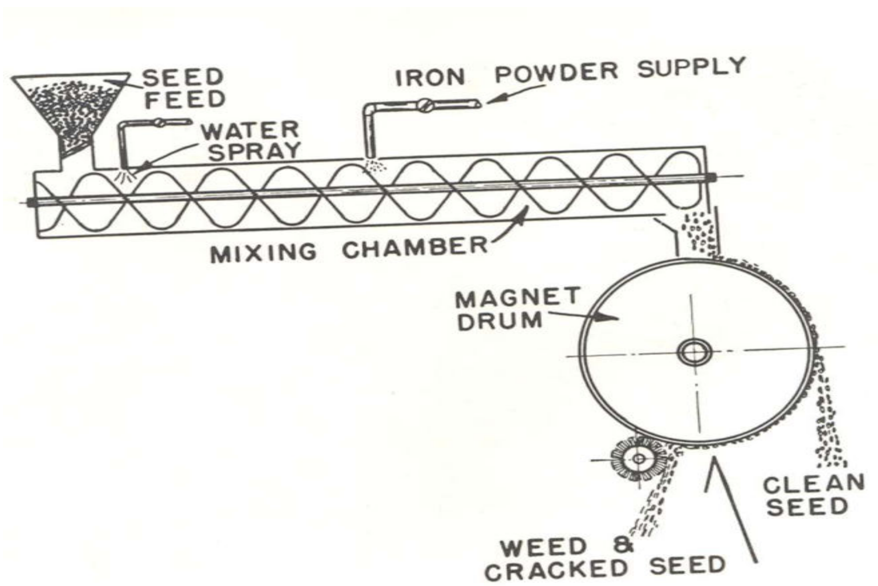
Moment of rough seed



H- 2. Magnetic Separator: – Iron powder is introduced into the seed mixture that has been slightly moistened after which the mass is agitated in the mixture. Rough textured seed, seed with gelatinous coat and irregular foreign material retain iron powder whereas the good seed with smooth seed coats do not. The seed then are passed over the magnetized rolls.

Contaminating seeds and inert material with iron powder adhering to them are held on the surface of the down by magnetic force. The adhering seeds are either drops due to gravity or are brushed off. Those seeds to which iron powder did-not adhere pass over the drum and are discharged as clean seed.

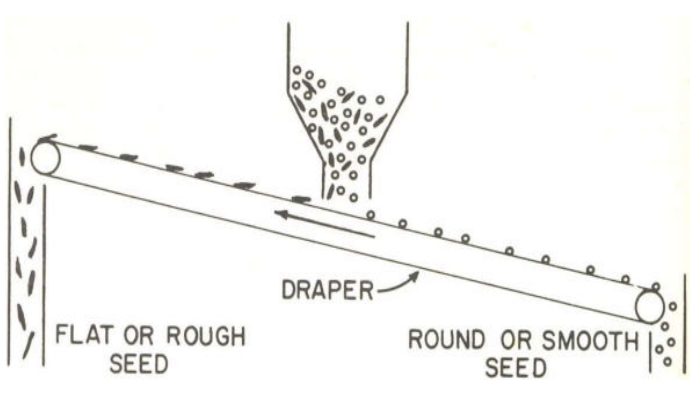
Magnetic separator



I. Separation According to Shape (roundness) or Surface roughness :

I-1. Inclined Draper: – The seed mixture feeds from feed hopper to the metering device which distributes seed in a thin layer across the width of the moving inclined draper belt at appoint near the center of its length. As the belt travels up-wards the round or smooth seed roll or slide down the draper faster than the draper is traveling upward. These seeds roll off the lower end. Flat, rough or elongated seed do not readily roll lie flat on the belt and are carried to the top of the inclined and discharge off the belt into a separate spout.

Inclined draper

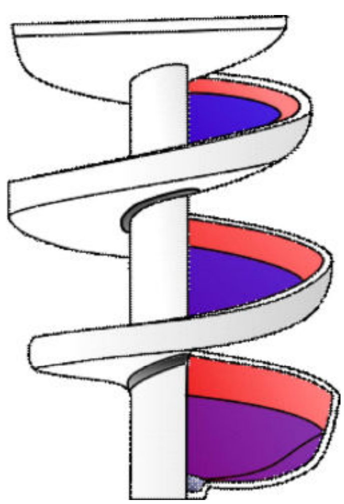


I-2. Spiral Separator: – This separator separate seed according to shape, density and degree of roundness or ability to roll.

This separator basically consists or one or more sheet metal flights spirally wound around a central tube or axis. The unit somewhat resembles to an open screw conveyer standing in a vertical position.

The seed mixture is fed onto the inner spiral flights from feed hopper. As the seed moves down the inclined inner flights, spherical seed roll readily and attain a higher velocity than non-spherical seed which tend to slide. The orbit of the round seed on the flights around the axis increases as velocity increases until the seed roll-over the edge of the inner flight drop onto the outer housing flight and discharge through a spot in the bottom of the machines, in contrast the non-spherical or irregular shaped seed do not attain sufficient velocity to roll over the edge of the inner flight and continue to slide toward the bottom of the machine where they discharge through separate spout.

Spiral separator



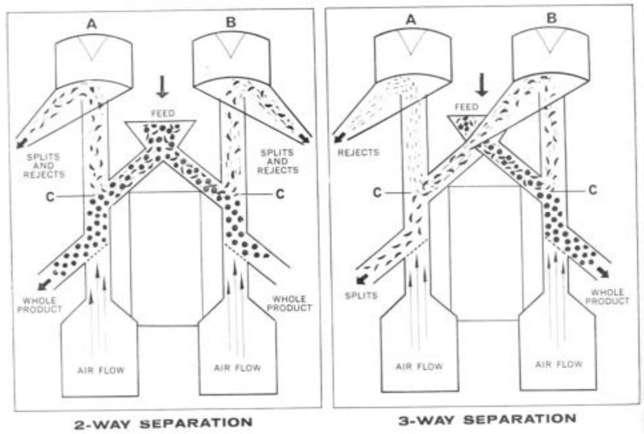
Spiral separator

J. Air Separators/Pneumatic Separators:

In pneumatic separator the fan in located near the air intake where it create a pressure greater then atmospheric causing air to be forced through the separating column under positive pressure.

Seed are fed into the moving vertical column of air through a feed hopper. When the seed mixture encounters the air steam those seed and other contaminants with a terminal velocity less then the air velocity are lifted and rise through the column toward the top where they are defected in to a discharge spout seed with a terminal velocity greater then the air velocity fall through the column of air until they seed an inclined screen positioned across the column, the seed are than deflected by the screen into the heavy seed discharge spout.

Pneumatic/Air separator



K. Bucket Elevators:

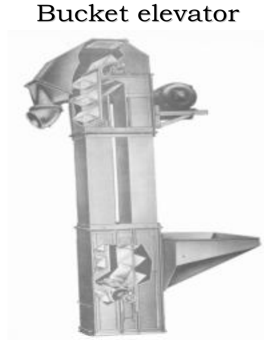
A bucket elevator consists of an endless belt or chain with evenly spaced buckets that run in a vertical or near vertical direction over top and bottom pulley. The top pulley or sprocket is powered and drive the belt or chain. The upper or discharge portion of the elevator is usually called the head. While the lower or feed end is called the boot. The assembly is generally enclosed in a steel or wood casing called the legs. The elevating leg (up leg) and the return leg (down leg) may be enclosed in the same or separate housing. Feeding of the elevator is accomplished through a hopper device on the up leg.

Based on the method of discharge bucket elevators may be classified as centrifugal and positive discharge bucket.

In centrifugal discharge elevator material is discharge from the buckets due to centrifugal and gravity force. The shape of the bucket, the speed and radius of the head pulley and position of discharge hopper must be in proper relationship for efficient operation. When this type of elevator is operated slower or foster then the speed for which it is designed, some seed fall back in to the down leg. Bucket shape varies but rounded or flat bottom buckets are generally used.

Buckets of a positive discharge elevator are mounted on a pair of chains. The move slowly and are designed so that the grain drop by gravity from each bucked into a hopper positioned to accept the discharge. This elevator is most useful when handling material which is fragile, light or do not otherwise discharge readily from a centrifugal elevator.

Bucket elevator



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Enhancing Field Performance & Storability of Seeds by Coating and Pelleting

P. M. Singh
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Coated or pelleted seeds to be dealt with appropriately in order to make positive identification of all individual seeds and inert matter which is impracticable without destroying the structures presented for testing. A wide range of materials may be used to coat seeds as individuals in discrete units as in pellets or spaced in strips or sheets. Where reference is made to seed pellets the rules also apply to encrusted seed and seed granules to seed tapes or to seed mats. For seeds thus coated, modified techniques are recommended to test the seeds, based on specific instructions.

Definitions:

Seed pellets. More or less spherical units developed for precision sowing, usually incorporating a single seed with the size and shape of the seed no longer readily evident. The pellet, in addition to the pelleting material, may contain pesticides, dyes or other additives.

Encrusted seed. Units more or less retaining the shape of the seed with the size and weight changed to a greater or lesser extent. The encrusting material may contain pesticides, fungicides, dyes or other additives.

Seed granules. Units more or less cylindrical, including types with more than one seed joined together. The granule, in addition to the granulating material, may contain pesticides, dyes or other additives.

Seed tapes. Narrow bands of material, such as paper or other degradable material, with seeds spaced randomly, in groups or in a single row.

Seed mats. Broad sheets of material, such as paper or other degradable material, with seeds placed in rows, groups or at random throughout the sheets.

Treated seed. Seed to which only pesticides, dyes or other additives have been applied which have not resulted in a significant change in size, shape or addition to the weight of the original seed and which can still be tested according to the methods prescribed in other chapters.

Sampling Size of lot:

The lot should be reasonably homogeneous, the maximum weight of lot may be as great as the maximum weight of lot which sampling procedures are prescribed. Subject to the tolerance of 5% and subjected to the seed number limitation.

Seed taps or seed mats may contain a maximum number of seeds of 1,00,000,000 (10,000) except that the weight of lot, including the coating material may not exceed 42,000 kg (40,000 kg plus 5%) when lot size is expressed in units the total weight of the lot must be given on the Certificate.

Sampling intensity:

Sampling the lot of seed pellets should be done according to the intensity appropriate to the particular lot. Sampling the lot of seed tapes should be done by taking packets or (from reels) pieces of tape at random analogously, following the prescriptions of 2.6.2 and 2.6.2. A., provided that packets or reels containing up to 2,000,000 (20 units of 100,000) seeds, may be combined as a basic unit and therefore are to be considered as one container.

Size of submitted sample:

Submitted samples shall contain not less than the number of pellets or seeds indicated in column 2 of table given below. If a smaller sample is used the following statement must be inserted on the Certificate : "The Sample submitted contained only…….. pellets (seeds) and is / not in accordance with the International Rules for seed Testing".

Table 1: Part I: Sample size of pelleted seeds in number of pellets

Determinations	Submitted samples not less than	Working samples not less than
Purity analysis (including verification of species)	7500	2500
Weight determination	7500	Pure pellet fraction
Germination	7500	400
Determination of other seeds	10000	7500
Determination of other seeds (encrusted seeds and seed granules)	25000	25000
Size grading	10000	2000

Table 1 : Part II :Sample size of seed tapes:

Determinations	Submitted samples not less than	Working samples not less than
Verification of species	2500 seeds	100 seeds
Germination	2500 seeds	400 seeds
Purity analysis (if required)	2500 seeds	2500 seeds
Determination of other seeds	10000 seeds	7500 seeds

Drawing and disposed of submitted sample : As submitted samples of coated seeds normally contain fewer seeds than corresponding samples of uncoated seeds, special care is necessary in drawing the sample to ensure that it is representative of the lot. Precautions are necessary to avoid damage to or change in the pellets or seed tape during drawing, handling and transport, and samples must be submitted in suitable containers.

Size of working sample: Working samples shall contain not less than the number of pellets or seeds indicated in column 3 of Table 1 Part I and Part II. if a smaller sample is used the actual number of pellets or seeds in the sample shall be reported on the Analysis Certificate.

Obtaining the working sample: For pelleted seeds use one of the dividers described viz., conical divider, soil divider or centrifugal divider of fall must never exceed 250 mm. For seed tapes take pieces of tape at random, to provide sufficient seeds for the test.

Purity analysis:

A purity analysis in the strict sense (i.e. of the seeds inside the pellets and tapes) is not obligatory though. If requested by the sender, a purity analysis on depelleted seeds or seed removed from tape may be carried out to separate the sample into different parts, to determine the percentage of each part by weight. Separations for pelleted seed are defined but for taped seed no separation is made.

Pure pellets: Pure pellets shall include:

- Entire pellets regardless of whether or not they contain seed,
- Broken and damaged pellets in which more than half the surface of the seed is covered by pelleting material, except when it is obvious that either the seed is not of the species stated by the sender or there is no seed present.

Unpelleted seed: Unpelleted: seed shall include:
- Free seed shall include :
- Broken pellets containing a seed that is recognizably not of the species stated by the sender.
- Broken pellets containing seed recognizable as being of the species stated by the sender but not included in the pure pellets fraction.

Inert matter: Inert matter shall include:
- Loose pelleting material
- Broken pellets in which it is obvious that there is no seed
- Any other material defined as inert matter in Rule.

Verification of species in pelleted Seeds:

In order to check that the seed in the pellets is largely of the species stated by the sender, it is obligatory to remove the pelleting material from 100 pellets taken from the pure pellet fraction of the purity test and determine the species of each seed. The pelleting material may be washed off or removed in the dry state. Similarly 100 seeds must be removed from tapes and the identity of each seed determined.

Procedure:

The pelleting material may be washed off or removed in the dry state. For taped seed, depending on the material the tape is made of, strip off or dissolve away the tape so that 100 seeds can be examined. When the seeds in the tape are also pelleted remove the pelleting material as indicated above.

Working sample:

For pellets the purity analysis shall be made on a working sample taken from the submitted sample. The size of the working sample shall be that indicated in column 3 of Table 11A, Part I. The analysis may be made on one working sample of this number of pellets or on two sub-samples of at least half this number each independently drawn. The working sample (or each sub-sample) shall be weighed in grams to the minimum number of decimal places necessary to calculate the percentage of its component parts to one decimal place.

1. Procedures for purity tests on depelleted seeds and seeds removed from tapes:

When a purity test on depelleted seeds is to be undertaken at the request of the sender the working sample of not less that 2500 pellets is depelleted by shaking in fine mesh sieves in water. A sieve of 1.00 mm mesh above a sieve of 0.5 mm is recommended. The pelleting material is dispersed in the water and the remaining seed material is dried overnight on filter paper and then in an air oven at the temperature indicated for the species under test. After drying, the material must be subjected to a purity analysis. The component parts (Pure seed, other seeds and inert matter) shall be reported as percentages of their total weight, ignoring the pelleting material. The percentage of pelleting material shall be reported separately only on request.

When a purity test on seeds removed from tapes is requested, the tape material of the working sample with paper tapes is cautiously separated and stripped off. Water soluble tape material is moistened until the seeds come free. When pelleted seeds are found in the tapes follow the procedure in the paragraph above. The moistened seeds must be dried and the free seed material must be subjected to a purity test as above. The component parts (Pure seed, other seeds and inert matter) shall be reported as percentages of their total weight ignoring the tape material.

Separation:

The working sample of pellets (orsub-sample) after weighing is separated into its components.

Calculation and expression of results:

The percentage by weight of each of the component parts shall be calculated one decimal place. Percentages must be based on the sum of the weights of the components, not on the original weight of the working sample, but the sum of the weights of the components must be compared of the working sample, but the sum of the weights of the components must be compared to the original weight as a check against loss of material or other error.

Reporting results:

The result of a purity analysis shall be given to one decimal place and the percentage of all components must total 100. Components of less than 0.05% shall be reported as trace.The name and number of seeds of each species found in the examination of the 100 seeds removed from pellets or tapes shall be reported on the International Seed Testing Association International Seed Analysis Certificate under 'Other Determinations'. The percentage of pure pellets, unpelleted seed and inert matter must be reported in the spaces provided on the International Seed Analysis Certificate for the components of the purity test on unpelleted seed.

2. Determination of other seeds :

This determination to estimate the number of seeds of other species is carried out only at the request of the sender. In determining the number of other seeds, the definition prescribed in Rule 3.2 shall be observed. Other seeds refer to species other than that of the pure seed as defined in Rule 3.2.1.

General principles:

The determination is made by a count of seeds of the species (or groups of species) designated by the sender, and the result is expressed as a number of seeds found in the weight and approximate numbers of pellets examined or for tapes in the length of tape (or area of mat) examined.

Procedure

Working sample:

The working sample shall be not less than that prescribed in column 3 of Table 11 A, part 1 and Part 2. The working sample of pellets may be divided into two sub-samples.

Determination:

The pelleting material and / or tape material shall be removed as described earlier but drying is not obligatory. The working sample is searched wither for seeds of all other species or of certain designated species, as required by the sender.

Calculation and expression of results:

The results is expressed as the number of seeds belonging to each designing species of category found in the actual weight and approximate number of pelleted seeds examined and for seed tapes the length of tape (or area of mat) examined. In addition the number per unit weight, per unit length or per unit are (e.g. per kilogram, per metre or per square metre) may be calculated.

Reporting results:

The actual weight and approximate number of pelleted seeds and / or the length of tape (or are of mat) examined and the scientific name and number of seeds of each species sought and found in this weight, length or area shall be reported on the International Seed Testing Association International Seed Analysis Certificate under Other Determinations', not withstanding that the result may in addition be expressed in some other way (e.g. number of seeds per kilogram, per metre or per square metre).

Germination test of Pelleted Seeds:

To determine the percentage by number of normal seedlings of the kind of seed of which the sample purports to be, using pellets from the pure pellet fraction or tape without removing the seeds from the tape material. An additional germination test on pure seed taken of the pellets or tape may be carried out at the request of the sender or as a check on a test of pellets or tapes, but care must be taken that the covering material is removed in such a way as not to affect the germination capacity of the seeds. A pellet is regarded as having germinated if it produces at least one normal seedling of the species stated by the sender. Seedlings that are obviously not of the species stated by the sender, even if normal for their species, are not included in the germination figure but their number shall be reported separately.

General principles:

Germination tests on pelleted seeds shall be made with pellets from the pure pellet fraction of a purity test. The pellets shall be placed on the substrate in the condition in which they are received (e.g. without rinsing or soaking). Germination tests on seed tapes are made on the tape without removing the seeds from the tape material or in any way pre-treating the tape.

Materials:

Paper, sand and in certain situations soil are permissible as substrates. For pelleted seed the use of pleated paper, and for seed tapes a between paper method of which the upright rolled towel has proved satisfactory in many cases, is recommended.

The pleated paper recommended for tests on pellets has a weight of 100 – 120 per square metre and a water absorption of 220-240%. The pleated filter papers are enveloped by cover strips, of weight 70g per square metre, and water absorption of 220-240%.

Counting equipment *viz.*, counting boards, vacuum counters:

Germination apparatus i.e.the bell-jar or Jacobsen apparatus, the germination cabinet, and room germinations.

Procedure

Working sample:

The pure shall be well mixed and 400 pellets counted at random in replicates of 100. The working sample from seed tapes shall consist of randomly taken pieces of tape to make up four replicates of at least 100 seeds each.

Test conditions:

Methods, substrates, temperatures, light conditions and special treatment as for particular species should be used. Where substrates prescribed are found not to give satisfactory results, pleated paper should be used for pellets and a between paper method for tapes.

Moisture and aeration:

The water supply may be varied according to the pelleting material and the kind of seed so as to achieve optimum conditions for germination. If pelleting material adheres to the cotyledons, water may be sprayed cautiously on to the seedlings at the time of counting.

Special treatments for breaking dormancy:

When fresh ungerminated seeds remain at the end of the test period a retest may be made using one of the special treatments prescribed.

Duration of test:

Extension beyond the period prescribed may be necessary. However, slow germination may be an indication that test conditions are not optimum and a germination test of seeds removed from the covering may be made as a check.

Evaluation:

Evaluation of seedlings as normal or abnormal shall be in accordance with the definitions and details of the essential structures. Abnormality may on occasion be due to the pelleting or tape material and when this is suspected a retest shall be carried out in soil of good quality.

Multiple seed structures:

Multiple seed structures may occur in pellets or in tapes or more than one seed may be found in a pellet. In either case these shall be tested as single seeds. The result of the test indicates the percentage of structures or pellets which have produced at least one normal seedling. Pellets or seeds in tapes producing two or more such seedlings are counted and their number recorded.

When pellets are tested for monogermity the numbers of pellets which have produced either one, two or more than two normal seedlings are determined in the germination test and each is expressed as a percentage of the total number of pellets producing at least one normal seedling.

Calculations and expression of results:

Results expressed as percentage by number. In addition, for taped seeds the total length of tape (or area of mat) used in the germination test is measures and the total number of normal seedlings is noted. From these data the number of normal seedlings per meter (or square metre) is calculated.

Reporting results:

The percentage of pellets or seed in tapes with normal seedlings, with abnormal seedlings and without shall be reported on the International Seed Testing Association International Seed Analysis Certificate. The method used for the germination test and the duration of the test must be indicated. In addition, for seed tapes the number of normal seedlings per metre of tape (or square metre of mat) shall be reported.

4. Weight determination and size grading of pelleted seed:

Because of the technical requirements of precision drilling, weight determination or size grading may be necessary.

Object:

The object is to determine the weight per 1000 pellets and/or size grading of the sample as submitted.

Principles:

For a weight determination the number of pellets in a weighted quantity of pure pellets is counted and the weight per 1000 calculated. For size determination a sample of the size specified in Appendix A is screened as specified and the percentage of each screening fraction determined.

Apparatus:

For weight determination a suitable counting machine or counting equipment for germination tests may be used. For size determination a suitable screening machine is used.

Certificates

Reporting results:

International Seed Testing Association International Seed Analysis Certificates for coated seeds should be clearly marked in the space following the heading ANALYSIS RESULTS with the words 'SEED PELLETS, ENCRUSTED SEEDS, SEED GRANULES, SEED TAPES or SEED MATS'. The name and number of seeds of each species found in the verification of species examination shall be reported under 'Other Determinations'.

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Importance of Post-Harvest Operations for improvement of Seed Quality

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All the operations performed on harvested agricultural produce to make it for final use comes under Post Harvest Technology. The end use may be for food or for seed purpose. Post-Harvest Technology is an integral part of agricultural production and its utilization.
It has following advantages:

1. Loss prevention
2. Value addition
3. Employment generation
4. Increasing the income of the farmer

Seed can seldom be planted in the condition in which it comes from the grower. In fact, many seed lots contain weed or crop seed or inert material that make them unfit for sale without processing. Crop seed also frequently have stems, awns, clusters, or other structures which prevent them from flowing through the drill freely.

Post-harvest operation of seed popularly known as seed processing is that segment of the seed industry responsible for upgrading the quality of seed by removing foreign material and undesirable seed, improving the planting condition of seed, and applying chemical protectants to the seed.

Services of the seed processor: Some of the services seed processors perform for farmers are:

1. Make possible more uniform planting rates by proper sizing and removing seed appendages which hinder planting.
2. Improve seed crop marketing by improving seed quality and maintaining dependable standards for planting seed.
3. Prevent the spread of weeds by removing weed seed from crop seed.
4. Improve crop quality by removing seed of the other crops from the pure seed.
5. Protect crops from insects and diseases by applying chemical protectants.
6. Reduce seed losses by removing high-moisture foreign material and by drying seed which are too high in moisture.
7. Facilitate uniform marketing by providing storage from harvest-time until the seed is needed for planting.

Thus, the seeds man is an important link between the seed producer and the seed user.

How seeds are processed

The seed processor must approach each lot of seed as methodically and analytically as the research scientist approaches his work. The processor should first carefully examine the seed to determine what his processing problem will be, and then decide how he can solve the problem to produce a final seed lot of the maximum purity and germination.

An important factor to consider is the moisture content of the seed prior to processing. Seeds with moisture content above 15% are subject to excessive damage in the processing line. In this case natural or artificial drying may be necessary. On the other hand, seed of soybeans, peas, and many other crops are sensitive to impact damage if they are below 10% moisture when processed. With these crops it may be necessary to allow the seed to 'temper' under high humidity conditions prior to processing.

Different kinds of seed can be separated when they differ in one or more physical characteristics. Physical characteristics now used to separate seed include:

Size: Seed differing in size, or width and thickness, can be separated with the air-screen cleaner or width grader.

Length: Seed of the different length can be separated with disc or indented cylinder separators.

Weight: Seed of different specific gravity can be separated with gravity tables, aspirator, and other air separators.

Shape: Round and flat seed can be separated with the spiral separator or draper belt. Surface

Texture: Rough-surfaced seed can be separated from smooth seed with fabric covered rolls (dodder mill) or inclined moving belts.

Colour: Large seed differing in colour can be separated electronically.

Affinity for liquids: The coats of some seed will absorb water, oils, etc., and become sticky,which provides a means of separating seed on the Buckhorn machine or the magnetic separator. Electrical conductivity: Seed differing in their ability to conduct an electrical charge can be separated with electrostatics separator.

After he has determined the most effective differences between crop seed and the undesirable material, the processor selects the machines that can separate seed by using. these differences. Then, as the seed flow through the machines, he must change its action by altering its settings to get the combination of adjustments that gives the greatest separating efficiency.

Preparing seed for processing:

Seed generally contains contaminants of various kinds as it comes into the processing plant. To get the seed into condition to flow easily through the processing operations, to improve capacity and separating precision during processing, and to prevent losses of quality, seed usually must be prepared for processing by sending them through one or more special machines or processes.

Excessive trash in the field-run seed interferes with proper processing, and slows down capacity. A scalper can be used to rough-clean seed when trash content is high. If seed have hulls, hard seed coats, beards, excessive glumes, or occur in clusters, a huller scarified or a debearder may be used. A Sheller must be used for ear maize; a dryer is essential when seed have high moisture content.

Basic Cleaning:

Basic seed cleaning refers to actual cleaning and grading of seeds. Unlike pre cleaning/conditioning, which may or may not be required, basic seed cleaning is an essential process in the seed cleaning operations. Many kinds of seeds can be completely cleaned and made into a finished product by basic cleaning.

Principle of Cleaning:

The separation of undesirable material and seeds from desirable seeds in an air screen machine is done on the basis of differences in seed size and weight. In some separation, seed shape could also be used. The air screen machine uses three cleaning elements.

1. **Aspiration:** The light seeds and chaffy material is removed from the seed mass through aspiration.
2. **Scalping:** In this operation, the good seeds are dropped through screen openings, but the larger material (trash, clods, etc.) is carried over the screen into a separate spout.
3. **Grading:** In this operation, the good seeds ride over screen openings, while smaller particles (undersized, cut, shrivelled, broken seeds) drop through.

Screen Opening:

Screens, in an air screen machine, perform both scalping and grading operations. They separate crop seed from foreign material, other crop seed and weed seed. Screens are constructed of either perforated sheet metal, or woven wire mesh. Openings in the perforated metal sheet may be round, oblong or triangular. Opening in wire mesh screens are square and rectangular. Screens are available in various sizes, each identified by a number indicating its size and shape.

Material handling equipment in seed processing plant:

Mechanical handling equipment is used to convey or transport materials from one place to another by mechanical means. It reduces the drudgery of human labour and at the same time increases the efficiency of machines installed in a processing queue.

The most popular types of mechanical handling devices for grain handling are:

1. Belt Conveyor
2. Bucket elevator
3. Screw conveyor
4. Pneumatic conveyor

Planning the plant layout:

Efficient arrangements of machines in the processing greatly reduce the costs of processing seed, as well as increases processing capacity. Seed plant layout varies according to crops handled and the elevating system used, but complete processing of the any seed follows the same general steps. A typical processing plant follows the following sequence of the operations-

1. Receiving
2. Bulk Storage
3. Conditioning or pre-cleaning to speed up flow of grain
4. Cleaning (normally with the sir screen cleaner)
5. Separating and upgrading (by relevant machines)
6. Treating to control seed-borne diseases and insects to provide protection to seedling in the field.
7. Drying and bagging
8. Storage and shipping

Seed processors, in their efforts to lower processing and handling costs, have developed two main systems of seed plant design; these are multi-storey and single-storey plants.

Multi-storey plants:

Multi-storey processing plants have been used for years in many countries. Seed are carried by elevator to the top floor and are emptied into large holding bins. Cleaning machines are placed in a vertical series on lower floors, and seed flow one machine down into the next by gravity. Processing is completed and seed are bagged off on the bottom floor.

Single-storey plants:

Most modern plants in India are being built with all cleaning equipment mounted on a single level or on platforms on the same floor. In the single-storey plants, seed are moved from one machine to the next by elevators placed between the machines. One man can supervise a single-level processing plant without running up and down stairs. Conveyors are often used to move seed horizontally on this system.

Layout variations:

Variations of the single-storey plant, or combinations of part multi-storey and part single-storey arrangements, are useful variations of plant layout systems. A popular arrangement places the air-screen cleaner on an upper level, while all other machines are: on a single level below the air-screen cleaner.

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Detection of Seed-borne Pathogens & their Management

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The Seed-borne diseases are one of the most important factors for low yield of crops, they also causes losses in terms of seed quality and quantity such as weight, shape , size, colour, odour, reduce market value and changes in starch, protein and oil content thereby reducing the commercial and processing value. The microflora associated with the seed reduces the germination and seedling vigour index. They are responsible for seed rot, seedling blight, root/stem rot as well as foliar infection. The major objectives of seed health testing are as follows :

1. Evaluation of planting value of seed samples.
2. Testing for seed certification
3. Testing for seed treatment
4. Testing for quarantine
5. Testing for advisability for feed or food.

Choosing Seed Health Testing Methods:

More than one method may be available for detection of a particular seed-borne pathogen. The selection of method depends upon the purpose of the test i.e., whether the seeds are to be tested for certification, seed treatment, quarantine etc. If for quarantine purpose, then highly sensitive methods are preferred because it is important to even traces of inoculum.

Testing Methods for Seedborne Fungi

1) Examination of dry seeds:

Certain fungi can be detected by direct observations of dry seeds or by using a stereo-binocular bright field microscope or hand lenses to detect seed discolorations, morphological abnormalities or fungal fruiting structures associated with the seeds.

a) Seed discolouration:

Discoloration of the seed coat in certain crop seed can be due to fungal infections. For example 1) Purple discolouration of soybean and guar seed coat is due to *Cercospora kikuchii*. 2) Black spots and blemishes on seed coat of soybean may be due to *Macrophomina phaseolina*. 3) *Alternaria alternata* causes black point of wheat. 4) *Drechslera oryzae* cuases dark brown to black spot on entire seed *surface of rice. 5) Red discolouration of rice kernels is caused by Epicoccum nigrum* 6) *Fusarium equiseti* and *Macrophomina phaseolina* causes gray to brown wrinkled seeds in mung bean.

b) Morphological abnormalities:

Abnormal shape and reduction in seed size can be caused by fungal infection. For examples 1) *Septoria nodurum* and *Septoria triticale* cause shriveling of wheat seed. 2) Alfalfa seed infected with *Ascochyta imperfecti* are light weight, dark and shriveled.

c) Mixed fungal fruiting structures:

Fungal fruiting structures such as sclerotia of *Clavicep fusiformis* (ergot of pearl millet) and *Sclerotinia sclerotiorum* (white rot of legume and sclerotial rot of cabbage) are found mixed with healthy seeds.

d) Observations using Bright Field Microscope:

Observing a seed under a steriobinocular reveals the presence of chlamydospores, oospores, spores etc. on seed surface, Seed-borne infection of the following diseases can be determined by using this observation for examples. 1) Karnal bunt of wheat (*Tilletia indica*) 2) Wheat flag smut (*Urocystis agropyri*), 3) Rice bunt (*Tilletia barclayana*), Loose smut of sorghum (*Sporisorium cruentum*), grain smut of sorghum (*Sporisorium sorghi*, Long smut of sorghum (*Tolyposporium ehrenbergii*) and pearl millet smut (*T. penicillariae*)

e) Observing seeds under Near Ultra Violet Light:

Observing seed under NUV light without treatment can detect seed infection of some fungi. Fluorescence is an assumptive test. Pea seeds infected with *Ascochyta pisi* and *Stemphylium botryosum* exhibit yellow green and dull orange fluorescence, respectively under NUV.

f) Examination after softening or soaking seeds:

This method is useful for detecting fungal infections in which spores are liberated into water after soaking. Submerging cereal seeds in water or other solution allows for liberation of spore masses from pycnidia. A slime layer on the water surface is examined for conidia. Fusarium infected soybean seeds when immersed in water swell more rapidly than non infected ones, since water penetrates easily through the injured testa.

g) Washing Test:

This test is used for detecting seed-borne fungi carried as spores on seed surfaces. The method provides quick results but in only useful for detection of those pathogens which adhere to the seed surface in the form of easily identifiable spores. Therefore, it does not have a wide application. A fixed number of seeds are placed in a flask containing detergent in sufficient water for soaking i.e. 1 gm seed in 10 ml of water and then flask is shaken on mechanical shaker for 10 min. The process is repeated if necessary. The suspension is centrifuged at 2500 to 3000 RPM for 10 to 15 minutes. The supernatant is decanted and sediment (pellet) is suspended in 2 ml of water. Then drops are examined under compound microscope. This method is quick and can be adopted for detecting chlamydospores, Oospores, smut spores and conidia of Alternaria, Cephalosporium, Curvularia, Drechslera, Fusarium, Peronospora and Pyricularia.

h) Incubation Methods:

There are two incubation methods i.e. blotter and agar plate are recommended by ISTA for routine examination of crop seeds for fungal infection. These tests are effective for detecting most seed-borne fungi.

A) Blotter Method:

The blotter test is a simple and inexpensive means of detecting pathogens and other microorganisms associated with seeds. The basic principle in this, method is to provide a high level of relative humidity and optimum light and temperature conducive for fungal development. A container capable of transmitting light such as plastic culture plates or zinc trays is used.

Protocol:

1. Blotters are soaked in distilled or sterilized water and placed in three layers in transparent plastic petri plates after draining off excess of water.

2. A fixed number of seeds per plate are placed in equidistant from one another under aseptic conditions. Large seeds such as maize, chickpea, pigeon pea, and soybean are placed at 10 seeds per 9 cm culture plate while 25 seeds are used for smaller seeds like sorghum, wheat and pearl millet.
3. After planting the seeds, the Petri plates are incubated for 7 days at 20 ± 2^0 C under near ultraviolet light (NUV) or fluorescent light with an alternate cycle of 12 hrs. Light and 12 hrs. darkness in an incubation room
4. The seeds are examined on 8^{th} day under steriobinocular microscope.
5. The fungi are identified mostly on the basis of morphological characters of conidia, conidiophores and fruiting structure**.**

B) 2, 4-D Blotter Method:

Due to germination of seeds in blotter method the seed coats are lifted at different levels which make the seed examination for associated fungi difficult. To overcome this problem the blotters are dipped in 0.1 to 0.2 per cent solution of sodium salt of 2, 4- dichlorophenoxyacetic acid in water e.g. *Pyricularia oryzae* in paddy seeds.

C) Deed freeze blotter method:

The seeds are plated as in standard blotter method and incubated for 24 hours at 20 ± 2^0 C as usual. Then plates are incubated at - 20^0 C in dark for next 24 hours. Again plates are kept back under original conditions for 5 days. This test is better for detection of *Cephalosporium acremonium* and *Fusarium moniliforme* associated with maize seed and also for *Colletotrichum dematium* of capsicum seed and *Alternaria padwickii* of paddy seeds.

D) Agar plate Method:

This method is used for identification of microorganisms based on growth and colony characteristics on nutrient medium. Two nutrient agar media i.e. 1) Malt Extract Agar (MEA) 2) Potato Dextrose Agar (PDA) are suggested for seed health testing by ISTA. Surface disinfection is essential if non selective medium is used.

Protocol:

1. Prior to plating, the seeds are treated with 1 % sodium hypochlorite (NaOCI) solution for 5 minutes to prevent saprophytic fungi development.
2. The seeds are placed in petri dishes containing PDA or MEA.
3. Then seeds are placed at equidistant per 9 cm plate.
4. Plates are incubated at 20 ± 2^0 C with an alternate cycle of 12 hr light and 12 hr darkness in an incubation room.
5. The seeds are examined on 5th and 8^{th} day of incubation.
6. Identification is based on microscopic observations i.e. colony colour and spreading habit of fungi.

5) Seedling symptom test:

The test is based on the distinguishing symptoms produced by seedborne fungi on growing seedlings under controlled conditions. The test is used for obligate as well as other pathogens which can produce symptoms on seedlings. Seeds are planted in sterilized crushed bricks, soil, sand, agar, towel paper and blotter. It is used for post entry quarantine control and testing the efficacy of seed treatment fungicides.

A) Hiltner's brickstone Method:

Sterile crushed brickstone pieces of 3-4 mm size are used in a container. One hundred cereal seeds are planted well spaced and covered with the same material up to 3 cm. sterile water is used for providing required moisture. The containers are placed in darkness at room temperature; seedlings are examined after two weeks for disease symptoms. Sterile gravel, sand and soil can also be used. Wooden boxes, cardboard boxes, iron or wooden trays, earthen pots of various sizes can be used for this test.

B) Rolled paper towel test:

This method is used for determining germination in seed testing laboratories. Pathogens that cause seed decay, seedling blight or seedling abnormalities can be detected. Two paper towels together, moistened with water, placed on wax paper and seeds are placed at equal distance. Another moist paper towel spread over the seeds. The lower 5 cm is turned over, the whole unit is rolled up and rubber bands are applied. The rolls are placed in a basket / tray in upright standing position and incubated at required temperature. The rolls are opened and seeds and seedlings are examined for disease symptoms and fungi.

C) Test tube agar method:

Culture tubes (160 x 16 mm) are filled with 10 ml 1% water agar and solidified to have slight slant. One seed is placed in each tube and incubated at required temperature needed for the pathogen and host under NUV or day light tubes within 12 hrs. alternate cycles of light and dark periods. Tubes are covered with an aluminium foil to retain moisture. The foil is removed when seedling reach the top. The required time for symptom expression depends upon the pathogen and host which is 10 to 14 days. In case of anthracnose, acervuli are formed on hypocotyls in legumes, where as in case of *Macrophonina phaseolina*, pycnidia are formed on hypocotyls. In case of wheat characteristic symptoms develop at the base of coleoptiles.

6) Histopathological techniques:

The exact location of the pathogen in the seed and it's further development is examined by histological techniques. Usually seeds are soaked in water, the soft seeds are processed for making blocks in way and microtomy is done. The sections are stained and examined. The seeds are also cut through cryostat microtome to avoid lengthy process. e.g. Hyaline hyphae stain blue with cotton blue, if highly pigmented the cell wall stain brown and cytoplasm blue.

7) Embryo Count Method:

The inoculums of few fungal diseases can be detected in embryos. i.e. loose smut of wheat (Ustilago segatum var. tritici) and loose smut of barley (Ustilago segatum var. nuda) .

Protocol:

The embryo count method as described in Working Sheet on Seedborne Disease – Loose Smut of Wheat (working sheet No.) prepared by Guar and Agarwal (1995) and published by National Seed Project (Crops)

- Soak 100 g - 120 g. of seeds to have 2300-2500 seeds depending on the 1000 grain weight of the variety in 5 per cent sodium hydroxide (NaOH) solution containing 0.02 per cent Trypan blue for 20 h at room temperature (25-24^{0}C)
- Pass the soaked material through 10 mesh sieve and retain the material in a 20 mesh sieve along with showers of hot (60^{0}C) water. (Fig. 3)
- Collect the extracted embryos in a beaker.
- Dehydrate the embryos in rectified spirit for 5-10 min.

- Take the dehydrated embryos along with chaff etc. in a beaker containing 50 ml of lactophenol (lactic acid + Phenol + Water)
- Add 100 ml water in the beaker and stir.
- Allow the material to stand for 5 min to settle the chaff at bottom.
- Collect the floating embryos in another beaker containing 25 ml fresh lactophenol.
- Warm the above material for 2 min.
- Pour the embryos in a grooved Petri dish and arrange in lines along with some lactophenol.
- Observe the embryos under stereobinocular microscope for the presence of mycelium.
- Mycelium appears a blue / light pinkish thread like knotted structure in the scuttellum of the embryo.
- Examine as far as possible all the extracted embryos. Count the total number of embryos including the infected ones.
- Calculate the number of embryos infected with the mycelium of *Ustilago segetum* and report the loose smut infection in percentage up to two decimal places.

8) Fluorescent Technique:

Some of the pathogens can be detected by fluorescent technique, though its scope is rather limited. Pea seeds infected with *Ascochyta pisi* emit a yellow-green fluorescence; wheat seeds infected with *Septoria nodorum* produce greenish fluorescence. This technique can also be used for identifying teleutospores of *T. tritici* and *T. controversa*. However, the presence or absence of fluorescence is not confirmed result and can be taken only as a supplementary test.

9) Biochemical Method:

The extent of fungal colonization of a given sample can also be determined by estimating ergosterol. It is major sterol component present exclusively in fungi could be an indicator of fungal growth in contaminated seeds. The ergosterol analysis by using HPLC is more rapid and sensitive technique to determine fungal biomass in infected seeds.

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Post Harvest Quality Control, Packaging and Labeling of Seed Lots

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Seeds are uniquely equipped to survive as viable regenerative organisms until the time and place are right for beginning of a new generation; like any other form of life, they cannot retain 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 seeds of most species are able to survive much longer under the proper conditions.

GENERAL SEED CERTIFICATION STANDARDS

The General Seed Certification Standards are applicable to all crops which are eligible for certification, and with field and seed standards for the individual crops, shall constitute the Minimum Seed Certification Standards. The word 'Seed' or 'seeds' as used in these standards shall include all propagating materials.

Purpose of Seed Certification:

The purpose of seed certification is to maintain and make available to the public, through certification, high quality seeds and propagating materials of notified kind and varieties so grown and distributed as to ensure genetic identity and genetic purity. Seed certification is also designed to achieve prescribed standards.

Certification Agency:

Certification shall be conducted by the Certification Agency notified under Section 8 of the Seeds Act, 1966.

Certified Seed Producer:

Certified seed producer means a person/organization who grows or distributes certified seed in accordance with the procedures and standards of the certification.

Eligibility Requirements for Certification of Crop Varieties:

Seed of only those varieties which are notified under Section 5 of the Seeds Act, 1966 shall be eligible for certification.

Classes and Sources of Seed:

Breeder Seed:-

Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of Foundation seed.

(a) Breeder seed shall be genetically so pure as to guarantee that in the subsequent generation i.e. certified Foundation seed class shall conform to the prescribed standards of genetic purity. The other quality factors of Breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis. The Breeder seed shall be packed and supplied by the breeders in the form and manner given below:

LABELLING OF BREEDER SEED

1. Breeder seed shall be supplied in sealed containers, duly stitched and sealed. A cloth-lined label of 12 cm x 6 cm containing following information shall be fixed on the container.

		Label No.
Crop		
Variety		
Class of seed	Breeder Seed	
Lot No.		
Date of test		
*Pure seed	%	
*Inert matter	%	
*Germination	%	
**Oil content	%	
Producing Institution (name and address)		

*Based on actual.
**It shall be applicable for sunflower crop only.
'The container should also have printed on it and the kind, variety and name of Institution'

2. The label shall be rubber-stamped with signature, name and designation of the concerned breeder. Colour of the label shall be Golden Yellow No. 356 (IS:5-1978)

3. Every breeder/breeding institute shall maintain the account of labels printed and issued.

Certified Seed:-

Certified seed shall be the seed certified by Certification Agency notified under Section 8 of the Seeds Act, 1966 or seed certified by any Certification Agency established in any foreign country provided the Certification Agency has been reorganized by the Central Government through notification in the Official Gazette. Certified seed shall consist of two classes, namely, Foundation and certified seed and each class shall conform to the following description:

1. Certified Foundation seed shall be the progeny of Breeder seed, or be produced from Foundation seed which can be clearly traced to Breeder seed. Thus, Foundation seed can even be produced from Foundation seed. During the production of certified Foundation seed, the following guidelines shall be observed:

(a) Certified Foundation seed produced directly from Breeder seed shall be designated as Foundation seed stage-I;
(b) Certified Foundation seed produced from Foundation seed stage-I shall be designated as Foundation seed stage-II;
(c) Certified Foundation seed stage-II will not be used for further increase of Foundation seed and shall be used only for production of Certified seed class;
(d) Minimum Seed Certification Standards shall be the same for both Foundation seed stage-I and II unless otherwise prescribed;
(e) Certification tag shall be of white colour for both Foundation seed stage-I and II and shall contain the information as to its stage;
(f) Production of Foundation seed stage-II shall ordinarily be adopted in respect of such crop varieties provided, when it is expressly felt by the Certification Agency that Breeder seed is in short supply;

(g) Production of Foundation seed stage-II may be adopted for the following group of crops:
- vegetatively propagated crops;
- apomictically reproduced crops;
- self-pollinated crops;
- often cross-pollinated and cross-pollinated crops, these being gene – pools should not loose their genetic identity and purity if measures to safeguard the same are adequately taken;
- composite and synthetics;
- parental line increase of hybrids.

2. Production of Foundation seed stage-I and II shall be supervised and approved by the Certification Agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to conform to certification standards specified for the crop/variety being certified.

3. (a) Certified seed shall be the progeny of Foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to standards prescribed for the crop being certified;

(b) Certified seed may be the progeny of Certified seed provided this reproduction does not exceed three generations beyond Foundation seed stage-I and

- it is determined by the Certification Agency that genetic identity and genetic purity will not be significantly altered;
- and when the Certification Agency is satisfied that there is genuine shortage of Foundation seed despite all the reasonable efforts made by the seed producer.

(c) Certification tag shall be of blue colour (shade ISI No. 104 AZURE BLUE) for certified seed class.

(d) Certified seed produced from Certified seed shall not be eligible for further seed increase under certification. Certification tags for such production which is not eligible for further seed increase under certification shall be super scribed with, "not eligible for further seed increase under certification".

Phases of Seed Certification:

Certification shall be completed in six broad phases listed as under:

(a) receipt and scrutiny of application
(b) verification of seed source, class and other requirements of the seed used for raising the seed crop;
(c) field inspections to verify conformity to the prescribed field standards;
(d) supervision at post-harvest stages including processing and packing;
(e) seed sampling and analysis, including genetic purity test and/or seed health test, if any, in order to verify conformity to the prescribed standards; and
(f) grant of certificate and certification tags, tagging and sealing.

Establishing Source of Seed:

The individual intending to produce seed under certification shall submit to the Certification Agency, one or more relevant evidence such as certification tags, seals, labels, seed containers, purchase records, sale records etc., as may be demanded by the Certification Agency during submission of the application, its scrutiny and/or during first inspection of the seed crop, in order to confirm if the seed used for raising the crop has been obtained from the source approved by it and conforms to the provisions contained in para V. This requirement also applies to both parents in seed production involving two parental lines.

Field Area for Certification:

There is no minimum or maximum limit for the area offered by a person for certification, provided the certified seed production meets all the prescribed requirements.

Unit of Certification:

For the purpose of field inspection, the entire area planted under seed production by an individual shall constitute one unit provided:

(b) it is all under one variety;
(c) it does not exceed ten hectares;
(d) it is not divided into fields separated by more than fifty meters between them;
(e) it is planted with or is meant to produce seed belonging to the same class and stage in the generation chain;
(f) the crop over the entire area is more or less of the same stage of growth so that observations made are representative of the entire crop;
(g) the total area planted, by and large, corresponds to the quantity of seed reported to have been used; and the Certification Agency's permission had been obtained to sow a larger area by economizing on seed rate; if that the case;
(h) raised strictly as a single crop and never as mixed;
(i) not so heavily and uniformly lodged that more than one third of the plant population is trailing on the ground leaving no scope for it to stand up again thus making it impossible for the Certification Agency to inspect the seed crop at the appropriate growth stage in the prescribed manner;
(j) as far as possible, so maintained as to show adequate evidence of good crop husbandry thereby improving the reputation for certified seeds; and
(k) not grown as inter, companion or ratoon crop unless otherwise specified in **Appendix-II**.

Appendix-II

CONDITIONS FOR INTER-CROPPING DURING CERTIFIED SEED PRODUCTION OF OILSEEDS AND PULSES

(i) Inter-cropping will be applicable to oilseeds and pulses crops only for production of certified seeds class. The foundation seed class shall be raised strictly as a single crop only;

(ii) Other types of cropping patterns such as mixed cropping etc. will not be permitted;

(iii) The crops selected for inter-cropping should belong to different genus and preferably with different maturity;

(iv) Only basic crop (Seed Crop) pertaining to oilseeds or pulses as the case may be will be registered for certification and companion crop will not be eligible for certification.

(v) It should be ensured that the number of rows of seed crop alternating with the companion crop are uniform throughout the field;

(vi) The Certification Agencies will prepare a list of the crop combinations which may be followed in respective States. The list so prepared will be circulated among the seed producers in advance. At the time of deciding the crop combinations, the Certification Agencies will ensure that :

(a) the companion crop does not hamper the operation needed for seed crop;
(b) it does not starve the seed crop of nutrients and moisture;

(c) it does not mature simultaneously with the seed crop or it does not carry weed seeds which may mix with the seed crop at maturity;
(d) it does not have common pests and diseases; and
(e) it does not render certification work difficult.

Use of Chemical Hybridizing Agents ('CHAs'):

(a) In case of hybrid seed production, the seed producer can use proper Chemical Hybridising Agents ('CHAs') on seed parent (female line) in order to induce male sterility. Consequently the Minimum Seed Certification Standards specified for production of 'A' and 'B' lines shall not be applicable for the relevant hybrid.
(b) The hybrid seed produced through the application of 'CHAs' shall be compulsorily subjected to grow-out test as a pre-requisite for grant of certificate.

Field inspection:

(a) The field inspection work which requires technically-trained personnel, shall be performed by the persons who have been so authorized by the Certification Agency;
(b) Field inspection meant to verify those factors which can cause irreversible damage to the genetic purity or seed health shall be conducted without prior notice to the seed producer;
(c) Soon after the completion of the field inspection, a copy of the report shall be handed over to the seed producer or his representative.

Re-inspection:

Seed fields not conforming to prescribed standards for certification at any inspection, the Certification Agency shall, upon the request of seed producer and after he removes the sources of contamination in the seed field and within the prescribed isolation distances and/or the contaminated plants in the seed field (if so directed by the Certification Agency perform one or more re-inspections provided such removal can ensure conformity of the seed crop to the prescribed standards and provided further that no irreversible damage has been caused to the quality of seed by the contaminant(s). The Certification Agency may at its discretion, also perform one or more re-inspections over and above the minimum number of inspections prescribed, if considered necessary.

Harvesting, Threshing and Transportation:

Seed crop meeting field standards for certification shall be harvested, threshed and transported to the seed processing plant in accordance with the guidelines issued by the Certification Agency. During these operations, seed producer will take all precautions to safeguard the seed from admixture and other causes of seed deterioration.

Bulking:

Bulking of unprocessed seed stocks to obtain larger homogeneous seed stocks may be permitted by the Certification Agency provided the stocks to be bulked meet the following requirements.

- belong to the same certified seed producer;
- belong to the same crop, variety, class of seed and stage in the generation chain;
- were produced in the same season and under similar agro-climatic conditions;
- were subjected to certification by the same Certification Agency;
- have more or less similar physical appearance and levels of moisture;
- are adequately homogenous in composition.

Seed Processing and Packing Schedule:

The Certification Agency shall prepare and communicate seed processing and packing schedule to all certified seed producers soon after the certification of seed crops at field stage. The seed producers shall adhere to the schedule specified by the Certification Agency. However, re-scheduling may be accepted by the Certification Agency on the request of seed producer on genuine grounds.

Seed Lot:

A seed lot is a physically identifiable quantity of seed which is homogeneous.

Lot Size:

A seed lot would represent any quantity of agricultural seeds upto a maximum of 20,000 kilogram's for seeds of the size of rice or larger (except maize seed, seed potato, sweet potato, yams, taro and chow-chow for which the maximum size of the lot may be 40,000 kilogram's) and 10,000 kilogram's for seeds smaller than rice subject to a tolerance limit of 5.0%. The quantities in excess of the above maximum limits shall be sub-divided and separate lot identification shall be given.

Construction of Seed Lot Number:

Each seed lot shall be assigned a specific number in order to facilitate maintaining its identity, tracing back to its origin, handling in stores, transit etc., accounting and inventory maintenance and referring/communicating about a certain quantity of seed.

PROCEDURE FOR CONSTRUCTION OF LOT NUMBERS

The lot number will have four parts. Each part will signify and conform to the details given as under:

1. **First Part:**

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

Month	Abbreviated form
January	JAN
February	FEB
March	MAR
April	APR
May	MAY
June	JUN
July	JUL
August	AUG
September	SEP
October	OCT
November	NOV
December	DEC

2. Second Part:

This shall be called the "Production Location Code" and will indicate the State or Union Territory, where the concerned seed field(s) was/were located. For this purpose, each State and Union Territory is allotted a permanent numerical.

3. Third Part:

(a) This shall be called the "Processing Plant Code" and will indicate the seed processing plant where the relevant lot was processed. For this purpose, the Certification Agency shall allot a numerical commencing from 01 to each seed processing plant within its jurisdiction irrespective to whom it belongs.

(b) In crops like groundnut, potato, sweet potato, tapioca etc. which may not be brought to the processing plant for post-harvest operations including grading, sorting, packing etc. the individual centre where such operations are carried out will be treated as a "Processing Plant" for assigning the Processing Plant Code.

4. Fourth Part:

This shall be called the "Seed Produce Code". It will indicate ultimate serial number of an individual lot. The procedure for assigning this code will be based on unit of certification. For this purpose, the Certification Agency shall allot a numerical commencing from 01 to each unit of certification. However, if seeds of more than one unit are bulked together then bulked unit will be treated as one unit. If the quantity of the seed from one unit of certification exceeds the maximum limit of lot size, it will be further sub-divided into a separate lot, in such cases Roman numerical commencing from (i) will be suffixed with seed produce code within brackets, for example if 586 quintals wheat seed is obtained from one unit of certification, it will necessitate the sub-division of the produce into three separate lots (200, 200 and 186 qtls.) if 01 is allotted to "Seed Produce Code", then sub-divided lots will be represented as 01 (i), 01(ii) and 01(iii).

5. All the four parts of the lot number shall be written in series with a 'dash (-)' between first, second, third and fourth parts to distinctly indicate the code number of each part. An example is shown below:

Lot No. --- MAY 88-12-01-01

MAY 88 --- Seed harvested in May 1988.

12 --- Seed crop raised in Madhya Pradesh

01 --- Seed processed in a processing plant identified as number 01 by the Madhya Pradesh State Seed Certification Agency.

01 --- Seed Produce Code which will trace to the particular unit of certification.

Seed Processing:

Seed processing means cleaning, drying, treating, grading and other operations which will improve the quality of seeds. Seed from fields which conformed to the standards of certification at field stage shall, as soon as possible after the harvest will be brought at processing plant for processing. The screen aperture size specified in **Appendix-VII** and **VIII** shall be used for cleaning and grading of seeds so that typical contaminants such as weed seeds, small seeds, damaged seeds, broken and shriveled seeds, straw, chaff, leaves, twigs, stones, soil particles etc. are removed. However, the Certification Agency is authorized to deviate under exigencies to use the screen of small aperture size than specified. In such cases, the Certification Agency shall record the reasons for reduction in the aperture of the screen. Processed seed shall not have seed of the size lower than the bottom screen used beyond 5.0% (by weight).

Seed Treatment:

When a variety, seed of which is under certification is susceptible to a seed borne disease organism or when seed under certification is carrying a seed borne pathogen and a seed treatment is available which may control the disease or pathogen when properly applied, the Certification Agency may require such seed to undergo such treatment before Certification. In case seed is required to be treated before sowing by the user, the chemical calculated at the recommended dose shall be kept in a plastic packet and placed inside the seed container with complete direction and precautions required for treating of the seed. The information about the treatment shall also be displayed on seed containers. If the seeds have been treated, the following instructions shall also be complied with:

(a) a statement indicating that the seed has been treated;

(b) the commonly accepted chemical or abbreviated chemical name of the applied substance; and

(c) if the substance of the chemical used for treatment and present with the seed is harmful to human beings or other vertebrate animals, a caution statement such as "Do not Use for Food; Feed or Oil purposes". The caution for mercurials and similarly toxic substances shall be word "POISON" which shall be in type size, prominently displayed on the label in red.

Samples and Sampling of Seeds:

Soon after completion of the seed processing or after seed treatment as the case may be, the Certification Agency shall draw a representative composite sample as per procedure specified in Seed Testing Manual. The quantity of seed samples so drawn shall be sufficient to provide three samples of the size of submitted sample. The composite sample will be divided into three equal parts, and one shall be sent for analysis to a notified Seed Testing Laboratory, the second part to the seed producer and retain the third part as a guard sample.

Seed Analysis Report:

The Seed Testing Laboratory shall analysis the seed samples in accordance with the prescribed procedure and deliver the Seed Analysis Report to the Certification Agency as soon as may be, but not later than 30 days from the date of receipt of the samples unless the seed is subjected to such tests which require more than 30 days for completion of the test.

Seed Standards of Genetic Purity:

(a) All certified seed lots shall conform to the following Minimum Standards for genetic purity unless otherwise prescribed:

Class	Standards for Minimum Genetic Purity (%)
Foundation	99.00
Certified:	
(i) Varieties, composites, synthetics & multilines	98.00
(ii) Hybrids	95.00
(iii) Hybrids of cotton, TPS, muskmelon, brinjal &tomato	90.00
(vi) Hybrid castor	85.00

(b) ***Grow-out Test:***

The Certification Agency shall conduct grow-out test to determine genetic purity of a seed lot whenever it is a pre-requisite for grant of the certificate and also on the seed lots where a doubt has arisen about the genetic purity.

Re-cleaning, Re-sampling and Retesting:

When a seed lot does not meet the prescribed seed standards, the Certification Agency on the request of seed producer may permit re-cleaning, re-sampling and retesting. The re-cleaning, re-sampling and retesting shall be permitted only once.

Seed Standards for Insect Damage:

A seed lot under certification shall not have apparent or visible evidence of damage by insects for both Foundation and Certified seed classes in excess of 1.0% for the seeds of maize and legumes and 0.50% for the seeds other than maize and legumes unless otherwise prescribed.

Seed Moisture Content:

Seed standards in respect of seed moisture shall be met at the time of packing of seed.

Downgrading of Seed Class:

If a seed field or a seed lot is not found meeting prescribed standards for the class for which it has been registered but conforms to the prescribed standards to the immediate lower class, the Certification Agency may accept such seed fields/seed lots for certification to the immediate lower class provided request has been made to this effect by seed producer. However, downgrading of the seed class shall not be applicable in case of hybrids and their parents.

Specification of the Certification Tag

SPECIFICATION FOR CERTIFICATION TAG

Length: 15 cm
Breadth: 7.5 cm

Quality---it shall be made of durable material such as thick paper, paper with cloth lining, wax coated paper, plastic coated paper etc.

Colour—Both sides shall be white for Foundation class and blue (ISI No.---Azure blue) for Certified class.

Contents and layout

TAG No…………………..	CA's	Certified Seed
KIND……………………..	EMBLEM	Class of seed………………..
		Certificate No………………
		Date of issue of
Variety…………………….	Name & Address of	Certificate………………….
	Certification	Date of test…………………
Lot No………………………	Agency	
"Use of the seed after expiry of the validity period by any person is entirely at his risk and the holder of the certificate shall not be responsible for any damage to the buyer of seed. No one should purchase the seed if seal or the certification tag has been tempered with"		Certificate valid up to…………………….. (Provided seed is stored under cool and dry environment)
		Validity of certificate further extended upto
Name and Full Address of the Certified Seed Producer……………………………………		………………………….

N.B. If tag is to be affixed on a smaller container then the size of the tag may be reduced proportionately. However, length and breadth ratio and contents would remain the same.

(CA's: Certification Agency's)

Packing, Tagging, Sealing and Issuance of the Certificate:

(a) On receipt of Seed Analysis Report and the results of the grow-out test wherever prescribed, and if seed lot has met prescribed standards, the Certification Agency shall ensure packing, tagging and sealing and issuance of certificate expeditiously. An authorized official of the Certification Agency shall endorse the signature on the reverse of each certification tag and shall affix rubber stamp indicating the official's name and designation. Containers to be used for packing of the certified seeds shall be durable and free from defects.

(b) Advance tagging may be permitted at the discretion of the Certification Agency with proper safeguards.

Refusal for Certification:

The Certification Agency shall have the authority to refuse certification of any seed production field or any seed lot that does not conform to the Minimum Standards prescribed for that particular crop, either for field or for seed or for both. Such refusal will be subject to any appeal made to the Appellate Authority constituted under Section 11(1) of the Seeds Act, 1966.

MODEL COMPOSITION OF THE APPELLATE AUTHORITY

The Appellate Authority	All State Governments/Union Territories which have established the Certification Agency under Section 8 of the Seeds Act, 1966 shall invariably constitute an Appellate Authority under Section 11 of the Seeds Act,1966.
Composition	The Appellate Authority shall consist more than one member preferably three members to represent such interests as the State Government think fit, of whom at least one person shall be representative of seed producers.

Term of the Appellate Authority	The members of the Appellate Authority shall, unless their seats become vacant earlier by resignation, death or otherwise, be entitled to hold office for three years.
Decision	The Appellate Authority should ensure that decision on the appeals filed is taken expeditiously.

Validity Period of the Certificate:

The validity period shall be nine months from the date of test at the time of initial certification. The validity period could be further extended for six months provided on retesting seed conforms to the prescribed standards in respect of physical purity, germination and insect damage for all seeds except vegetatively propagating material for which lot shall be re-examined for seed standards specified for respective crop. A seed lot will be eligible for extension of the validity period as long as it conforms to the prescribed standards.

EXTENSION OF THE VALIDITY PERIOD

1. The extension of validity period of Certified seed shall be for a period of six months, at each subsequent validation as long as the seed conforms to the prescribed standards.

2. Holder of the certificate or his authorized representative may request for extension of the validity of certified seed before expiry of the previous validity period to a Certification Agency of the area in which the seed is located. He shall furnish the relevant information such as name of the crop, variety, class of seed, quantity of seed in lot, lot number, size and type of containers, number and date of certificate etc. to the Certification Agency at the time of submission of application.

3. The Certification Agency after receipt of application for extension of validity period shall verify that tags, labels and seals are intact on each seed container and arrange to draw samples and its analysis in a notified seed laboratory. The sample would be tested for physical purity, germination and insect damage.

4. If reprocessing and rebagging at the time of extension of validity is requested to a Certification Agency which has not initially certified the seed, it may be permitted provided Certification Agency is of the opinion that such operation may improve the quality of seed and seeds are not badly invaded by fungus, pest etc. Infested seed lots shall meet the conditions laid down in para XXV of the General Seed Certification Standards. Whenever such operations are undertaken a sample from each lot will be drawn before the seed containers are opened and shall be divided into three equal parts and sealed. One part shall be retained by the Certification Agency, another part by holder of the certificate or his representative and remaining sample will be sent under Registered Post to Certification Agency which had initially certified the seed. Besides this, holder of the stock shall retain at least two bags/containers for smaller packing upto 10 kg and one bag/container above 10 kg in original packing of each seed lot being validated upto the next validation or till the stock is disposed off.

5. After analysis of sample, if seed is found to conform to the prescribed standards, the Certification Agency shall extend the validity of seed for a further period of six months from the date of expiry of previous validity period or date of test, whichever is earlier. The date of test and period of validity and name of Certification Agency who has extended the validity period

must be rubber stamped on the tags affixed on the seed containers. However, if new tags are required to be issued due to reprocessing and rebagging of the seed, the information indicated on the certification tags issued at the time of initial certification and name of the Certification Agency who performed the initial certification shall be recorded on the new tags. The serial numbers of new tags used for a seed lot shall be informed to the Certification Agency who performed the initial certification. The Certification Agency shall preserve at least two tags out of the tags removed from a seed lot and ensure the destruction of remaining tags in its presence.

6. A complete record shall be maintained by the Certification Agency of each lot offered for extension of the validity period.

Revocation of Certificate:

If the Certification Agency is satisfied, either on reference made to it in this behalf or otherwise that:

(a) the certificate granted by it under Section 9(3) of the Act has been obtained by misrepresentation as to an essential fact; or

(b) the holder of the certificate has, without reasonable cause, failed to comply with the conditions subject to which the certificate has been granted or has contravened any of the provisions of the Act or the Rules made there under, then, without prejudice to any other penalty to which the holder of the certificate may be liable under the Act, the Certification Agency may, after giving the holder of the certificate an opportunity of showing cause revoke the certificate, under the provisions of Section 10 of the Act.

Retention of Certification Records:

The Certification Agency shall preserve in order all the documents including the guard samples pertaining to certification of each seed lot for two years from the date of grant/ extension of the certificate and four years in respect of rejected seed crops or lots from the date of communication of rejection unless and otherwise required for longer period.

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Seed Threshing Methods and its effect on Seed Quality

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Abstract
In India and other developing countries, common staple foods include rice, wheat, maize, sorghum, millet, and oats. Pulses like black gram, green gram, and lentil are also consumed for protein. Threshing, threshers and their impact on seed quality, thus, have great importance in Indian agricultural sector. Mechanical threshers were introduced in the 1950s and are now widely used, with around 30 million in operation in India. Multi-crop threshers in 3.7 kW capacities have been developed and commercialized, reducing total losses, power consumption, and human drudgery while ensuring quality produce. Different parameters affect performance, such as the speed of the threshing cylinder and feed rate. Rectangular spiked threshing cylinders with 600 mm tip diameter and 6 mm spike thickness gave the best results, while round spiked cylinders with 8 mm thickness delivered good output capacity and threshing efficiency with fine straw quality.
Key Points: Threshing, quality, seed, threshers, cereals, pulses, oilseed, etc.

1. Introduction

Through the Sustainable Development Goals, the global community has committed to achieving a world free of hunger by 2030. This will require the sustained production of about 60 percent more food than at present, which is both nutritious and safe, and produced in ways that do not damage the environment. Under most scenarios, there are no surplus land or water resources to deploy to increase agricultural production. The most sustainable path to this goal is through enhanced productivity sustainably. That means producing more yields with fewer external inputs. To support this, farmers need to use well-adapted crop varieties. To achieve this goal, rural housing will be particularly important for resource-poor small-scale and family farmers, who produce most of the food consumed in vulnerable communities in developing countries. The use of planting material of adapted varieties is of utmost importance.

Seed industry is a sub-sector of Indian agriculture and allied industry. Seed is the primary input in agriculture which encapsulates the genetics of Plant variety. The seed coming from the field after harvest usually contains undesirable materials that must be removed during processing to obtain clean seeds suitable for planting. Seed quality, thus, depends on the handling methods or seed processing techniques adopted during harvesting and post-harvest handling. Deterioration can occur during drying, threshing, processing, collecting, handling and transporting. Indeed, mechanical damage is a major cause of seed deterioration during harvest and post-harvest stages. Very dry seeds are prone to mechanical damage and injury (cracking and bruising), resulting in physical damage or fracturing of essential seed parts. Broken seed-coats permit early entry and easy access for micro flora, making the seed vulnerable to fungal attack and reducing its storage potential. Processing of seeds is thus very important to enhance the quality of seeds. Seed processing begins with threshing and pre-cleaning in the field. The seed is put through multiple stages of processing to turn it from raw seed to cleaned seed, which is then tested for quality characteristics before being offered to farmers as quality seed.

The primary aim of this chapter is, thus, to reveal the fundamental principles of different techniques employed for seed threshing and their impact on seed quality, considering that threshing is the primary and most significant operation carried out after the crop is harvested.

2. What is Threshing?

Threshing can be defined as the separation of seeds from spikes and straws. The process of separating grains from plants is called "threshing". This process can be carried out either in the field or in the barn, and it can be done by hand or with the help of animals or machines. Threshing must be performed with utmost care, regardless of the system used, as any carelessness can lead to breakage of the grain or protective husk. This can cause a reduction in product quality and subsequent damage due to the action of insects and fungi. It is essential to take precautions while transporting harvested crops from the field to the barn to avoid any damage.

3. Principle of Threshing

The threshing is a mechanism which separates the grain from the stalks, panicles, cobs and pods. Threshing is based on the principle that when:

(a) Some impact or pounding is given on the crops; the grains are separated from the panicles, cobs or pods.

(b) The crop mass posses through a gap between drum and concave, wearing or rubbing action takes place. This separates grains from panicles.

Thus the rupture of the bond between the grains and ears is due to the factors like: (a) impact of beaters or spikes over grains and (b0 wearing or rubbing action. The strength of bond between the grains and the panicle depends upon: crop type, crop variety, ripening phase of grain and moisture content of grain.

However, the efficiency and quality of threshing depends upon: (a) drum speed, (b) number of beaters, (c) drum size, (d) gaps between drum and concave, (e) quality and condition of plant mass fed to the thresher, (f) Direction of feeding and rate of feeding.

4. Type of Threshing

Traditionally, seeds are threshed manually or using animal power. Nowadays, mechanical threshers are also available. So, the common methods of threshing can be given as:

(A) Traditional threshing methods

The extraction of seeds from dry seed heads such as onions, lettuce, and brassicas, as well as dried fruits like chilli, pepper, and gourds, or fleshy fruits like tomatoes, cucumbers, and melons, requires careful consideration. To separate the seeds from other plant debris or straw, threshing can be done through manual methods, with animals, or mechanically. Hand threshing is the simplest and most cost-effective method if enough labor is available. Beating or rubbing the seeds against a solid wall or on the ground with a sickle or flail can do this. The thickness or depth of the plant material being threshed should be adequate to prevent damage to the seeds.

(1) Manual Threshing

Farmers repeatedly beat the crop on the floor with flax or other wooden objects to separate the seeds from the thorns and chaff. Manual threshing is labor-intensive and expensive for large quantities of seed; moreover, it may cause physical harm. Simple threshing equipment includes corn shellers and paddle-operated threshers for grain. Manual threshing for dry seed separation are: (a) Rubbing, (b) Beating, (c) Flailing, (d) Rolling, (e) Walked on, and (f) simple mechanical threshing.

Rubbing: It is rubbing of seed materials with a pressure in an open-ended trough line with ribbed rubber (bamboo contained). This method is quite suitable for pod materials such as brassicas and radish.

Rolling: Seed materials are rolled on threshing floor or tarpaulin repeatedly and seeds are easily separated.

Beating: The seed materials are beaten with the help of wooden pliable sticks repeatedly with a tolerable force as the seeds are separated but not broken.

Flailing: In this technique specially designed instruments are used for separating the seeds from the plants. e.g. Sweet corn.

Walked on method: in this method, spread on the threshing floor and children or other persons are asked to walk on the seeds materials till the seeds are separated. Seeds which have been hand threshed are usually still mixed with the plant debris and further separation is done by winnowing or sieving.

Hand threshing is, thus, a popular method used by women workers that involves using surplus local labor to thresh high-value vegetable seeds. This method is relatively simple, cost-effective, and easy to carry out. There are several ways in which hand threshing can be performed.

Animal-powered threshing

Animals (e.g. oxen or donkeys) trample on the harvested material to separate the seeds from other plant parts. Although slow, this method is gentle and results in a low level of mechanical damage to the seed.

Mechanical Threshing

However the common methods of threshing are:

(1) Manual Threshing
(2) Animal Threshing
(3) Machine threshing

(3) Mechanical threshing

Mechanical threshers are available in both stationary and mobile forms, powered either by an engine or a tractor. The primary benefit of using a mechanical thresher is that it allows farmers to perform large-scale operations in a relatively short amount of time. However, there is a risk of damaging the seeds during the process, which can be minimized by properly adjusting the machine. The machine is composed of two primary components: the cylinder (or threshing drum) and the concave, both of which are enclosed in a steel plate. The cylinder consists of serrated bars surrounding a sturdy shaft that rotates around bearings situated at each end. The concave is curved to match the cylinder and is stationary, with perforations included. Other components include outlets for seed, straw, and chaff, and some designs have fans, screens, and conveyor systems such as a screw conveyor or belt for moving the stalks, seed, and straw. All of these components, including the cylinder, fan, and conveyors, require electricity to operate. When it comes to the extraction of vegetable seeds, there are several types of threshing machines available with adjustable cylinder speeds. The effectiveness of these machines is heavily influenced by the cylinder clearance, concave mesh size, airflow rate, and screen size. Proper adjustments to the speed of the beaters, the gap width between the beaters and the concave, the airflow, and the sieve sizes must be made to ensure that the seed is not damaged during mechanical threshing. Care must be taken during mechanical threshing to avoid harming the seed.

Process of threshing operation

Crop stalks or bundles are manually fed into the threshing chamber through the inlet feed-hopper. The rotating cylinder pulls the stalks into the threshing chamber, where they are beaten to extract the seeds. A stream of pressurized air is utilized to separate lighter materials such as dry leaves, stems, and dust. The concave holds the material for a sufficient time to ensure that the stalks are completely beaten and the seeds are separated from the straw. The seeds and fine chaff fall through the concave and are separated by fanned air to eliminate the chaff. The seed is released onto a heap, bag, or conveyor. The straw is released separately from the threshing chamber onto another conveyor, bag, or heap.

Performance Threshers

To achieve optimal results while threshing, it is important to follow these guidelines:

- The concave clearance should be regulated according to the crop type to ensure the appropriate distance between the concave and cylinder.
- The rotation speed of the cylinder should be adjusted based on the crop conditions.
- The crop feed rate into the threshing chamber should be controlled.
- The power of the wind pressure should be adjusted to remove as much light material as possible without wasting seeds.
- Before threshing, it is important to assess the moisture content of the grain, stems, and ears/panicles.

It is important to assess the moisture content before extracting seeds from plant material. Dry plant material is better for seed extraction, but seeds that are over-dried are more likely to be damaged during the threshing process. The moisture content of the plant material can vary throughout the day, so it is best to use experience and physically examine the harvested material to determine the optimal time of day for threshing.

5. Damage-free threshing of seeds

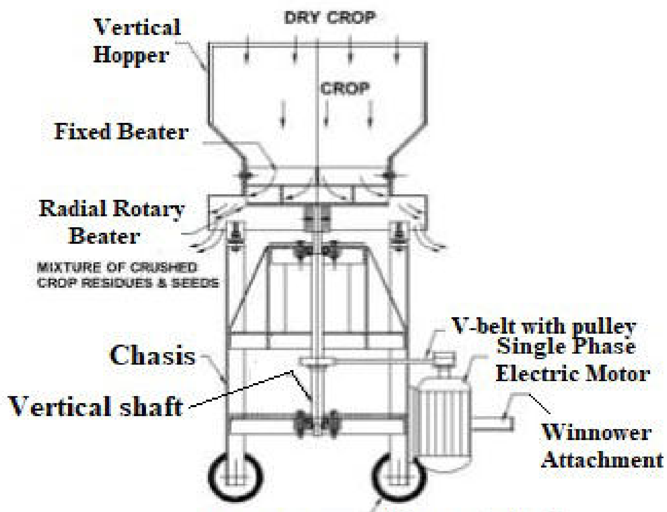
Manufactured by Seed Processing Holland, STM-350 is a seed thresher that's suitable for processing stock seed productions and breeding stations. It threshes **vegetables seeds, field crops and the hemp seeds out of pods, umbels and buds** without damaging them. Operators need to manually feed the plants into the machine using the inlet table, where the pods and umbels are then broken down into smaller pieces with three **polyurethane beaters**. Since the beaters are constructed with polyurethane, they're able to withstand strong forces. The speed and the distance between the threshing basket and beaters can further be easily adjusted according to specific user requirements. Once the threshed seeds go through the threshing basket, they're processed on a shaking screen, which sorts the seeds into one overflow and lower fraction. The overflow fraction is emptied into an anti-static bin, while the remaining seeds are moved to the air separator to be separated into heavier and lighter parts. Once the seeds are separated from the pods or umbels, the good and heavy ones are collected in an anti-static bin. For the enabling of operators to visually inspect and adjust the process wherever necessary, manufacturer now has designed with numerous clear polycarbonate windows. This machine following major benefits:


Seed Thresher (STM-350)

- Compressed air nozzles make chamber cleaning easy
- Screening, air cleaning, and threshing are integrated into one machine to save labour and time
- Automatic cleaning system ensures an extremely short changeover time

6. Vertical flow thresher

A vertical flow thresher has been developed by Khuntia and Murty (2017) for complete threshing of a variety of pulses having diverse physical characteristics like different shape and size of seeds, pods and plants and crushing of entire crop residues into powdery mass suitable for animal feed simultaneously. Threshing and crushing mechanisms are totally different from axial flow threshers. Significant features are 99% threshing efficiency without breakage of seeds irrespective of different types of pulses, such as black gram, green gram, horse gram and red gram with >90% germination of germination of threshed seeds. Combined threshing and crushing actions are executed by multiple progressive shears between a set of radial rotary beaters and a stationary beater inside a vertical hopper. The crops flow vertically downwards into shear zones by scissoring actions of the beaters and gravity. Therefore power consumption is reduced drastically and this machine is operated by 2.0 hp single phase electric motor for threshing of 150 to 250 kg seeds or 400 to 500 kg dry crops per hour.



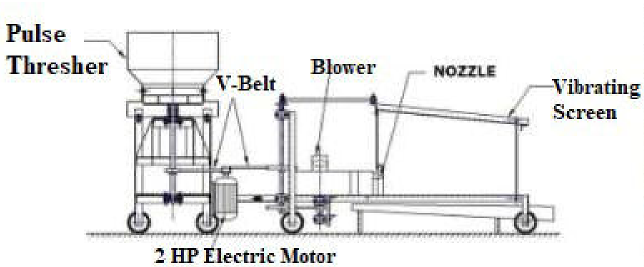
Vertical Flow Pulse Thresher

Winnowing of seeds is carried out by a winnower-cum-grader which can be attached to the thresher during need. They have reported that the developed semi-automatic vertical flow pulse thresher-cum-winnower highly efficient for threshing of a wide variety of pulses having diverse physical characteristics with >99% threshing efficiency, <1% seed loss in crop residues, almost nil damage of seeds, >90% germination, crushing of entire crop residues into powdery animal fodder, 2.0 hp power requirement and increase of 10% yield of seeds over traditional methods.

This Vertical Flow Pulse thresher-cum-winnower is a pulse thresher that has been designed at CSIR-IMMT, Bhubaneswar to overcome the deficiencies in the existing threshers. It can thresh and clean the grains of a **wide range of pulses with less power consumption**. The commercial prototypes of the semi-automatic Pulse Thresher and Winnower were developed and tested in different villages of Odisha.

Mechanism of VFP thresher

The pulse thresher is a unique machine that uses a set of moving and fixed beaters along with a cylindrical hopper to thresh and crush different pulses without any need for adjustment. The threshing and crushing operations are carried out together with multiple point contacts, and the threshing period is short. The machine executes around 7000 shear actions per minute in a narrow progressive shear zone, requiring very less energy (approximately 1 kwh) for operation. A 2 or 3 hp prime mover is provided to counter overloading of crops into the thresher. A Schematic diagram & picture of Pulse thresher-cum winnower is shown below in figure.



Assembly of semi-automatic VFP thresher-cum-winnower

Mechanisms of winnower

The pulse thresher is connected to a set of winnowers for separating and cleaning seeds from crop residue. From the figure it clear that the winnower includes an air blower, nozzle, and vibrating sieve. The blower and nozzle create a rectangular air jet that removes dust and crop residues, leaving clean seeds on the sieve. Both operations can be carried out together or separately.

Axial flow threshing machines

Axial flow threshing machines have a cylindrical threshing drum with pegs, knives, or rasp bars on its surface. The drum rotates in a perforated chamber called the "concave." The crop is fed between the drum and concave and subjected to impact and frictional forces that detach seeds from pods. Louvres help move the crop spirally between the drum and concave. Axial flow threshers are effective for cereals and some other crops. However, modifications are necessary to obtain high threshing efficiency for different types of crops. Existing multi-crop axial flow threshers are not suitable for a wide variety of pulses. Therefore, there is a need to develop a new thresher that is capable of threshing a variety of pulses and is widely accepted by farmers.

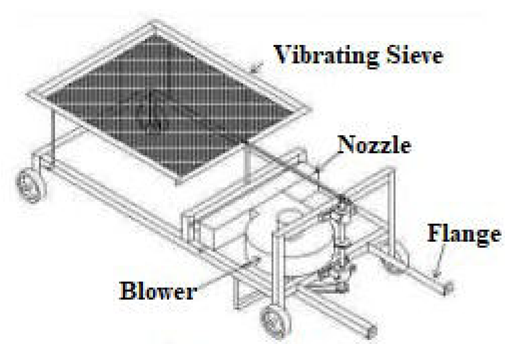
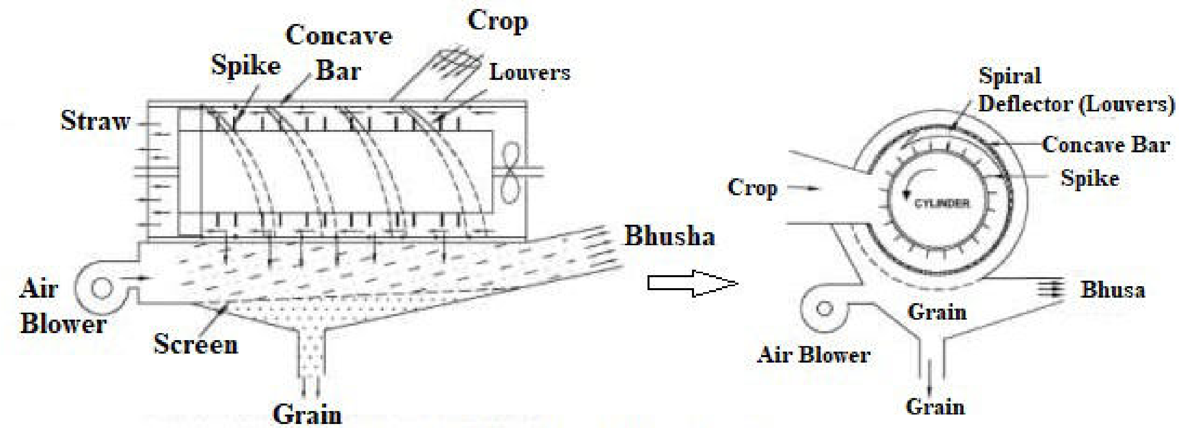


Diagram of Winnower

All axial flow threshing machines have a threshing drum, which consists of a long cylindrical shaped member to which a series of pegs, knives or rasp bars are attached on its surface. The threshing drum is mounted on two bearings and rotates in a perforated trough like chamber, called the “concave”. During threshing, crop is fed between the threshing drum and the concave, where it is subjected to a high degree of impact & frictional forces which detach seeds from pods. The crop moves spirally between the threshing drum and a circular concave for several complete turns, with the help of louvers, which are simple plates attached helically to the casing covering the threshing drum. Schematic diagram of axial flow threshing machine is shown below.



Basic mechanism of axial flow thresher

Crop is thus threshed for a longer duration by the repeated impact of the threshing pegs. In these machines, almost all of the grain is separated from the straw through the concave perforations. Straw is finally ejected through a large straw outlet at the end of the concave. Most of Axial flow threshers are effective for cereals and few other crops like wheat, paddy, soybean, sunflower, barley and maize; but adjustment of its parts & changes of some parameters are necessary during threshing different crops to obtain high threshing efficiency. Some researchers have attempted to modify the axial flow wheat threshers to suit for threshing of a few other cereals, pulses and oil seeds. The major modifications are carried out in construction of concaves, concave clearance, cylinder, size, shape, types and numbers of moving objects (spike tooth, rasp bars etc.) and also rpm of cylinder etc., although the changes are theoretically but practically not feasible for all types of crops. The existing multi-crop axial flow threshers at present are not suitable for a wide variety of pulses having varying moisture content. Again some adjustments or replacements of few parts are essential for threshing of pulses like red gram, pigeon peas etc. as reported in the literatures. However farmers found difficulty in adjusting and changing the parts during threshing of pulses and cereals. Again the power requirement is very high in these threshers. So the multi-crop axial flow threshers are not popular among the farmers for threshing of general pulses. Therefore it was desirable to develop a new thresher, which is capable of threshing a variety of pulses and widely accepted by the farmers.

Multi-crop threshers, designed on the basis of axial flow principle, are suitable for threshing wheat, paddy, oilseed and pulse crops. These threshers have provision to regulate threshing drum and blower speed independently so as to reduce grain breakage and improve cleaning.

7. Impact Threshing methods on Seed quality:

The quality of seeds in terms of germination and vigour is influenced by the methods of threshing used. For instance, soybean seeds threshed by stick beating and processed manually exhibit significantly higher vigour index than those threshed and processed by machine, regardless of the variety. The various methods of threshing cause breaks, cracks, bruises, and abrasions in the seeds, leading to abnormal seedlings that may not be suitable for planting. The available information suggests that mechanical injury to seed not only reduces the production of normal seedlings but also lowers the storage potential of the damaged seeds that would have otherwise produced healthy seedlings before storage. Physical seed damage can manifest as fractures of the radical or bruising of the cotyledons, which are difficult to detect under the seed coat. In severe cases, damage to the radical can lead to abnormal seedlings that fail to germinate. Any damage to the cotyledons is also a cause of concern because it hinders the translocation of essential nutrients to the growing embryonic axis, resulting in delayed seedling growth.

The mechanical and physical properties of seeds are essential when designing, handling, and processing equipment for them. The resistance to impact, among other mechanical and physical properties, plays a vital role in designing threshers, equipment for loading and unloading, storage structures, harvesting machines, drying equipment, conveyors, spouting, and free-fall dropping equipment. Soybean seeds are inherently weak structures and are more susceptible to mechanical thrust, which increases their deterioration. The impact of different threshing methods, such as hand, beating by stick, and mechanical, on different soybean cultivars (Giza 21, Giza 35, and Giza 111) has been reported to show that threshing by hand resulted in higher germination percentage and seedling vigour than the other two methods at all stages of storage.

Mechanical damage to bean seeds is a major concern for seed producers, farmers, and food processors as it is the most common cause of poor seed quality in large-seeded legumes. This damage usually occurs when seeds are threshed at inappropriate moisture levels and high drum speeds. The degree of mechanical damage is a crucial seed quality factor that can affect the value of soybean seed lots. According to studies, soybean seeds that were threshed using stick beating had a lower percentage of mechanical damage compared to the other two methods - multi-crop thresher and combine harvester - regardless of the variety. Researchers have tested various threshing methods for barnyard millet, including manual beating with a flexible stick, threshing with tractor treading, and threshing using a paddy thresher. Among these methods, threshing with a paddy thresher had the highest threshing efficiency (69.2 percent) and required the least amount of time. The seeds that were threshed by the paddy thresher also had the highest quality parameters, such as germination (77 percent) and vigour index (1701). The impact of velocities, number of impact loadings, and time on the percentage of seed damage and loss in germination to soybean seeds were studied, and it was found that increasing the impact velocities from 12.4 to 22 m/s, the number of impact loading from 1 to 3 times, and the time to three months increased the percentage of seed damage from 2.76 to 24.29 percent and the percentage of loss in germination from 28 to 96, respectively. Sinha and Pandita, 2002, tested Okra cv. Pusa A-4 seeds by manually threshing them, threshing with tractor treading, deawner (400 rpm), and Pullman thresher (650 rpm). They found that manual threshing resulted in the highest seedling dry weight and vigour index and the least mechanical damage to the seed. Tractor treading led to the highest mechanical damage to the seed.

Masilamani et al (2015) have conducted an experiment to determine the impact of various methods for extracting Albizia lebbeck seed pods on man-hours, extraction cost, seed recovery, viability, germination, and seedling vigor. Three methods were tested: splitting by hand, beating with a pliable stick, and threshing with a paddy thresher. The results showed that viability was not significantly different (97.5%) across the extraction methods. The seeds extracted using a commercial paddy thresher had the highest germination percentage and lowest extraction cost for 50 kg of Albizia lebbeck pods, at 13% and Rs. 87.5/-, respectively. This was followed by beating with a pliable stick (9% and Rs. 187/-) and splitting by hand (5% and Rs. 500/-). Irving et al. (1981) noted that amaranth seeds have embryos that encircle the perisperm in one plane, making them susceptible to mechanical injury during combine harvesting, which can lead to deterioration. The percentage of normal grain amaranth seedlings decreased, and the number of abnormal seedlings increased as the threshing cylinder speed increased from 8.1 to 30.7 ms-1. While there was no apparent injury to hand-harvested seeds or seeds threshed at 8.1 ms-1, scanning electron micrographs of seeds threshed at 12.8 or 22.4 ms-1 revealed damage to the seed coat and the endosperm. When the threshing cylinder speed was increased to 30.7 ms-1, the damage extended to the embryo.

Traditional threshing methods commonly practiced by the farmers are stamping (treading) by heavy animals, rolling the roller/ tractor or by beating the dry crops by heavy stick. Due to such improper threshing 10 to 15% seeds are lost in the crop residues, maximum 85% seeds are recovered and 50 to 60% crop residues are crushed to small sizes. the crop residues, maximum 85% seeds are recovered and 50 to 60% crop residues are crushed to small sizes. Traditional harvesting methods involve up-rooting matured pulse plants from the field, drying the green crop under sun till moisture content is reduced below 10%, and then threshing the dry crop under sun as mentioned above till most of the pods are open and seeds are released from the crop. Then large size stem & root of the plants are separated manually from the powdery mixture of seeds and crop residues. The powdery mixture is then winnowed by artificial air stream or through natural wind to separate seeds from crop residues and finally seeds is sieved manually to separate sand, mud etc. About 85-90% of seeds are collected from crops for human consumption and 10-15% seeds are lost in crop residues as unthreshed pods. Animals also eat away 3-5% seeds during threshing (Khuntia et al. 2001). Loss of seeds in crop residues is estimated to nearly 1-2 million ton pulses per year in India. The powdery crop residue, called 'Bhusa' is an important animal feed. As the crop residue or Bhusa is a mixture of dried green leafy biomass & un-threshed pods with seeds and has nutritious value, most of the farmers feed their bullocks and cows with Bhusa. The traditional methods are highly labour intensive and non-economical. Also cleaning of seeds is not very good, which leads to damage of pulse due to pest infection during storage (Khuntia and Murty 2017)

8. Seed Extraction from Wet or Fleshy fruits

The selected fruits are harvested for seed in the same way that is picked for the market. The seeds extraction from wet / flash fruits can be done by the following methods.

- Manual method
- Fermentation method
- Mechanical method

- Chemical method
- Juice and seed extraction method

Manual method

Principle of Crushing, scraping, separation, scooping, extraction, etc. are commonly used in the manual method of seed extraction. This method can be used for the following crops as given below:

(a) For watermelon: Maceration,
(b) For brinjal: Crushing
(c) For cucumber: Scraping
(d) For muskmelon: Separated
(e) For pumpkins: Scooping
(f) For squashes: Extraction

9. Conclusion

Farmers have adopted various power thresher designs with capacities ranging from 3.7 kW to 11.2 kW for threshing food grains, oilseeds, and pulses. These machines have helped reduce human drudgery while ensuring the timely completion of threshing operations. Lightweight power threshers with lower capacity (0.75 kW) have been developed specifically for use in hilly regions. MPUAT spices thresher (3.7 kW) has proven to be an efficient machine for threshing spice crops with a high output capacity. In addition to axial flow, vertical flow threshers are now widely used across the country for threshing sunflower, groundnut, soybean, rice, and wheat, and are commercialized through the establishing connection with industries.

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Seed Treatment: Principles and Procedures

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Agriculture relies on the growth of seeds. They are the first stage in the lifecycle of a crop and if seeds fail to germinate, crops fail. Seeds face a lot of challenges from diseases to pests to environmental stresses. While seeds can overcome these on their own, the chances of success can be improved with seed enhancement. Seed treatment is one of the most effective ways to support the growth of seeds and reduce the challenges that they face. Seed treatment refers to the application of biological, physical and chemical agents and techniques that can be applied to seeds to provide them protection from seed-borne pathogenic organisms and storage insects. Seed treatment can also encourage healthy crops by improving their immunity and promoting uniform germination. While traditional crop protection methods that are applied on a broader level to the crops have their place, with seed treatment, the needs of every individual seed can be met. Seed treatment enhances the resistance of the seeds, making them stronger against pest attacks and stresses in their environment. Chemical or biological seed treatments can provide critical protection since the germination stage, protecting the emergence out of the soil and during the first stage of the crop cycle by preventing seeds against soil-borne pathogens, seed-borne insects, diseases, and pests.

Benefits of Seed Treatment:

There are many benefits of seed treatment that are making them popular with farmers. Some of these benefits are as follows:

- Seed treatment protects seeds from insects & diseases
  One of the foremost benefits of seed treatment is the additional protection that it provides to the seeds. During the early stages of growth, it is critical that seeds don't fall prey to diseases or pests or else they will fail to germinate. With untreated seeds, there is also a chance of plant diseases spreading which is something that can be prevented when they are treated to improve their immunity.
- Seed treatment controls soil insects
  Seed treatment is not only beneficial for seeds but also for the soil. It can control soil insects and also add much-needed nutrients and valuable microorganisms that help the plants grow.
- Seed treatment improves germination
  Germination of a seed depends on a variety of factors but the chances of germination can be improved with seed treatment. Since seed treatment is equally applied to all the seeds, it can also promote uniform germination of the crop. Seed Treatments formulations are special and safe for crops and were designed in order to avoid any potential damage such as delay in germination or irregular emergence, neither phytotoxic effect than un-appropriated formulations for other uses in the field may cause.
- Early and uniform establishment and growth

Seed treatment ensures early germination of the seeds and the crop establishment is generally uniform. It is possible due to care been taken by the chemicals used for seed treatment to protect them from the harmful pests and pathogens.

- Enhances nodulation in legume crop
  Healthy seed promotes higher nodulation as well. It is because the nodulating bacteria does not have to encounter the insect pests of pathogens to nodulate. Hence, it is normally observed that seed protection leads to higher nodulation in leguminous crops.
- Provides protection from storage insects
  Storage insects is a big issue for commercial seed production. As the harvested seeds has to be stored till the next cropping season it is important that seeds are protected in storage from stored grain pests and remain viable for germination. Seed treatment helps is achieving the goal.
- Controls soil insects
  The chemicals used for seed treatment are also important for managing soil insects. Therefore, dual objectives could be achieved through seed treatment by managing stored grain pests as well as soil insects that can be potential pests.

- Microbial seed treatment
  One of the latest developments is microbial seed treatments. Microbial seed treatments can reduce fertilizer and pesticide applications and increase yields. Different beneficial fungi and bacteria are used to treat seeds in order to obtain the desired benefits. Microbial seed treatments have the advantage that less microbial material is needed, thus reduces the cost. Microbial inoculants were developed by institutions and companies and the seeds treated with microbes have enriched carbon starved soils, provided drought resistance, decreased fertilizer and pesticide applications, and increased crop yields.

Types of Seed Treatment:
Modern seed treatments and seed processing has come a long way in the past few decades. More and more farmers are using commercial seed treatments in agriculture across the world. For some, pre-treated seeds are also an option that can be directly used without the need to apply the treatment yourself. The importance of seed treatment and its many benefits cannot be overlooked as they give farmers more opportunities to reduce the risk of failure for their crops. There are many types of commercial seed treatments available today. Depending on the need of the specific crops, farmers can pick a single or a combination of multiple seed treatments with chemicals or biological agents. Seeds are especially vulnerable to fungi in the early stages of growth and some fungi can be hard to combat on their own. Fungicide seed treatment can provide them protection and prevent fungal diseases. Pests are another concern that farmers have to factor in while looking at the early stages of growth. Many insects target seeds and can damage them before they even germinate. Insecticide seed treatments can provide protection against such pests with the added benefit of having a lower concentration of chemicals than the pesticides applied to fully-grown crops. Microbial inoculants are seed treatment products that can stimulate plant growth, promote soil biodiversity, and even address specific issues such as nitrogen fixation in legumes. With this beneficial microorganisms are delivered directly to the area where the plant interacts with the soil, which encourages growth. With plant growth regulators, seeds have additional assistance for germination and an enhanced tolerance for stresses during the critical early stages of growth. This seed treatment for germination is also helpful when seeds have to germinate in tough conditions. Fertilizer seed treatments are

another type of seed treatment that helps with plant growth. Seed treatments with biofertilizers can enhance fertilizer performance or supply micronutrients to the soil to enrich the growth environment for the seeds.

- **Seed disinfection:** Seed disinfection refers to the eradication of fungal spores that have become established within the seed coat, or i more deep-seated tissues. For effective control, the fungicidal treatment must actually penetrate the seed in order to kill the fungus that is present.
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- **Seed disinfestation:** Seed disinfestation refers to the destruction of surface-borne organisms that have contaminated the seed surface but not infected the seed surface. Chemical dips, soaks, fungicides applied as dust, slurry or liquid have been found successful.
-
- **Seed Protection:** The purpose of seed protection is to protect the seed and young seedling from organisms in the soil which might otherwise cause decay of the seed before germination.
-

Conditions under which seed must be treated

- **Injured Seeds:** Any break in the seed coat of a seed affords an excellent opportunity for fungi to enter the seed and either kill it, or awaken the seedling that will be produced from it. Seeds suffer mechanical injury during combining and threshing operations, or from being dropped from excessive heights. They may also be injured by weather or improper storage.
-
- **Diseased seed:** Seed may be infected by disease organisms even at the time of harvest, or may become infected during processing, if processed on contaminated machinery or if stored in contaminated containers or warehouses.
-
- **Undesirable soil conditions:** Seeds are sometimes planted under unfavourable soil conditions such as cold and damp soils, or extremely dry soils. Such unfavourable soil conditions may be favourable to the growth and development of certain fungi spores enabling them to attack and damage the seeds.
-
- **Disease-free seed:** Seeds are invariably infected, by disease organisms ranging from no economic consequence to severe economic consequences. Seed treatment provides a good insurance against diseases, soil-borne organisms and thus affords protection to weak seeds enabling them to germinate and produce seedlings.
-

Procedure for Seed Treatment:

Seed treatment is a term that describes both products and processes. Seed treatment can be done in one of the following types.

- **Seed dressing:** This is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings can be applied at both farm and industries. Low cost earthen pots can be used for mixing pesticides with seed or seed can be spread on a polythene sheet and required quantity of chemical can be sprinkled on seed lot and mixed mechanically by the farmers.

- **Seed coating:** A special binder is used with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology, by the industry.
- **Seed pelleting:** The most sophisticated Seed Treatment Technology, resulting in changing physical shape of a seed to enhance palatability and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application.

Precautions in Seed Treatment:

Most products used in the treatment of seeds are harmful to humans, but they can also be harmful to seeds. Extreme care is required to ensure that treated seed is never used as human or animal food. To minimise this possibility, treated seed should be clearly labelled as being dangerous, if consumed. The temptation to use unsold treated seed for human or animal feed can be avoided if care is taken to treat only the quantity for which sales are assured.Care must also be taken to treat seed at the correct dosage rate; applying too much or too little material can be as damaging as never treating at all. Seed with a very high moisture content is very susceptible to injury when treated with some of the concentrated liquid products.

Suggested readings:

O'CallaghanM (2016) Microbial inoculation of seed for improved crop performance: issues and opportunities. Applied Microbiology and Biotechnology 100, 5729–5746.

Sharma, K.K., Singh, U.S., Sharma, P.,Kumar, A.,SharmaL. (2015) Seed treatments for sustainable agriculture-A review. Journal of Applied and Natural Science 7 (1) : 521 – 539.

Neergaard, P. (1977). Seed Treatment, Procedures and Equipment. In: Seed Pathology. Palgrave, London. Pp. 595-621.

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Major Precautions for Assuring Seed Quality During Seed Certification

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QUALITY SEED

- Seed is the most crucial, vital and basic input for attaining sustained growth in agriculture productivity and production.
- The efficiency of other inputs like fertilizers and pesticides depend upon quality seed.
- Genetically and physically pure seed of improved variety is designated as quality seed.
- High percentage of germination, vigour and optimum moisture content are important characteristics of healthy quality seed.

What is seed quality:
One of the accepted and general definition of word quality is FITNESS FOR USE. An equally good definition is CONFORMANCE TO REQUIREMENTS

Seed quality parameters.

- PHYSICAL QUALITY
- GENETICAL QUALITY
- PHYSIOLOGICAL QUALITY
- SEED HEALTH QUALITY

Characteristics of Quality Seed:

- The quality seed have high genetic purity.
- Germination percentage as per minimum.
- Quality seed exhibits comparatively high seedling vigor.
- The physical purity of quality seed is also very good. The seed should be free from inert matter, seed of weed and other crops/varieties.
- Quality seed is free from disease and pest free and is also considered as healthy.
- All seeds should be uniform in size, shape and color etc. to fetch good price in the market.

Causes of Seed Deterioration:

- Mechanical Mixtures
- Genetic Changes
- Moisture Content
- Mechanical Injury
- Environmental Variations
- Diseases and Pests

Seed quality control Mechanism:

- SEED CERTIFICATION
- SEED LAW ENFORCEMENT
- SEED TESTING FOR QUALITY ANALYSIS

- INTERNAL QUALITY CONTROL SYSTEM

SEED CERTIFICATION
"Seed Certification is a regulatory process designed to secure, maintain and make available certain prescribed level of genetic purity, physical quality, physiological quality and seed health of SEEDS including VEGETATIVELY PROPAGATING MATERIAL of notified crop varieties.

SEED CERTIFICATION STEPS
- ✓ **APPLICATION BY SEED PRODUCER / FARMER**
- ✓ **EVALUATION/SCRUITINY OF APPLICATION FORM ALONG WITH REVENUE RECORD**
- ✓ **REGISTRATION**
- ✓ **SEED SOURCE VERIFICATION**
- ✓ **FIELD INSPECTIONS (2% QUALITY CONTROL INSPECTIONS BY UNIT INCHARGE AND IN ADDITION 1% BY CENTRAL QC TEAM)**
- ✓ **EXPECTED YIELD/HARVESTING**
- ✓ **FIELD PV (2 STEPS)**
- ✓ **RAW-SEED PROCUREMENT**
- ✓ **RAW SEED PV AT PROCESSING PLANT/GODOWN**
- ✓ **SEED PROCESSING AND SAMPLING (2% QUALITY CONTROL SAMPLING BY UNIT INCHARGE AND IN ADDITION BY CENTRAL QC TEAM)**
- ✓ **SEED TESTING – GOT TEST / LAB TEST**
- ✓ **PACKING & TAGGING**
- ✓ **RELEASE CERTIFICATE UNDER SECTION 9 OF SEED ACT 1966**

Important Problems & Issues
- ✓ The Public Sector organization should arrange the Seed Production Program in compact area. RSSOPCA has initiated A Compact Area Approach for the successful organization of Seed production.
- ✓ What is Compact Area Approach (CAA) ?
- ✓ Seed production programme of about 50 Acres in periphery of 5-6 km around a village.

Breeder Seed:
- ✓ None supply/less supply/very late supply of breeder seed.
- ✓ Misuse of breeder seed.
- ✓ Poor quality of breeder seed.
- ✓ Minimum two field inspection should be conducted by BSP team, preferably at flowering and maturity stage.
- ✓ B/S standards are prescribed in IMSCS. Genetic purity standards should be fixed as in OECD.
- ✓ Breeder seed is not properly graded, packed, treated and tagged.
- ✓ Off season GOT of Breeder seed.
- ✓ Selection of progressive farmers
- ✓ One class and one variety to one farmer.
- ✓ One grower should take production programme from one production agency
- ✓ Seed field is not found in location of as mentioned in form 1/B.
- ✓ Subletting of Seed production Programme to others.

Disparity in seed rate and area sown.
Proper isolation is also a problem in quality seed production

The total area sown in Rajasthan is 159 lacs hacs during Kharif-2017 while Bajra (Pearl Millet) is grown in 43 lacs hacs. Because of unsatisfactory isolation the Bajra seed is not produced on large scale in Rajasthan .

Improper and not timely rouging is also a major problem in quality seed production.

- ✓ Off types
- ✓ Pollen shedders
- ✓ Inseparable other crop plant
- ✓ Objectionable weed plants
- ✓ Objectionable diseased plants/ear heads

Subsidy is a major Problem in quality Seed Production.

Crop	Subsidy Amount (Rs./Qtls.)
Wheat	1000/-
Barley	1500/-
Pulse	2500/-
Oilseed	1000+1200=2200/-
Hybrid (Maize, Bajra, Jowar)	5000/-

- ✓ Harvesting by combine is also problem.
- ✓ Old gunny bags are used
- ✓ Buckram slips are not affixed on raw seed bags
- ✓ Farmer code numbers are not mentioned on raw seed bags
- ✓ Code wise grading is not undertaking.
- ✓ Proper sieve size are not used during grading.

Seed Testing:

- ✓ Representative sample should be submitted to STL
- ✓ Randomization of testing should be adopted
- ✓ Confidential coding of seed sampling
- ✓ Quantity of seed lots should not be mentioned in forwarding letter
- ✓ Advanced tagged seed lots if found sub standard than tags are not return to certification agency in most of cases
- ✓ Storage and fumigation of seed is not proper
- ✓ Foundation seed should be stored in cold storage / air condition

Constraints:

- ✓ Presently, horticultural, fruit crops, plantation crops and forest seeds are under consideration for seed certification,
- ✓ Large quantity of seed is produced and distributed as labeled seed for which germination, physical and genetic purity conditions are required. This leaves enough scope for production and distribution of spurious seed.
- ✓ Noncompliance if Inter-State Seed Certification procedures.

- ✓ Insisting grow-out test for all the crops and varieties which is inconsistent with the procedure of Indian Minimum Seed Certification standards.
- ✓ At present, breeder, foundation and certified seed production is at a low pace.
- ✓ Delay in results of tests conducted on the lots of seeds.
- ✓ International test for varietal identification such as electrophoresis, machine vision, chromatographic test, etc. are not used in India at present.

Efforts made by RSSOPCA to ensure quality certified seed

- ✓ Receipt and Verification of land revenue record.
- ✓ Restriction of one variety programme to one seed grower.
- ✓ Verification of source of seed for every bag.
- ✓ Physical verification of raw seed against the estimated yield at farmers field.
- ✓ Physical Verification of produce at processing plant.

Efforts made by RSSOPCA to ensure quality certified seed

- ✓ Evaluation and ranking of Processing plant for registration.
- ✓ Calendar of operations for certification work.
- ✓ Sealing of raw seed.
- ✓ Establishment of Green House at GOT farm.
- ✓ Farmers identification Code wise processing of raw seed.

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Current Status, Challenges and Future Prospects of Indian Seed Industry

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ABSTRACT

Seed is required for the continuance of life and acts as a bridge of hope between the present and future. The agricultural sector relies heavily on the availability and quality of seeds for a successful harvest. The response of all other inputs is heavily reliant on seed quality; with excellent seed alone accounting for 15-20% of total yield depending on the crop, and this figure can be increased to 45% with efficient management of other inputs. India boasts a thriving seed business. The seed business has evolved with Indian agriculture. Indian farmers have gone a long way since the practice of storing seeds from previous crops. With 4.4 percent of the worldwide seed market, the Indian seed industry is currently the world's fifth largest seed market, worth more than Rs 2500 crore. India is practically self-sufficient in flowers, fruits, vegetables, field crop seeds, and other items traded on foreign markets. In general, it is expected that paddy, maize, and vegetables will drive the expansion of the Indian hybrid seed market over the next five years. Government policy support has also played an important role in the seed industry's growth and evolution. From the 1966 Seed Act to the 2004 Seed Bill, India's seed policy provided insights into the country's shifting demands and market dynamics. Government help and supporting regulatory reforms have recently hastened the industry's transformation. The private seed sector has substantially impacted the Indian seed market. This celebration has been made possible by finance and technical know-how gathered from around the globe. The seed industry in India is expected to be worth US$6.3 billion by 2022. Looking ahead, IMARC Group estimates the market to reach $12.7 billion by 2028, with a compound annual growth rate (CAGR) of 12.43% between 2023 and 2028.

Keywords: Seed Sector, Indian Seed Industry, Current Status, Challenges and Future Prospects

Introduction

The most essential and important component for sustainable agriculture, acting as a bridge between the present and the future, is seed. India has established itself as a thriving seed market on a global scale, and the seed business has evolved and grown alongside Indian agriculture throughout the years. Beginning with the custom of saving seeds from past harvests, Indian farmers went on to establish a strong formal, informal, and integrated seed system throughout the nation. Over time, formal seed system diversity has been more honed. The

Indian seed industry has undergone significant development, especially in the previous 30 years. For a successful harvest, the agricultural sector is heavily reliant on the availability and quality of seeds (Chauhan et al., 2016). Therefore, with the aid of cutting-edge technology and contemporary agricultural practises, attempts are made to develop upgraded kinds of seeds in order to raise the amount and quality of product. The fact that agriculture is the primary industry in India ensures a wealth of potential for the local seed market. The Indian seed industry had a value of US$ 4.9 billion in 2020, according to the most recent analysis from IMARC Group, "Seed Industry in India: Market Trends, Structure, Growth, Key Players and Forecast 2021-2026."

Seeds are the primary basis for human sustenance as they are the repository of the genetic potential of crop species which is used in crop improvement (FAO 2017). With increasing living status and consciousness of the masses towards the health and nutritional security, the consumption of vegetables has increased over the years. Although vegetable production in India has increased (187.47 mt) with time but shrinking land resources (10.43 mha) and increasing environmental challenges have made the development and use of quality seeds more important to meet the increasing demand of vegetables by Indian populace (NHB 2018-19, 1st advance estimate). Food, nutritional and socio-economic security of country is therefore dependent on the seed security of farming community (FAO 2016). Production of quality seed and timely availability of the quality seed to farmers is a major area which has to be taken into consideration. Quality seed alone can enhance the total production about 15–20% and it can be raised up to 45% with effective management of other inputs (seednet.gov.in and Ali 2016). But the irony is that the vegetable growers of India do not get quality vegetable seeds at proper time in spite of readiness to spend considerable money. They do not have knowledge to judge the quality of the seed. Improper germination of the vegetable seeds and problem of mixture of different variety has also been reported. Another major problem is very weak and unorganised seed production system in India. Unavailability of skilled labour for hybrid vegetable seed production and development of proper seed storage structure also needs attention (Ali 2016). On this background, this study was planned to identify the priority areas in vegetable seed sector where future research and development efforts should be channelized for strengthening vegetable seed sector in the country.

A significant restructuring of the Indian seed market has taken place as a result of the government's adoption of several progressive policies (Roy *et al.,* 2021). The National Seed Policy of 2002 and the Seed Development of 1988 have both contributed to the development of the Indian seed industry's R&D, product development, supply chain management, and quality assurance (Singh and Chand, 2011). Because of this, India has become the fifth-largest seed market in the world. Additionally, the active involvement of the public and private sectors has been essential in building a solid foundation for the sector. This includes starting initiatives to encourage farmers who previously used outdated open pollinated types to switch to hybrid seeds. A significant boost to the market has come from other growth-inducing factors like rising income levels, commercialization of agriculture, patent protection regimes, and intellectual property rights over plant types. These factors are likely to contribute to the Indian seed market's continued robust growth between 2021 and 2026 (www.imarcgroup.com, 2022).

In reality, many of the revolutions and changes that our nation has seen can be attributed to seeds. The seeds of high yielding wheat varieties that provided good yields were also the foundation of the renowned "Green Revolution," which helped India's agriculture reach new heights. Similar to how "Bt cotton" altered India's cotton industry. Always, good seeds yielded good harvests. Finding a good seed, however, is a tremendous endeavour. Before it reaches the farmers, it undergoes years of study and standardisation procedures. These seeds, which are distributed by research centres or private businesses, are the main source of agriculture in India today.

These seeds are now a crucial component of Indian agriculture. Essential and inescapable parts of agriculture are seeds. They transform labour and resources into a bountiful harvest. In actuality, the seed itself determines how all other inputs react. According to studies, quality seeds alone can contribute anywhere between 15 and 20 percent of the overall production, depending on the crop, and with effective management of other inputs, that contribution can increase to 45 percent. The fact that more high-quality seed is becoming available has a significant impact on the production of food grains (Chauhan *et al.,* 2013).

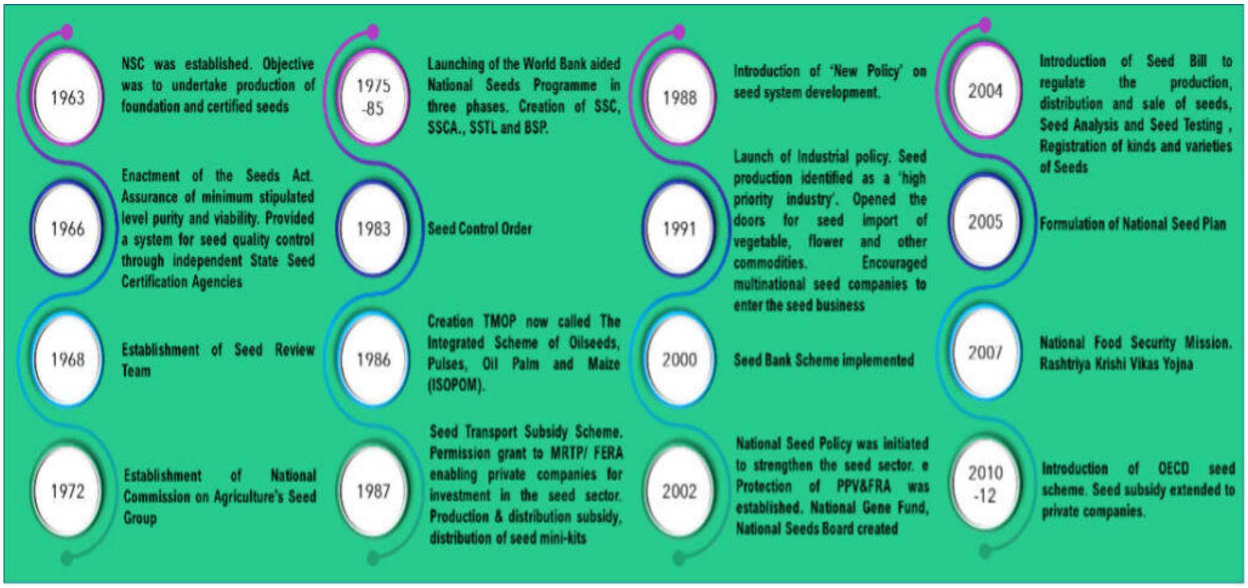
The expansion of the seed industry has followed the expansion of Indian agriculture. The seed industry generously helped Indian agriculture at every stage. The 1960s were a particularly important decade for the Indian seed industry, and many important and influential things happened then. National Seed Corporation (NSC) was founded in 1963. The goal was to start producing foundational and accredited seeds. It has now developed into a Schedule 'B' Miniratna Category-I corporation that is fully owned by the Government of India and is managed by the Ministry of Agriculture and Farmers Welfare. Currently, the NSC is working with its registered seed growers to provide certified seeds for almost 600 kinds of 60 crops. Around 8000 registered seed growers are active throughout the nation and are involved in various agro-climatic seed production programmes (NSC, 2015). In order to control the expanding seed industry, the Indian government passed the Seeds Act in 1966. According to the Seeds Act, seeds must meet minimum requirements for physical purity, genetic purity, and percentage germination by either mandatory labelling or voluntary certification. Additionally, the Act established a system for regulating the quality of seeds through independent State Seed Certification Agencies that were put under the supervision of State Departments of Agriculture (Agriculture Today, 2016). The seed industry experienced two more significant policy developments in the 1980s, including the approval of MRTP (Monopolies and Restrictive Trade Practices)/FERA (Foreign Exchange Regulation Act) companies for investment in the seed sector in 1987 and the introduction of a "New Policy" on seed development in 1988. In addition, the World Bank's National Seeds Programme (1975–1985), which was launched in three phases, resulted in the establishment of State Seed Corporations, State Seed Certification Agencies, State Seed Testing Laboratories, Breeder Seed Programs, etc.

A number of other laws were passed during this time, including the Seed Control Order (1983), the Technology Mission on Oilseeds & Pulses (TMOP) in 1986, which is now known as the Integrated Scheme of Oilseeds, Pulses, Oil Palm, and Maize (ISOPOM), the Production and Distribution Subsidy, the Distribution of Seed Mini-kits, and the Seed Transport Subsidy Scheme. In the early 1990s, assistance for the seed industry increased. The manufacturing of seeds was designated as a "high priority industry" under the 1991 Industrial Policy. The new policy on Seed Development opened the doors for the restricted import of vegetable and flower seeds in general as well as seeds of other commodities, in line with India's larger liberalisation and privatisation policies during the same period. It also encouraged multinational seed companies to enter the seed business. As a result, more than 24 businesses started conducting research and development. The National Seed Policy, 2002 was started to further develop the seed industry and to address the unaddressed areas in the Seeds Control Order. New varieties were to receive intellectual property protection, this industry was to enter planned development, farmers' interests were to be safeguarded, and agro-biodiversity preservation was to be encouraged. This national seed policy from 2002 had ten main objectives: promotion of domestic seed, strengthening of the monitoring system, infrastructure facilities, transgenic plant varieties, varietal development and plant variety protection, seed production, quality assurance, distribution and marketing, infrastructure facilities, and transgenic plant varieties. The Protection of Plant Varieties & Farmers' Rights Authority (PPV&FRA) was created in accordance with this policy to handle the registration of existing and new plant varieties. Additionally, a National Gene Fund was established to carry out the benefit-sharing agreement, offer village communities compensation for their contributions to the advancement and preservation of plant genetic resources, and to promote the preservation and sustainable use of genetic resources. The National Seeds Board (NSB) was established to take the position of the Central Seed Committee and Central Seed Certification Board, which were charged with carrying out and implementing the Seeds Act's requirements and advising the government on all issues pertaining to seed planning and development. The 2004 Seeds Bill aims to control the creation, sale, and distribution of seeds. Every seller of seeds, even farmers, must adhere to a set of minimal requirements. The Standing Committee has suggested exempting farmers' seed exchanges and sales from this requirement. Since December 2004, the Bill has been pending (Agriculture today, 2016).

The evolution and development of the seed platform have also benefited from the government's policy support, which is an indication of India's shifting needs and market dynamics. Public research organisations like the Indian Council of Agricultural Research (ICAR) and international organisations like the Consultative Group on International Agricultural Research (CGIAR) made significant contributions with new, better seeds for a variety of crops. Given their significance for both farmers and society as a whole, seeds are now governed by an increasing number of rules that serve different policy objectives. Creating laws and regulations that support both formal and farmer-based seed systems while minimising negative effects on breeding, selection, and seed production in either system is a difficult task for legislators.

The Indian seed industry is significantly impacted by the private seed sector. International funding as well as specialised technological abilities have made this possible. With an emphasis on high-value hybrids of vegetables and grains and new technologies like Bt cotton, Indian seed corporates and multinational firms in the Indian seed business brought in a solid R&D basis for product development. Farmers now have access to a wide variety of goods, and the seed industry is now focused on a "farmer-centric" and market-driven approach.

Prominent seed policy and initiative milestones in India (Das, 2022):



(NSC=National Seed Corporation; SSC=State Seeds Corporations; SSCA=State Seed Certification Agencies; SSTL=State Seed Testing Laboratories; BSP=Breeder Seed Programmes; TMOP= Technology Mission on Oilseeds & Pulses; MRTP=Monopolies and Restrictive Trade Practices); FERA=Foreign Exchange Regulation Act; PPV&FRA=Protection of Plant Varieties & Farmers' Rights Authority; OECD=Organization for Economic Co-operation and Development)

Emerging Seed Technologies

Priming and Enhancement Protocols: These protocols prepare seeds to excelunder various growing conditions. Particularly valuable in regions experiencingstressors, they boost seed performance independently or in conjunction with theseed's genetic attributes.

Film Coating and Pelleting: Film coating involves a protective layer applied toseeds, aiding precise planting and acting as a vehicle for pesticides, nutrients, andgrowth promoters. Pelleting shares similar benefits, enhancing seed protection andhandling.

Seed Treatments: Seed treatments encompass the application of biological orchemical pesticides to seeds, with contact or systemic action against pests anddiseases during germination and early growth stages.

Bio-stimulants and Nutrients: Integration of bio-stimulants and nutrients intoseeds fosters improved germination rates and rapid seedling establishment,contributing to overall plant vitality and productivity.

AI-Responsive Sensors/Substances: Seeds infused with AI-responsive sensors or substances can adjust plant responses to external stimuli, bolstering adaptabilityand performance across varying conditions.

Clean and Green Planting Materials: This technology revolves around generating environmentally friendly and high-performing planting materials for horticultural crops, aligning with sustainable cultivation practices.

Genetic Advancements in Variety Development: Genetic enhancements play a pivotal role in creating seed varieties with amplified traits such as disease resistance, augmented yield, and enhanced adaptability to shifting environments.

Metabolic Cues and Molecules: Seed enrichment with molecules or metabolites that act as cues in biological pathways can augment metabolic processes and overall plant well-being.

Tech Transfer: Facilitate technology dissemination to fields via farmer training and extension services

Empower Smallholders: Ensure affordable, quality seeds and provide capacity-building programs.

Indian seed sector- Public and Private

Indian private and public seed sectors the expansion of the seed industry can be compared to the expansion of India's agricultural output. With 4.4 percent of the global seed market, India currently holds the fifth-largest position in the seed market behind the United States (27 percent), China (20 percent), France (8 percent), and Brazil (6 percent) (Fig. 1).

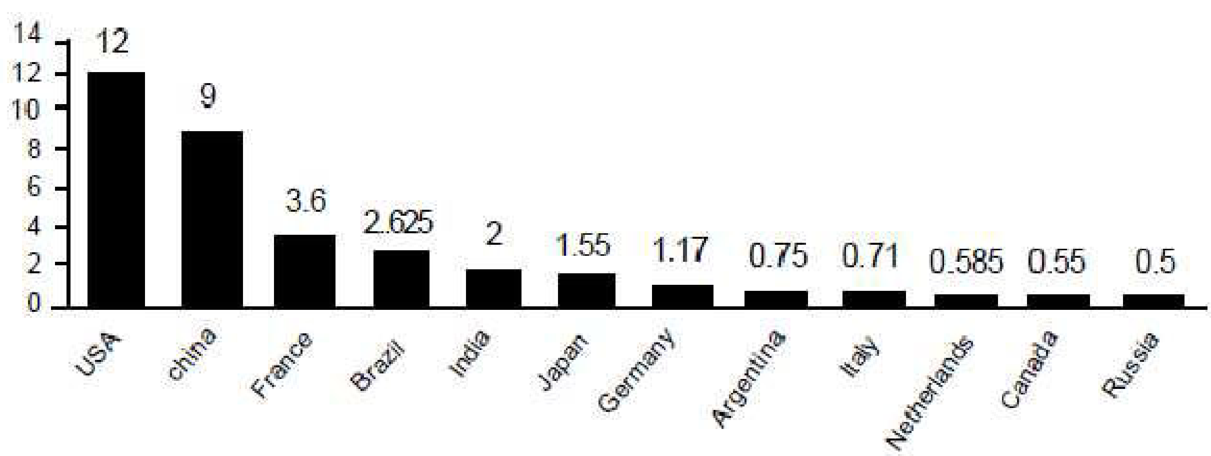


Fig.1: Market size-USD Bn

In terms of international trade, India is nearly self-sufficient in terms of flowers, fruits, vegetables, and seeds for field crops. The hybrid seed market expanded at an astounding CAGR of 36.1% between FY'2007 and FY'2013, according to Ken Research's report, "Indian Seed Industry Outlook to FY'2018 - Rapid Hybridization in Vegetables, Corn and Rice to Impel Growth." Varietal seed market share in India's overall commercial seed market has drastically decreased, from 72 percent in FY'2007 to 36.8 percent in FY'2013. Non-vegetable seeds including corn, cotton, paddy, wheat, sorghum, sunflower, and millets make up a large portion of the Indian seed market. In FY'2013, the non-vegetable seed market in India accounted for 82.2% of the total seed market. Cotton holds the greatest part of the non-vegetable seed market in India with a contribution of 40.8%. In general, it is anticipated that paddy, maize, and vegetables will propel the growth of the Indian hybrid seed market during the next five years. Better rice hybrids are anticipated to be created, providing research varieties with a yield advantage of at least 3–4 tonnes per hectare (Fig. 2 &3).

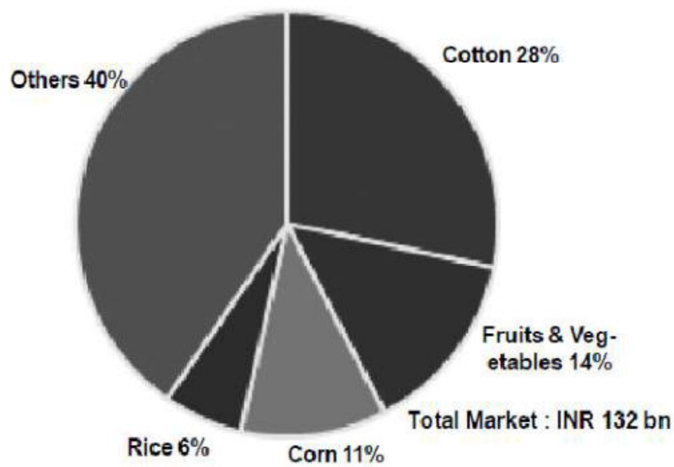


Fig.2 : Indian seed market size by value

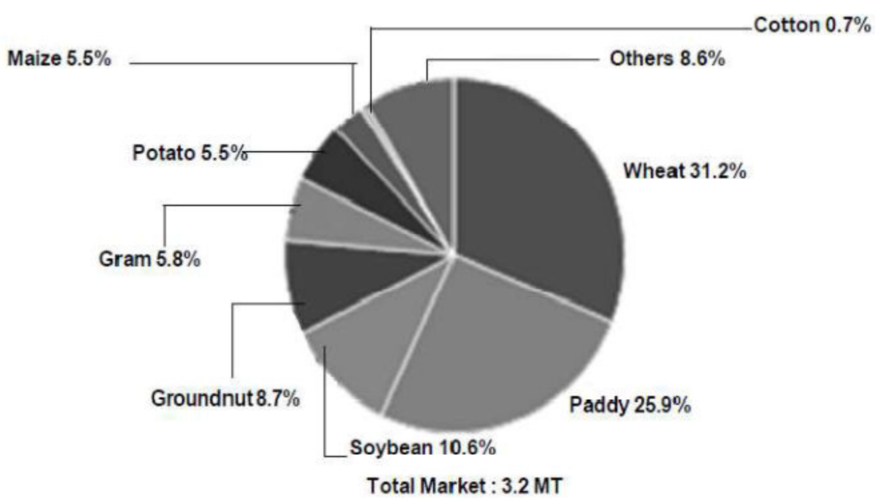


Fig. 3 : Indian seed market by volume

The conventional open pollinated varieties have fallen out of favour with the introduction of newer types of seed variations. They were valued at 0.19 billion USD in 2010, or around 12% of the market's overall worth. The Seed Replacement Rate (SRR) of the open pollinated seeds, which are saved throughout time for their desired characteristic, varies from 20 to 80%. (Agriculture today, 2015). Government implementation of several progressive initiatives (Fig. 4). In terms of R&D, product development, supply chain management, and quality assurance, the National Seed Policy of 2002 and Seed Development, 1988 have both contributed to the development of the Indian seed business. Because of this, India has become the fifth-largest seed market in the world. Additionally, both the public and business sectors actively participated.

Indian seed producing system:

The restricted generations principle is mostly followed by the Indian seed multiplication programme. The technique provides appropriate quality assurance mechanisms in the seed multiplication chain to ensure that the varietal purity is preserved while the seeds are transferred from the breeder to the farmer, and it justifies the use of three generations of seeds: breeder, foundation, and certified seeds. The Department of Agriculture and Cooperation (DAC), Ministry of Agriculture, Government of India, receives seed indents from various production agencies and forwards them to State Departments of Agriculture (DoA), which compiles the information crop by crop and forwards it to the Project Coordinator/Project Director of the relevant crops in ICAR for final distribution of production responsibility to various State Departments of Agriculture. The task of producing foundation seed with the required infrastructure has been assigned to the NSC, State Farms Corporation of India (SFCI), SSC, State Departments of Agriculture, and private seed producers. The SSC, Departmental Agricultural Farms, Cooperatives, and other entities oversee the production of certified seeds. Quality/certified seed production and distribution are generally the responsibility of state governments.

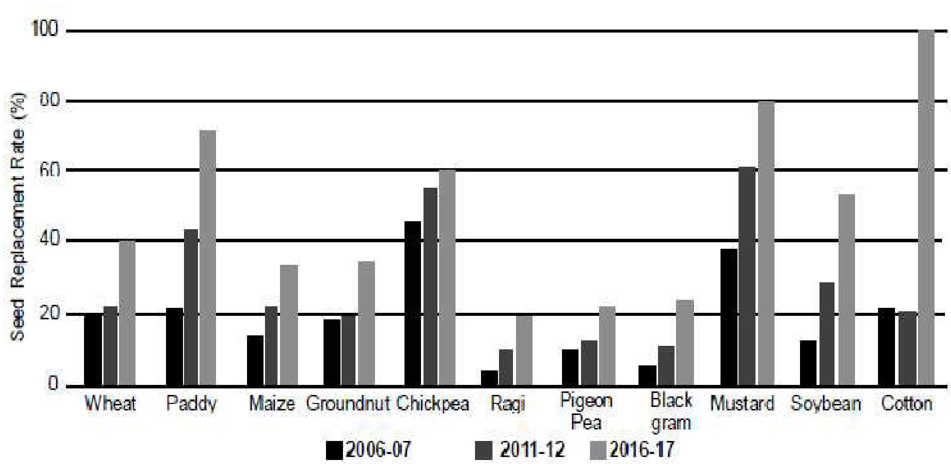


Fig. 4 : Seed Replacement Rate of major crops in India

Seed Replacement Rate (SRR) of major crops in India:

SRR is the proportion of the crop that was sown or planted throughout the season using high-quality, certified seeds other than farm-saved seeds. SRR is one way to double farmers' income because it directly affects productivity and income enhancement for farmers.

Seed Replacement Rate of Major Crops (%), India, 2006-2017

The Indian seeds market, which experienced a CAGR of almost 17% between 2010 and 2017, reached a value of US$ 3.6 billion in 2017, and is projected to rise at a CAGR of 14.3 percent between 2018 and 2023, reaching a value of more than US$ 8 billion by 2023. Due to the sectors' crucial contribution to building a solid industry foundation, the Indian seed market has undergone a significant transformation. This includes conducting campaigns to encourage farmers who previously used outdated open pollinated types to switch to hybrid seeds. Other factors that stimulate growth include rising income levels, commercialization of agriculture, patent protection laws, and intellectual property protections for plant varieties (Agriculture Today, 2015) (Fig 5).

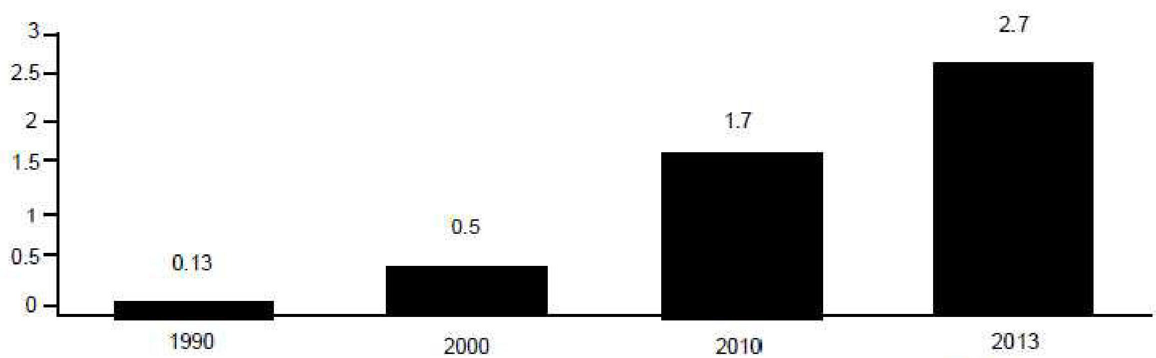


Fig. 5 : Indian Seed Industry growth over years (Value in USD Bn)

Only a few small regional players and government organisations are now involved in the propagation and distribution of conventional and enhanced agricultural types. On the other hand, hybrid seeds currently hold the largest market share in terms of overall value. In reality, given that this segment of seed requires 100% SRR, it is a sector with great potential for private participants. The companies Syngenta, Dupont, Mahyco, J K Seeds, Bioseed, Rasi, and Bayer are only a few of the ones in this industry. Genetically modified seeds, or GM seeds as they are more generally known, fall under the most contentious category of seeds. With significant R&D expenditures, it was observed that this type of seeds was successfully taking a sizeable portion of the market. Unfortunately, the erratic government actions and policy initiatives have deflated this sector's optimism. Among the businesses working on this line of seeds are Monsanto, Dupont, Syngenta, Rasi, and Pioneer. The market for seeds in India is largely dominated by farm-saved seeds, despite the robust data supporting the commercial seed sector. The practise of storing seeds, its economic viability, and the simplicity of using saved seeds have made them the most popular category of seed variations among Indian farmers up to this point. This group includes about 75% of the seed used in the nation.

The country's seed market has a considerable presence from the public sector. This includes 15 State Seed Corporation (SSC), National Seed Corporation (NSC), and State Farms Corporation of India, as well as 99 ICAR research institutes, 65 Agricultural Universities (SAUs & DUs), and (SFCI). The Indian Council of Agricultural Research (ICAR), State Agricultural Universities (SAU) system, and institutions in the public, private, and cooperative seed sectors are all involved in the programme. The seed industry in India is made up of two national level corporations, National Seeds Corporation (NSC) and State Farms Corporation of India (SFCI), 15 State Seed Corporations (SSCs), and about 100 major players. 22 State Seed Certification Agencies (SSCAs) and 104 State Seed Testing Laboratories (SSTLs) are available for quality assurance and certification (Chauhan *et al.,* 2014b, Datta *et al.,* 2013, NSC, 2015). The manufacturing and distribution of seeds have seen a considerable shift toward the private sector since the late 1990s. However, the public sector continues to hold a monopoly over the organised seed business, particularly for food crops (cereals). In India, the private sector mostly profits from high-priced, low-volume crop seeds, such as those for vegetables (Hanchinal, 2012). Their research focuses on developing cultivars that can withstand extreme weather conditions as well as pest and disease resistance. 50 large national and multinational firms and 500 small and medium-sized players comprise the private sector (Agrawal 2012a). The hybrid seed industry is leading the pack of potential growth sectors. With over 300 businesses, the Indian hybrid seed market has been expanding at a rate of 15–20% yearly over the previous several years, and by 2018 it is anticipated to reach about Rs 18,000 crore (Agriculture today, 2015).

Varietal Replacement Rate (VRR) of major crops in India:

VRR is a crucial element in boosting crop output. The development of seed programmes that can deliver high-quality seed of high-yielding varieties with superior genetics heavily influences the rate of improvement in food production. Recent statistics show that among all crops, wheat experienced the quickest rate of VRR, followed by mungbean, chickpea, soybean, rapeseed & mustard, rice, and pigeon pea.

Varietal protection in India:

India has a number of intergovernmental agreements that directly affect agriculture as a member of the World Trade Organization (WTO), which has a dozen such accords. In accordance with the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement, India established the Protection of Plant Varieties and Farmers Rights (PPV&FR) Authority under the Protection of Plant Varieties and Farmers Rights Act, 2001. It has been in operation since November 11, 2005. For a system to effectively safeguard plant varieties, farmers' and plant breeders' rights, and promote the creation of new plant varieties, PPV&FR had to be established.

Seed certification system in India:

In general, seed certification is a method for preserving the physical identity and genetic purity of recognised crop varieties by maintaining and making a steady supply of high-quality seeds and propagation materials accessible to the general public. To guarantee the quality of seed production and multiplication, India has a system known as seed certification. Maharashtra was the first state to formally create a Seed Certifications Agency (SCA) as a component of the DoA in 1970, while Karnataka was the first state to formally establish an autonomous SCA in 1974. 22 states in the nation currently have their own SCAs because to the Seed Act of 1966. In the majority of nations, including India, seed certification is optional whereas labelling is required.

Seed production and supply chain in India:

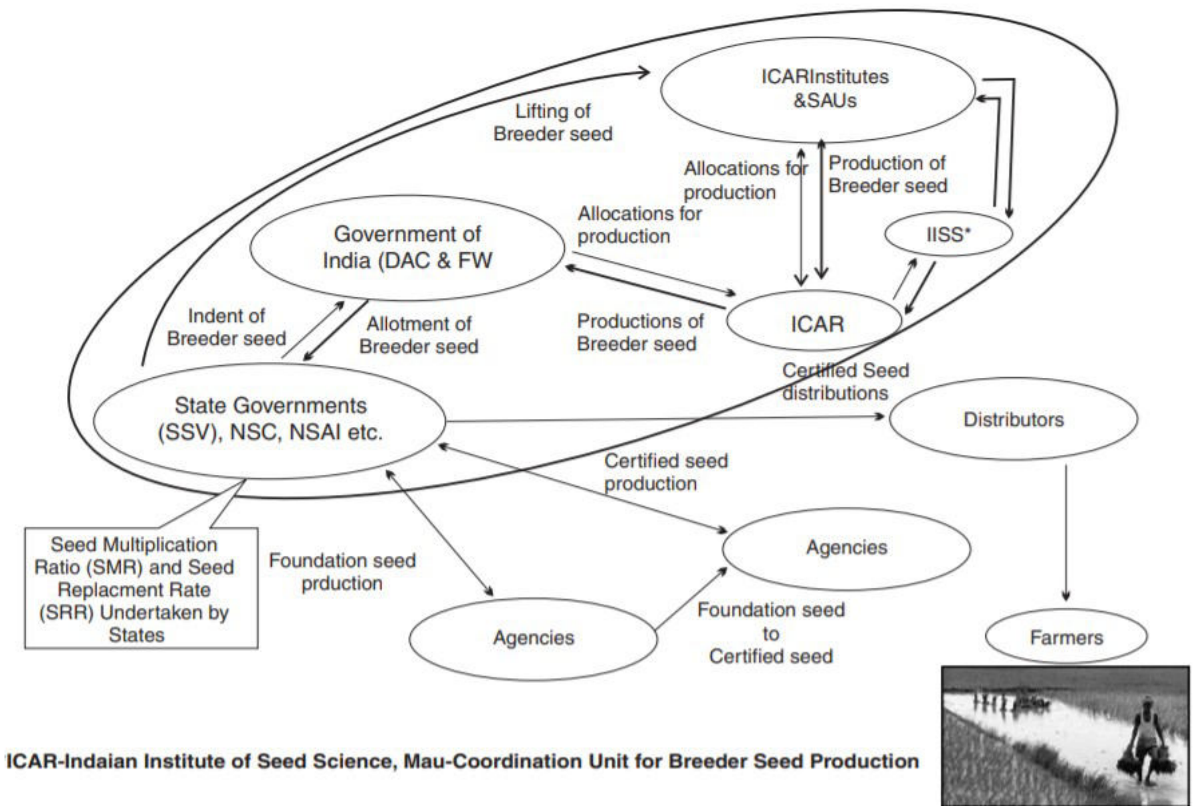


Fig.-6: Seed production and supply chain in India
(https://seednet.gov.in/Material/Channels_of_Seed_Supply.aspx)

Problems of seed industry

On global front, population will be reach 9 billion mark by 2050 with India leading the march, means each farmer will have to produce more food with dwindling land and water resources. Seed research is the key to releasing the potential of technologies at the cusp of climate change. In the Indian context, farm stored seed has historically provided the majority of farmers' seed needs; currently, 65% of farmers use their own saved seed or seed that has been donated to them (Vision 2050, Directorate of seed Research). Instead than production itself, the bigger problem is making excellent seed available at the correct moment. Seed replenishment should be given top importance because it is the main factor in determining productivity. The main challenge is to improve imbalanced SRR, which is the ratio of area seeded to total cropped area, by using certified/quality seeds rather than farm-saved seed.

Key problems of seed sector in India:

Short shelf life of the seed: Certified seeds are only good for one season and must be revalidated before being used in the following season. The retailers do not have the necessary arrangements to store the seeds for an entire year.

Unpredictability of the demand: Due to the unpredictability of nature, changes in commodity prices, and other factors, it is extremely difficult for dealers (private or cooperative) to accurately predict demand for certified seeds.

Lack of effective monitoring mechanism: At the point of sale, there is no effective monitoring system in place to control seed quality. Once the product is sold, the seed producing, and marketing agencies have no control over their production.

Lack of infrastructure: Farmers' access to seeds at the right time continues to be a challenge. Poor infrastructure in remote villages, a lack of purchasing power at the time of sowing, and the uncertainty of rainfall, on which sowing is heavily reliant, exacerbate the problem.

Inadequate extension services Regarding the efficacy of the programmes they provide for popularising contemporary agricultural methods, particularly improved seed procedures, the agriculture department with its many extension services leaves a lot to be desired. However, rather than focusing on the results-oriented strategy for successful impact, extension functionaries are typically perceived as active simply for the purpose of distributing micro kits and doing field demonstrations.

New prospective of seed sector

The range of agro-climatic conditions and the biodiversity that nature has endowed us with present India with exciting chances to compete globally in the production and promotion of a variety of seed crops for export. Given that hybrid rice barely covers 4.1% of the country's land, we must help India. 2011 saw a total paddy seed turnover of Rs. 21.8 billion. If improved varieties cover 50% of the planted land and hybrids cover 10%, the amount might rise to Rs. 42 billion over the following four years (ISTA, 2012). Due to its alternate uses, such as the manufacturing of biodiesel, maize demand has increased globally during the past few years. India is fourth in the world for both production and land area, with an average productivity of 2.5 t/ha. Future wheat and rice production is projected to suffer due to global warming; under this scenario, maize, a C4 plant, may play a significant role in reducing the negative effects of climate change. Therefore, in the near future, the Indian seed market will develop significantly as a result of the concentration on high-quality hybrid maize seeds.

Technological advances in sectors related to seed science and technology are highly commended on a national and international level. One area that requires a lot of policy, infrastructure, and human resource assistance is seed testing and quality assurance. Creating facilities of the highest calibre for seed testing, certification, and to satisfy the requirements of international conventions, such as UPOV, ISTA, etc., so that seed from India can carve its position in global trade Even if India ranks fifth in terms of value share, there is still of room to improve the statistic and achieve success in the global seed trade. With its wide range of agroclimatic zones, limitless alternatives for crops, and likely greatest research workforce, India has a significant possibility to establish itself as a leader in the global seed market. Expanding the knowledge of conventional seed science and technology, such as floral biology, pollination, seed development, maturation, and seed production technology per se, can open up significant opportunities in maximising productivity levels and, consequently, the nation's ability to feed itself and maintain its socioeconomic security. There are a wide variety of opportunities for improving seed quality. Strategies for improving the quality of second- and third-generation seeds will be crucial in giving seeds a completely new dimension. The creation of seeds with all necessary additives that provide acceptable planting value across various agro-climatic zones by protecting them against biotic and abiotic challenges will emerge as a cutting-edge technology in the near future. In the near future, a new era of seed design will emerge in which seeds are purchased or sold on a number basis, making them the most valuable input in cropping systems (Vision 2050, 2015).

Prospective under Seed Quality Augmentation:

Utilizing advanced polymer systems (thermo/hydro) for seed design, smart delivery systems (nanotechnology) for controlled release of analytes, and state-of-the-art disinfection techniques (thermo/plasma treatments) 2 for seed protection are some examples of how intelligence additives are being used for coating and pelleting of seeds, application of OMICS technologies to increase seed quality. A few methods worth mentioning are the creation of image analysis systems for seed and seedling quality assurance.

Prospects of seed export:

About 0.6 percent of the seeds exported worldwide originate from India (ISF, 2012). India agreed to take part in the OECD Seed Schemes in five categories, including Grasses and Legumes, Crucifers and other Oil or Fiber Species, Cereals, Maize, Sorghum, and Vegetables, in order to increase seed exports.

One of the worldwide frameworks for certification of agricultural seeds moving in international trade is the OECD Seed Schemes. Its goal is to promote the use of consistently high-quality seeds in the member nations. Following internationally recognised standards for seed quality assurance will undoubtedly increase our seed exports and make India a major player in the world of seeds (Vision 2050, 2015).

Prospective for production of high-quality seed
Seed Production Research:

The future of agricultural production will largely depend on the creation of new varieties and hybrids of different crops, supported by effective and affordable seed production technology. For the country's seed production system to be expanded, attention must be paid to the diversification of seed production areas and the development of suitable seed production technologies. It may be possible to significantly increase the use of seed production technologies in non-traditional places by identifying alternate or specific areas for high-quality seed production and by mapping disease-free seed production zones.

Climate Resilient Seed Production:

The success of plant reproduction is greatly influenced by the environmental circumstances present during the growth season. Moisture and temperature are two environmental elements that have a direct impact on reproduction. Early reproductive activities include pollination; fertilisation, anthesis, stigma receptivity, and early embryo development are all extremely vulnerable to moisture and/or temperature stressors. Any of these processes going wrong increases early embryo abortion, which causes poor seed set and lowers the seed yield. Unknown physiological processes underlie reproductive failure under stressful situations. In order to create appropriate crop management techniques and lessen the negative impacts on the reproductive phase, it is important to understand how climate change affects the development of seeds for various crops (Vision 2050, 2015).

Organic seed production:

Organic farming will undoubtedly carve out a legitimate place for itself in the future, so it is important to focus on developing crop- and location-specific organic seed production technology. Organic seed (production technique, field and seed standards) is essential for location-specific, producer community-based organic agriculture because seed is the foundation of production systems.

Application of GIS/GPS/ Remote Sensing for higher seed productivity: The GPS/GIS uses include equipment guiding, such as micro irrigation systems, fertilizer/pesticide applicators, and tillage implements, as well as mapping of pests and diseases to avoid unnecessary overlaps and skips and enable precision in seed production. Quality seed production essentially refers to the business of making seeds with the highest genetic purity and other quality characteristics, such as high germinability, vigour, and freedom from insect pests and illnesses, available. To maintain the highest level of genetic integrity, various techniques are already in place.

Proprietary Seed Production Technology (SPT):

Using a genetically modified (GM) line to propagate a male sterile line, which is subsequently utilised as one of the parents to produce hybrid seed, is known as proprietary seed production technology (SPT). The hybrid does not inherit the genetic alteration. The SPT principle could be used with other crops, especially cereals (wheat and rice), some legumes, and oilseeds, where improved hybrid systems are needed and where alternative male sterility systems have not yet been created.

Genetic use restriction technology (GURT):

The term "genetic use restriction technology" (GURT) refers to suggested techniques for limiting the usage of genetically engineered plants by making second generation seeds sterile. Conceptually, there are two different forms of GURT: Variety-level Genetic Use Restriction Technologies (V-GURTs): These GURTs create sterile seeds, meaning that the crop's seed could only be sold for use as food or animal feed rather than for further propagation. The enormous number of indigenous farmers who use their farm-saved seeds will be immediately impacted if technology ever receives permission, and they would be obliged to purchase seeds from seed manufacturing firms. As a result, there is considerable opposition to the spread of GURT technology in underdeveloped nations. T-GURT: This second kind of GURT alters a crop so that the genetic modification put into it cannot be used unless the crop plant is treated with a chemical that is offered by the developer. Farmers are now able to store seeds for yearly usage thanks to technology. However, until they purchase the activator compound, they are unable to use the improved trait in the crop. The term T-GURT refers to a technology that is constrained at the trait level.

Seed Quality Assurance/Varietal Maintenance and Testing:

For the scientific community, business community, and farmers, innovation means diverse things. All technological advancements would be of little use to the farmer unless he received refined end products (seed) that were genetically pure (true to type) and have other desired traits like high germination and vigour, sound health, etc. For improved seed quality assurance and simple access to the global seed trade, several seed testing procedures now used in India need to be enhanced in accordance with international standards of seed testing such as ISTA, AOSA, and OECD. When determining the distinctiveness of varieties, biochemical and molecular markers such as protein electrophoresis, isoenzyme analysis, and DNA fingerprinting using first and second generation markers may be used in addition to the Grow Out Test to ensure genetic purity. Differentiating closely related and substantially derived types has to receive special attention (EDVs). The development of user-friendly molecular detection kits for quick and precise identification of types, hybrids, diseases, and GMOs should also be a priority. It is necessary to do research on certification criteria, segregation from non-GM crops, and affordable kits for transgene detection using micro array chips and proteomic techniques as a result of growing biotechnological involvement in various crops and the creation of GM crops.

Seed Biotechnology:

To create seeds of the highest quality, genomic research should be done to identify the gene(s) controlling dormancy, germination, and longevity as well as genes that are stress tolerant. An area with enormous promise for quality improvement is transcriptomics of seed development to unravel molecular regulation of better seed features. Creation of a national database for crop variety DNA profiles. Creation of a DNA bar coding system to monitor the supply and production of breeder seeds. Field and seed standards and techniques are being validated or improved, including separation distance, sample size, physical purity, and ODV. creation of interactive software for weed seed identification and standardisation of minimal weed seed standards. Establishing ISTA approved laboratories and creating systems for standardisation in seed testing and reporting. Only a few fields—including high performance phenotyping and second-generation imaging technologies—can handle quality-related issues.

Seed Quality Enhancement Intellicoat Technology:

A polymer-based technology that uses seed coating to regulate the timing of germination. It is based on Intelimer polymers, which stand out from other polymers in that they can be designed to drastically alter their physical properties when heated or cooled through the use of a programmed temperature switch. The time of germination of the coated seeds can be modified, and the issue of parental line synchronisation in hybrid seed production can be solved by coating the seeds with Intelimer polymers that have a needed pre-set temperature switch mechanism. Additionally, this technique supports relay cropping systems.

Cold Plasma Coating:

Under conditions of high energy and low temperature, seeds could be coated with a variety of (hydrophobic/hydrophilic) gaseous polymers. In these circumstances, the gases reach the plasma state and cover the seed surface. It has been demonstrated that using this technique allows one to regulate the rate of germination.

Molecular Impulse Response (MIR):

It is a non-chemical, energy-based improvement that is designed to improve plant tolerance to various abiotic stress effects by frequently boosting germination, speeding up maturity, and improving yields. For a brief increase in free radical levels inside seed cells, MIR employs an extremely low energy electron shower. As a result, the cell's natural defence system produces more antioxidants, which neutralise the free radicals and leave the cell with more antioxidants overall than before the process started.

Bioprospecting:

Application of biological agents to crop seeds has primarily concentrated on rhizobacteria, or root-colonizing bacteria. Rhizobacteria known as PGPR (Plant Growth Promoting Rhizobacteria) are those that have advantageous impacts on plants during colonisation. Plant growth stimulation and biological disease control are two advantages of PGPR. In addition to increasing production by 5, early season growth promotion is frequently induced. This can take many different forms, such as improved seedling emergence, higher biomass of roots and/or foliage, and earlier blooming.

Nanotechnology for Seed Quality Enhancement:

The field of seed treatment using carbon nano tubes (CNTs) and a variety of nanoparticles (gold, silver, and borates) is entirely new and has not yet been completely explored. Nanotechnology's use in seed science research is still in its infancy, and its full potential has not yet been realised. It is a research field with no end and will completely reorient the idea of seed enhancement. This includes designing smart delivery systems (CNTs, nanofibres) loaded with nutrients/PGRs/pesticides for sustained release, dormancy breakdown, longevity enhancement, vigour augmentation, physiological process regulation, and molecular modification (Ali, 2016).

Key prospective to strengthen the seed sector in India:

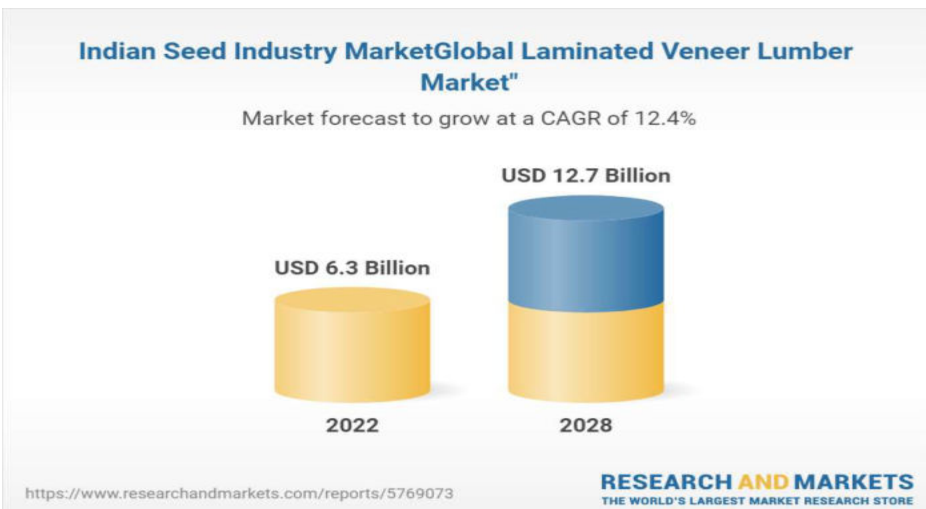
1. About 0.6% of the seeds exported worldwide originate from India. India agreed to take part in the OECD seed schemes in five categories, including grasses and legumes, crucifers and other oil or fibre species, cereals, maize, sorghum, and vegetables, in order to increase seed exports.
2. The future of agricultural output will be primarily dependent on the creation of superior crop types and hybrids, supported by effective and affordable seed production technology.
3. For the country's seed production system to be expanded, attention must be paid to the diversification of seed production areas and the development of suitable seed production technologies.
4. To create appropriate crop management methods and lessen the negative consequences, it is important to examine the impact of climate change on the development of different crops' seeds.
5. Since seeds are the basis of all production systems, it is essential for location-specific, producer community-based organic agriculture to use organic seeds (production technique, field and seed standards). Applications for GPS/GIS include guiding machinery, such as micro irrigation systems, fertilizer/pesticide applicators, and tillage implements, as well as mapping pests and diseases to avoid unnecessary overlaps and skips and enable precision in seed production.
6. For improved seed quality assurance and simple access to the global seed trade, several seed testing procedures now used in India need to be enhanced in accordance with international standards of seed testing such as ISTA, AOSA, and OECD. The use of biochemical and molecular markers, such as protein electrophoresis, isoenzyme analysis, and DNA fingerprinting using first- and second-generation markers, may be used in addition to conventional genetic purity testing to determine the distinctiveness of varieties.
7. To create seeds of the highest quality, genomic research should be done to identify the gene(s) controlling dormancy, germination, and longevity, as well as genes that are stress tolerant. Image analysis can quickly and accurately determine the morphology and vigour of seeds during the maturation stage. In addition to germination, desiccation resistance, and longevity, chlorophyll presence on seeds has a direct relationship to maturity.
8. Creation of cutting-edge seed storage and processing techniques, such as thermal seed processing facilities (high precision, high throughput process).
9. Polymer-based method that uses seed coating to regulate the timing of germination. The time of germination of the coated seeds can be modified, and the issue of parental line

synchronisation in hybrid seed production can be solved by coating the seeds with Intelimer polymers that have a needed pre-set temperature switch mechanism. Additionally, this technique supports relay cropping systems.

10. Seed treatment using carbon nanotubes (CNTs) with a variety of nanoparticles (gold, silver, and borates) is a brand-new area that has not yet been completely explored. Nanotechnology's use in seed science research is still in its infancy, and its full potential has not yet been realised.
11. Application of biological agents to agricultural seeds has mostly targeted rhizobacteria, or root-colonizing bacteria. Rhizobacteria known as PGPR (Plant Growth Promoting Rhizobacteria) are those that have advantageous impacts on plants during colonisation through the stimulation of plant growth and biological management of plant diseases.
12. In terms of seed health, the seed industry has two responsibilities: providing farmers and seed producers with seed that is sufficiently healthy and adhering to global phytosanitary standards.

Future of Indian Seed Industry:

The seed industry in India size reached US$ 6.3 Billion in 2022. Looking forward, IMARC Group expects the market to reach US$ 12.7 Billion by 2028, exhibiting a growth rate (CAGR) of 12.43% during 2023-2028.



Conclusion

The Indian seed sector is adjusting to the country's shifting patterns of food consumption more quickly. However, both in urban and rural areas, the percentage of money spent on food has fallen during the last three decades. The present seed business may need to create new goods or technologies in the near future to keep up with the growing mechanisation of India's agricultural sector due to workforce constraints. Future seed sales in the nation are predicted to see a rise in the use of hybrid seeds. The need for seed varieties with greater nutritional and health benefits is another expected trend in the seed market.

There is a need for promoting joint venture collaborations between industry and national and international institutions related to seed. if Government also extends the benefit of subsidy to truthfully labeled seed of promising hybrids produced by the private sector, may be beneficial for seed sector. Sharing of germplasm is imperative for crop improvement, while the national repository makes available the germplasm to the researchers and national seed companies, the private sector must also come forward and share their valuable germplasm with the public sector institutions for research purpose. Also, these need to be stored in the Gene Bank for posterity.

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Seed Storage Structures and Their Maintenance

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Abstract:
Seeds have the ability to withstand moisture loss and maintain their viability in a dry state. The advancement of agriculture and the exchange of varieties and genes have led to the evolution of storage techniques. Suitable storage conditions are necessary to maintain the original quality of seeds. The aim of seed storage is to minimize deterioration and sustain quality for the required duration. This chapter provides an overview of both traditional and advanced storage structures. To meet the increasing demand for food grains from the growing population, it is essential to minimize seed loss during and after harvest. Seeds are stored for different periods to ensure equitable distribution throughout the year. In India, post-harvest losses are estimated to be around 10%, out of which storage losses are estimated to be 6.58%. However, with improved agricultural technology, seed producers can store seeds for longer periods with minimal loss.
Key Points: Storage, structures, agricultural produce, traditional, improved maintenance, etc.

1. Introduction

The primary purpose of any seed storage facility is to maintain the viability and vigour of seeds during the storage period. This period may vary from a few months to several years, depending on the kind of seed and its intended use. Therefore, the type of storage structure depends on the duration of the storage. During storage, it is fundamental to keep the seed dry – a condition governed primarily by seed moisture content and storage temperature, both of which must be carefully controlled within the storage facility.

However, a large proportion of the seed produced for agricultural purposes only requires storing through to the following planting season, in which case normal air temperature and relative humidity may be sufficient, depending on the kind of seed and the local climate. Storage structures must protect seeds from wetting, overheating and infestation by pests. It is only in areas with extremely high temperatures and relative humidity that additional protective measures (i.e. temperature and humidity control) may be required to maintain seed quality during storage. Finally, storage structures should be fitted with locks and other appropriate security measures adopted, as required.

2. Main purpose of seed storage

Seed storage is necessary to maintain the seed in good condition from harvesting to planting. For some crops, little or no storage is needed as seeds can be sown immediately after harvesting. The primary purpose of seed storage at the farm level is to preserve seed stocks for sowing in the following season. However, extended storage – i.e. keeping seed for ≥ 2 years to meet future demand may be necessary for various reasons:

• Farmers in local communities desire to preserve the material of well-adapted and preferred seed varieties.

• There is a perceived risk of crop failure in difficult conditions. Hence, some production from a good harvest is kept as a buffer stock to cover seed needs in less productive years. The yield and quality of seeds, particularly germination and vigor, can be unpredictable due to growing conditions.

• The demand for certain crops and seeds varies from time to time. When seed suppliers fail to market all their seed during the immediate planting season, the unsold seed is carried over to the second planting season. However, not all seeds naturally store well for this purpose; for example, groundnut, soybean, and onion seeds have a naturally short storage life.

• Eliminating the need to produce seeds every season is a potentially efficient and economical strategy for foundation seed enterprises producing seed varieties with limited demand during any given season. Many types of seed lots, mostly vegetable, flower, and forage seeds, in international trade are not used the first year after production.

• Sufficient time for breaking dormancy is provided, thus improving the percentage of germination.

• Genetic resources are conserved, which requires long-term seed storage. Regardless of the specific reasons for storage of seed, the purpose remains the same – to maintain a satisfactory capacity of the seed for germination and field emergence. The facilities used and procedures adopted in storage must focus on this purpose. During storage, seeds must be regularly tested, particularly for germination capacity.

Seed storage is an important process that involves different stages, such as harvesting, drying, threshing, processing, storage, and transportation. The longevity and strength of the seed are affected by these stages, making it crucial to understand their impact. Seeds are delicate and living organisms, and their shelf-life is influenced by various factors, such as soil nutrition, plant health, and others. While providing optimal conditions for crop growth and health is essential, the greatest impact on seed viability and strength is made during harvesting, threshing, extraction, drying, cleaning, transportation, and storage. Therefore, it is important to minimize seed damage and maximize seed viability and strength from pre-harvest to post-harvest handling.

3. Different stages of seed storage

Harvest maturity (storage on the plant)

Seed quality is greatly affected by environmental conditions from the time the seeds reach physiological maturity until harvest. Weather damage is often a serious factor during this stage, which can result in reduced germination capacity and vigour of certain crop seeds, such as soybean and groundnut, before harvesting. Other factors, such as soil conditions, mineral nutrient deficiencies during plant growth, water stress, high or low temperatures, disease, and insect damage, may also cause seed quality deterioration, leading to reduced viability and vigour at physiological maturity.

Therefore, it is crucial to maintain the initial seed quality at the highest possible level, minimizing damage from weather and other factors and adopting good practices such as raising a healthy seed crop, harvesting early, and making adequate and timely arrangements for seed drying and threshing.

Harvest to processing (storage from harvesting to processing)
Since seeds have high moisture content at harvest, seed deterioration can berapid following harvesting. If the cereal seed moisture content is > 13% at the time of harvest, rapid and serious deterioration can occur during the periods of storage involving: transport from the field to drying and the threshing floor; transport from the threshing floor to the processing plant; and storage at the processing plant. At MC ≥ 13%, mould can grow and heating may occur. The utmost care is required when handling material with a high moisture content after harvest. If seed is harvested at MC > 13%, take steps to preserve seed quality. Note that freshly harvested seed may seem dry overall, but individual seeds with high moisture content can initiate mould growth in spots. **Aerate freshly harvested seed** – even when the seed appears dry. **Prevent mechanical admixture and maintain seed lot identity.**

Distribution and marketing (storage in warehouse)
After processing, the seed is placed in different forms of storage to await distribution or marketing. Although the ageing of seeds and the reduction in germination cannot be stopped entirely during storage, they can be controlled by providing good storage conditions.

Storage in transit, at retail and on farm
Construction of excellent warehouses serves no purpose if the seeds lose their viability as a result of improper storage during transit, at the retail store or on the user's farm. Adequate storage precautions are necessary at all these points.

4. Factors Affecting Seed Longevity in Storage

- Seed type
- Initial seed quality
- Seed moisture content
- Relative humidity and tempera ture

5. Basic Features of Seed Storage Structures
A seed storage facility needs to be economical and appropriate for the specific situation. Furthermore, a seed storage structure must provide protection from w**ater, admixture, insect, rodent, fungi, fire, etc.**

Water
It is crucial to prevent seed in storage from coming into contact with any source of water – including rain and ground moisture – as this would increase the seed moisture content. High seed moisture content induces respiration, leading to heating, mould growth and possible sprouting, which spoil the seed and decrease its quality:

- Keep the roof, floor and sidewalls free of holes and cracks that may permit the entry of water in any form.
- Provide some kind of waterproof floor – an elevated floor or a concrete floor with a moisture barrier underneath – to counteract the possibility of contact with soil moisture.

Admixture

A storage facility typically holds more than one type of seed and it is important that different kinds do not become mixed:

− Construct and organize the facility to keep seed lots separate and prevent contamination.

− For bulk storage, provide a separate bin for each variety; for bag storage, stack seeds of different varieties separately on pallets.

− Clearly label all bags, bins and other containers with relevant details to facilitate identification and inspection.

Insects

Efficient cleaning is fundamental that facilitate insect control (including elimination of insect breeding places) and make the store suitable for fumigation.

Rodents

Maximum protection against rodents is essential to prevent them from entering and gaining access to the seeds – rodent control precautions vary according to the type of storage facility. The use metal bins with tight covers and Treat cloth bags are suggested for effective rodent control.

Fungi

Temperature differentials can cause water vapour to move from warmer to cooler areas of a storage bin, **usually to the upper surface**; this moisture movement can provide conditions favorable for fungus growth because fungi grow best under warm humid conditions. So build the storage structures to provide a cool and dry environment and adopt effective ventilation during construction to prevent the accumulation of water vapour.

Fire

It is important to minimize fire hazards, especially in wooden buildings. So the maintenance of cleanliness both inside and around the building is utmost important. In addition apply chemical treatment to wood to retard burning. Use spark-proof switches and rodent-proof wiring to reduce the chances of sparks and electrical fires, as well as dust explosions.

6. Types of Storage Structures

There are three main storage systems or packaging options for seeds are discussed here:

(1) Bulk
(2) Bag
(3) Hermetically sealed containers

In spite of the above, there number of storage structure for the seed classified in different categories such as:

(a) Indoor and outdoor storage structure
(b) Traditional and improved type storage structures
(c) Indigenous and modern storage structure
(d) On form and storage structure with cooling facilities

Any storage structure among these systems is adopted on the basis of following factors:

- Type and quantity of seed.
- Value of seed.
- Purpose of storage.
- Intended length of storage.

The packaging method used conditions the choice of storage facility. For example: there are some packages that allow for free exchange of air (e.g. woven poly bags or paper bags) and are best placed in conditioned storage, which provides a cool and dry environment that facilitates the free movement of air. Sealed containers (e.g. jars, cans or foil packets – typically used for high value seeds) are best protected for extended periods in cold storage. This method is suited to situations where relative humidity is hard to control. Although storage facilities are generally classified as either indigenous or tradition and improved or notes modern:

(A) Indigenous or traditional storage structures

Smallholder farmers in rural areas have designed their own structures and methods for storing seeds in bulk or in a variety of smaller containers made from locally available materials. The informal seed sector predominates in many developing countries, and much of the seed farmers use is stored at local level in these indigenous storage facilities. Indigenous structures are not new inventions: they have survived the test of time. Their design and use vary according to climatic conditions, and reflect the tradition and cultural context of specific societies and an intimate knowledge of the environment. Consequently, many of the structures and practices at this level are ecofriendly. Depending on local needs, they differ in design, shape, size and function, and include: bamboo baskets, various wooden structures, underground pits, mud or brick structures, earthenware pots and gourds. The use of indigenous structures is closely associated with local storage practices and application of natural products as biological pesticides, insect repellents or disinfectants (e.g. neem oil and leaves, wood ash, cooking oil and cow dung). However, the description of some storage structures and their storages applications is given Table 1.

(I) Wooden Structures

Thombarai

Structure is made of Acacia (thorn tree) wood and is rectangular. Height from the ground level is 1 m and has four supporting wooden pillars at the bottom. For collecting and pouring the seeds a small door with an opening is provided at top. Straw is spread over the top and sealed with mud after filling the seeds.

Mara thombai

A rectangular wooden structure called thombai is used to protect seeds and grains from insects,

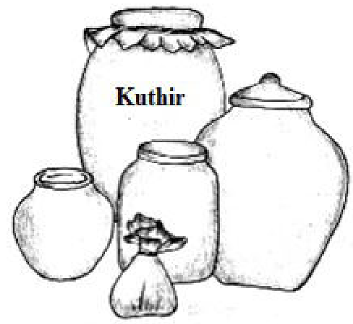
- A rectangular **wooden structure** called thombai is used to protect seeds and grains from insects, moisture, mold growth, and animal attacks.
- The wall is made of wooden boards, 1.5-2m high and built 80cm above the ground on four poles.

moisture, mold growth, and animal attacks. The wall is made of wooden boards, 1.5-2m high and built 80cm above the ground on four poles. It is divided into 4 drawers, each with a capacity of 1000kg, and has a small outlet for seed removal at the base.

(II) Mud Structures

Kuthir Mud Structure

Farmers in Tamil Nadu store cereals in tall mud pots called "kuthir." These pots are made of clay soil and plant fibers mixed with cereal husks to make them stronger. The pots have a narrow opening at the top and a tight lid, and seeds can only be accessed through the top opening.



Earthen pots

Earthen pots are made of clay to a convenient size. Walls are coated with clay and the mouth is closed with stiff cow dung paste reinforced with cloth. Pots can be arranged vertically one over the other as per requirement. Capacity varies as per size of the pots.

Closed mud-walled bins or silos

Closed storage bins made of mud mixed with chopped straw are widely used in arid regions to store grain and seeds of sorghum,

(a) Mud-walled bin

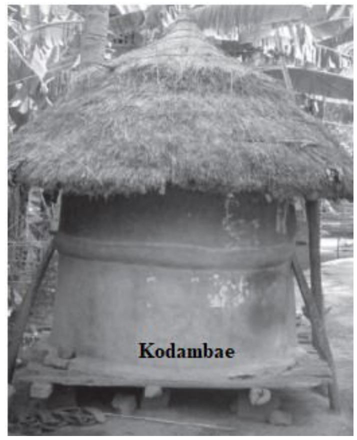
(b) Mud-walled

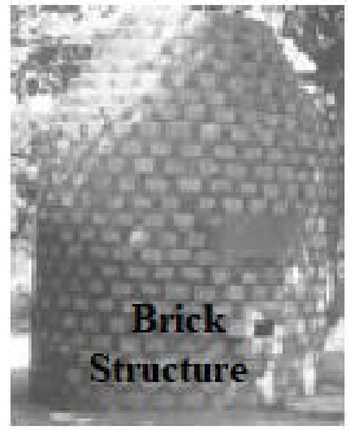
millet, pulses, paddy and peanuts. The silo usually has a lid; a straw roof provides protection against rain. It is raised above the ground to prevent soil moisture from entering, and guards are in place to keep out rodents. Moisture or condensation problems are virtually inexistent due to the low moisture content of the stored produce and the good insulation capacity of the mud used.

(III) Brick Structures

Kalangiyam

Farmer's houses have rectangular brick walls with a strong concrete base. Smooth plastering keeps insects away. Wooden lid at the top is for loading and unloading storage materials. Structure size and capacity varies as per the farmer's needs.





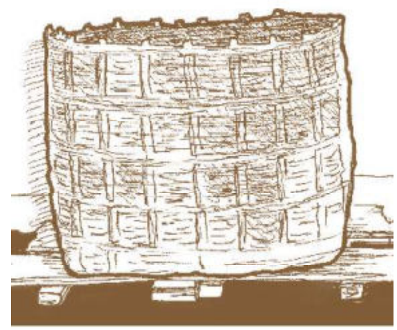
Kodambae

Farmers build round structures with big stones at the base and wooden sticks on top. Walls about 1 meter high are made of mud or cement and bricks. A conical roof made of bamboo or coconut fronds is built on top. Seeds are collected through a wooden opening and stored inside. Capacity is 1000 kg.

(IV) Bamboo Structures

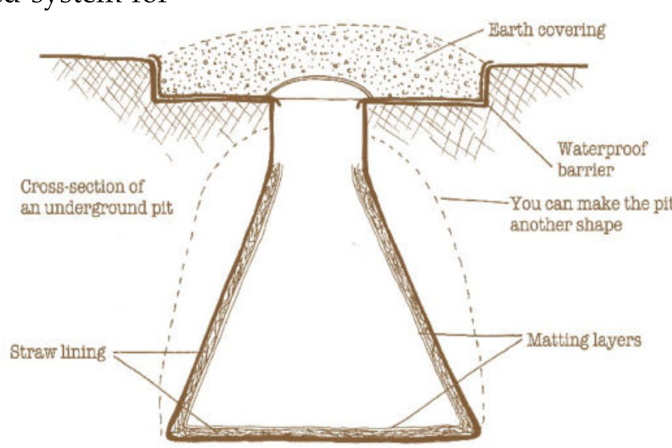
Plastered bamboo baskets

This is a traditional bin with large storage capacity. The walls are covered with a layer of straw and plastered with cow dung slurry. A layer of dried neem leaves is placed at the bottom. The cow dung slurry acts as disinfectant; the neem leaves act as insect repellent.



(V) Underground pit storage

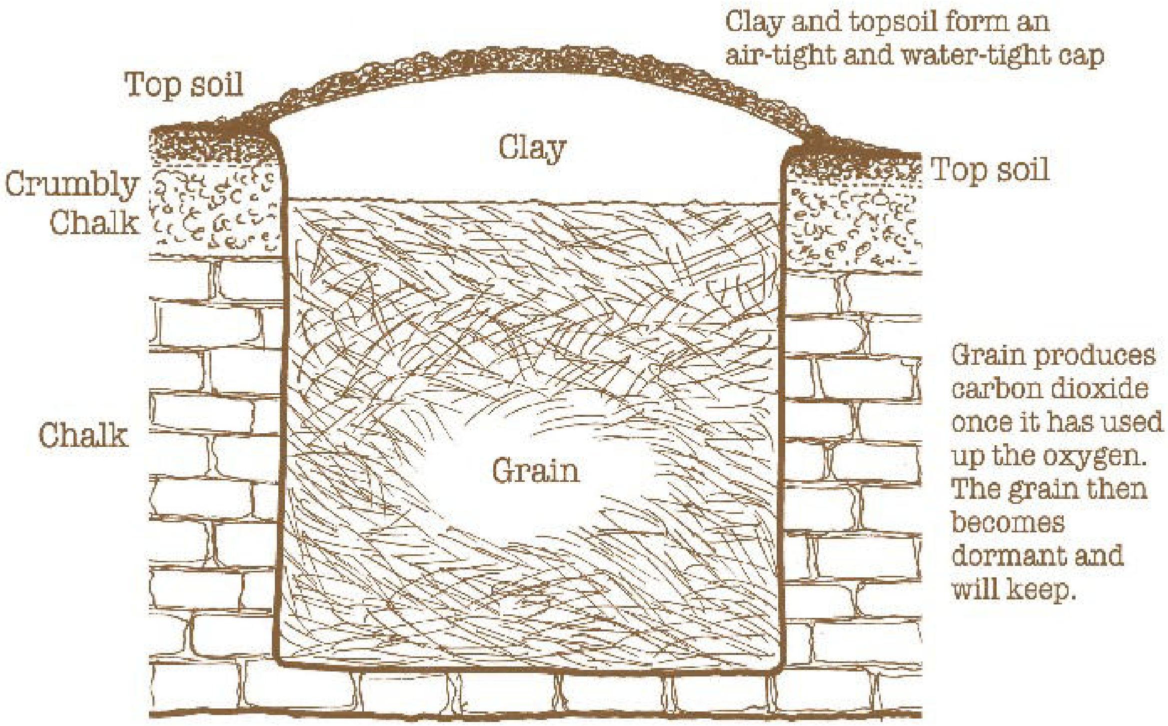
On-farm storage in underground pits is a closed system for storing cereal seed and keeping it cool. It is used in dry regions where the water table does not endanger the contents. A suitable site must be chosen: relatively dry, with the right type of soil and free of termites. There are several types of pits, most of them *flask-shaped* (i.e. wide at the bottom, tapering to a small opening at the top), covered with sticks, cow dung and mud, or with a large stone embedded in soft mud. The pit walls are



Underground flask-shaped pit

covered with cow dung and mud, and made waterproof to prevent entry of both ground- and rainwater. In areas with a sufficiently dry climate, underground stores are an excellent alternative to many other on-farm storage systems. The major advantages are given below:

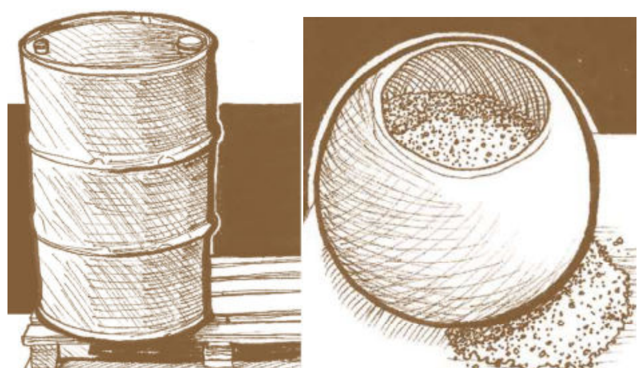
• Structure airtight and cool – not affected by fluctuations in temperature.
• Limited development of insects and mites and little growth of mould – if pit is kept satisfactorily air- and watertight.
• Environment more hygroscopic than the seed – tends to keep soil moisture away from the seed mass.



Underground clay pit storage

(VI) Traditional small bins (metal and earthen)

Traditional storage bins used by African farmers are small (e.g. calabashes, gourds, clay or earthenware pots, wooden containers and oil drums). They are used for closed storage of seed and pulse grains (e.g. cowpeas). They can be made hermetic by sealing the walls inside and out with liquid clay, and closing the small opening with stiff clay, cow dung or a wooden cork reinforced with cloth. If the grain is dry (MC < 12%), small bins rarely present problems for



Traditional small storage bins

storage. However, note that the condensation may occur in closed storage systems (especially in metal containers such as oil drums); and shade must be provided to maintain constant storage temperatures.

(VII) Traditional or farm-level bulk storage

Bulk seed storage takes place at both traditional and formal/commercial level. It involves the use of a wide range of storage structures. At farm level, seed is often stored in bulk in woven bamboo baskets or containers made from wood, metal or plastic. The containers are located inside the house or placed in special mud or wooden constructions. They vary in shape, size and capacity and are normally closed. The major advantages of traditional or farm-level bulk storage are: (a) this storage technique is good protection against penetration by pests, (b) cool and dry microclimate (particularly in mud constructions), (c) airtight conditions – therefore oxygen is used up by respiration of pests and grains leading to self-destruction of pests. There are some disadvantages of this type of storage technique such as: (a) this technique has poor resistance to rain (mud constructions) – therefore regular repair work or rebuilding may be necessary, (b) appearance of crack as period of storage prolonged that is providing ideal hiding places for insects and (c) there is a risk of condensation (particularly in metal containers).

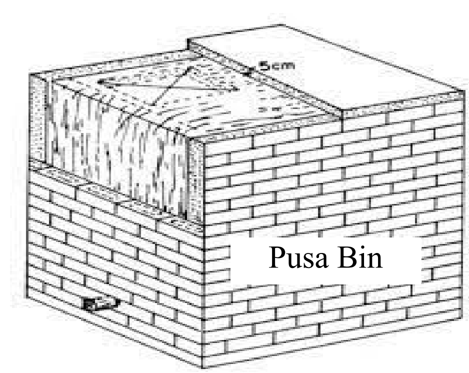
(B) Modern/Improved storage Structures

Various kinds of traditional stores have been modified, improved and are developed to make them more suitable for long-term storage. Some of them are given below:

• Pusa bin (Developed by IARI) • RCC ring bin • Udaipur bin • Bamboo bin • Hapur bin (kothis) • Coal tar Drum • Pusa Kothar • Gharelu thekka • Controlled Conditioned	• Metal bin • Stone bin • PKV Bin • Baked Bin • Metal drums • Pucca kothi • Pusa Cubical • Cold Storage

Pusa bin (Developed by IARI)

The grain and seed both remain safe in the bin for more than one year with proper precautions. A modification of the ordinary mud storage structure is commonly used in villages. Pusa bins are of rectangular in shape and have a capacity of 1 to 3 tonnes. To provide moisture proof and airtight conditions, polyethylene film of 700 gauge thickness has been embedded at the top, bottom and on all the sides of the mud bin. The embedding process provides mechanical support and safety to polyethylene film. The construction of outer walls with burnt

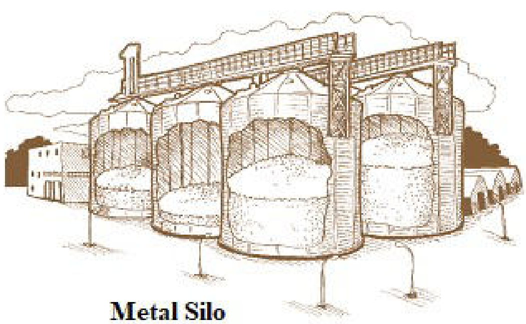


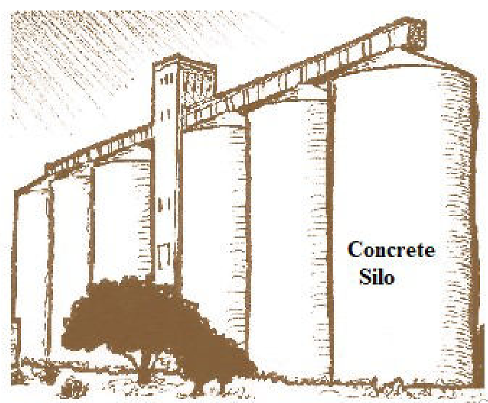
bricks up to 45 cm height makes the structure rat proof as well. The bin is constructed with unburnt bricks on burnt bricks or concrete floor to avoid rat burrowing.

Metal and Concrete silos

Large grain or seed collection companies sometimes use metal or concrete silos with a capacity of 20–2 000 tonnes. Silos are easily sealed for fumigation and little grain is spilt or wasted. On the other hand, they are not favoured in hot climates because hot spots and moulds form as a result of moisture migration inside the silo. This technique of seed storage has several advantages such as:

- It has capacity of large quantities of storage.
- There is no need to purchase storage containers (e.g. poly bags) in silos.
- In these storage structure there is low level of insect incidence (and when there are insect pests, fumigation is easier than in bag storage).
- There is almost no wastage. Since here is no leaking type waste from bags.
- Inspection is very easy in silos, resulting in savings of labour and time.





Metal bins made of steel, Aluminium R.C.C are used for storage of grains outside the house. These bins are fire and moisture proof. The bins have long durability and produced on commercial scale. The capacity ranges from 1 to 10 tonnes. Silos are huge bins made with steel/ aluminium or concrete. Usually steel and aluminium bins are circular in shape. The capacity of silo ranges from 500 to 4000 tonnes. A silo has facilities for loading and unloading grains.

RCC Ring Bin

RCC ring bin is built with cement concrete rings placed one over the other. These types of bin have a steel inlet opening on the roof. An outlet is provided either at the base or at the lower ring itself. Capacity varies according to the diameter of each ring.

Stone bin

Stone bin (Chittore bin) is made of locally available 40 mm thick stone slabs with dimensions of 680 mm x 1200 mm with square cross-section. The inlet and outlet are made of asbestos. This bin has a capacity of 3.8 quintal.

Udaipur bin

These bins are made out of used coal tar drums. This type of bin can store 1.3 quintal quantities of wheat and maize seeds. These bins can be made to have more airtight lid if the drum outlet end is given small cut to unload the bitumen. These bins are suitable for storing of food grains for short duration and can be adopted by small farmers.

Bamboo bin

These bins are made of two walls of bamboo with polythene lining in between and have varying capacities. These bins are suitable for short – duration storage and can be adopted by small and marginal farmers.

Baked Clay Bin

Baked clay bin of 7q capacity (paddy) is made of 16 burnt rings jointed by mud plaster; cement mortar and cow dung coatings one after another. The ends of the rings are made in such a manner that they fit into each other. These rings are kept on a polythene sheet covered and plastered platform of brick masonry and cement sand mortar. An outlet is provided for the discharge of the grain. The top is covered with a mild steel lid. Because of the low cost and good performance these are particularly useful for small and marginal farmers. Do not store their produce for longer duration.

Hapur bin (kothis)

The IGSI (Indian Grain Storage Institute) has developed metal bins for domestic storage of food grains. This bin made of galvanized iron and/or aluminum sheets. Circular bins of 2, 5, 7.2 and from 200 to 1000 kg capacity are available. The cost of bins from 200 to 1000 kg capacity ranged from Rs. 350 to1200.00 per bin.

Metal drums

Farmers store sorghum, maize, millets and groundnuts in clean and dry metal drums with a capacity of 600 kg. Seeds are filled using a funnel and tightly closed with a cap. Drums protect the seeds from rodent damage and can be fumigated to prevent pest attack.

Coal tar Drum

An alternate model of metal bin is coaltar drum bin which is of low cost with similar technical performance. These bins are of 520 mm dia. and 900 mm height. They can store 1.5 q of wheat and 1.2q of Bengal gram. This is developed by CIAE Bhopal.

Pucca kothi

The structure is built indoors using burnt bricks and cement on an elevated floor. It should have an airtight polythene sheet after plastering the walls. There should be an inlet at the top and an outlet at the bottom. Iron bars can reinforce the walls. Its purpose is to maintain stored product moisture level. Capacity depends on available space in rural houses.

Pusa Kothar

Presently storage is practiced in small compartments of a room (5.3 m x 2 m x 4 m) called kothar. The roof is constructed with the help of wooden poles and mud slabs, leaving near the front wall three filling holes each of 0.5 m x 0.5 m size. Two out lets of G.I. sheets of 15 cm dia. and 30 cm length are fitted at the floor wall on the front side.

Pusa Cubical

This is a room like structure (3.95 x 3.15 x 2.60 m). It a modification of Pusa bin to provide large storage capacity of 24 tonnes on a platform of 3.73 m x 2.93 m x 0.07 m is made with unburnt bricks on a concrete floor (except 22 cm of outer sides with burnt bricks). A polyethylene sheet is placed on this platform and another platform of similar dimension is made with unburnt bricks. The 22 cm thick inner walls are constructed up to 2.6 m height. A wooden frame of 1.89m x 1.06 m for door is fixed in the front side of 3.95 m wall. The roof can be made by wooden beam placed at 15 cm distance and covered with unburnt bricks.

Gharelu Thekka

Storage capacity ranges from 1 - 3 metric tonnes. Structure consists of metal base fabricated with 22 gauge sheets, rubberized cloth container and bamboo posts for lateral support. Structure height is 2 m. Structure is moisture proof, airtight and suitable for periodical fumigation.

Cold Storage

It is low temperature (<20°C)storage/ RH <30% is ideal for low -volume, high -value seeds for 4-5 years. It is expensive storage technique. It is unsuitable for storing of paddy and wheat seeds

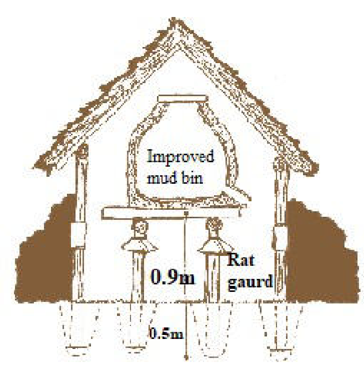
Controlled Conditioned

Cold storage facility used with the dehumidifier. Low temperature (<20°C) and low RH (<50%) storage is generally for1–2 years. Low temperature (at 15°C) and low RH (at 30%) is used for storage of vegetable and nucleus seeds for 3–5years.

Other Improved Storage

(a) Improved/ Commercial bulk storage

There have been several attempts to improve on traditional stores and make them more suitable for long-term storage. Many traditional stores perform excellently in their appropriate climatic conditions, while others can be improved with minor changes.

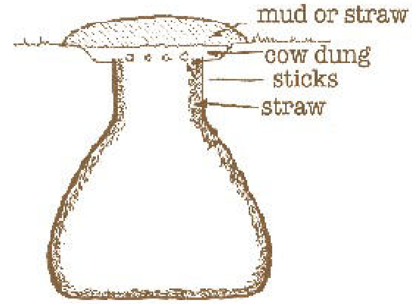


(b) Improved mud bins

Improved mud bins are plaster the walls of traditional storage bins (woven baskets) with mud mixed with cement/lime (stabilized soil technique) to prevent cracks. In these structures inlets and outlets are made more airtight by equipping them with lockable covers. In additions, the other features (e.g. raised floor or platform, rat guards and thatched roof) are retained and improved, and also the surrounding area in this technique is keep clean.

(c) Improved underground pits

Underground pits are improved using plastic sheets or concrete mixed with mud and straw to improve the lining of the walls and make the pit more airtight. The entrance to the pit is sealed properly and surface drainage around the pit is improved to prevent seeds on the top and around the sides from becoming moldy.



(d) Hermetic seed storage

Hermetic storage is a method of storing seeds in air-tight containers to prevent insects and fungi without using insecticides. This technique can maintain seed quality for up to one year. Three types of hermetic seed storage containers are available for smallholder farmers: locally available containers, Purdue Improved Crop Storage (PICS) triple-layer sacks, and GrainPro Super Bags. Simple water bottles and recycled vegetable oil containers are common containers for storing water and local beverages in African villages. PICS and GrainPro sacks come in 50 and 100 kg sizes and can be used for seed and grain storage.

Table-1: Description of some storage structures and their storages applications.

S. N.	Name of Structure	Structural Materials	Agricultural Produce	Capacity	Remarks
1	Bamboo structures	Split bamboo woven in the form of a cylinder with wide base and narrow mouth	Paddy, wheat and sorghum	500 kg	Life 4-5 years. Weight loss due to insect attack is 5 % in paddy and 15 % in sorghum.
2	Mud and earthen structures	Clay, straw and cow dung- 3:3:1. Earthen structures are made, Sun dried and then burnt in fire	Paddy, wheat, Sorghum, oil seeds and pulses.	5 to 10 q	Life 8- 10 years. During rainy season develop cracks and moisture absorption followed by insect and mould infestation
3	Wooden structures	Local wood is painted black. At the top, 30 cm x 20 cm in let and at the bottom 30 cm x15cm outlet is provided	Paddy	10 q	15- 20 years. Neither airtight nor moisture proof
4	Brick structures	Rectangular, structures built as part of the house, with brick in cement or lime mortar having a wall thickness of 40 –50 cm. At the top 50x 50 cm inlet and at bottom 15 x15cm outlet is provided.	Paddy, sorghum and wheat	25- 30 q	25- 30 years. High initial cost, not insect and moisture proof.
5	Underground structures	Circular pits vary from 100–400cm in depth and 50 – 100 cm dia. at neck and 250 –300 cm at the bottom For filling and emptying there is an opening at the top. Before filling the sides and bottom are packed with straw and husk. After filling the pit is gain covered with straw and stone, the finally with mud.	Cereals	100 –200 q	Safe against insects but, loss of seed viability and handling difficulties made it out of date.
6	Miscellaneous plant materials a. Paddy straw b. Stem of	**a.** paddy straw is wound in the form of rope to varying diameter **b.** stems wound like a bin and both sides are plastered with mud and	Paddy, other cereals and pulses Paddy and other cereals Pulses, gourd seeds	30–100q	1-2 q2-5 kg Not insect and rat proof Temporary. Only small quantity of seed lots.

	vitex and pigeon pea stalks c. Bottle gourd shells	cow dung **c.** empty shells are used			
7	Metal corrugate G.I. sheets	Sheets of about 3 m high are held vertically along one edge and edges of the other sheets are overlapped and bolted to each other. Thus the circle with 2-4 m dia. is completed with many such sheets. They are covered on the top with the plain M.S. or G.I. sheets.	Various types of seeds	Vary	Vary Temporary
	Hessian cloth/ jute bags	These made from natural fibres found in the skin of the jute plant. Because of its rough texture, hessian is mainly used to make sacks, rope, string and other rustic products.	Wool, tobacco, and cotton, as well as foodstuffs such as coffee, flour, vegetables, and grains	5 kg and 50 kg	Hessian, also known as burlap, is a woven fabric made from jute or sisal fibers. These are an environment-friendly option for storing various agricultural products
	Gunny bags	Modern-day versions of these sacks are often made from synthetic fabrics such as polypropylene. Sack made from hemp burlap.	Cereal, pulses, oilseeds, potatos onion and vegetables.	35 to 100 kg	
	Hermetic Storage	Simple water bottles and recycled vegetable oil containers	Various types of Seeds such: paddy, milled rice, seeds and other cereal crops such as corn and coffee	20-100 kg	To store variety of seeds for long periods without loss due to insects and without using any insecticides.

7. Maintenance of Seed Storage Structure

Seeds can deteriorate over time when stored, and this process can be accelerated by various factors such as climate, insects, pathogens, and other external factors. Birds and rats may also damage the seeds while searching for food. To protect seeds from these external factors, it is important to store them in clean, hygienic godowns. Here are some key points to consider when constructing a godown:

a) Choose a location that is easily accessible by transportation.

b) Avoid building seed godowns near the seashore, where the high atmospheric humidity can accelerate seed deterioration.

c) Do not construct seed godowns in low-lying areas where water may stagnate.

d) Build seed a godown in locations where atmospheric humidity is low, air circulation is good, there is sufficient sunlight, and the godown is elevated.

e) Install ventilators at the bottom to ensure free air circulation.

f) Ensure that ground moisture does not reach the floor.

g) Use wire mesh to make the godown rat-proof.

h) Do not build godowns near industrial areas where smoke can be harmful to the seeds.

Further, when it comes to the maintenance of seed in a godown, it is important to consider the following points to ensure the efficient use of the storage structure:

1. The godown should be clean and dry.
2. Seed bags should not be stacked directly on the floor but should be placed on wooden pallets.
3. The height of the stack should not be more than 6-8 bags.
4. Different seed lots should be kept separately.
5. The godown should be sprayed periodically, once a week or fortnightly, with either Malathion 50 EC (1:300 Chemical: Water) @ 5 lit. sq. m-1 or 0.25% Nuvan @ 1 lit. 100 m3-1.
6. Altering the chemicals at weekly intervals will provide better control.
7. Seed lots can be fumigated with Aluminium phosphide @ 3 gm/cu.m in an airtight condition for 7 days. This can be done as a prophylactic measure and on minimal infestation by insects.
8. Seed lots should be periodically tested for seed quality, once a month.
9. Based on the seed testing result, seeds can be dried under the sun for the removal of moisture. This reduces insect and pathogen infestation.
10. New seed lots should be kept away from old seed lots to avoid secondary infestation of insects.

11. Seeds should be treated with a combination of fungicide and insecticide (e.g. Thiram @ 2 g kg-1 + carbaryl @ 200 mg kg-1).

12. Frequent supervision of each and every lot is a must.

13. Seed bags should be restacked once in 3 months for free aeration. Low-cost interwoven polythene bags should be used instead of gunny bags to prolong the life of the seed.

14. Pesticides, fungicides, fertilizers, and rejects should not be stored with the seed.

15. Each lot should be accurately labeled, and registers for stocks should be maintained.

16. Per-acre or per-hectare packing (small) is preferable for easy handling and effective supervision.

8. Conclusion

To enhance traditional storage structures, scientific advancements are crucial. To cater to different agro-climatic conditions in India, in-depth research is necessary for contemporary storage structures. Provision of provisional storage structures should be made available to state and central government authorities to manage bulk grains without experiencing any form of loss or damage.

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Role of Moisture Content & its Measurement Techniques for Better Storage and Longevity of Seeds

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Testing moisture content in Seed Sample is very important aspect of Seed Testing. The moisture content of a sample is the loss in weight when it is dried in accordance with the Seed Testing Rules. It is expressed as a percentage of the weight of the original sample. The submitted sample shall be accepted for moisture determination only if it is in intact, moisture - proof container from which as much air as possible has been excluded. The moisture determination of the seed sample must be started at earliest possible after receipt of sample.

Procedures:

Weighing shall be in grams to three decimal places. Seeds of larger size (Table 1.) are ground before drying unless its high oil content makes it difficult. After grinding, the sample is passed through different sizes of sieves (Table 2.). Pre-drying before grinding is required for samples having moisture content more than 17%. After pre-drying, the sub-samples are reweighed in their containers to determine the loss in weight.

I. Low constant temperature oven method:

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

II. High constant temperature oven method:

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

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

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

Where,

M_1 - is the weight of the container and its cover (in grams),
M_2 - is the weight of the container & its cover (in grams) and its contents before drying and
M_3 - is the weight of the container, cover (in grams) and contents after drying.

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

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

Table 1. Grinding requirements for Different Crop Seeds:

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

Table 2 . Pre-drying requirements:

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

III. Universal moisture meter:

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

1. Compression unit
2. Moisture meter dial
3. Thermometer
4. Compression knob
5. Cups of different volumes

Moisture estimation is made quick by the advent of digital moisture meters. The principle involved is that electrical conductivity of moist material is directly proportionate to the amount of moisture content in it. A representative sample of prescribed weight or volume (Table 3.) is taken and placed in the sample cup. It is fixed in the lower house of compression unit.

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

Table 3. Determination of moisture content by universal moisture meter:

Crop	Sample size		Compression	Factor
	Weight (g)	Volume*		
	FIELD AND FODDER CROPS			
Barley	50	B	0.600	
Maize	60	B	0.560	
Oat	30	B	0.400	
Pearl millet	60	B	0.500	
Rice	50	B	0.550	
Sorghum	50	B	0.675	
Wheat	30	A	0.275	Add 1%
Moong and urid		A	0.275	Add 1.5%
Chickpea		C	0.500	Subtract 1%
Horse gram		A	0.275	
Lentil		A	0.250	x 0.7 + 3.5%
Pigeon pea, field pea		C	0.450	
Castor		C	0.500	Multiplied by 0.5
Groundnut	25		0.300	Multiplied by 0.6
Groundnut (kernel)	26		0.450	Multiplied by 0.56
Safflower	15		0.450	Multiplied by 0.66
Sesame			0.550	Subtract 0.5%
Soybean	60	C	0.575	Subtract 2.5%
Sunflower	30	B	0.500	Multiplied by 0.6
Rape seed and mustard			0.450	Multiplied by 0.6
Cotton (linted)	30	C	0.360	Subtract 5%
	VEGETABLES			
Kidney bean	50	B	0.400	
Okra		C	0.425	
Cabbage		A	0.260	Multiplied by 0.6
Cowpea		A	0.325	Multiplied by 0.8
Cucumber		B	0.525	Multiplied by 0.8
Lettuce		B	0.500	Multiplied by 0.9
Onion		A	0.250	Subtract 2.5%
Tomato	25	B	0.250	Multiplied by 0.8
Turnip	25		0.200	Multiplied 0.8
Watermelon		B	0.425	Subtract 3.5%

Coriander		C	0.325	Multiplied by 0.6

* A, B and C - Container size

The moisture content must be reported to the nearest 0.1% in the space provided on the Analysis Certificate. Seed lot with moisture content more than the minimum seed certification standards (Table 4.) are recommended for drying.

Table 4. Minimum seed certification standard for moisture percentage:

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

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Integrated Management of Insect-pest Infestation in Seed lots during Storage

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During storage, seeds are severely destroyed by insects and other pests. Reliable data on losses caused by pests in modern stores as well as in traditional seed stores in the developing countries are rarely available, but probably an average 1% loss in industrialised countries contrasts with l0-30% in developing countries. Insect damage in seeds not only affects seed germination but its vigour also. Most of the storage insects develop in the godowns except some like pulse beetle, which infest crop at maturity and are brought in by the harvested produce in the store, where they multiply and damage healthy seeds.

There are several effective methods available for the management of stored seed/grain from insect pests under varied conditions. Ideally integrated pest management should rely on the blend of those proven tactics. Integrated pest management (IPM) is integration of all the available control techniques to keep the insect below economic injury level in socially and economically sound manner. The Food and Agriculture Organisation of the UN defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM has been urged by entomologists and ecologists for adoption of pest control for many years.

The concept of Integrated pest management have also generated the concept of economic injury level (EIL) and economic thresh hold level (ETL). An EIL is defined as the level of pest damage on which cost of damage exceeds the cost of resources upon control actions. ETL is population density at which control action should be initiated to prevent an increasing pest population from reaching the economic injury level. For seed storage ETL is very close to zero where Indian Minimum Seed CertificationStandard (IMSCS) demands a high value on freedom from sign of insect infestation.

Management of insect infestation in seed lots can be divided into two broad areas based on the type of intervention followed. They are

1. Preventive measures and
2. Curative measures

1. PREVENTIVE MEASURES:

The following preventive measures are recommended:

A. Sanitation and handling of seed lots:

Removing dirt, debris, mud balls, foreign particles, insects and infested grains from healthy grains is a common practice followed by the objective of minimizing storage losses. This has been shown to reduce insect infestation (Pillayar, 1979). Seed lot bags should be stacked on wooden dunnage 0.5 meters away from the wall, above the ground and stock to stock. Bags should be stacked in rows having a space of nearly 2 to 3 meter in-between and height of a row should not be more than 15 bags 1eavng about 1/5 space of total storage from the roof.

B. Drying:

The moisture content of the seed above the minimum level required for insect development (12-13 percent) results in storage losses. Sun drying and the use of mechanical dryers can be opted to bring moisture down. Improper drying of paddy grains during post harvest operations not only enhances the insect infestation, but also enhances breakage during milling. Staggered sun drying with short exposure to sun spread over large number of days (9-11 am for 8 days) reduces insect infestation.

C. Use of improved storage structures

Gunny bags or jute bags with close weave can reduce insect infestation. Impregnation of gunny bags with insecticides can prevent entry of insects (Prakash et al., 1981). Polythene lined gunny bags were suggested by Muthu and Pingale, (1955). Polyester- polythene 400 gauge lined canvas was found to be resistant to all types if insect attack. Improved storage structures, namely aluminum bin, Pusa bin, Pusa cubicle PAU bin, IGSI domestic bin, TNAU insect removal bins have been found very effective for bulk storage and reducing insect damage.

D. Disinfestation of stores/receptacles

Treatment of bulk and bag storage structures with insecticides is an important practice to avoid latent infestation in reused bags and bulk storage structure. The insecticides commonly recommended are malathion and dichlorvos.

E. Legal method

In India, the Destructive insects and Pests Act 1914 and its latest amendment, the Plant Quarantine Order 2003, govern the regulation or restriction of movement of insects through commodities in the country and among different areas within the country.

2. CURATIVE MEASURES

A. Physical Control Measures

The infestation of stored grains by insect pests largely depends on the three factors, temperature, moisture content of grain, availability of oxygen. All these factors are required for normal development and multiplication of insects. Hence, they have to be properly manipulated through design and construction of storage structures/godowns and storage practices so as to create physical conditions unfavorable for attack by insects.

i. Use of Low and High Temperatures

The insects can be controlled either by increasing or decreasing storage temperature. The optimal temperature for most of the storage insects is between 25 and 33^{o} C. Temperatures between 13 and 25^{o} C will slow development. High temperatures of 35^{o} C and above will stop development. High temperature disinfestations using heated air grain driers, fluidized beds, spouted beds, pneumatic conveyors, a counter flow heat exchanger, high frequency waves, microwaves, infra red waves and solar radiations have been satisfactorily used for in disinfecting grains.

ii. Mixing of Inert Dust

Many diatomaceous earth (DE), dusts is now commercially available and used for managing stored-product insects and mites, or to improve fumigation efficiency. Activated clay (kaolin) has been used in protecting seeds from the attack of storage insects. This method is very effective against most of the storage pests and nontoxic to higher animals. The other inert dusts used in stored-product protection can be categorized into 4 groups.

1st group	Clays, sand, paddy husk ash, volcanic ash and wood ash(shown to possess insecticidal properties)
2nd group	Dolomite, magnesite, copper oxychloride, rock phosphate and ground sulfur, lime (calcium hydroxide), limestone (calcium carbonate), and common salt (sodium chloride).
3rd group	Dusts that contain synthetic silica (silicon dioxide).

4th group	Dusts that contain natural silica, such as diatomaceous earth (DE), which are made up fossilized skeletons of diatoms

iii. Oils: Many edible and non-edible oils such as mustard, ground nut, Neem, castor, Karanj etc. have been used to control storage insect pests particularly pulse beetles successfully. To date, no resistance has been reported. The oils act primarily at contact sites by obstruction of the respiratory system (hypoxia) and also as an oviposition repellent, because eggs do not adhere on the surface of seed/grain. However, dose requirement of oils for seed is different from the grains.
iv. Irradiation: Low dose irradiation completely kills or sterilizes the common grain pests, and even the eggs deposited inside the grains. Moreover, only a single radiation exposure of grains is sufficient for disinfestations. This, therefore, is ideally suited for large-scale operations, thereby offering substantial economic benefits.

iv. Use of Modified Atmosphere

The use and manipulation of natural components of the atmosphere, e.g. oxygen, nitrogen and carbon dioxide, to preserve food grains and products is known as "MODIFIED" or "ALTERED" atmosphere storage. The normal gases of the atmosphere can be changed to achieve control of storage pests. Modified atmosphere systems depend on either depletion of oxygen to suffocate the organisms or the addition of carbon dioxide to act directly and kill them.
Low Oxygen Atmospheres: Flushing storage structure/container with nitrogen to displace the normal atmosphere produces **Oxygen Deficient Atmospheres**. Liquid nitrogen from tanks may be used as a gas source.
High Nitrogen Atmosphere: Nitrogen is used to flush out oxygen from airtight container to achieve higher mortality of storage insects and microbes. In this system higher concentration of nitrogen is required to get <1% O_2 in the head space. This is commonly used in food commodity for better storage of food products and in modified atmosphere packaging of high value vegetable seeds.

Carbon Dioxide Rich Atmospheres: Insects are generally killed more rapidly by carbon dioxide than by lack of oxygen. A concentration of 60% carbon dioxide will give over 95% kill of most of the stored grain insects after a four-day exposure at 27°C or higher. However, longer periods are needed for complete kill. An initial level exceeding 70% carbon dioxide and maintained at or above 35% for ten days is appropriate for complete insect mortality at temperatures above 20°C.

In seed storage, insects can be controlled by decreasing O_2 or increasing CO_2 or N_2 concentration in the atmosphere, thereby interfering with the normal respiration of insects. This is achieved by modified atmospheric storage, controlled atmospheric storage or airtight storage. In case of modified atmosphere, the storage atmosphere is modified by introducing CO_2 or N_2 replacing O_2. Controlled atmosphere is precisely maintaining the composition of selected gases such as CO_2, O_2 and N_2 at specified concentration under normal pressures or under partial vacuum. Airtight or hermetic storage of grains/seeds lead to decrease in available O_2 and increase in CO_2 due to respiration and metabolism of the seeds.

v. Use of Paraistoids: *Uscana*, an egg parasitoid is identified for biological control for pulse beetle. It parasitizes 0 to 84 hours old eggs of *Collasobruchus* that leads destruction of host eggs. Short life cycle and high rate of egg laying of *Uscana*are useful characters to include this in IPM of *Collasobruchus.*

vi. Use of Plant Products

The powders of the leaves of Neem, and Nochi, Vitex *negundo* when mixed with seeds gives protection from insects. The fresh leaves of Begunia mixed with paddy at the rate of 2% w/ protected the grains from insect attack for 9 months. Garlic extract is yet another plant product which is nontoxic and was found to be seed protectant. Neem leaf powder, turmeric powder, Sweet Flag Rhizome powder all at 10g /kg have been found to be effective against seed storage pests.

B. Mechanical Control Measures

The mechanical control methods are quite practicable. Several mechanical devices have been designed and developed both for monitoring and mass trapping stored product insects. They are insect probe trap, pitfall trap, two-in-one trap for pulse beetle, indicator device, automatic insect removal bin, UV – Light trap for warehouse and stored grain insect pest management kit, sticky traps, bait traps and pheromone traps. All these devices can be used for both monitoring and mass trapping of stored grain insects.

Use of Light traps:

- Most insects are nocturnal and phototropic.
- Detects presence of insect and its build up easily.
- With an electrocution net it kills insects that are attracted to it.
- Mohan et al. (1994) at TNAU used a 4W ultraviolet light (peak emission at 250 nm) at 1.5 m above ground level in the alleyways and corners of godowns. This detected accurately the presence of lesser grain borer, *R. dominica*

Fig: Light Trap

Use of Sticky traps

- It helps in early detection of insects and its infestation levels, especially in the bins.
- Hagstrum*et al* (1994) observed that sticky traps correctly predicted the presence of lesser grain and rusty grain beetles in samples drawn from 79-86% of the bins.

Fig: Sticky Trap

Use of Pheromone traps:

- These traps are baited with a synthetic pheromone that influences insect's behaviour.
- These chemicals are species specific and do better monitoring.
- Helps in early detection at low population levels. Thus, helps in detecting re-infestation
- Pheromone traps with adhesive glue helps also in removing a proportion of the population (i.e. mass trapping).

Storage insect	Scientific name	Main host	Pheromone component	Purpose
Khapra beetle	*Trogoderma granarium*	Stored wheat	Z, E-methyl 8-hexadecenal (92:8)	M/MT
Pulse beetle	*Callosobruchus chinensis*	Stored pulses	'Erection', a mixture of hydrocarbons, dicarboxylic acid	M/MT
Lesser grain borer	*Rhyzopertha dominica*	Stored cereal	Dominicalure 1: (S)-(+)-1-methyl butyl (E)-2, butyl (E)-2, 4-dimethyl -2-pentenoate	M/MT
Grain moth	*Sitotroga cerealella*	Stored cereal seeds	(Z.E.) 7,11- hexadecadienyl acetate	M/MT
Indian meal moth	*Plodia interpuctella*	Stored cereal seed	(Z.E.) 9,12 – tetra decadienyl acetate	M/MT

M-Monitoring, MT- Mass Monitoring

II. Chemical control measures

a. Prophylactic treatment

1. If the produce is meant for seed purpose, mix 1 kg of activated kaolin or malathion 5% D for every/100 kg of seed and store/pack in gunny or polythene lined bags.
2. Apply one of the following pesticides at the specified dosage over the bags. Malathion 50 EC : 10 ml per litre of water and 3 litres of spray solution per 100 sq.m. (or) DDVP 76% SC : 7 ml per litre of water and 3 litres of spray solution per 100 sq.m.
3. Air charge alleyways or gang ways with one of the following chemicals. Malathion 50 EC : 10 ml/litre of water (or) DDVP 76% SC : 7 ml/litre of water. Apply one litre of spray solution for every 270 cu.m. or 10,000 cu. feet. Spray the chemicals on the walls and floors and repeat the treatment based on the extent of flying and crawling insects.
4. Gunny bag impregnation: Empty bags are soaked in 0.1% malathion emulsion for 10 minutes and dried before using for seed storage.

b. Curative treatment

Choose the fumigant and work out the requirement.

i. Aluminium phosphide: The dosage of Aluminium phosphide for cover fumigation is 3 tablets of 3 grams each per tonne of grain and for shed fumigation is 21 tablets of 3 grams each for 28 cu. metres. The period of fumigation is 5 days.

Aluminium phosphide is most commonly used. In case of cover fumigation, mix clay or red earth with water and make it into a paste form and keep it ready for plastering all round the fumigation cover or keep ready sand-snakes. Insert the required number of aluminum phosphide tablets in between the bags in different layers. Cover the bags immediately with fumigation cover Plaster the edges of the cover all round with wet red earth or clay plaster or use sand-snakes to make leak pr*oof.* Keep the bags for a period of *5* - 7 days under fumigation Remove the mud plaster after specified fumigation period and lift the cover in the corner to allow the residual gas to escape. Allow aeration and lift cover after a few hours. Follow similar steps in case of shed fumigation also.

ii. Methyl bromide (MB): MB which has been widely used in temperate regions of the world has been found unsuitable for Indian conditions as it affected seed germination drastically at temperature above 20°C.

iii.Hydrogen Phosphide or Phosphine (PH_3):

Some of the properties:

- AlP tablets is available in the names of `Celphos, Quickphos' etc. It weighs 3 and 1 g Pellets (used against rodents) and liberates phosphine gas 1/3 of its weight.
- Ammonium carbonate, ammonium bicarbonate, urea and paraffin, are also added. The chemical reaction is
- $AlP + 2NH_4 OC (O) NH_2 + 3H2O = \uparrow PH_3 + Al (OH)_3 + \uparrow 4NH_3 + \uparrow 2CO_2$
- CO_2 suppresses flammability of PH_3 while diffusing from the tablet in presence of moisture. Ammonia is a warning gas and it reduces fire hazards.
- Aluminum phosphide produces carbide or garlic type odour. It is heavier than air and has low water solubility. It is highly inflammable *per se;* a safe and convenient method to evolve gas.
- The larvae and adults succumb more easily. While the eggs and pupae are usually hardest to kill. The tolerance of eggs and pupae can be overcome by relatively long (10-day) exposure periods.
- Phosphine does not affect the germination of seeds of cereal, legume with one or two fumigations at comparatively high concentrations. Up to four repeated applications showed no adverse effect on viability and vigour of different crop seeds in a multi - location trial carried out under the National Seed Project in India.

Approved insecticides for the control of stored insect pests as per CIB& RC

S.N.	Insecticides
1	Aluminium Phosphide 56% m/m*
2	Aluminium Phosphide 15% Tablet*
3	Aluminium Phosphide 77.5 % GR*
4	Deltamethrin 2.5% WP
5	Methyl Bromide Technical*

6	Methyl Bromide 98% + Chloropicrin 2% w/w Fumigant
7	Ethlyene Dichloride + carbon tetrachloride (3:1)

*To be used by Govt. approved agencies under expert supervision only whose expertise is approved by the Plant Protection Advisor to Govt. of India.

Important Fumigants, their dosages and exposure period:

Fumigant	Dose ml or g/ m^3 space	Dose ml or g/ t seed	Exposure period (h)	Repetition (number)	Ovicidal toxicity
ED: CT mix.	480	740	24	2-3	low
EDBr	32	56	24	02	normal
CS_2	480	740	24	01	low
MBr	32	56	12	02	high
PH_3	02	03	5-7	3-4	Moderate

Fumigation procedure:

Two methods are commonly followed for fumigation of seed lots namely, space fumigation and cover fumigation. Space or room fumigation is less effective than cover fumigation because fumigant used is determined by g phosphine/cu m of space while in case of cover fumigation it is calculated on the basis of g phosphine/tonne of material to be fumigated. Proper air tight condition can be created under cover whereas in room fumigation leakage is a common problem. Dosages are decided on the basis of extent of infestation, prevailing temperature and type and stage of insects. Normally, under Indian condition 7-10 days exposure period is ideal to kill all type of insects and their stages. PH_3 concentration should not be less than 200mg/cum during the entire exposure period. Phosphine fumigation is less effective during winter season, particularly when temperature is < 20 oC. Therefore, longer exposure period may be required.

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SOPs for Seed Quality Assurance

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ABSTRACT

As a demanding industry in the recent period, there is always a need for healthy seeds in order to produce a high yield the following season. Seed storage is required to sustain a high-yielding crop. A wide range of biological and non-biological activities cause significant seed losses during storage. The causes of these crop losses must be investigated because they have an impact on market prices and seed quality. Careful postharvest management can help seeds retain their quality. To limit loss while maintaining crop quality and safety, it is vital to develop the most appropriate techniques for assessing losses that occur during the process. The purpose is to create high-quality seeds that meet national and international standards and may meet the supplier's requirements. This chapter highlights the Standard Operating Procedures (SOPs) for postharvest practices and considerations used to protect seed quality. A comprehensive study of the more effective, inexpensive, practical, and productive methods is provided; it is based on the needs of developing countries, but it is equally applicable to more industrialised countries.
Keywords: SOPs, seed, postharvest, measures, quality, assurance, storage, drying, lab

Introduction

Better seed quality and post-harvest storage methods are what allow the seed industry to continue to exist. A high achievement and quality assurance are sought after by this seed quality programme. One of the most demanding industries in the modern era is seed quality. The bulk of small-scale farmers' seeds, particularly those for cereals and legumes, are grown and kept on the farms. By using efficient storage strategies, the main issue—damage caused by biological elements like insects and molds can be reduced (Delouche and Caldwell, 1960 & Woodstock, 1966). The prevention of crop losses and the storage of seeds and grains is the top priority of farmers. Due to the risk of crop loss, farmers frequently buy new seeds or grains from the market to create the next harvest for a higher yield. The development of efficient seed storage methods that can confirm improved crop yields and lower the likelihood of storage losses is required (Gregg and Billups, 2010).

The value of the seeds enables farmers to grow high-yielding crops from healthy and high-quality seeds. The ability of a seed to produce desirable quality, healthy, and high-yielding crops at low planting rates is referred to as seed quality (Gregg and Billups, 2010). Seed quality cannot be achieved automatically or through an ongoing process. The quality of the seeds is under strain from the environment. To provide farmers with the highest quality seeds, efforts are being made. Any stage of handling or production has the potential to degrade the seed's quality. All seed activities must be managed technically carefully in order to reduce these losses (Boxall et al., 2002).

SOPs for Seed Storage

When stored at ambient or natural temperatures, seeds react quickly to changes in temperature, the presence of oxygen, and relative humidity. By adjusting the humidity, temperature, and oxygen levels, one can influence the metabolic activity, age, and longevity of seeds (Mohammed, 2014). Prior to storage, the seed's moisture content must be reduced up to an acceptable level because desiccation could cause damage to the seed. Due to the lower humidity, seeds can be kept for a longer amount of time. As a general rule, if the seed moisture level is between 5 and 14 percent, reducing the moisture content to 1 percent doubles the life of the seed. Seeds need to be stored in a cool environment since higher temperatures have a greater impact on higher moisture content. When the temperature is lowered by 5°C, the life of the seed doubles and is applicable between 0 and 50°C. Hermetic storage in a sealed container allows for the regulation of oxygen levels, reducing both the physiological ageing of the grains and the physical harm caused by insects and microbial development (Harrington, 1972).

Postharvest SOPs of seed storage

1. Drying

Cereal and legumes reach physiological maturity at moisture contents between 35 and 45 percent, depending on the crop. When seeds have a moisture level between 10% and 14%, temperature has an impact on how long they can be stored. Timely harvesting and drying of crops are essential for a high-quality yield.In most cases, fungal infection and insect and other pest attacks cause biologically active seeds to degenerate quickly. Reduced respiration in seeds is the primary goal of drying (Boxall et al., 2002 & Kiaya, 2014). The procedure also prevents quality loss brought on by pest insects and other fungus. The process of drying itself may have an impact on the seeds' quality. The seed may suffer if it is dried extensively at a high temperature. Simple drying techniques are utilised in the summer by exposing clothing to the sun and getting enough wind. To deal with higher output or harvesting during the wet season in multi-cropping, different drying methods have been developed for high-yielding varieties and enhanced agricultural practises and irrigation (López et al, 2010 & Mujumdar and Law, 2010).

2. Sun-drying

In emerging tropical nations, seeds are typically dried by sun exposure. When the crop is ready for harvest, the procedure is used. Some seeds, like maize, can be sun dried, but crops become more susceptible to pest attacks like insects, rodents, and birds, as well as mould damage, throughout the drying process.Although it is a typical occurrence, spreading threshed seed to dry on sheets or a tray runs the danger of contaminating it with dirt or stones. For instance, paddy is available in big quantities at rice mills (Boxall et al., 2002). On specially constructed drying floors that make it simple for rainwater to drain off, rice is dried. To aid in drying, the seeds are spread out in thin layers, flipped at regular intervals, and covered at night with sheets. The technique has some drawbacks because temperature is an unpredictable variable.High temperatures in paddy rice can stress or break the seeds, which results in significant damage during milling. Dust, air pollution, insect infestation, and human or animal disturbance are all potential sources of yield contamination (Boxall et al., 2002 & Kiaya, 2014).

3. Solar drying

It is a version of solar drying in which solar rays are gathered in a unit created especially for the removal of air in a sufficient ventilation system. The device uses less time and has a temperature that is 20–30° greater than open drying (Chen and Mujumdaer, 2008). In solar dryers, air is heated using solar collectors and then let to travel to the seed beds. It has two fundamental designs: forced convection dryers force air through solar collectors and seed layers, while natural convection dryers exploit thermal gradients. These dryers are appropriate for use on farms. The old design of the Asian Institute of Technology in Bangkok, which consists of a drying bin, a solar chimney, and a solar collector, has formed the basis for other convection dryers (Boothumjinda et al., 1983). The solar collector is made of a layer of burned rice husk or a black polythene sheet and is covered with a clear polythene sheet.In the drying bin is a pedestal with holes in it. The following are the procedure' drawbacks: a high structural profile, stability issues in windy conditions, and the requirement for routine replacement of polythene sheets (Boxall et al., 2002).

3.1 *Mechanical dryers*

Mechanical dryers use the same drying technique as forced convection solar dryers; the air is forced through the seed bed and heated with the aid of a flat plate as opposed to conventional methods. Drying occurs at one of two points in a modern automated storage system: either in prestorage dryers (before seeds are loaded into freestanding loading containers) or in store dryers (after seeds are loaded into the final storage compartment) (Kiaya, 2014). Continuous flow dryers used in prestorage dryers employ ambient air, and a thermostatically regulated furnace, powered by electricity, diesel, or gas, produces heat. Heat can be delivered directly or indirectly. Because the combustion product has a separate outlet and does not go through seeds, the indirect method is recommended. While grains are flown into the system and collected at the correct moisture level in continuous flow dryers, seeds are supplied into properly defined batches in batch dryers (Boxall et al., 2002).

3.2 *Tray dryers*

Batch dryers having flat beds called tray dryers. To thoroughly dry the seeds, they are spread out on the mesh tray at a depth of 600–700 mm. Warm, dried air is then pushed through the seeds (Boxall et al., 2002 & Kitinoja and Gorny, 1999).

4. Radial drying bins

Two vertical metal mesh cylinders with one within the other make up the radial drying bin. Between these two cylinders, seeds are loaded, and air is forced into the inner cylinder and transferred from the inner to the outer mesh cylinder. You can remove air from the central cylinder by forcing air through seeds in the opposite direction. Seeds in the inner cylinder that are in direct contact with the hot air run the danger of being overdried. At the exit side, near the outside, the air is cooler and wetter (Boxall et al., 2002).

5. Continuous flow dryers

The moisture content of the seeds can be reduced by sucking or blowing hot air through the system from top to bottom. A bin and cooling system are located at the bottom of the drying portion. Seed beds can be vertical, sloping, or horizontal. Conveyors, scrapers, vibration, or gravity are used to transfer seeds. The speed, size, and rate of flow of the dryer's outlet belt all affect how much moisture is removed. The relative orientation of the air stream and seed flow alters the continuous flow dryer (Radajewski et al., 1987). Below are descriptions of several continuous flow dry processes.

5.1 Cross flow

The two perforated sheets allow air to move horizontally through the seeds, allowing the seed to pass through and into the column. The dryer's advantage is that the moisture gradient can be established at any point during the drying of seeds (Boxall et al., 2002). Cross-flow dryers have been employed extensively recently.

5.2 Counter flow

Seeds are discharged from a spherical bin using an upward airflow. Even when the hottest air flows through the driest seeds, little evaporative cooling occurs.

5.3 Concurrent flow

When air is moving through a seed bed concurrently, the wettest seeds are exposed to the warmest air. High temperatures increase drier efficiency and chill the seeds by evaporating moisture (Heid, 1980).

5.4 Mixed flow

Mixed-flow dryers have advantages over cross-flow dryers. The combination of contemporaneous, counter, and cross flow dryers in mixed flow dryers offers the major advantage of efficient fuel use. The largest obstacle to the adoption of mixed flow drying, however, is the decrease in yield caused by uneven seed flow, which causes uneven drying (Boxall et al., 2002).

5.5. Mixed flow tower

They are made up of tall rectangular storage bins, and horizontal triangle ducts run the length of the dryer's breadth. The remaining ducts are used to remove dampened and cooled air, while half of the ducts are utilised to introduce warm air. It has several air and seed flow directions (Heid, 1980).

5.6 Fluidized bed dryer

The seeds are dried by hot air that is blown over them after passing through several types of batches. The cross-flow dryer theory underlies how the dryers operate. The degree of drying determines the speed and depth of the drying beds. Conveyor dryers and cascade dryers are the two primary dryer designs. Cross-flow dryers with gravity feeding are the cascade dryers. Roller dams control the seed depth, while output elevators control the speed. Changes can be made to the dryer's design to alter its length. In a conveyor drier, air is forced onto the seeds through an inclined fliudized bed, with heavy duty, roller chain, and variable speed conveyors controlling the seed flow. These dryers can be unidirectional, bidirectional, or multidirectional; the directional change helps with waste material removal and dryer size reduction (Boxall et al., 2002).

6. Store-based or in store drying

In this alternative drying procedure, seeds are loaded into bins or bulk floor storage before being dried in stores (Chung, 1986).

6.1. Large-scale floor storage

They are made with particularly reinforced walls that can support the weight of seeds. The seeds are stacked at a constant depth. The plenum chamber runs in the middle of the store or walls with perforated lateral ducts, below or above the floor level under the majority of seeds, and the fan is located at one side of the building for aeration purposes (Boxall et al., 2002).

6.2 Bin drying

One or more bins are used for drying, and other bins are used for storage in this form of drying. Due of the decreased handling, dryers decrease the possibility of physical harm. The drying process is faster and safer thanks to the shallow layer of seed around the bins. The semi-dried batches, which consist of ventilated floors or lateral ventilation systems around 0.5 m above the base (Bartosik, 2005), free up room for incoming seeds.

6.3 Bag dryers

It is challenging to dry seeds in bags because there is inadequate protection against air passing through the seeds. In fan blowers, hot air is blown from the floor apertures and sacks are put on them, as opposed to sack platform dryers, which blow air through the air duct's floor. In the moisture extraction unit, larger bags are placed in the middle of the tunnel. Hot air is circulated through the air ducts with the aid of a fan. To prevent uneven drying, proper dimensioning must be observed. However, because of short circuits in some places, this technique is not suitable for even drying seeds(Boxall et al., 2002).

Storage losses

According to reports, harvest-related agricultural losses amount to a total of 30%. However, this is the "worst case" estimate to use for the crops in the development priority area. Before harvest, storage losses cannot be estimated. Crop losses can result from a variety of biological, climatic, handling, harvesting, storing, and distribution, as well as social and cultural reasons. 50 percent of post-harvest and storage losses can be distributed with appropriate handling. There is no way to determine the precise sum of such damages. There has been work done to identify the trustworthy baseline techniques for calculating crop loss activities. To calculate the standardised post-harvest losses for different crop operations, a methodology has been developed (Harris and Lindblad, 1978). The Food and Agricultural Organization (FAO) of the United Nations has encouraged loss assessment and loss reduction programmes. The goal of these projects was to prevent the decline of staple food crop production. Even though there was no set approach for evaluating storage losses, the methodology for assessing seed loss during harvest was summarised (Boxall, 1986). The loss assessment phenomenon is non-generalizable, particularly for perishable commodities, due to sampling methodologies, different handling and storage products, and irregular batch movement. An acceptable, cost-effective, and relevant technique should be carefully designed with positive goals in mind. Due to their distinct nature, perishable goods require a variety of procedures, whereas grain seeds require rather standard methods. It is possible to compare the weight loss of undamaged and damaged seeds in order to determine standard moisture content and dry matter. Storage is used to prevent yield losses on a biological and economical level. We needed to be aware of what was causing these losses in order to prevent them (Kiaya, 2014).

1. Damage and loss

Damage and loss are sometimes used interchangeably, which can be confusing. Loss is defined as a quantifiable drop in the quality or quantity of food. The term "superficial deprivation of commodities" refers to damage where physical decay causes loss of the product. Although a damaged good can still be used, a loss represents a permanent deterioration. (Mohammed, 2014).

2. Classification of storage losses

The stored seeds are directly impacted by the main cause of losses. Economic effects can be attributed to qualitative or quantitative storage loss categories. Physical weight or volume loss, which is regarded as a quantitative loss, is easily calculable. By judging a commodity and comparing it to goods of similar quality, one can estimate quality losses. Changes in flavour, texture, appearance, nutritional value loss, and the presence of pollutants can all cause consumers to reject a commodity. To illustrate the agricultural storage losses, the following categories can be listed (Boxall, 2002): They could have a biological, chemical and biochemical in nature.

2.1. Natural catastrophes or biological losses

Rodents, insects, birds, and microorganisms (fungi and bacteria) are biological causes that cause crop deprivation. Crop weight loss, crop rotting, and other faults brought on by microbe growth on the crops lower the market demand for the produce. If produce is kept in storage for an extended amount of time, infestation development may become a problem. Birds, rodents, and microbiological (fungi and bacteria) attack in the field can worsen storage conditions and cause more severe damage or loss to wheat seeds. If the disease is only superficial, there will be a quality loss; if it spreads deeper into the seed layers, there may be a quantity loss. It is feasible to employ the remaining portion of the affected area when a superficial disease is present (Kader, 2002). Chemical losses result from pesticides and chemical interactions and include flavour, colour, texture, and nutritional value loss (Atanda, 2011). Due to enzyme-activated processes, biochemical losses can include softening, discolouration, and unpleasant flavour. Bruising, breaking, processing, and damage while handling or harvesting are all examples of mechanical losses. Climate conditions like low or high temperatures, unsuitable storage atmospheres, and high humidity are all related to physical losses. Chemical and metabolic losses can also be mediated by physical factors (Mohammed, 2014). Weight loss as a result of respiratory heat loss is considered a physiological loss. Infection and pathogen damage are more likely to occur during wilting, senescence, ripening, and wilting. In contrast to perishable crops, where losses are caused by mechanical, physiological, and microbial factors, biological and microbiological variables are significant in seed. Secondary crop losses caused by improper equipment, technology, and control handling are the variables that promote initial crop losses. Lack of harvesting tools, expertise, packaging, handling, adequate containers, suitable transport, drying and storage conditions, correct processing technology, and competent management are the contributing factors (Kiaya, 2014).

3. Weight loss

Slimming down loss of weight is not always an indication of crop loss. Weight loss may be caused by a decrease in moisture content. Recognizing shrinkage factor is a useful technique in business transactions. If moisture loss is not taken into consideration when grading for price control, it might result in financial loss. Feeding birds, insects, rodents, and microbes can cause weight loss. By comparing the weight before and after being stored in the bag, weight loss can be calculated. Additionally, an increase in weight may result from an increase in moisture content brought on by water production in the seed brought on by insect infestation. Weight loss may be difficult to notice if insect infestation increases the moisture content of the seed or if insects devour the seed and leave behind dust (Boxall, 2001). A useful mass of infested and non-infested seeds is crushed into flour and their weights are compared in order to identify these losses. Infested mass will produce less flour than sound mass, as will be seen. Be on the lookout for unethical techniques that adulterate rocks, soil, sand, or water to compensate for weight loss. Therefore, it is necessary to evaluate both the amount of foreign matter present in the yield as well as variations in moisture (Grolleaud, 1997).

4. Quality decline or loss

Consumers place a high value on quality, and local merchants have various standards for judging it depending on the situation. Size, shape, and appearance are affected by biochemical elements such acidity, sugars, flavour, and fragrance. Contamination and the presence of foreign debris, such as bug pieces, rat hair, excrement, weed seeds, dirt, glass, and plant parts, can also cause quality degradation. Pesticides, oils, poisons created by fungi, soluble insect excrement, and dangerous organisms transferred by rodents are among the contaminants that are challenging to remove. Consumers boosting the standard norms will result in an increase in loss potential (Lipinski et al., 2013).

5. Nutrient loss

The loss is based on the qualitative and quantitative nutritional value lost to the human population, which has an impact on that people's nutritional state. This is primarily brought on by pests feeding on particular seed parts. Plodia and Ephestia consume the seed embryo selectively while removing the vitamin and protein content. Because so many pests consume cereal seed bran, the vitamin content is decreased. Selective feeding of Liposcelis spp. on rice bran and embryo **(Pike, 1994).** Weevil consumes endosperm and rejects the presence of carbohydrates (Grolleaud, 2002).

6. Reduction of seed viability

It is related to the decline in seed viability. Temperature, excessive respiration, moisture content, infestation, light, and infestation-control techniques could all be contributing factors to the losses. When compared to other insects, those that attack the embryo only suffer significant germination losses. Standard germination tests can be used to identify seed loss (ISTA, 1966).

7. Financial loss

Direct effects (the aforementioned causes) or indirect effects are both responsible for commercial losses (cost of preventive action or equipment). There could be a loss of reputation, financial loss, and loss brought on by legal action. Commercial loss might have an impact on international trade. With expertise and understanding, losses can be quickly minimised. Inappropriate storage is not always the cause of postharvest losses. The degradation of wheat seeds may be caused by biological, physical, or mechanical reasons. To get high-quality products from the farm to the market, it is necessary to expand the intervention approaches. For instance, Somalia and Malawi declined to accept the corn because of insect spread after the Tanzanian outbreak of pest in the maize crop (Tyler et al., 1990).

8. Damage based on temperature

Fresh goods rapidly decay when exposed to high-temperature sun radiation. The problem should be avoided by providing adequate ventilation and cooling for the crops. As temperature rises, respiration likewise rises. Similar to this, crops may suffer damage from low temperatures between 0 and 2°C. However, several plants from tropical and subtropical regions shown resistance to chilling injuries at 12–14°C. When a product is separated from its environment, chilling damage (skin pitting, discolouration, uneven or irregular ripening, and sensitivity to quick deterioration) become evident (Lipinski et al., 2013).

SOPs for estimation of losses

1. Estimation of seed losses in storage

Insects, rodents, and moulds are the main causes of seed loss during storage. Although many scientists have previously been interested in this topic, more effective methods must yet be developed in order to prevent insect-related seed loss. By boring or eating seeds, insects can cause both qualitative and quantitative loss; weight loss has received more attention (Boxall, 2002).

2. Insect related weight reduction

The evaluation is done by collecting samples of the seed at different points after storage and comparing the samples to see how they have changed. To estimate storage losses at various times, measuring amount loss with successive samples taken at various intervals will be employed. Each seed batch's sample collection and quantity loss are evaluated in accordance with this. Samples must be taken in bulk stores without disrupting the pattern of infestation. When further regular sampling is not practicable, three samples must be taken: the first at the beginning of storage, the second at the halfway point of the storage period, and the third at the end of the seed's storage duration. It is observed that utilised seed and quantity loss follow a pattern (Boxall, 2001).

3. Techniques for calculating weight loss

When additional sampling is possible, two techniques are employed to estimate the weight loss of the insects: the volumetric approach and the thousand grain mass (TGM) method. When further sampling is not practicable, count and weight procedures as well as converted percentage methods are employed (Boxall, 2002).

4. Volumetric approach

Bulk density method and standard volume weight (SVW) are two names for the volumetric approach. By using equipment, this is utilised to determine the bulk density of a clean sample. From the sample of seeds taken at the start of the storage period, SVW is calculated, and losses are calculated. Using a standard volume container, this method precisely measures the weight loss caused by grain boring insects and moisture variation over time. Moisture can be treated as a constant term and the crop as dry matter in the stand volumetric method to establish an appropriate ratio for moisture content and dry weight of seed. Changes in moisture content, however, can also have an impact on volume and frictional characteristics. Because there is a direct correlation between sample volume and moisture content, the seed should be packed loosely. Calculating the standard volume of dry matter at various moisture contents is important to keep the moisture constant. The procedure takes time, care, and a well-equipped laboratory (Adams, 1978). Weight of insecticidal dust, which sticks to the seed surface and increases the volume of seed and frictional character, is another factor that influences sample volume. The process of sieving can be helpful in removing dust. Volumetric phenomena, however, are less useful since losses are overestimated (FAO, 2013).

5. Using the mass in thousand grains

With a fixed number of seeds instead of a constant volume, this method varies from the volumetric method. This indicates that the weight of the seeds is multiplied by 1,000 and adjusted for dry matter. It is determined by weighing and tallying the seeds in a particular sample. Measurements are taken at the start of seed storage to establish a baseline reading, which is then used to compare future measurements(Reed, 1987).

6. The count and weight approach

When the baseline readings of seed storage are not collected at the beginning of the season, the method sometimes called "Gravimetric method" is used. This estimation makes use of a sample of 1000 seeds and a basic medium. After separating the damaged seeds, the weight and quantity of seeds in each sample fraction are calculated. The values are then entered into the ensuing equation to determine the outcomes:

$$\text{Wt. loss (\%)} = \frac{(UxNd)-(DxNa)}{U(Na+Na)} x100 \qquad (1)$$

Where,

U = weight of the undamaged seeds (g),

D = weight of the damaged seeds (g),

Na = the number of the undamaged seeds, and

Nd = the number of the damaged seeds

For a single sample, this approach does not require the moisture content of the distinct fraction, and the changes in assumptions are most likely negligible. The method does take into account concealed infestation in the damaged category, as well as insect-random seed infestation, which is not always accurate (Adams and Harman, 1977). For low levels of infection and many infestations in large seeds, the approach can produce false findings. The technique is helpful for rapid estimating at extremes at the field level. Many improvements have been developed in order to overcome the biased estimation. For instance, different-sized seeds can have hidden infestations due to their varying moisture levels. Before counting and weighing, these seeds are categorised and graded according to size (Boxall, 1986); seriously harmed grains are segregated, and readings of hidden grains are collected after infestation appears (Ratnadass et al., 1994). The hidden infection can also be determined by dissecting seeds, however this procedure is time-consuming and runs the risk of changing the moisture content of the seeds due to calculations that must be conducted on dry matter.

7. Vertebral pest losses

It is impossible to measure the damage caused by vertebral pests because they remove the entire seed from the sample, like rats and birds do. By comparing the reference % of seed loss and average seed weight, the loss can be calculated (Boxall and Gillett, 1982). Than estimate the losses caused by pests and rodents, population studies and feeding experiments are used, although their accuracy is frequently inferior to that of increased efforts (Hernandez and Drummond, 1984). Pests only consumed stored grains as part of their diet; feeding experiments may overstate the loss of seeds that were kept in storage. It's debatable how much seed rodents actually destroy. When compared to losses to buildings, structures, personal property, and potential health issues, crop loss from rodents comes in last.

8. Weight loss by molds

Mold-infected seeds will lose weight, and the weight loss can be measured using the same technique as weight loss caused by insects. The weight loss from the mouldy seed increased as a result of moisture absorption, allowing for compensation of the mould loss. Due to the lack of obvious signs of infection on the surface, the procedure is not very effective in determining the actual loss of seeds, and the seeds may be mistaken for undamaged ones. Damaged seeds are distinguished from undamaged seeds in order to calculate the weight loss caused by mould. Moldy seeds are then distinguished from damaged seeds. Mold will cause a loss of weight that is equal to its own weight (Boxall, 2001).

9. Total seasonal loss

The losses listed above represent the starting losses for a particular period of time. The image might not be accurate; there must be a connection between the patterns of seeds used during a season. In an undisturbed stored crop, insects will be responsible for the majority of the loss if sample loss is 10% throughout the course of storage seasons. Due to insect exposure throughout various time periods during the season, the seeds will lose variable amounts at different intervals of time (Boxall, 2001). With time, as pest infestation grows, the percentage of seeds lost increases gradually. When the moisture content of the seeds has been taken into account, the loss in seeds can be estimated by weighing the seeds both when they are still in the store and when they are taken out. By deducting the loss brought on by other insects, the loss not caused by insect damage can be found. The actual seed losses after storage are far lower than the estimated amount. Numerous loss assessment procedures for businesses and farms have been reported (Boxall, 1986). To acquire the greatest assessment results, it's important to develop a process that works for each commodity. Small numbers of losses were reported for commercial operations, but none were reported for cooperative level storage. The situation is a reflection of the quick purchasing and selling of seeds in developing nations. This paints an image of private sector involvement (market emancipation and parastatal marketing), but there is little data on storage loss. Entrepreneurs might keep a lot of seed in storage for a while. However, this level of farm storage has been raised by the private sector. To measure the storage losses in agricultural storage, a lot of time, energy, and money were expended, but the endeavour was not as successful as the prior initiatives. Additionally, the study ought to be conducted with the post-harvest industry as a whole, and exact measurements ought to be avoided. A social survey might be useful in identifying the farmers' issues so that loss estimation and the proper measuring methods can be used (Goletti and Wolff, 1999).

SOPs for Harvest and maturity indices

Commodities that have been harvested or handled carelessly may have bruises and other injuries, which have a negative impact on their market value and render them unsightly. Injuries create a place for microbial attack that leads to rotting, increased respiration, and a reduction in storage life. Crop loss and serious seed damage might result from improper harvesting (FAO, 2011).

1. Harvesting and handling

The initial stage of postharvest and the final stage of crop production is harvest. The manner and state of the harvest have an impact on how the crops are handled, processed, and stored moving forward. Because of their high water content and premature harvest, seeds lose quality and degrade in storage. Crops that are harvested too early suffer biological and physical losses as a result of repeated watering and drying (Kiaya, 2014). After harvest, wet seeds must be promptly threshed and dried.

Different plant parts are harvested using different techniques: forage is harvested by trimming the entire plant; cereal seeds are harvested by threshing and cleaning a portion of the plant; and straw or chaff is harvested for further processing. Small-scale producers use threshing combines and harvesters (equipped by community organisations) to perform threshing and harvesting, but in developing nations, threshing and harvesting by hand is unlikely to cause harm to or degradation of stored crops. Mechanical harvester equipment is used by large-scale commercial growers, although its application is constrained by the growth of cash crops. Harvesting by hand lowers the danger of crop damage in storage after harvest. Threshing combines were used for small-scale production to perform the harvesting process (Kiaya, 2014). For the purpose of threshing, traditionally, seeds are thrashed with a stick or against a hard surface (wooden bar, log of wood, stone, and wooden metal or tub). The approaches may result in cracks or damage to the seeds, however walking on the seeds will be a less harmful method. Sorghum, millet, or wheat grain heads or ears are frequently bashed with sticks. However, hand harvesting is physically taxing and is not always the most cost-effective option. High-level damage is caused when maize cobs are pounded with sticks or shelled by hand. To lessen seed damage, mechanised threshers are designed; the models are quite complex.

Threshing, cleaning, or combine harvesters are used to harvest seeds in tandem with other processes. Mechanical machinery created specifically to collect grain seeds is used for large-scale harvesting (Boxall, 2002).

SOPs of Seed storage facilities

Grains and seeds are hardy plants that typically only need straightforward storage arrangements.

1. On farm storage

The seeds must be protected against biological elements including microbes, birds, rodents, mites, and insects as well as physical harm from high temperatures, inclement weather, snow, and rain in order to store them safely outside or indoors. Many nations store the majority of their seeds using the agricultural storage method (Semple, 1992). The storage structure has a range of 100 kg to a few metric tonnes in terms of capacity. According to the weather, modifications to locally made storage structures could be made. There are a few conventional storage facilities. High-density and high-molecular-weight polyethylene, plywood, aluminium, ferro-cement, and other materials are frequently used to make the bins. Plywood is the most ideal material for storage structures, and hermetic storage underneath structures come in a variety of sizes and configurations. This increases the amount of carbon dioxide and decreases the amount of oxygen, which makes seed storage dangerous for insect and microbial attack (Shejbal and de Bioslambert, 1988). Although traditional approaches are less expensive, they are ineffective against microbial and pest attack. At the agricultural level, seeds are also kept in silos or metal bins.

2. Storage in bags

While silos for bulk storage, seeds elevators, and flat storage structures are utilised in rich countries, seeds are often stored in traditional warehouses in underdeveloped countries in gunny or woven polypropylene bags (Kennedy and Devereau, 1994). The procedure of bag storage is time-consuming and expensive, and there is a higher risk of biological losses and seed spilling. Due to warehouse flooring that isn't acceptable, there can be an issue with humidity and water seepage. Bags don't require any aeration equipment or fumigation facilities. The concept will not be viable in underdeveloped nations because of the tiny farm size and less expensive manual labour.

3. Bulk storage

There are two ways to store seeds in bulk: vertically (in silos or bins) or horizontally (on floor stores). Horizontal stores are made up of specifically built floors of warehouses with adequate ventilation on the floor and walls that are reinforced to support the weight of the seeds. Bins and silos are specially made storage units that can be circular or square, clustered or standalone, and include unloading and loading processes that typically include aeration systems. Belowground or partially belowground storage or enamelled, sealed silos for the storage of seeds with a high moisture content are further options for bulk storage. The procedure is suitable for handling or storing seeds in bulk (Bailey, 1992).

4. Hermetic storage

The seeds are protected from biological harm by the conventional techniques of storage in the natural oxygen build-up and lower oxygen levels. For seeds with lower moisture content and reduced infestation of insects per kilogramme of seeds, the conventional storage approach is ineffective. In hermetic storage, the controlled environment treatment and fumigation must be augmented (Alvindia, 1994).

5. Outside storage

In the absence of permanent storage, this is the interim measure of storage. The stacks of seeds are covered with polyethylene covers, and the godowns and silos are constructed on plinths. In a week, the cover must be raised to the seventh or eighth layer in order to effectively aerate the stacks. For wheat and paddy, the cover and plinth (CAP) technique is frequently utilised. However, there is a danger that the cover will be damaged by wind or rain, making effective fumigation impossible (Semple, 1992).

6. Guidelines for quality seed storage

By specifically building the tiny stores to silos or warehouses that play a protective function against unfavourable temperature conditions, ground water, rain water, pests, and thefts, the quality of seeds may be maintained. The store's layout and contents need to be managed (Kiaya, 2014).

Moisture management

It is necessary to have a water disposal system and a well-designed roof (overhung or gutter) to stop water from flowing into the store. Water is moved away from the stores through drains. To stop water from dripping into the store, side-by-side connecting of shelves should be avoided in large warehouses. Water-resistant floors and walls protect against ground water, while a raised floor and efficient drainage systems reduce the risk of flooding. To regulate the humidity inside the storage structure, a suitable ventilation system is required (Boxall, 2001).

It is challenging to regulate temperature in storage structures; particular design components are required. The use of controlled ventilation can be used to measure temperature. Insulated shops can control temperature throughout the chilly night. Building stores in an east-west direction with reflective materials outside can be an efficient way to manage heat. The heat of the storage structure can be further reduced by thick walls and large roofs (for shade). To change the temperature in a store, heaters and refrigerators can be placed; the machinery works best in insulated stores. The degree of insulation in these storage structures, however, is dependent on the environment (Longstaff, 1988).

Controlled Atmosphere Storage (CAS) and Modified Atmosphere Storage (MAS)

To create a controlled atmospheric composition around seeds that differs from air (78.08 percent nitrogen, 20.95 percent oxygen, and 0.03 percent carbon dioxide), changed atmospheric conditions add or remove gases from the environment. This also entails a decrease in oxygen and an increase in carbon dioxide content. The degree of control between CAS and MAS varies, while CAS is more precise. The method is applied to make whole-store fumigation easier (Paster et al., 1991).

Transportation

Commodities being moved from fields to storage facilities may sustain some damage, which could subsequently result in produce degrading. The goal here is to keep the produce dry and free of moisture. Seeds from the polluted container carry a residual risk of insect infestation. Vibration during transport, bad vehicle and road conditions, poor driving, unsafe container stacking, the use of inappropriate containers, and irresponsible handling can all result in mechanical injuries. Produce loses moisture due to overheating caused by the sun or a car's engine, which promotes natural decay and decomposition(Boxall, 2002).

Quality and safety

The class, degree, excellence, or superiority of a crop is determined by the quality of the product. The set of traits, qualities, and attributes that provide a commodity value as food or a source of the following crop's production collectively make up its quality. The marketing quality of the crop might be impacted by foreign material or high moisture content. In seeds, high moisture levels may promote shrinkage or biological and biochemical harm. Low moisture can break or harm the seeds in paddy rice and lentils. Broken and discoloured seeds have a lower marketable quality and are more susceptible to insect and microbial attack (Boxall, 2001). The fundamental goal of a farmer is to produce products that appear to be good and have few visible flaws. These products must also perform well in terms of yield, disease resistance, ease of harvest, shipping quality, and meeting national and international quality standards. The buyer or consumer places more value on looks; they are anxiously interested in good seed and long-term storage. For distribution to suppliers and the market, the product's safety must be guaranteed (Mohammed, 201).

Postharvest quality evaluation methods

After harvest, there are two ways to evaluate the crop's quality: analytically or objectively, and subjectively or sensually (Ranganna, 2000). The subjective method has difficulties when assessing the quality of hazardous materials (Jha SN, Garg, 2010). The nature of an objective technique can be destructive or non-destructive. Commodity sorting by hand is inefficient, expensive, unreliable, subjective, tiresome, and slow. Regarding varietal and temporal dependence, food exhibits complicated and dynamic activity.

Visual inspection, x-ray imaging, computed tomography, near-infrared spectroscopy, thermography, electromagnetic testing, liquid penetrant testing, magnetic particle testing, acoustic emission testing, infrared and thermal testing, magnetic resonance imaging, electronic nose, and other non-destructive methods are among the physical principles-based non-destructive methods (Siddiqui, 2015).

The advantages of quality evaluation or grading are as follows:

1. It makes it easier to buy a product you haven't seen.
2. Incentives for quality and safety improvement.
3. Grading gives the market data context.
4. It makes it easier to compare prices and quality.
5. It lessens the likelihood of deception and dishonest marketing.
6. The procedure can enable various marketing strategies, including commodity exchanges, futures trading, inventory credits, credit letters, and expediting the resolution of disagreements over composition or quality (Smith, 1995).

STANDARD OPERATING PROCEDURE FOR SEED QUALITYASSURANCE

A. Duties and Responsibilities of Quality Assurance

1. Sampling of seed for checking purity, Germination and seed Health.
2. Ensure Selection of seed for Multiplication & Production.P
3. roper Storage of Produce at farmer level and proper Shifting towarehouse/processing plant to avoid loss of seed viability & purity.
4. To get maintain suitable Temperature & Humidity during Storage.
5. Inspection and sampling of every seed present or coming from outside.
6. Seed quality checks every 2-3 months in a year.
7. Check seed quality before dispatch.

B. Standard Operating Procedure for Seed Movement

1. Any seed movement from store to and back will be managed by the Quality Assurance department.
2. The outgoing seed will be with following information:
   a. Name of variety/hybrid
   b. Purity (minimum standard)
   c. Germination %age (minimum standard)
3. The seed division will not be responsible of seed which has been kept for more than seven days at shop or outside warehouse without proper storage.

4.Any seed coming back from the field will be reported to quality assurance departmentfor checking of purity and germination.
5. The warehouse in-charge will not place any seed in the warehouse unless cleared by the quality assurance department.
6. The movement of seed will be variety and lot wise printed on each bag.
7. Bin cards will be displayed on each consignment indicating variety name.
8. Seed coming back from the field must have dealers name & place.

C. Role of Quality Assurance Laboratory

The science of evaluating the planting value of the seeds. By seed testing we can assess thequality attributes of the seed lots which have to be offered for sale and minimizing the risk ofplanting low quality seeds.

(a). Objective & Importance of Seed Testing

Seed testing is required to achieve the following objectives for minimizing the risks of plantinglow quality seeds:

1.To identify the quality problem and their probable cause
2.To determine their quality, that is, their suitability for planting
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.
5.The primary aim of the seed testing is to obtain accurate and reproducible results regarding the quality status of the seed.

Importance

- The importance of seed testing was realized more than 100 years ago for assured plantingvalues. The adulteration of vegetable seeds by stone dust which was packed in some partsof the world particularly in Europe.
- Seed testing has been developed to aid agriculture to avoid some of the hazards of cropproduction by furnishing the needed information about different quality attributes*viz.*, purity, moisture, germination, vigour and health.
- Quality control of seed depends on the different seed testing protocols which determinethe genuineness of the cultivar.
- Testing of seed to evaluate the planting value and the authenticity of the certified lot.
- Seed testing is required to assess the seed quality attributes of the seed lots.
- These quality attributes are seed moisture content, germination and vigour, physical andgenetic purity, freedom from seed borne diseases and insect infestation.
- The testing of seed quality is carried out on seed samples drawn from seed lot to be usedfor cultivation.

Role of Quality Assurance Laboratory

Seed testing laboratories are essential organization in seed certification and seed quality controlprograms. The main objective is to serve the producer, the consumer and the seed industry byproviding information on seed quality.

Analysis of seed in the laboratory: Seed testing is possible for all those who produce, sell anduse seeds. Seed testing is highly specialized and technical job. With a view to maintainuniformity in quality control the seed analysis laboratory includes for distinct sections:

1. Section for purity testing: Purity analysis of seed lot is considered under two factors
   (a). Testing the cleanliness of seed lot and
   (b). Testing the geneuiness of the cultivar
2. Section for moisture testing
3. Section for viability, germination and vigour testing.

Sampling in Seed Testing Laboratory

The seed samples received in the laboratory (submitted sample) are required to be reduced to obtain working samples for carrying out various tests. A number of methods are available for obtaining working samples.

1. Physical Purity

The purity analysis of a seed sample in the seed testing laboratory refers to the determination of the different components of the purity *viz.*, pure seeds, other crop seeds, weed seeds and inert matter.

2. Germination

Germination is defined as the emergence and development from the seed embryo, of thoseessential structures, for the kind of seed in question, indicates its ability to produce a normalplant under favourable conditions.The test is conducted under favourable conditions of moisture, temperature, suitable substratumand light.

3. Determination of moisture content

The moisture content of a seed sample is the loss in weight when it is dried. It is expressed as apercentage of the weight of the original sample. It is one of the most important factors in themaintenance of seed quality.

Conclusion

SOPs for quality seed assurance is the utmost requirement for higher-quality harvests, seed quality needs to be preserved. These days, the main issue in developing nations is seed maintenance. Better postharvest handling and seed storage techniques must be developed in order to be more cost-effective, practical, and effective. Translation of information into agricultural outcomes should be the main goal for researchers. The value of healthy seeds, factors influencing seed quality, post-harvest seed storage techniques, and techniques and safety precautions for their quality assessment for the maintenance of good quality seeds to meet the international standards with a focus on developing countries' needs are all covered in this chapter. This could be accomplished by choosing more sophisticated and sensitive technology, paying close attention to how seeds react to their environment and their mothers.

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MANAGEMENT AND MAINTENANCE OF SEED PROCESSING PLANT

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ROLE OF PLANT MANAGER

Direct and manage all plant operations with overall responsibilities for production, maintenance, quality and other production related activities

TYPICAL WORK ACTIVITIES OF PLANT MANAGER

- Direct and manage plant operations for Production, Maintenance, Quality Receiving and Shipping.
- Oversee crew activities which includes; sewing bags, stacking bags, loading out trucks, driving fork lifts, sampling of seed, maintenance of machines and ware house equipments

- Develops Budget and manages within Budged guidelines.
- Establish and Monitor overall plant performance for Production and Quality standards
- Ensure product quality meets establish quality standards

- Works toward continuous improvement in seed recovery and productivity.
- Interface with Growers concerning cleaning of seed
- Hires new staff if required

- Control and Minimizes labour overtime and repair expenses.
- Manages and maintains existing plant facilities and equipments in appropriate working conditions to meet business needs.

- Implement and maintains preventive maintenance programs.
- Performs all duties in accordance with safety rules and regulations

KNOWLEDGE ,SKILLS AND EXPERIENCE OF PLANT MANAGER

- Strong Technical knowledge in seed processing methods.
- Strong leadership skills.
- Proven supervisory experience.

- Broad knowledge of safety and environmental systems and procedure.
- Result oriented.
- Ability to accept and support change.

- Ability to interface with growers, staff and other functional areas of community.
- Problem solving ability.
  (Team and Individual)

- Excellent interpersonal skills and the ability to motivate people towards the Goal.
- Working knowledge of Budget and Financial Statements.

MANAGEMENT TECHNIQUES

MANAGEMENT OBJECTIVE

The basic management objective in a seed extractory is the attainment of quality seed. Quality is defined as good vigor, high purity percent, and germination percent.

- The management process to achieve this objective, or any objective, may be separated into five parts:
- **PLANNING,**
- **ORGANIZATION,**
- **MOTIVATION,**
- **CONTROL, AND**
- **INNOVATION** .

Each part is dependent upon the other. Seed extraction easily fits into these five areas.

PLANNING

By the extraction year a fair estimate of crop size should be available to the manager. With this information it is then possible to plan budgeting data: cost, length of time to accomplish the job, size of crew, equipment needs, and contingencies. These items are the very least required of a good extraction plan.

ORGANIZATION

Organizing the job is where crew deployment takes place. A manager should know the people in the crew and how to best deploy them; i.e., what they are best suited to do. Not all crew members function at the same levels. This is where skillful managers can best organize the utilization of their crew.

MOTIVATION

Motivation is a very fragile word. The concept is not that difficult to understand. Webster defines motivate as some inner drive, impulse, intention, etcetera, that causes a person to do something or act in a certain way; incentive, goal. Dwight Eisenhower is quoted as saying "Leadership is the ability to get a person to do what you want him to do when you want it done, in a way you want it done, because he wants to do it." I feel this is the core of seed extraction management.

CONTROL

Control can be obtained in a few ways. As a manager you can be in the extractory checking on the crew's work constantly, or you can establish checks at various points in the process. If an accountability system is established, the spot check works rather well.

INNOVATION

In seed extracting this is, and must be, an on-going process. There is no single best method of cleaning seed. Each seed lot is slightly different. The size, weight, and shape of seed differs not only between lots but also within lots. The crew often times can be the best source of new ideas.

SEED PROCESSING CONTENT

- Seed processing involves **Cleaning** the seed samples of extraneous materials, **Drying** them to optimum moisture levels, **Testing** their germination and **Packaging** them in appropriate containers for conservation and distribution.

1.SEED CLEANING

- The cost of maintaining unprocessed seed lot is high and space is limited. Debris and damaged seeds can spread infection. Therefore, place only good quality viable seeds in storage.
- Seed cleaning involves removal of debris, low quality, infested or infected seeds and seeds of different species (weeds).

2. SEED MOISTURE TESTING

- Methods prescribed by the International Seed Testing Association (ISTA) are used for determining the seed moisture content.

ISTA has prescribed two kinds of oven-drying methods for determining moisture content:

- Low-constant temperature oven method for groundnut (oily seeds).
- High-constant temperature oven method for sorghum, millets, chickpea and pigeon pea (non-oily seeds).

Equipment used to determine seed moisture content

3. SEED DRYING

(1) Sun Drying

(2)Mechanical Drying

（3）SEED VIGOR TESTS

Vigor is the sum total of all those properties in seed which upon sowing result in rapid and uniform production of healthy seedlings under a wide range of environments, including both favorable and stress conditions. Vigor tests supplement information about seed quality.

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