Variation of Physical Properties in Gravity Separated Soybeans

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ABSTRACT

EXPERIMENTS were conducted to study the physical characteristics of soybeans sorted by a gravity separator. The sorted fractions differed significantly ($P \leqslant 0.05$) in seed size as well as in seed mass. No significant differences ($P > 0.05$) in seed specific gravity of the various fractions were found due to the high correlation between seed mass and seed volume. The lightest fraction had significantly ($P \leqslant 0.05$) lower bulk density and was significantly ($P \leqslant 0.05$) more brittle than the remainder of the seedlot.

INTRODUCTION

Gravity separation is a process that utilizes a fluidized bed for sorting granular materials. This technique was first used by the mineral industry for ore reclamation and has since been adapted for use in many other areas. The seed industry utilizes gravity separators to upgrade quality of seed lots by removing diseased, damaged, or other undesirable seeds that are somewhat lighter that the remaining good quality seeds. Removal of low quality seed can sometimes permit recovery and sale of a portion of a seed lot which would otherwise not meet quality requirements for seed usage. This practice has become popular in the industry since seed quality standards are normally high.

Material to be sorted on a gravity separator is placed in a thin layer 3 to 7 seeds deep on an inclined perforated deck (Fig. 1). Air is introduced through the deck in sufficient quantity to fluidize the material. The lighter seeds float upward in the material, leaving heavier particles in contact with the deck surface. Vibrating the deck in a controlled manner will cause friction to push the heavy seeds up the slope, while seeds not contacting the deck are drawn down the slope by gravity. By providing some means for removing each portion from the deck, a quality differentiation can be made. In practice, this is done by using a deck that slopes in two directions (Fig. 2), allowing the material to spill over the edge. Simple dividers can be used to separate various fractions of the material.

Because of the inherent nature of the machine and the close separation required, proper adjustment of a gravity separator is difficult and requires a skilled operator. This difficulty is compounded in some high-quality seed lots because there often is no discernible visual difference between high and low quality fraction. Since discarding a large portion of a valuable crop is costly, some other rapid means of quality determination must be employed when adjusting the gravity separator for such crops. Test weight (bulk density) is frequently used in the seed industry to distinguish among various quality fractions in gravity separated crops. Low quality seed usually is lower in test weight than good seed. By making test weight measurements at intervals along the discharge edge, it is easier to determine the correct discard percentage. Experience with soybean separation has shown that only small test weight differences exist between fractions of a typical soybean lot. No information was found in the literature on variation of test weight and other physical properties of soybeans along the discharge edge of a gravity separator.

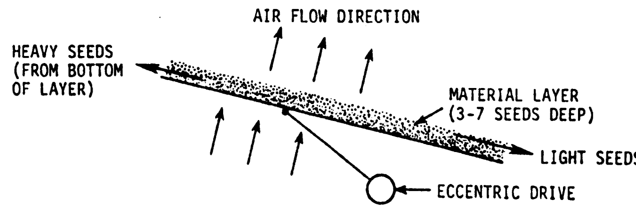

Fig. 1—Typical gravity separator cross section.

LITERATURE REVIEW

Research data pertaining directly to gravity is somewhat limited. The USDA (1968) published a handbook which contains an excellent description of the basic principles involved in operation and adjustment of

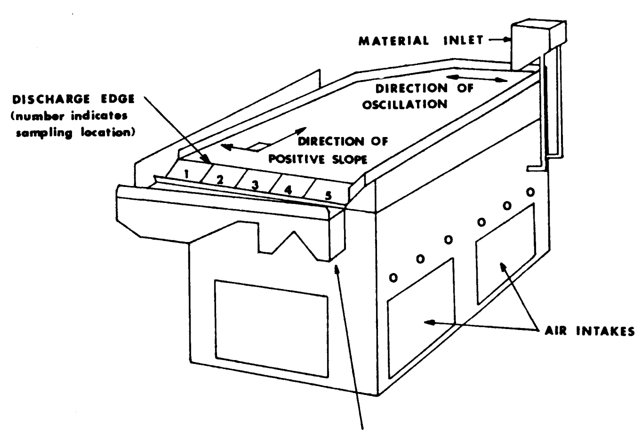

Fig. 2—Perspective view of Oliver model 50 gravity separator used for this study (drawing adapted from photo provided by Oliver Mfg. Co., Rocky Ford, CO).

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gravity separators. Mississippi State University (1968) lists three general rules for gravity separation. According to this source, mixtures of seeds of similar size and shape but with different seed densities will be split into fractions of different specific gravity. Seeds with uniform seed density but differing in size can be separated by size. Mixtures containing wide variations in both seed density and size cannot be separated properly.

Some information is available to describe types of separations possible on a gravity table for soybean seed. Misra (1981) found that removal of the lighter fraction from soybean seed lots using a gravity separator raised the average germination of the remaining seed by about 2 percentage points. Further studies (Misra et al., 1985) indicated that the gravity separator also successfully removed splits that were produced during movements of seeds from one location to another in a seed conditioning plant. Gaul (1983) found significant differences in test weight, seed coat damage levels, and breakage susceptibility in various fractions of corn sorted by gravity separation.

A few reports of research on density characteristics of grain were also found. Kerr (1950) found that test weight could sometimes be taken as an indicator of seed coat durability in corn. Shelef and Mohsenin (1968) used a specific gravity gradient column containing a mixture of liquid carbon tetrachloride-cyclohexane to determine the density range of individual kernels within given grain samples. Individual kernel specific gravities ranged from below 1.10 to over 1.32 within one lot of corn. Similar trends were also found for buckwheat, alfalfa, wheat, and clover.

This experiment was conducted to quantify the variation of basic physical characteristics in fractions of a soybean seedlot sorted by gravity separation.

PROCEDURE

A split-plot experimental design with three varieties and two replications was used. The three varieties were 'Beeson,' 'Williams,' and 'Corsoy.' Replications consisted of the same soybean variety obtained from different seed farms. Approximately 273 kg of each seedlot were equilibrated to a moisture content between 8 and 9% by using a set of laboratory natural air dryers. Prior to gravity separation, all seed lots were screened and aspirated using a Crippen model H434 seed cleaner to remove broken seed and foreign material. Seed was then passed through an Amos model 100 spiral separator to remove non-round and shriveled seed. The gravity separator used for the test was an Oliver model 50 equipped with a 16-mesh deck and an adjustable feed gate. No dust hood was provided over the deck, and no attempt to recycle a middling fraction was made. To assure operating conditions for each lot, all seed discharged from the gravity deck was recycled manually for several minutes after start-up to provide time for machine adjustment. Care was taken to provide uniform deck coverage at a capacity of about 818 kg/h for all lots.

One sample of each seed lot was drawn at the seed inlet to the gravity separator and also at each of five locations across the discharge edge (Fig. 2). All samples weighed about 1 kg and were drawn by hand in a random order. Samples were stored in polyethelene bags closed by wire fasteners. All samples were held at 10 °C for approximately five weeks prior to further analysis.

Physical properties measured included split percentage, test weight, seed mass, seed volume, and breakage susceptibility. Percentage of splits was obtained by screening the initial sample with a 4.0-x 19-mm (10/64-x ¾-in.) slotted sieve and weighing splits that fell through the slots. Test weights were obtained using screened samples and a standard test weight apparatus. Average seed mass and volume results were obtained by weighing a 100-seed subsample and then determining the volume of the subsample by use of a Beckman model 930 air comparison pycnometer. Seed mass and volume values were used to calculate average specific gravity of soybeans.

A 500-g subsample was removed from each sample to test for breakage susceptibility. A series of 3 drops through a vertical 5-m tube onto a 45 degree inclined steel plate was used to simulate the handling of seeds in a soybean seed conditioning plant. All samples were fed at a uniform rate by using a Syntron vibratory feeder and were caught in a plastic wastebasket to minimize extraneous damage following initial impact (Fig. 3). A 4.0-x 19-mm (10/64-x ¾-in.) slotted sieve was used to determine percentage of splits in the subsample after the drops. This percentage was taken as an indicator of relative breakage susceptibility of the sample.

RESULTS

Data was analyzed by using a combination of the Minitab program (Ryan et al., 1976) on the VAX

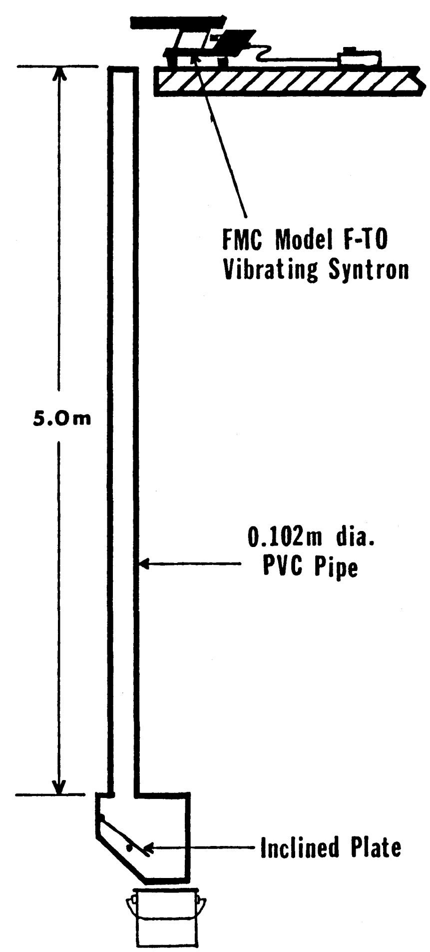

Fig. 3—Set-up used to determine breakage susceptibility of samples.

TABLE 1. EFFECT OF VARIETY ON PHYSICAL PROPERTIES OF SOYBEANS

Variety	Specific gravity	Mass, g/100	Volume, cm^3/100	Test weight, kg/m^3	Splits, %	Breakage susceptibility, %
Williams	1.256a*	17.39ab	13.84ab	757.4a	0.48a	2.0a
Corsoy	1.262a	15.92b	12.62b	754.8a	0.95a	2.15a
Beeson	1.262a	19.24a	15.24a	747.1a	1.53a	7.12b
Average	1.260	17.52	13.90	753.5	0.99	3.76

*Means with the same letters within columns do not differ significantly according to a Fisher's Least Significant Difference Test at the 5% level.

TABLE 2. EFFECT OF SAMPLING LOCATION ON PHYSICAL PROPERTIES OF SOYBEANS

Location	Specific gravity	Mass, g/100	Volume, cm^3/100	Test weight, kg/m^3	Splits, %	Breakage susceptibility, %
1 (Heavy)	1.260a*	18.55a	14.72a	757.1a	0.003a	1.67c
2	1.260a	17.82b	14.14b	751.7a	0.003a	1.78c
3	1.261a	17.40c	13.80c	756.7a	0.062a	2.65bc
4	1.262a	17.06d	13.52d	754.4a	0.218a	3.98b
5 (Light)	1.259a	16.67e	13.25e	741.0b	4.993b	9.02a
6 (Initial)	1.259a	17.59bc	13.97bc	755.1a	0.646a	3.43bc

*Means with the same letters within columns do not differ significantly according to a Fisher's Least Significant Difference Test at the 5% level.

Computational System and an analysis of variance procedure on the Statistical Analysis System (SAS, 1982) provided by Iowa State University. The analysis of variance procedure indicated that there was no significant difference ($P>0.05$) among varieties in terms of specific gravity, bulk density and percentage of splits (Table 1). Beeson was found to be more susceptible to breakage than the other two varieties included in the study. Corsoy soybean seeds were significantly smaller in size and lighter in weight compared with soybeans in Beeson variety.

Table 2 lists average values of physical properties for all varieties at each location. A summary of results for each property considered follows.

Specific gravity, averaged across locations, varied insignificantly ($P>0.05$) over a range from 1.259 to 1.262. Seed mass varied significantly ($P \leq 0.05$) over a range from 16.67 to 18.56 g/100 seeds. A consistent trend toward lower seed mass in samples closer to the light end (location 5) was noted, with an average value at location 5 almost 2g/100 seeds lower than the samples at the heavy end (location 1). The average seed mass at the light end (location 5) was also almost 1g/100 seeds lower than the input sample (location 6). Seed volumes determined by using the air-comparison pycnometer varied over a range from 13.25 to 14.72 cm^3/100 seeds. A very high correlation ($r = 0.996$) between seed volume and seed mass was found (Fig. 4). For this reason, the same trends discussed for seed mass also hold for seed volume. This linear relationship between seed volume and mass supports the finding of a constant specific gravity for all samples.

Virtually all splits in each sample were concentrated in the light fraction (location 5). Only the fraction from this sampling location had a significantly different ($P \leq 0.05$) percentage of splits from that in any other location (Table 2). Average split percentages in the light fraction (5%) were almost eight times higher than in the initial sample (0.65%, Table 2).

Samples collected from location 5 were also significantly lower ($P \leq 0.05$) in test weight than the initial sample (Table 2). No significant ($P>0.05$) difference between test weights of the other fractions was found. The data indicated a strong relationship between test weight and splits content (Fig. 5) for all samples taken from location 5 (light fraction).

Breakage susceptibility, as measured from the 5-m drops, indicated that samples from the light end (location 5) were more susceptible to breakage than samples from any other location. Samples taken from location 5 contained 2.6 times as many splits as the initial samples after drops (9% vs. 3.4%, see Table 2). There was also a strong correlation between brittleness (breakage susceptibility) and test weight for the discard

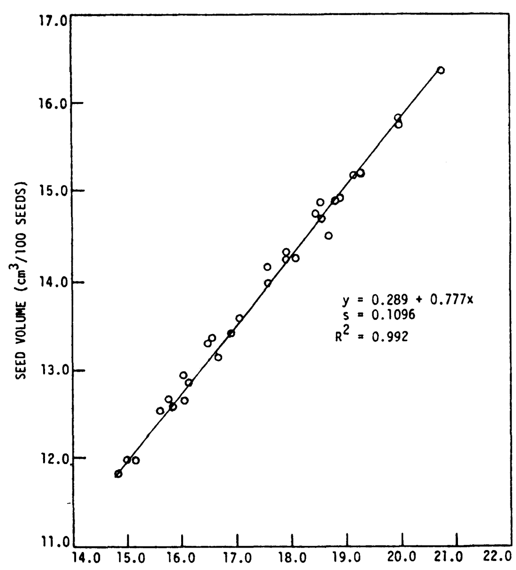

Fig. 4—Average seed volume from air comparison pycnometer vs. average seed mass.

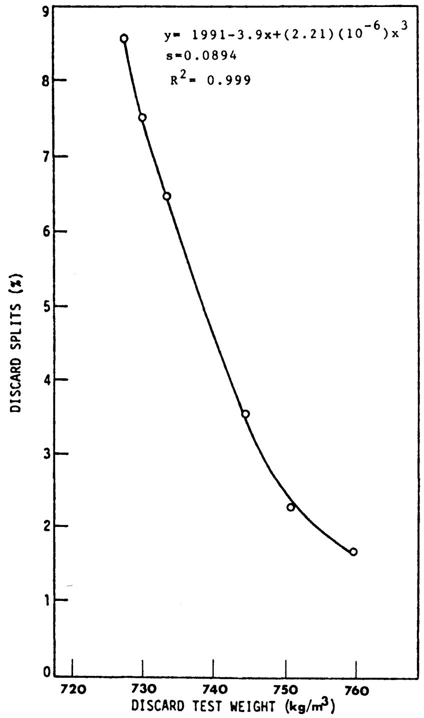

Fig. 5—Percentage of splits vs. test weight for samples from location 5.

samples (Fig. 6). Discard samples with low test weights tended to be more brittle than discard samples with normal test weights.

CONCLUSIONS

1. The gravity separator produced a definite size separation, as measured by the volume of 100 seeds, when used to sort soybean seed.

2. A consistent change in seed mass was noted in samples from various locations along the discharge edge of a gravity separator.

3. No significant differences (P>0.05) in seed specific gravity of the various fractions were found. This was due to the high correlation between seed mass and seed volume of various fractions.

4. The lightest fraction had lower bulk density and was more brittle than the remainder of the seedlot.

5. Light fractions with lower test weights tended to be more brittle than the light fractions with normal test weights.

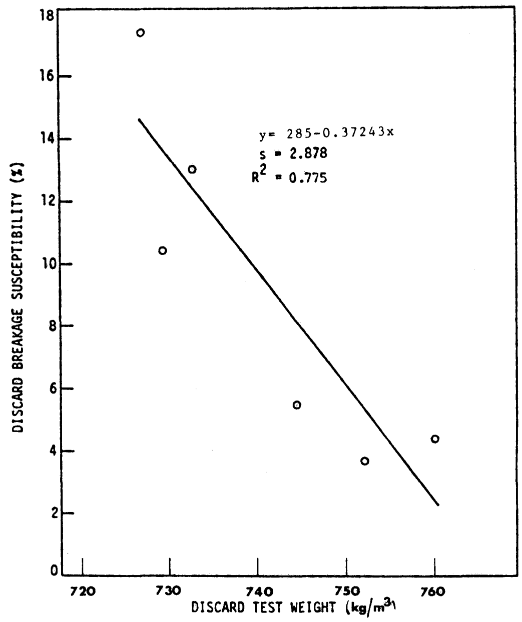

Fig. 6—Percent of split generated by drop vs. sample test weight for discard samples. (Location 5).

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