SEED PROCESSING

ICARDA TRAINING MANUAL

L. Grass and B. Gregg

ICARDA

International Center for Agricultural Research in the Dry Areas

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is one of 15 centers supported by the CGIAR. ICARDA's mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources.

ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and serves the non-tropical dry areas for the improvement of on-farm water use efficiency, rangeland and small-ruminant production. In the Central and West Asia and North Africa (CWANA) region, ICARDA contributes to the improvement of bread and durum wheats, kabuli chickpea, pasture and forage legumes, and associated farming systems. It also works on improved land management, diversification of production systems, and value-added crop and livestock products. Social, economic and policy research is an integral component of ICARDA's research to better target poverty and to enhance the uptake and maximize impact of research outputs.

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A Training Manual

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International Center for Agricultural Research
in the Dry Areas

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Foreword

Seeds provide the link between research and farmers in what is often called the "seed chain." *This chain* involves several different activities such as field production, processing, distribution, marketing, and quality assurance. The delivery of good quality seed of superior varieties to farmers in sufficient quantity and at the right time, place and price demands good coordination and management of all these activities.

The mechanical processing of seed to enhance its quality is one of the more specialized links in this chain. In fact such processing, followed by packaging and marketing in sealed bags, is one of the main features that distinguishes improved seed from that saved by farmers. Processing equipment is also one of the major investments required in the establishment of a seed program or company. However, this equipment requires skilled operation if it is to do its job properly and for that reason it is essential to match the capital investment with staff training. This should cover both the principles on which the machines work and the practical adjustments required to achieve the optimum results.

For this reason, the Seed Unit at ICARDA has always given a high priority to the training of staff from national seed programs. Many courses have been organized over the years both at Headquarters and in countries of the region. With the adoption of a "Train-the-Trainers" approach, there has been a gradual shift to in-country training, in which national programs assume the leading role in organizing courses, with technical support from the ICARDA Seed Unit.

There are many benefits in this devolved approach to training, including its cost-effectiveness and the opportunity to tailor the courses to meet local and regional needs. The Seed Unit of ICARDA has embarked on the preparation of a series of training manuals covering the main topics of quality seed production. This is the first manual in this series, and we believe it provides a good blend of principles and practice. We hope this manual will be used in training courses on seed processing and, thus, make a valuable contribution to the strengthening of seed programs throughout the region.

Prof. Dr Adel El-Beltagy
Director General
ICARDA

Preface

Seed from the field contains various contaminants such as weed seeds, other crop seeds as well as inert material such as stones, chaff, straws, etc. Seed processing includes all operations which prepare harvested seed for planting. The quality of processed seed depends on the efficiency of removing impurities and low quality seeds, preventing mechanical damage and contamination to seed, and treating it for protection from soil microorganisms and insects.

Seed processing is a highly technical and specialized job. It is based on the availability of the right equipment and on the knowledge and skills of the operator. An inexperienced operator not only wastes time and seed but increases operating costs and provides low quality seed. This is often related to lack of adequate training on the one hand, and to high turnover and transfer of trained personnel on the other hand. This is common in most WANA countries, where the private sector is starting to emerge but governments still dominate the seed sector. Constant training is required to maintain competent staff capable of judging, formulating and implementing processing operations effectively and efficiently.

Well-trained personnel are very important. They must be familiar with the principles of each cleaning machine, as well as be able to judge and utilize their abilities to use these machines in an appropriate sequence. Moreover, they must have a thorough knowledge of the morphology and physical properties of seeds of cultivated species and weed seeds commonly occurring in the country, and be familiar with seed testing techniques and quality standards.

Information on seed processing is available in many books and scientific journals, but most of it is couched in academic language. It often takes considerable time to read and may be difficult to use in a day-to-day practice by a plant operator or a manager. Also, these on-the job people who need the information do not usually have access to international publications which contain the required information.

This manual has been prepared from information already existing in many publications, and incorporates the expertise of a number of specialists who participated in the "Train-the-Trainers" course on seed processing at ICARDA in 1997. Moreover, the information was arranged so it could be easily understood and used by most seed processing operators.

The ICARDA-Seed Unit, since its inception, has been involved in training public and private sector personnel of national seed programs through technology transfer, regional and in-country courses, and development of training materials. This manual has been developed primarily to assist trainers in running the follow-up training courses for the "Train-the-Trainers" program and for the requirements of operating personnel who are actively engaged in seed processing.

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About the manual

The manual is organized into two parts:

Lecture notes

Lecture notes are designed to give the user an overview of all operations of seed processing. They aim to provide in-depth knowledge of the working principles of seed processing, different steps and operations conducted during seed cleaning, and different machines used to dry, clean, grade, and treat seed. Each machine is described, how it is used, how it works, how it is adjusted, and how adjustments affect its performance and capacity.

In addition to processing machines, the manual covers related topics such as internal quality control and its benefits; mechanical damage and seed contamination and how to minimize them; storage principles, storage pests and how to control them; and management and organizational aspects.

Each section is followed by a list of questions. These help to draw attention to important parts of the machines, their function, and how they are used and adjusted.

Practical sessions

These are designed for use in training on small- or large-scale machines. These analyze step-by-step what the trainee needs to do and to know. Each practical session should be completed only after the lecture in class has covered that topic.

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The authors wish to express their thanks to the Government of The Netherlands (DGIS-Regional Seed Training Project) for its valuable support to the training activities in the Seed Unit. This has enabled the Unit to respond to the expressed needs of national seed programs and also undertake supporting activities such as the preparation of this training manual for use in courses.

LECTURE NOTES

PRINCIPLES OF SEED PROCESSING

What is seed processing

Harvested seed contains various contaminants such as weed seeds, other crop seeds as well as inert material such as stones, chaff, straws, etc. This foreign material has to be discarded before the seed can be marketed and planted. The operation to do so is called processing, ***the final step that converts raw seed into finished product and improves its quality***. The final quality depends on how well the job was done, the efficiency of removing impurities and low quality seeds, and preventing mechanical damage and contamination to seed.

Seed processing is a highly technical and specialized job. It is based on the availability of the right equipment and on the knowledge and skills of the operator. An inexperienced operator not only wastes time and seed but increases operating costs and provides low quality seed. This is often related to the lack of adequate training on the one hand, and to high turnover and transfer of trained personnel on the other hand. Constant training is then required to maintain competent staff capable of judging, formulating, and implementing processing operations effectively and efficiently.

Definition of terms

- ***Seed processing: Processing refers to preparing. Seed processing refers to preparing seed for marketing and planting purposes***. Seed processing is the broader term and generally refers to five main functions aiming at raising the quality of harvested seed to a marketable condition and to prepare seed for planting purposes. These are drying, cleaning, grading, treating, and packaging.
- ***Drying*****:** Is the action of removing excess water from harvested seed. Drying not only reduces the danger of heat damage and mold and insect growth thus preventing loss of viability, but also prepares seed so that it can be processed more efficiently. This should be carried out before cleaning.
- ***Cleaning*****:** Refers to the operation that removes any foreign material other than the seed in question from the seed lot.
- ***Grading*****:** Is the process of sizing clean seed to produce an even product suitable for mechanical planting.
- ***Treating*****:** Is the action of coating the seed with a chemical formulation, either for protecting seed from insect damage during storage (insecticides) and/or to prevent development of seed and soil-borne diseases after planting.
- ***Packaging*****:** Is the last operation in the processing line before seeds are stored or delivered. It is the action of putting the correct amount of seed needed by the farmer for planting in a proper container.

Why seed is processed?

There are several reasons for processing seed (Fig. 1):

- Removing ***other crops and weed seeds***.
- Removing ***immature and shriveled seeds***; these may be viable but of no agricultural value.

- Removing ***damaged seeds,*** broken, cracked, split, or diseased and insect damaged seeds that are of low germination.
- Removing ***foreign materials,*** trash, chaff, stems, pods, insects, dust, dirt, stones, soil particles, etc. These are not harmful but tend to hold moisture and add to the weight of the seed lot.
- ***Size-grading***; removing large and small seeds to secure uniformity.
- Improving seed ***lot appearance***.
- ***Treating seed*** with protective chemicals.
- Maintaining or ***improving seed germinability***.

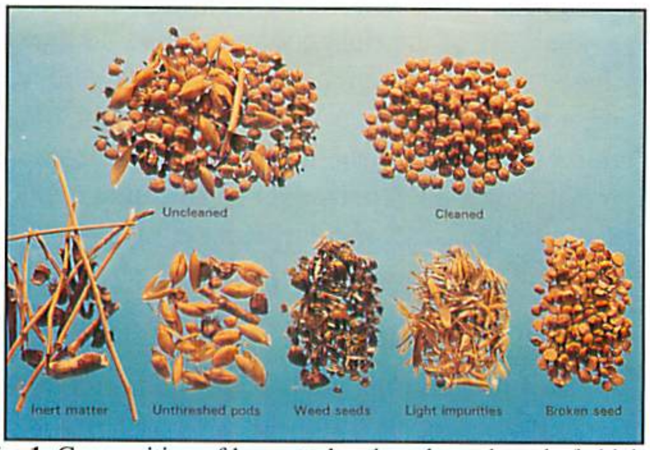


Fig. 1. Composition of harvested and uncleaned seed of chickpea

The ultimate goal of seed processing is to supply the farmer with seed that is free from diseases, has a high germination capacity, is adequately clean, and graded and treated with fungicide and insecticide so that it can be used for planting.

For a farmer appearance is an important factor in buying seed of an improved variety. A farmer cannot see the genetic make up of that seed (performance, genetic resistance to diseases and insects) but he can see its physical characteristics and distinguish seed that has the same shape, size, color, etc. Therefore, seed needs to be cleaned and graded before it can be sold to farmers.

Seed processing principles

The above objectives should be achieved effectively, efficiently, and with minimum loss and damage to the seed, and at minimum cost.

To do so, the processing operator must be aware of the following principles:

Principle 1

Seed processing, except for chemical treating, is based primarily on differences in physical properties between desirable material (crop seed) ***and undesirable material*** (contaminants). Seed and impurities, which are not different in at least one of these characteristics, cannot be effectively separated. The most prominent example of this is contamination with other varieties of the same species.

Principle 2 ***The operator should be as familiar with seed quality properties and physical characteristics of seeds and contaminants as he is with seed processing equipment.*** The operator must be able to exploit these physical differences within the seed lot for better separation. Also, he should have knowledge of the working principles that each machine is using to separate materials, and how to adjust it for maximum performance. Nevertheless, he should also be familiar with flow patterns generally used to process each seed crop. Furthermore, knowledge of the capabilities and limitations of each machine is important for successful seed processing.

Principle 3 ***Seed processing requires several operations, for which many different machines are used.*** A single machine cannot separate seeds that differ in all characteristics. Each single machine separates seed mixtures based on one or two characteristics only. If further separation is needed a different machine has to be used.

Principle 4 The critical difference is ***the minimum difference in seed characteristics*** that a particular machine can detect to make separation between good seed and impurities. The larger the difference the better the separation. Small differences between good seed and impurities will result in poor separation and great seed loss.

Principle 5 ***Satisfactory cleaning requires that seed lots be processed in a specific sequence***: pre-cleaning, basic or fine cleaning, and grading. It may not be necessary for every seed lot to pass through all machines. The choice and sequence of the machines to be used depend on: (i) the kind of seed being processed, (ii) the amount, nature, and kind of contaminants present in raw seed and (iii) quality standards that must be met (Fig. 2).

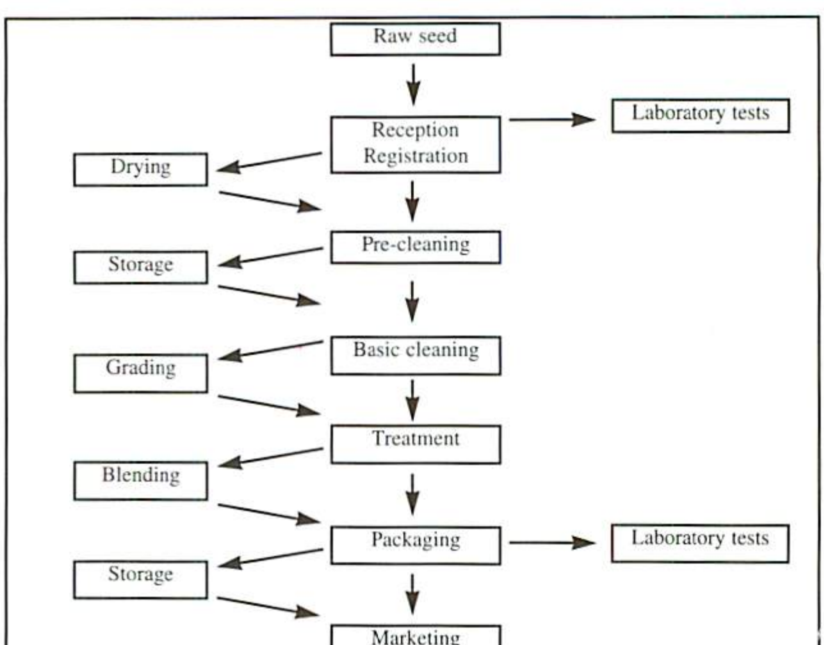


Fig. 2. Flow of seed within the processing plan

Principle 6 ***Each processing step should be handled effectively*** (complete and effective separation) and ***efficiently*** (maximum capacity with effective separation at minimum cost) ***with minimum loss*** (keep rejects as low as possible with effective separation) and ***minimum damage to the seed*** (prevent loss of quality).

Principle 7 ***You can improve seed quality by processing, but you can not produce high quality seed by processing low quality seed.*** The outcome depends on the initial seed quality received. Seeds with sufficient initial quality are easier to clean and to improve their quality than seeds with low initial quality. Moreover, inter-varietal mixtures and in some cases heavily infested seed are impossible or very difficult and costly to separate with cleaning machines. Therefore, seed processing should begin in the field with:

- Proper field selection and rotation
- Adequate roguing of seed fields (Fig. 3)
- Proper weed and disease control
- Careful field inspection
- Proper harvesting and threshing.

These procedures, if conducted properly, will minimize seed contamination and infection.

Fig. 3. Roguing at different growth stages of the crop: flowering (A), and maturity (B)

Principle 8 ***The outcome (quality of the seed) of the processing operation is a function that depends not only on the availability of the machines, but also on combined efforts of both the seed producer and the seed processor.*** The seed producer depends on the ability of the processor to prepare his seed for sale and use. In his turn, the processor depends on the seed producer to deliver a standard raw material (Fig. 4).

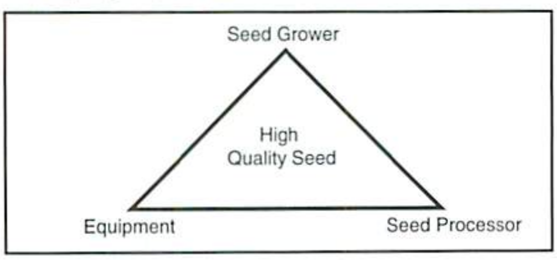


Fig. 4. Seed processing is not just availability of good equipment

Basis of seed separation during processing

Separation is based on differences in physical properties among desirable material (good seed) and undesirable material (contaminants).

Different machines are used to separate seed from contaminants. Each machine is designed to correspond to one or two specific characteristics of the seed in contrast to those of impurities in the seed lot (Table 1).

Table 1. Separation methods and related seed characteristics

Seed characteristics	Separation machine
Size: refers to the common differences in the individual bulk of seeds with the same general outline	Air-screen cleaner
Length: the longest dimension of a seed	Indented cylinder Disc separator
Width and thickness: width refers to the narrowest dimension of a seed in cross-section, while thickness is applied to the broader cross-sectional dimension. Only round seeds have the same width and thickness	Air-screen cleaner
Shape: refers to the natural outline of the seed	Air-screen cleaner Spiral separator Belt grader
Density: measured by the specific gravity of a seed	Air-screen cleaner Gravity separator
Color: usually used as an after-treatment or finishing process for special crops, but not routinely applied for all crops	Color sorter Sensor
Surface texture: refers to the relative roughness or smoothness of the seed coat	Roll mill Draper separator Magnetic separator
Affinity for liquids: refers to the rate at which seed surface will absorb liquids	Magnetic separator

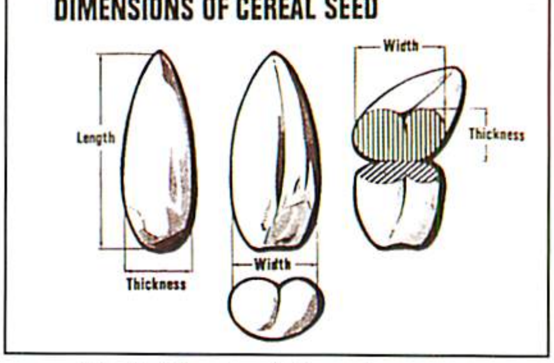


Fig. 5. Wheat seed dimensions

General flow of seed processing

Seed processing is a complex operation, which encompasses several steps ranging from receiving raw material, drying and pre-cleaning, basic cleaning, grading, and treating to storage.

The first step of seed processing is reception and pre-cleaning where received seed is first sampled to determine the impurities and seed moisture. Tested seed may go either directly to the cleaning process or into temporary storage to await processing. The next step is basic cleaning and grading.

The air-screen cleaner is the most important and widely used machine for basic cleaning. While a pre-cleaner and air-screen machine are essential in almost every processing line, other machines may or may not be required. Depending on the kind of seed to be processed and the degree of impurities in the incoming raw material, further processing may include cylinders, gravity table, spirals, belt graders, etc. Seed processing plants can be either mobile or fixed:

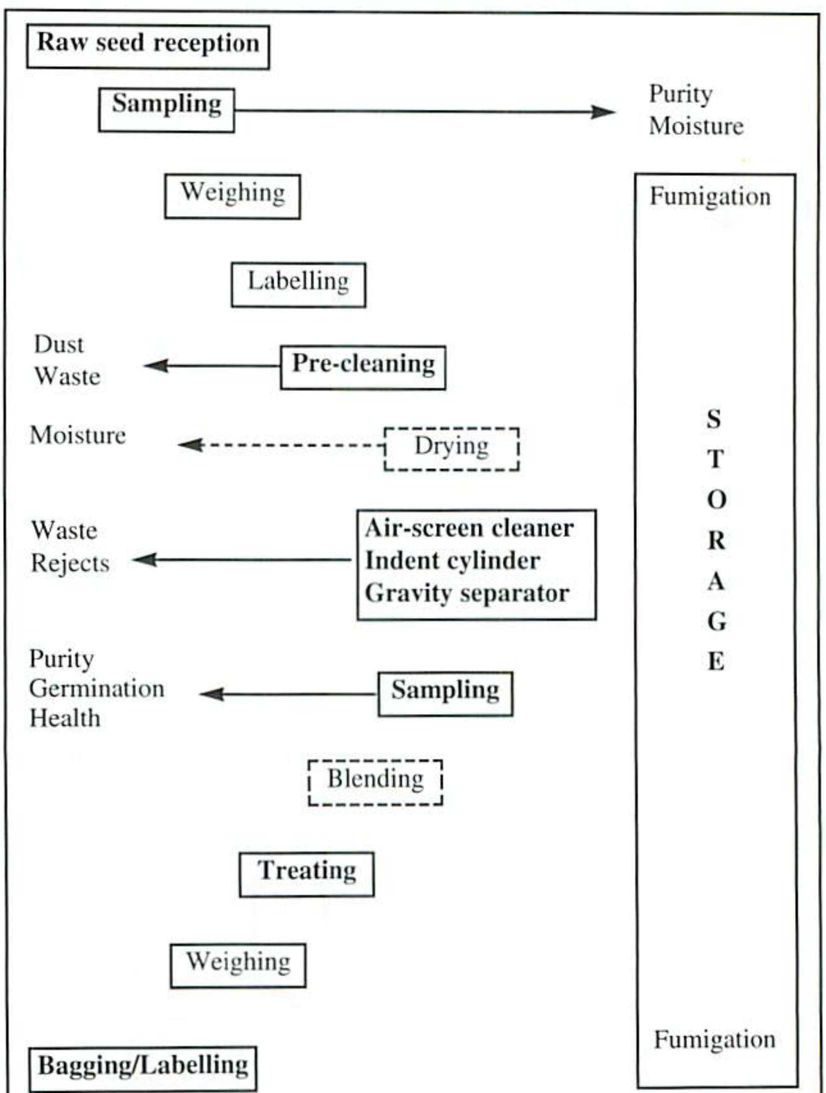


Fig. 6. Seed processing operations

Types of processing plants

- ***Mobile***: In general, it consists of one or two combined machines of small capacity. More often, it is an air-screen cleaner alone or combined with an indented cylinder. A separate treater may accompany the processing machines. The power may be electrical or fuel.
- ***Fixed***: Two types can be distinguished:

1. ***Vertical*** (Fig. 7): In this type of plant, machines are put in different floors in a multistoried building. The incoming seeds are first elevated to bins on the top floor and allowed to fall by gravity from machine on one floor to the other machine for the next operation. The ground floor is reserved for seed packaging and storage.

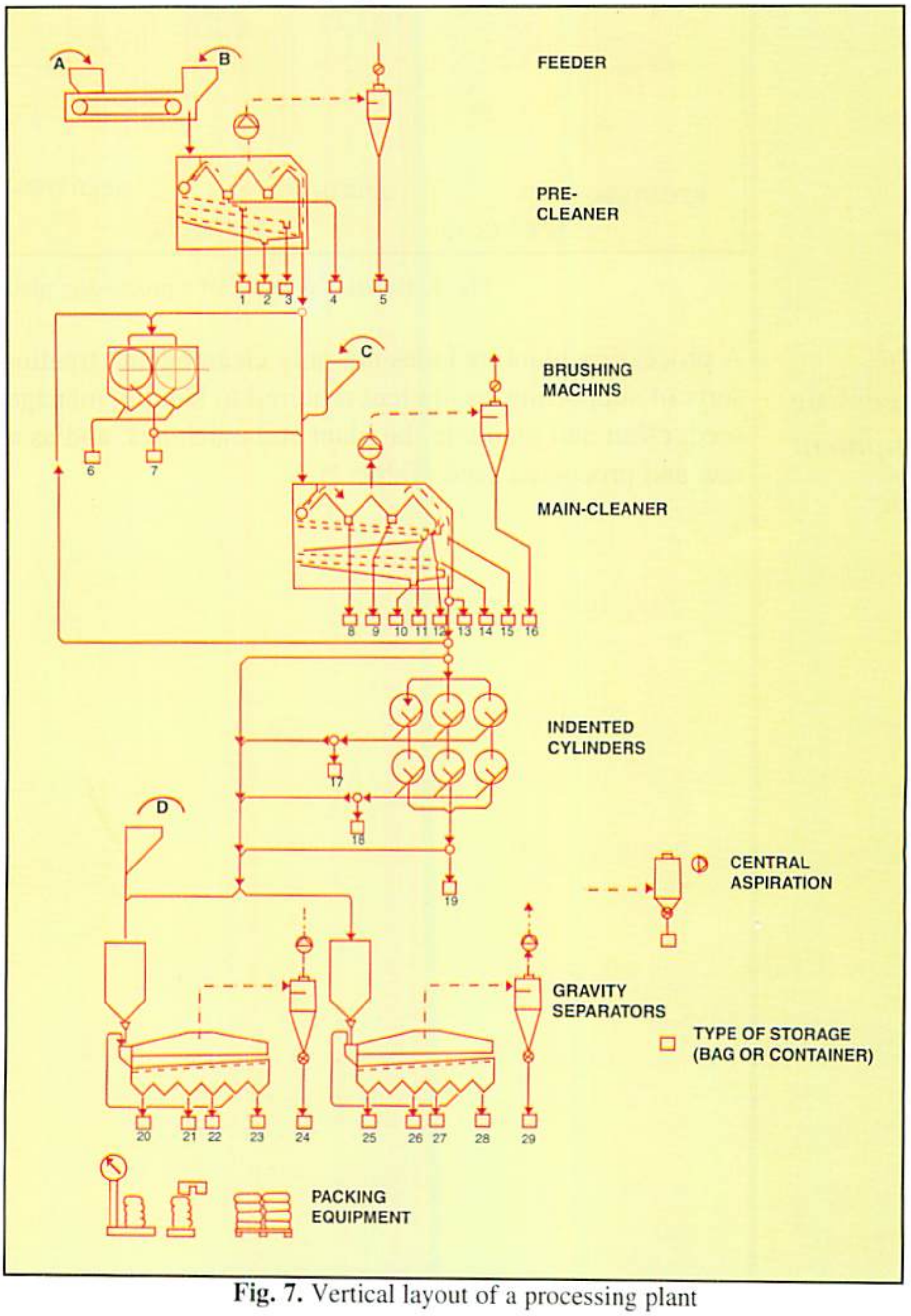


Fig. 7. Vertical layout of a processing plant

2. ***Horizontal*** (Fig. 8): In this type of plant, all the machines are laid down in the same floor. Seeds are elevated into surge bins above a particular machine, pass through that machine by gravity and then re-elevated for the next cleaning operation. This type of arrangement is less costly to construct and easier to supervise.

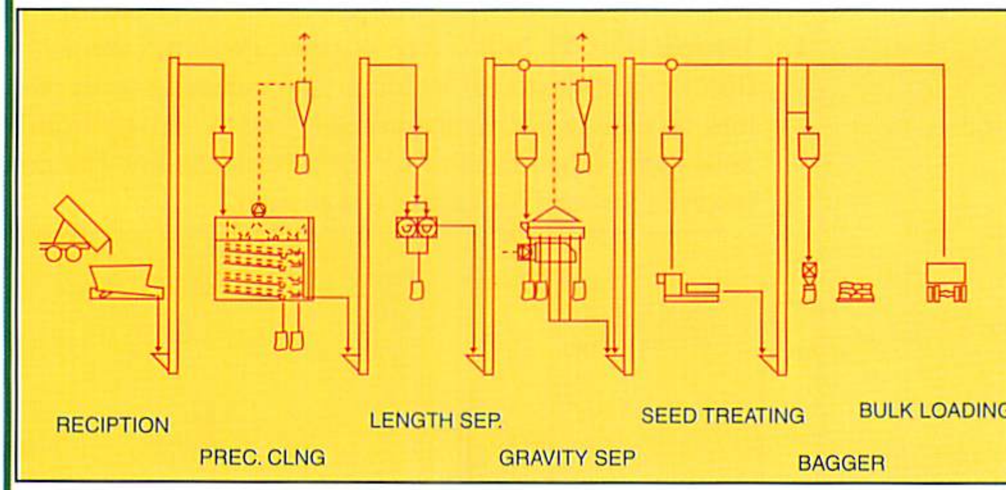


Fig. 8. Horizontal layout of a processing plant

Seed processing equipment

A processing plant includes not only cleaning and treating machines, but all sorts of supporting equipment required to handle, manage and protect the seed, clean and maintain the plant and machines, and assess the quality of raw and processed seed (Table 2).

Fig. 9. Large processing plant

Fig. 10. Medium size processing plant (ICARDA plant)

Fig. 11. Small processing plant in Sudan. A screen cleaner only (Courtesy M. Turner)

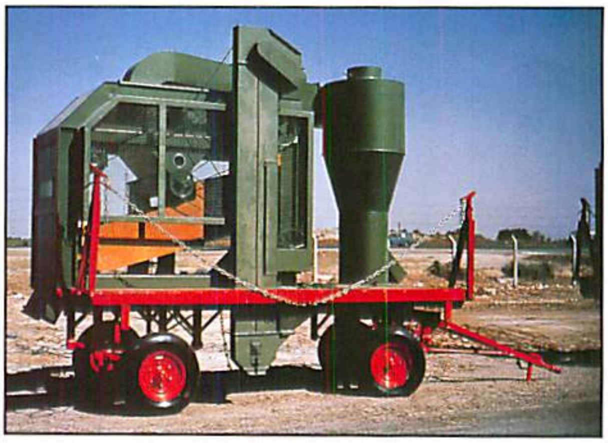


Fig. 12. Mobile processing machine (air-screen cleaner)

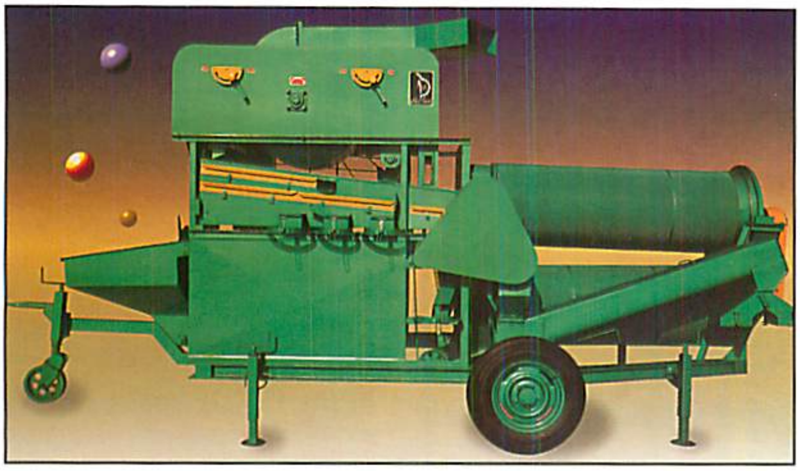


Fig. 13. Mobile processing machine (air-screen cleaner + cylinder) in Iran

Table 2. Processing equipment

Processing machines	Function	Supporting equipment	Function	IQC system	Function
-Scalper De-awner Scarifier	-Pre-cleaning and special treatments (de-awning of barley, threshing small seeds, scarifying hard seed	-Elevators/conveyors	-Receiving, elevating and conveying seeds	-Sampling, moisture, purity and viability testing equipment	-Assess quality before and after processing and to monitor the efficiency of different processing machines
-Dryer	-Dry seed to safe moisture	-Bag closers	-Close/seal/sew filled bags	-Complete set of hand screens for testing	-Testing and proper selection of right screens
-Air-screen cleaner Indent cylinder Gravity table	-Basic and fine cleaning and grading	-Brooms, shovels, vacuum cleaners, air compressor	-Clean-up and sanitation	-Labelling and identification equipment	-Labelling
-Spiral separator, Air aspirator, roll mill, magnetic separator	-Special cleaning and grading machines	-Bags, scoop shovels, pallets, forklift trucks	-Seed handling	-Monitoring equipment	-Ambient air temperature and seed moisture (drying, storage)
- Treater	-Application of fungicides/ insecticides	-Set of screens, cylinders, and decks	-Proper selection		
-Blender	-Seed lot mixing	-Dust collection and ventilation systems	-Dust and light waste lifting		
-Weigher/Bagger	-Weigh desired amount of seed and put it in the bag	-Sprayers, traps, bait stations, gas proof sheets, gas detectors	-Insect control		
		-Gas masks, dust masks, helmets, gloves, glasses	-Personnel safety		
		-Electricity generators, emergency light, firefighting equipment, first aid kits, emergency oxygen	-Emergency		
		-Maintenance tools, spare parts	-Maintenance		

Table 2.1. Machines used to clean agricultural crops

Seed Crop	1	2	3	4	5
Alfalfa, lucerne (*Medicago sativa*)		x	x	o	Velvet roller, spiral separator (o), magnetic separator, air separator (o), scarifier
Barley (*Hordeum vulgare*)	De-awner	x	x	x	Air separator
Broad bean (*Vicia faba*)	Scalper	x		x	Air separator, color separator (o)
Bean (*Phaseolus vulgaris*)		o			Air separator, color separator (o)
Chickpea (*Cicer arietinum*)	Scalper	x	x	o	
Clover, red (*Trifolium pratense*)		x	x		Velvet roller, spiral separator (o), magnetic separator, air separator (o)
Clover, white (*Trifolium repens*)	Brushing	x	x	o	Magnetic separator (o), band grader (o), scarifier
Cotton (*Gossypium* spp.)	Delinter, scalper		x	x	Aspirator pre-cleaner,
Lentil (*Lens esculenta*)	Scalper	x	x	x	Spiral separator (o), scarifier (o), color sorter (o)
Maize (*Zea mays*)					
Oat (*Avena sativa*)	Clipper	x	x	x	Belt grader, air separator
Pea (*Pisum sativum*)		x			Color separator
Rapeseed (*Brassica napus*)		x			Magnetic separator (o), spiral separator
Rice (*Oryza sativa*)		x	x		
Sorghum (*Sorghum bicolor*)		x	x	o	
Soybean (*Glycine max*)		x	x		Spiral separator, color sorter (o)
Sugar beet (*Beta vulgaris*) monogerm		x	o		Belt grader, triangular screens, air separator
Sugar beet (*Beta vulgaris*) multigerm		x			Belt grader, triangular screens, air separator
Vetch (*Vicia sativa*)		x		o	Spiral separator, air separator (o)
Wheat (*Triticum aestivum*)	Scalper	x	x	x	Air separator (before gravity)

1 = pre-cleaning machines, 2 = air-screen cleaner, 3 = indent cylinder, 4 = gravity table, 5 = other machines, (o) = optional

Questions

1. What is seed processing?

2. Why do we need to process harvested seed?

3. Can processing operations eliminate almost any quality problem in most seed lots?

4. Can proper selection and use of processing equipment compensate for a poor job of seed production in the field?

5. Does seed processing eliminate non-germinating seed?

6. How are undesirable materials separated from good seed? List at least four seed physical characteristics important for seed processing and the machines which use each characteristic to accomplish separation?

7. Why does seed pass over series of machines instead just of one before it is completely cleaned and ready to be planted?

8. What should the seed processing plant operator know and do to accomplish satisfactory cleaning?

9. Draw a general flow diagram for processing a crop seed of your choice.

RECEPTION and PRE-CLEANING

The first step in seed processing is reception and pre-cleaning, a stage which involves weighing, sampling, testing, pre-cleaning, and temporary storage. It is the basic operation before seed can be safely dried, stored, or effectively cleaned.

Received raw seed may be (i) immediately cleaned, bagged and put into clean seed store or (ii) pre-cleaned and put in temporary storage to await further cleaning (Fig. 14).

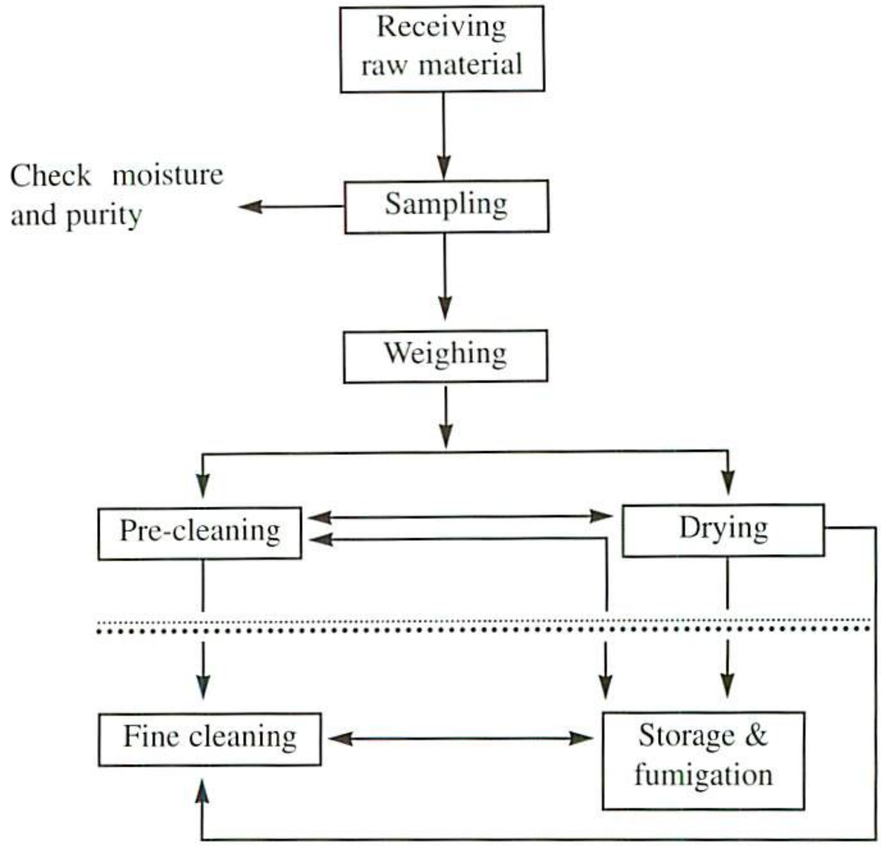


Fig. 14 . Reception and pre-cleaning operations

Reception of raw material ensures that responsibility for the seed lot is handed over from the grower to the seed processor. To ensure proper seed identity and avoid damage or mixture, as soon as a seed lot is received it should be:

- Properly labeled and identified
- Sampled and tested
- Properly dried
- Fumigated, if required
- Pre-cleaned
- Safely stored in an area, which preserves its identity and quality.

What is raw seed?

Raw seed is non-cleaned seed, a mixture of good seed and foreign materials.

Raw seed includes (Fig. 15):

- ***Inert matter*** (dust, chaff, earth particles) and ***off-size seed*** (broken, shriveled, immature seeds), which are not harmful by themselves but influence seed purity and flowability, and contribute to insect infestation and storage problems.

- ***Weed seed, diseased seed, and seed of other crops and varieties***, which seriously affect seed quality and crop production.

Fig. 15. Composition of raw seed: clean seed (A), immature and shriveled seed (B), broken seed (C), trash and chaff (D), other crops seed (E), weeds seeds (F), and earth particles (G)

Sampling and seed testing

As soon as seed is received it should be immediately sampled and its moisture content determined. Samples should also be examined to determine the composition of the seed lot.

Note: Details concerning sampling and testing are illustrated in the internal quality control section.

Weighing

Weighing is necessary to calculate the reject percentage, capacity and output of the processing operation, and for packaging and marketing purposes. Seed are weighed twice during seed processing: (i) when seed is first received and (ii) when the seed leave the cleaning line.

- ***First weighing*** refers to the weighing at the reception point. This requires large scales as seed are usually received in bulk. The scale can be placed outside the plant as a platform or weighbridge scale (Fig. 16), or inside the plant as a hopper scale. The platform scale is more flexible to use than a hopper scale and is usually used for weighing heavy loads of incoming seeds received on trucks, trailers, or wagons (Fig. 17).

- ***Second weighing*** refers to the weighing at the end of the processing operations. Bagging scales are commonly used for this purpose. They are small enough to weigh the capacity of a bag accurately. They may be manual, semi-automatic, or fully automatic (see packaging section).

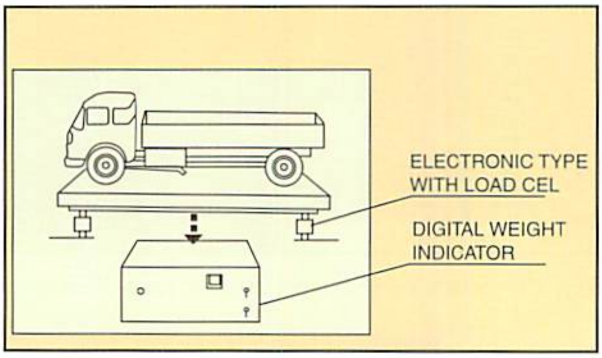


Fig 16. Platform scale

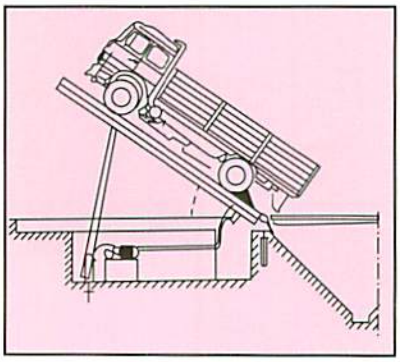


Fig. 17. Tipping into reception pit

Intake hoppers

Intake hoppers are part of the receiving system, where raw seed is first unloaded and fed into the processing line.

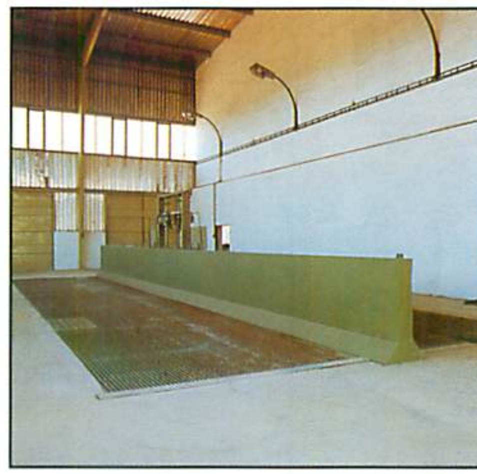
The design of the intake hopper depends on how seeds are received (bag or bulk), and the type of trucks transporting the raw seed. An intake system should be:

- Designed to handle the weight of loaded trucks.

- Provided with a protection system which prevents large foreign material from falling into the system (strings, wood pieces, large rocks).
- Accessible and easy to clean out to avoid any possible admixtures.

The best intake systems are those systems through which seeds pass into the cleaning machines by gravity. Other feeding systems such as screw and chain conveyers should be avoided because they are difficult to clean and cause damage to the seed.

Fig. 18. Large intake hopper suitable for truck drive-through



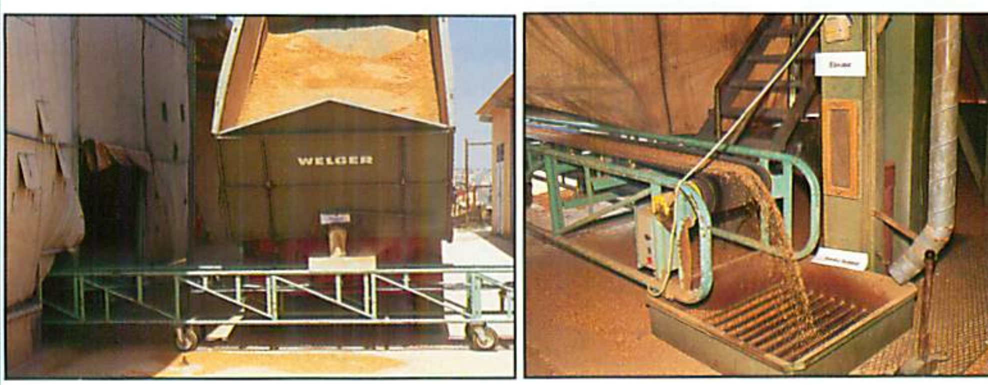
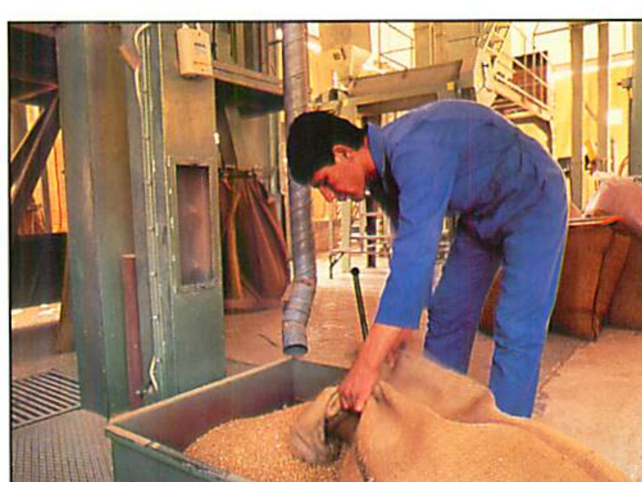


Fig. 19. Small intake hopper suitable for belt conveyors

Fig. 20. Small intake hopper suitable for bags



Pre-cleaning

The main purpose of this operation is to facilitate the movement of the seed mass through the subsequent machines.

Pre-cleaning operations eliminate coarse impurities (bulky particles much larger in size than the desirable crop seed), fine impurities (particles lighter in weight and smaller in size than the desirable crop seed) and prepares the seed mixture for basic and fine cleaning. The operation of removing large particles is often called scalping and is a common process to all crops.

Note: Not all seed lots received need to be pre-cleaned. The decision depends on the condition of seed in the field and during harvesting and threshing conditions. Hand-harvested seed rarely require pre-cleaning.

Benefits from pre-cleaning

By removing large materials and dust from the seed lot upon reception, you will:

- ***Reduce the drying required***, increase the rate of drying and reduce drying cost
- ***Reduce the contamination risks*** of both the seed and the machines by pathogenic organisms carried on the surface of seeds, leaves, straw, and earth particles
- ***Reduce the risk of seed heating*** during storage and increase the efficiency of control of storage molds and insects
- ***Increase the efficiency*** and effectiveness of basic cleaning equipment (uniform feeding rate, minimizing feed hopper stoppages, and reducing the resistance of seed to airflow)
- ***Improve the chances for complete separation*** of crop seed from other impurities and contaminants (accurate and sensitive adjustment)
- ***Reduce the dust content***, which reduces health and safety problems.

Pre-cleaning machines

***The most widely used machines are*:**

- ***Aspirators:*** provide very cheap pre-cleaning by winnowing.
- ***Scalper:*** the usual pre-cleaning machine. The most commonly used scalper is the vibrating air-screen which allows good seed to pass through, while larger material is scalped off. The scalper may have single or multiple screens.
- ***De-awner/debearder:*** used for complete threshing of partially threshed seed and to remove unnecessary appendages such as awns that interfere with seed flowability and affect seed sizing/operations.

Possible uses of the De-awner include:

- Removing awns from seed of grasses and cereals
- Improving appearance and increasing seed test weight of barley
- Clipping oats and improving seed appearance
- Partial decortication of sugar beet seed
- Breaking up legume pods and seed heads
- De-awning weed seed to permit separation from crop seed.

Remark: A De-awner is not used until it is necessary because (i) it can cause seed injury unless used carefully and (ii) it is costly, requiring high horse power.

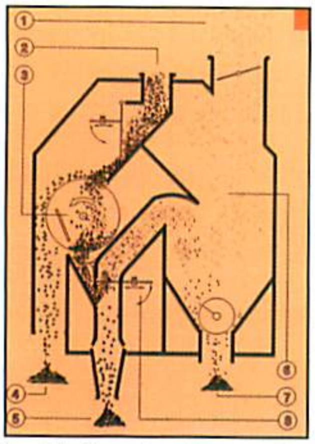


Fig. 21. Pre-cleaning rotating drum with air

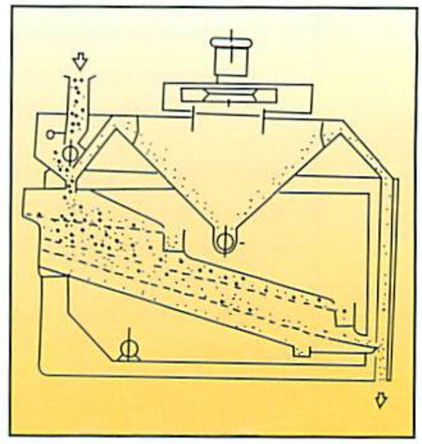


Fig. 22. Pre-cleaning oscillating screens with pre-and post aspiration

Fig.23. Pre-cleaning machine in Iran

Place of the pre-cleaning

Pre-cleaning machines should be the first in the processing line:

- Ahead of the main receiving elevator, just ahead of the air-screen cleaner.
- In case of seed drying, pre-cleaning is performed before seed enter the drier.

Fumigation (see fumigation section)

Temporarily stored seed should be handled in the same way as clean seed regarding storage conditions and storage pest control.

Received seed should be fumigated at least once to:

- Eliminate existing insects
- Avoid new insect infestation
- Avoid spread of infestation and contamination of other seed lots
- Avoid contamination of processing machines.

Questions

1. Define raw seed mixture.

2. How do you determine the processing requirements of a particular seed lot?

3. List the steps and operations performed when you first receive a seed lot.

4. What is the purpose of pre-cleaning?

5. What are the most commonly used pre-cleaning machines?

6. What are the principles by which the scalper separates seed?

DRYING

Why seed drying

Seed attain maximum germination and vigor at physiological maturity, while still at high moisture content. After this stage, seed quality and yield decline due to weathering, insect and disease damage, etc. Where weather permits, seed are allowed to field-dry to safe harvesting and handling moisture content. Under adverse weather conditions, seed must be harvested at high moisture content. At high moisture content, seed will heat and deteriorate rapidly if it is not immediately and properly dried to safe storage moisture content.

Drying not only reduces the danger of heat damage and mold and insect growth, thus preventing loss of viability, but also prepares seed so that it can be processed more efficiently.

What is drying?

Drying is perhaps the most sensitive and difficult operation in seed processing. ***It simply means removing excess water from the seed.***

Drying involves the simultaneous process of heat and moisture diffusion through and out of the seed. Heat from the air is transferred to the seed, increasing the vapor pressure difference between seed and air, thereby driving moisture out of the seed back to the air.

Drying takes place when there is a net transfer of moisture out from the seed into the air and stops when equilibrium is reached between the vapor pressure of the seed and that of the surrounding air. ***It is a two-stage process*** (Fig. 24). First, moisture from the seed surface moves into the surrounding dry air (stage 1) and then the moisture inside the seed migrates to the seed surface (stage 2).

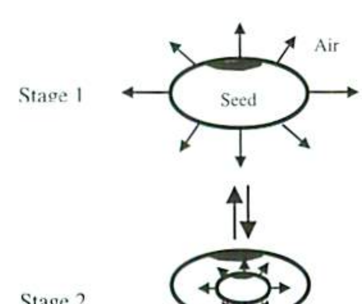


Fig. 24. Drying is a two-stage process

When water evaporates from the seed surface into the atmosphere, a moisture gradient is set up inside the seed that causes internal moisture to move toward the seed surface. Rapid evaporation of moisture from the seed surface will create a high moisture gradient resulting in extreme moisture stress and damage to the embryo.

Related terminology definitions

Hygroscopy: seed is hygroscopic (Fig. 25), it loses or gains moisture to/from the surrounding air as its moisture content is higher or lower than that which is in equilibrium with atmospheric relative humidity.

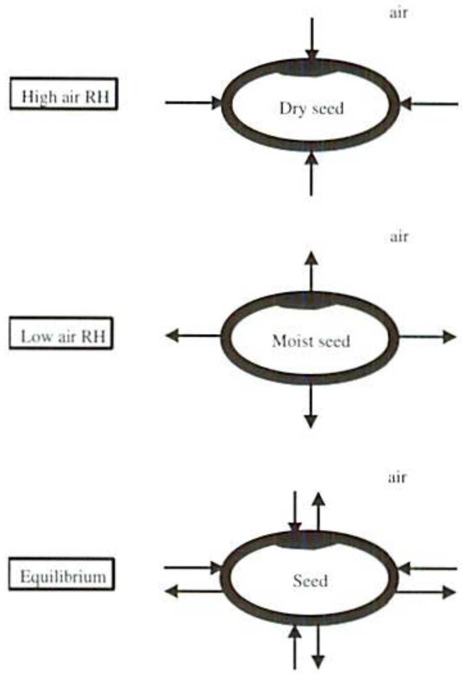


Fig. 25. Seed is hygroscopic

- ***Relative humidity*** (%RH) = percent of total moisture (invisible water vapor in the air) actually in the air as compared to the maximum amount of moisture that air at a given temperature could hold. Just as seed holds different amounts of water, air also holds different amounts of moisture at a given temperature:

  - As temperature increases, air can hold more moisture so its moisture-holding capacity increases (g water vapor/kg dry air); with the same amount of moisture, the air %RH goes down.

Temperature (°C)	Water vapor at saturation g/kg dry air
00	03.8
10	07.6
20	14.8
30	26.4

The amount of water air can hold almost doubles for each rise of 10°C.

  - As temperature decreases, air holds less moisture so its moisture-holding capacity decreases; with the same amount of moisture, its

%RH goes up. If saturated air is cooled, it cannot hold all the vapor present in the air and condensation occurs as dew or rain.

- Hot air is lighter so it rises up; cooler air is heavier, so it settles down.

- ***Equilibrium:*** the point where the percentage moisture content of the seed and air %RH are balanced. At this point there is no movement of moisture from or to the seed. Seed is then in its equilibrium state.

- ***Water in the seed exists in three states:***
  - *Chemically bound water*: bounded water to the inner parts and structure of the seed. The removal of this water is not desirable during drying; seed will die as a consequence.
  - *Associated water*: internal water not chemically bound, but associated with internal seed tissues. The removal of this involves two steps, diffusion of moisture to the seed surface followed by surface evaporation.
  - *Free water*: surface moisture, a film of water surrounding the seed. Easily removed by air under proper conditions.

Seed moisture content = free water + associated water

- ***Isotherm:*** is the sigmoidal curves of desorption or adsorption (Fig. 26).

- ***Hystheresis:*** equilibrium may be reached by adsorption or desorption. The difference between the two equilibrium moisture contents is called hystheresis. If dried seeds are put in high RH conditions, they will absorb moisture and will reach an equilibrium moisture content lower than that of the undried seed.

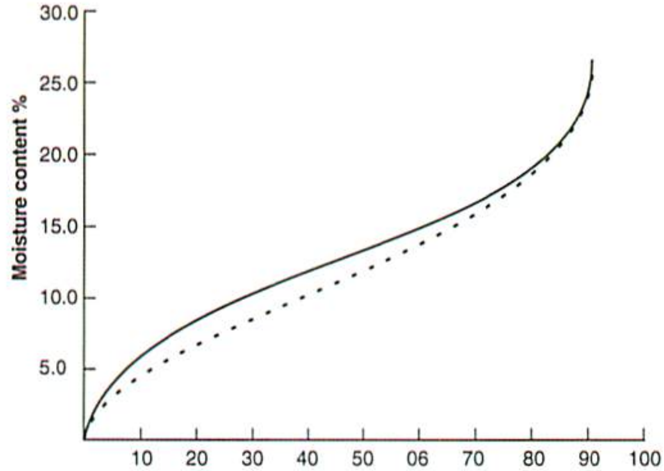


Fig. 26. Desorption (——) and adsorption (------) isotherms for wheat at 30°C

High moisture content causes heating

Unless seed is dried to a safe moisture content, high seed respiration rates which can cause over heating, mold, and insect growth will cause rapid loss of viability.

Also, high moisture content can lead to seed damage (bruising). Therefore, seed moisture content must be reduced as soon as possible.

Note: High moisture content causes heating in seed mass as a result of seed's own metabolism and promotes the growth of molds and insects.

Moisture content	Effect on seed
35-60%	germination
18-20%	heating
12-14%	mold growth
>9%	insect activity

High drying tempera-tures cause heat damage

Seeds are very sensitive to extreme temperatures. High temperatures may damage seed and impair viability. Heat damage may cause:

- Loss of viability
- Abnormality in the seedlings
- Internal cracks and split seed coat similar to mechanical damage.

The extent of damage depends on the temperature, exposure time, and initial percent moisture content. The higher the initial seed moisture content, the more sensitive the seeds are to high temperatures.

Drying procedures

Factors that should be considered before and during drying (Fig. 27):

- ***Harvest at optimum seed moisture content:*** harvest only when seed is completely mature and has been field dried to a safer moisture content. But don't wait until seeds shatter or are so dry that threshing damages them.
- ***Following harvest, seed is usually pre-dried*** to allow temporary storage.
- ***Storage and pre-cleaning:*** wherever possible, natural drying is used at this initial stage. If necessary, seed can be dried again to a lower moisture content.
- ***Dry with air which has enough moisture-holding capacity*** to remove moisture from the seed. As seeds warm up (don't get seeds too hot, they die), moisture migrates from them more easily.
- ***Pre-clean seed before drying*** to remove dust and trash and reduce drying cost.
- ***Do not dry seed in wet weather when RH is high*** (e.g., early morning, night, wet/foggy day). Dry the seed in the middle of the day, when the sun heats the air and lowers its RH.

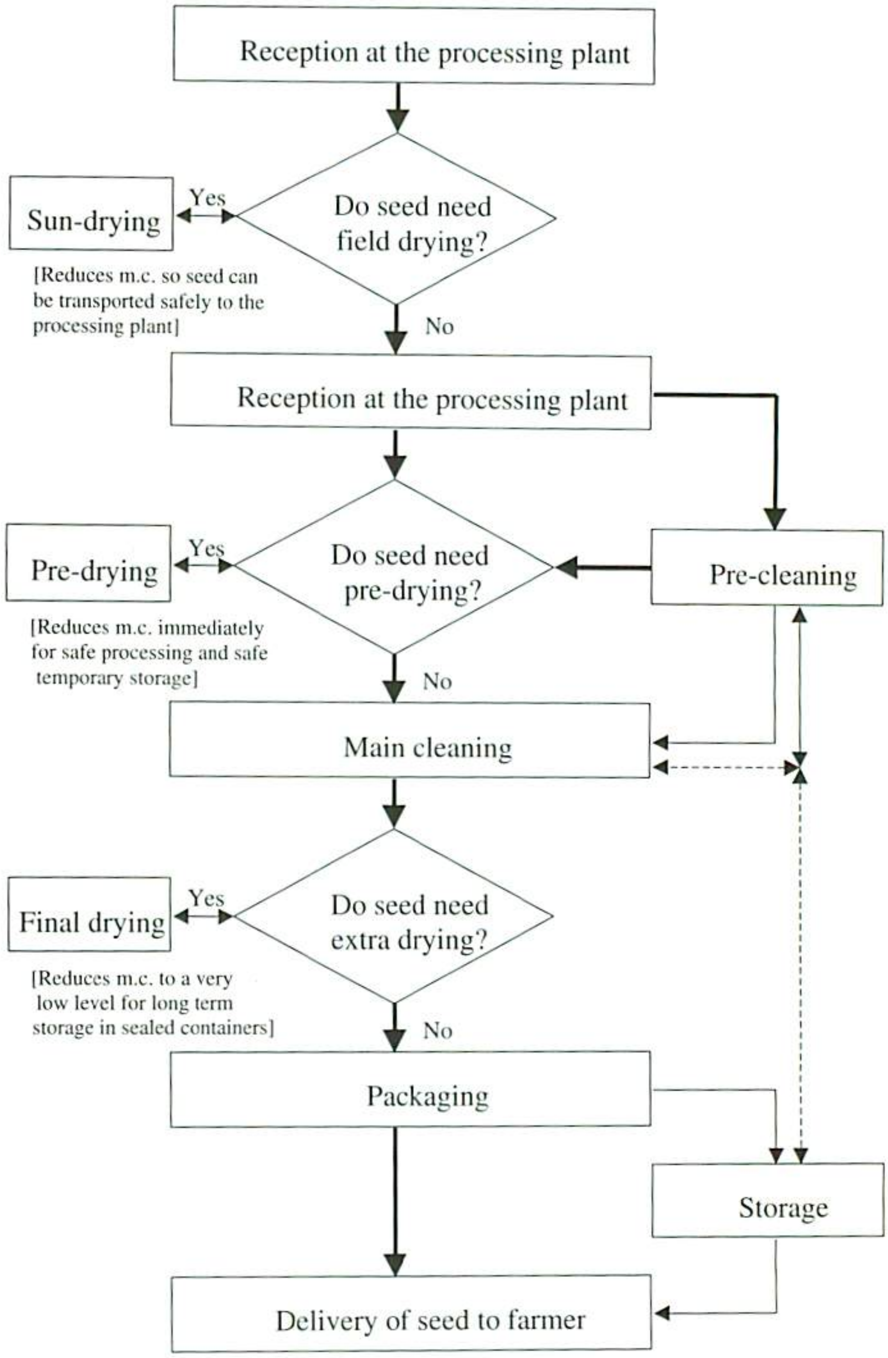


Fig. 27. Drying process

Different ways of drying seed

Drying seed can be accomplished by:

- ***Natural drying*** is the process by which seed loses water naturally using atmospheric air. This is the case in the field at ripening time. Weather is a major factor for field drying. A hot dry wind prior to maturity may cause rapid seed drying and results in seed damage. Adequate field drying conditions are moderate temperatures and RH.

- ***Artificial drying***, using heated air (driers) or unheated air (dehumidifiers) that is blown to flow through a seed mass.

Sun-drying

Sun-drying is the most widespread practice in areas with dry conditions. Mostly used for vegetable seed after extraction and washing.

Fig. 28. Sun-drying

Advantages
- Very low initial cost
- Reduces the cost of drying
- Flexible capacity

Disadvantages
- Slow drying process
- Depends on the weather
- High risk of contamination
- Possible loss due to birds and rodents
- High labor input

Procedures
- Spread the seed on a vapor-proof surface (plastic sheet, raised concrete floor, screen bottom trays for small seed lots, etc.) which protects seed from ground moisture
- Spread the seed in a thin layer (avoid thick layers or piles), so they are exposed to the sun (which heats them and the surrounding air) and the wind (which blows away air that has absorbed moisture)
- Stir the seed constantly to facilitate rapid, uniform drying
- Sun-dry in the middle of the day only (when air is dry) and take up seed at night (when air is humid and RH increases)
- Protect seed from birds or rats

Remark: Do not dry seed in bags on a concrete floor. Use a bag dryer with heated and forced air for seeds in sack.

Dehumidified air-drying

Dehumidified air-drying refers to unheated air that is re-circulated through the seed mass, until the seed moisture content is reduced to the desired level.

It is more commonly applied to small amounts of seed which must be dried to a very low moisture content and sealed in vapor-proof packages.

Advantages
- Easy and simple to manipulate
- Low risk of seed damage from hot air

Disadvantages
- Cannot be used for large-scale production
- High cost of investment

Procedures

Unheated air is forced into a seed mass within a closed system. It removes moisture from seed, and is recycled through a dehumidifier to dry it. This air is forced again through the seed mass. No heating is required.

Forced hot air-drying

This is the most widespread practice in semi-humid and humid conditions where natural drying cannot be used.

Advantages
- Allows early harvesting
- Reduces shattering and weathering in the field
- More rapid drying in terms of capacity
- Accomplishes drying regardless of weather

Disadvantages
- Heavy initial costs
- High drying cost
- Risk of high temperature seed damage
- Requires skilled personnel and regular monitoring
- Risks of breakdown or fuel shortage at critical times

Procedures

Artificially heated air is forced to flow through a mass of seed in bulk or in bags to absorb released moisture from seed.

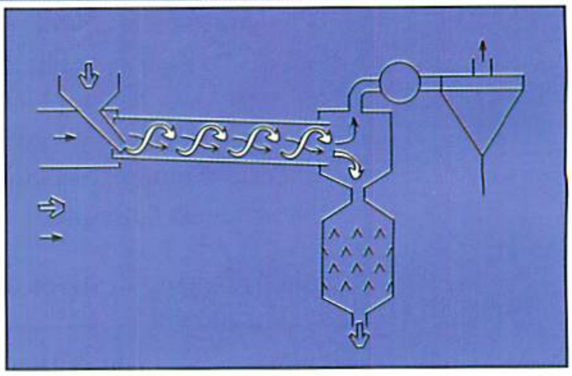
- Blow, using a fan, heated air through a bulk seed mass, so that the moving air carries away the air that has absorbed moisture from seed.
- Choose a fan with adequate static pressure (according to the depth of seed layer, seed characteristics).
- Heat the drying air to increase its moisture-holding capacity.
- Blow air uniformly, so it flows through all parts of the seed mass. No area, however small, should be a dead spot through which air does not flow properly.
- Set the drying temperature to below the maximum safe temperature for each kind of seed. Seed temperature rises as seed are dried with heat air. Don't let the seed get too hot; temperatures higher than 43°C kill the embryo (depends on seed type).
- Drying time; the higher the initial moisture content, the longer the time needed to reach the desired moisture level.
- Avoid fast drying; dry seed gradually in different stages.
- Air flow or air velocity: select the right airflow to dry the seed fast enough to prevent the development of moulds.
- Seed depth depends on seed resistance to airflow and kind of seed. For fast drying, the layer depth should be much thinner than for slow drying seeds.
- Control and strictly monitor the drying temperature. Periodically check and determine seed moisture content. Take random samples and determine the moisture content to ensure that no wet spots remain in the seed mass. Wet spots cause heating.

- Prevent the RH of drying air from rising after it absorbs moisture from seed. To do this, keep the air flowing through the seed so moist air is carried away and replaced with dry air.
- Test for germination and viability. Decline in germination indicates excess of either temperature, relative humidity, drying time, or uneven air flow due to larger seed depth, or malfunctioning of fans.

Table 3. Drying systems and types of driers

Drying system	**Type of driers**	**Observations**
Continuous drying	Rotary driers	Suitable for quick and normal drying seeds, raw seeds or chaffy seeds with moderate moisture. Small to big lots. Not suitable for seeds with high moisture.
	Continuously flowing vertical drier	Suitable for quick and normal drying seeds and free flowing seeds. Not suitable for small seed lots of different varieties. Suited for large volume of single variety.
	Continuously flowing Belt drier	Suitable for quick and normal drying seeds. Small to very small lots, chaffy seeds.
Batch drying	Floor driers	All types of seeds, all sizes, seeds in bags.
	Bag driers	Suitable for small seed lots or where many varieties are handled (breeder and basic seed). All types of seeds in sacks.
	Box driers	Suitable for larger seed lot and slow drying seeds. All types of seeds.

Fig. 29. Rotary drier
O = air heater
D = rotating drum
Cy= cyclone
Co= separate cooler
S = supply seeds
A = dried and cooled seed
E = exhaust drying air
F = fan
(Kreyger, J. 1973)



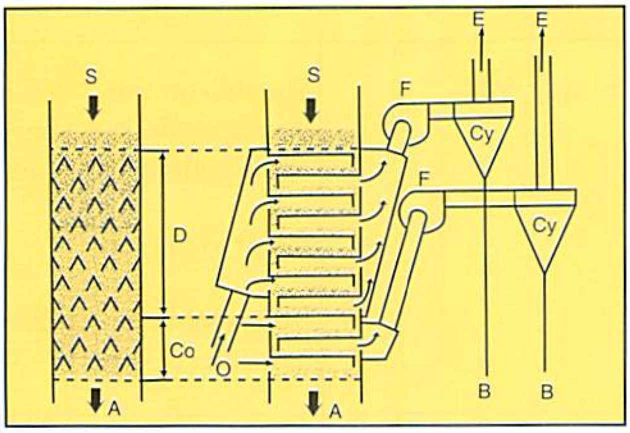
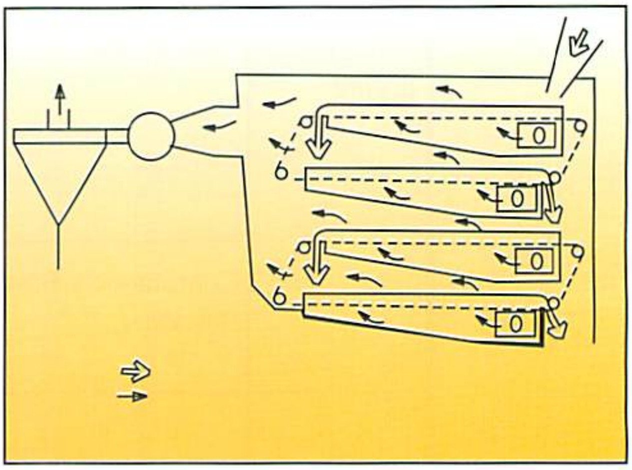


Fig. 30. Vertical flow through drier
D = drying zone
Co= cooling zone
S = supply seed
Cy= cyclone
O = heated air
A = dried and cooled seed
F = fan
(Kreyger, J. 1973)

Fig. 31. Belt drier
D1, D2, D3 = drying zones
Co= cooling zone
A = dried and cooled seed
Cy= cyclone
S = supply seed
F = fan
(Kreyger, J. 1973)



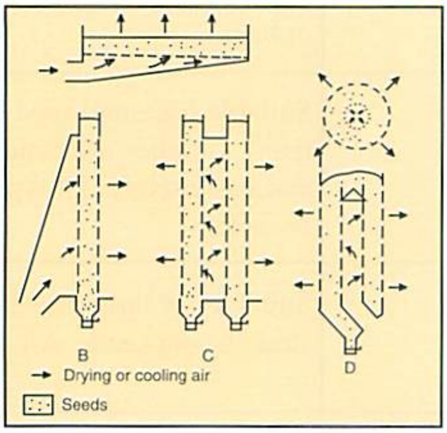


Fig. 32. Simple batch drier
A = horizontal tray drier
B = vertical single layer batch drier
C = vertical double layer batch drier
D = cylindrical drying bin with central duct

(Kreyger, J. 1973)

Selection of a suitable drying system

The selection of a suitable drying system is based on the following factors:

- ***Drying capacity:*** Sufficient capacity to match the volume of seed to be dried.
- ***Initial investment:*** Initial cost and maintenance cost.
- ***Fuel or power*** availability and cost.
- ***Kind and chemical composition of the seed:*** Seeds may be distinguished according to their tendency to release excess moisture. There are three main categories: *fast drying* (sugar beet, grass seeds), *normal drying* (cereals), or *slow drying* (maize, rice, beans, lupin) seeds.
- ***Size of the seed lot*** and how the seed is delivered (bulk, sacks, boxes).
- ***Initial moisture content*** and the desired moisture content after drying.
- ***Flowing properties of the seed:*** Two main categories can be distinguished: free flowing seeds and seeds with bad flowing characteristics known as chaffy seeds.
- ***Temperature and relative humidity of the surrounding air:*** Cool and damp weather will increase the drying cost, whereas the supplemental heat needed is much less in hot and dry weather.

Why multiple-stage drying

Rapid drying means rapid evaporation of moisture from the seed surface. This will create a high moisture gradient between the seed surface and its internal tissues, thereby resulting in an extreme moisture stress and damage to the embryo. To overcome this, seed should be gradually dried, removing small amounts of moisture at a time.

Multiple-stage drying involves drying seed in several steps as described below:

- Dry just enough to remove moisture from the seed surface.
- Then stop drying until the seed moisture inside moves again to the surface.
- Dry the seed again to remove surface moisture.
- Repeat the above procedure until you reach the desired seed moisture content.

Another reason behind this is that drying seed at once, or drying it faster increases the chances of mechanical damage. Cell membranes tend to stretch excessively and break during rapid drying. When the seed surface is drier than the inside tissue, the stress due to the shrinking dry layer causes the seed to crack. The higher the seed moisture content, the more sensitive the seed is to high temperatures.

Example: Maize drying

- Dry ears to 14-16% moisture.
- Shell the seed.
- Dry shelled seed to 12-13%.
- Dry to 9-11%.
- Process and treat.
- Dry to 8-9% (in case you use sealed vapor-proof bags).

Questions

1. What is seed physiological maturity?

2. Define seed drying.

3. Why is drying necessary? Under what conditions?

4. Define atmospheric relative humidity and describe its interaction with temperature.

5. What are the two types of water that constitutes seed moisture content?

6. What are the effects of high moisture content on seed quality?

7. What are the three different ways of drying seed? Give their advantages and disadvantages.

8. What is rate of drying? How is it determined?

9. Does a dehumidified air system use hot air? Explain.

10. List at least four steps of drying management to prevent loss of seed quality and lower the cost.

11. What is the safe temperature range for drying most seed?

INTERNAL QUALITY CONTROL

Internal versus external seed quality control

In a seed production system, seed must be subjected to both internal and external quality control measures. External quality control is the official control conducted by the seed certification agency, while internal quality control (IQC) is a series of measures carried out by the producer/processor himself to ensure that good quality seed is obtained during the whole process of its production, cleaning, storage and marketing.

The main idea is to control the processes of producing/processing seed rather than relying on the official tests to control the end product at the end of the process. IQC is, therefore, a management tool that helps the producer/processor/store manager to discard low quality seed at early stages and ensures that the quality of the end product meets the required standards.

Why IQC in processing

An IQC system is required in the processing plant to regularly monitor and test the:

- Incoming seed, to assess and determine its quality and identify processing requirements.
- Seed after each processing step, to be sure the equipment is working properly, the seed is adequately cleaned and graded, and damage and waste of good seed is minimized.
- Final cleaned seed prior to official testing, to be sure it meets the required standards.
- Seed held in storage, to be sure it has not deteriorated and lost its quality.

Benefits from an IQC system

IQC is an internal management tool, which helps ensure that:

- Low-quality lots are discarded before expenses are wasted on them
- Seed quality meets standards and is not lost at any point
- Seed are not lost in separating, handling or other operations
- All operations are conducted as cost-/time-efficiently as possible.

A close and systematic examination of the seed, combined with the operator's experience, will:

- Help to set the premium price to be paid to seed growers
- Indicate machines and adjustments required for an effective separation
- Save time and allow effective and efficient cleaning
- Reduce the cost of cleaning
- Improve seed quality.

Organization of an IQC system

An IQC system:

- Is set up as a special section or department with highly trained staff and necessary equipment. It reports directly to the Manager.

- Cooperates with, guides, and assists all other departments including production, processing, and marketing to ensure that quality meets standards and operations are cost-effective.

The IQC system must be empowered to stop/change/adjust/alter any operation in order to ensure required seed quality through:

- Improving operating efficiency and economy
- Eliminating any problem and preventing its recurrence
- Preventing excessive loss of seed or seed quality.

Facilities and means

Seed processing plants must have necessary equipment and well-trained personnel for accurate and effective IQC.

- A small laboratory equipped to conduct sampling, purity analysis, moisture determination, germination testing, and processing requirements. Basic quality control facilities require small investment but pay higher returns.
- Qualified personnel to supervise operations and exercise quality control during all stages of seed processing.

List of laboratory equipment:

- Pre-cleaning test: Hand screens, small-scale cleaning machines.
- Sampling: Sampling devices, dividers, bags, labels, markers.
- Moisture content: Moisture meters, oven, adjustable grinding mill, aluminum containers with lids, set of wire sieves, desiccator, analytical balance.
- Purity: Seed blower, set of graduated sieves, purity working table, binocular, microscope, hand lenses, tweezers, scalpels, needle, dishes, quick reference collection of other crop and weed seeds.
- Germination cabinet, counting devices, substrata, germination boxes, watering bottles, measuring cylinders, tweezers, needles, spatulas, labels.

What are the characteristics of high-quality seed?

The quality parameters that affect the planting performance of seed are purity, germination, and vigor. For marketing purposes, appearance is also a critical factor.

High-quality seed can be defined as seed of improved variety which:

- Is high in species, varietal, and physical purity
- Has high germination and vigor
- Is free from weeds and seed-borne pests
- Has low moisture content
- Is properly treated and packed for distribution to farmers.

Cleaning test results as a basis for seed grower payment

Seed growers may be paid according to cleaning test results or according to amount of finally cleaned seed.

- ***Payment according to amount of finally cleaned seed:*** this is done when the processing plant is not equipped to perform internal quality control. The seed grower must wait until his seed lot is cleaned to be paid.
- ***Payment according to cleaning test results:*** this is done mainly in three steps:
  - Seed moisture content: if moisture content is above the contract moisture content, the difference of percent moisture content equivalent in seed weight is reduced from the initial weight.
    Example: the moisture content of delivered seed (5000 kg) was 15% which is above the contract moisture content of 14%. The actual weight to be paid is: $5000 - (0.15 - 0.14) \times 5000 = 4950$ kg.
  - Theoretical waste percent: the cleaning test (purity by hand sieving) gives, for example, 25% waste. The theoretical amount of cleaned seed will then be: $(1 - 0.25) \times 4550 = 3712.5$ kg.
  - Pure live seeds (PLS): the percent of pure live seed should be calculated according to the following formula:

This result may be used for payment of bonus or deduction of the price from the second step.

$$PLS = (\%\ pure\ seed \times \%\ normal\ seedlings)/100$$

Note: Paying according to cleaning test results assume that you are convinced that the analysis performed predicts the real quality of the received and cleaned seed lot, and the final amount of cleaned seed.

What are the tests to be performed by IQC?

The tests to be conducted by IQC laboratory include:

- Sampling
- Purity test
- Moisture content determination
- Germination test
- Mechanical damage tests
- Contamination tests
- Seed lot uniformity tests.

Why seed sampling?

Sampling is carried out at all steps of seed processing (Fig. 33). Seeds are sampled upon reception to:

- Test for purity, moisture, and seed health
- Accept, reject, or subject the seed lot to a special treatment

- Offer a price according to seed quality
- Mix similar small seed lots into a large working seed lot
- Check if machines are doing a good job of processing
- Make necessary adjustment
- Confirm that purity, germination, and health are up to specified standards, or the seed lot needs further cleaning
- Blend seed lots to reach acceptable quality
- Submit a sample for an official seed analysis before marketing to farmers.

Terms related to sampling

- ***Seed lot:***
  - Before processing: seed lot is defined as a given quantity of seed of one cultivar of a known origin and year of production delivered by one seed producer.
  - After processing: seed lot is that quantity of seed which is uniform within permitted tolerances as to percentage of pure seed, germination, inert matter, other crops, weed seed, and rate of occurrence of noxious weed seeds. Any variation must be reduced by further processing, mixing or blending, or separating the lot into two or more uniform lots.
- ***Primary sample:*** a small quantity of seed taken from a single position in the lot.
- ***Composite sample:*** a series of primary samples taken from different parts of the lot and combined into a single large sample.
- ***Submitted sample:*** sample sent to the official laboratory for testing.
- ***Working sample:*** sample on which the laboratory tests are performed.

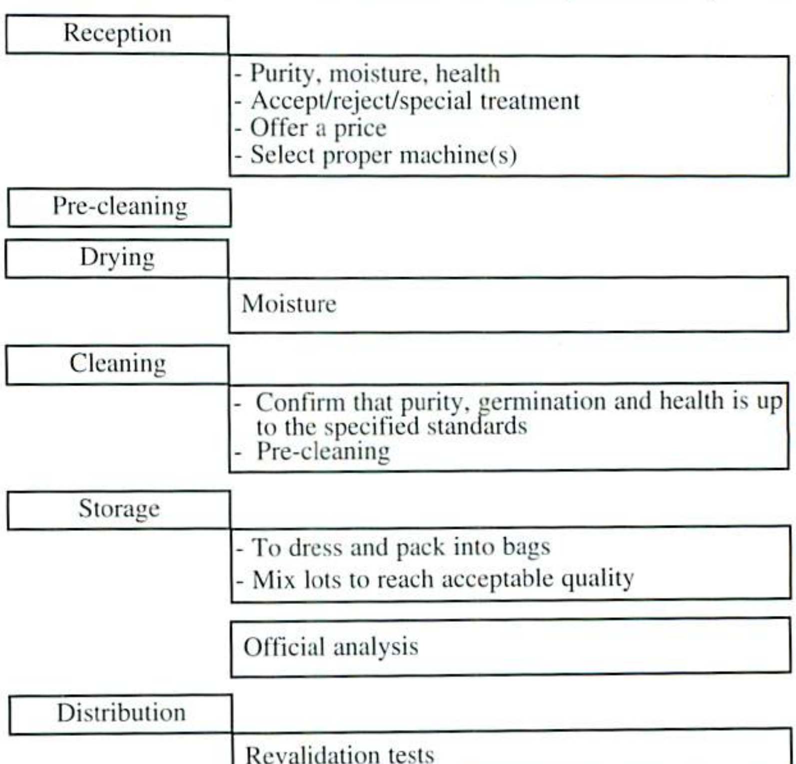


Fig. 33. Sampling stages

How to sample?

Sampling can be done manually or automatically before unloading. Different techniques are available, depending on the conditions under which the seed is delivered.

- ***Seeds delivered in bags and small containers*** should be sampled with a seed trier or bag sampler.
- ***Seeds delivered in bulk in large containers*** greater than 2 meters deep should have individual samples drawn using the cargo sampler from different horizontal and vertical positions chosen at random. Insert sampler tool into the bulk in at least seven uniformly-distributed parts of the container.
- ***Seeds with poor flowability and delivered in bags or containers*** should be sampled by hand, taking approximately equal amounts of seeds from bottom, top, and middle of bags or containers.
- ***Sampling seed during processing:*** sample at regular intervals from the seed stream, making sure that the entire cross sectional area of the seed stream is uniformly sampled and seed entering the sampler cannot bounce out again. This can be done by hand or by using an automatic sampler.

Note: A raw seed lot is often more varied (heterogeneous) than processed seed. In drawing a sample, approximately equal amounts of seed should be taken from each container, bag, or from each place in a container. These portions should be thoroughly mixed and a representative sample taken from this mixture. Sampling by hand is the best method in some cases.

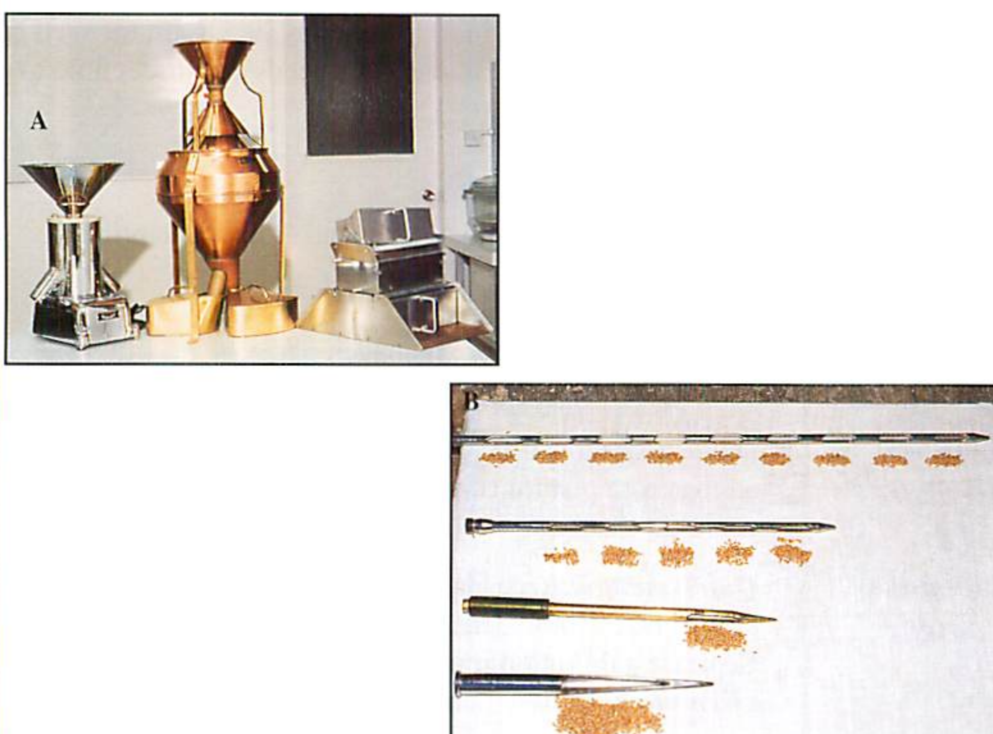


Fig. 34. Seed sampling equipment: (A) dividers and (B) sampling triers

A B C

Fig. 35. Sampling of raw seed using an automatic sampler (A), a sample trier for bulk seed (B), or seed bags (C)

Why testing for moisture content

Seed moisture content is the amount of water in the seed expressed as percentage by weight. It is one of the most important factors influencing their viability and appearance.

As raw seed is received, but prior to storage, a seed sample should be taken and tested immediately to determine seed moisture because:

- Seed that is high in moisture will often contain considerable high moisture trash and green material. If this is removed during pre-cleaning, it may lower seed moisture enough to allow storage without additional drying.
- High moisture content of the seed may lead to heating, increased respiration, and spoiling of the seed.
- Seed that is too low in moisture may be unsafe for seed processing and could be rejected. Extremely dry seeds are susceptible to mechanical damage.

Seed moisture is often used :

- In weight determination and calculation of the price
- As a mean of quality assessment
- As a guide for seed drying
- As a guide for the store manager.

How to measure seed moisture content

Moisture content can be calculated from loss in weight if a sample is fully dried to zero moisture content; or it can be measured with instruments which measure the conductivity or dielectric properties of seed.

- ***Quick method:*** measurement by moisture meters. Electric instruments should be calibrated against an accepted basic moisture-testing method. Separate calibration must be made for each kind of seed.
- ***Oven method:*** based on determining the percentage of weight loss from a known seed weight by drying. Depending on the kind of seed to be tested, the method may be:

- Low constant temperature oven method: 103°C for 17 hours mainly used for oily seeds.
- High temperature constant oven method: 2 hours at 130°C for cereals (4 hours for maize and 1 hour for other crops).

Oven method procedures

Follow steps below:

- Set the oven at 103°C or 130°C, depending on the type of seed.
- Weigh and number empty containers including the lids (M_1).
- Mix the sample thoroughly, and draw two replications from two independent working samples.
- Grind if necessary: usually small seeds are dried whole, while larger ones must be ground before drying.
- Place each sample in a container and weigh the containers with their content (M_2).
- Put the containers on their lids and quickly transfer to oven at required temperature.
- Start timing when oven reaches the required temperature.
- After the required drying time, open the oven, put the lids on their respective containers and transfer them to a desiccator for 30 to 45 minutes to cool down.
- Weigh the containers with their contents to an accuracy of three decimal places (M_3).

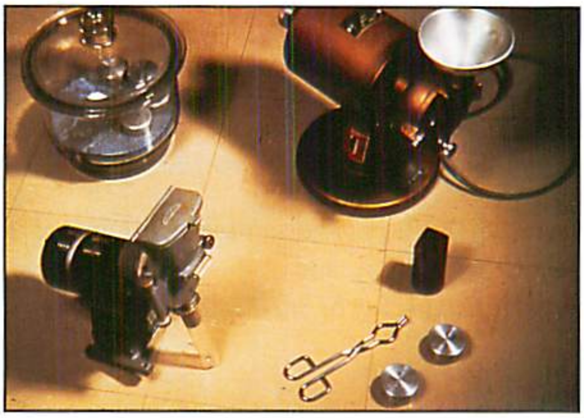


Fig. 36. Moisture testing equipment

Fig. 37. Moisture testing using oven method

Calculation and expression of results

- Seed moisture % calculation

$$\textit{Percent moisture content} = (M_2 - M_3) \times \{100/(M_2 - M_1)\}$$

Where:

M_1= weight of empty container

M_2= weight of sample plus container before drying

M_3= weight of sample plus container after drying

- Expression of the results

Seed moisture content may be expressed on wet weight or dry weight basis. It is important to specify the procedure used. The two methods for calculation are:

Wet weight basis: amount of water lost is divided by the initial weight of the sample and multiplied by 100:

$$\frac{(\text{weight before drying} - \text{weight after drying})}{\text{weight before drying}} \times 100$$

Dry weight basis: amount of water lost is divided by the weight of the sample after drying and multiplied by 100:

$$\frac{(\text{weight before drying} - \text{weight after drying}}{\text{weight after drying}} \times 100$$

Since the weight after drying is less than the weight before drying, dry weight percentages will be slightly greater than wet percentages, assuming other conditions are the same.

Why purity analysis

The object of the purity analysis is to determine:

- ***The composition***, by weight, of the sample being tested and by inference the composition of the seed lot, and
- ***The identity of various species of seed and inert matter*** constituting the sample.

Samples are examined for purity by visual examination or a complete purity test. This examination is conducted to:

- Evaluate the quality of received raw seed and determine the kinds and quantities of contaminants that must be removed to achieve the desired purity
- Decide whether to accept or discard a seed lot or subject it to special treatments
- Assist the processing operator in planning for processing (machines and sequence of machines to use), selecting screens for basic cleaning, and making necessary adjustments

- Confirm that purity is up to specified standards, or you must re-clean the seed lot.

Failure to conduct a pre-cleaning examination of raw seed is often a primary reason for sub-standard seed quality and costly re-cleaning.

After processing, pure seed should be free from admixtures such as inert matter (dust, small earth particles, plant debris, etc), weed seeds, shriveled seed, broken seed, diseased seed, and seeds of other crops. Varietal purity must be taken care of in the field, during seed production, not during processing.

What are the terms related to purity?

- ***Pure seed:*** includes intact seed and pieces of seed units larger than one half their original size of all varieties of each kind of seed under consideration or as claimed by the seed producer. Also, includes diseased seeds except those changed by infection by smut balls, sclerotia, and nematode galls that are classed as inert matter.
- ***Other crop seeds:*** include all intact or pieces of seed classed as a crop other than the kind being tested.
- ***Weed seeds:*** include all seeds of plant species that are not planted or used as crops.
- ***Inert matter:*** includes seed-like structures from both crop and weed plants and other matter: broken or damaged seeds one half or less than the original size, seeds of legumes with removed seed coat, other matters, etc.
- ***Noxious weeds:*** some weeds are such serious pests that they substantially reduce yields and, once introduced into a field are extremely aggressive and difficult to eradicate. Also, weed seeds that are difficult to separate during processing.

How to test for purity

The following procedures are suggested when conducting a purity test:

- Weigh and record the weight of the working samples.
- Divide the working sample into two sub-samples.
- Place the working sample on the clean surface of a purity board and examine it. Judge each particle individually.
- Separate into three fractions: pure seeds, inert matter, and other crops.
- Identify the type of inert matter and write down the scientific names and numbers of other seeds found.
- Weigh the three fractions separately.
- Add up the three fractions and calculate the percentage of each component.
- Retain the pure seed fraction for germination test.

Fig. 38. Checking the quality of received raw seed

Fig. 39. Purity test

Fig. 40. Necessary equipment for purity test

Fig. 41. Fractions issued from purity test: pure seed, inert matter, and seeds of other crops and weeds

Why test seed for germination

Seed germination is probably the most widely used, convincing, and accepted index of seed quality throughout the world.

- It is an analytical procedure to evaluate seed viability and germination under standardized conditions, and to determine the planting value of a seed lot and its storage potential.
- It enables the seedsmen to determine and compare the quality of seed lot before it is marketed.
- It is used to satisfy labeling laws, and to provide standardized marketing of seed lots.

Seed germination is defined as "the emergence and development from the seed embryo of those essential structures, which, are indicative of the ability to produce normal plants under favorable conditions."

Germination test procedures

Follow the steps below:

- Set the germinator at the required temperature and humidity.
- Prepare the substratum.
- Count four replicates of 100 seeds each from the pure seed fraction.
- Plant seeds in the germination substrate, properly label, place on trays, and transfer to germinator.
- Allow appropriate time for all seedlings to develop to a stage at which it can be determined whether all essential parts are present.

Evaluation of the seedlings

Seedlings and non-germinated seeds must be carefully removed from the substrate at the end of the testing period. Each seedling/seed is carefully examined and classified into normal or abnormal seedling and fresh ungerminated, hard, or dead seed.

- ***Normal seedlings:*** seedlings possessing essential structures that are indicative of their ability to produce plants under favorable conditions. Only normal seedlings are considered germinable and reported in the percent germination.
- ***Abnormal seedlings:*** all seedlings that cannot be classified as normal seedlings.
- ***Fresh ungerminated seed:*** intact seeds, which absorbed water but did not germinate by the end of the prescribed period of germination test.
- ***Hard seed:*** seed of legumes that are not imbibing water by the end of the prescribed germination period.
- ***Dead seed:*** seeds other than hard, fresh ungerminated, decayed, or soft seeds.

Note: The procedures and definitions related to the above tests are well described by ISTA (Seed Testing Rules 1996).

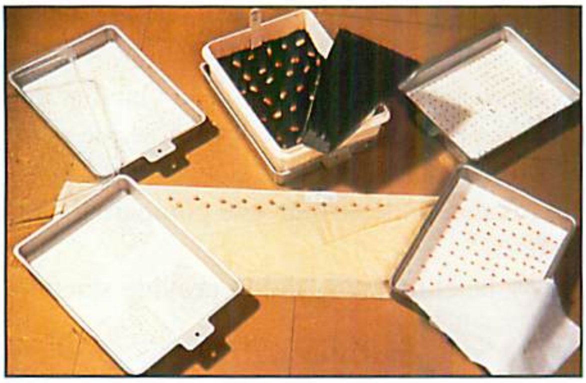


Fig. 42. Equipment for germination test

Fig. 43. Germination cabinet

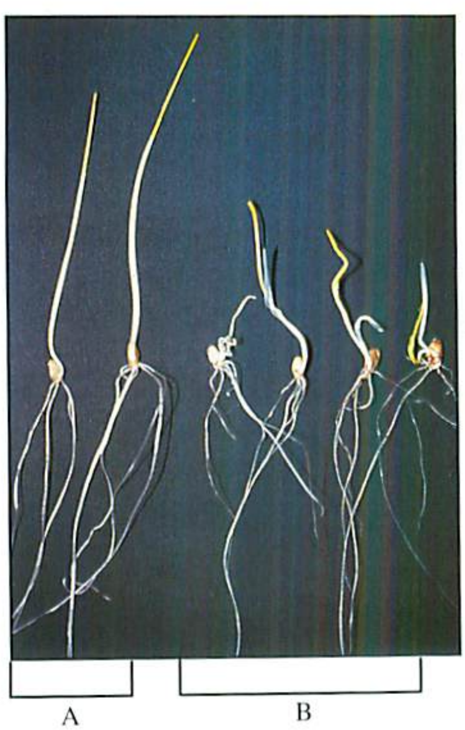


Fig. 44. Seedling evaluation: normal (A) and abnormal (B) seedlings

Questions

1. Define the internal seed quality control system.
2. What are the most important components of seed quality?
3. What are the benefits of an intensive internal quality control system?
4. List some equipment needed to operate an IQC laboratory.
5. Define sampling.
6. How would you define a seed lot?
7. Why do we sample the seed lot?
8. What is the difference between primary, composite, submitted, and working samples?
9. How do you sample bulk vs bagged seed?
10. Why do we test seed for moisture content?
11. List three methods which can be used for moisture content determination.
12. Why do we have to perform a moisture test as quickly as possible upon reception of the seed lot or sample?
13. Describe the procedure used to determine moisture content by the oven method.
14. Why is there a difference between the expression of moisture content by dry and wet weight basis?
15. What is the purpose of purity testing?
16. Define pure seed.
17. What is the difference between physical and varietal purity? Is varietal purity taken into consideration during purity analysis?
18. What are the four components considered as part of the purity test?
19. Define a noxious weed. How is its incidence evaluated in the purity test?
20. In the purity test, leguminous seeds without seed coat or testa will be classified as inert matter, Yes or No? Explain.
21. Pure seeds are only those that are complete, healthy, mature, and capable of germinating, Yes or No? Explain.

22. Define seed germination.

23. Explain the normal seedling concept.

24. What is the difference between hard seed and firm ungerminated seed?

25. What are the possible types of substrates used in germination testing?

26. Describe the procedure of a germination test.

SEED MECHANICAL DAMAGE

Mechanical damage

Seeds that are produced in excellent conditions may have their viability and appearance impaired by incorrect handling during harvesting and/or processing. Damage can occur during these stages as a result of impact, abrasion, and compressive pressure/weight produced by contact with the hard surfaces of machinery and storage bins. These forces not only affect the structural integrity of the seed (seed coat) but may cause damage to internal tissues as well (embryo).

Sources of damage

Seed mechanical damage may occur in several operations.

- ***Harvesting/threshing:*** this is often the major source of mechanical damage to seeds if done improperly.

- ***Cleaning:*** seed cleaning is a sequence of operations accomplished by more than one machine. Seed passing through one or several machines increases its chance of being injured.

- ***Chemical treatment:*** many treaters use augers to lift or mix the seed which is often too harsh for some seeds.

- ***Handling:*** processing machines are connected by elevators; seed may pass through several elevators which lift and drop seed into machines and bins. So, seed is exposed many times to hard surfaces, which may cause mechanical injury.

- ***Transport:*** seed may be damaged during handling and transport.

Expression of mechanical damage

Mechanical damage decreases the quality of damaged seed by different ways.

- Increasing the rate of seedling abnormalities detached seed structures, breaks within structures, split or abnormally developed structures, restricted growth, etc. (Fig. 45).
- Decreasing germination rate.
- Shortening the storage life accelerates aging.
- Invasion by fungi injuries allow pathogens to enter.

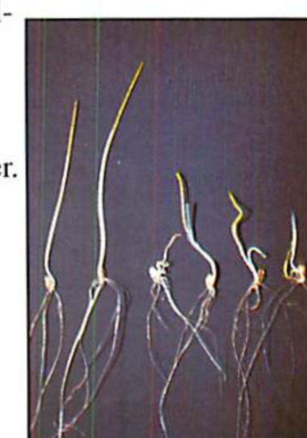


Fig. 45. Seedling abnormalities from mechanical damage. Seedling on the left is normal

Types of mechanical damage

There are several types of mechanical damage:

Impact versus abrasion damage

- ***Impact damage:*** imposed by dropping or by load pressure. Seed may be fractured either by striking or being struck by a hard object or firm surface. Impact damage exerts a shear force to internal tissues (crack propagation) and may rupture the seed coat as well. Severe impacts may kill the embryo. Damage from repeated impact is cumulative.

- ***Abrasion damage:*** imposed by contact between parts of the machine. Abrasion affects primarily the structural integrity of the seed such as seed coat, pericarp, etc.

Seed injury may be visible or invisible

- ***Visible***, affecting mainly the seed coat and external structures. Seed cleaning techniques are sufficiently effective in removing this type of damaged seeds, including broken seeds.

- ***Invisible***, affecting internal parts of the seed and especially the germ. This only becomes visible once the seed has germinated.

- ***Microscopic*** breaks particularly in the seed coat. These make the seed susceptible to attacks by microorganisms (Fig. 46).

According to seed moisture content, seed may be bruised or fractured

- Moist seed tend to ***bruise*** during impact damage. Bruised seed does not have an immediate serious effect upon seed soundness and viability as fractured seed, but hastens the rate of deterioration, especially if seeds are not dried promptly and properly.

- Dry seed tend to ***fracture.***

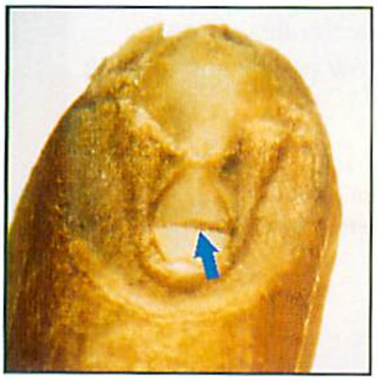
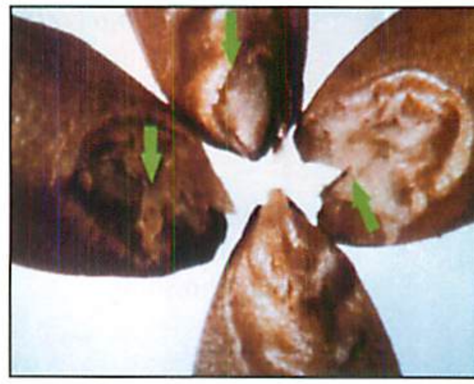


Fig. 46. Type of microscopic seed embryo damage (× 20). The arrow shows a fracture at the central part of the embryo

Fig. 47. Types of damage (× 20) that result from improper processing. Grain without an arrow shows a typical sound seed



Detection of mechanical damage

Mechanical damage can seldom be avoided during seed processing and handling. Therefore tests must be used to assess and evaluate the extent of this damage.

Different methods are used to detect damaged seeds:

- ***Examination and inspection of dry seed:*** involves mainly visual examination by naked eye and/or magnification glass. Sieving is a routine procedure used for determining fine and broken material. Also, some fast chemical tests such as Fast Green test (for seed coat damage of large seeded cereals, maize); Indoxyl acetate test (for seed coat damage of large seeded legumes, soybean); Ferric chloride test (for mechanical damage of seeds, field bean).
- ***X-ray method:*** useful in revealing internal injuries on embryo structures.
- ***Tetrazolium test:*** useful in revealing nature and type of mechanical injuries. Red stained seed are sound, whereas injured tissues are not normally stained.
- ***Growth test:*** examination of seedlings during growth tests provides more realistic evaluation of mechanical injuries.

How to minimize seed damage

Knowledge of seed structures, the nature of injuries to these structures, and locations where damage may occur can be of great help in preventing seed injury.

Mechanical seed injuries cannot be avoided entirely but their extent and seriousness can be greatly reduced.

At harvest

- ***Harvest at full maturity:*** at physiological maturity, no further grain development occurs and seed start drying naturally. However, at this stage seed moisture content is still rather high and if harvested, seed are easily damaged. When weather conditions permit, leave seed on plants until it becomes much drier. The proper time for harvest and handling is at the stage of full ripeness. Seeds do not become fully dry until they are mature. Immature seed may be bruised instead of being broken during harvesting.

- ***During harvest:*** adjust the combine properly to reduce losses and minimize damage to the seed. Keep the cylinder speed as low as possible and carefully adjust cylinder-concave clearance. The effect of this adjustment depends on seed moisture content at harvest.

Hint: It is more profitable to bring viable seed with high trash content from the field than to bring in ready-cleaned seed that is damaged during harvesting/threshing.

During Processing

- ***Drying:*** when dried to low moisture content, seed becomes safe for storage following harvest but becomes more vulnerable to mechanical damage during processing. Damage from impact or abrasion is more severe when seeds are threshed or processed at low moisture content (e.g., below 10% for wheat). Likewise, seeds with high moisture content (e.g., 16% or above for wheat) are more susceptible to damage. Seed should be dry enough for processing purposes, with additional drying later, if needed for storage.

- ***Crop kind:*** some crop seeds are more susceptible to damage. In general, large seed crops, e.g., soybean, beans, peas, and broad bean are more susceptible to injuries and must be handled with care. Seeds of small-seeded crops tend to be less susceptible to mechanical damage.

- ***Elevators:*** augers and screw elevators should be avoided and only slow speed bucket elevators should be used. Plastic buckets are more gentle on the seed than metal ones (metal buckets sharpen over time, allowing more injuries to the seed). Also, the distance that seed travel, in elevators, between machines should be minimized.

- ***Bins:*** in dropping seeds into a bulk bin, bin ladders should be used. Spiral chutes should be used to carry seed from spout to bin at a safe velocity. Long drops from elevator spouts to bins should be avoided. Bins should be lined with rubber to cushion the shock of seed striking the sides of the bin. Deep bins which allow a long drop should also be avoided.

- ***Feeder:*** Elbows and sharp bends (angles) in seed pipes and spouts should be avoided.

The entire seed processing operation should be examined for locations where seed can receive impacts, and all possible points where injury may occur should be eliminated.

Questions

1. List sources of mechanical damage to seed.

2. List some possible ways to identify mechanical damage.

3. Suggest ways to minimize seed damage during seed processing.

MECHANICAL CONTAMINATION

Mechanical contamination

Processing is the principal means of removing contaminants, but it can also be a major source of contamination. Processing should be carried out without contaminating the crop seed with seed of other varieties and crops.

Genetic and physical purity are important aspects of seed quality. Genetic purity allows the transfer of true-to-type variety from the breeder to the farmer. ***Genetic purity is best controlled and taken care of in the field.*** Physical purity indicates the level of contamination by seeds of other crops and weeds. Mechanical/physical contamination can happen during harvesting, threshing, handling, drying, cleaning, bagging, treating, or storage.

Genetic and physical purity of the seed must be protected in all operations of seed production and supply. Management during seed processing must include measures to prevent seed admixtures and ensure seed purity.

How to prevent seed contamination

Complete cleaning of machines between lots, between varieties, and between crops is essential. The following suggestions aid in proper sanitation between lots and help prevent accidental mixtures:

Processing plant

- Only one variety or lot should be in the processing area at a time. Seed awaiting processing should be kept in the storage area.
- Process the early multiplication generations of a variety in the middle of the processing of the same variety in the following sequence: certified seed, basic seed, prebasic seed, and then certified seed again.
- Clean warehouses, floors, corners, ramps, etc. of all trash, dust and seed after each lot is processed. Use a vacuum cleaner and compressed air. Begin at the point where seeds enter the plant; continue cleaning in the sequence of seed flow (ramp, dump pit, elevators, conveyors, bins, then machines and floors).
- Use proper labels at all times.
- Use new bags.

Receiving area

- Keep surrounding area clean.
- Clean after each seed lot.
- Clean intake hopper.

Air-screen cleaner

- Clean elevators and surge bin first.
- Remove all screens and brushes. Open the feed hopper gate. Turn on power. Open upper and lower air and run machine empty for a few minutes.
- Clean exterior parts of machine with brush and compressed air.
- Inspect inside and outside of machine and all supports; remove any seed or loose debris that are lodged in any opening.
- Vacuum air chambers.
- Clean screens by rubbing the bottom of the screen with a stiff brush to remove seed lodged in screen openings.

- Clean brushes with compressed air and sharp-pointed probe. Balls are preferred over brushes because seed lodges in the brushes and leads to mixing.
- Vacuum all debris from floor under and around machine.
- Vacuum all discharge spouts.
- Wipe off excess grease from pulleys, shaft, bearings, and grease fittings.

Cylinders

- Clean the elevator and the surge bin first.
- Open feed control to the maximum. Invert the lifting trough inside the cylinder; increase speed to its maximum and run machine for a few minutes.
- Clean exterior surfaces of the machine with a brush and compressed air.
- Clean hopper, lifting, auger, and shaft with compressed air. Remove lodged seed and debris particles.
- Clean all discharge spouts.

Gravity table

- Clean the elevator and the surge bin first.
- Clean the feed hopper, the deck, and exterior ledges with compressed air.
- Run the machine for a few minutes with the feeding gate open, maximum air, and high speed.
- Remove any remaining seed from the deck and discharge spouts.
- Clean all discharge spouts.
- Clean motor, exposed pulleys, belts, shields, and grease fittings with brushes and air blast.
- Remove the air filter and vacuum out the inside of the machine. Clear filters with air blast.

Elevators

- Open the elevator boot, vacuum loose seed, and debris from the elevator boot and surrounding floor.
- Run the elevator to dislodge loose seed.
- Inspect belt and buckets. Turn the belt by hand and remove lodged seed from behind each bucket by air blast and sharp-pointed tool. Place spacers between buckets and the belt; this holds buckets out from the belt and prevents seed from hanging behind the buckets.
- Vacuum the feed hopper.
- Where possible, use self-cleaning elevators.
- Elevators should not be mounted in pits too small for clean out access. Pits should be large enough to allow a worker to get in and clean out the elevator boot.

Surge bins

- Clean the inside of the bin.
- Clean seed ladders.
- Open the discharge gate and blow compressed air through the bin.

Questions

1. What are the sources of seed contamination?

2. How can you minimize/prevent contamination?

3. Is it possible to separate seeds of different varieties of the same crop by processing machines?

AIR-SCREEN CLEANER

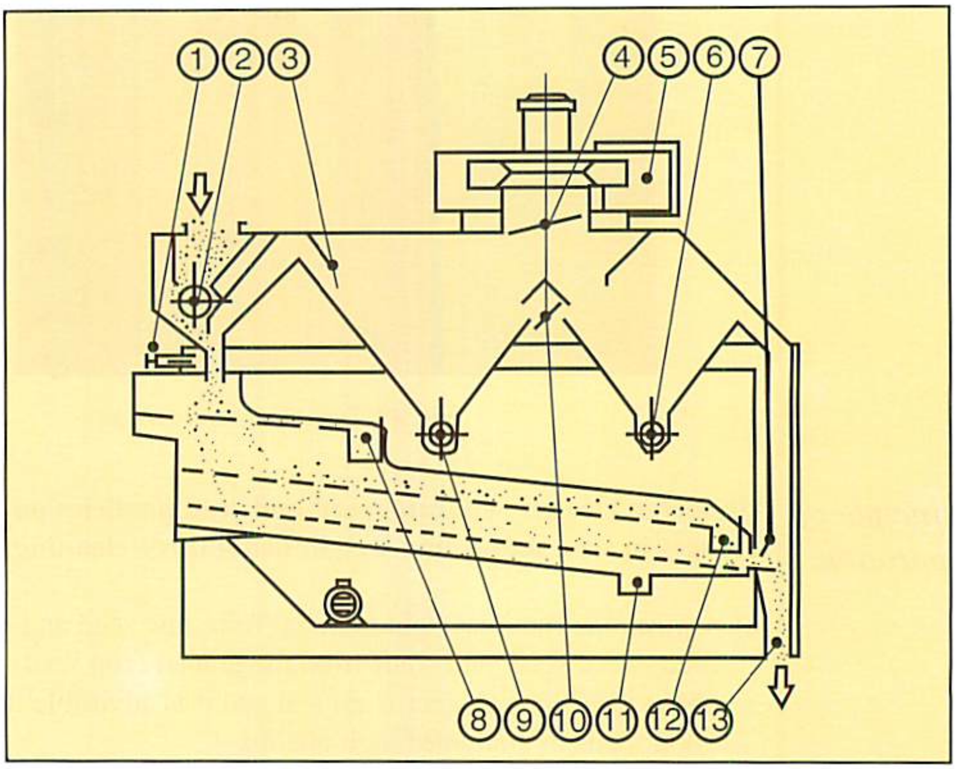
What is basic cleaning?

The purpose of basic cleaning, often known as fine cleaning, is to remove impurities that are larger and/or smaller in width and thickness and lighter than the desirable crop seed. It is similar to pre-cleaning, but more refined and precise with slightly different machines.

Basic cleaning is ***common*** to all kinds of seeds and it is usually performed by a machine called an ***air-screen cleaner*** which operates by air suction and the oscillation of two or more screens. A simple combination of air and screens permits the elimination of most impurities.

Description of an air-screen cleaner

The air-screen cleaner is the basic machine in all the processing plants. Seeds should pass through an air-screen cleaner before any further separation is attempted by other machines. It removes the oversized, undersized, and light-weight contaminants from the seed. The seed of many crops may be completely cleaned using only an air-screen cleaner.



(Westrup Manual 1985)

Fig. 48. Air-screen cleaner

1. Distributor regulator
2. Feed roller
3. Pre-aspiration adjustment
4. Main air control
5. Aspiration fan
6. Heavy-air separated waste
7. Air gat
8. Overflow from scalper screen
9. Light air separated waste
10. False air intake control
11. Throughs from bottom screen
12. Overs from top screen
13. Tail aspiration leg

Fig. 49. Typical air-screen cleaner

Principle of separation

Air-screen cleaner separates seed and seed particles on the basis of differences in size, shape, and weight using three cleaning principles:

(a) ***Aspiration:*** removes light material from raw seed and light weight crop seed, weed seed, and chaff from the graded crop seed. The air-separation of the air-screen cleaner is critical and it is advisable to sacrifice a few good seeds to guarantee high quality.

(b) ***Scalping:*** removes larger material than the crop seed (good seeds drop through screen openings, while larger foreign material rides over the screen into a separate spout).

(c) ***Grading:*** removes smaller particles from the crop seed (good seed ride over the screen, while small particles drop through.

The ***capacity*** and ***efficiency*** of an air-screen cleaner is determined by the dimensions of the screens to use. The screens have two dimensions:

- ***Width of the screen***, used to determine the cleaning capacity of the machine.
- ***Length of the screen***, determines the separation efficiency (how long the seed has to travel on the screen to make a good separation).

There are many makes, sizes, and models of air-screen cleaners, ranging from small one-fan, single-screen machines to large eight-screen cleaners with three air suction stages. A typical air-screen cleaner uses two aspiration and four screens.

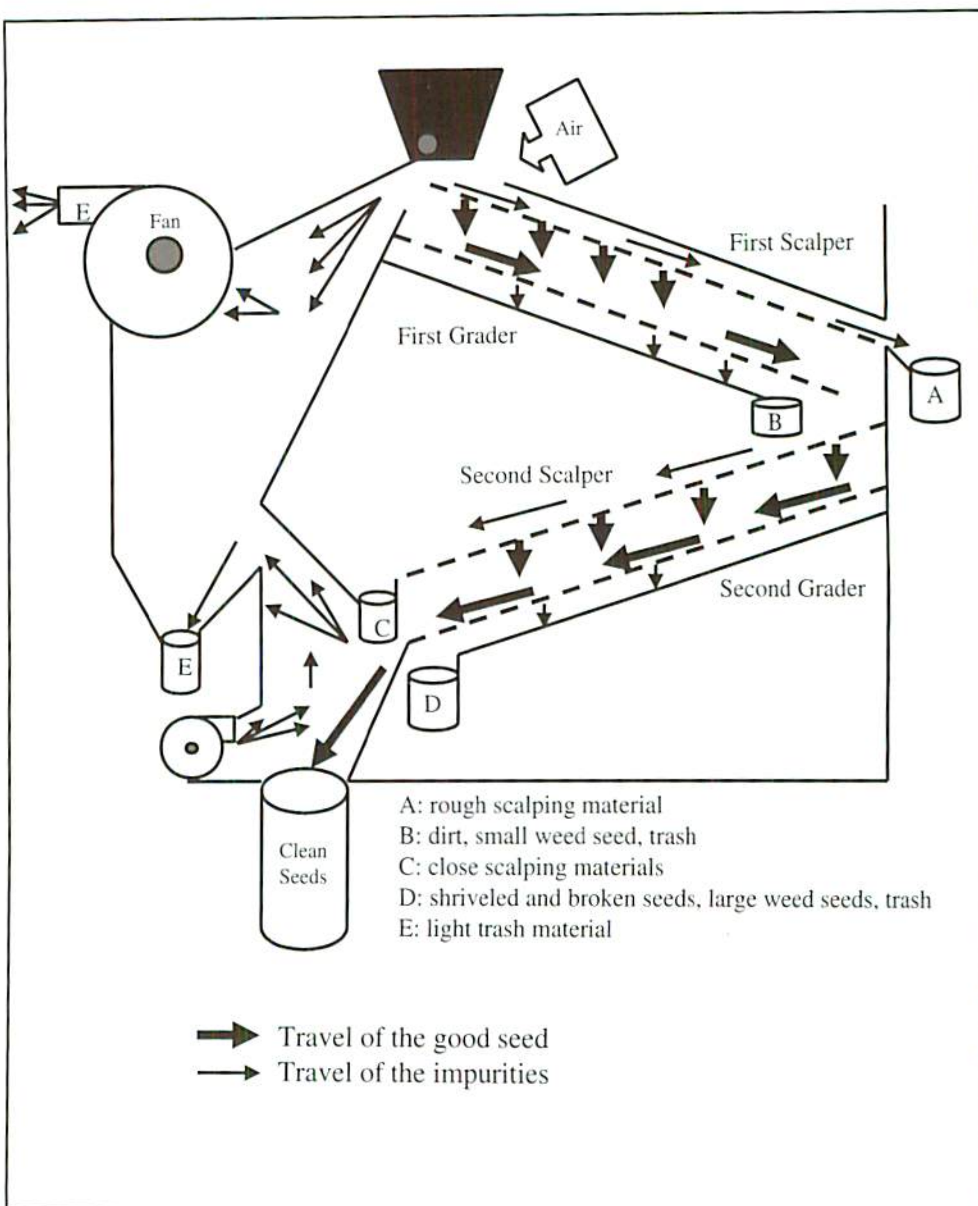


Fig. 50. Working principles of a typical air-screen cleaner

Table 4. Functions of a typical air-screen cleaner

Air/Screen	Parts	Function
Head-end aspiration	Aspirator (suction)	Removes dust and light material before it reaches the first screen, so that the remain-
ing		material can be distributed uniformly on the top screen.
First top screen	Scalper	Discards large material: good seed drop through and large material stays on top of screen.
First bottom screen	Grader	Removes small particles: good seed rides over the screen and small trash, weed seed and dirt drop through.
Second top screen	Close scalper	Acts as close scalper (same action as first top screen).
Second bottom screen	Fine grader	Acts as close grader scalper (same action as first bottom screen).
Second or tail-end aspiration	Aspirator (suction)	Takes out the rest of light crop seed and trash. The graded crop seed pass through an air stream which sucks away light weight crop seed, weed seed, and chaff.

Types of screens

The size and type of screens and the shape of their perforations are responsible for the performance of an air-screen cleaner.

More than 100 different screen perforation sizes and shapes are available. The two basic types used in processing are ***round*** hole and ***slotted*** screen openings (Table 5). Screens with square or triangular openings have limited application, mostly for cereal crops.

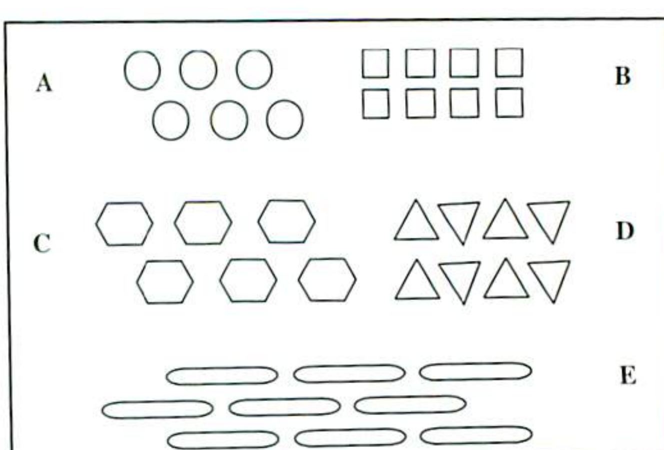


Fig. 51. Different shapes of screen perforation: circle (A), square (B), hexagonal (C), triangular (D), and oblong or slotted (E)

Table 5. Types of screens and perforations measurement

Type	Openings	Basis of separation	Measurement
Sheet metal	Round Oblong Triangular	Width Thickness Shape	Diameter of the opening (metric system in mm, and in USA diameter in fraction of an inch) width and length of the slot; length of each side of the equilateral triangle; or diameter of the largest circle inscribed in the triangle
Wire mesh	Square Triangular	Shape	Number of openings per inch/cm in each direction and width of opening

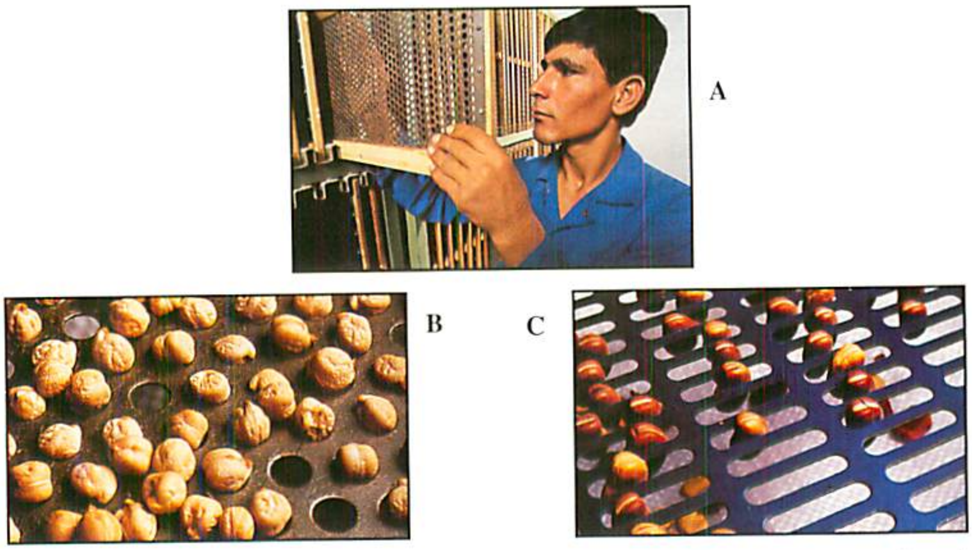


Fig. 52. A large selection of sieves with different sized perforations is essential (A). Round perforation screens separate on width (B) and oblong or slotted perforation screens separate on thickness (C)

How to select screens (Table 6)

Selection of appropriate screen type:

- ***Sheet metal screens:***
  - The round perforation screens are more efficient in separating the large elongated dirt components from the raw seed. Therefore, the scalping screen of an air-screen cleaner should have round perforations under normal circumstances.
  - The function of the top screen with different sections is complementary to that of the scalping deck. It gives a wide range of opportunities and choices for adjusting the screen perforations according to need.
  - The contaminant separation at bottom screen level is based mainly on thickness. Thus, slotted holes should be used in most cases for bottom screens.
- ***Mesh screens:*** not widely used for agricultural crops.

Table 6. Screen selection

Seed to be cleaned	Top screen	Bottom screen
Round-shaped seed Soybean, wheat, chickpea Broad bean	Round-hole	Oblong or slotted hole

Round top screen will drop round seed and prevent large material from dropping through. Oblong or slotted bottom screen holds up round good seed, but drops broken, split seeds, and weed seeds and particles smaller than the round crop seeds. Use the smallest possible perforation on top screen to allow just good seed to drop and the largest possible perforation on bottom screen to keep the good seed.

Elongated seed Oat, ryegrass	Slotted	Slotted

Slotted top separates weed seeds or large material rounder or thicker than the crop seed. Bottom oblong screen drops weed seed, broken crop seed or hulled crop seed and other material thinner than the crop seed. Be certain that slots in the top screen are long enough to allow the good seed to drop and the slots in the bottom screens are long enough to keep the good seed and drop weed seed.

Triangular screens are sometimes very effective as bottom screens for cleaning elongated seed. Used to drop round seed from elongated seed. The point of the triangle perforation should always point uphill; otherwise too many good seeds will be lost, and long seeds will clog the openings.

Lens-shaped seed Lentils	Slotted	Round-hole

Slotted top screen permits the lens-shaped seed to turn on edge and drop through, while rounder or plumper seed and foreign material passes over the screen. Round bottom screen holds up lens-shaped seed as they lie flat and ride over, while round weed seeds are small enough to pass through the top screen drop.

Note: How to decide on the ***shape*** and ***size*** of the screen perforations:

(a) ***Shape*** of the perforation depends on whether the differences between the seeds and the impurities are in length, width, or thickness.

(b) ***Size*** of the perforation depends on whether the impurities are bigger than the good seed (scalping or top screen perforation size is selected to let the good seed pass through and the impurities ride over the screen) or smaller than the good seed (bottom screen perforation size is selected to let the impurities pass through and the good seed ride over the screen).

Screen selection test

The selection of appropriate screen should be based on actual tests made on seed sample.

The test is made in the laboratory and involves the following steps:

- ***Sample*** the seed lot.
- ***Separate the seed sample*** into pure seed, other crop seed, weed seed, and inert matter.
- ***Note size, shape, and weight*** of contaminants in relation to those characteristics of the crop seed.

Use hand test screens

- ***Top screen:*** select a range of four to five screens with openings larger or smaller than the seed crop. Stack these screens with large size on the top and the smallest on the bottom. Put a blank on the bottom of the stack. Place two handfuls of seed on the top screen. Shake the screens vigorously until all seeds have found their level. Remove the screens from the stack one at a time, starting at the top. Note the material held by each screen. The screen that just let the crop seed fall through, but holds material larger than the seed, is the right size to use.
- ***Bottom screen:*** a similar procedure is followed for the bottom screen. The screen that holds the crop seed but lets broken seed and smaller weed and crop seeds to fall through, is the correct size to use.

Hints:

- Selection of top screen perforation size: start from the smallest size and keep increasing until the right separation is achieved.
- Selection of bottom screen size: start from the largest size and keep decreasing until the right separation is achieved.
- Because of different conditions caused by the air and vibration of the machine, it is often necessary to use screens, which are slightly different from the ones selected on the basis of hand screening test.
- Having some good seed in the impurity fraction is always an indication of good screen selection. No good seed in the impurity fraction means that impurities are still in the good seed.
- If the seed is very valuable, e.g., pre-basic seed, it is important not to lose any good seed so further separation may be sought on a machine operating on a different principle.

Example: wheat

How to separate long material (stems, seeds with awns) and small impurities (split and broken grains) from good wheat seed?

Top screen: used to discard longer material from the good seed. The separation is then based on length. But why are round perforations used in most cases? The probability of long material passing through an oblong opening is greater than for a round opening. So round openings will retain more (longer) material than oblong openings. The gravity point of the material/seed plays an important role in this concept.

Bottom screen: used to eliminate small impurities from good seed. But why do we use oblong openings in most cases? Broken seed and small weed grains will pass through round openings but split kernels will have difficulty going through. Separation is therefore made according to the thickness of the particles. Oblong perforations are more suitable to separate seed mass according to this characteristic.

At the end, you may still have some broken seeds left with the good seed. These are mainly half-size seeds broken transversally. Since there is no difference in thickness between these and the good seed, they will not go through the oblong opening. A cylinder must be used in this case because of differences in length (see chapter on indent cylinder).

What is the critical difference?

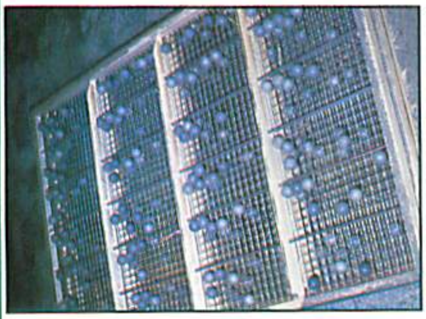
The critical difference is the smallest difference in size, between good seed and impurities, needed for the air-screen cleaner to make a separation.

The bigger the difference, the better the separation. Smaller differences result in poor separation and greater seed loss. If there is an overlap in sizes of seed and contaminant a different type of machine has to be used.

Brushes or balls to keep the screen clean?

The cleaning efficiency of a screen is directly related to the percentage of perforations that remain open during operation.

Three ways to keep the screen clean during operation:
(a) ***Brushes:*** placed underneath the screen. They travel back and forth and sweep the underside of the screen. Used on pre-cleaners with steeper angles up to 15° and on fine cleaners at about 5°.
(b) ***Balls:*** place in a frame of wire mesh under the screen. The rubber balls bounce up and down pushing jammed seeds out of the holes.
(c) ***Knockers:*** placed over the screen, and used to tap it. Knockers may cause mechanical damage to seed.



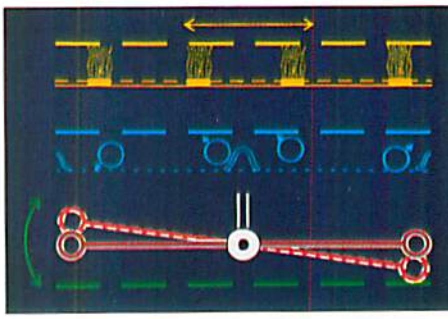


Fig. 53. Brushes (A), balls (B), or knockers (C) can be used to kept screens clean during processing (remove seed that gets stuck in the perforations)

Note: No balls are needed under top screens. Bouncing of the balls will agitate the seed mass and cause large material to take vertical position and then drop through. They also dislodge jammed seed.

How to estimate the percentage of rejects in the received raw seed

The basic steps to calculate expected percentage of rejects (the amount of loss necessary to obtain a clean product) in a typical raw cereal seed material are as follows:

- Use the hand screens selected from the previous test.
- Make a stack of the two hand screens selected with the round hole screen on top, the slotted hole screen in the middle, and a blank on the bottom.
- Weigh 1 kg of raw seed (W1).
- Pour onto the top screen. Shake until all particles have found their level.
- Weigh the material kept on top screen (scalped material = W2) and material that passed through the bottom screen (small particles = W3).
- Add the weight of the two components together. This is the weight of rejects (W2 + W3).
- Subtract this weight from the initial weight and divide the difference by the initial weight. This is the amount of loss necessary to obtain a clean product.

$$\% \text{ Clean output} = \frac{W1-(W2 + W3)}{W1} \times 100$$

Where:

W1= initial weight
W2= weight of material kept on top screen
W3= weight of material that passed through the bottom screen

Note: This calculation neglects aspirated material.

Operation of the machine

The sequence of operation for different systems of air-screen cleaner is as follows:

- First, turn on the air system.
- Second, turn on the screen driving system.
- Then, turn on the feeding system.

This is due to three main reasons:

- The working condition of the air system is initially judged by listening to its sound. This can not be done when the screen system is working.
- The raw material passes through the pre-aspiration system before it reaches the screen system.
- The feeding of material to any processing system must start only when that system is fully working. Open the feeding system in such a way that a thin layer of seed flows over the top screen.

The sequence of stopping is the opposite of starting, except under emergency situations.

Adjusting and improving the efficiency of air-screen cleaner (Table 7)

There are five common adjustments to air-screen cleaners:

- ***Rate of feeding:*** control the feeding rate so as to have uniform flow, one layer deep.

- ***Air adjustment:*** there is no specific adjustment to make, it depends on the weight of the seed crop. Adjust the air vents until all material lighter than the crop seed is drawn out. The pre-and tail aspiration are two components belonging to the same system. Thus, their adjustment is a matter of balancing them. To make necessary adjustments, it is recommended to examine from time to time all fractions resulting from air-screen separation. Adjust air, starting from the lowest to the highest level. As a general principle the head end removes mainly chaff while the tail end aspiration removes light and shriveled seed.

- ***Speed vibration*** *or screen shake:* this controls the rate at which seeds get through or ride on the screen. High speed causes faster seed flow but bad separation. Rapid shaking helps the seed to bounce, turn on end, and go through openings. Low speed slows the flow and causes screen perforation to jam. The layer of seeds on the screen becomes thicker, and the seed then travel all the way without getting a chance to contact the screen openings.

- ***Inclination of the screen:*** affects the seed movement over the screen. Steep inclination will increase the capacity but decreases the separation efficiency; while flat inclination decreases capacity but increases the separation efficiency as seed remain on the screen longer.

- ***Screen combination:*** the top screen removes seed and seed particles larger and thicker than the crop seed, whereas the bottom screen removes seed and seed particles smaller and thinner than the crop seed. Round perforations screen separates according to width, slotted screens according to thickness, and triangular according to shape (Table 8).

Note: Pre-cleaners usually slope at about 15° with high speed vibration and low amplitude while basic or fine cleaners slope at about 5° with slow speed vibration and larger amplitude.

Remarks:
- Secure the machine to a firm foundation in order to avoid unnecessary vibration.
- Always check air ducting and air exhaust. Avoid poor connections, sharp turns, and elbows of the air ducting systems. A poor exhaust system causes not only poor air separation, but a dirty and dusty processing plant as well.
- Regularly examine the cleaned seed and all other discharged fractions; adjustments should be made accordingly.
- Adjustment of feeding rate, screen inclination, and vibration speed should

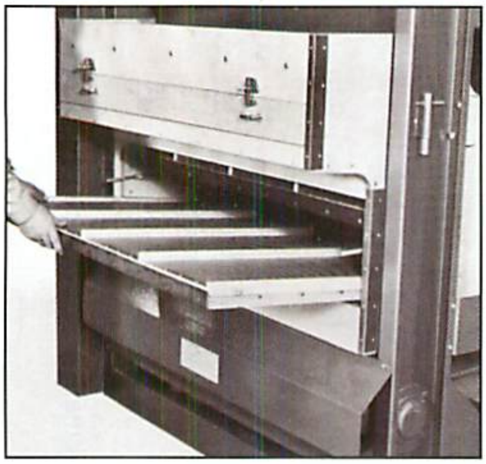


Fig. 54. Changing screens

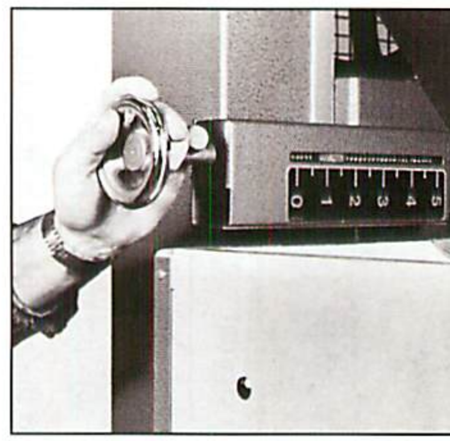


Fig. 55. Adjustment device for an adequate feeding rate

be made during screen operation so that results can be observed.

- Throughput should be increased until seed is falling through the lowest sieve over most of its length. If all seed that is going through a sieve has done so in the first half then throughput could be doubled.
- Conduct a purity analysis of the cleaned seed to determine how good cleaning the seed lot was.

Hints:

- Length of the screen affects seed separation. If separation is accomplished at the upper section of the screen, you may want to blank the lower portion of the screen to avoid additional drop of trash particles and weed seed.
- Cover the screen to prevent seed bouncing and to allow seed to lie flat and contact the perforations. Mainly used for round seeds that tend to bounce and roll down faster.

Maintenance of the machine

- Keep all rotating shafts bearings greased and clean.
- Clean the entire machine after use. Remove all the screens and use compressed air and vacuum cleaner.
- Store spare screens in dry conditions. Clean before storage.

Table 7. Adjustment and improving the efficiency of an air screen cleaner

Problem	Trouble shooting
Poor or incomplete separation	Brushes not operating (perforations are clogged)
Some scalping material (long seed or trash) drop through with the good seed	Blank off the lower section of the top screen with a heavy paper and tape just below the point where all the good seed drop through the screen
Not uniform seed layer on screen	Adjust rate of feeding
Dust and light chaff material on the top screen	Adjust head end air suction
Seed bounces violently on screen	Screen must vibrate slowly to allow the seed to fit itself exactly in the opening and pass through
Speed at which the seed moves over the screen	Governed by the desired capacity and desired separation Increased screen pitch (high inclination) increases the capacity but
reduces	the separation Flat pitch increases the time the seed remain on the screen and thus the separation but reduces the capacity
Light seed remains in the good seed	Adjust tail end air suction. For efficient cleaning, the lower air should blow out a few good seed
Dirty and dusty plant	Check air exhausts and ducts
Not cleaning seed	Decrease the capacity

Table 8. Suggested screen size for agricultural crops (all sizes in mm)

Crop	First scalper	First grader	Second scalper	Second grader
Barley (*Hordeum vulgare*)	6.5 R	4.5 S	4.0	2.1-2.4 S
Broad bean (*Vicia faba*)	12.0 R	-	-	5.5-6.0 S
Bean (*Phaseolus vulgaris*)	10.0 R	-	-	3.75-4.5 S
				4.25-5.5 R
Chickpea (*Cicer arietinum*)	8.0-11.0 R	-	-	4.0-5.0 S
				5.0-5.5 R
Clover, red (*Trifolium pratense*)	2.5 R	2.4 R	1.5 S	1.0-1.2 R
Clover, white (*Trifolium repens*)	1.5 R	1.4 R	0.9 s	0.8 R
Lentil (*Lens esculenta*)	5.0 R	-	-	3.0-3.5 R
	8.0 R			5.5-6.5 R
Maize (*Zea mays*)	-	-	-	2.5 S
Oat (*Avena sativa*)	7.5 R	3.2 S	3.1 S	1.8-2.2 S
Pea (*Pisum sativum*)	9.0-10.0 R	-	-	3.75-4.5 S
				4.25-6.5 S
Rapeseed (*Brassica napus*)	3.2 R	2.8 R	2.3 R	0.9-1.0 S
Rice (*Oryza sativa*)	6.0-7.5 R	-	-	1.8-2.1 S
Rye (*Secale cereale*)	6.25 R	3.3 S	3.2 S	1.8-2.0 S
Soybean (*Glycine max*)	9.0 R	-	-	3.0-4.0 S
Wheat (*Triticum aestivum*)	6.25 R	4.5 S	4.25 S	2.0-2.5 S

R= round hole
S= slots

Questions

1. What is basic cleaning?

2. Explain the operation principles of an air-screen cleaner. Can an air-screen cleaner separate seed according to the shape of seed?

3. Describe the procedure used to select appropriate screen sizes.

4. Name and describe the two types of materials for screen fabrication. What shapes are available in each type? How are the opening dimensions measured?

5. What screen perforation would be used to separate seeds according to their width and thickness?

6. Describe the principles of operation of a four-screen air-screen cleaner.

7. How many fans does an air-screen cleaner have? Describe the function of fans.

8. Describe the procedure used to estimate the percentage of rejects and clean output.

9. What are the operations usually done to a seed lot before it goes to the air-screen cleaner? Why?

10. What is the difference between scalping and grading?

11. What are the necessary adjustments for an air-screen cleaner to perform an effective separation of good seed and contaminants? What is the sequence of adjustment for setting up and operating the machine?

12. How can you determine that the feed rate is correct? Discuss.

13. How is the undesirable vibration of a machine minimized?

14. Describe the mechanisms used to prevent jamming and plugging of screen perforations.

15. How do you start an air-screen cleaner machine and why do you have to follow a particular sequence?

16. How many waste products are discharged from the air-screen cleaner? Describe each fraction.

INDENT CYLINDER/DISC

Length separator

Length separator is often the most important cleaning machine used after an air-screen cleaner. It is used to:

- ***Remove remaining particles that differ in length***, either shorter (weed seed and broken crop seeds) or longer than the good seed (other crop seed).
- ***Upgrade the general appearance*** of the seed lot (uniform in length).
- ***Size-grade*** cleaned seed for precision planting.

The work of cylinders is often essential and is complementary to the air-screen cleaner. For many crops, the air-screen cleaner combined with the cylinder produce a clean seed lot. These two machines separate seed according to the important characteristics of seeds: width, length, thickness, and weight (air separation).

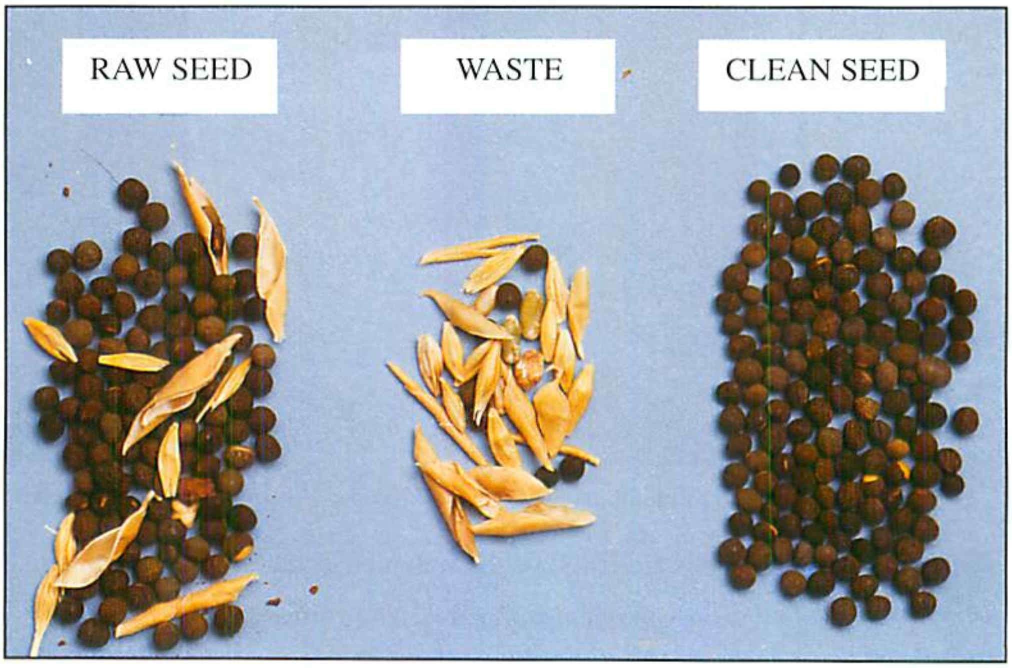


Fig. 56. Functions of an indent cylinder

Note: The length separator is most effective on a uniform seed lot, so it is usually used after an air-screen cleaner.

Types of length separators

There are two types of length separators:

- ***Indented cylinder*** (Fig. 57), consisting of a rotating horizontal cylinder and an adjustable horizontal separating trough.

- ***Indented disk separator*** (Fig. 58), consisting of a series of indented disks (cast-iron disks) mounted on a rotating horizontal shaft. Each disk has many undercut pockets (indentation) on each side.

Fig. 57. Indent cyliner

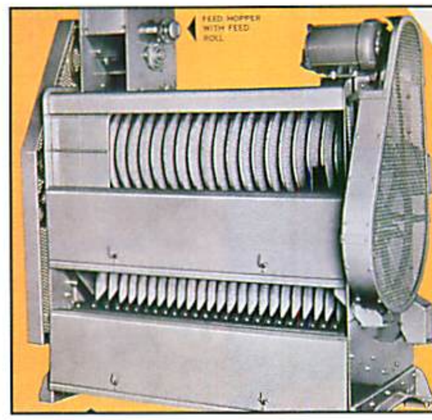


Fig. 58. Disc separator

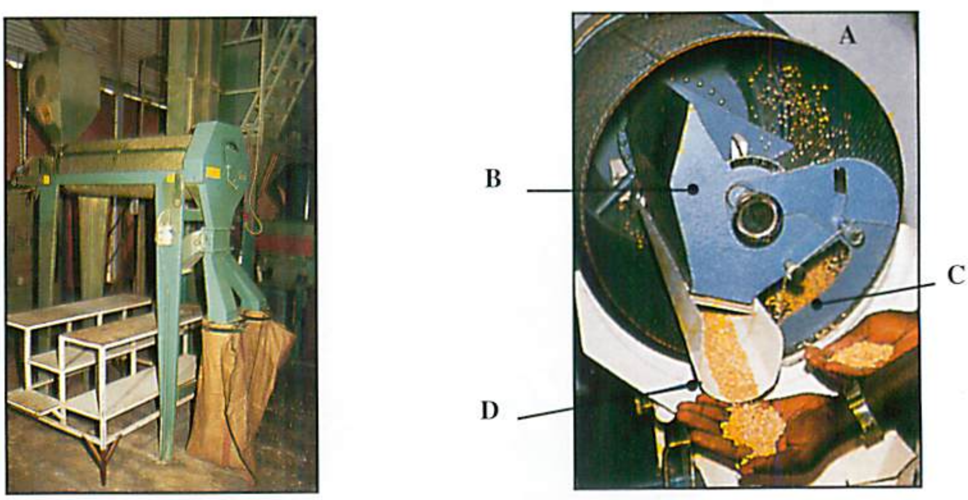


Fig. 59. Indent cylinder: Cylinder (A), trough (B), retarder (C), outlets (D)

Types of cells of the indented cylinder

The cells (indents) of the indented cylinder are available in different shapes:

- ***Semi-spherical indents***: used to lift round seeds.
- ***Cylindrical indents***: more effective in lifting all kinds of seeds.
- ***Conical indents.***

Fig. 60. Shape of indent: semi-spherical indents

Principles of separation by the indent cylinder

Principles of separation:

- Indented cylinder is designed to separate seed mixtures on the basis of their ***length***.

- Separation is accomplished by ***lifting short particles*** out of a seed mass containing both long and short particles. The seed mass can then be lifted in a cylinder with larger indents to remove all the good seed and leave all the long seed and trash behind.

- As the cylinder rotates, ***the indents lift and catch the desired seed*****/seed particles**, holding them out of the seed mass until the indents are inverted to the point where gravity causes the particles to fall. ***Short seeds are lifted and carried in the cylinder's indents*** until they fall out into the trough. ***Long seeds are not lifted***, they remain in the cylinder, move along the length of the cylinder which slopes slightly and discharge from the lower end.

- Length is the primary, but not the only factor affecting the cylinder's separation. Other seed characteristics such as position of center of gravity, surface texture, moisture content, and size influence how the seed will fit into and be held in the indent.

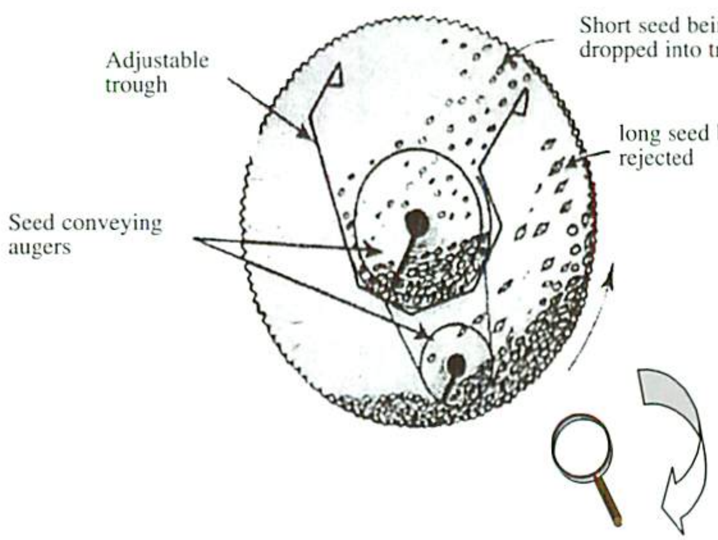


Fig. 61. Principles of seed separation by an indent cylinder

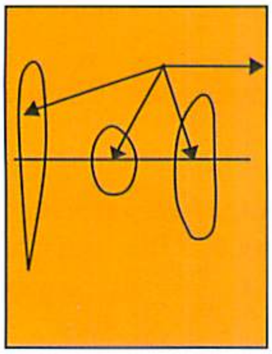


Fig. 62. Position of gravity center for different seed shapes

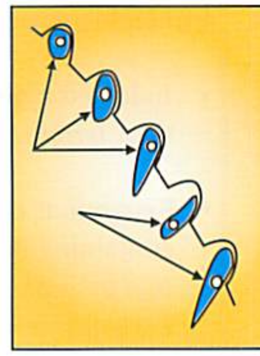


Fig. 63. Seed will be lifted or rejected based on the position of its gravity center on the indent

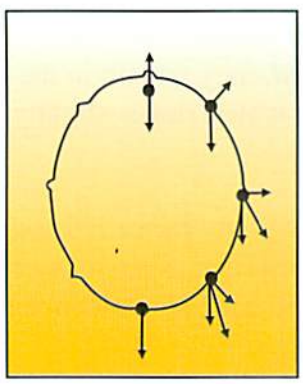


Fig. 64. Force diagram shows how lifted seed remains in the indent until it drops by gravity force

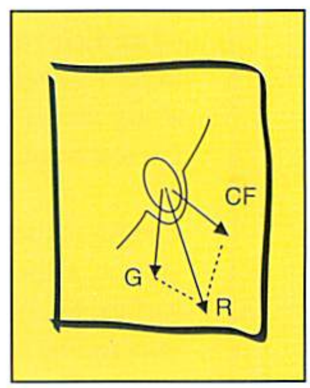


Fig. 65. Forces applied on seed: centrifugal force tries to hold seed in pocket (about half as big as force of gravity) and gravity tries to make seed fall

Applications of the indented cylinder

The indented cylinder can be used in two different ways:

1. ***Short reject materials*** (right separation): smaller or shorter round seed, mostly weeds, broken grains, and other impurities shorter than the crop seed are removed. Short impurities are lifted into the trough, whereas the longer crop seed are left in the cylinder. This is a high capacity application.

Examples:
(a) Cereals: remove broken seeds which have similar width and thickness, but different length.
(b) Lentils: remove small impurities which escaped separation in the air-screen cleaner.

2. ***Long reject materials*** (reversed separation): the crop seed is lifted into the trough, while longer impurities are left in the cylinder from where they flow to the long material outlet. It is a low capacity application.

Examples:
(a) Cereals: remove oats from wheat or barley and barley from wheat.
(b) Lentils: remove vetch as well as cereals and unthreshed pods.

Fig. 66. Long application

Fig. 67. Short application

Some considerations for separating long reject material:

- For the same crop seed, the indent size should be larger.
- There is risk of losing good seed, unless the machine is carefully adjusted.
- Slow process/low capacity: two long grain cylinders are required to cope with the capacity of the short/round reject application (Fig 68).

Note: Can barley be separated from wheat?
The answer is yes. It is technically possible to make such a separation, but it is not financially sound. You need to sacrifice 30 to 40% of mixture of barley and wheat in order to have clean wheat seed. This fraction of the seed have the same dimensions and weight and cannot be separated by any machine.

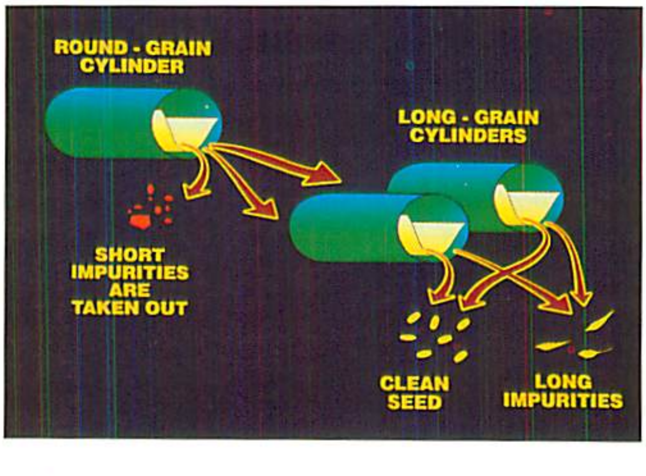


Fig. 68. Cylinders can be used in two different ways: long or round application

Adjustment and trouble shooting (Table 9)

For an efficient separation/grading, five components must be regularly adjusted. These are:

- ***Feed rate:*** even flow.
- ***Cylinder size:*** appropriate pocket size is crucial. It is recommended to have sets of cylinders of different pocket sizes.
- ***Trough setting:*** setting the trough at a high position can result in poor separation whereby short material falls back into the seed mass and is discharged with the good seed. The adjustment should be started from the lowest setting point. As the trough goes higher the percentage of good seed that is lifted becomes less and less until this percentage is equal or approaching to zero, the adjustment is then fixed.

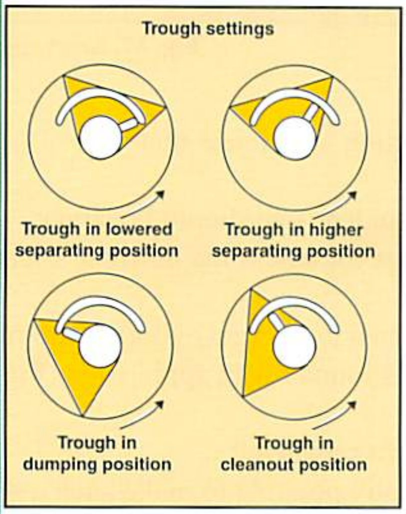


Fig. 69. Trough settings

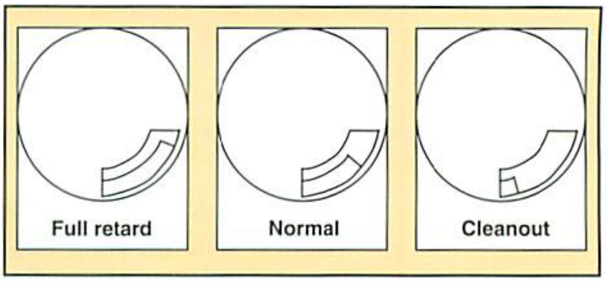


Fig. 70. Retarder control

Hints: If the initial position of the trough is approximately at 45 degrees on the side of the cylinder, after a few minutes you need to check the product. If further separation is required turn the scale towards the left, and if less separation is required turn the scale towards the right side. If the trough is set to a very high position (flat) or very low position (steep), it means that the indents are of the wrong size.

- ***Rotation speed:*** should not be too fast so that seed remains constantly in the indents; nor too slow so that lifted seed will drop too early.
- ***Cylinder tilt***
- ***Retarder position:*** this conditions how long the seed remains in the cylinder.

Maintenance of the machine

Bearings and motor parts should be kept clean and properly greased. Spare cylinders should be stored in a dry and clean place. They must be standing on the end in order to avoid deformity.

Table 9. Adjustment and troubleshooting of an indented cylinder

Factor	Adjustment	Results or corrections
Feed rate	Too slow	Low capacity
	Too fast	Incomplete separation
	Variable	Poor cleaning
Trough setting	Raising the trough	Increases the distance that seed must be lifted and allows more seed to fall back into the main mass and be discharged with the long seed. The indent is too big if the trough must be set in a very high position
	Lowering the trough	Decreases the distance that seed must be lifted, so increases the size and amount of seed lifted up into the lifting trough. If the trough is too low and seed still cannot be lifted to the trough, or seed fall back, this indicates that the indent chosen is too small
Speed of cylinder	Too slow	Indents will reject some short seed that should be lifted Low speed causes seed to drop out of the indents too early
	Too high	Longer seed will be lifted to the trough The centrifugal force will be too high and the seed will not fall out of the indents A speed of 36 rpm is suitable for most seeds. For small seed such as t, lower the speed to 25 B 30 rpm
Cylinder tilt (end-to-end slope)	Raise feed end	Seed travels faster through cylinder
	Raise discharge end	Holds seed in the cylinder longer
Retarder	Low	Long seed move faster out of the cylinder
	High	Holds seed in the cylinder longer
Indent size	Slightly smaller than the optimum size	Increase cylinder speed, lower lifting trough, raise the retarder
	Slightly larger than the optimum size	Decrease cylinder speed, raise lifting trough, lower the retarder

Questions

1. What is the purpose of using a length separator?

2. How does an indented cylinder separate a seed mixture?

3. Describe how seeds are lifted in the indent and then dropped. What are the forces controlling this process?

4. What processing operations are done to seed before it goes to the cylinder?

5. Can seeds which differ in length by less than 50% be separated? Explain.

6. Define the two possibilities in which an indented cylinder can be used to separate seeds.

7. Why is removing long reject particles called low capacity application?

8. How can the capacity of a cylinder be increased?

9. Can an indented cylinder be used alone or before the air-screen cleaner? Why?

10. What are the main adjustments of an indented cylinder?

11. What will happen when the cylinder rotation speed is too high or too low?

12. What will happen when the lifting trough is set too high or too low?

13. How many separations are produced by one cylinder?

14. How can you minimize the loss of good seed?

15. What shape of seeds would be unsuited to length separation?

GRAVITY SEPARATOR

Why gravity separator

Seed and contaminants that are similar in size and shape but different in weight (diseased or insect damaged seeds, germinated seeds) cannot be easily separated by either air-screen cleaner or indented cylinder. Separation could be accomplished only by a gravity separator.

A gravity separator is often used to:

- ***Separate seed or particles of the same size, but with difference in specific gravity or relative weight.*** These may include insect-damaged, deteriorated, moldy or rotten seed, empty or sterile seed, some weed seed, soil particles and stones.

- ***Improve germination of a seed lot*** by removing light seed with low germination (deteriorated, diseased, or insect damaged seed).

- ***Remove weeds and stones.***

Description of the gravity separator

Parts of a gravity separator include:

- Feed hopper (inlet) and adjustable feed gate
- Exchangeable porous deck
- Air chamber equipped with a fan that blows air through the deck
- Motor allowing oscillation of the deck
- Discharge hoppers
- Adjusting features for air, oscillation speed, lateral and longitudinal slopes.

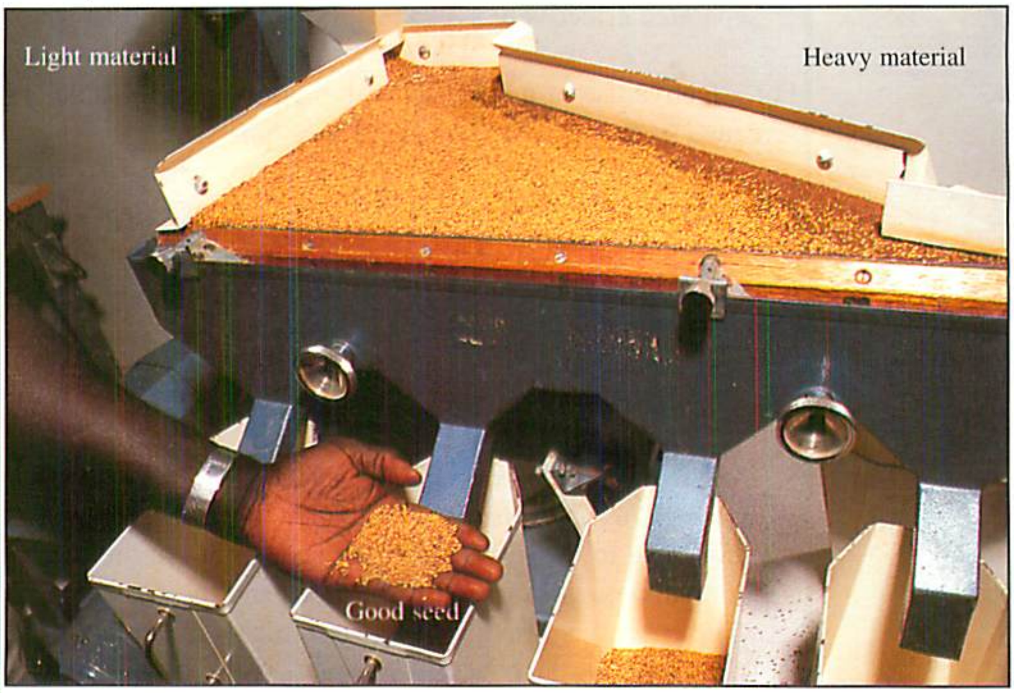


Fig. 71. Description of the gravity table: Deck (A), and outlets (B)

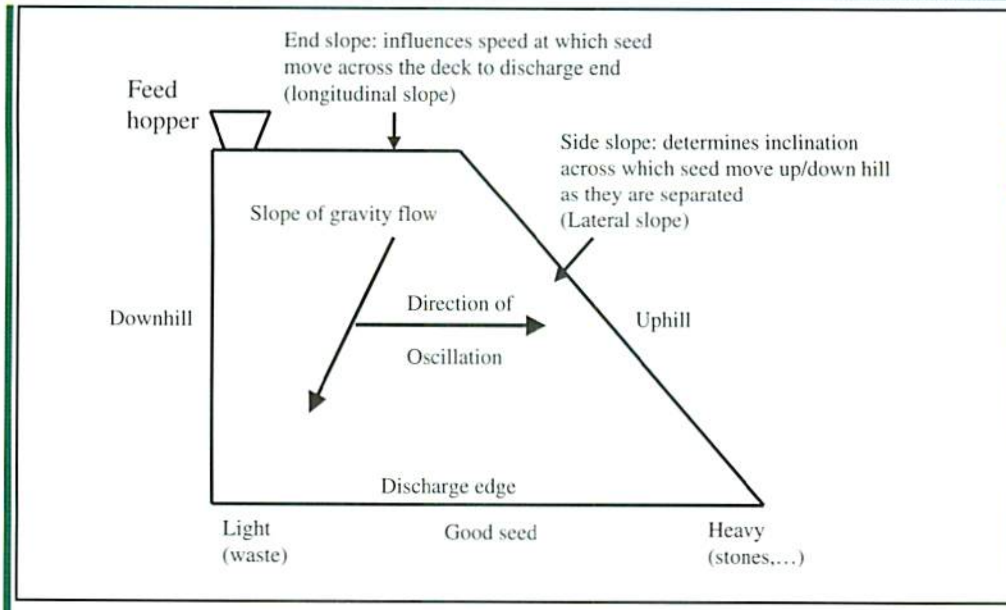


Fig. 72. Schematic diagram of a gravity separator

Principles of separation

The gravity table separates particles mainly according to their density or specific weight. Although seed density is the main characteristic influencing separation, seed size is an important related factor.

A consideration of both factors leads to the following three rules:

- Seeds of the same size but different in weight will be separated according to specific gravity.
- Seeds of the same specific gravity but different in size will be separated according to size.
- Seeds differing in both size and specific gravity cannot be stratified and separated effectively.

For effective use of gravity separation, a seed lot must be cleaned and screened so that all particles are of the same size.

The separation is accomplished basically in two steps: (i) ***stratification*** where seed mixture is stratified into vertical layers of different densities and (ii) ***separation*** where the stratified layers are horizontally separated and discharged separately.

Stratification

- *How stratification is accomplished*: seed from the feeder fall into an air stream. This air is used to fluidize the material so that light seed and particles float to the top, leaving the heavy ones at the bottom. The relative terminal velocities of individual seed and the air stream determine whether seed is lifted in the air or remains in contact with the deck. However, only 1/10th (approximately) of the terminal velocity is required to fluidize seed. Terminal velocity is influenced by seed density, size, shape, and surface texture.

If $A_V > S_{fV}$ seeds are lifted in the air.

If $A_V < S_{fV}$ seeds are not lifted and remain lying on the deck.

If $A_V = S_{fV}$ seed are suspended motionless in the air.

Where: A_V = air velocity; S_{fV} = seed fluidizing velocity

- *Stratification zone*: is the deck area where stratification takes place. The faster this operation takes place the smaller this zone will be and the better the separation. This depends on the differences in specific gravity of the seed mass being stratified. The larger this difference is, the faster is the stratification process and the smaller is the stratification zone thus leaving a large deck surface for the separation process. On the other hand, the smaller this difference is, the slower the stratification process and the larger is the stratification zone thus leaving a small deck surface for the separation process.

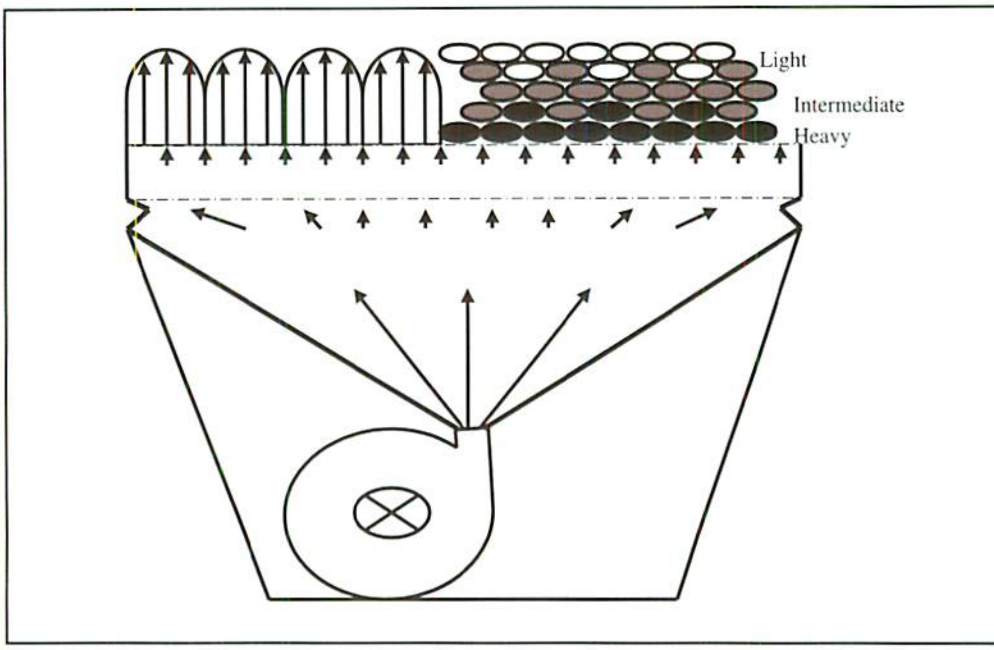


Fig. 73. Stratification. Lighter seeds are lifted whereas heavier seeds remain on the deck

Separation

- *Stratified vertical layers must be separated horizontally,* so that they discharge into different spouts. A combination of deck slope and deck vibration is used to separate the layers. The vibration of the inclined deck moves the heavy seed and particles uphill by friction. The light particles floating on the air move down hill under influence of gravity.

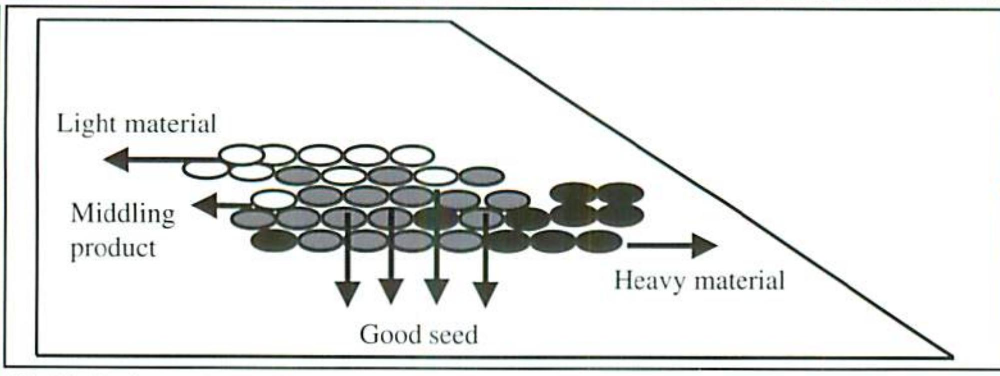


Fig.74. Horizontal separation of the stratified layers. Arrows indicate the direction of each seed layer

- *Separation zone:* determines the effectiveness of separation. The larger the separation zone is the better (complete) the separation is. The smaller the separation zone the poorer the separation.

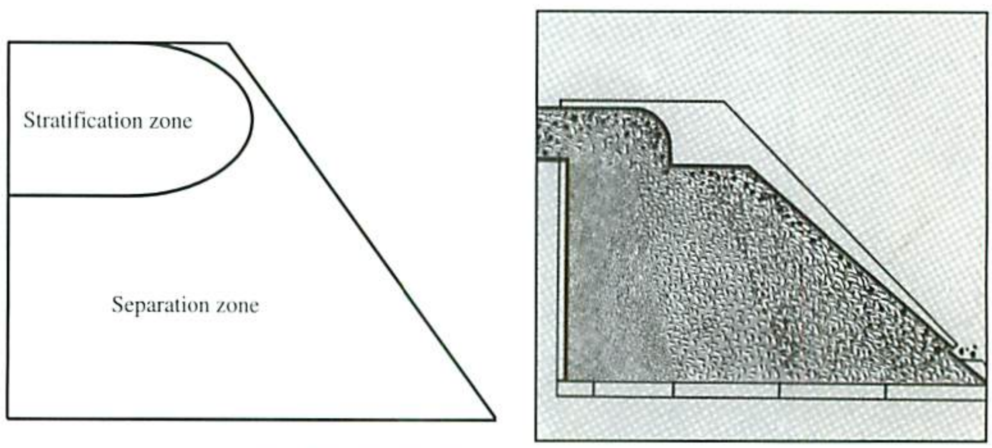


Fig. 75. Stratification and separation zones

Using adjustments to operate the gravity separator

There are two types of adjustments:

1. ***Efficiency adjustment:*** includes air, side slope, and deck oscillation amplitude and speed adjustments.

2. ***Capacity adjustment:*** refers to feed rate and end slope adjustments.

However, each adjustment has some effect on both efficiency and capacity.

- ***Air adjustment:*** the air flow/volume should be adjusted to make all seeds just move but not jump. Stop the deck movement and use only air pressure to check on the amount of air needed. Too much air will move the seed to the right (heavy side) and too little air will cause seed to move to the left (light side).

- ***Speed of the deck:*** the vibration should be gradually increased until heavy seeds move uphill. High speed and amplitude cause the seed mass to move uphill (right) while low speed and amplitude cause the seed mass to move to the left of the deck. In general, a slow speed and high amplitude suits large seeds such as beans but high speed and low amplitude suits small seeds. Careful adjustment, but trial and error is needed. The speed should be adjusted to the amount of air so that there is always a uniform seed layer on the entire deck.

- ***Feeding rate:*** the feeding rate should be regular, continuous, and even.

- ***Lateral inclination:*** side slope should be adjusted so that seed mass is not shifted to the lower side of the deck, or moved away from the upper side plate.

- ***Longitudinal inclination:*** end slope should be adjusted so that the seed mass moves at a reasonable speed. Larger inclination will cause seed to travel fast from the inlet to the discharge end, resulting in poor grading. Smaller inclination will allow seed to spend much time on the deck, resulting in sharp grading but at reduced capacity.

Hints:

- Adjustments must be balanced to produce two basic results: (1) seed must be stratified as rapidly and effectively as possible and (2) seed bed must cover the entire deck to separate the different zones as widely as possible.

- Adjustments should be made gradually, one at a time until a satisfactory separation and capacity are obtained. Allow time for the deck load to change completely between adjustments.

- After adjusting feed rate, over compensate with air and sometimes side tilt, then bring separator back into balance with deck speed control.

- Proper adjustment is obtained when the middling product is a true middling fraction consisting of large light particles and small heavy particles only.

The deck cover of the gravity separator should be carefully chosen according to the crop seed to be separated. In general, wire mesh deck is used for most field crops (cereals and food legumes) and cloth deck for very small and light seeds (Medicago, clover).

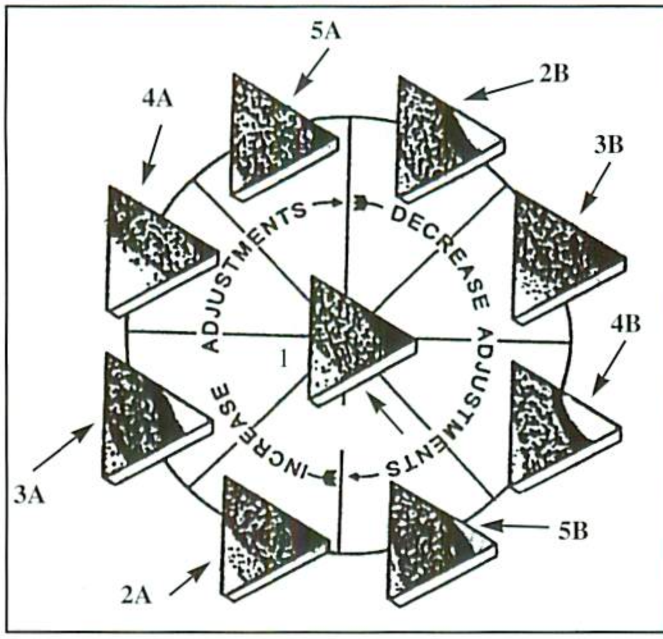


Fig. 76. Gravity separator adjustment check chart (Hammond et al. 1968)
Correct errors of adjustment in the following order: air adjustment 2A or 2B, oscillation speed 3A or 3B, end slope 4A or 4B and side slope 5A or 5B; 1 = Normal opeation; A refers to insufficient; B refers to excessive (Example: 2A = Insufficient air and 2B = excessive air)

What is middling product?

Middling product is an intermediate fraction of heavy and light seed, a mixture of good and bad seed. This portion of seed is usually re-cleaned to save the good seed and remove the remaining impurities.

- Large middling product results from poor stratification and separation. Factors contributing to this state include: (i) poor sizing of seed mass, (ii) slight difference in density of seed, and (i) high feeding rate.
- Middling product cannot be completely avoided, but can be minimized if size graded seed is used and adjustments are well made.

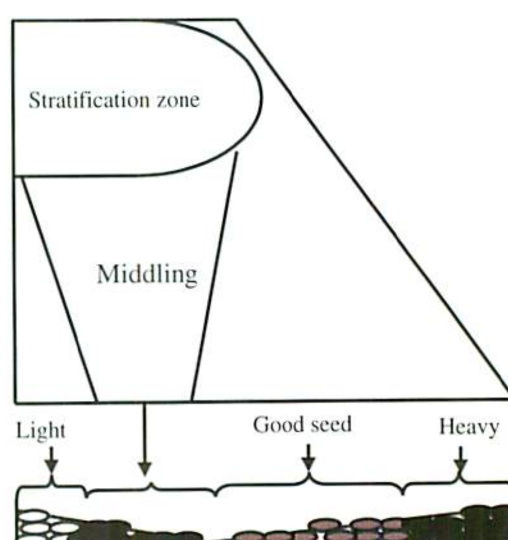


Fig. 77. Middling product

Middling salvaging methods

Different ways to re-clean the middling product:

- Direct feeding of the middling product onto a smaller gravity separator.
- Collect the middling product and return it to gravity separator or air-screen cleaner hopper at the end of processing operation.

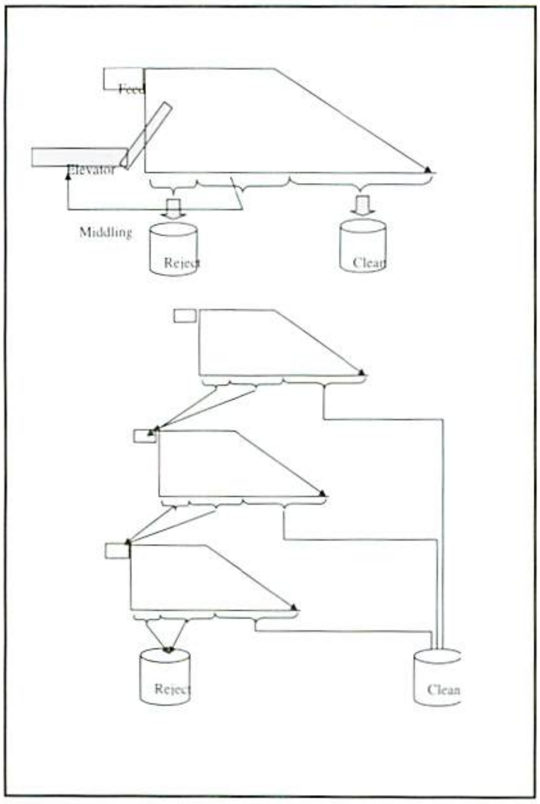


Fig. 78. Middling salvaging methods

Operation of the machine

Start the gravity separator according to the following sequence. Stop the machine in the opposite sequence:

1. Air system: should be at the level to make seed just moving not jumping.
2. Vibration system: set at the lowest level and gradually increase.
3. Feeding system: should be continuous and even.

Mainten-ance

Maintenance checklist: regularly check and examine the gravity separator parts below:

- Check that the machine is secure to the foundation.
- Check that bearings and threads for adjustment of the inclination are greased.
- Check that the deck is clean (under and top side) and has no dead spots. Cover the deck if the machine is not in use.
- Check the incoming air for cleanness.

Table 10. Gravity separation troubleshooting

Problem	Possible cause	Solution
Unwanted (false) vibration Upset stratification	Weak foundation Loose deck	- Solid and firm foundation - Check bolts securing the machine to the floor - Tighten deck clamps
Insufficient air pressure	Blower running backwards Filter protection not removed In-coming air not clean Dirty filter, dirty deck	- Check motor wire connection - Remove filter shield - Use clean air - Clean filter, clean deck
Dead or blind spots	Dust or grease plug air openings in the deck	- Clean the deck - Cover deck after use - Check bearings for excess grease - Use dust-free air
Surging or irregular travel of material	Irregular power Belt slippage Irregular feed Large material (tags, strings) plugging feed hopper	- Check power connection - Keep belt tight - Constant and uniform rate of feed: seed bed thick enough to cover the deck at all times NB. Better to always operate at optimum and get maximum throughput
Capacity	Low	- To increase: increase feed rate; this requires tore deck speed, less side tilt and more end tilt
	High	- To lower: decrease feeding rate and this requires less deck speed, more side tilt and less end tilt
Deck load towards light side (empty space on heavy side)	Excess air, wrong deck speed, or high side tilt	- Decrease air or increase speed, or lower side tilt or lower back side
Deck load towards heavy side (empty space on light side)	Too little air, wrong, deck speed or low side tilt.	- Increase air, decrease speed, raise side tilt
No stratification with insufficient or no separation	Too much air Insufficient air Wrong deck	- Adjust air: excess air boils deck load, mixes it - Adjust air: insufficient air deadens seed bed - Large seed requires more air (large deck openings), while small seed requires less air (small deck openings)
	Seed mixture not suitable for gravity separation	- Seed mixture must be cleaned and screened so that all particles are of the same size
No separation	Too much air	- Adjust air: excessive air causes heavy seed to flow downhill with light seed - Adjust air: insufficient air lets all seed lie on the deck and move uphill
Too much middling product	Poor pre-sizing Slight difference in density High feeding rate	- Size grade carefully - Return to gravity table using small elevator - Feed from large gravity table onto a small table - Return to same gravity table at the end of operation - Return to air-screen cleaner

Questions

1. Why do we use the gravity separator?
2. Can seeds differing in both size and density be separated effectively by a gravity separator? Why?
3. What processing is done to a seed lot before it reaches the gravity separator? Why?
4. Where is the gravity separator usually placed in the processing line?
5. Define stratification and separation of seeds.
6. What are the five adjustments of a gravity separator? Which control the efficiency and which control the capacity?
7. How is the air adjusted and controlled? What does it mean when seeds are lying dead on the deck surface, or seeds are bubbling?
8. What does it mean when one side of the deck is uncovered (has no seed on it)? How can you correct this situation?
9. Does speed of oscillation affect stratification, separation or both? Explain.
10. How many discharge spouts are provided on a gravity separator?
11. Define the middling product. How can you minimize it?

OTHER MACHINES

What are the other machines?

These machines are those that are not commonly used or that are specific to certain type of crop seed and perform specific separation and grading. These include: ***spiral separator***, ***belt grader***, ***velvet roll separator***, ***magnetic separator***, ***color separator***, ***stoner***, and ***scarifier***.

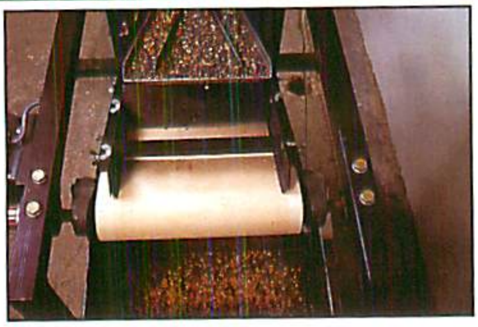
Spiral separator

- ***Basis of separation*:** Separates seeds according to their shape and ability to roll.
- ***Function:*** Round seeds roll smoothly down the inclined flight and build up a high velocity that allows them to roll over the edge of the inner flight to the outer flight where they are discharged separately.
  Flat or irregular-shaped seeds slide down slowly and do not build up enough velocity to escape from the inner flight, so they are discharged separately.
- ***Common use:***
  -Crop seed cleaned: soybean, vetch, peas, brassicas, lentils.
  -Contaminants removed: wheat seed, oat, ryegrass, gallium, broken grain.

Fig. 79. Spiral separator

Belt grader (draper mill)

- ***Basis of separation:*** Like the spiral separator, the belt grader is intended for the removal of rough or elongated seeds, stems, and flat parts from smooth round seeds.
- ***Function:*** As the inclined belt travels uphill, round seed roll down the belt and discharge at the lower end. Flat, irregular seeds, and rough-textured impurities remain on the belt and are carried to the top where they are discharged.
- ***Common use:***
  - Crop seed cleaned: sugar beet, ball-shaped seed such as peas, vetch, red clover, flower seed.
  - Contaminants removed: inert material such as stems and flat particles, dodder, oats, buckhorn plantain.



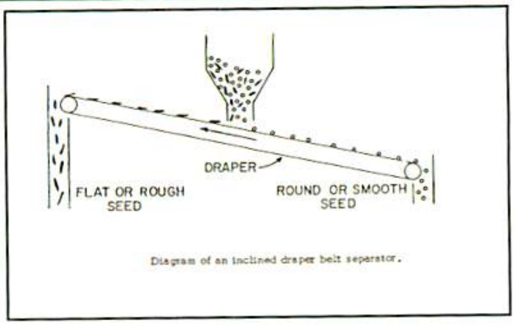
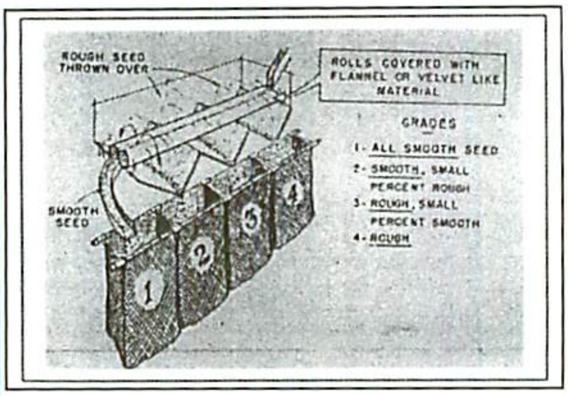


Fig. 80. Belt grader

Velvet roll separator (dodder or roll mill)

- ***Basis of separation:*** Separates seeds by differences in surface texture.
- ***Function:*** As the rolls rotate in opposite directions, rough-textured seeds are caught by the velvet nap and are thrown against the shield where they bounce back and forth until they fall over and out of the rolls. Smooth-textured seed are not caught by the velvet nap, so they smoothly slide down the rolls and are discharged at the end.
- ***Common use:***
  - Crop seed cleaned: medics, red clover, beans, hairy vetch, alfalfa.
  - Contaminants removed: dodder, wrinkled peas, shriveled, immature or damaged crop seed, and inert material such as stems and dirt clods.



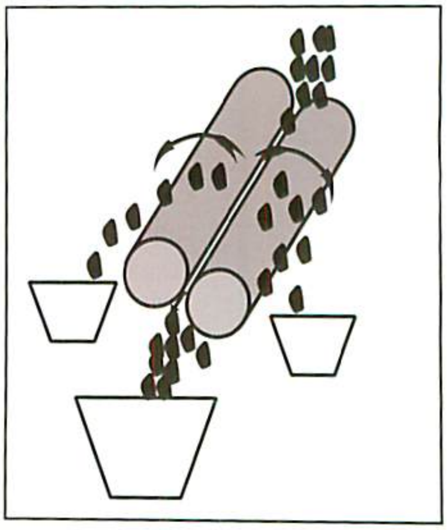


Fig. 81. Velvet roll

Magnetic separator

- ***Basis of separation:*** Separates seeds by differences in surface texture or related seed coat characteristics which affect the ability to absorb water or other liquid. Removes rough-textured or broken seed, seed with cracked coat, and impurities with sticky surface from seeds with smooth coat such as legumes.

- ***Function:*** The separation involves two steps. First, the seed mixture is pretreated by adding moisture and iron powder. The rough, porous, or sticky contaminants pick up the iron powder, whereas smooth seed do not. Second, the treated seed mixture passes over a revolving drum which has a high magnetic field. The iron-powder coated impurities are attracted to the drum, while the smooth uncoated seeds drop out separately.

- ***Common use:***
  - Crop seed cleaned: red and white clover, alfalfa, medics, brassicas.
  - Contaminants removed: dodder, buckhorn plantain, various inert components and wild mustard.

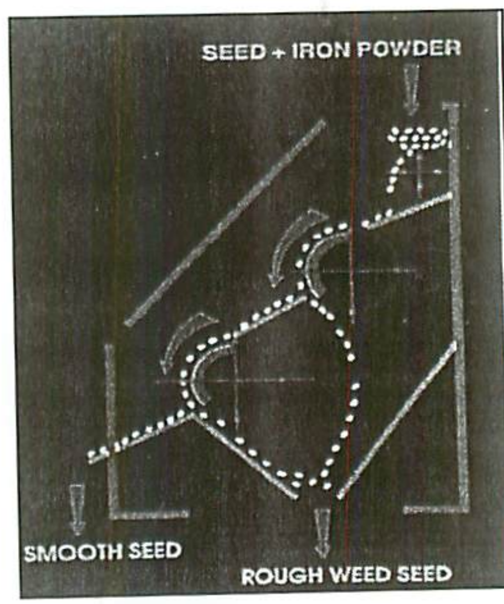


Fig. 82. Magnetic separator

Color separator

- ***Basis of separation:*** Separates seeds according to color or light/dark characteristics.

- ***Function:*** The electronic device senses color or light differences that cannot be detected by human eye. The seed mixture passes through the viewing chamber where each seed is inspected one by one, from three angles, by photo cells. If any seed or other particle which is not of the standard or accepted color passes this point, the detector signals the main amplifier to operate the air ejector to discard the different-colored seed.

- ***Common use:***
  - Crop seed cleaned: rice, maize, peas, beans, faba beans, sunflower.
  - Contaminants removed: discolored seeds, ergot, and sclerotia.

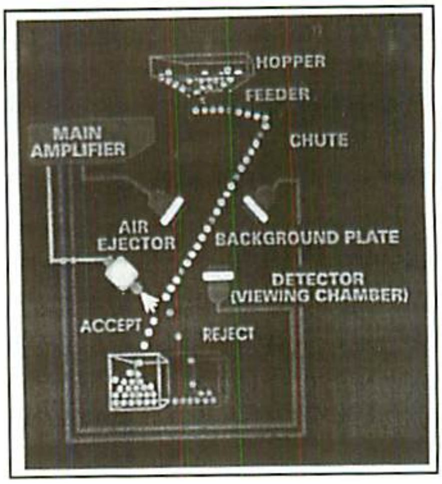


Fig. 83. Color sorter

Stoner

- ***Basis of separation:*** Separates according to weight. Used to remove heavy inert materials from cleaned seed (sand, dirt, gravel, small rocks).

- ***Function:*** Same principle as with the gravity separator, but is much simpler.

- ***Common use:*** To salvage good seed from the heavy waste product coming from the high side of the gravity separator.
  - Crops cleaned: small-seeded legumes, beans, peas, lentils, etc.
  - Contaminants removed: sand, dirt, gravel, small rocks, etc.

Scarifier

- ***Basis of separation:*** Used as pre-cleaning machine mostly for seed legumes.

- ***Function:*** It scratches the hard seed coat by forcing the seed against an abrasive surface.

- ***Common use:*** Softens seed coat and reduces hardseededness.

Fig. 84. Scarifier (Laboratory model)

Questions

1. How does a spiral machine separate seed? Why is it used, and for which crops?
2. Draw a spiral separator.
3. What are the different fractions obtained from spiral separation?
4. The roll mill separates seed by what differences?
5. For which crop seed is the roll mill used?
6. How does the roll mill function?
7. What is the purpose of using the color separator in seed processing? Describe how separation is made.
8. What is the principle used by the magnetic separator to separate seed? What is added to seed before magnetic separation?
9. What is the purpose of using the stoner? Where is it placed in the processing line?
10. What cleaning operations are required before a stoner can be used?

SEED BLENDING

Why seed blending

It is expected that seeds from different bags within a lot, or from different positions within a single bag are uniform in germination, purity, size, etc. However, in practice, there is no absolute uniformity but there is always some variation. Blending minimizes this variation and makes sure that each bag meets the quality standards.

The blending operation mixes the seed mass so that all constituents are present in each bag in the same proportions they were introduced into the mixture.

Blending is used to :
- ***Bulk together small seed lots*** from many small farmers to form an economic lot size.
- ***Get all bags of a seed lot uniform in composition.***
- ***Upgrade low quality seed lots***, mix small grower lots of uniform quality, to get uniform large lots.

Principles of seed blending

The lots to be blended should have comparable characteristics as much as possible.

- ***Do not blend seeds that differ in physical characteristics***: blending depends on the physical properties of the seed, such as size, weight, shape, and surface texture. The greater the difference between the constituents, the less chance there is for uniformity to be achieved because they will segregate again after blending has been done.
- ***Do not blend to save low-quality seed.***
- ***Do not blend seed of different crops/varieties***.

Blending equipment

There are two types of blending equipment: batch blenders and continuous flow blenders.

Batch blenders: They have the advantage to blend vertically and horizontally. However, they have limited capacity and can handle only as much seed as the blender can contain.

Equipment used:
- Rotary drum blenders (baffles, tilted drum, etc.).
- Conical mixers.
- Vertical spiral conveyor blenders (vertical auger in center of mixing chamber).
- Planetary vertical batch blenders (off-center paddles stir, mix).
- Bin blenders of special emptying designs (several discharges, located in different places).

Continuous flow blenders: These are not limited by capacity; blend seed flowing through the blender. However, they can blend only horizontally; cannot blend top/bottom (front/back) in a lot.

Equipment used:

- Continuous centrifugal blender (divides seed into several streams, then re-blends them).
- Horizontal spiral, ribbon, blade, etc., auger-type mixers (like an auger, blend seed as they pass through).
- Bin feeding devices (feeds seed into bin in layers, instead of at one point).
- Multiple bins to feed seed together into a mixer/blender (seed from different bins flow into a continuous blender).

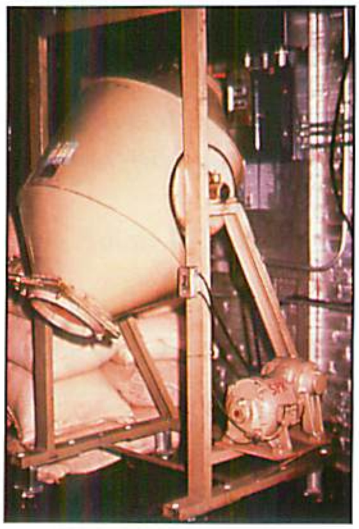


Fig. 85. Blending equipment

How to determine amounts of seed to blend together

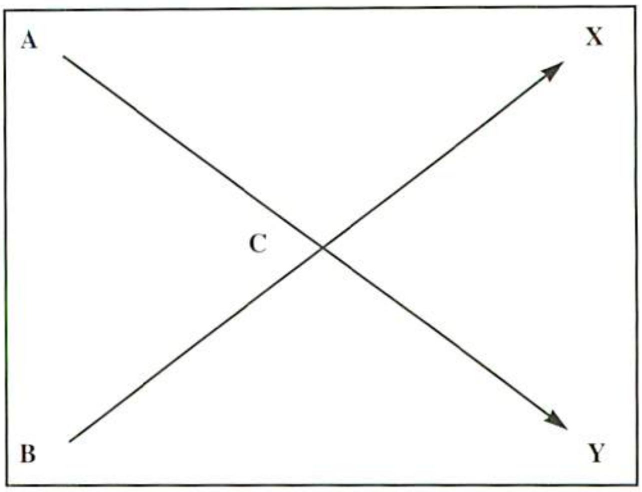
Calculation of the amount of seed to be mixed together to get a uniform seed lot depends on the quality of the sub-lots to be blended:

- If the sub-lots are uniform in quality, there is no problem. Just pour them in together at about the same ratio.
- If the sub-lots are not uniform in quality, use the Pearson Square to calculate ratios/parts of each sub-lot to pour in together.

How to use Pearson Square

How many parts of lot 1 with A quality and lot 2 with B quality to blend to get a seed lot 3 with final C quality.

1. Draw a square and put the subject quality feature (e.g., germination %, purity) of the lot in the following order:
   - Lot 1 on the upper left-hand corner of the square.
   - Lot 2 on the bottom left-hand corner of the square.
   - Lot 3 in the center of the square.
2. Always put the seed lot with higher quality at the top of the square and the seed lot with lower quality at the bottom of the square. Place the desired quality level of the final lot in the center of the square.
3. Draw lines diagonally across the square, from each lot number.
4. Subtract diagonally the number in the center from the numbers on the left-hand corners and put the results on the opposite right-hand corners.
5. The numbers placed on the right-hand corners are the number of parts of the seed lot that can be blended together to produce the final seed lot.



Where:
- A and B, any desired quality component (% germination, purity, specific weight)
- X= (C - B), number of parts/ratio of seed lot A
- Y= (A - C), number of parts/ratio of seed lot B

So, lot C will have X parts of lot A and Y parts of lot B.

Final test

To make sure the obtained lot truly meets standards after blending different seed lots:
- Take several samples from different parts of the lot (different groups of bags).
- Analyze/test them separately.

Questions

Define blending and state when it is needed.

Exercises:

1. *Blending two lots to get a specific final germination or purity.*
   How many parts of each lot to blend so the final lot has 80% germination? Lot 1: 60% germination; lot 2: 90% germination.

2. *Blending two lots, using one lot of known weight, to get a final lot of specific quality?*
   Lot 1: 500 kg with germination of 60%. How much of lot 2, which has a germination of 90%, should one blend with lot 1 to get a final lot with 80% germination?

3. *How much of each sub-lot to blend to get a final lot of a specific amount and specific quality?*
   How much of lot 1 (18 kg/hl) and how much of lot 2 (13 kg/hl) should one mix together to get a lot of 1000 kg with test weight of 16 kg/hl?

4. *Blending several lots to get a final lot of specific quality.*
   How much of each of the following sub-lots should one blend together so the final lot has 86% germination? Lot 1= 98%, lot 2= 96%, lot 3= 94%, lot 4= 72%, lot 5= 76%, and lot 6= 80% germination.

Note: You must have the same number of small lots which are *above* and *below* the desired quality level.

SEED TREATMENT

What is seed treatment?

In contrast to drying, cleaning, and grading, which eliminates extra moisture and impurities from the seed, treatment adds a certain amount of dressing chemical to the seed.

Seed treatment takes place after all the other operations are completed. It mainly implies coating of the seed with an insecticide and/or fungicide to protect the germinating seed, the resulting seedling, and/or the plant.

Why seed treatment

Seed-borne pathogens/pests reduce the germination of seed, prevent development of young seedlings and/or result in infected plants and yield losses. Therefore, seeds are treated to promote good seedling establishment and early plant growth, to avoid the spread of seed-borne diseases, and to minimize yield losses.

Seed treatment may benefit the seed in four main ways:

- ***Protects seed*** while in storage.
- ***Reduces or eliminates primary seed-borne inoculum*** on/in the seed and nearby soil.
- ***Protects healthy seed*** against soil-borne organisms, including insects, prior to, and during germination.
- ***Protects the emerging seedlings*** against diseases and insects during early growth, when they are highly susceptible to attack. Sometimes, protects the plant against foliage diseases.

Remarks: Seed treatment is mainly effective against fungal pathogens and insects, but is less effective against bacterial, nematode and viral pathogens. It does not improve germination of low germinating or dead seed but can reduce its germination if incorrectly applied.

Seed treatment could have negative effect

Pesticides are generally poisonous to fungi and insects, but in certain circumstances they can be also poisonous to seed. This may reduce germination and cause seedlings abnormality.

The harmful effect of chemical treatment on seed depends on:

- Dosage; overdosing causes toxicity.
- Moisture content of the seed; high moisture content intensifies the trouble rather than being the cause of it.
- State of the seed coat; injuries in seed coats enhance the absorption of the pesticide by the embryo.
- Storage conditions; long storage periods, high moisture content and high temperatures intensify the negative pesticide effect.

Note: Do not treat seed which is expected to be stored beyond the following season. Treat only the needed amount just before delivery. The reason is that treated seed not sold for seed purposes cannot be sold as grain.

Formulation of seed treatment

A seed treatment chemical is composed of three fractions: (i) active material, (ii) carrier (liquid or powder) to dilute the active material, and (iii) additive, which ensures the stability of the product during storage and application. These three fractions may be used in different combinations called formulations.

Two main categories of seed treatment formulations can be distinguished:

Dry treatment: usually consists of the active ingredient in the inert dust.

- *Advantages*: easy to apply; does not penetrate the seed so less risk of phytotoxicity.
- *Disadvantages*: does not adhere adequately to the seed; loss of chemical during handling and hazardous to operators and to environment.

Wet treatment:

- *Suspension:* a wetting agent may be added to the powder; usually water is added to form a slurry.
  - *Advantages*: possibility of applying more and different material at a time; less hazardous to operators.
  - *Disadvantages*: requires drying the seed after treatment; risk of phytotoxicity; deteriorates easily during storage. Also, needs mixing operation of dry powder and water or else increased transport costs if bought ready mixed.
- *True liquid:* the active ingredient is dissolved in an organic solvent.
  - *Advantages*: easy to apply; chemical adheres well to the seed; less hazardous to operators.
  - *Disadvantages*: irregular and uneven distribution of the chemical on all seeds; risk of phytotoxicity.
- *Coating:* the active ingredient is suspended in a liquid polymer material.
  - *Advantages*: chemical binds tightly to the seed; possibility of applying many layers of different chemicals; possibility of adding attractive colors; safe to operators.
  - *Disadvantage*: expensive.

Contact or systemic chemical?

It is essential to know the mode of infection, in order to understand the effect of a treatment and choose the proper seed treatment. Two types of pathogens can be distinguished:

- ***External contamination***: pathogens adhere to the external surface of seed. Seeds are usually not infected but transmit pathogens to the seedling after planting (e.g., common bunt caused by *Tilletia* spp., flag smut by *Urocystis agropyri*). Healthy seed may also be infected from contaminated seed. Use contact fungicides.

- *Internal infection*: pathogens infect the internal parts of seed, embryo (e.g, loose smuts caused by *Ustilago* spp.or *Ascochyta* spp.). Infected seed does not show any symptoms. Use systemic fungicide.

What is a good seed fungicide?

A good seed treatment fungicide should be:

- Highly effective and toxic to the pathogen but non-injurious to the seed and the future plant at recommended dosage
- Cheap and easy to obtain
- Convenient to handle and easy to apply
- Harmless to humans, livestock, and wildlife
- Non-explosive and non-corrosive to equipment
- Stable for relatively long periods of time during seed storage.

Equipment for applying seed treatments

A wide range of equipment may be used to apply seed treatment.

Farm treaters

- *Shovel*: spread seed on a clean, dry surface in a thin layer. Dilute the proper amount of chemical with water and sprinkle it over the seed mass. Mix thoroughly into the seed mass using a shovel.
- *Hand- or motor-driven drum*: place the seed and the proper amount of chemical in the drum and rotate slowly until all seeds are covered.
- *Revolving drum* (e.g., concrete mixer): measured amount of chemical is continuously applied to the seed using a vibrating feeder (in the case of dry chemical) and the seed and chemical are blended together in a coating chamber.

Note: Uneven mixing and incorrect dosage is always a problem with this kind of equipment. Over-dosage not only costs more, but also damages seed viability.

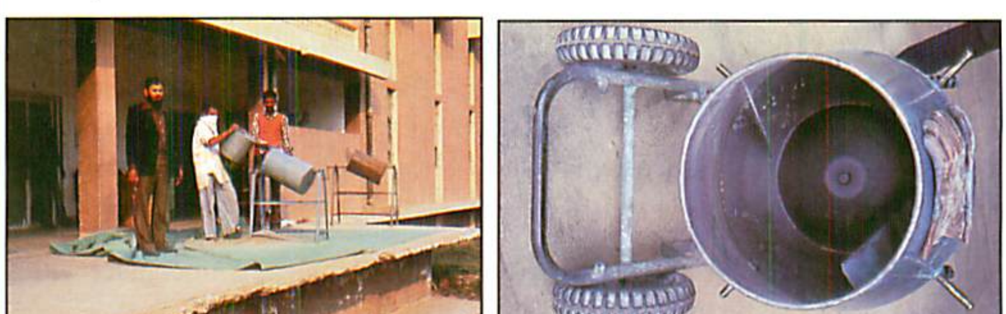


Fig. 86. Types and principles of farm drum seed treater

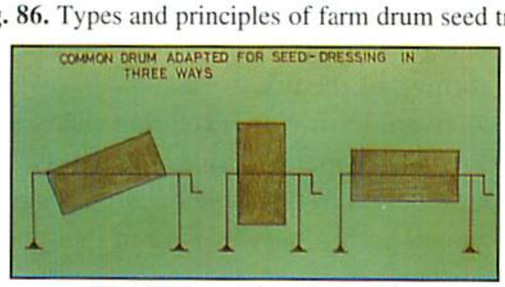


Fig. 87. Revolving drum mixer

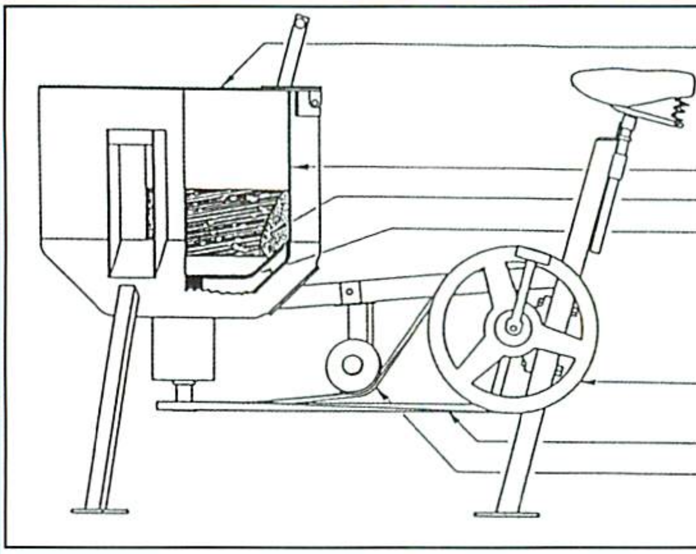


Fig. 88. Bike rotor treater

Commercial treaters

Commercial seed treaters apply precise pre-determined quantities of chemical to pre-determined quantities of seeds (e.g., milligrams or milliliters of pesticides per kilogram of seed). In general, they are composed of two main systems.

- *Application systems*: may be classified into the flowing categories:
  - Dust application: based on compressed air or simple mechanical dust conveying devices.
  - Liquid application: includes three systems:
    1. Low pressure-pumping system to discharge the pesticide solution through plastic tubes to a low-efficiency mixing system such as rotating drums
    2. Low pressure-pumping system to discharge the pesticide solution directly to a high-efficiency spray system such as the spinning disc
    3. High-pressure pumping system to discharge the pesticide solution through metal tubes and microscopic nozzles (liquid atomizing system) to a low-efficiency mixing system such as conveying belts

- *Mixing systems*: place where chemical is in contact with seed. Two main types can be distinguished:
  - A single drum tilted toward its end and rotating around a central or an eccentric axis in which the seed and the chemical are mixed by repeated turning of the drum.
  - A fixed drum with a rotating shaft in the center which carries plastic brushes or metal devices to increase the efficiency of mixing. Seed is discharged to this type of mixing system through a rotating disc over which preliminary mixing of the incoming seed and the pesticide (as a mist) takes place.

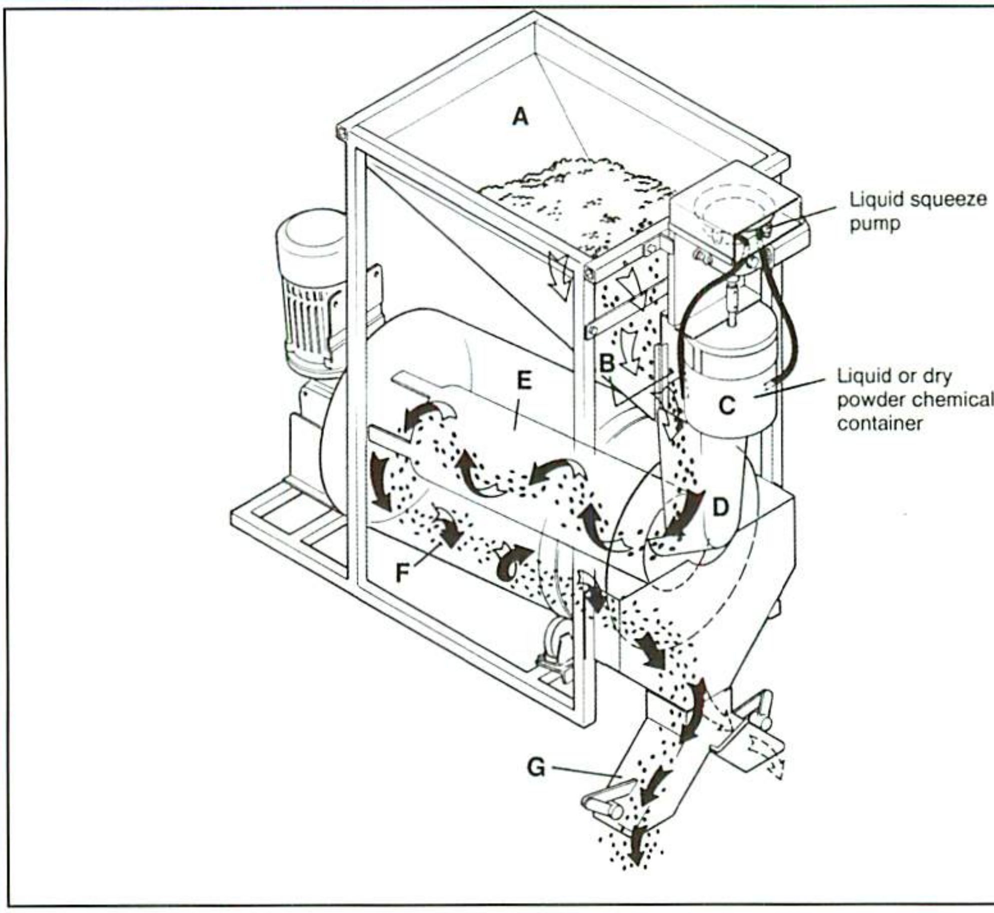


Fig. 89. Typical commercial treater

Fig. 90. Auger treaters

Fig. 91. Different parts of an auger seed treater. Hopper (A), auger (B), and the helices inside the auger (C)

Fig. 92. Laboratory seed treater

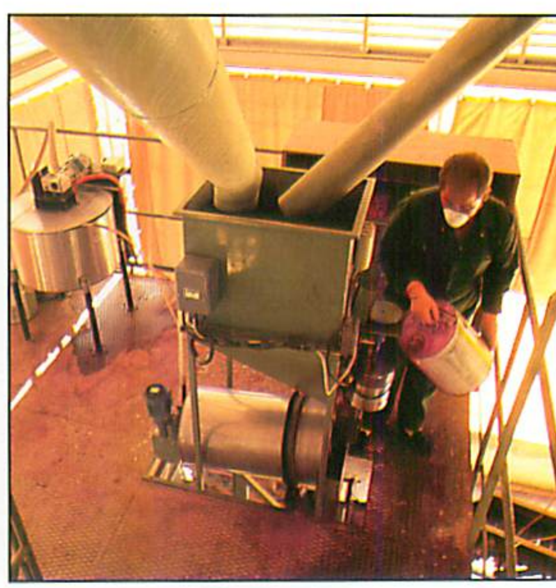


Fig. 93. Commercial seed treater

Calibrate seed treater before use

Always calibrate the treater before use to guarantee that the seed will receive the appropriate amount of chemical and the application is uniform.

Care must be taken to treat seed at the correct dosage rate. Overdose may kill or reduce germination. Always check that each seed receives a proper application of the treatment. Some seed receive none and it is not protected, and some seed receive more which may cause reduction in germination.

Safety (identification of treated-seed)

Pesticides are potentially dangerous and have to be used with care. During treatment application, you should:

- Operate the ventilators
- Wear protective clothing (mask, rubber gloves)
- Eat, drink, or smoke while working
- Wash thoroughly after each operation (wash off any splashes on skin immediately)
- Flatten and bury empty chemical packages (drums, cans). Never wash or re-use for any other purpose.

Most products used to treat seed are poisonous. Extreme care is required to ensure that treated seed is never used as human or animal food.

Treated seed should be identified:

- ***By incorporating a dye*** into the treatment to give the seed a contrasting color. The brighter or more dirty-looking the color, the better the contrast is.

- ***By labeling the seed*** as ***poison-treated*** with a special tag showing ***skull*** and ***crossbones***, ***name of the chemical*** used and the ***antidote*** in case the chemical is taken internally. Add warning statement such as "treated seed, not fit for human consumption."

Questions

1. Why do we treat seed before planting?

2. Do you have to treat all seeds at once or just the quantity of seed needed for sale?

3. Does a seed treatment improve germination of low quality seed?

4. How do you select the best fungicide?

5. What chemicals are used for treating seed in your country?

6. List some methods and equipment used to treat seed with chemicals.

7. How do you calibrate your seed treater?

8. How are treated seeds identified? Why?

SEED PACKAGING

Why are seeds packaged?

Packaging is the last operation in the processing line before seeds are stored or delivered. Packaging is essential for several reasons. It

- ***Facilitates transport*** and handling of seed
- ***Preserves the purity*** of seed and prevents contamination
- ***Protects seed*** from mechanical damage
- ***Preserves germination*** and vigor of the seed
- ***Allows proper seed storage***
- ***Facilitates distribution*** and dispatching of seed to farmers according to their needs
- ***Promotes*** seed trade.

Kind of material used for seed packaging

Different types of packaging material can be found in the market. These can be classified into three categories:

1. ***Moisture-vapor-permeable bags:*** permit free exchange of moisture between seed and the surrounding environment.

   - *Woven cloth bags*
   - *Jute bags:* natural fiber, strong, allow rough handling without seed loss, easy to sample by triers and to close, useful for seed trade, stack well in storage, easy to handle and to sew, convenient for in-bag drying. However, woven cloth bags are not resistant to rodents and birds, and applied pesticides (dust) may escape easily from the cells. Cost depends on the availability of the material in the country.
   - *Cotton bags:* same advantages as for jute bags but they are expensive and offer little protection against insects and rodents. More suitable for samples and small lots of valuable seeds.
   - *Polyethylene bags:* synthetic fiber, deteriorates easily if exposed to direct sunlight so they should be protected. Difficult to stack (bags may slide and fall down). Cost depends on the availability of the material in the country.
   - *Paper bags:* may be simple or multi-wall paper. Useful for smaller quantities and valuable seeds. Useful for seed trade. Not strong, so they may tear easily. More difficult to sample. Easily damaged by rain. Transmit moisture easily.

2. ***Moisture-resistant bags***

   - *Plastic film bags:* not moisture-proof but are moisture resistance. The most commonly used material is polyethylene and polyester. Resistant to puncturing, more expensive than fiber
   - *Jute bag:* laminated with thin polyethylene film
   - *Paper bag:* laminated with thin polyethylene film
   - *Cardboard:* protects physical quality

Moisture-vapor-proof containers

- *Paper bags with aluminum lining*
- *Aluminum foil bags:* for very small quantities of seed
- *Paper laminated from the outside or inside*
- *Tin cans:* used mainly for small quantities of seeds. Moisture content of the seed should be very low. Additional drying is required. Drying seeds to excessively low moisture content is difficult and expensive. Very dry seeds are more easily cracked or broken on handling. Very dry seed in vapor proof packages can be stored for 2-4 years in open storage. Protective against rodents and insects.

Type and size of the bags

Seed may be packed into containers or bags. Bags are universally used for most field crops seed. The size of the bag should take into consideration:

- The correct amount of seed needed by the farmer for planting
- The average man's capability to carry it during loading and unloading
- Ease in handling by the farmer during transport and planting.

Criteria for selection

Selection of suitable packaging material is dictated by several factors:

- ***Kind of seed*****:** value of the seed in relation to the cost of package (field crops, vegetable seed, flower seed)
- ***Amount of seed to be packaged*****:** amount needed by farmer for planting
- ***Package material*****:** type of material, tensile and bursting strength, and tearing resistance to preserve physical quality and withstand normal handling
- ***Cost and availability of packaging material*****:** locally made or imported material reliability of supply
- ***Moisture permeability*****:** permeable or sealed material
- ***Storage environment*****:** conditioned or non-conditioned storage
- ***Duration of storage*****:** short-, medium-, or long-term storage
- ***Weather conditions*****:** weather in the place where seed is stored, and that expected during shipment and shipping destination

In general, jute and cloth bags are used for seeds of cereals, pulses, and oil-crops. However, paper, aluminum foils and polyethylene bags are used for small quantities and high value crop seeds (vegetables and flowers).

In any case, the bag should be:
- Easy to handle, transport, and store
- Strong enough to avoid losses and to protect seed against contamination and mechanical damage.

How containers are closed

Seeds should be delivered in unopened bags to minimize risk of contamination. Closing depends on the type of package and material used:

- Cloth bags may be hand tied or sewed by hand or machine.
- Moisture-proof containers may be sealed by applying heat (polyethylene) or just closed by a sealing machine (tin cans).

Package labelling

Labels are used for two reasons:

- To provide information on seed being sold
- To promote seed sale.

Information on the label may include: crop, cultivar, % live seeds, purity, noxious weeds, seed treatment, etc. This information may be:

- Printed on a tag and attached to the bag or glued to tin cans, cardboard boxes
- Printed or stamped directly on the bag.

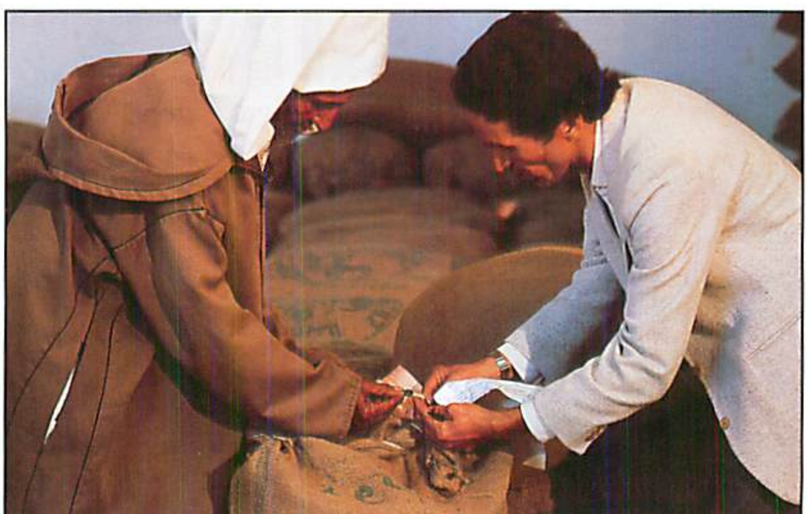


Fig. 94. A farmer checking seed label

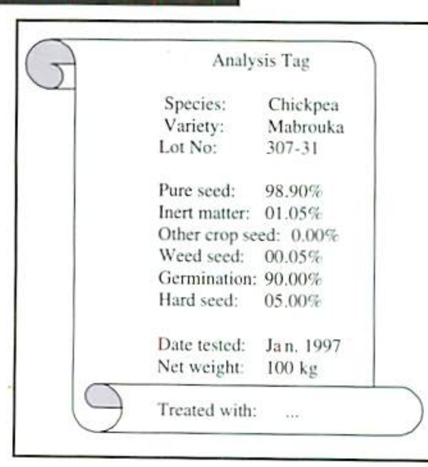


Fig. 95. Typical label

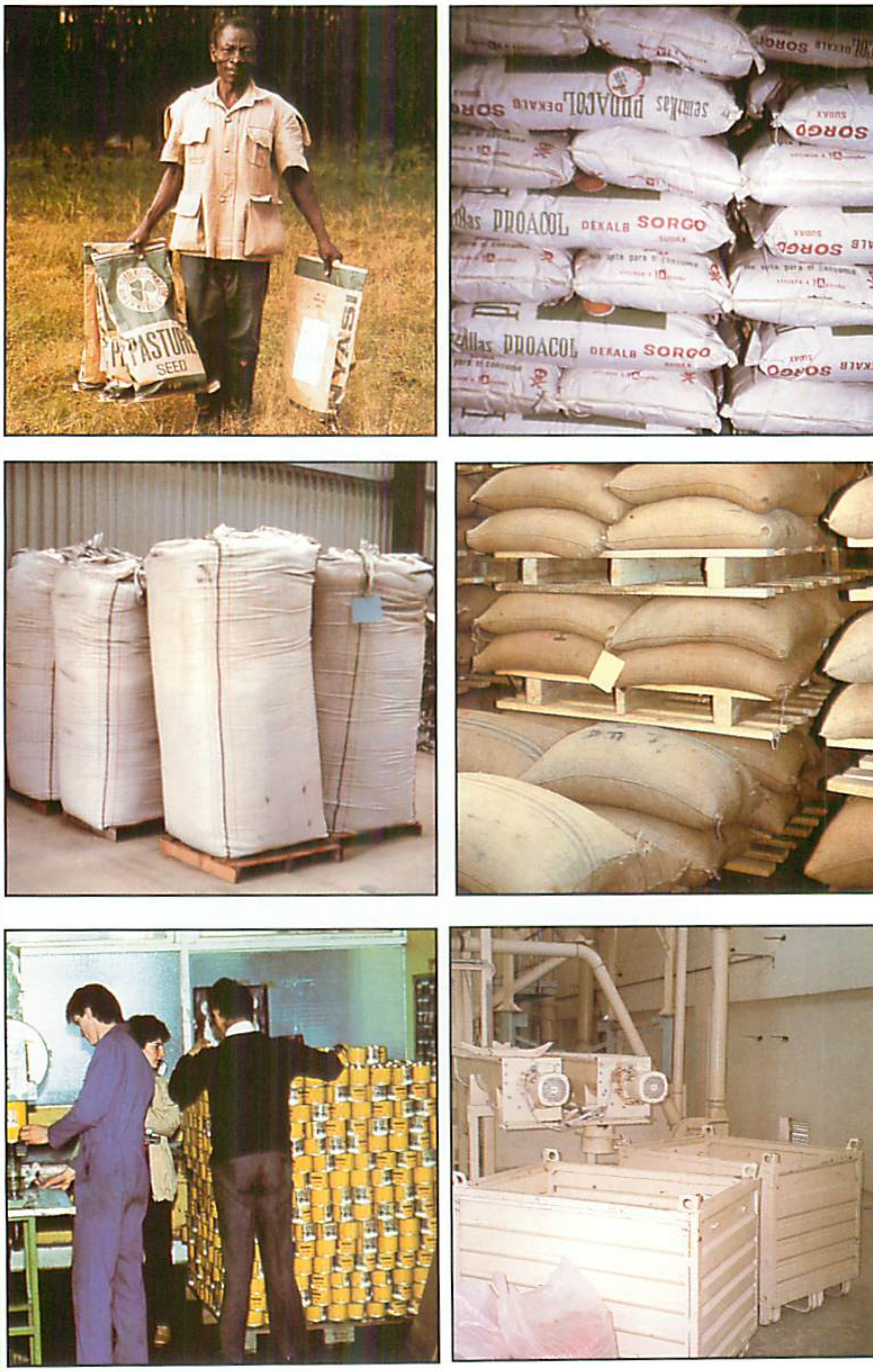


Fig. 96. Different packaging material and design

Questions

1. What are the functions of a seed package?

2. List the factors that influence the selection of packaging material.

3. What are the types of packaging material? List at least two advantages and two disadvantages for each type.

4. What is the importance of having a label on the bag?

SEED STORAGE

Storing seed

Storage starts in the field at seed maturation. It continues through harvest and during delivery to the processing plant, during processing, in transit from processing to distribution sites, and ends on the farm when the seed is planted.

During storage the viability and vigor of seed must be maintained at all times. Adequate facilities and conditions for storage are required to maintain seed quality so that seed reach the farmer with acceptable viability.

In a dry environment where relative humidity is naturally low, seed storage is not a problem. This applies to most of the WANA region. In contrast, adverse environmental conditions exist in the tropics, where temperature and relative humidity frequently exceed the accepted levels for safe storage. This requires special facilities and management to preserve the viability of stored seeds.

Seed storage periods

Seed is stored most of the time. It is stored in the field, on-farm, in the processing plant, during transport and handling, and at distribution centers (Fig. 88).

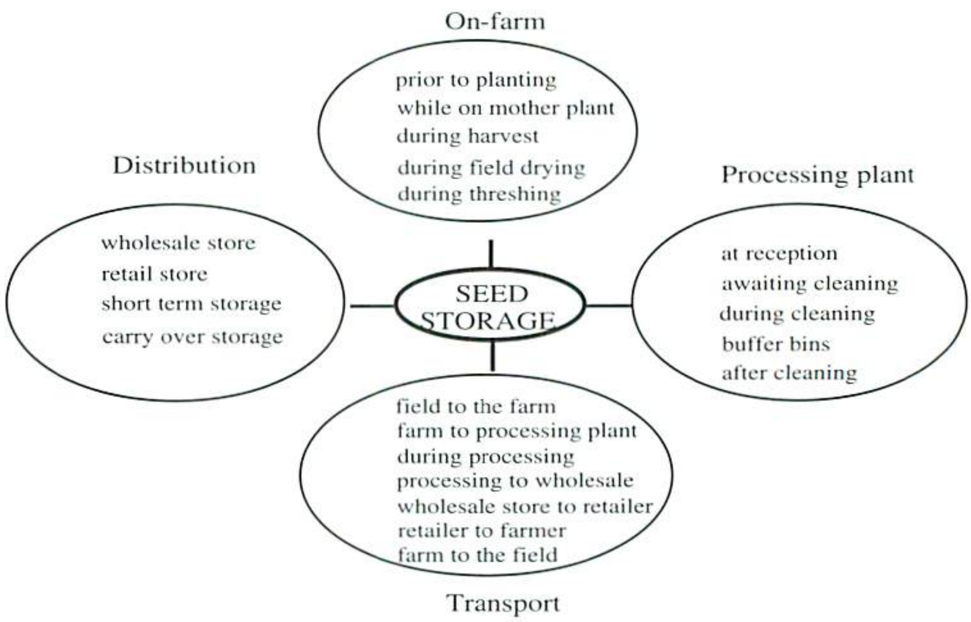


Fig. 97. Seed storage stages

Factors affecting seed viability

A number of factors can affect seed viability before and during harvest or during storage.

Pre-harvest factors

- *Provenance*: seeds obtained from different sources may show differences in viability behavior.
- *Pre-harvest and harvest environmental conditions*: adverse weather conditions (frost, excessive rainfall, drought,) prior to and during harvesting can impair seed viability.
- *Insect damage* and infestation with plant diseases
- *Contamination* with field fungi

Note: Seed which begin to deteriorate in the field usually do not store well.

Harvesting factors

- *Stage of maturity*: immature, shriveled seed do not store well
- *Mechanical injury* affects the storage life span
- *Heat damage* in the field during sun-drying.

Processing factors

- *Heat damage* during drying
- *Mechanical damage*
- *Insect infestation*

Storage factors

- *Genetic variation*: seed longevity is an inherited characteristic at both the species and cultivar levels.
- *Seed moisture, relative humidity, and temperature*: the higher these factors, the more rapidly the seed deteriorate.
- *Microflora and other organisms*: six types of organisms are associated with seeds in storage: bacteria, fungi, mites, insects, birds, and rodents. Their activity leads to damage which causes loss of vigor or viability. The activity of the first four organisms depends on temperature and moisture content of the seed and relative humidity of the environment.

Ideally, stored seed should be:

- Fully mature
- Uninjured
- Free of field fungi, insects, and other pests
- Unaffected by extreme temperatures and moisture conditions during ripening
- Of high initial quality.

Table 11. Seed response and risk at different levels of moisture content

Moisture content (%)	Reaction
40 - 80	Immature seed, still developing. Germination occurs.
18 - 40	Physiologically mature, but not yet at harvest maturity. Seed susceptible to mechanical injury, seed respiration rate is high, insects and molds are active, heating occurs High risk of deterioration. Germination occurs.
13 - 18	Reasonably safe for harvest, resistant to mechanical damage. Respiration still high and heating may occur. Mold and insect damage may occur.
10 - 13	Reasonably safe for short term storage of cereals under temperate climate conditions.
8 - 10	Seed susceptible to mechanical damage. Insect and mold activities are low. Safe for 1-3 years open storage under temperate climate conditions.
4 - 8	Safe for sealed storage.

Interaction between seed moisture content, temperature and relative humidity

Seed moisture content, temperature, and atmospheric relative humidity (RH) are the most important factors affecting the longevity and viability of stored seeds. In general, the higher these three factors are, the more rapid the seed deteriorates.

Seed moisture content is associated with ambient relative humidity. Seeds are hygroscopic; they absorb or lose moisture from or to the atmosphere until seed moisture content and atmospheric relative humidity reach equilibrium. Seeds reach a moisture content equilibrium with the RH of the air, not with the absolute humidity. Equilibrium level varies according to:

- ***Ambient temperature:*** the lower the temperature, the higher the moisture content of seeds at a given relative humidity.
- ***Chemical composition of the seed:*** the equilibrium moisture contents of different seed lots at the same RH will not be the same. Seeds differ in their chemical composition (lipid, protein, starch). Oils do not absorb moisture, protein absorb the most water per unit of weight, and starch absorbs less than proteins.
- ***Hysteresis*** phenomenon.
- ***RH of the ambient air*** is the main determinant of the seed moisture content.

Table 12. Estimated grain equilibrium moisture content

Crop	T (°C)	Relative humidity (%)									
		10	20	30	40	50	60	70	80	90	100
Barley	5	4.7	6.9	8.7	10	12	13	15	18	22	31.0
	10	4.7	6.8	8.6	10	12	13	15	18	21	30.6
	15	4.6	6.7	8.5	10	11	13	15	18	21	30.3
	20	4.6	6.6	8.4	10	11	13	15	17	21	29.9
Beans (edible)	5	4.8	7.2	9.3	11	13	15	17	20	25	36.1
	10	4.8	7.1	9.2	11	13	15	17	20	24	35.7
	15	4.7	7.1	9.1	11	12	15	17	20	24	35.4
	20	4.7	7.0	9.0	10	12	14	17	20	24	35.0
Corn (yellow)	5	5.3	7.9	10.2	12	14	16	19	22	27	40.1
	10	5.0	7.5	9.7	11	13	16	18	21	26	38.3
	15	4.8	7.2	9.3	11	13	115	17	20	25	36.6
	20	4.6	6.9	8.9	10	12	14	17	20	24	35.2
Rice (rough)	5	6.5	8.9	10.7	12	14	15	17	19	23	30.5
	10	6.3	8.6	10.4	12	13	15	17	19	22	29.5
	15	6.1	8.3	10.0	11	13	14	16	18	21	28.6
	20	5.9	8.0	9.7	11	12	14	16	18	20	27.7
Sorghum	5	6.5	8.8	10.7	12	14	15	17	19	22	30.0
	10	6.4	8.7	10.5	12	13	15	17	19	22	29.5
	15	6.3	8.6	10.3	12	13	15	16	19	22	29.1
	20	6.2	8.4	10.2	11	13	14	16	18	21	28.6
Soybean	5	2.1	3.9	5.8	7.7	9.9	12	15	19	26	47.1
	10	2.0	3.8	5.6	7.5	9.6	12	15	19	25	45.8
	15	2.0	3.7	5.4	7.3	9.4	11	14	18	25	44.5
	20	1.9	3.6	5.3	7.1	9.1	11	14	18	24	43.3
Wheat (durum)	5	6.1	8.6	10.6	12	14	16	18	20	24	33.6
	10	5.9	8.3	10.3	12	13	15	17	20	23	32.7
	15	5.8	8.1	10.0	11	13	15	17	19	23	31.8
	20	5.6	7.9	9.7	11	13	14	16	19	22	31.0
Wheat (soft)	5	6.6	8.8	10.6	12	13	15	17	19	22	28.9
	10	6.4	8.6	10.3	11	13	14	16	18	21	28.1
	15	6.2	8.4	10.1	11	13	14	16	18	20	27.4
	20	6.1	8.2	9.8	11	12	14	15	17	20	26.7

Rules of thumb:

- For each 1% reduction in moisture content, the storage life of seed is doubled, when seed moisture content is between 5 and 14%.
- For each 5°C lowering of storage temperature, the storage life of the seed is doubled, when temperatures are between 0 and 50°C.

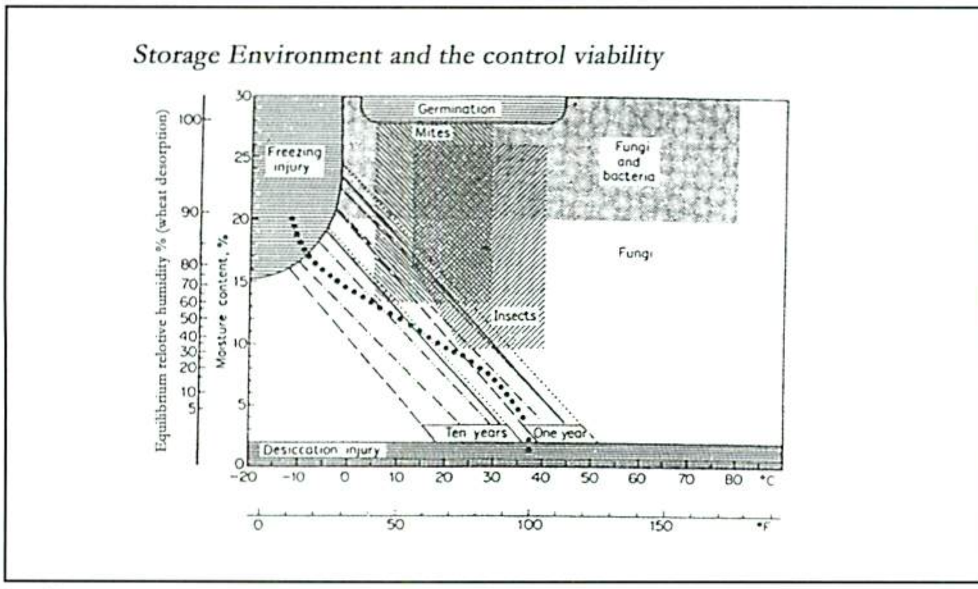


Fig. 98. Relationship between seed moisture content and storage problems at different temperatures (Roberts, 1972).

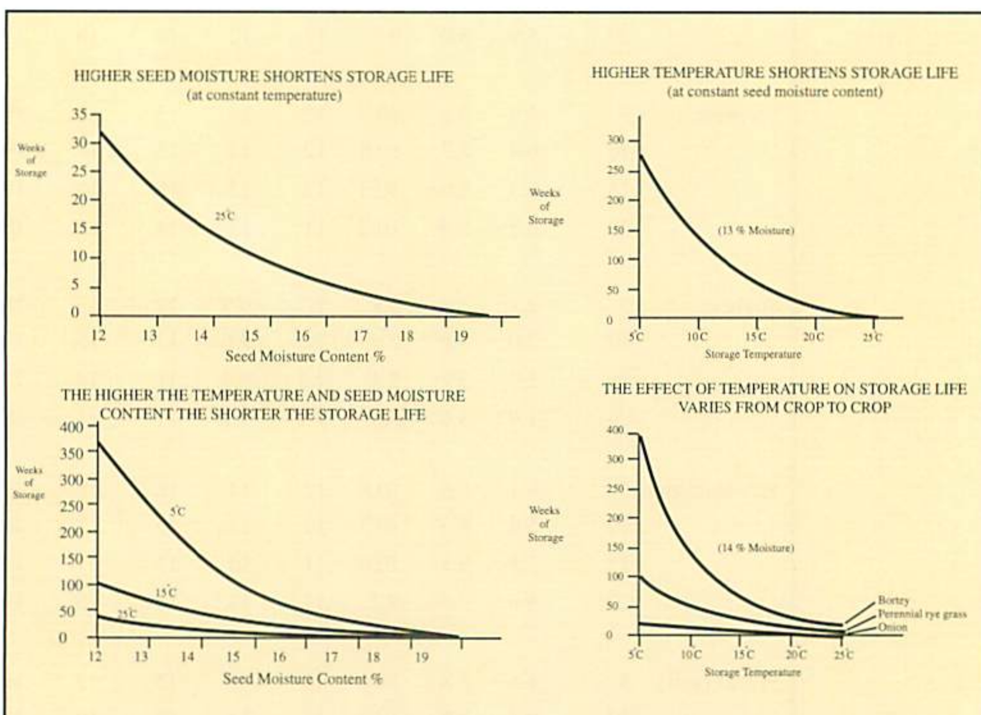


Fig. 99. Relationship between moisture content, temperature, and RH(Douglas 1980)

Seed storage fungi

Infestation, growth, and reproduction of both storage microflora and insects are strongly influenced by seed moisture content, ambient temperature, and RH.

Fungi which attack seeds can be divided into two groups:

- ***Field fungi*****:** fungi that invade seeds developing on the plants in the field, or after the seeds have matured and the plants are either still standing or are cut but awaiting threshing.

- ***Storage fungi*****:** comprise two genera *Aspergillus* and *Penicillium*.

Field and storage fungi may result in seed deterioration:
- Decrease in germination
- Production of mycotoxins harmful to humans and animals
- Heating
- Discoloration
- Killing the germ
- Total seed decay and spoilage.

What are the basic requirements for the growth of seed storage pests?

Basic requirements for the growth of fungi are similar to those for the growth of other living organisms-food, water, favorable temperature, and suitable atmosphere. Microflora activity is related to RH rather than seed moisture content, because seed moisture content has equilibrium relationships with RH.

- Field fungi require a moisture content in equilibrium with RH of at least 90-95 % to grow (equivalent to seed moisture content of 25-35% for cereals).
- Storage fungi can grow on seed whose moisture content is in equilibrium with RH of 70 to 85% for *Aspergillus* and 80 to 90% for *Penicillium* species. The activity of most serious storage fungi decreases rapidly as the RH drops below 50% and stops at less than 35%.
- Storage bacteria require at least 90% RH for growth, so it is hardly necessary to consider them.
- With regard to the effect of temperature on the growth of microflora, certain organisms can grow at –8°C, while others grow at temperatures as high as 80°C.
- There is little insect activity at seed moisture content below 8%.
- Favorable temperatures for insects and fungi activity and development are between 21 and 27°C. Most fungi, mites, and insects do not develop below 0, 5, and 15°C, respectively. At lower temperatures, little heat builds up inside the seed mass from the living and breathing of insects, molds, and seed itself.

The rate at which fungi develop on a seed lot depends greatly on the history and condition of the seed lot, the degree to which they are already invaded by fungi, insect activity, presence of damaged seed, and the type of seed.

Safe seed storage under temperate climate conditions

Measures to be taken in the field

- Harvest at complete seed maturity. Do not delay harvest.
- Harvest and thresh at optimum seed moisture content to minimize mechanical seed injury. If seed has high moisture, dry in the field.
- Deliver threshed seed immediately to processing plant.

Measures to be taken in the processing plant

- Check and determine seed moisture content. If high, dry immediately to safe moisture.
- Check for insect infestation. If any, proceed to fumigation.
- Test seed lot for germination and purity. Discard low quality seed lots.
- Pre-clean seed immediately upon reception; delay creates problems. Seed containing an appreciable amount of foreign material is more subject to damage by storage fungi. In most cases, insect infestation takes place while seeds are kept in pre-processing storage structures. Also, dirty seed deteriorate more rapidly than cleaned seed.
- Use new bags to avoid both insect infestation and mechanical mixtures. If old bags are used, they should be thoroughly cleaned and sprayed with an insecticide or fumigated.

Measures to be taken before storage

- Clean all storage areas before use. All storage structures should be cleaned, then sprayed with an insecticide (e.g., Malathion, 1 part in 25 parts of water at a rate of 5 liters/100 m^2).
- Fumigate raw seeds at reception, in particular seed of pulses where insect infestation (bruchids) comes from the field.
- Processed seed should be kept separate from unprocessed or carry-over seed.

Measures to be taken during storage

- Store cleaned and non-cleaned seed well apart.
- Store different types of seeds, in particular, pulses and cereals well apart for better insect management.
- Check and monitor seed conditions regularly.
- Inspect the incoming seed for insects:
  - Inspect stored seed at regular intervals for fungi, insects, rodents, and birds. Insects that grow inside the seed are often not seen until after

they have caused damage.
- Test seed for germination and viability (germination test, Tetrazolium test, accelerated aging test).
- Check the seed moisture content, relative humidity, and temperature weekly.

- Keep the storage area clean at all times.
- Careful seed handling: use pallets to stack bags, keep bags in good condition, each lot stored separately, label all seed bags and lots, keep records up-to-date, do not store rejects with seeds.
- Provide adequate ventilation.
- Fumigate and apply pest control periodically.

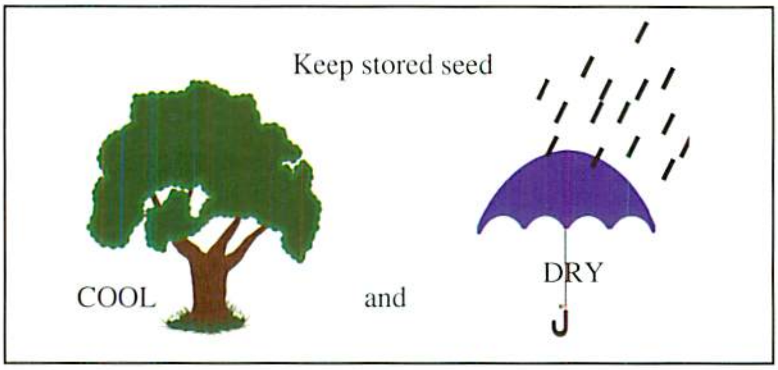


Fig. 100. Always keep stored seed cool and dry

Types of seed storage

There are two main types of seed storage:

- ***Controlled storage*** (conditioned): infrastructure designed to provide required dry, cool and protective conditions. Temperature and RH are fully controlled. Mainly used for long-term storage.

- ***Open storage*** (non-conditioned): seed stored under ambient conditions. No mechanical equipment needed, except ventilation fan may be used sometimes. Mainly used for short-term storage.

Managing seed stores

Even with the best storage facilities, seed deteriorate and costs are high if management procedures are inadequate to keep the seed in good condition and maintain favorable storage conditions.

Some practical management recommendations:

- ***Seed lot identity:*** if identity of a seed lot is lost, its value is lost. Maintain seed identity by: (i) identifying every bag with secure and complete labels, and (ii) dividing the storage into small and numbered areas (use painted lines on the floor).

- ***Seed purity:*** avoid contamination and mixture of seeds. Prevent contamination by: (i) keeping bags in good conditions and in their correct lots and assigned area, (ii) avoiding scattering of seeds, and (iii) stacking each seed lot by itself to avoid mixtures.

- ***Stacking:*** proper stacking is an important factor in storage management. It ensures efficient storage capacity and prevents damage to seed. Improper stack height may cause mechanical damage to seed at the bottom due to pressure or weight and to seed at the top if bags fall or dropped off the stack. Also, improper stacking may cause poor ventilation around seed. Good stacking management includes: (i) proper ventilation by providing adequate spacing between stacks, and between the stack's walls and the ceiling, (ii) not stacking bags directly on the floor or in piles, usually stacking bags on the pallets, and (iii) stacking bags on pallets in a pattern which ties the bags together so they do not fall or slide.

- ***Carry-over:*** carry-overs must be managed to minimize deterioration. Proper management of carry-overs includes: (i) calculating the anticipated carry-over at harvest and immediately store it under adequate storage conditions, (ii) carrying-over only lots of high seed viability and vigor, and (iii) selling immediately those lots with relatively low viability and vigor.

- ***General store management:*** this is the task of the storekeeper. He should manage the store properly, keep it in good condition, and make sure all activities are carried out properly and completely at the right time.

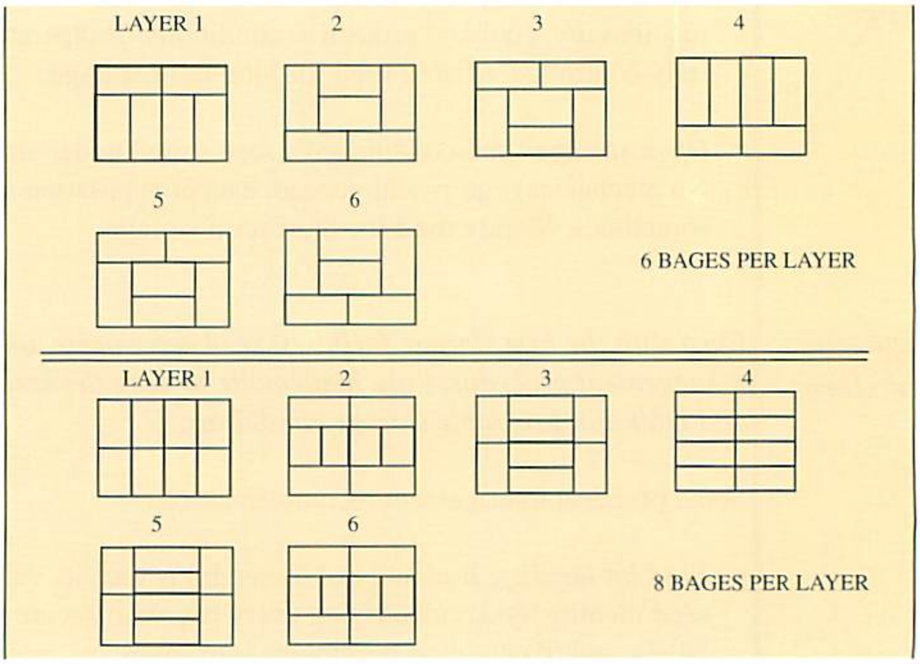


Fig. 101. Stacking patterns for different layers of bags. Six layers of bags is considered the maximum to stack safely on a pallet.

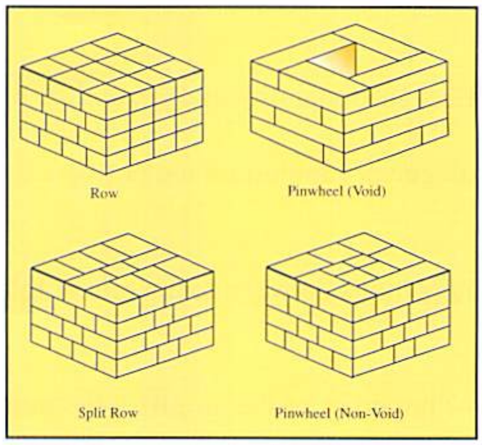


Fig. 102. Stacking patterns for different layers of bags

Records and reports

The storage manager should keep accurate up to date records on a daily basis.

Records

The following information should be kept up to date on a separate card for each lot: lot number, crop and variety, year produced, initial total weight and total number of bags, weight of each seed bag, quality test dates and results, storage location, date and amount of each quantity sold and delivered, date and address of delivery, amount remaining after each sale, etc.

Reports

Up-to-date and regular reports should be made available to the seed firm manager and the marketing unit. This will allow the concerned unit to plan the marketing (move excess seed from one area to another). Reports should include: storage unit name and location, lot number, crop and variety, amount and dates of seed sales and delivery, destination address, seed quality information (germination and date of tests), etc.

Questions

1. What factors affect seed viability and storability, before and during storage?

2. Why is seed storage very important under tropical conditions as compared to temperate conditions?

3. What are the interactions between temperature, relative humidity, and moisture content of the seed?

4. Does the relative humidity of the air affect the moisture content of the stored seed? If yes, how?

5. What are the common storage fungi?

6. When temperature is increased by 5°C, the storage life of the seed is doubled, halved, or stays constant?

7. When seed moisture content is lowered by 1%, seed storage is doubled, halved, or stays constant?

8. What are the moisture levels for insect and mold activity?

9. How do you manage seed storage to prevent loss of viability?

INSECT PEST CONTROL

Types of storage pests

Several hundred insect species are present in nature and about 50 species cause harm to stored seed. Most of these belong to *Coleoptera* (beetles, grain borers), *Lepidoptera* (moths), *Sitophilus*, and bruchids. Most of them attack the seed coat and/or embryo, resulting in decreased germination or total destruction of the seed.

Infestation may start in the field prior to harvest and continue in the warehouse, or may take place while the seed is stored.

Example:
- Univoltines bruchids: one generation a year, infestation starts in the field; eggs cannot develop on dry seeds (*Bruchus lentis*).
- Multivoltines bruchids: several generations a year, infestation occurs in both field and store; eggs can develop on dry seeds (*Callosobruchus chinensis* and *C. maculatus*).

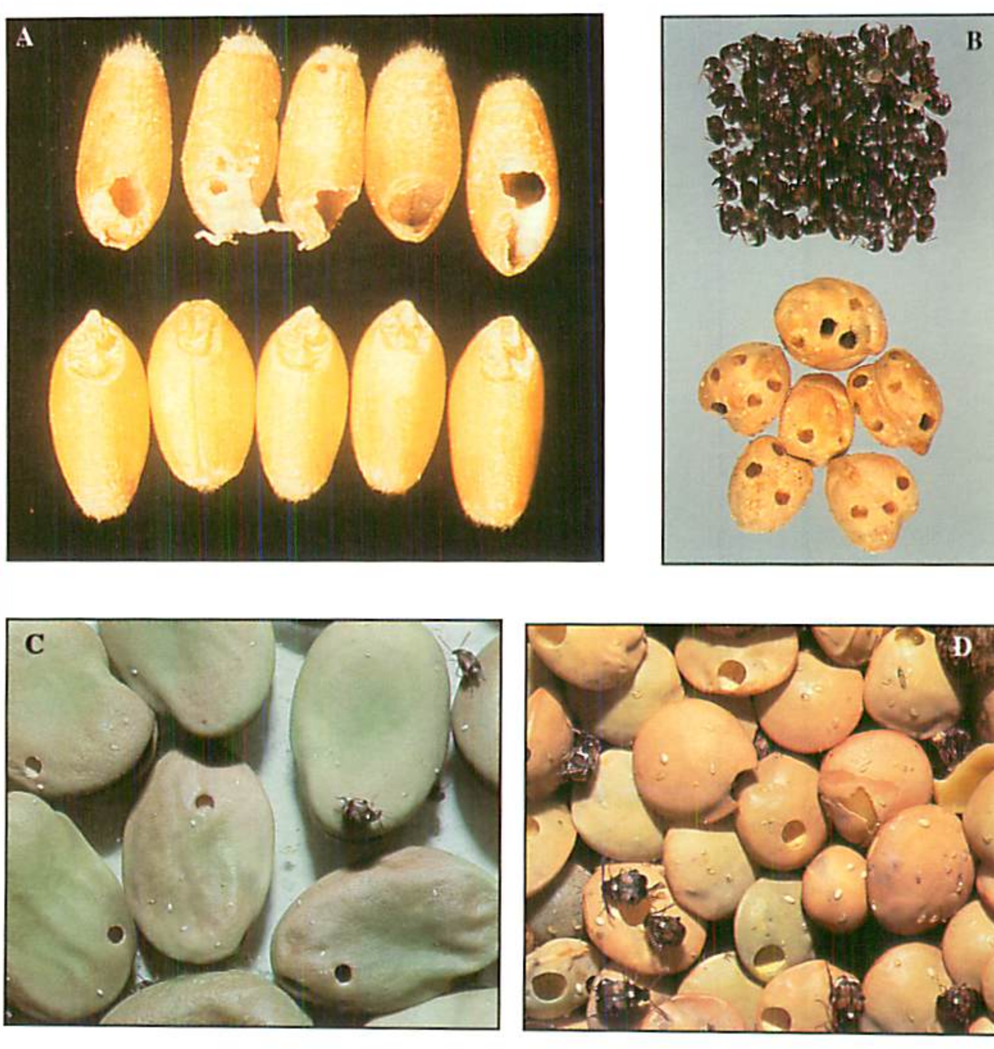


Fig. 103. Types of insect seed damage on wheat (A), chickpea (B), faba bean (C), and lentil (D)

Sources of infestation

There are several sources of infestation:

- Fields
- Carried-over commodities, waste, and rejects
- Agricultural machinery
- Seed processing plants
- Farm seed stores
- Means of transportation
- Alternative hibernation sites and hosts
- Re-used sacks.

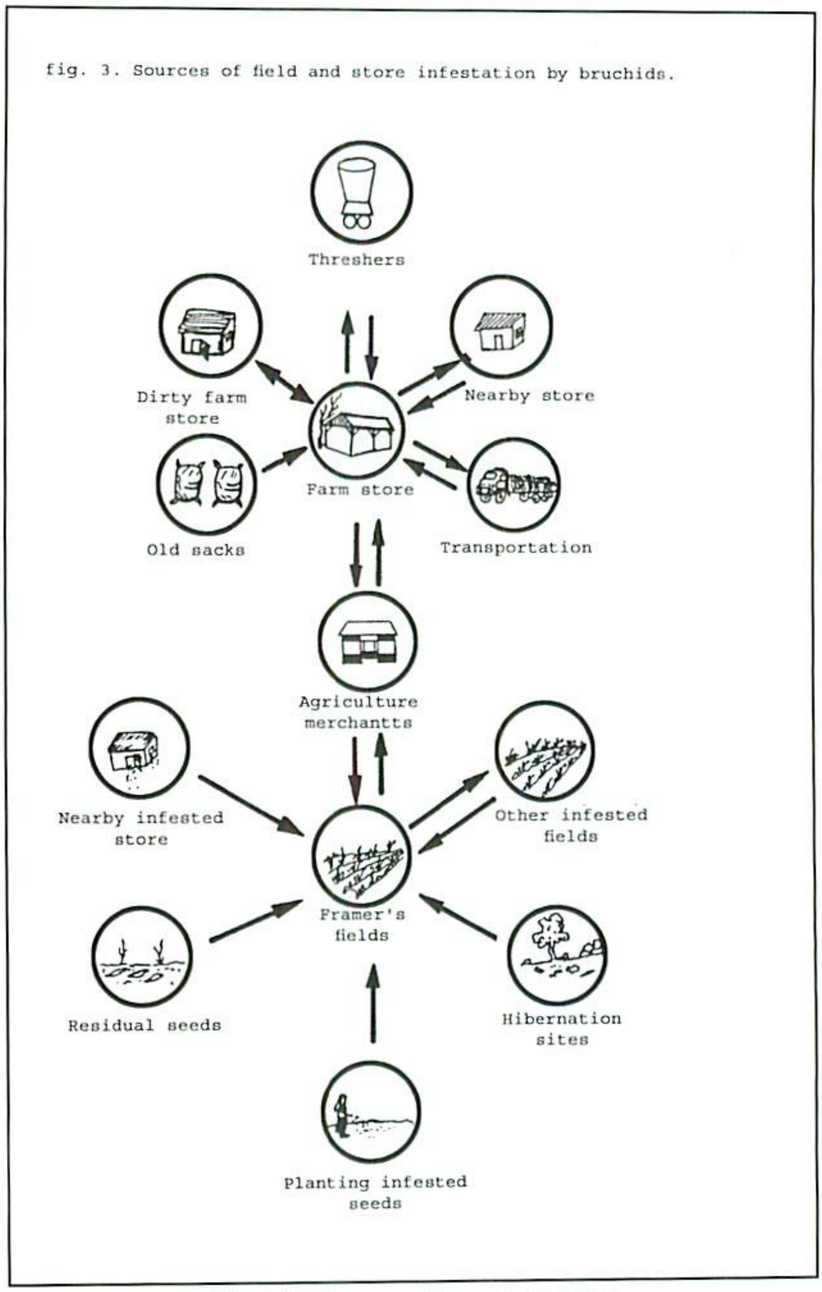


Fig. 104. Sources of insect infestation

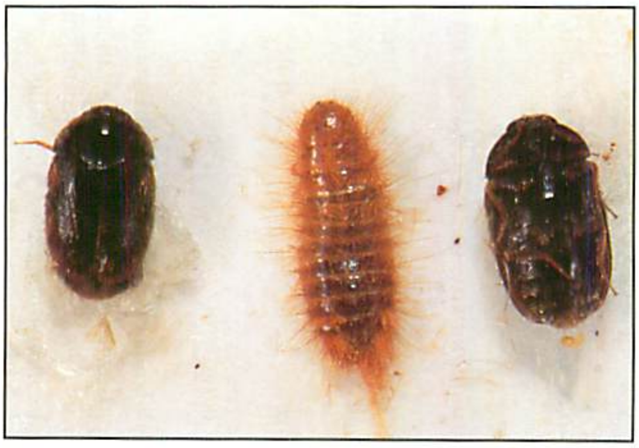
Insect identification (Table 13)

Oryzaephailus surinamensis L.

Tribolium castanium (left) and *T. confusum* (right)

Sitophilus orizea (left), *S. zeamais* (center) and *S. granarius(right).*

Rhizoporta dominica F.



Trogoderma granarium

Fig. 105. Insect identification (courtesy A.A. Niane)

Table 14. Major storage insects

Latin name	Common name	Type of seed	Location	Remarks
Sitophilus granarius	Grain weevil	Cereal grain	In warehouse Infestation may start in the field before harvest.	In temperate zones Makes grain warm and moist which leads to mould formation
Sitotroga cerealeila	Grain moth	Cereal grain	In warehouse Infestation may start in the field before harvest.	
Acanthoscelides obtectus	Bean beetle	All legume seed	In warehouse Infestation may start in the field before harvest.	Mainly in stores in temperate zones
Prostephanus truncatus	Larger grain borer	Maize	In warehouse Infestation may start in the field before harvest.	
Rhyzoptera dominica	Lesser grain borer	Cereals	Warehouse	Bores into grain eating interior and leaves a seed coat in place
Trogoderma granarium	Khapra beetle	Oilseeds, cereals	Warehouse	
Plodia interpunctella	Inadian-meal moth	All seeds	Warehouse, silos, processing plant	Only the germ is eaten
Acarus siro	Flour mite	Cereal grain	Warehouse, silos, processing plant	
Sitotroga cerealella	Angoumois grain moth	Cereals (wheat and maize)	Field, warehouse	
Niptus hololeucus	Golden spider beetle	Deteriorated grain		
Ptinus tectus boield	Australian spider beetle	Rice, legumes		
Carpophilus hemipterus	Dried fruit beetle	Oilseeds		Temperate zones
Tenebroides mauritanicus	Cadelle	Cereals	Warehouse, silos, processing plant Storage bins	
Trogoderma granarium	Khapra beetle	Cereals		
Cryptolestes ferrugineus	Rust-redgrain beetle	All types of grain		Germ feeder
Oryzaephilus surinamensis	Saw-toothed grain beetle	Oilseeds, cotton seeds processing plant	Warehouse, silos,	
Tribolium confusum	Confused flour beetle	All type of seeds		
Sitophilus oryzae	Lesser rice weevil	Cereals		

Key steps for insect control

To control insects in a processing plant or storage warehouse, follow these main steps:

- ***Monitoring:*** have an inspection or surveillance program which will yield prompt awareness of a possible problem (presence, importance, level, source) before it occurs.
- ***Identification:*** determine the extent and nature of the possible problem (species, type, level, mean of transmission).
- ***Control:*** devise a plan for controlling the problem (integration of all possible means to achieve good, cheap and safe pest control).

Monitoring and inspecting the situation

The easiest way to avoid damages by insect pests is to prevent their occurrence and spread. Inspection and monitoring are excellent tools for early detection of insect infestation.

Inspection for insect infestation

Inspection is an essential step in pest control. It must be frequent and thorough enough to detect the potential or actual problem, and to evaluate the extent of it. Inspection for insect infestation or potential infestation should be:

- Routinely scheduled (regular searching for insects, insect harborages, improper storage, sanitation, sanitary perimeters, spillage, outdoor areas)
- Conducted by trained and qualified staff. The person in charge should be familiar with stored-grain insects, including their habits and their reproductive cycle. He/she must have the proper equipment (flashlight, notebook, spatula, small bags, labels, small portable vacuum).

Note: Documentation is very important. Keep reports of previous inspections and review them from time to time. (Reports gives history, and allows inspectors to anticipate possible infestations).

Monitoring insect infestation: The monitoring procedures include:

- Visual observation: involves sampling, sifting, and counting
- Special treatment for latent infestation: chemicals, X-rays, and sound amplification
- Chemical attractants: synthetic pheromones and food attractants are valuable where insects are difficult to locate and their population hard to assess
- Bait stations: attractive sticky food, especially for moths and beetles
- Traps: light traps function as an early warning monitor system; nets, aspirators may be used
- Combination of the above methods is best.

Indication of the presence of insects in the seed store: take sample of seed, examine, and check for the presence of the following states:

- Decay or powder
- Clustering of seeds
- Bad smell
- Higher temperature in the seed bag than ambient air
- White spots on the seed coat, these are eggs
- Larvae skin.

Identification of the problem

When an infestation occurs, the most important element of control is the identification of the insect or insects involved.

The choice of control method depends on an accurate identification because different insects, no matter how much they may look alike, occasionally do not respond to control measures in the same manner.

Identifying the species of the insect and its habits, particularly its means of propagation, may lead to the source and solution of the problem.

What you should know:

- ***Insect metamorphosis:*** insects undergo dramatic changes during their life cycle before reaching adulthood. From eggs they hatch into small larvae, which feed and grow larger during successive larval stages; enter a relatively immobile stage called pupa, from which they emerge as winged, sexually-mature adults, bearing no resemblance to the earlier stages.
- ***Insect behavior***:(flier, crawler, night fliers, incidental non-pest species, temperature preference, nocturnal).
- ***Insect description***: source of documentation and necessary information, experts/entomologist in case of an emergency outbreak, etc.

Control of insect pests

Plan for control

- Define the magnitude of the problem.
- Select control treatment based on:
  - risk of potential for contamination,
  - physical facilities available,
  - risk to employees, and
  - cost.

What are the control methods?

- ***Sanitation:*** Very important because it breaks the life cycle of many pests and prevents further development. Sanitation is the basis of every good pest control program.

Outside sanitation and weed control reduce harborages and alternative hosts close to buildings. Older buildings provide a suitable environment for insect development. Cracks and crevices should be minimal.

- ***Physical and mechanical methods:*** The measures destroy the insect outright, and disrupt normal physiological and behavioral activities by other means than the use of chemicals (extremes of temperature, light traps).
- ***Exclusion:*** Exclusion of pests is an important part of prevention (physical barriers).
- ***Chemical treatment:*** Insecticides are an essential part of pest management programs. They are immediately effective, relatively inexpensive to use, and have a broad spectrum of application.
- ***Integrated pest management*** (IPM): Offers an array of procedures to manage insect pests systematically.

Insecticides are categorized into four classes.

- ***Fumigants:*** chemicals which at a given temperature and pressure are in a gaseous state which is toxic to insects (see section on fumigation).
- ***Protectants:*** chemical control agents that are applied to the commodity and provide intermediate or long-term protection against infestation by specific insect pests.
- ***Repellents:*** have characteristics which repel insect entry or movement across a treated area.
- ***Space treatment chemicals:*** control exposed insects and prevent entry of insects into non-infested storage area.

Table 14. Insecticides for control of storage pests

Active ingredient	Trade name	Manufacturer
Bromophos	Nexion	Celamerck
Dichlorovos	Nuvan, Nogos	Ciba Geigy
	Vapona	Shell
Fenitrothion	Folition	Bayer
	Sumithion	Sumitomo
Jodfenphos	Nuvanol	Ciba Geigy
Lindane	Nexit	Celamerck
	Perfektan	BASF
	Lindane	Gustafson
Malathion	Malathion	American Cyanamid
Metacrifos	Damfin	Ciba Geigy
Phoxim	Baythion	Bayer
Pirimiphos-methyl	Actellic	Zeneca
Tetrachlorvinphos	Gardona	Shell

Note: Formulations may be for spraying, dusting, fogging, etc.

Questions

1. What are the possible sources of insect infestation?
2. Describe the difference between the univoltines and multivoltines insects in food legume crops.
3. What are the key steps for insect control?
4. Define insect monitoring system.
5. What are the methods used to control insects in the storehouse?

SEED FUMIGATION

Characteristics of fumigants and fumigation

Fumigants are particularly useful for the control of storage insects because they diffuse and penetrate into places where other forms of control are impractical or impossible.

A fumigant is a chemical which, at required temperature and pressure, can exist in the gaseous state in sufficient concentration lethal to a given pest in a prescribed period of time. One disadvantage is that a fumigant is not persistent.

Fumigation is the process of applying gas under appropriate conditions to control the target organism. Fumigation is mainly used as a curative measure for stored seed and as a preventive measure for quarantine.

Types of fumigants

Two products, ***aluminum* or *magnesium phosphide*** and ***methyl bromide***, are mainly used in the seed production program.

Phostoxin (aluminium or magnesium phosphide): Gas released is called phosphine (PH_3).

Advantages
- Has excellent penetration capacity because of its small molecular weight (34.04).
- Easy to apply and handle, has a delayed release, and the gas is released gradually.
- Effective against most pests.
- Its weight is similar to that of the air; no fans are necessary to re-circulate the air and distribute the gas, so there is no need to place the phostoxin all over the seed stack.
- Has no influence on germination; seed can be treated repeatedly without danger of viability loss.
- Does not affect smell or taste of the fumigated product.
- No residues remain on the grain, so it can be safely used for food grain.

Disadvantages
- Inflammable at normal temperature can be explosive.
- Corrodes copper, silver, and gold.
- Requires a longer fumigation period than most other fumigants.

Methyl bromide

Advantages:
It has a quick action. After 12-24 hours the seed stack can be aerated. For this reason it is often used in seaports, where storage is expensive and products must be fumigated and evacuated as soon as possible (molecular wt. 94.95).

Disadvantages:
- Extremely toxic, odorless, and colorless.
- Residual effect in the seed.
- Accumulates in the human body.
- Heavier than air, must be applied from the top of the seed stack, and fans are needed to re-circulate the air.
- Negatively affects germination; can be used only once in seed lifetime.

Note: Because of all its disadvantages, methyl bromide should not be used as a fumigant, its use should be banned.

Fig. 106. Methyl bromide and Phostoxin being applied to seed stocks

Formulation of phosphine

Phosphine gas is produced on site from the following formulations:

- Tablets of 3 g, which release 1 g gas.
- Pellets of 0.6 g, which release 0.2 g gas.
- Bags of 34 g, which release 11.3 g gas.
- Plates of 100 g, which release 33 g gas.

Upon exposure to atmospheric moisture, the formulation releases the phosphine at a controlled rate and the gas diffuses through the enclosed space to kill insects.

$$AlP + 3H_2O \longrightarrow PH_3 + Al(OH)_3$$

Dosage and exposure

- **Concentration × *time method:*** This combination is generally used to ensure the success of a treatment. While it is a useful method for most fumigants such as methyl bromide, it cannot be easily used for phosphine. Although concentration and exposure time are still the main factors that determine the toxicity of the phosphine, the length of the exposure time is more important. Phosphine is a slow acting gas, it is slowly absorbed by insects, even at high concentrations. Therefore, high concentrations may not increase toxicity; in fact they may cause insects to go into a protective narcosis that will allow them to survive.

- ***Dosage is usually indicated by the manufacturer.*** The recommended dosage is 2.5 g phosphine gas per cubic meter (Phostoxin releases 1/3 of its weight as gas). Raising the dosage is not recommended, since it may negatively affect the treatment rather than improve it.
- ***Exposure time:*** Exposure time is also indicated by the manufacturer, but is a function of ambient temperature. The required fumigation period decreases as temperature increases. However, there is an absolute minimum time of 3 to 5 days. The longer the exposure, the better the treatment.

Conversions from g/m³ to ppm and vice versa

To convert grams per cubic meter (g/m^3) into parts per million by volume (ppm): divide the value in g/m^3 by the molecular weight of the gas and then multiply by 22.4, this will give you a value in cm^3 of gas per litre of air. If you multiply this value by 1000 you will have a value in ppm by volume or if you divide it by 10 you will get a value in % by volume.

Example 1: To convert 10 g/m^3 of Phosphine (molecular weight of PH_3 is 34.4) into cm^3 per litre, ppm or % by volume.
- $(10 / 34.4) \times 22.4 = 6.7$ cm^3 per litre
- $6.7 \times 1000 = 6700$ ppm by volume
- $6.7 / 10 = 0.67$ % by volume

Example 2: To convert 6700 ppm of Phosphine into g/m^3
- $6700 / 1000 = 6.7$ cm per litre
- $6.7 / 10 = 0.67$ % by volume
- $(6.7 \times 34.4) / 22.4 = 9.4$ g/m^3

What conditions are suitable for a successful application of phostoxin?

- **Location:** Fumigants are regularly applied in many different kinds of enclosures, from fumigation chambers to warehouses, other storage facilities, transportation facilities, and under gas-proof sheets. Generally, any space that can be enclosed and made gas-tight is suitable for fumigation.

- ***Humidity:***
- The air's relative humidity (RH) should not be lower than 30% because no gas will be released below 30% RH.
- At absolute 30 % RH, the exposure time should be at least 10 days.
- Provide water for dry areas; place containers of water under the fumigation sheet.

- ***Temperature:*** the effectiveness of treatment declines as the temperature falls.
- Under 5°C, do not fumigate.
- 5-10°C , 10 days exposure.
- 11-15°C, 8 days exposure.
- 16-20°C, 6 days exposure.
- Above 20°C, 4 to 5 days exposure.

- ***Hygienic conditions:***
- Fumigation should only be used under proper hygienic conditions.
- The possibility of re-infestation should be kept to a minimum. Remember that fumigants are not persistent.
- It is always preferable to spray the entire area with an insecticide before fumigation to kill flying insects outside the seed.
- After fumigation, the seed storage should be aerated and thoroughly cleaned with a brush or broom to remove all dead and dying insects. All removed trash should be kept far away from the seed storage so that insects cannot breed and re-infest the seed.
- To prevent re-infestation, use a surface treatment with Malathion. Dichlorovinyl dimethyl phosphate (Dichlorovos) can be used to treat processing sheds, because it has a volatile action and is effective against flying insects.

- ***Proper dosage/exposure time:*** For fumigant to be effective, it is necessary to maintain a certain concentration of the gas in a confined space for sufficient time to control all stages of the pest organism.

- ***Adequate sealing:***
- Fumigation sheets should be gas-tight, not damaged, and properly sealed to the floor. The best way is to use sand-snake bags or paper tape.
- The floor should be gas tight, preferably concrete.

Safety precautions

When handling and applying fumigants, it is essential to know their hazards, how to detect and measure concentrations of released gas in the air, and the precautions necessary to avoid hazards.

Safety rules:

- Store fumigants in a safe place, out of reach of ordinary personnel. Only authorized and trained personnel can do the job.
- Never work alone.
- Use a gas mask with the correct filter.
- DO NOT eat, drink, or smoke during or immeadiately after fumigation.
- Wash or shower after work.
- Place warning signs that indicate the fumigant being used, date of application, and person in charge.
- Make available first aid treatments to deal with any accidental exposure to the fumigant.
- Monitor gas: gas detection devices are necessary to determine the fumigant concentration during fumigation and to assess the safety of a structure during aeration.
- Fumigation should be conducted away from residence/office areas.
- Aerate after uncovering.

- Clean-up after fumigation: collect residue and throw in water. Bury empty containers.
- Remove warning signs after the fumigation process is completed.
- Fold and properly store fumigation sheets for next use.

Threshold limit values

Threshold limit values refer to gas concentration in the air under which a person is not affected.

Threshold limit values for principal fumigants:

Methyl bromide
- Threshold limit value: 5 ppm
- Approximate odor threshold: 0 ppm
- Skin absorption: slight
- Chronic effects: affects nervous system

Phosphine
- Threshold limit value: 0.3 ppm
- Approximate odor threshold: 1 ppm
- Skin absorption: negligible
- Chronic effects: none known

Note: These values should not be regarded as a base line between safe and dangerous concentration.

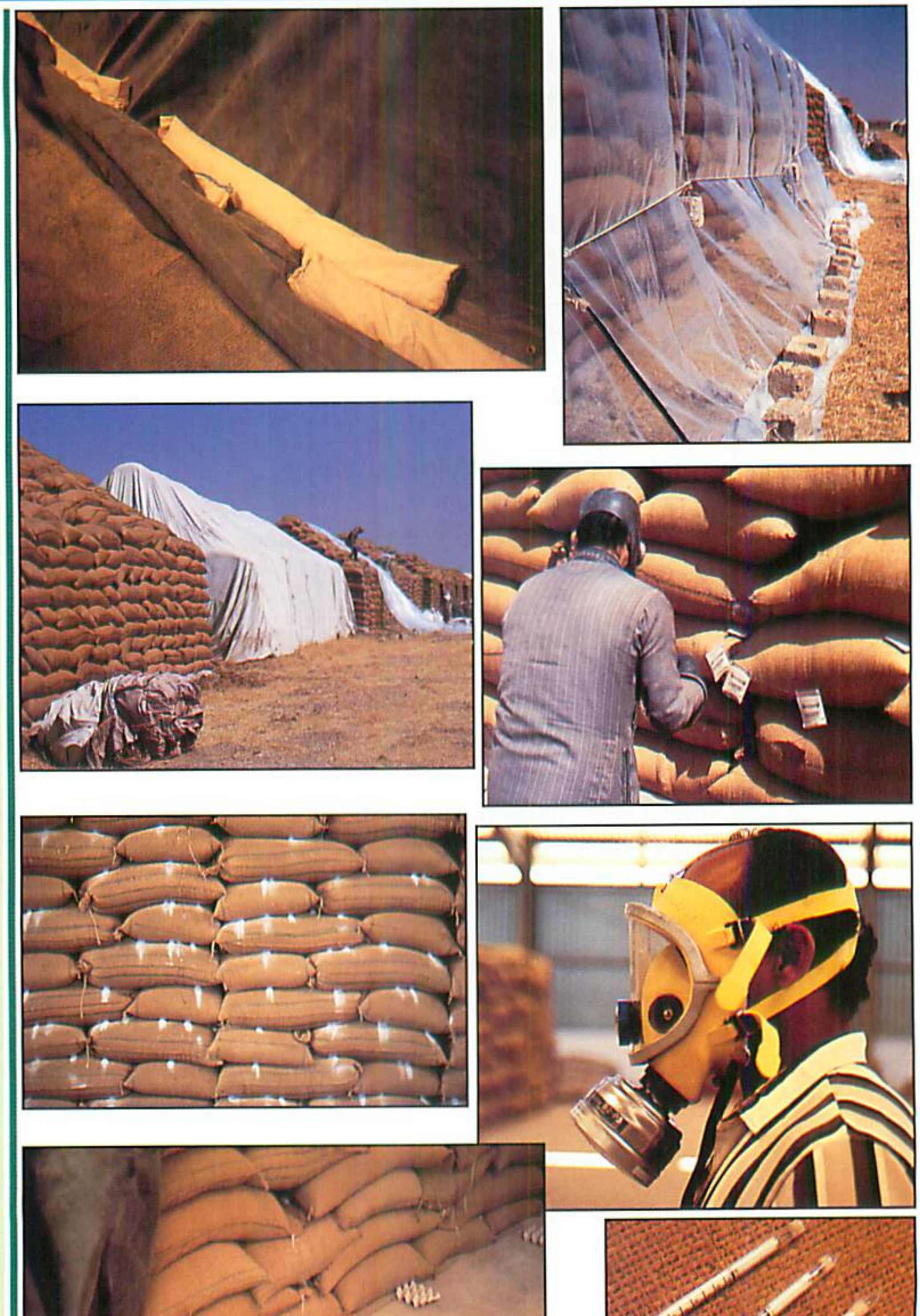


Fig. 107. Steps of Phostoxin fumigation

Questions

1. What is meant by fumigants and fumigation?

2. List the differences between Phosphine and Methyl bromide.

3. Why do we need at least 30% relative humidity for successful phosphine fumigation?

4. What are the requirements for a successful fumigation application?

5. Why is overdosing not recommended when using Phostoxin?

RODENT AND BIRD CONTROL

Damage caused by rodents and birds

Rats, mice, and birds can be very destructive not only to seed but also to warehouses and machines. They can:

- Damage bags, boxes and other containers, and eat seeds
- Scatter seed, contaminate seed lots, spoil the appearance of bags
- Mess up buildings, destroy wiring, destroy floors, and any wooden parts of a building
- Contaminate/dirty machines and bins.

Controlling rodents and birds

Rodent and bird control is quite difficult. One activity cannot control them; control requires a balanced program of:

- ***Sanitation:*** keeping the plant and area clean
- ***Exclusion:*** keeping them out
- ***Killing:*** getting rid of those that get in.

Sanitation

Outside and surrounding areas: Keep outside areas clean so that birds and rats cannot find cover near the plant. If the area is less attractive to them, they are less likely to get into the plant buildings.

- Keep bushes/weeds cut, and grass well-mowed.
- Eliminate mud holes and low places where water stands after rains. Keep the entire area well drained and clean.
- Pave around buildings for 1-2 m, to reduce cover and prevent rats from digging under the buildings.
- Carefully keep the area clean around outside dust collectors. Pave these areas.
- Carefully and regularly remove all trash. Do not have a trash dump near the plant. If trash is composted, locate this at another place. If trash is incinerated, keep the incinerator area clean and free of weeds. Also, do not store discarded equipment, boxes, etc. around buildings.

Inside buildings: Keeping the inside of all buildings clean helps reduce attraction of birds and rats from outside, and prevents them from staying inside the buildings.

- Keep dust vacuumed or swept up. Immediately clean up all spilled seed and waste from floors, screenings, waste products, dust, etc. Clean around elevators, cleaners, spouts, etc.
- Keep walls and corners free of dust, trash, and spider webs. Walls and floors should be smooth-surfaced.
- Do not stack seed directly on the floor; stack bags on pallets to reduce cover for rats.
- Do not stack seed against walls; leave at least 75 cm space between the

wall and stacked seed, for samplers to pass and to reduce cover for rats.
- Keep waste in metal containers with tight-fitting lids.
- Control water inside the building, so rats and birds cannot get it.
- Paint walls with light color to avoid dark corners or places frequented by rats.

Exclusion

Keeping rats and birds out is difficult, but well-planned building construction and careful operations can help control their entry.

- Floors should be above ground level, at truck bed height. If a truck dump pit is used, have a concrete ramp access to it.
- Use only one stair for personnel to get in.
- Outside walls should be smooth and of a material that rats cannot chew.
- Install a smooth 25 cm wide rat shield around the building at a height of 1.0-1.5 m, to keep rats out.
- Door and window frames should be of steel and fit closely to floor/walls and doors/windows, so no crack wider than 6 mm is left.
- Windows should be screened with metal (copper) mesh with openings small enough to keep out flying insects.
- Keep doors shut when not in use. Install "bird-proof" transparent plastic panels over doors which must be left open.
- Do not leave equipment, boards, bags, etc. stacked outside, where rats can climb on them and get to the building above the rat shield.
- Inside the building, leave no ledges on which birds can build nests. Below windows, form cement plaster slopes.

Killing

Birds and rats that get in and must be killed immediately. Killing requires a combination of several methods.

Poisoning: A wide range of rodenticides is available.

- Baits with slow-killing, anti-coagulant poisons are accepted by rats better than fast-killing poisons.
- Keep poison baits constantly in place; rats soon avoid baits. Initially, baits should be offered without poison to lure the rats to the feeding place.
- Keep poisoned water and feeders in strategic places. Allow no other water inside the building.

Trapping: Occasionally install rat traps. Bird trap nets can sometimes be used.

Fumigation:

- At regular intervals, or when infestations appear, fumigate the entire building to kill rats, birds, and insects. Phostoxin kills all three.
- Fumigating seed lots before they are brought in eliminates pests (insects, mice, and rats) from within the bags.

Questions

1. Describe some damages caused by pests.

2. What are the possible ways to control rodents and birds?

REJECTS AND DUST HANDLING

Dust/waste/ rejects

Dust: fine inert material created during harvesting, threshing, handling, transporting, and processing of seed. It is a:

- Health hazard to workers
- Fire and explosion hazard to electrical equipment
- Danger to machines (bearings, etc.)
- Bad effect on appearance/saleability of seed bags
- Bad impression of management skills.

Waste: material which has no value, except perhaps for compost (awns, leaves, stems, pods, etc.).

Reject: seed which has some value as grain or livestock feed (poorly developed seed, broken seeds, oversize kernels, etc.).

Keep waste and rejects separate; waste/rejects with feed value can be sold. Also, store and keep them separate from good seed.

Problems associated with waste and rejects

Problems generated by waste and rejects:

- Attract rats, birds, and insects
- Source of insect infestation
- Source of noxious (harmful) weed seed
- Potential source of seed contamination and mixtures.

Source of dust, waste, and rejects

Dust and fine particles:

- Comes in with the seed (dirt, dust, etc., from the fields)
- Is created during handling/cleaning, by rubbing materials off of seed each time seed pass through a machine or elevator.

Waste and rejects

- Are created every time cleaning/separating removes inert matter, trash, other crop/weed seed, etc., and rejected seed (broken, immature, moisture/insect-damaged, moldy, undersize, etc.).
- Amount depends on the crop seed and how clean it is when it arrives:
  - wheat seed- averages about 5% waste and rejects;
  - rice seed - 5-10%;
  - small legume seed - 20-30%; and
  - some chaffy grass seed - 70-80%.

Dust control

- ***Reception:*** To receive seed in an outside room which has good air flow or at least a dust hood/exhaust over the receiving elevator hopper. The seed should then be sent directly over an air-screen scalper to remove most of the dust and waste before the seed goes into processing or raw seed storage.

- ***Scalper/air-screen cleaner:*** The air systems in these machines take out dust and light waste and blow them out to a dust collector. These machines should be installed in a separate room, to pre-clean seed as it is received, and before it goes into storage or further cleaning and grading.
- ***Elevator feed hoppers:*** A dust hood should be installed over the hopper. The exhaust fan pulls out dust coming up when seed is dumped into the feed hopper.
- ***Elevator heads and discharge spouts:*** A centralized dust extraction system can be connected to the heads and spouts of elevators.
- ***Conveyors:*** Vibrating conveyors or belt conveyors usually need no dust control except an extraction hood over the seed intake and the seed discharge. Augers should not be used, except for waste/rejects.
- ***Bins:*** Metal or plywood covers (with access doors for clean-out) can be installed to seal the tops of bins. If desired, an extraction duct may be connected to one side of the bin cover, with a screened air entry vent on the other side.
- ***Gravity separator:*** A dust hood should be installed with an exhaust fan over the gravity deck; it may also pull dust from the feed hopper. Air should be allowed to flow in between the hood and the deck, above the sides of the deck. Otherwise, the dust extraction may upset the air flow and stratification of the gravity.
- ***Length separator:*** Most models have a dust extraction outlet built into the body cover of the machine. A dust duct pipe may be connected to this, so an extraction fan can pull out dust.
- ***Other machines:*** If the machine is enclosed, a dust extractor can be attached to an appropriate point to pull dust out of the machine. If the machine is open, a dust hood with extraction fan can be installed over (and partially around) the machine.
- ***Treater:*** Dust extraction ducts should be connected to the treater in order to draw out air with treatment dust, especially around the treater's blender/mixer. It may be necessary to connect a second duct connected to the lower part of the treating application chamber. An exhaust hood should be fitted over/around the treater in order to remove chemical dust from the surrounding air.
- ***Bagging area:*** An extraction hood or a ventilation fan should be installed to remove dusty air from the bagging area.
- ***General operating area:*** Louver windows (screened to keep out insects and birds) should be fitted so that wind blows through, but does not allow rain to enter. Fans should force air through the building in order to provide central dust extraction and ventilation.

Note: When a special dust extraction system is installed, it uses fans that require considerable horsepower. This is a significant additional investment and operating expense.

Handling waste/ rejects methods

Controlling waste/rejects removed in processing involves:
- ***Collecting*** from all machines
- ***Handling/moving*** them to a central point
- ***Storing*** temporarily
- ***Disposing***.

Collecting methods

Bagging system method

Waste/rejects are bagged at each machine. Waste/rejects from each spout can be bagged separately, or two or more can be spouted together into a single bag. This method requires:
- Adequate spouting from each waste/reject discharge
- A bag holder at each spout
- A means of closing bags
- A means of moving bags
- Workers to move the bags to a collection/storage point.

Advantages:
- Low initial investment
- Keeps all waste/rejects separate

Disadvantages:
- It requires constant labor, bag handling and storage
- The floor needs frequent cleaning
- Bags can be expensive
- Laborers sometimes let bags overflow and spill

Conveying system method

Waste/rejects from all machines go into a conveying/elevating system that carries them all to a central collection/storage point. If the cleaning machines are in a straight line, the system may be a conveyor that runs under all machines, receives and carries all waste/rejects to an elevator to a storage bin.

Advantages:
- Constantly moves waste/rejects out to storage without labor.
- Does not spill/scatter seed
- No bag costs
- Takes waste/rejects out of the building quickly

Disadvantages:
- High initial investment
- Additional operating power costs
- Unless there are two separate systems, it mixes together all wastes and saleable rejects

Handling/ moving methods

Bagging system method: Filled bags are sewn shut, then bags are moved by bag cart or forklift.

Conveying system method: In a straight-line plant layout, belt or vibrating conveyors carry bulk waste/rejects from all machines to an elevator. In a diffuse (not straight line) plant layout, several augers or conveyors carry bulk waste/rejects from machines to elevators.

Storage methods

Bagging system method: Bagged waste/rejects can be stored on pallets in a storage. Bags may be emptied into an elevator to put the waste/rejects in a storage bin (but this adds unnecessarily to the work).

Note: Do not store waste/rejects in the same building with good seed. Waste/rejects are more susceptible to insects, and attract rats.

Conveying system method

- Waste/rejects can be bulk-stored in bins. If a dual conveying system is used to keep waste separate from saleable rejects, several bins may be required.
- Waste/reject bins should be on tall legs, high enough for a truck to go under the bins. This permits waste/rejects to be dumped directly into trucks. Loads should be covered during transport.
- Sometimes, waste/rejects are conveyed/elevated directly into a truck. When the truck is fully loaded, it is transported to the disposal point (incinerator/compost pile for waste, feed/grain mill for saleable rejects). Loads should be covered during transport.

Disposal method

Disposal of waste

- Light trashy waste/rejects can be (i) burned in an incinerator; (ii) dumped in a compost heap to form soil-building compost, or (iii) dumped in a public sanitary landfill.
- Local laws/regulations may restrict disposal.
- If compost pile or sanitary landfill is used, it should receive special treatment to control insects and rats.

Disposal of saleable reject seed

- If not contaminated by treatment or other chemicals, it may be sold for feed or food grain use.
- A contract can be made with one agency to take rejects for an entire season. They should transport the rejects from the seed plant.

Disposal of materials containing seed of harmweeds: Weed seed viability must be destroyed, by:

- Fumigation with Methyl bromide,
- Burning (completely incinerating), or
- Grinding finely so that seed embryos are destroyed.

Questions

1. What is the difference between dust, waste, and rejects?

2. What methods are used to control them?

SUPPORT OPERATIONS

Elevators and conveyors

Seed processing is a sequence of activities accomplished by different machines. These machines are connected by conveying systems in which seed is lifted from one machine/bin into different machines and bins.

Types of conveying systems:

Vertical conveyors: the most common type of vertical elevators used in processing plants is the bucket elevator. It consists of an endless belt with a series of buckets or cups. The speed of the belt, the type of buckets, and the design of the head discharge are all important in minimizing seed injury. The buckets should be made of plastic instead of metal, as used for commercial grain. Spacers should be placed between the belt and the buckets to minimize seed contamination and for easy cleaning out.

Horizontal conveyors:
- Belt conveyors: used to handle raw seed or clean seed in bulk or in bags.
- Screw or auger conveyors: used for grain handling, but should be avoided in seed handling as they cause mechanical seed damage. They are hard to clean and have high power requirement.
- Pneumatic conveyors: closed-duct system, which moves seed by air. Advantages include low or no mechanical damage; flexible system since it can be placed in any position. Disadvantages include high initial cost and high power requirement. They are not widely used in processing plants.

Selection of the conveying system is based on:

- Type of seed, especially whether fragile or resistant to damage
- Direction, vertical, or horizontal
- Distance of seed movement
- Capacity of the processing machines
- Ease of clean-up and low mechanical seed damage.

Selection of the proper conveying system with adequate capacity causing little damage to seed and easy to clean up, has an important influence on processing effectiveness and efficiency.

Proper placement of correct seed conveyors is based on special requirements:

- Adequate handling capacity, to increase processing efficiency
- Prevention of mechanical contamination and adulteration
- Minimum mechanical shock or abrasion to seed.

Some considerations for proper selection and installation of conveying systems:

- Use an elevator whenever seed must be lifted up into a bin.
- Use low-speed "seed" elevators.

- Install elevators close to the machine which feeds it.
- Install elevators in waterproofed pits in the floor, so that the top of the feed hopper is at floor level. Put a grating over the hopper to prevent accidents.
- Provide easy access to elevator boots, belts, buckets, heads, etc. for clean-out when changing varieties.
- Seed pipes should have a 45° downward flow angle, and feed seed into the center (not side) of bins.
- Avoid long drops down discharge spouts from elevators. Instead of a tall elevator and long discharge spout, use a short elevator and horizontal conveyor to reach machines farther away.
- Use horizontal vibrator conveyors or belt conveyors to move seed horizontally from machines to elevators, or between elevators.
- Avoid using augers for seed; they can be used for waste/rejects.
- Use 2-way or 3-way valves on elevator discharge spouts, to bypass a machine.
- Spouts should have a rubber "shock absorber", "seed ladder", etc. to minimize mechanical damage when seed drop into a bin.

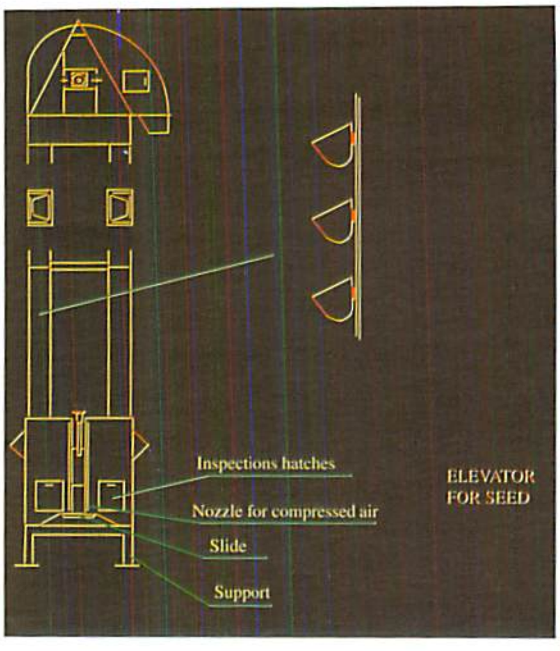


Fig. 108. Schematic diagram of a bucket elevator

Fig. 109. Buckets of a bucket elevator

Bins

Since all machines seldom operate at exactly the same capacity, a holding (surge) bin over each machine is necessary to collect and supply seed so the machines can operate uniformly and efficiently. Without bins, all machines must be slowed down to the capacity of the slowest machine. This results in losses of capacity, separation, time, and cost efficiency.

Some considerations for selection and installation of holding bins:

- Each machine should have a bin mounted over its feed hopper.
- Each bin should hold at least 2-4 hours cleaning output.
- The air-screen cleaner's bin should hold over 4 hours output.
- The treater bin should hold over 4 hours output.
- The bagger-weigher bin should hold the output of one working shift (usually 8 hours).
- Bins must have separate supports, ladders and/or catwalk so workers can get into bins to clean them. If dust is a problem, bins should have covers.
- If seed are fragile, a "seed ladder" should be installed in the bin to prevent seed injury when they drop into the bin (Fig. 111). Always put a rubber "shock absorber" at the end of the spout feeding the bin.
- Bins must be completely smooth inside, so there are no cracks which can hold seed or harbor insects.
- Each bin should have an easily-operated shutoff gate at its discharge with the same dimensions as the outlet to its machines intake hopper. Smaller discharge outlets will restrict the feed to the machine.

Fig. 110. Example of an installed bin

Fig. 111. Bin ladder inside the bin

Bagging and weighing

Weighing: Seed are weighed twice during seed processing. Firstly, when seed is received, and, secondly, when the seed leave the cleaning line (see reception section).

Bagging operation:

- Fill bags with a bagger-weigher which is installed on a bag conveyor. Do not scoop seed into bags, then weigh and close. For sewn bags, use a bag sewing machine installed on the bag conveyor.
- If possible, use pre-closed "valve-pack" bags, and fill with a valve-pack bagger-weigher. This eliminates the sewing machine and bag closing operations.
- Bags may be closed by hand-tying with string or using stitching machines. Polyethylene bags must be heat sealed if hermetic storage is required.
- Bags should be properly labeled. Labels should include all information about the species, cultivar, generation, and lot reference number. If seed is treated it should be also indicated. The tag or label should be firmly attached as part of the stitching or sealing operation.
- Have bagging area readily accessible by forklift and/or manual "bag trucks". Do not use laborers to carry bags to storage; they drop/throw bags and cause mechanical injury to dry seed.
- Stack bags on pallets immediately after the bags are filled/closed. Transport bags to storage, and stack bags in storage, on loaded pallets.
- Use a bag elevator if possible to save heavy lifting of bags onto the pallet.

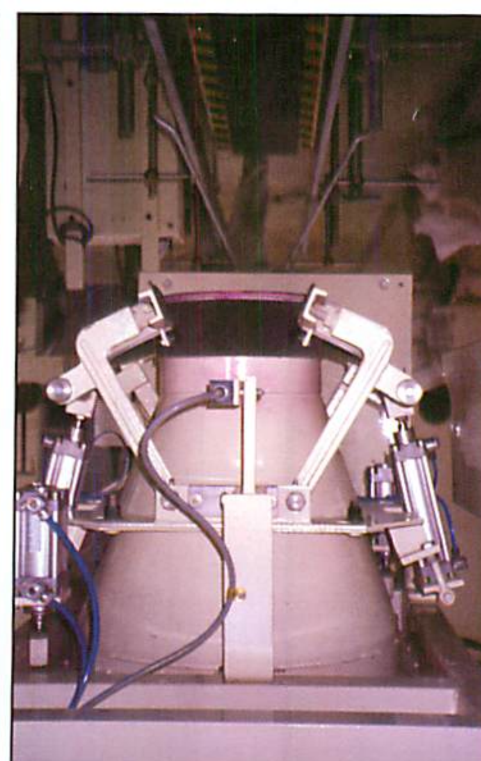


Fig. 112. Automatic weighing and bagging equipment

Other necessary equipment

Fig. 113. Scale for weighing bags

Fig. 114. Forklift truck

Fig. 115. Small cleaning equipment (broom, vacuum cleaner, etc.)

Fig. 116. Air compressor

Questions

1. Describe support equipment and their function.

PLANT MANAGEMENT

Management principles in seed processing

Careful processing is very important in producing quality seed. This step is the most capital-intensive component of the seed program. All seed require processing; where the seed is cleaned, graded, sized, blended, treated, packaged, stored, and distributed. Along with adequate facilities improved management skills can upgrade processing efficiency. Appropriate planning and scheduling, timely maintenance, regular quality control, adequate lot and operation recording, constant monitoring, and inspection will no doubt improve the quality and increase the quantity of seed being processed with less time, less cost, and less seed loss.

Management refers to the process of conducting a complex series of tasks requiring the action of several elements. Managing seed processing operations refers to all measures to be implemented and activities to be carried out to secure the timely processing and supply of seeds of prescribed quality standards in the required quantity.

Principle 1: Processing is not an independent operation, but it is an essential part of the sequence of supplying good quality seed. Processing MUST:

- Bring seed up to specific quality standards and within a specific time
- Not mix or adulterate seed
- Always maintain identity of each bag of seed
- Be cost and time efficient.

Principle 2: The plant manager must have sufficient technical and managerial background and SHOULD:

- Be realistic and prepare an advanced plan for the coming season
- Pay careful attention to details and quality of products
- Have constant follow-up
- Know what/how/ when to do things.

Principle 3: Planning is the key word. The only things that ever happen without a plan are problems and confusion! The plan MUST:

- Be prepared in advance
- Be realistic
- Allow for likely conditions
- Be flexible (provide options and back-ups, if needed).

SMART planning

- **S**pecific
- **M**easurable
- **A**chievable
- **R**ealistic
- **T**ime bound

Objectives of the plant manager

The objectives of the plant manager are to:

- Bring received seed up to the desired quality, purity, and condition
- Have seed ready when it is needed for marketing and planting
- Operate cost-effectively and time-efficiently.

Managing time

The workload is not uniform throughout the season. There are active periods, mainly at harvest and at planting time and there are off-season periods, when the machines are not working at all. Good planning is required in advance.The processing plant manager's responsibilities include the following:

Make a processing plan to show how much and what type of seed must be ready by what date .

- Get specified information from the marketing section regarding seed needs and delivery dates.
- Prepare a detailed processing plan to show what will be done to each seed lot, when it will be done, and what is required to do to it. Plan the seed flow, sequence, and all required operations.

Operate cost- and time-effectively.

- Have a well-prepared plan for each day's work and assign work.
- Process several lots of the same variety consecutively to reduce the number of clean ups between lots of different cultivars and species.
- Put buffer bins on the top of each machine. This will enable other machines to continue operating if you must stop one machine for a few minutes. In addition this will reduce labor cost, increase capacity, and allow more precise separation.
- A large bin over the treater lets you operate the treater intermittently instead of constantly. This saves power and labor.
- Do routine maintenance between shifts to reduce lost time.

Managing space and clean up

Although the actual operation of cleaning takes only a few hours, a seed lot may spend weeks and months in the processing plant before it is dispatched.

Maintain clean space.

- Repair floors, doors, buildings, ramps, etc.
- Constantly clean machines, floors, walls, and surroundings of the plant.
- Monitor and resist any infestation by rodents, birds, and insects.

Maintain identity of each lot and each bag of seed.

- Label each bag, box, bin, and stack of bags.
- Have an organized lot numbering system.
- Have only one lot at a time in the processing area.
- Stack, store, and handle each lot separately; mark off warehouse floor into smaller numbered squares to show exact location in storage.

Managing personnel

The efficiency of the processing operations is highly dependent on the skills of the operators. Safety of the workers is another important issue as there is always high risk of injury by machines, of poisoning by toxic chemicals, and health hazard by breathing dust and fire/explosion by electrical equipment.

Continuous and regular training, and constant supervision are necessary.

- Arrange for an adequate labor force. All staff and workers should be full-time employees if possible.
- Train staff and workers.
- Assign responsibilities and control so that tasks are timely and properly executed.

Managing equipment

Repair and maintenance of all the machines are very important for the success of any processing operation. Get all equipment into the best possible condition in off-seasons and preferably just before harvest time. Maintain and repair equipment as required to prevent interrupting operations.

In off-seasons, get all equipment into the best possible condition.

- Have the proper equipment ready to process each crop seed.
- Each year, conduct major overhauls and repair. Have the mechanic and operators go through each machine in detail and completely overhaul it (repair or replace worn or damaged pipes, supports, bins, etc. Paint bare metal spots, lubricate and service all bearings, gear boxes, etc.).
- Retain a good stock of spare parts.

Maintain the machines continuously.

- Prepare and put up posters on maintenance schedule and work which should be done daily, weekly, monthly, and annually.
- Make sure to have a permanent qualified mechanic and train operators in simple preventive maintenance.
- Check and be sure that operators supervise operating machines at all times. Require operators to report "strange noises" or potential problems immediately. Frequently check that equipment is properly maintained, clean and adjusted.

Managing seed processing operations

Immediately dry seed to safe moisture content, clean/separate to bring seed quality up to the required standards, and treat seed as required immediately before sale.

Receive, and immediately sample and test each incoming seed lot. As each lot comes in:

- Check labels on each bag; make sure all are of the same lot, and are labeled. Check for damage and any variation in quality.
- Have the IQC section sample and test the lot for seed moisture, insects, physical damage, cleaning requirements and estimated loss, germination and estimated final quality.

- Immediately reject and return to the grower any seed lot which is sub-standard and cannot be brought up to standards by processing, before time and money are wasted on it.
- Initiate records on an accepted lot and schedule operations on it.
- Immediately fumigate lots which show any signs of insect infestation. A good policy is to fumigate all seed lots as soon as they are received.
- Guide the received seed lot to drying, storage or processing, as required.
- Store raw unprocessed seed separately from processed and clean seed.

Clean to bring seed quality to the required standards.

- Based on initial tests above, identify machine (s) required to remove all contaminants. Identify all cleaning requirements before setting up the machines.
- Frequently check all machines and adjustments, and sample clean seed and waste products. Make changes and adjustments as required.
- Have the processing area and machines clean all the time. Have only one kind of seed at a time in the processing area.

Managing seed treatment operations

Equipment: be sure that the treater delivers more precise dosages and distributes chemicals more uniformly on the seeds.

Chemicals: both insecticides and fungicides could be applied to control pathogens carried on seeds, protect seedlings and seeds in the soil, protect against some diseases which affect mature plants, and protect against storage insects.

Treat seed as required.

- Treat with chemicals and at rates recommended by the appropriate research agency.
- Purchase chemicals early for delivery before operations start.
- Be sure that the treatment includes a dye which colors the seed, and that a treatment tag is attached to each bag.
- Be sure that the workers are properly trained to handle chemicals and treated seed safely, and waste chemicals are properly disposed of.

Managing seed quality

Quality can be affected at any time during processing operations through contamination, mechanical damage, pest infestation, etc. Internal quality is an important tool for the manager.

Have a strong and competent IQC section with a proper small laboratory and equipment.

- Use IQC as the quality control arm of management, so it can stop and/or change any operation which does not achieve high seed quality.

- Have IQC study and analyze all operations constantly. Suggest improvements which reduce seed loss, reduce time or cost, and improve seed quality.
- Have IQC sample and test all incoming seed and then recommend acceptance or rejection of the seed lot, recommend processing requirements, estimate percent seed loss and expected final quality, suggest lots to blend, etc.
- Have IQC sample every 1-2 hours the clean seed and all waste products coming from every machine and suggest adjustment changes to improve quality.
- Set a schedule for retesting seed in storage, so each seed lot has a new or current test results before the planting season.
- Arrange in advance for official sampling and testing of new clean seed lots, so seed dispatching is not delayed.

Prevent seed contamination or adulteration.

- Thoroughly clean-up all machines—and inspethem—before changing varieties. Keep processing area clean at all times.
- Avoid tearing bags and spilling seed. Use new bags.
- Make certain that each bag, box, bin, or other container of seed is fully labeled and records are up-to-date.
- Show exact warehouse location on records of each lot. Store each lot separately. Do not stack one lot on top of another. Use stack cards to identify each stack.

Mechanical handling increases the risks of impacts which break or damage the seeds. To reduce mechanical damage:

- Use low speed elevators with rubber buckets
- Put seed ladders (rubber-padded step-down devises) in bins and at similar slopes/ drops to prevent damage by slowing seed velocity
- Use rubber pads at points where seeds strike solid surfaces.

Managing records and seed lot identity

This is an important part of management. Every single operation should be recorded and documented, and each seed lot and seed bag should be identified.

Initiate and keep up-to-date records adequate for seed law requirements and for good management control.

- Have records which are easy to keep, but show everything done to the lot. A single comprehensive lot record card is most efficient. This should show details of receiving, drying, internal quality testing, cleaning, treating, bagging, storage, official testing, shipping, and delivery.
- Keep records up-to-date immediately when anything is done to the lot.
- Have a specific person assigned to keep records and regularly check records and reports.

Managing dust, waste, and rejects

Large quantities of waste and rejects are produced during each operation. This needs a well-established disposal system to avoid a build-up of this material and contamination of both seed and the plant. Waste causes space and storage problems, attract insects and rats; while dust leads to health hazards, may cause fire and explosion, and danger to machines.

Keep waste and rejects separate with useless waste products in one bin and rejects that can be salvaged and used for grain or livestock feed in another bin.

- Use exterior cyclones to collect dust/trash and empty trash bins regularly.
- Bag waste products at each machine's waste product spouts, or use a separate conveying system to carry all wastes to a central rat-proof bin.
- Do not store wastes in the building with good seed. Keep them in separate storage and dispose of them as quickly as possible. If the waste contains noxious weed seed or useless trash, burn it according to local regulations. If it can be used as feed/grain, sell it so that it is removed regularly.
- Constantly sweep/vacuum dust from floors, machines, ledges, etc.

Managing seed packaging

This is the last operation in the processing line before seeds are stored or delivered to the farmer. Seeds may be packed into different bags or containers. Also, the packaging material is numerous and the selection of suitable material and type of containers is governed by several factors (kind of seed, cost and availability of material, condition and duration of storage, etc.).

Package in bags which meet farmers' needs.

- Do not bag in sizes convenient to you; bag size should be convenient for use by the farmer (a proper quantity that can be delivered to farmers in sealed and unopened bags) and easy to handle, stack and transport.
- Different crops need different bags. Have an adequate supply of proper bags.
- Label each bag as it is filled. Labels should include complete information and test results.

Managing storage

Seed storage is an essential part of the chain that supplies the seed. Seeds should be stored without loss of quality and quantity.

Prevent damage to seed, and loss of seed or seed quality.

- Storage conditions: Keep all areas including exteriors of the buildings clean. Control rats and mice and keep out birds. Keep seed dry and well-ventilated.
- Handling and stacking: good planning minimizes in-storage seed move-

ment, reduces labour costs, makes delivery easier and faster, and allows "first-in, first-out" handling.

- Quality control and testing: seeds deteriorate and die over time; ensure regular viability/germination testing.
- Insect/pest control: integrated pest management combining sanitation, exclusion and eradication. Better chemical control combines use of insecticides, seed treatment, spraying walls and floors, and fumigation.

Managing safety market preparation

Have seed ready when it is required for marketing.

- Have the marketing department list the quantity and type of seed needed by specified dates.
- Prepare a detailed "Processing Plan" to show how marketing requirements will be met, and detailed requirements for labor, bags, treatment chemicals and supplies, operating days and hours, etc.
- Schedule shipping/delivery in advance. Follow the "first-in, first-out" system of selling the oldest seed first.
- Keep selling records up-to-date daily.

Table 15. Planning steps, questions to answer	Purpose
How much seed will be received during what period of time? What kind of crops, varieties, etc. How much clean seed is needed and delivery time? Who will do what? What are the critical points in your processing line that most influence the quality of the output?	To determine how much receiving, drying and cleaning capacity is required To secure labor and shifts, etc. To secure bags, chemicals, etc...
How is raw seed received?	To determine the type of receiving facilities you need
What are the quality standards to be achieved for each crop seed? What processes are required for a particular seed lot? What are the materials to be removed from the seed crop? What physical difference could be used to ensure proper separation?	To determine which machine (s) to be used
What must be done to seed in advance so each machine can work effectively?	To determine the order and sequence of the machines
Is incoming raw seed dry enough to keep in bulk without damage? How long does it take to dry one load? How much new seed will be received during this time?	To determine the drying system and capacity needed
In addition to pre-cleaning and drying does your seed need special pre-processing operations? (Examples: shelling maize; de-bearding oats, barley, grasses; hulling and/or scarifying clovers, alfalfa, beans, cowpeas; re-threshing chaffy grasses; decorticating beet seeds; etc.)	To determine additional special machines
Is it necessary to treat the seed? What—and how many—chemicals are to be applied to the seed? Are the chemicals compatible? Can they be applied in one treatment,or are two or more applications required? Can water be supplied without problems? What dust control and worker safety measures are required?	To determine chemical treatment requirements
Is drying required after the seed is treated? What is the seed moisture content after treatment? Will seed be sealed in vapor-proof bags? How long will the seed be stored? How will the seed be handled/transported/distributed? Do ambient conditions damage germination during transport? Is special (e.g., dehumidified) drying to low moisture required?	To determine drying requirements after treatment, type of bags, storage conditions, and capacity needed
Official testing by certification agency	To schedule their visits for sampling

Table 15. Seed processing and storage card

<table>
<tr><th colspan="8">SEED LOT IDENTIFICATION AND PRELIMINARY TESTS RESULTS</th></tr>
<tr><td>Lot No. ....
Crop.........................
Variety......................
Category....................</td><td colspan="2">Producer........................
Date received................
Number of bags............
Total weight..................</td><td colspan="2">Internal analysis...........
Pure seed..................%
Moisture...................%
Undesirable material....</td><td colspan="3">Observations...........................
Overall condition of seed lot....
....</td></tr>
<tr><th colspan="8">SEED PROCESSING</th></tr>
<tr><td>DRYING</td><td colspan="2">CLEANING</td><td colspan="2">TREATING</td><td colspan="3">PACKAGING</td></tr>
<tr><td>Date..........................
Initial quantity..........
Initial moisture..........
Final moisture...........
Final quantity...........</td><td colspan="2">Date.............................
Initial quantity...............
Weight clean seed........
Weight rejects...............</td><td colspan="2">Date............................
Quantity treated...........
Chemical.....................
Rate............................</td><td colspan="3">Date.......................................
Quantity..................................
Weight of one bag..................
Number of bags.......................</td></tr>
<tr><td></td><th colspan="7">OFFICIAL SEED TESTING RESULTS</th></tr>
<tr><td>SAMPLING</td><td colspan="2">PURITY TEST</td><td colspan="2">GERMINATION TEST</td><td colspan="3">CERTIFICATE</td></tr>
<tr><td>Date of sampling .....
Name of sampler .....
Date of test ....</td><td colspan="2">Pure Seed...................%
Other crop seed..........%
Weed Seed....................
Weed species................</td><td colspan="2">Date Germination
....
....
....</td><td colspan="3">Number..................................
Certified.................................
Rejected.................................</td></tr>
<tr><th colspan="8">SEED STORAGE, SALES AND DELIVERY</th></tr>
<tr><th>INITIAL QUANITY</th><th colspan="2">SEED SOLD</th><th colspan="2">REMAINING SEED</th><th colspan="3">DELIVERED TO</th></tr>
<tr><td>Date</td><td>Quantity</td><td>Number of bags</td><td>Quantity</td><td>Number of bags</td><td>Name</td><td>Receipt No.</td><td>Signature</td></tr>
</table>

Questions

1.What are the role and duties of the seed processing plant manager?

2.Describe his activities during each step of seed processing.

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PRACTICAL SESSIONS

Session 1	***Quality control*** Demonstration of sampling, moisture content, purity and germination tests. - Describe the procedures of each test. - Demonstrate or conduct each test.
Session 2	***Description and principles*** Demonstration of the principles of functioning of different machines used in processing seed. - Describe the machine. - Outline the principles of each machine. - Operate the machine and run a small seed sample. - Explain the possible adjustments while the machine is working.
Session 3	***Working group: small-scale machines*** - Divide the participants into small groups of 3 to 5 persons. - Assign a seed sample to each group to be cleaned. - Let the participants choose the appropriate machine and manipulate it. - Assist and guide the participants on adjusting the machine.
Session 4	***Working group: large-scale machines*** - Describe the large-scale machines. - Outline the principles. - Assign a large sample to the participants and guide them to clean it: sampling, purity testing, hand screening, selection of screens. - Operate the machines one by one. - Make necessary adjustments for each machine. - Sample the seed after each machine to check the quality of seed, adjustments. - Run all processing machines at once. - Examine the output.
Session 5	***Fumigation and insecticide*** Demonstration of fumigation and insecticide spraying methods.

INTERNAL QUALITY CONTROL OPERATIONS

Objectives

Upon completion of this exercise you will be able to:
- Describe and conduct different quality tests.
- Estimate and calculate rejects/waste levels.
- Detect mechanical damage on seed.

Procedures

1. Sampling

2. Moisture content
- Be familiar with different methods used to test seeds for moisture content.
- Conduct basic and quick testing methods.
- Recognize the advantages and disadvantages of each method.

3. Purity
- Conduct a purity analysis of a seed sample.
- Use hand sieves to determine composition of raw seed sample.
- Examine raw seed to choose the screens.
- Be familiar with common weeds, identify all crop species and weed species that occur in the sample, use seed collection herbarium.
- Calculate, using tolerance table, and report results.

4. Germination
- Be familiar with germination conditions (substrate, temperature, moisture, light) and testing equipment.
- Conduct germination test.
- Identify normal and abnormal seedlings, hard seeds, dead seeds, fresh ungerminated seeds.
- Use tolerance table.
- Calculate and report results.

5. Rejects/waste
- How to estimate the reject level from examination and use of hand screens.

The basic steps to calculate the expected percentage of rejects (the amount of loss necessary to obtain a clean product) in raw seed material are as follows:

- Use the hand screens selected from the previous test.
- Make a stack of the two hand screens selected with round hole screen on top and slotted hole screen in the middle and a blank on the bottom.
- Weigh 1 kg of raw seed (W1).
- Pour and shake until all particles have found their level.
- Weigh the material kept on top screen (scalped material = W2) and material that

passed through the bottom screen (small particles = W3).
Add the weight of the two materials together, that is the percentage of rejects (W2 + W3).
Subtract this weight from the initial weight and divide the difference by the initial weigh, this is the amount of loss necessary to obtain a clean product.

$$\% \text{ clean output} = \frac{W1 - (W2 + W3)}{W1} \times 100$$

W1= initial weight.
W2= material kept on top screen.
W3= material that passed through the bottom screen.

6. Mechanical damage
- Sample seed before processing and after each machine.
- Be familiar with seed structures and different types of damage.
- Examine seed for mechanical damage. Use magnifying glass.
- Conduct same test as described in the lectures.

ELEVATORS: BUCKET ELEVATOR

Objectives

Upon completion of this exercise you will be able to;

- Describe the components of an elevator
- Know how to clean an elevator
- Operate an elevator
- Determine its capacity, belt speed.

Procedures

Use a known quantity of seed:

- Be familiar with the different parts of the elevator as discussed in class.
- Clean the elevator using compressed air. Open the inspection boots and clean all parts of the elevator and close inspection boots.
- Examine the belt, buckets, etc.
- Feed seed to the elevator.
- Operate the elevator.
- Remove the head cover and observe how seed is taken by the buckets and how they are discharged from the bucket. Check whether the buckets are full, the seed falls out of the buckets, etc.
- Examine the seed for mechanical injury.
- Determine the time required to elevate a known quantity of seed, then calculate the elevator capacity per hour.
- Make significant changes in adjustments as indicated by the installation and note the results.
- Calculate the belt speed (m/min); use head pulley rpm and diameter.
- Turn the elevator off.
- Open the boot inspection and check for seeds remaining in the buckets, and seeds lodged behind the buckets.
- Clean all parts of the elevator again and close inspection doors.

SCALPER

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of a scalper
- Operate a scalper.

Procedures

- Record weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Inspect intake hopper and elevator for remaining seed and clean them.
- Clean scalper using compressed air.
- Select screens to use.
- Pour seed in the intake hopper.
- Operate the elevator.
- Operate the scalper.
- Make significant changes in adjustments and note the results: increase and decrease feed rate, increase and decrease air, increase and decrease screen vibrations.
- Examine the output: clean seed, waste and rejects, and make necessary adjustments.
- Check the different spouts and note the material discharged from them.
- Weigh different fractions and determine the percent of scalped material and percent of clean seed output.
- Conduct purity test, germination and test weight, and compare with initial tests.

DEAWNER

Objectives

Upon completion of this exercise you will be able to:
- Describe a de-awner
- Operate the machine and make necessary adjustments.

Procedures

Use barley seed
- Record: weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Feed a known quantity of seed into the machine.
- Make significant changes in adjustments and note the results: increase and decrease feed rate, speed of beater shaft, dust exhaust air.
- Make necessary and final adjustments.
- Examine processed seed and note the results: appearance, flowability, mechanical injury.
- Calculate the percent loss.

SCARIFIER

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of a scarifier
- Know how to use the machine and improve seed germination.

Procedures

- Be familiar with different parts of the machine as discussed in class.
- Record germination, purity.
- Scarify the seed.
- Retest the seed after scarification and note the results.
- Has the seed quality been improved? How?

AIR-SCREEN CLEANER

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of an air-screen cleaner
- Know how to clean an air-screen cleaner
- Know how to select an appropriate screen
- Operate an air-screen cleaner
- Know how to adjust different components of the machine.

Procedures

1. Screen selection
- Sample the seed lot.
- Separate the seed lot into pure seed, other crop seed, weed seed, and inert matter.
- Note size, shape and weight of contaminants in relation to those characteristics of the crop seed.
- Use hand test screens.
- Top screen: select a range of four to five screens with openings larger and smaller than the crop seed. Stack these screens with largest size on the top and the smallest on the bottom. Put a space on the bottom of the stack. Place two handfuls of seed on the top screen: shake the screens vigorously until all seeds have found their level. Remove the screens from the stack one at a time, starting at the top. Note the material held by each screen. The screen that just lets the crop seed fall through but holds the material larger than the seed is the right size to use.
- Bottom screen: a similar procedure is followed for the bottom screen. The screen that holds the crop seed but lets broken seed, and smaller weed and crop seeds to fall through is the correct size to use.
- Arrange the screens in the proper order of use and put them apart.
- Use hand screens to demonstrate and study what screen perforations are used for cleaning round seed, elongated seed, lens-shaped seed.

2. Air-screen cleaner operation
- Record weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Remove screens and clean all parts of the machine as discussed in class.
- Put the selected screens in the proper order.
- Operate the machine: air, vibration and then feed.
- Make significant changes in adjustments and note the results: increase and decrease feed rate, vibration speed, upper and lower air, pitch of screens, feed rate.
- Note the function of the top and bottom screens.
- Examine different spouts and note type of material discharged from them.
- Sample material from each spout and conduct purity test and germination and compare with the initial results.

INDENTED CYLINDER

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of an indented cylinder
- Know how to clean an indented cylinder
- Operate and adjust an indented cylinder.

Procedures

- Record weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Clean all parts of the cylinder as discussed in class.
- Make significant changes in adjustments and note the results; increase and decrease feed rate, cylinder rotation, and lower or raise the lifting trough.
- Practice long and short separations.
- Make necessary adjustment and note the results. Was the desired separation accomplished? Does seed lot meet stand? Is further processing required?
- Calculate the percent of good seed lost. Adjust the machine to prevent this loss or try to recover this good seed.
- Is there any mechanical injury?

GRAVITY SEPARATOR

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of a gravity separator
- Know how to clean a gravity separator
- Operate and adjust a gravity table.

Procedures

- Record weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Clean all parts of the separator as discussed in class.
- Make significant changes in adjustments and note the results; increase and decrease feed rate, air, deck oscillation, end slope, side slope.
- What adjustments are required to correct the following conditions: (i) lower or upper side of the deck have blank or uncovered space, (ii) seed mass seems to lie dead on the deck surface, and (iii) seed bed bubbles and separation is poor.
- Examine different spouts and note type of material discharged from each one.
- Sample each spout and conduct purity test and germination and compare with the initial results.

SPIRAL SEPARATOR

Objectives

Upon completion of this exercise you will be able to:
- Describe the components of a spiral separator
- Operate a spiral separator.

Procedures

- Record weight of seed lot to be cleaned, variety, % purity, % germination, test weight.
- Be familiar with different parts of the machine as discussed in class.
- Pour the seed into the machine and observe how the separation is accomplished.
- Examine different spouts and note type of material discharged from each one.
- Sample each spout and conduct purity test and germination and compare with the initial results.

SEED TREATER

Objectives

Upon completion of this exercise you will be able to:
- Describe the different parts of the machine
- Know how to clean all parts of the machine
- Calibrate and operate a seed treater
- Determine its capacity and effectiveness.

Procedures

- Operate the treater.
- Observe chemical application to the seed.
- After operation, draw a sample of 1000 treated seeds and examine them individually under magnification. Evaluate the uniformity of coating and separate the seed into the following fractions: seed with no visible treatment, seed completely coated, seeds with spots of treatment.

SEED PROCESSING OPERATIONS PLANNING

Objectives

The objective is to be familiar with all steps of seed processing operations and build the confidence of the trainee to conduct all these operations at once.

Procedures

- Reception:
  - Register the seed lot and variety.
  - Sample the seed.
  - Conduct moisture content and purity tests.

- Pre-cleaning operations:
  - Decide which machine to use for pre-cleaning.
  - Do you need drying?

- Basic cleaning operations:
  - According to internal quality tests, draw the flow diagram for cleaning this seed lot.