A PORTABLE BEAN SIZE GRADER

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Bean size grading for inspection purposes has traditionally been accomplished with the use of a series of screens, or superficially by visual inspection. Screening machines are usually large and not easily moved. A convenient and portable system was required for field use to classify small samples. Seed is marketed in Canada according to standards of the Seed Act and Regulations. The uniformity of seed size is a quality factor for beans, including soybeans (*Glycine max* (L.) Merr.) and field beans (*Phaseolus vulgaris* L.). The regulations define soybean seed uniformity as those seeds which fall within a range of ± 1.80 mm in diameter as measured with round-hole seed screens. There are tolerances for small or large seeds which are outside the acceptable range. For example, Canada Certified No. 1 seed may have up to 5% over or undersized seeds and Canada Certified No. 2 up to 8%.

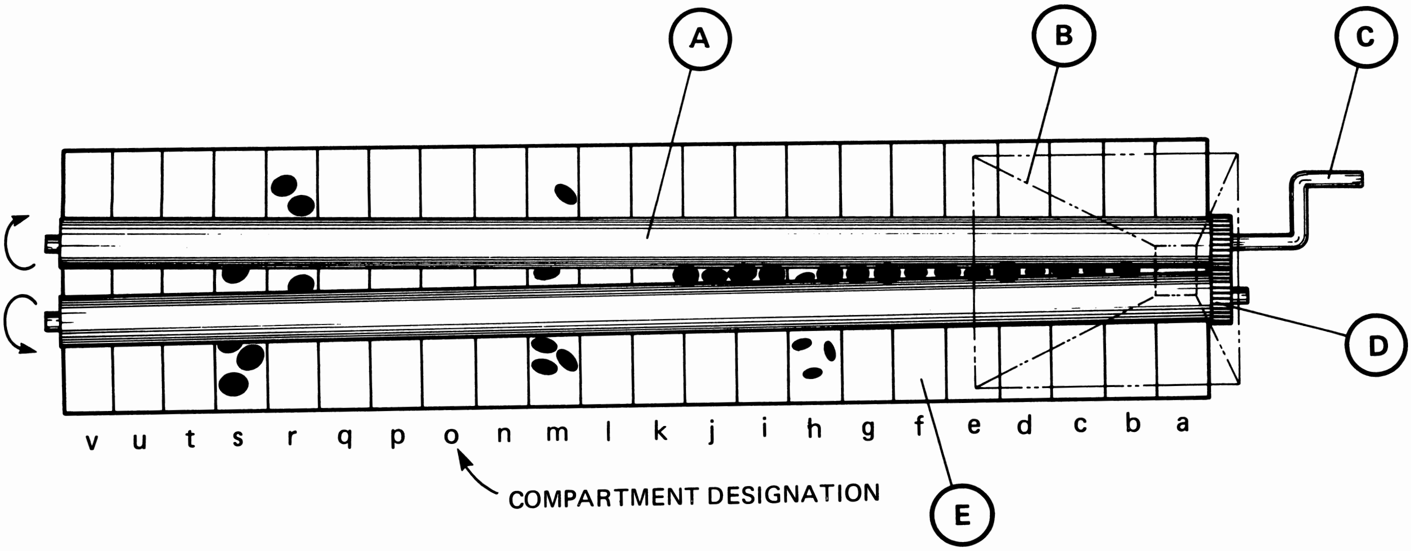

Figure 1. Schematic diagram of bean size grader. A, roller; B, hopper; C, crank; D, spur gear; E, multi-partitioned container forming a series of compartments.

DESCRIPTION

A grader was designed similar to that described by Morgan and Constantin (1976), utilizing the same divergent roller principle that is common to a number of size grading machines. The grader (Fig. 1) has two diverging, counter-rotating rollers capable of classifying seeds according to their minor diameters, in increments of 0.40 mm. The rollers (A) are of aluminum, each 24 mm in diameter, 560 mm in length, and are mounted to provide an adjustable "downhill" slope (maximum 6°) toward the wide opening. They are spaced 1.19 mm (All dimensions given in this paper are a result of conversion of English to metric dimensions, not the precision of measurement) apart at the higher end and 9.92 mm apart at the lower end. The resulting tapered space allows beans to fall through into grading compartments as the space between the rollers becomes sufficiently large for the seeds to drop. The slope and counter-rotating action of the rollers encourages the beans to continue moving toward the end where the gap between the rollers is widest.

A hopper (B), with an adjustable throat size, accommodates a 400-seed sample and allows the beans to enter the roller chute as the rollers are rotated. Rotation is accomplished by a hand crank (C) turning one roller and a pair of spur gears (D, 25.4 mm pitch diameter) to counter rotate the other at the same speed in an upward direction between rollers.

Grading of seeds into sizes that differ by 0.40-mm increments is achieved by a 22-section container (E) below the rollers that catch the seeds as they fall. The partitions are spaced at 25.4-mm intervals to coincide with a space difference in the space between the rollers of 0.40 mm. Thus 22 sizes of beans, each with a mean variance of 0.40 mm could be collected from a single sample, with a range from 1.19 to 9.92 mm in minor diameter.

EVALUATION

During initial testing it was found that the slowest practical roller speed and minimum practical slope resulted in the most accurate size classification. The faster the seed travels down between the diverging rollers, the greater is the risk of a seed being projected beyond the proper size compartment into the next. A single sample of 400 seeds can be size-sorted and graded in about 5 min.

Trials were conducted using 48 samples

TABLE I. NUMBER OF SEEDS PER COMPARTMENT IN THREE CONSECUTIVE TRIALS ON A SAMPLE OF 100 SOYBEAN SEEDS

	Compartment t					
	i	j	k	l	m	n
Width of opening between rollers over compartment (mm)	4.36–4.76	4.76–5.15	5.15–5.55	5.55–5.95	5.95–6.35	6.35–6.74
Trial A	2	18	44	33	3	
Trial B	2	17	45	33	3	
Trial C	2	16	46	33	3	
Mean	2	17	45	33	3	

See Fig. 1.

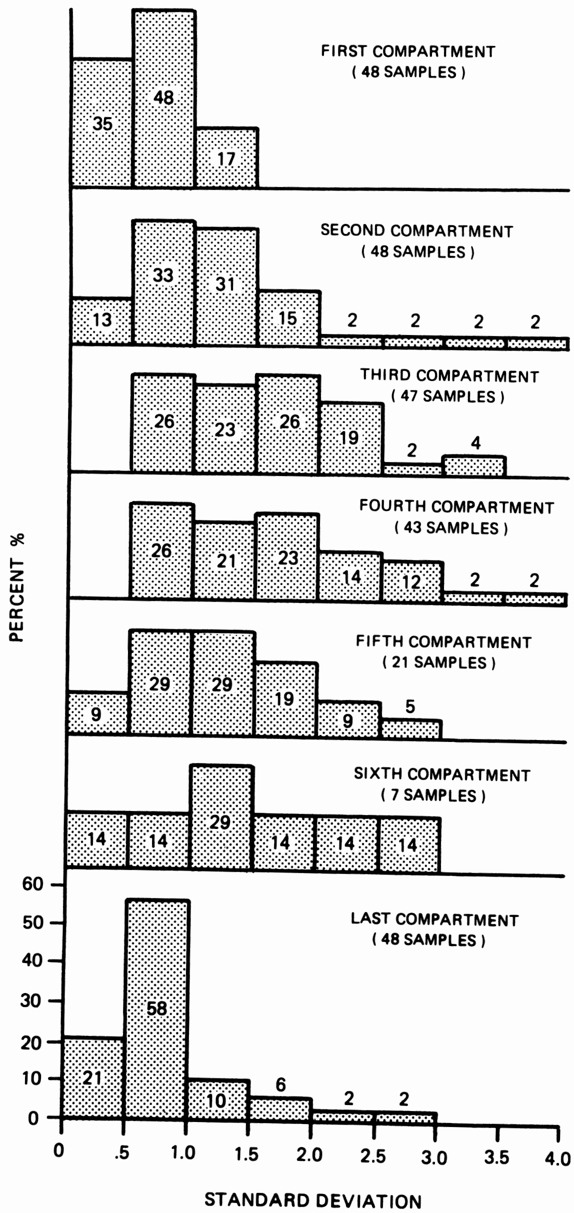

Figure 2. Bar graph showing the standard deviation of seed counts in various compartments vs. the percent of samples falling within the ± 1.80-mm range.

of 100 soybean seeds. The samples were obtained from 28 different seed lots of various cultivars, qualities and from various levels of processing. Counts were made of the number of seeds falling in each size compartment, and each sample was put through the grader three times. An example of one of the samples tested is shown in Table I. According to the standard which allows a 1.80-mm range, the seeds falling in slots j to m would be within the 1.80-mm range, and 2% of the seed would be outside the 1.8-mm range.

The repeatability of the trials was analyzed by calculating the standard deviation of seed counts for each compartment. The data were then pooled so that the repeatability of end compartments from each sample could be estimated. As a regulatory testing device, the error associated with the compartments outside the acceptable range of seed sizes (± 1.80 mm) is critical, while misplacements within the accepted range is of little significance. The end compartments generally have fewer beans than those in the middle and consequently have a lower standard deviation. The data are summarized in Fig. 2. The samples tested had seed sizes falling in a range of between three and eight compartments. To examine the repeatability of the two end compartments, a sample with the seed falling in four compartments would have standard deviation data recorded in the first (one end), second, third, and last compartment vs. the percent of samples falling within the ± 1.80-mm range. Figure 2 shows the range of standard deviation of each compartment, indicating that the first and last compartments have an average standard deviation of 0.517 while those in the middle have an average deviation of 1.475, which is the least critical of the two.

Further trials were conducted to determine the precision of the device to sort seeds by minimum diameter. Three 100-seed samples were obtained from different seed lots. The seeds were measured with a micrometer caliper, labelled with a felt marker, and run through the grader four times. The results summarized in Table II, show that some seeds "overshoot" the compartment that they are expected to fall into and that the variability is due to the misplacement of seeds by not more than one compartment. This trend appears to be consistent, so that the average seed size in each compartment was usually up to 0.40 mm greater than the previous compartment. Since the distribution of seed sizes may be skewed within a compartment, the average size between compartments could vary up to 0.80 mm. In sample 1, for example, the difference between mean size of seeds falling in compartments l and m was 0.41 mm.

CONCLUSION

The repeatability could be increased by lengthening the rollers (A) and multi-partitioned container (E) while reducing the taper between the rollers, or alternately, by increasing the number of compartments in the grader. Seeds of other legumes or cereal grains could be size graded with the

TABLE II. MEAN SEED SIZE, AND PERCENT OF SEEDS PER COMPARTMENT OBTAINED IN TRIAL RUNS ON THREE SAMPLES OF SOYBEAN SEEDS OBTAINED FROM THREE DIFFERENT SEED LOTS

	Compartment designation					
	i	j	k	l	m	n
Width of opening between rollers over compartment (mm)	4.36–4.76	4.76–5.15	5.15–5.55	5.55–5.95	5.95–6.35	6.35–6.74
Mean seed size (mm)						
Sample 1	4.52	4.84	5.23	5.46	5.87	6.15
Sample 2	4.51	4.88	5.18	5.52	5.85	6.15
Sample 3			5.23	5.53	5.80	6.08
Seeds per compartment (%)						
Sample 1	2.26	3.51	18.05	31.33	33.33	11.53
Sample 2	10.8	18.77	22.11	20.05	19.28	9.00
Sample 3	—	—	16.06	51.81	30.83	1.30

apparatus, provided they have a distinct minor diameter that is related to mass.

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