Methods for Determining the Extent of Stinkbug Damage in Soybeans. I. Density Method

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ABSTRACT

The decrease in soybean density resulting from stinkbug punctures forms the basis for the proposed method. An instrument has been developed which measures the time required for individual seeds to fall from one fixed point to another through a vertical column of water. The difference between the mean time of fall of a smaller number of undamaged seeds picked from a sample and the mean time for the sample as a whole is a measure of the relative amount of stinkbug-damaged tissue in a sample. Time required for a determination is reduced from 40 to 50 min. by the present method to 10 to 15 min.

The rapid increase in the production of soybeans in the Southern states has intensified the problem of stinkbug damage. Soybeans with stinkbug punctures have lower oil content and higher fat acidity than sound beans (1,2). The percent of small beans and the number of discolored and moldy beans developing during storage are greatly increased (1,2). Buyers discount prices paid for stinkbug-damaged soybeans on the basis of percent of damage. It becomes increasingly necessary to have a method for determining extent of damage that is accurate and reasonably rapid.

The only method now available is visual examination for stinkbug punctures. The beans in the sample (125 g.) are examined individually. Stinkbug-damaged beans are segregated and weighed. The percent by weight of damaged beans is taken as the percent of damage. This procedure leads to extremely inaccurate results. A bean with 10 punctures is much more shriveled and, therefore, lower in weight than a bean with only one puncture. On a weight basis, therefore, the fewer punctures found in the segregated soybeans, the greater is the damage reported; the opposite is obviously in accordance with fact. Individual punctures vary greatly in the amount of damage they inflict. A more mature bean which is beginning to harden may be damaged only slightly by a puncture, whereas an immature and succulent bean may be deeply penetrated and completely shriveled by one puncture.

Forty to fifty minutes' time is now required to examine one sample. Under the proposed method 10 to 15 min. is required and results are based on the actual amount of damaged tissue present.

The method described here is based on the fact that the density of soybeans is decreased by stinkbug damage. The time required for individual beans to drop from one fixed point to another through a vertical column of water is measured to determine values which are inversely proportional to the densities of the beans. This measurement will be hereinafter referred to as "time of fall." Within a given sample the mean value of times of fall; when applied to a larger number of soybeans, has been found to bear a linear relation to the amount of stinkbug-damaged tissue. The relation does not hold true when applied to beans from different samples, owing to

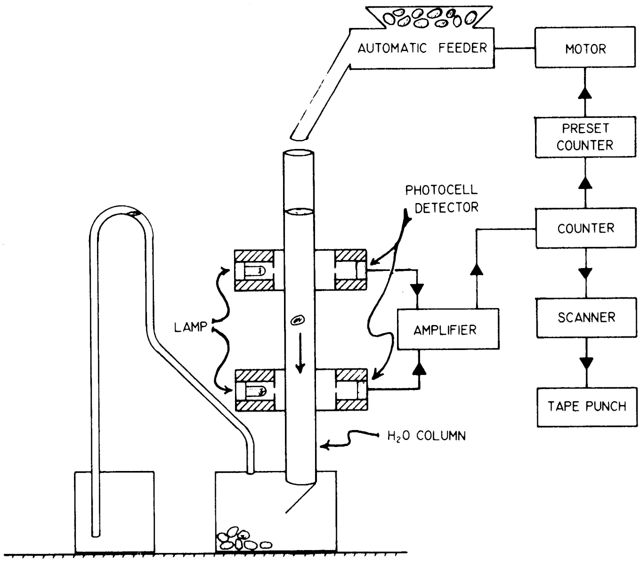

Fig. 1. Block diagram of instrument for determining time of soybean descent in water column.

the appreciable variation in density found in different samples of undamaged soybeans. Therefore it is necessary to subtract from the mean time of fall of beans in a sample the mean time of fall of undamaged beans picked from a separate portion of the sample. The differences so obtained may be used in developing a regression equation for calculating extent of stinkbug damage from mean time-of-fall values. An instrument has been developed which determines rapidly the time of fall of the bean between fixed points. The measurements can be fed into a computer where mean values are calculated rapidly.

INSTRUMENTATION AND OPERATION

Two very narrow (0.005 in.) horizontal light beams, with vertical spacing of 6 in., measure the rate of descent of the soybeans in the water column without disturbing the rate of fall. The water column focuses the light beam to cover one-half the photo cell surface (Fig. 1). Interruption of the upper light beam creates a starting pulse for the electronic counter; interruption of the lower light beam stops the counter. The counter reading, in millisec., is the elapsed time of fall between the two light beams. Immediately after the stop-signal pulse, the elapsed time registered on the counter is fed through an interface scanner to a tape punch. The values recorded on the punched tape are then processed by a computer which yields a printed copy of the number of items in the sample, mean value, and standard deviation. Before start of the time measurement, the descent of the bean is stabilized in the water column which is filled to 5 in. above the upper light-beam sensor. To prevent air bubbles from attaching to the bean when it enters the water, a drop of wetting agent (Tween 20) is mixed thoroughly into the water in the top section of the column. Beans are dropped into the column automatically. A predetermined counter stops the feeder when the preset value of 200 beans per sample has been measured.

MATERIALS AND METHODS

Samples were obtained from elevators, grain inspection stations, and agricultural experiment stations in the South. They had been sieved to remove trash and then blended with a Boerner divider. Splits may be picked from the beans in the hopper of the instrument while the determination is being made. Splits without seedcoat, or with disproportionate amounts of seedcoat, differ in density from whole beans.

Under the present visual examination method, two samples found to have the same percent of damage may contain vastly different actual amounts of stinkbug-damaged tissue. This method is completely unsatisfactory as a standard for evaluating the accuracy of a proposed new method in which determinations of actual amounts of damaged tissue are involved. Each sample must be made to serve as its own standard. This procedure is also necessary in order to establish the correlation between amount of damage and mean time of fall. The procedure determines the difference between the mean time of fall for undamaged beans picked from the sample and the mean time of fall for the sample as a whole. The assumption can be made, with introduction of only minor errors, that the same degree of change in mean time of fall for different samples represents the same amount of stinkbug-damaged tissue.

Within a single sample, which has been thoroughly blended, the pattern of distribution and the ratio of damaged to undamaged tissue should be fairly uniform throughout. Standardized subsamples can be made from a single sample by picking from it by hand all of the damaged beans and adding them back to the undamaged in such proportions as to produce desired percentages by weight. Each of 12 samples was made into 10 subsamples containing known percentages of damage. (Percent by weight of beans containing damage was taken as percent of damage.) These 120 standard subsamples were run, and they constitute the data presented.

In making a determination, ten completely sound soybeans, bearing no evidence of stinkbug punctures, were selected by visual examination from a portion of the sample. These were run separately in order to establish the mean time of fall for undamaged beans in the sample. About 2 min. is required for this operation. Two hundred beans taken from another portion of the same sample are then run and the mean time of fall determined. The mean time of fall for undamaged beans is subtracted from the mean time for the 200-bean sample to give a difference which is related to the amount of stinkbug-damaged tissue present.

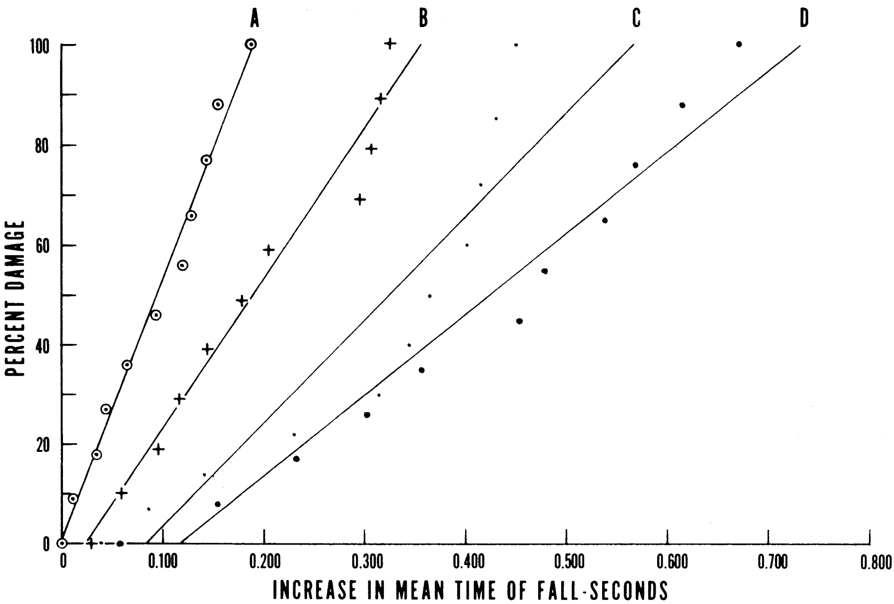

Fig. 2. Graphs A, B, C, and D show the relation between increase in time of fall and percent of damage for four of the 12 samples used. Each point on a graph represents a subsample.

RESULTS

Figure 2 shows graphs A, B, C, and D of four of the 12 samples used (40 subsamples). In each graph, increase in mean time of fall is plotted against percent of damage for each of the subsamples. Sample A shows the highest correlation and C the lowest of any of the 12 samples. Visual examination indicated that the individual damaged bean in D contained, on the average, a much greater amount of damaged tissue than the individual damaged bean in A.

Every subsample of the 12 samples is represented by a point on Fig. 3 where increases in time of fall are plotted against percent of damage as determined by visual examination. If a sample showed an increase in mean time of fall of 0.675 sec. (corresponding to 100% damage in D), the percent of damage calculated from the regression equation would be approximately 200%. The ordinate values on the regression line do not represent *actual* percentages of damage; they are, however, a scale of values giving relative amounts of damaged tissue. In order to reduce this scale to a range of 0 to 100, all of the ordinate values were reduced by one-half. The ordinate scale on the right side of the graph then applies.

This scale provides a means of ascertaining relative amounts of damaged tissue from the measured increase in time of fall.

DISCUSSION

Two hundred undamaged soybeans picked from the same sample were run in groups of 10. The standard deviation of the mean values of times of fall for the group from the mean value for the 200 beans was 0.04 sec. When the beans were taken in groups of 20, the standard deviation was reduced to 0.02 sec.; accuracy could be increased by picking a greater number of undamaged beans from a sample.

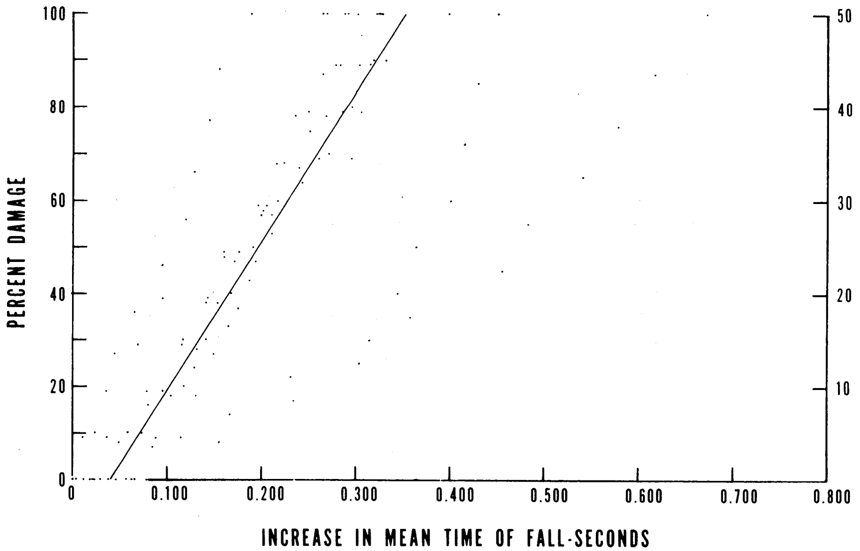

Fig. 3. Increase in mean time of fall vs. percent of damage (ordinate scale on left) and mean time of fall vs. relative damage (ordinate scale on right). Regression equation for increase in mean time of fall vs. percent damage: Y = –13.6 + 323.1 X. Regression equation for increase in mean time of fall vs. relative damage: Y = –6.8 + 161.5 X.

Other conditions besides stinkbug punctures undoubtedly contribute to increases in mean time of fall. In a sample containing only a small amount of stinkbug damage, accuracy can be increased if moldy, misshapen, or shriveled beans not containing punctures are picked out. Picking may take place from the hopper of the instrument while the sample is being run.

With the exception of a few subsamples in sample A, all subsamples would be found to contain amounts of damage greater than zero if referred to the regression line of Fig. 3. Visual examination indicates that some stinkbug punctures are so small and superficial as to be almost undetectable. For all practical purposes the damage is zero. This is the condition that existed in A.

For the present tests, mean time of fall ranged from 1 to 2 sec. The mean time of fall for undamaged beans ranged from 1.0 to 1.5 sec.

The instrument could be adjusted to give a shorter time of fall, and the time required per sample would be decreased correspondingly.

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