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Principles of Seed Conditioning

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Comments

Discussion of basic seed conditioning principles and techniques.

PRINCIPLES OF SEED CONDITIONING

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When seed are brought in from the field, they contain undesirable materials such as pieces of stems, dust, weed seeds, other crop seed, and off-size, discolored, broken, and otherwise impaired units of the crop seed. Before the seed can be sold for planting through regular trade channels, enough of the undesirable materials must be removed to enable the seed to meet quality standards demanded by the farmers and required by law. In addition to removal of undesirable materials, seed often need to be treated with a fungicide before marketing. Preparation of seed for market, therefore, involves a series of mechanical operations designed to remove undesirable materials, apply a chemical treatment as needed, and to package the seed in some container suitable for distribution and marketing. These various operations/processes are termed seed conditioning, and encompasses, more specifically, operations such as receiving, pre-conditioning (debearding, hulling, partial cleaning, etc.), conveying, cleaning, sizing, up-grading, treating, and packaging. Seed conditioning is an important element in the business of providing an ample supply of high quality seed for the farms, gardens, recreational areas, pasture lands, and so on, of the world.

The seed conditioner should be interested in the operational efficiency whether he is operating an existing facility or planning a new installation. Here, however, we are more concerned with technical efficiency which consists of, but is not necessarily limited to, the following:

(1) Removal of contaminants

- Inert material
- Weed seed
- Other crop seed

(2) Sizing of seed

(3) Minimum seed loss

(4) Removal of weather damaged, insect damaged, off-size, and otherwise quality impaired seed.

(5) Maximum capacity consistent with acceptable seed quality.

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An economically efficient seed conditioning plant will have the required technical efficiency and can be operated with maximum output for the economic (capital and labor) resources committed. To attain the above goals one must understand the basic steps in seed conditioning and the physical bases for seed separations.

Steps in Conditioning

The steps in seed conditioning are shown in the usual order of performance in Figure 1. RECEIVING and storage capability should be adequate for the expected rate of receiving. A facility receiving seed in bulk at harvest time should have a dump pit/elevator storage bin combination large enough to hold at least an average truck load. This would permit a truck to return to the field in a very short time.

DRYING is important at any time seed are harvested at moisture contents higher than would allow safe storage. Thus, drying units must be available as needed.

PRECLEANING and preparation for conditioning and storage is a step that is too often neglected. Precleaning is most useful when there is a large amount of trash or green, wet material in the seed. Precleaning prior to drying can result in greatly enhanced capacity of the dryers. Precleaning promotes better flow through conveying equipment and allows for higher capacity and/or more precise screen selection in operation of the basic cleaning equipment.

Other kinds of preparation or pre-conditioning are required in special cases such as de-bearding grass seed, shelling corn, or legume seed hulling and scarifying.

BASIC CLEANING is accomplished by the air-screen cleaner which makes use of a series of screens and air separations to remove light trash, dust and undesirable materials both larger and smaller than the crop seed. Often this is the only step necessary to condition the seed to an acceptable quality level for marketing and planting. Other seed lots, however, will require further conditioning to remove difficult to separate weed seed, to size the seed or to upgrade germination and vigor. SIZING and/or UPGRADING, in turn, may require one or more machines which exploit various physical characteristics of the seed to effect the desired separations.

After the above operations have been accomplished the next step is TREATING. This step is referred to in Europe as "dressing" and may include application of fungicides, insecticides and/or other materials such as growth regulators, etc. Seed are not always treated prior to the PACKAGING step. Packaging may consist of the traditional bagging operation, large specialized "bulk" bags which may hold a ton or more, or it may be dispensed with altogether. Some larger facilities are now

equipped to hold seed in bulk after conditioning and load directly into trucks for transport to the fields. After conditioning storage is the final step before distribution and marketing and should be adequately planned and provided for.

Throughout all the steps in conditioning, the conditioner must not lose sight of the fact that he is dealing with living materials and must take steps to protect their viability during all the separating and handling operations.

The Physical Bases of Seed Separations

To effect a separation among particulate materials, there must be sufficient difference in one or more physical characteristics for a machine(s) to sort out the undesirable material from the desirable. Since there are usually several differences between the crop seed and the various undesirable materials, the conditioner should select the one which is great enough and common enough to allow mechanical separation by a machine at a reasonable capacity and with an adequate degree of precision.

The physical characteristics most commonly exploited in cleaning and separating seed are listed and discussed below.

Size

Where there is a great difference in the overall size between the desirable and undesirable materials it is acceptable to think in terms of separating them on the basis of overall size. However, when they are nearly the same overall size, it is more precise to think of them in terms of the three dimensions - width, thickness, and length (Figure 2). Seed or other particulate materials differing in any one or more of these dimensions can be separated as follows (Figure 3):

Width: Seed having the same length and thickness but differing in width can be separated by screens with round perforations.

Thickness: Seed with the same length and width but differing in thickness can be separated by screens with oblong perforations. The width of the opening is associated with the thickness of the seed.

Length: Seed with nearly the same width and thickness but differing in length can be separated with a rotating indented disc or indented cylinder with indentations of the proper size to lift shorter seed but not so large or deep as to lift the longer seed.

Weight or Specific Gravity (Figure 4)

Weight or specific gravity separations can be made by passing the

seed mixture through an airstream or over a gravity table which utilizes an air floatation process and a vibrating deck. Such separations are often referred to by engineers as "terminal velocity" separations since seed appendages and shape also affect the response of the seed. Allowing the seed to fall free between a highly charged electrostatic field and a grounded plate also results in movement of the lighter weight seed toward the plate and effects a weight or density separation.

Shape

The previously mentioned components of size (width, thickness, length) also relate to shape. However, some seed have a flattened side or may otherwise be irregular in shape but inseparable by screens from a more rounded or uniform seed (Figure 5). Such a situation can be exploited by devices which allow a separation by the relative velocity which the seed attain when they are allowed to roll freely on an inclined plane, such as a sheet metal plane wrapped around a center post, which allows the faster seed to discharge off the outside of the curve as is the case with a spiral separator. It may also be accomplished by an inclined flat belt which is adjustable for both pitch and velocity. The belt conveys the slower seed over the top end while the more rounded seed roll "downhill" faster than the belt moves "uphill" and discharge off the low end. Another possibility of a shape separation is a small inclined vibrating deck covered with sandpaper or other textured material. The flatter seed tend to sit on the deck and "climb" to the high side while the round seed roll down and off the low end.

Seed Coat Characteristics (Figure 6)

Seed of similar size and shape but differing in surface texture can be separated by several methods. Two rollers 4 in. in diameter and 60 in. long or longer can be covered with velvet or flannel and mounted side by side so that they touch along their entire length. By rotating the rollers in opposite directions so that seed fed into the trough formed by the rollers will be thrown upward, the rougher seed will be affected more than the smooth and can be thrown over the side. If the pair of rollers is also inclined, the smoother seed can be discharged at the lower end. A separation obtained by using a horizontal belt of fabric or carpeting has also been developed whereby the smoother seed are wiped off the side of the belt and the rougher particles are carried under the wiper. This separator does an excellent job of removing soil particles and small stones from beans.

Some seed have a seed coat covered with a material that becomes sticky when moistened. In other cases seed with cracks caused by mechanical damage or with a rough seed coat may attract and hold moisture better than slick, hard coated seed. If a small amount of water or oil is uniformly applied and thoroughly mixed and some finely divided iron powder is added, the iron powder will stick to the moist seed. If the seed are in turn passed over a magnetized drum, the iron coated seed

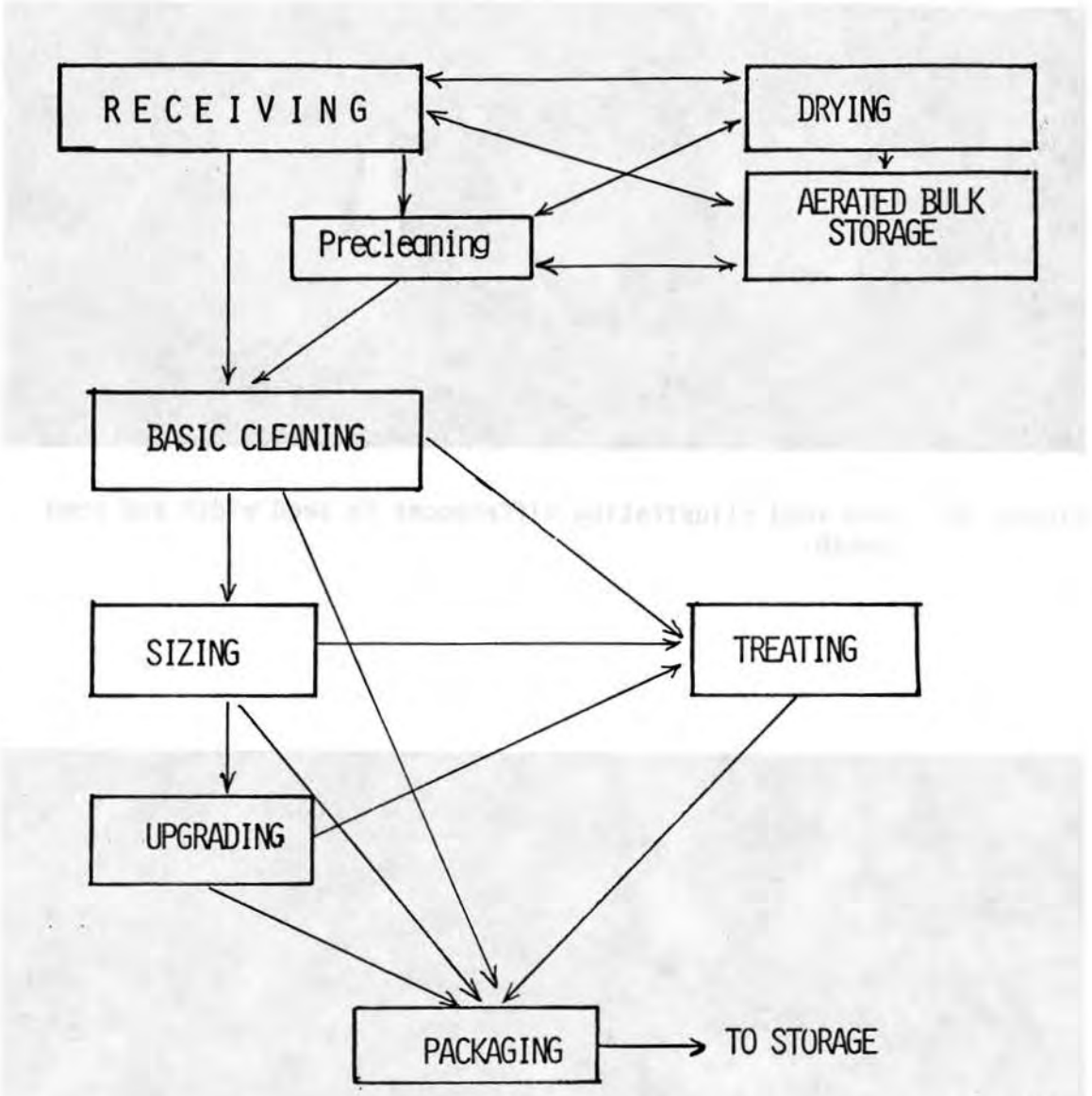


Figure 1. Steps in seed conditioning and alternate pathways among steps.

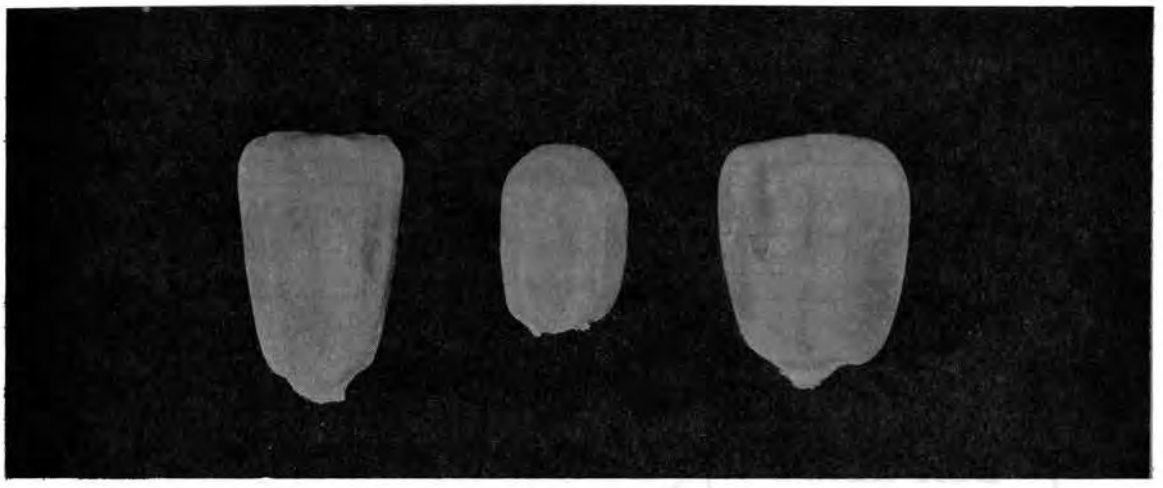


Figure 2a. Corn seed illustrating differences in seed width and seed length.

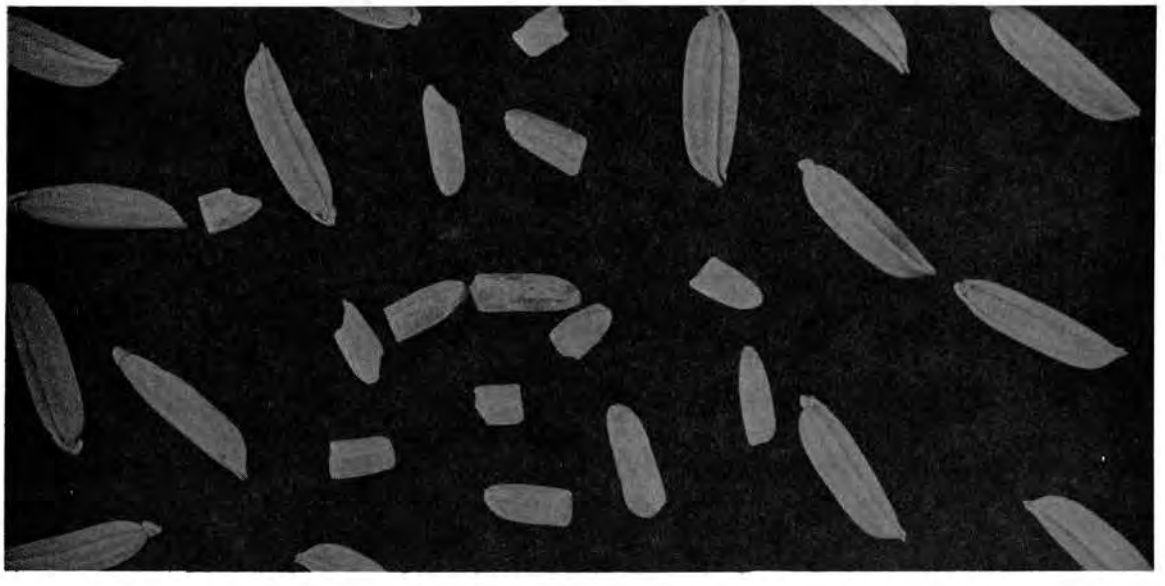
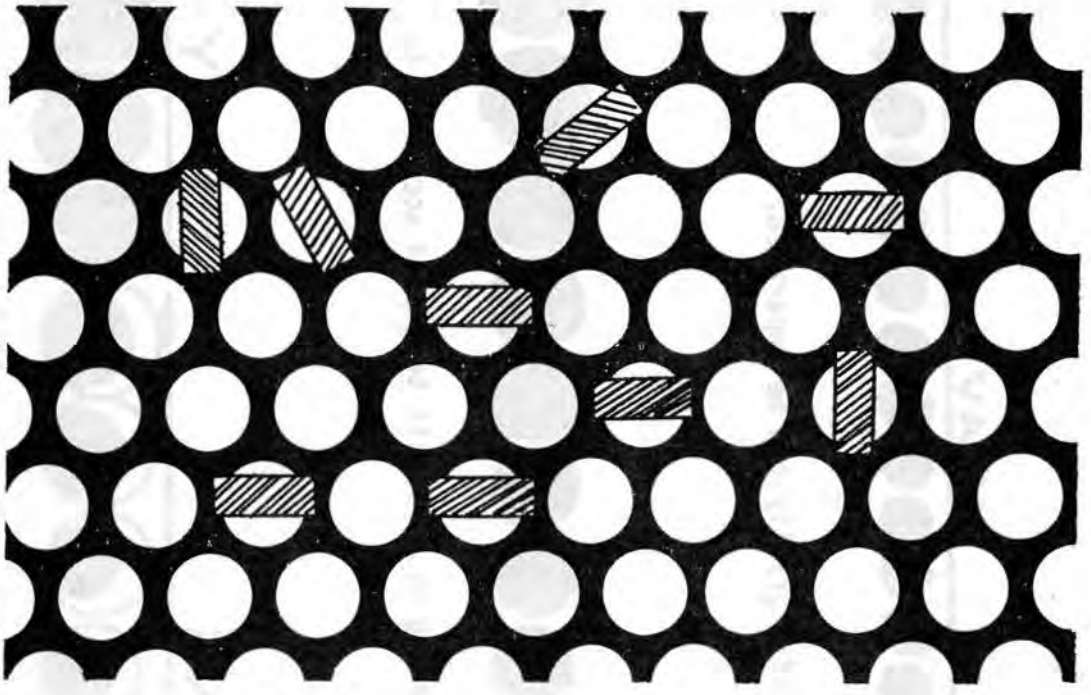


Figure 2b. Rice seed illustrating differences in the length dimension of intact and cross broken grains.



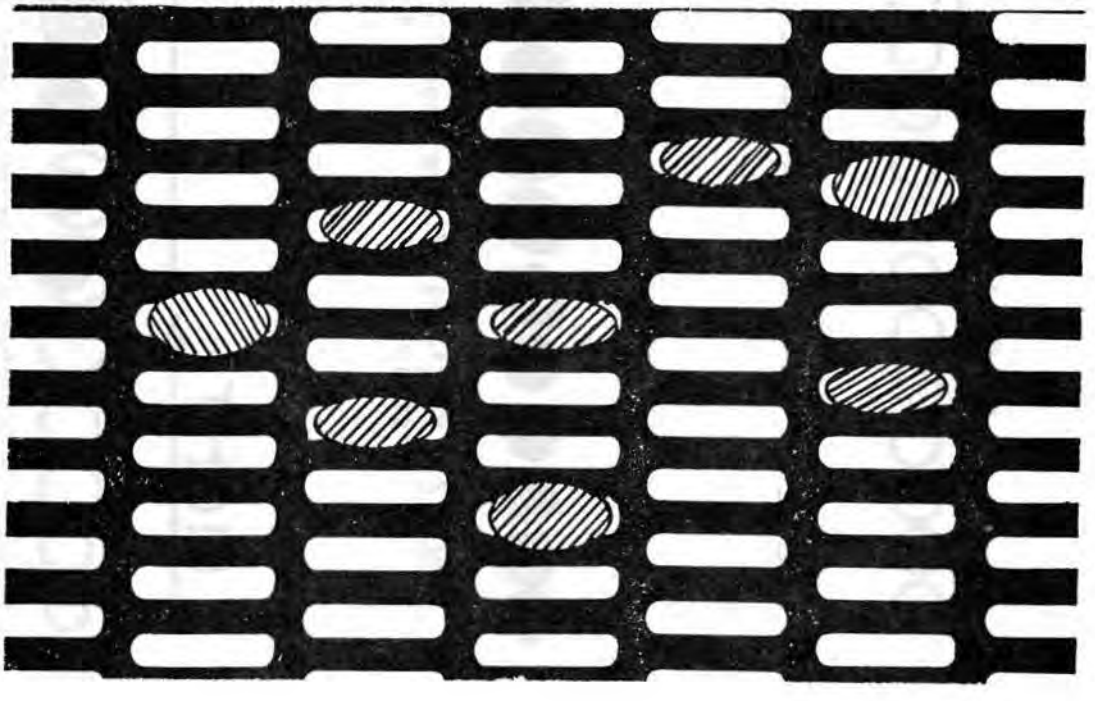


Figure 3. Seeds differing in width are separated with round hole screens (above); seeds differing in thickness are separated by screens with oblong openings (below).

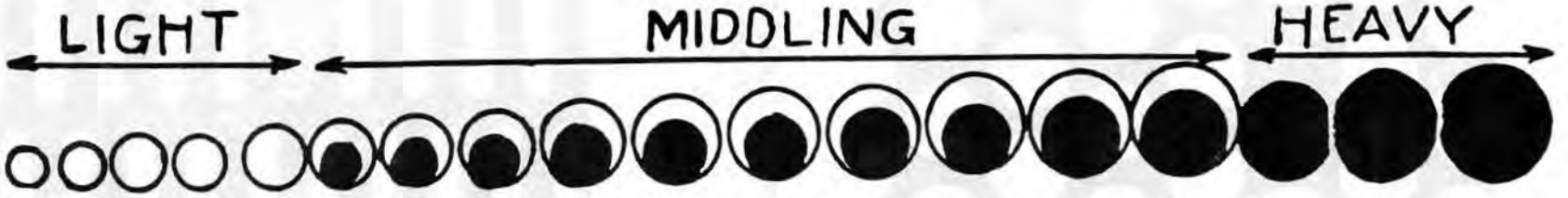
A

Rule 1. Particles of same size but differing in specific gravity can be separated.

B

Rule 2. Particles of same specific gravity but differing in size will be graded according to size.

C



Rule 3. Particles differing in both size and specific gravity cannot be efficiently separated.

Figure 4. Seeds and/or particles of about the same size but differing in density can be effectively separated.

can be deflected out of the stream of good seed. A process similar to the above magnetic separation is utilized by blending finely ground sawdust with seed which contain seed of weedy plantains (Plantago spp.). The moistened plantain seed become sticky and covered with sawdust, which makes them larger and permits separation on the basis of size or weight.

Color

Equipment is available which can detect the color and/or brightness of light reflected from a seed as it passes through its range of "vision", electronically compare it to a standard and accept or reject it.

Electrical Properties

Seeds also differ in their ability to hold or conduct an electrical charge. Although many conditions affect a seed's electrical properties, consistent differences in such properties can be used to make some difficult separations. A typical electrostatic separator consists essentially of a grounded roller which carries a single layer of seed beneath an electrode.

Two types of electrostatic separations are made (Figure 7). In the "pinning" separation, the electrode places a high-intensity electrical charge onto the seed. Some seed absorb and hold the charge, stick to the grounded roller and are carried to a discharge spout. Others lose their charge readily and are dropped into a separate spout. The "lifting" separation is made by passing seed through an electrical field created by a different type of electrode. Here, charges on the seed are rearranged in reaction to this electrical field. Some seeds are attracted to the electrode and lifted into a different flight path as they fall from the roller. Other seeds which react less to the electrical field follow a normal flight path to the discharge spout.

The electrostatic separation is sensitive to relative humidity and to seed moisture content. The best results are obtained on relatively dry, warm days. This separation method is not widespread in the seed industry at this time.

Changing Physical Properties (Chart 1)

Sometimes it is possible to modify the physical characteristics of seed to effect better separations or improve flowability. Equipment such as debeaders and hullers do change some physical characteristics. It is important that the conditioner understand the physical bases for separations and the equipment which takes advantage of specific physical differences to make the separations. Only then can one make logical decisions to obtain maximum operational efficiency in an existing facility or select new equipment to the best advantage.

Pre-Conditioning Considerations

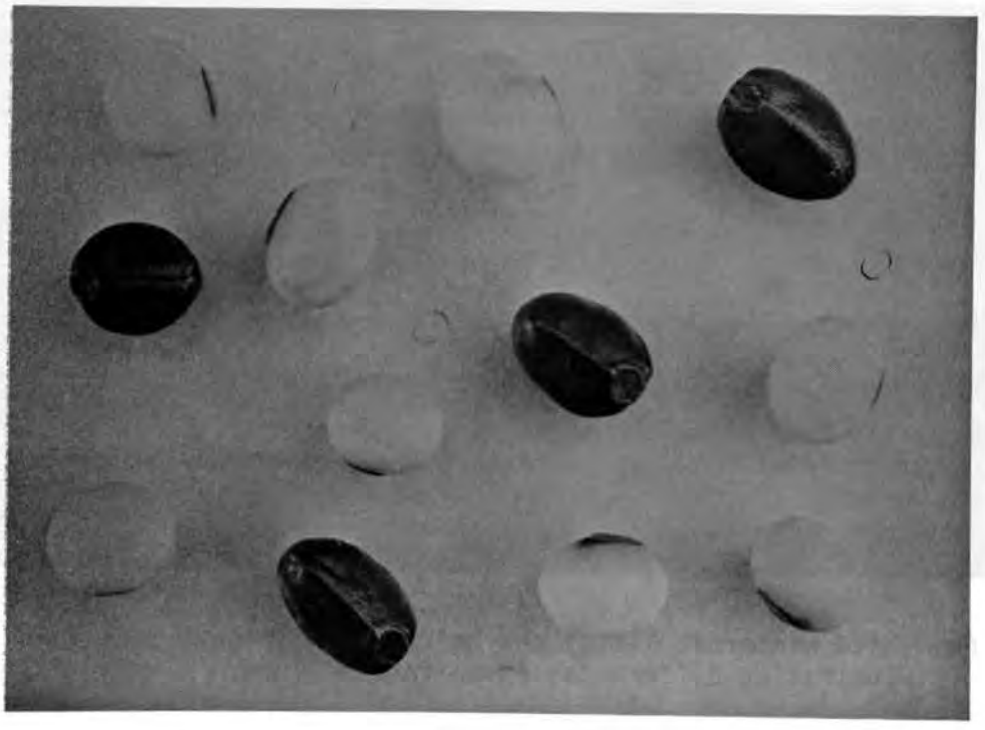
The removal of undesirable materials from a seed lot is an art based on the application of scientific principles. Just as a doctor must know how your body functions when you are well, the operator/manager must have a thorough knowledge of good seed. In good seed, emphasis is placed on (1) genetic purity, (2) mechanical purity, and (3) high germination percentage. In seed conditioning, primary interest is on improving mechanical purity and germination percentage, because these two factors are most often manifest in different physical characteristics of a seed.

Seed conditioning was defined previously. In the broad sense, it encompasses all the steps involved in the preparation of a harvested seed lot for marketing. In common usage, seed conditioning includes (1) preconditioning, (2) basic cleaning, (3) size grading (4) upgrading and (5) treating and packaging. This common concept of seed conditioning is used here.

The main purposes of seed conditioning are: (1) to remove contaminants; (2) size grade to improve plantability; (3) upgrade quality; and (4) apply seed treatment materials. To achieve these purposes, the conditioner must decrease the percentage inert matter, other crop seed, weed seed, and poor quality seed present in the original lot. Note that these factors which must be affected during conditioning are the same as those for which seed are examined under the various seed laws, that is, pure seed, inert matter, other crop seed, weed seed, and germination.

The conditioning of individual seed lots is divided into three sequential events: (1) pre-cleaning examination, (2) removal of undesirable materials, and (3) upgrading and/or sizing. The first two steps are essential for effective conditioning of all lots, while the third is dependent upon the kind of seed being conditioned, the nature and kinds of contaminants, the quantity of each contaminant in the raw seed, and the quality standards that must be met.

A basic requisite for effective seed cleaning is the capability of the conditioner to identify the undesirable materials that need to be removed. He must also know enough about seed to be able to distinguish between good, healthy seed and those of questionable quality, because at some point in the conditioning operation, a decision has to be made concerning which seed to keep and to discard. Thus, the conditioner's ability to render the desired service is affected by: (1) the equipment available; (2) their arrangement within the plant; (3) skill in operating the equipment; and (4) knowledge of seed characteristics. Notice that the first two of these factors were fixed when the conditioning plant was built. Therefore, operational skills and knowledge of seed characteristics are the only variables immediately available to management to control seed quality.



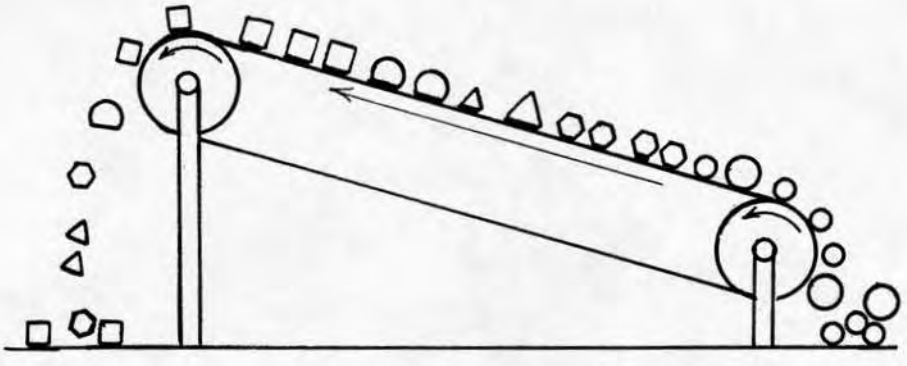


Figure 5. Top: Soybean and purple moonflower seed illustrating differences in shape or degree of roundness.
Bottom: A degree of roundness type separator.

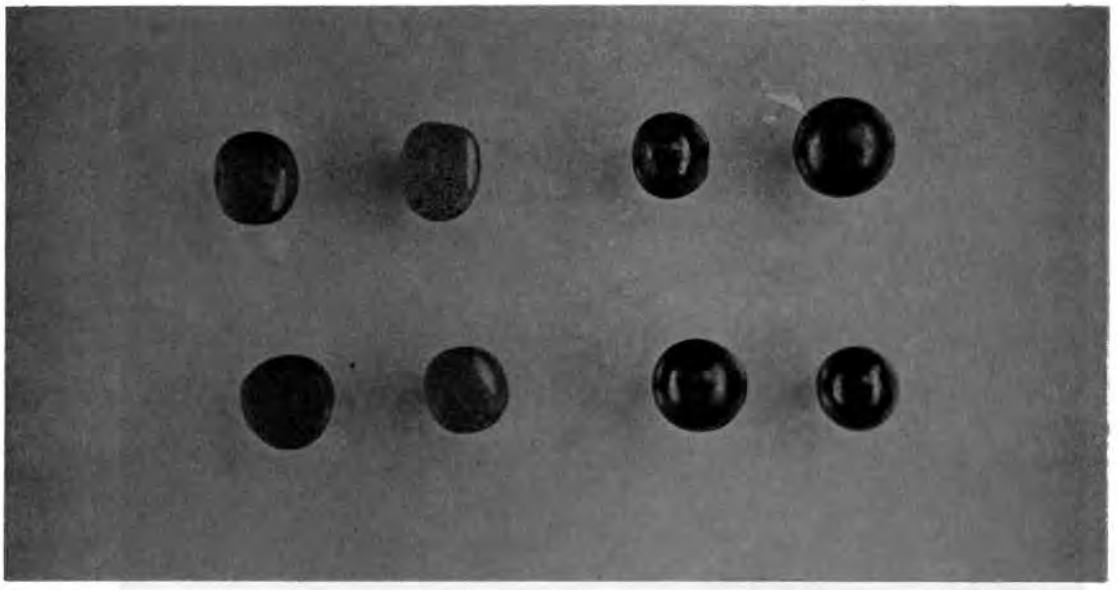


Figure 6a. Wild winterpea (left) and hairy vetch (right) seed illustrating differences in surface texture.

Figure 6b. Buckhorn plantain seed (small blackened seed) and crimson clover seed. The buckhorn seed are covered with iron powder.

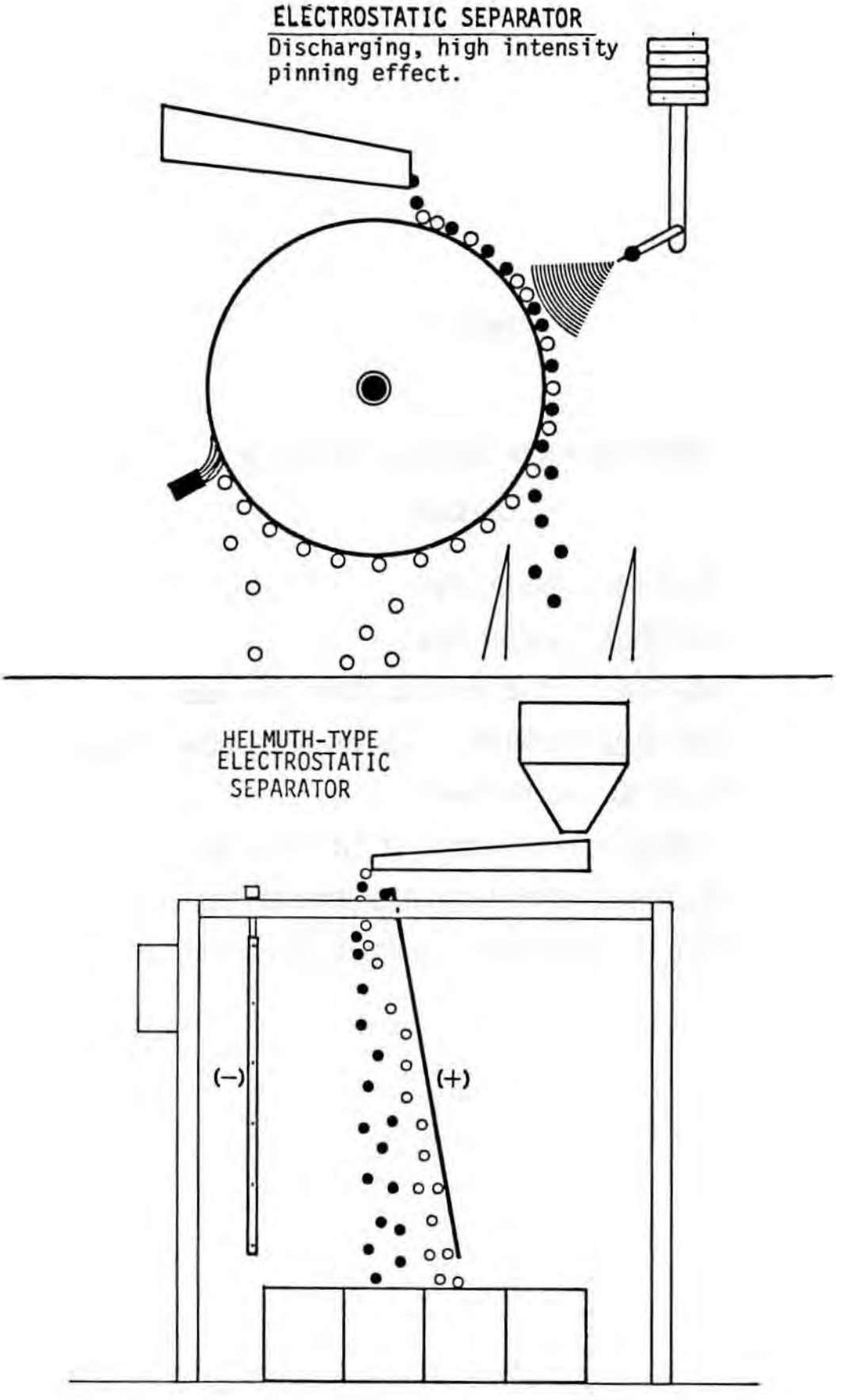


Figure 7. Two types of electrostatic separator.

CHART 1

MODIFICATION OF PHYSICAL PROPERTIES

Examples

DEFUZZING - Tomato Seed

DEFRINGING - Carrot Seed

DEWINGING - Pine Seed and Other Tree Seed

DEBEARDING (DEAWNING) - Barley, Oats, Other Grasses

DELINTING - Cotton Seed

CLIPPING - Oats (removal of tips of hulls)

HULLING - Sericea Lespedeza, Bermudagrass

BREAK-UP - Flax Balls, Unthreshed Spiklets

The Pre-Cleaning Examination

As previously indicated, the first step in conditioning each seed lot is the pre-cleaning examination. Before giving any consideration to the equipment to be used in cleaning a lot of seed, a representative sample of the lot should be examined to determine the following factors:

1. Frequency of occurrence of contaminants
2. Size variation of the good seed
3. Differences in physical characteristics
4. Flowability
5. Need for pre-conditioning
6. Damaged seed

There is no significance to the order in which these factors are determined.

The primary purpose of the pre-cleaning examination is to determine the separable components of the seed lot. Remember: unless there are distinguishable physical differences among the components of the seed lot, no separation is possible. Thus, it is the components of the seed mixture and not the machine that determine if a particular separation is possible or practical (Figure 8).

Contaminants which have physical characteristics similar to those of good seed are of greatest concern. When examining the seed lot, particular emphasis must also be placed on determining the presence of contaminants such as noxious weed seeds, nematode galls, etc., which could cause the seed to be unsalable even though the mechanical purity may exceed 99%.

Contaminating materials obviously much larger, smaller, or lighter than the good seed are not of great concern except when such materials affect seed flowability or when they represent more than about 20% of the seed lot. Seed lots containing a very high percentage of inert matter or removable crop and weed seed normally must be cleaned at a reduced rate of flow to allow removal of these materials and to avoid flooding of the discharge spouts provided for materials removed from the seed mass.

Frequency of occurrence of contaminants refers to the ratio between the desirable seed or characteristics of a lot and the undesirable. When looking at the seed to be cleaned, a thorough examination may reveal an undesirable characteristic, but it usually is the ratio of good to bad that is important, not the fact that a minor, oftentimes

correctable defect is noted. This is usually a judgment decision, but we are generally willing to give up or overlook one thing to get something we really want.

Depending upon the quality standards which must be met, certain contaminants can sometimes be ignored. All clean seed will contain a fractional percentage of inert matter. Many lots contain small amounts of other crop or common weed seed because the cost of removing them exceeds the value that would be added by their removal.

Variation in size of the good seed is one factor frequently overlooked when examining seed for conditioning. Research conducted in 1875 showed that the very smallest seed in most lots are of little value for reproductive purposes. On the other hand, subsequent research on seed size indicates that the exceptionally large seed in a lot, although nice to look at, are usually not the most desirable for reproductive purposes. Therefore, in seed, what we really want are those large enough to perform their function, but small enough to avoid problems due to excess size.

For most crops, the better the climatic conditions for seed production, the more uniform the size of the seed. In all species, the more uniform the seed size, the easier the seed are to clean. Experienced operators know that different varieties of the same species often differ significantly in average seed size and adjust the machines accordingly. One of the poorest testimonies to a seed conditioner are screens marked with the name of a crop. Such marking usually indicates a disregard for the natural variation in seed size and other variable physical characteristics of a seed lot.

Another factor determined during the pre-cleaning examination is flowability. This refers to the ease and uniformity with which seed will flow in the absence of mechanical force. Seed must flow uniformly through the equipment before they can be effectively separated from the contaminants. As a general rule, a lot of seed which has an angle of repose greater than 70 degrees should be pre-cleaned or conditioned before attempting any separation by the air-screen or subsequent machines. Anyone who has spent a day or two forcing seed into an elevator or pushing seed through a bin opening will testify for the need of predetermining the flowability of every seed lot.

Most seed lots which have been harvested and threshed mechanically will flow through a properly designed conditioning plant. However, an occasional lot of any kind of seed may lack the necessary flow characteristics because of natural appendages on the seed, high quantities of coarse, inert matter, high moisture content, or poor threshing. Such lots should be pre-conditioned to improve flowability.

A factor related to flowability is the need for pre-conditioning. The term pre-conditioning is used in two different contexts. First, it

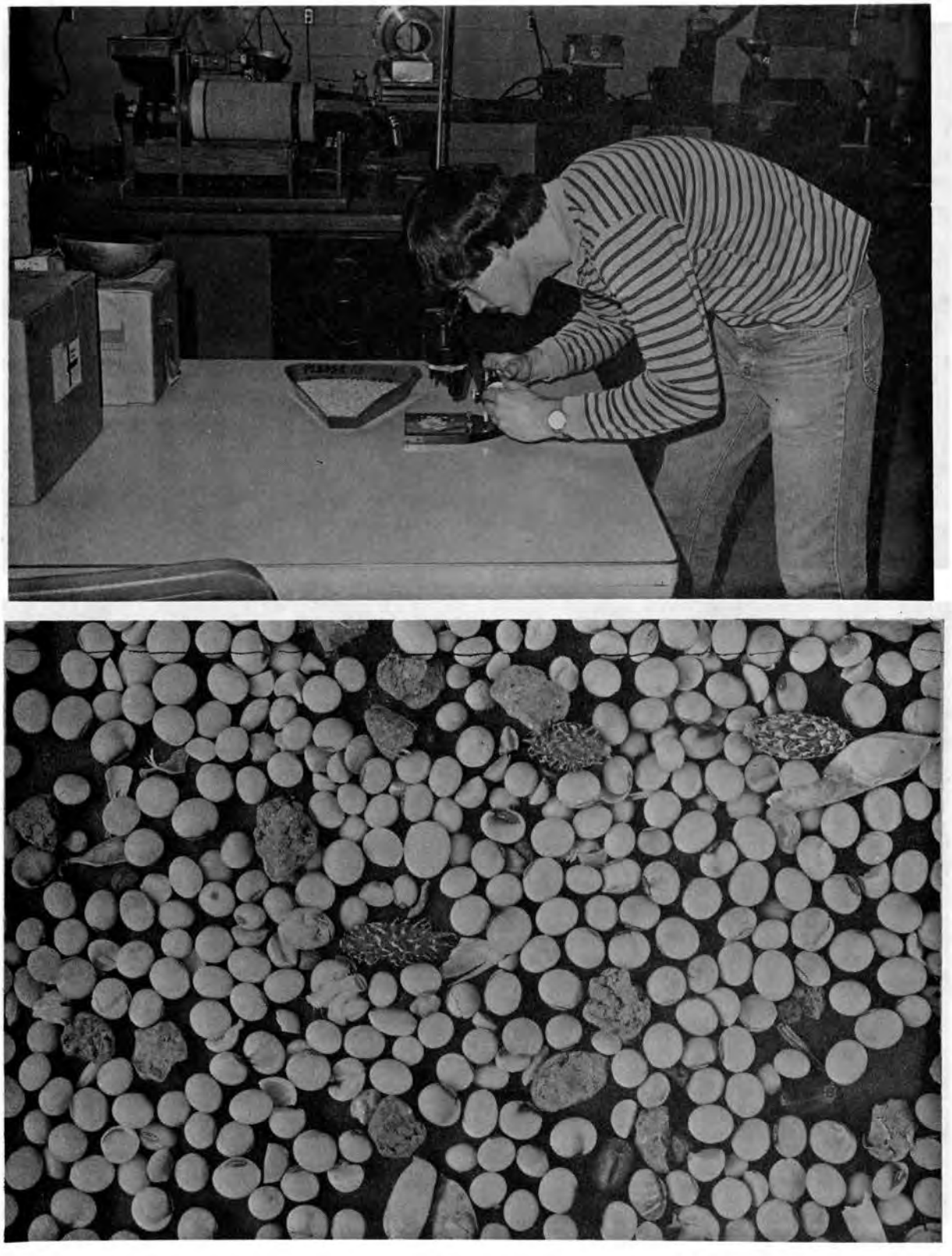


Figure 8. The first step in conditioning is to find out what needs to be removed.

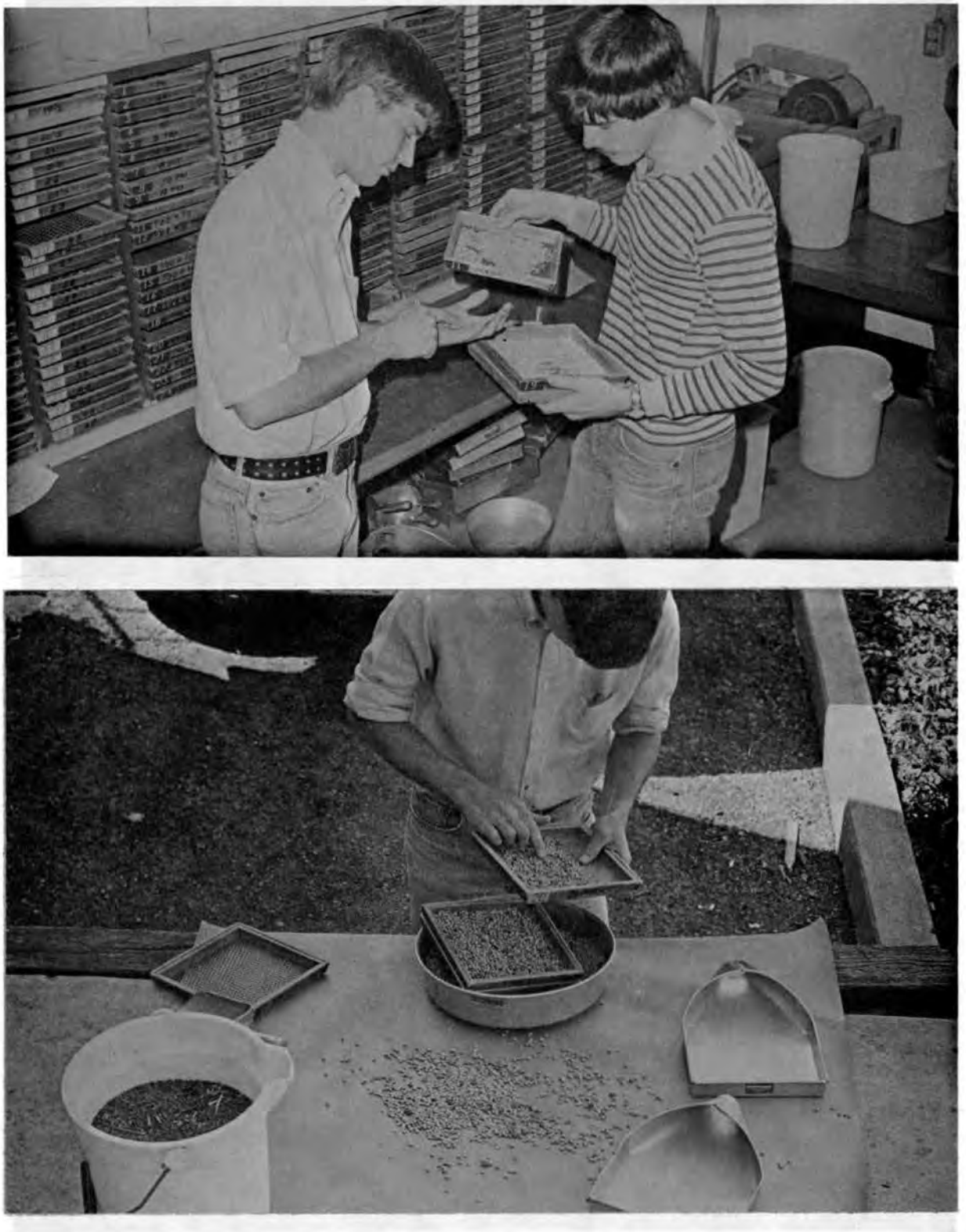


Figure 9. The pre-conditioning examination: thorough and in a well lighted place.

may refer to any method used to circumvent or remove those obstructions which reduce flowability. If long pieces of plants, such as straw or stems, or large quantities of sand or soil are the cause of poor flowability, these are normally removed with a scalper or aspirator. Drying lots which are high in moisture or which contain green plant materials often will give a lot the desired flow characteristics. Of course, corn must be shelled. There are several techniques which can be used to improve flowability, but the method used will depend upon what you want to remove.

The second meaning applied to pre-conditioning refers to the removal of undesired or unncessary coverings and appendages from the seed which may interfere with the cleaning process. This type of pre-conditioning also serves to improve the appearance of the product. It is customary to hull and/or scarify combine-run seed of many of the small seeded legumes to facilitate cleaning and increase the speed of germination. Awned varieties of oats and barley are normally debearded both to improve flowability and appearance.

The final factor which should be determined during the pre-cleaning examination is damaged seed. There are three main causes of seed damage: (1) insects, (2) diseases, and (3) mechanical abuse.

When insect are active in the seed, the lot should be fumigated using a fumigant recommended for use on seed. Disease damaged seed are usually lighter in specific weight than healthy seed of the same dimensions. Thus, the presence of more than 2 or 3% damaged seed is an indication to increase the velocity of the final air separation on the air-screen cleaner and the possible need to utilize a gravity separator. In most instances, seed lots that require specific procedures to remove disease damaged seed should be treated with the appropriate fungicide.

Mechanical damage to seed can be classified into three categories: (1) seed destroying, (2) major, and (3) minor. As the name implies, seed destroying damage is gross mechanical injury which splits or breaks the seed, such as split beans or cross broken seed. Usually, these seed parts can be removed because breaking changes the physical characteristics.

Major damage is damage to the seed coat or covering which is visible to the naked eye, such as cracked or chipped corn seed and machine cut cottonseed. Nothing can be done to remove such seed from the lot unless the damage alters the physical characteristics of the seed. Seed having minor damage, such as pin-holes, are not normally noticed in the pre-cleaning examination.

Technique for Making Pre-Cleaning Examinations

Under optimal conditions, the operator/manager will have an opportunity to condition a sample of each seed lot with hand screens and/or

model equipment (Figure 9). Organizations equipped to conduct such tests are among the most efficient in their cleaning and conditioning operations. Such testing requires advanced sampling and control over delivery of various seed lots to the conditioning plant. This type sampling and control is not feasible for plants engaged in custom cleaning operations or conditioning seed coming directly from the field.

An intermediate method of making the pre-conditioning examination is to conduct a routine purity analysis on a sample of the field run seed. This analysis will provide valuable information on the kind and rate of occurrence of the various contaminants. However, such factors as comparative physical difference between the good seed and contaminants, variation in seed size, flowability, and damaged seed must still be determined on the basis of a visual examination.

In spite of the more desirable methods of examination listed above, the pre-cleaning examination is most frequently made by simple visual examination of several handfuls of the field-run seed taken at the time the seed arrive. To make this examination, the seed are poured slowly from hand to hand or spread into a thin layer on a table or floor, in a well-lighted area, and mental notes made concerning potential separation problems. It should be obvious that this method will result in a higher frequency of lots which are below or above desired quality levels after cleaning than when more detailed methods are utilized.

Precision of the "eye-ball" examination method can be increased if one knows the approximate weight of a handful of seed. This can be easily determined by weighing several handfuls of seed of various kinds. Greater repeatability can be gained if the operator will close his fingers against the fat part of his hand. For most persons, this will be a sample of one or two ounces.

Regardless of the techniques used for the pre-cleaning examination, it is of vital importance that one be knowledgeable in seed identification and purity analysis. An experienced operator can closely approximate the percent cleaning loss, mechanical purity of the clean seed, and the probable presence of undesirable seed before the seed enter the conditioning plant by combining his knowledge of seed with that of equipment operation.

SEED CONDITIONER

- Know thy seed
- Know thy machines
- Know ye principles
- Know thyself