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Soybean Seed Processing

Howard C. Potts & Charles E. Vaughan ^{1/}

By the time soybean seed are delivered to the processing plant, some seeds will have deteriorated in the field while others will have been split or damaged during harvesting, drying and storage. After all of this, it is the processing manager's job to use his knowledge of seed and skill in operating the available machines to assure management that the seed which are placed in the bag are pure, undamaged, weed free and of the highest possible germination.

Before discussing the techniques for processing soybean seed, a review of the reasons for processing, some useful keys, and the stepwise sequence used by successful processors may prove helpful.

There are at least six good reasons for processing crop seed of any kind. These are as follow:

1. Condition the seed - clean seed store with fewer problems.
2. Improve purity - prevents the spread of weeds.
3. Improve germination of the lot - fewer seed are required per acre.
4. Improve plantability - more uniform stands produce more.
5. Improve appearance - an important selling point.
6. Protect the seed - use of fungicides will improve stands when seed are planted either before or after optimum planting time.

There are five keys to successful processing. The first key is (a) Knowledge of the Seed itself. Soybean are fragile, split when dry and vary in size characteristics from lot to lot and in shape from one variety to another. The second key is derived from an awareness of the variations in the length, width, thickness, shape, specific gravity, surface texture of both the soybeans and the weed or other crop seed which occur in soybeans. These are the (b) Principles of Separation. The third key is (c) Knowledge of the Machines - their capabilities and limitations.

To utilize these three bits of knowledge - seed characteristics, principles of separation and equipment capabilities - requires that the

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fourth key - (d) Proper Equipment - be available. But even the proper equipment is not sufficient if the model or numbers of machines are not capacity correlated and sequentially arranged. This leads to the fifth key - (e) Layout of the Processing Line which is the topic of another paper. These "reasons" and "keys" should be kept in mind constantly when discussing the art and science of processing soybean seed.

A competent seed processor knows that every lot of soybeans follows the sequence below as the seed are being cleaned.

- I. Pre-cleaning examination.
- II. Removal of undesirable materials.
- III. Upgrading and/or sizing.
- IV. Packaging.

The balance of this discussion is directed to the first three steps of this sequence as they relate to cleaning soybeans.

I. Pre-cleaning Examination

The most important and troublesome weed seed and other contaminants occurring in soybean seed are shown in Figure 1. A few seconds spent in sampling and determining the composition and contaminants of every load or lot of seed can be as important as the actual cleaning, except when the processor has the time and money to reclean the lot.

Any weed seed or other contaminates which have at least one dimension similar to that of the soybeans will probably require the use of some machine, in addition to the air-screen cleaner. When considering the best means of cleaning soybeans, remember the difference in the diameter's of the largest and smallest good seed will be about 6/64-inch. Although a particular weed seed may appear to be larger or smaller than the average soybean; weed seed also vary in size. For example, despined cockleburs are much longer than soybeans but some have the same diameter as the larger soybeans. The cockleburs are also lighter in specific weight and less rounded. Which of these three seed characteristics would you utilize to make the separation; length, specific weight or degree of roundness?

The oversights and failures to obtaining an accurate estimate of a lot's composition during the pre-cleaning examination is a principal cause for sub-standard seed quality and stop sale orders. A stop sale order issued because of excessive inert matter or weed seed is usually the fault of the processing manager!

II. Removal of Undesirable Materials

Split soybeans; seed of common morning glory, purple moonflower (giant morning glory), and cocklebur; soil "peds", and unthreshed pods account for 99% of the undesirable materials which commonly occur in and can be removed from soybean seed. Seed of Johnson grass, crotalaria,

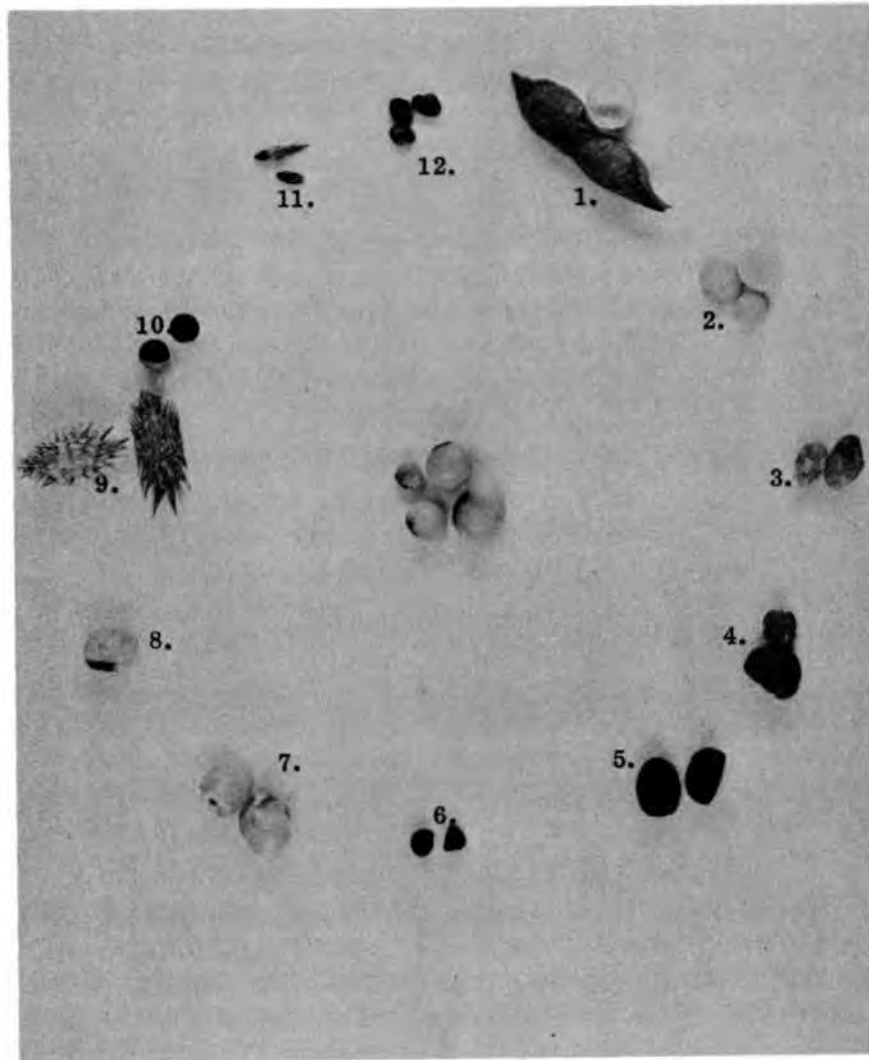


Figure 1: Soybean seeds and common contaminants in combine-run seed. (1. hulls and pods, 2. split seed, 3. diseased seed, 4. soil "peds", 5. purple moonflower, 6. common morning-glory, 7. corn, 8. cowpeas, 9. cocklebur, 10. ballonvine, 11. johnson grass, 12. crotalaria).

and several other weeds frequently are found in combine run seed. However, these seed are not difficult to remove because of their small size, relative to that of soybeans.

Normally, the air-screen cleaner and spirals are the only machines required to clean soybeans, but an occasional lot will require a separation based on weight differences.

A. Air-Screen Cleaner:

The air-screen cleaner is the basic machine used for cleaning soybeans. For this discussion a 4-screen, 2-air cleaner will be used as the example. The screen arrangement assumed is the first and third as scalping screens and the second and fourth as grading screens. (Figure 2). It is assumed the reader is familiar with the seed flow through an air-screen cleaner, therefore, the discussion starts with screen selection, follows the seed through the machine, and ends with adjustment of the air systems.

The first step, selection of the proper screens is easy if you just want to meet competition. However, if you are really interested in high quality soybean seed, screen selection will be made for every lot processed. Generally a processor that has for example, "bottom screen soybeans" written on a 9/64 x 3/4 screen has no genuine interest in precision processing. Such marking assumes all soybeans are the same size. This is a false assumption as will be shown later.

The first screen should have round perforations sufficiently large permit essentially all seed to pass through before they travel more than 1/3 the length of the screen when operating at optimum capacity. To do this, this screen should have perforations 4/64 to 6/64-inch larger diameter than the largest soybean seed in the lot. This requires a number 22 or 24 round hole screen as the top screen for most soybean varieties. The third screen, which is also a scalping screen, should have perforations about 2/64-inch larger than the largest seed in the lot, i.e., a number 20 or 22 round. Using scalping screens of these sizes should remove all cockleburs which still have spines and any remaining unthreshed pods.

The two grading screens selected for the second and fourth positions are most critical when cleaning soybeans. The second screen may have either slotted or round hole perforations. If the lot contains common morning glory, johnson grass, and similar size weed or immature soybean seed, a round hole screen with perforations the size of the smallest good seed, is recommended. The use of a number "12" or larger screen in the second position is particularly effective for removing seed of common morning-glory. If the lot contains no common morning-glory or similar size seed then a slotted screen, 8/64 or 9/64 x 3/4-inch, can be used to remove small weed seed, splits and inert materials.

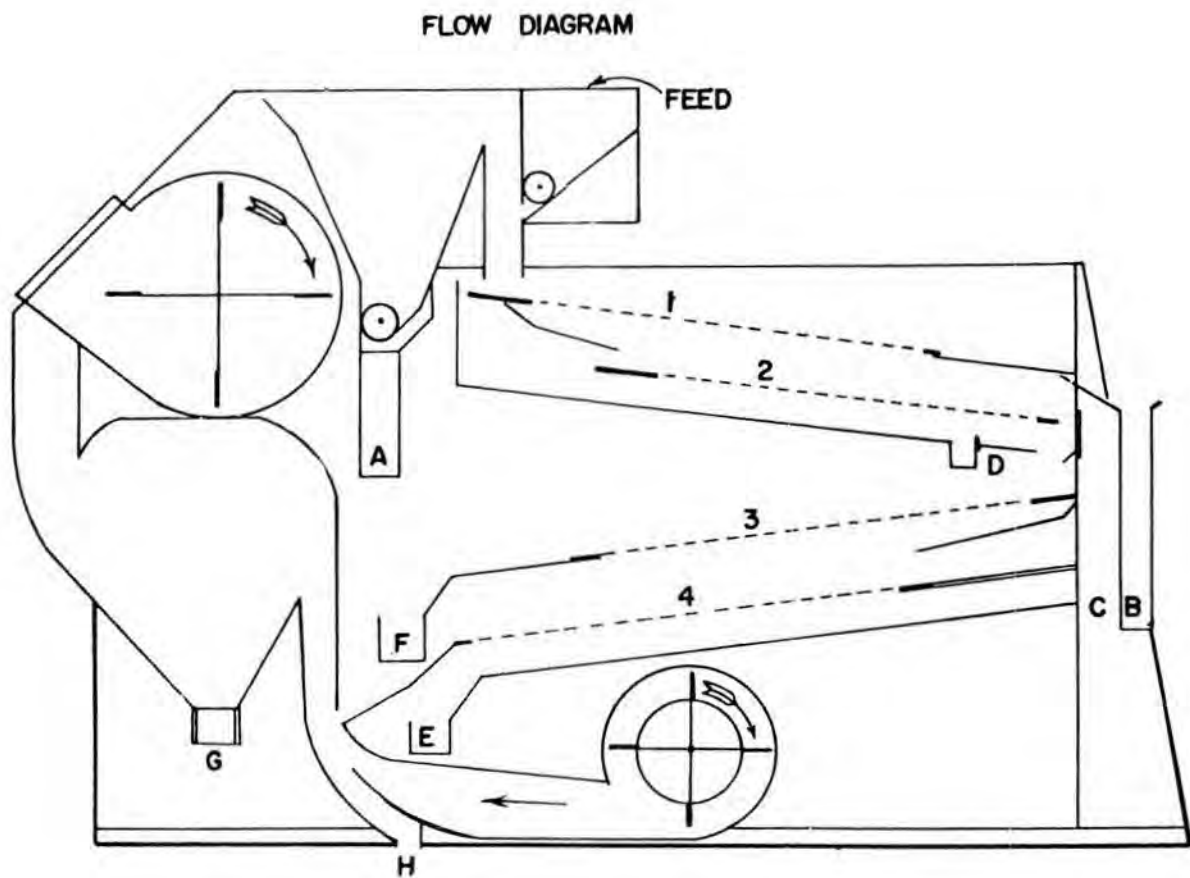


Figure 2. Cross Section of a 4-screen air-screen cleaner. (numerals indicate screen numbers; letters identify points of discharge).

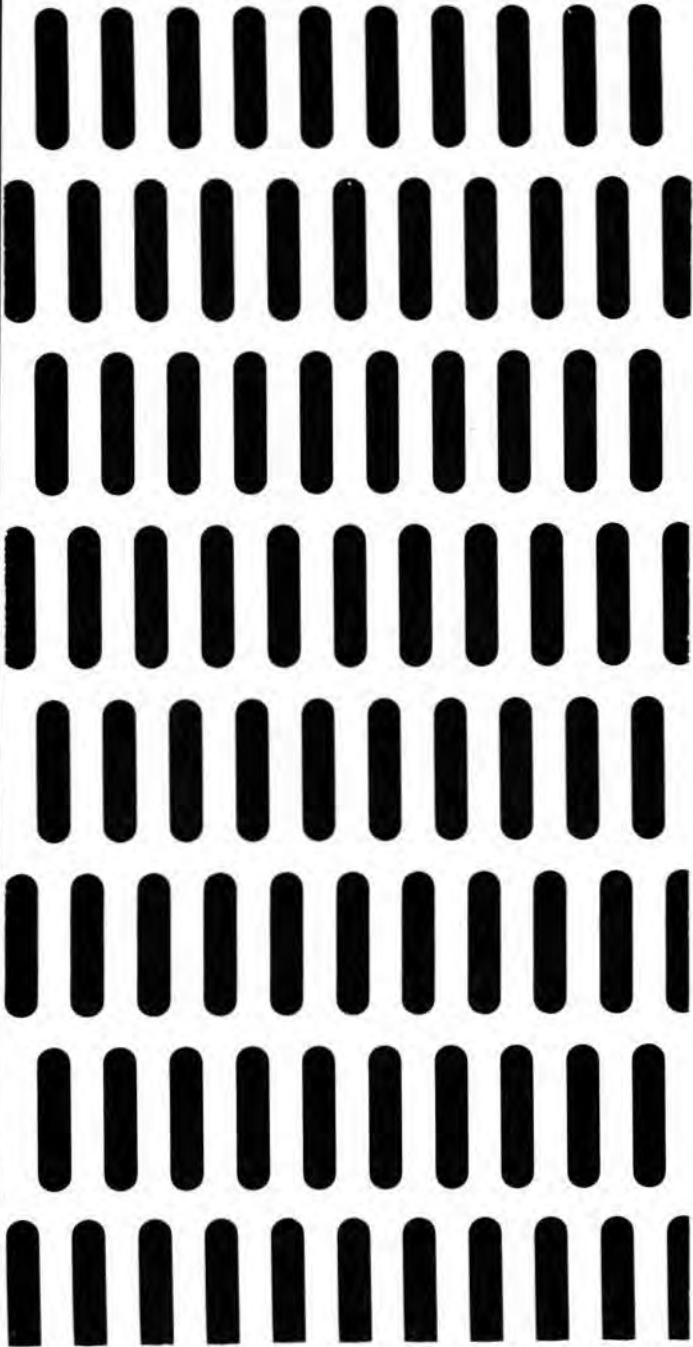
One processor rebuilt a screen for use in the second position. The upper-half of this screen now has slotted perforation, $8/64 \times 3/4$ -inch, and the bottom half, round perforations, $12/64$ -inch in diameter. This screen is reportedly very effective as long as the rate of feed is maintained at or below the manufactureres recommended rate for cleaning seed.

The fourth screen, the final grading screen in our example, is used primarily to remove splits and small immature seed, which are usually flattened. Most processors use either a $8/64$ or $9/64 \times 3/4$ -inch slotted screen as the final grading screen. Either of these two screens is the common bottom screen selected by the "common" processor. Rarely is there a good soybean seed small enough to pass through a $9/64 \times 3/4$ -inch opening.

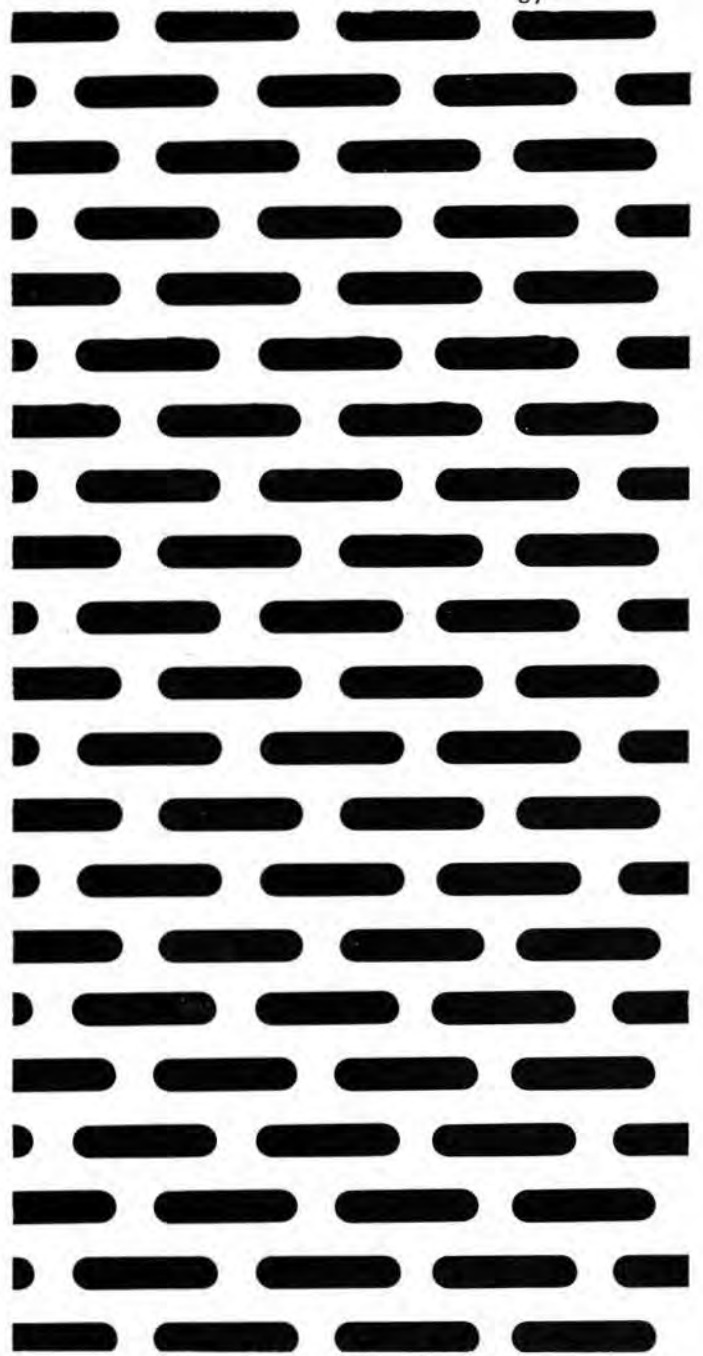
The discriminative processor will select a screen with oblong openings the same size as the smallest good seed in the lot. This means a screen having perforations of $11/64$ -, $12/64$ -or occasionally $13/64 \times 3/4$ -inch. In other words, a screen having perforations of $2/64$ -to $3/64$ -inch greater width than that commonly used should be selected for maximum efficiency. Use of screens having the wider perforation will increase the capacity of both the air-screen machine and spiral separator, but will not increase the loss of good seed when the bottom screen is selected on the basis of size of the smallest good seed.

When interested in removing the highest percentage of split seed, use of a screen with oblong cross-slot perforations, $1/64$ -inch wider than the commonly used oblong slot perforation, is recommended. Our research indicates that an $11/64 \times 3/4$ cross slot perforation is more efficient than a $10/64 \times 3/4$ oblong slot but less efficient than an $11/64 \times 3/4$ oblong slot when removing split soybeans. The only difference between oblong and cross-slot perforated screens of the same size designation is the orientation of the perforation in relation to the flow of the seed (Figure 3).

Why use a screen with cross slots? A split soybean tends to lie with the flat side against the screen as it moves down the screen. On an oblong slot screen a split seed may slide over the perforation because the width of most splits is greater than the screen perforations. Additionally, before a split can turn on edge and pass through an oblong slot perforation it must move at a right angle to the flow the seed mass. On the other hand, use of a screen with cross-slot perforations encourages the leading edge of a split seed to engage the perforation and the seed mass aids in pushing the split through the perforation since there is no change in direction of movement of the split. Increased use of grading screens in the fourth position having cross-slot perforations with perforations the diameter of the smallest good seed offers the opportunity for both slightly increased capacity and greater processing efficiency.



Oblong - slot



Oblong Cross - slot

Figure 3. Comparison of oblong perforations (arrow indicates direction of seed flow).

It should be apparent that the proper use of a set of hand screens will pay good dividends both in terms of time saved in selecting the proper screens and increased cleaning efficiency. The selection of grading screens with the largest perforations possible without loss of good seed and scalping screens with the smallest perforations practical is a key to processing efficiency.

Attaching an oil cloth or canvas apron or drape so it lies lightly on top first screen is very desirable when cleaning soybeans. The apron will prevent seed from bouncing down and off the screen, as well as keeping the unthreshed pods, stem pieces, etc. from turning on end and dropping through the screen. "Blanking-off" the lower half of the first screen with paper, plastic or sheet metal will also keep the longer materials from passing through the screen. Use of screen dams to agitate the seed mass increases the percent splits removed on screens with oblong perforations.

Two frequently ignored adjustments available on most air-screen cleaners are the screen pitch and screen cleaners or brushes. When cleaning soybeans the pitch on the first and third screens should be near the maximum 12° slope. The pitch on the second and fourth grading screens should be near the minimum 6° slope angle. Keep in mind that increasing the slope of a screen decreases the effective size of the screen perforations slightly and reduces the time a seed is on the screen. Properly positioned, unworn brushes are essential to maintaining cleaning efficiency. Every blocked perforation, per square foot of screen area, reduces the cleaning capacity approximately 0.25 percent on a screen with $10/64 \times 3/4$ -inch perforations. By the time one can observe blocked perforations on a vibrating screen, capacity has been reduced 5 to 10%.

The air adjustments can be made only after the machine is operational. The upper air should be adjusted to remove essentially all inert materials, including the splits if desired. This minimizes pollution in the processing plant while reducing the volume of materials to be separated by the screens.

The lower air should be adjusted to remove an occasional undamaged, non-diseased seed. An occasional good seed means one seed out of every 10,000 or a double handful out of every 200 bushels processed. The "occasional good seed" rule is still the best method of judging the effectiveness of the lower air separation.

A major cause of poor soybean processing is the tendency to operate the machine at an excessive capacity. In most instances, seed processors who claim cleaning capacities in excess 200 bu/hr on a four-screen single-stream cleaner are not processing soybean seed, rather they are simply running soybeans through an air-screen cleaner! When the layer of seed passing over the second screen is more than one seed in depth the machine is being overfed. When overfed some of the split seed and larger weed seed never contact the grading screens, therefore, these

materials remain in the seed lot.

B. Spiral Separators:

If after cleaning on the air-screen cleaner the soybeans still contain more than one split seed per handful and/or any common morning-glory seed the seed lot should be cleaned on a spiral separator. The presence of excessive splits or seed similar in size to morning-glory is an indication of improper screen selection and/or overfeeding. Certainly all seed lots which contain seed of purple moonflower, cocklebur, giant ragweed or a significant percentage of immature soybeans should be cleaned through the spiral separator to remove these contaminants.

We suggest the use of "flight dams" to remove purple moonflower seed from soybeans. Flight dams can be made from 6-inch strips of wood, 1/4" thick and 3/4" wide, attached to the inner flights of the spiral in the following sequence.

1. From the point where the seed enter each flight, measure 22" along the outer edge and lay a wood strip across the flight at an angle down the flight's slope and position it with a spring-type clothes pin. The free end of the "dam" should be at least 1½ inches from the center post.
2. Attach a second series of dams one turn down the spiral.
3. Attach a third series one turn below the second series.
4. Attach a clothes pin, but not a dam, one turn below the third series at an angle to deflect seed to the center.

Recently, adjustable flight dams which can be easily attached to the spiral separator have been placed on the market. These are very effective.

The original research on flight dams, conducted by A.H. Boyd of the STL staff, revealed the addition of these dams permitted removal of essentially all (99.99%) of the purple moonflower seed with a "good seed" loss of only 3.0%. Without the flight dams the good seed loss was 1.9%, but the purple moonflower seed remained in the soybean seed.

Increasing numbers of soybean processors run all lots over the spiral separator whether or not splits or weed seeds are present. This decision is justified on the basis that in the absence of a significant percentage of splits, or any weed seed, the appearance of most lots can be improved by removal of many of the flat and irregularly shaped seed. However, some varieties, and an occasional lot of most varieties, have a

high percentage of flattened seed and cannot be cleaned with the spiral separator without excessive loss of good seed. Such lots should be identified during the precleaning examination. Thus, spiral separators are not a "cure-all" for all lots of soybeans.

Spirals will not separate soybeans from cowpeas, soybeans from balloon-vine or soybeans having cracked seed coats. Remember, the contaminating material must be significantly less rounded than the soybean for the spirals to be effective.

C. Gravity Table:

Some processors have reported difficulty in obtaining the desired level of seed quality due to the presence of round soil particles (peds) or de-spined cockleburs. Separations of both these contaminants is easily accomplished with a gravity table, after the seed lot has been cleaned with the air-screen cleaner and spiral. De-spined cockleburs have a specific weight approximately two-thirds that of soybeans but the soil-peds are usually much heavier. Because of these weight differences the cockleburs will discharge from the low end and the soil-peds from the high end of the gravity table. Good seed losses in the range of 3 to 8% should be anticipated for those lots which are cleaned with a gravity table.

Only slight success should be anticipated through using the gravity separator to remove mechanically damaged, diseased, or badly deteriorated, whole beans from good soybean seed. Thus, because of the high loss of good seed and the small probability of increasing the physiological quality of the seed lot, only an occasional, "special" lot of soybeans will require cleaning with the gravity table.

III. Size Grading Soybeans

Currently, interest in size grading soybeans is high. Some research has revealed several interesting points concerning; seed size distribution, the quality of seed in different size classes, and the effects of removing the small seed from lots of soybeans.

Regardless of the variety, soybeans grown under different climatic conditions will vary both in average seed size and range in size from the smallest to the largest good seed. In one study, seed of three varieties produced at Mississippi State were planted the next year in South Carolina, Texas, Louisiana and Mississippi to assure production under different environments. After harvest, the thresher run seed were returned to the Seed Technology Lab.

The seed of each lot were size graded into size classes differing by 1/64-inch in diameter and tests conducted on the seed of each size class. The average seed size and the percentage of the lot in each size class for the Lee 68 variety are given in Table 1. Note two factors; first the 2½/64-inch difference in average seed size of the 6 lots and

second, the diameter of the smallest size class in each lot. This variation in size was due to differences in the environment under which the soybeans were produced.

From the data in Table 1 can you determine a single correct answer to each of the following questions? What screen size should be in the bottom position when cleaning Lee 68 soybeans? To size grade Lee 68 soybeans, what is the size range in 64th-inch for "medium-size" seed from each lot? Isn't it apparent that each lot has its own size characteristics, therefore, no single answer is best for either question or all six lots.

The distribution of physiological quality of the seed among the different size classes was also evaluated. A series of physiological tests were conducted, however, only the results from the standard germination test are discussed. Observe the levels of germination among the composite samples and compare them with each size class in Table 2. Notice that regardless of the average germination, seed of the smallest size-class and in one instance the largest size-class (lot 17) are lower in germination than the composite sample.

Logic would appear to indicate that removal of the poor quality seed from each lot should increase the quality of the remaining seed. The data in Table 3 shows the effects on germination brought about by removing seed of the smallest, two smallest, smallest and largest, two smallest and largest, and largest size-classes from each lot. There was no effect!

The reason for the lack of any effect becomes obvious when the quantity of seed removed is considered. The smallest size class is less than 1% of the total weight in each lot (Table 1). The two smallest size-classes constituted a maximum of 5.5% of any lot. Therefore, even if these small seed had zero germination, the maximum improvement in germination of the lot remaining would have been 4% in lot 13, and less than 3% in lot 15.

The conclusions of these studies were:

1. In soybeans, seed quality is not directly related to seed size.
2. Seed lots grown under different environmental conditions may vary in size distribution and average seed diameter by as much as 2/64-inch.
3. Generally, seed of the smallest size class in a lot are inferior in quality, however, their removal will not significantly improve the over-all quality of the remainder of the lot.

Table 1. Dimensional size composition of 6 lots of Lee 68 soybeans (after Aguiar).

Lot No.	Source (State)	Average Seed Size (64th-inch)	Seed Diameter (64th-inch) (Percentages)							
			11	12	13	14	15	16	17	18
13	SC.	13.8	0.4	5.1	24.6	52.3	15.3	2.4	0	0
14	SC.	13.8	0.4	5.0	23.5	54.1	13.8	3.3	0	0
15	TX.	16.2	0	0	0.9	3.0	14.6	43.1	31.7	6.9
16	TX.	16.3	0	0	0.9	2.6	14.2	42.2	32.8	7.4
17	LA.	15.1	0	0.8	4.4	21.4	37.4	28.2	7.0	1.0
18	MS.	15.1	0	0.7	2.7	19.3	43.1	29.3	4.9	0

Table 2. Germination percentages of 6 lots of Lee 68 soybeans (after Aguiar).

Lot No.	Composite Sample	Seed Dimension (64th-inch)							
		11	12	13	14	15	16	17	18
13	93.4	71*	89	91	95	95	91	--	--
14	88.7	78*	89	85	91	88	89	--	--
15	59.2	--	--	48*	66	70**	58	56	58
16	80.1	--	--	86	90**	84	82	77	77
17	61.6	--	41*	61	57	63	65	59	51*
18	91.8	--	55*	87	96	93	90	94	--

* Significantly lower in germination than the composite sample.

** Significantly higher in germination than the composite sample.

Table 3. Effect on germination percentages by removal of selected size classes of seed (after Aguiar).

Lot No.	Composite Sample	Size Class Removed				
		Smallest	Two Smallest	Smallest & Largest	Largest	Two Smallest & Largest
13	93	94	94	94	94	94
14	89	89	89	89	89	89
15	59	59	59	59	59	57
16	80	80	80	80	80	80
17	62	62	62	62	62	62
18	92	92	92	92	92	92

4. Because of variability in the average and range of seed size among lots of the same variety, the terms "small", "medium", and "large" seed have no general or scientific validity except as they apply to individual lots, i.e., small seed in one lot may be the same size as medium seed of another lot.
5. Use of grading screens having the same size perforations for every lot of soybean seed of the same variety decreases the efficiency of the grading operations and possibly the capacity of both the air-screen machine and spiral separator.

In summary, there appears to be a real opportunity to improve both efficiency and effectiveness in processing seed soybeans. However, before some processors achieve the desired level of efficiency, screen selection must be made on a lot by lot basis and increased attention will have to be given to proper machine adjustment. These technical factors should be coupled with the establishment of processing goals in keeping with the actual cleaning capacity of the machinery available. Based upon the currently available information there is no advantage, in terms of improving physiological quality, in dimensional sizing of soybean seed.