Colorimetric Determination of Grain Damage

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Colorimetric Determination of Grain Damage

Abstract
Evaluation of mechanical damage has always been one of the most elusive problems associated with the harvesting, handling, and marketing of grains. A standard method to describe the quality of grain from the standpoint of physical or mechanical damage has not yet been developed. And without a standard measure, the equipment manufacturer cannot determine when he has developed an improved harvesting machine, the farmer cannot determine when he is harvesting a better quality of grain, and the grain industries cannot determine when they are processing a better quality of product. Hence, there has always been a need to develop a fast and efficient technique for the accurate determination of quality of grain. The desired technique has to be simple so that everyone can use it, and, on the other hand, it has to be a bulk method (for statistically sound results), by which each and every kernel would be equally checked for a consistent evaluation of qualitative, as well as quantitative, damage in the sample. And finally, the result should be presented on a continuous scale because mechanical damage occurs on a continuous scale from hairline cracks and tiny spots of pericarp missing to complete breakage and fines.

Disciplines
Agriculture | Bioresource and Agricultural Engineering

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Colorimetric Determination of Grain Damage

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MEMBER
ASAE

EVALUATION of mechanical damage has always been one of the most elusive problems associated with the harvesting, handling, and marketing of grains. A standard method to describe the quality of grain from the standpoint of physical or mechanical damage has not yet been developed. And without a standard measure, the equipment manufacturer cannot determine when he has developed an improved harvesting technique for the accurate determination of quality of grain, and the grain industries cannot determine when they are processing a better quality of product.

Hence, there has always been a need to develop a fast and efficient technique for the accurate determination of quality of grain. The desired technique has to be simple so that everyone can use it, and, on the other hand, it has to be a bulk method (for statistically sound results), by which each and every kernel would be equally checked for a consistent evaluation of qualitative, as well as quantitative, damage in the sample. And finally, the result should be presented on a continuous scale because mechanical damage occurs on a continuous scale from hairline cracks and tiny spots of pericarp missing to complete breakage and fines.

REVIEWS OF LITERATURE

The USDA numerical grading system was established at a time when corn and other grains were shelled at low moisture with minimal damage. The adoption of combining corn at high moisture has introduced substantial levels of kernel damage. Combine-shelled corn contains a small portion of grain fines. The bulk of the kernels, however, are seriously damaged. But the present grading system does not account for all types of mechanical damage.

The visual inspection method has been widely used by research workers for accurate evaluation of mechanical damage. But this method is very time-consuming, and human fatigue influences the result (McKibben 1929, Morrison 1955, and Schmidt et al. 1968).

The other tests, such as the standard germination test, acid germination test (Arnold 1959), tetrazolium test (Moore 1961, 1967), and carbon dioxide production method (Steele 1967), give a pretty good indication of the mechanical damage, but all are time-consuming. Techniques such as the corn breakage tester (Kaminski 1968), electric color-sorting technique (Boyd et al. 1968), and infrared photographic technique (Chung and Park 1971a, 1971b), do not give a true and accurate picture of the damage level. Other experimental methods such as the water-absorption method (Chung and Park 1971a), light-absorption method (Wirtz 1971), and relaxation-time method (Mahmoud 1972) are not sensitive enough to distinguish the damage level between samples.

Hence, not one of the techniques mentioned is fast and accurate enough to satisfy the present need.

PRINCIPLE OF OPERATION

Mechanically damaged grain would have a ruptured seed coat. The more severe the damage, the more the starchy area or inner portion of the grain would be exposed. In other words, the damage level is directly proportional to the total exposed area of the kernels in a sample. The exposed area of the ruptured seed coat can effectively be used as a criterion of damage to develop a technique for evaluation of grain damage.

The basic principle behind this technique is to use a dye or a chemical that will adhere only to the exposed area of the damaged grain and not to the seed coat. The next step is to use a solvent that will dissolve or bleach the dye sticking to the damaged part of the grains. Hence, by this technique, we can get back the dye that was adhering to the damaged part of the kernels. If the dye used follows the Lambert-Beer Law, then the amount of the dye present in the sample can be measured by using some colorimetric technique. This can be done by using either a simple colorimeter or an expensive spectrophotometer.

EXPERIMENTAL PROCEDURE

The objective of this study was to examine the effect of kernel damage on absorbency, while keeping all the parameters under control. The mechanical damage occurs on a continuous scale, but it is very difficult to obtain a desired damage level for experimental purposes from corn shelled by a combine. Hence, artificially damaged kernels were used for this experiment. The mechanical damage can occur on any part of the kernel; for example, the tip, seed coat, embryo, endosperm, horny endosperm, crown, or a combination of them. Artificially damaged corn kernels were prepared by cutting the kernel longitudinally so that all the parts of the seed mentioned are exposed to the dye. A single-edge razor blade was used for cutting the seeds.

The artificially damaged samples were prepared by adding the split kernels (according to the required percentage damage) with the sound hand-shelled kernels to make a 25-g sample. The samples were then completely soaked in 0.1 percent Fast Green FCF dye for 10 min. All the samples were then washed off under running water for 30 sec. By this operation, the extra dye on the surface...
of the seed coat was washed off. The only places at which the dye was left were the tip and the exposed part of the kernel. The samples were then re-soaked in 200 ml of 0.01N NaOH solution for an hour. All the samples were stirred for 1 min and allowed to settle for 15 min before the absorbency readings were taken.

In this experiment a Beckman DB-G grating spectrophotometer has been used to read the concentration of the dye in the NaOH solution. The cell thickness was 1 cm. The wave length used was 610 nm. Distilled water was used as the reference solution in the reference cell. The spectrophotometer was calibrated for zero absorbency with distilled water in both the cells. In pouring the sample solution in the cell, caution was taken so that the sides of the cell were clean and no bubbles were left inside. Fig. 1 shows the relation between absorbency and percentage of artificially damaged corn kernels.

COLORIMETRIC EVALUATION OF COMBINE-HARVESTED DAMAGED SAMPLES

The samples of corn used were harvested by combines. The varieties were unknown, and the moisture content was very low. These samples already were visually inspected for damage evaluation (Chowdhury and Buchele 1975). A 50-g corn sample was taken. The sample was soaked in 0.1 percent Fast Green FCF dye for 10 min and then washed off under running water for 30 sec. By this operation, the extra dye on the surface of the seed coat was washed off. The only places at which the dye was left were the tip and the exposed part of the kernel. The sample was then resoaked in 300 ml of 0.01N NaOH solution. The resoaking time was not controlled at that point. The sample was stirred for 1 min and was allowed to settle for 15 min before absorbency readings were taken. The Beckman DB-G grating spectrophotometer was used for this purpose.

Fig. 2 shows the relation between the absorbency reading and the total mechanically damaged corn kernels, which includes all damaged kernels by visual inspection. No statistical test was performed on the data, but there was a positive correlation between the total percentage damage and the absorbency. Fig. 3 shows the relation between absorbency and the damage index (Chowdhury and Buchele 1975). The damage index is a measure of both quantity (percentage) and quality (severity) of damaged kernels.

CONCLUSIONS

This technique may satisfy the present need for damage evaluation for the grain industries. The whole operation is rather simple and can be performed within a few minutes (by selecting the higher concentration of the dye and the right normality of the solvent). This technique can be used as a reasonably accurate method to describe the quality of grain from the standpoint of mechanical damage caused during harvesting, handling, and marketing of grains.

The concentration of the dye can be measured either by an inexpensive colorimeter or by an expensive spectrophotometer. A spectrophotometer can be converted into a damage meter just by changing the scale.

This technique may also be applied for for fast and accurate evaluation of mechanical damage to other cereal grains.

The farmers, country elevator operators, grain dealers, seed producers, grain importers and exporters, workers in wet and dry milling industries, and food industries, harvesting equipment manufacturers and research and development workers in this field need a fast and accurate technique for evaluation of grain damage. It is believed that this technique might serve the purpose.

References


(Continued on page 811)
TABLE 6. FUEL VALUE, SULFUR CONTENT, AND COST OF COAL AND CORNSTALKS.

<table>
<thead>
<tr>
<th></th>
<th>Kansas coal</th>
<th>Wyoming coal</th>
<th>Iowa cornstalks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average heat value (BTU/lb)</td>
<td>27.9 (12,000)</td>
<td>21.6 (9,300)</td>
<td>18.1 (7,800)</td>
</tr>
<tr>
<td>Sulfur content (percent)</td>
<td>4.0</td>
<td>0.5</td>
<td>0.06</td>
</tr>
<tr>
<td>Cost ($/J)</td>
<td>0.94</td>
<td>1.05</td>
<td>0.61</td>
</tr>
<tr>
<td>Cost ($/MBTU*)</td>
<td>1.00</td>
<td>1.11</td>
<td>0.64</td>
</tr>
<tr>
<td>Sulfur/Kg/J</td>
<td>1.43</td>
<td>0.13</td>
<td>0.018</td>
</tr>
<tr>
<td>Sulfur/Lbs/MBTU</td>
<td>3.33</td>
<td>0.54</td>
<td>0.08</td>
</tr>
</tbody>
</table>

*Includes price of coal at mine plus transportation to Ames, Iowa, and cost of harvesting cornstalks plus local transportation.

USE OF PLANTLAGE FOR FEEDING BROOD COWS

Research shows that 2727 kg (3 tons) of plantlage, when properly supplemented with minerals and protein, will feed a brood cow for 1 year. Grain, however, must be fed at calving time to promote a milk supply for the nursing calf.

Twelve million acres of Iowa corn could thus support an 8-million brood cow herd. With 90 percent calf drop, 7 million head of calves will be produced. This calf crop would fulfill Iowa's need for calves and yet leave approximately 3 million head for exporting to Texas, Kansas, and other western states. The other Corn Belt states also would have calves for exporting to other states or countries. This development depends, not on increasing the acreage of corn, but only on harvesting what is already grown.

Stiff competition to the brood cow for the corn residues will come from using cornstalks as a fuel in steam boilers.

Table 6 compares the fuel value and sulfur value (content and cost delivered to generating plant) of Kansas and Wyoming coal and cornstalks.

Table 6 shows that cornstalks are a premium fuel, which must be rations and burned with high-sulfur coal to reduce the sulfur content of emissions to the EPA prescribed level.

The time will come when the prescription for farming will dictate the quantity of crop residues that must be left on the land on the basis of the slope of the land, the type of conservation tillage system, soil type, crop, etc. Trade-offs will be permitted in which a farmer planting corn on ridges laid out across the slope can remove all the above-ground residue, while another farmer using a chisel plow must leave 3362 kg/ha (IV2 tons/acre) of residue in the field.

CONCLUSIONS

The energy problem being faced by America will require the farmer to remove surplus crop residues for feeding brood cows, heating farm houses, drying grain, and for off-farm energy generation, paper making, etc.

The first call for crop residue will be for protecting the soil from wind and water erosion. The farmer cannot do much about the slope of land and soil type, but he can employ conservation tillage systems to increase the quantity of crop residues that can be made available for off-field uses.

The development of machinery for harvesting the crop residues and conservation tillage equipment is needed for feeding the brood cow herds and for providing a portion of the nation's fuel supply.

Reference


