The Effects of Wetting Corn and Broken Corn and Foreign Material on Aquagrams

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ABSTRACT

Combine-harvested corn from two hybrids was air-dried at ambient temperature in a bin to about 12% moisture, dried in the laboratory to 10.5% moisture, and then rewetted to increase the moisture to 15.5%. The distribution gradient of moisture in freshly wet corn kernels was highest in corn without any broken corn and foreign material (BCFM) and decreased as the percentage of BCFM increased. Most of the added moisture was absorbed by the 3–5% BCFM in the sample. Aquagram standard deviations of freshly wet corn with or without BCFM were much higher than in corn equilibrated to 15.5% or even 17–20% moisture. Within 24–48 hr this moisture was more uniformly transferred to the whole corn kernels.

Pomeranz and Czuchajowska (1986) and Martin et al (1986) reported on use of an aquagram, a recorded millivolt signal from the Tag-Heppenstall (T-H) moisture meter, to detect blending of wet and dry corn. The aquagram standard deviation (AG-SD) is a measure of moisture variability in a grain sample. AG-SDs of digitally filtered signals increased from 63 mV in equilibrated 15.5% moisture corn to about 75 mV in the presence of broken corn and foreign material (BCFM), to about 150 mV in the presence of heat- or mold-damaged kernels, and to about 200 mV in high-moisture corn (17.0% or above) (Martin et al 1987).

The objective of this study was to establish what effect BCFM would have on the AG-SD of samples of corn to which water was added to increase moisture content.

MATERIALS AND METHODS

Two hybrids of corn, Pioneer 3377 and Bo Jac X-603, were used in the study. Both hybrids were combine-harvested during the fall of 1985 at 20% moisture. The corn was air-dried at ambient temperature in a bin to about 12% moisture and then in the laboratory to 10.5% moisture. About 12 kg of each hybrid was used for the study. BCFM for the study was separated from the corn by a Carter Dockage Tester using a 4.76-mm round hole sieve. Moisture contents of dry corn and BCFM were measured separately by oven drying to determine the amount of water required to wet dry corn and BCFM blends to an average of 15.5% moisture. Moisture determinations were made on corn samples blended with 0, 3, and 5% BCFM and on BCFM separated after addition of water. Mixtures were divided into nine tempering jars, and the moisture level was determined after tempering intervals of 15 min, 1, 2, 4, 8, 24, 48, 72, and 144 hr.

Four methods were employed for triplicate moisture determinations: 1) Dickey-john (D-J) GAC II moisture meter; 2) Tag-Heppenstall moisture meter; 3) AG-SD; and 4) oven method (ASAE 1986). An AG-SD determination was derived from a moisture signal measured with a Weston moisture meter (formerly T-H) model 8004 type 1 power roll electrode and model 8003 type 4 meter box panel (Martin et al 1987). A Nicolet 4094 digital oscilloscope (Nicolet Instrument Corp., Madison, WI) recorded the AC coupled signal from the roll electrodes with a scan time of 1 msec per point at a constant range setting of 10 V. The recorded signal was processed by computer software supplied by Nicolet Instrument Corp. to determine the standard deviation (SD) of the AC component generated by the measurement. Two calculations were made for each signal: a) a base SD for the signal with no corn between electrodes, and b) a mid-SD of the signal recorded between the start and stop of corn passing between the electrodes. All frequencies greater than 30 Hz were digitally filtered from 2.048 sec of the signal before measuring the mid-SD. The base SD compensated for differences in AC carrier signal amplitude created with switch settings on the meter box panel and was used to calculate the AG-SD as follows:

$$\text{AG-SD} = 260 \times (\text{filtered mid-SD}) / \text{base SD}$$

Four experiments were conducted on Pioneer 3377: 1) without

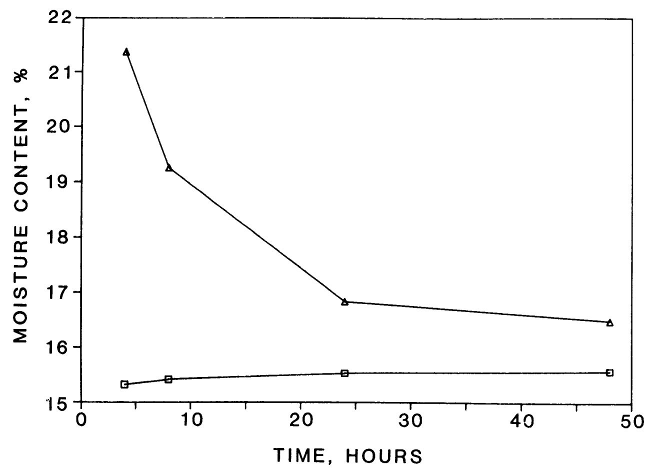

Fig. 1. Plot of water in Pioneer Hybrid corn and 5% broken corn and fine material (BCFM) stored at room temperature for 48 hr after wetting from 10.5 to 15.5% moisture. Moisture determined by oven drying. □ = Corn, Δ = BCFM.

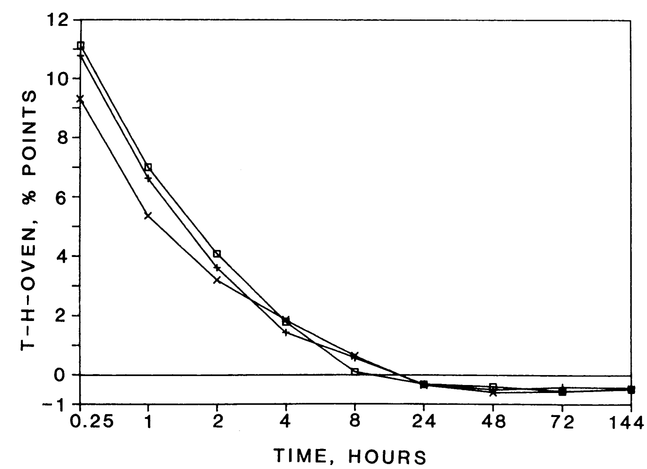

Fig. 2. Plot of water migration, calculated as T-H minus oven moisture; average of Bo Jac and Pioneer hybrid corn, stored up to 144 hr with 0, 3, or 5% broken corn and fine material (BCFM). □ = Corn, + = with 3% BCFM, x = with 5% BCFM.

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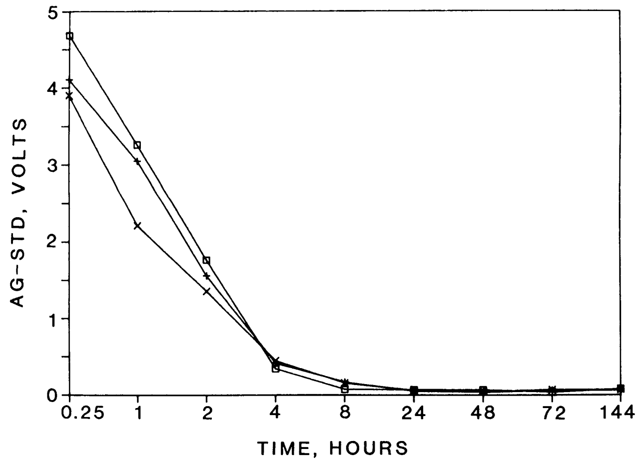

Fig. 3. Plot of aquagram standard deviation (AG-SD) values, averages of Bo Jac and Pioneer hybrid corn, stored up to 144 hr with 0, 3, and 5% BCFM. □ = Corn, + = with 3% BCFM, x = with 5% BCFM.

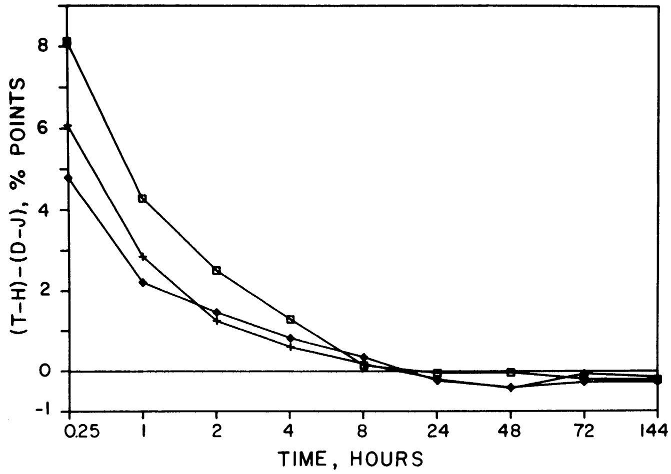

Fig. 4. Plot of water migration, calculated as T-H minus D-J moisture; average of Bo-Jac and Pioneer hybrid corn, stored up to 144 hr with 0, 3, or 5% BCFM. □ = Corn, + = with 3% BCFM, ◇ = with 5% BCFM.

BCFM, 2 mixing jars; 2) with 3% BCFM, 2 mixing jars; 3) with 5% BCFM, 2 mixing jars; and 4) with 5% BCFM, 4 mixing jars (BCFM removed before T-H moisture determinations).

For the first three experiments, 3 kg of corn was distributed between two mixing jars. BCFM and water were added to the jars, which were then sealed, mixed for 15 min, and held at room temperature (about 22°C).

In experiments 2 and 3, the distribution of BCFM in the corn after mixing made it difficult to control precisely the amount of BCFM that went into each tempering jar. To account for this small variability, experiment 4 was included. For this experiment 2 kg of corn was distributed among four glass jars, and 5% of BCFM was added to each 500 g of corn. After adding water calculated to achieve 15.5% moisture, the jars were rolled 15 min and held at room temperature (about 22°C) for 4, 8, 24, and 48 hr for moisture determination. BCFM was removed by sieving with a 4.76-mm round hole sieve before the T-H and AG-SD determinations.

With the second hybrid, Bo Jac X-603, two experiments were conducted on BCFM-free corn and on corn blended with 5% BCFM. In both experiments, 10.5%-moisture corn was distributed among nine glass tempering jars before adding BCFM and water. Each jar was mixed for 15 min and held at room temperature.

RESULTS AND DISCUSSION

The added water was absorbed rapidly by BCFM, raised the humidity in the sealed jar, and was later transferred to the corn (Fig. 1). The transfer of water was rapid during the first 24 hr and slower thereafter. Even after 48 hr there was a 1% difference in moisture between the corn and the BCFM. Some difference, however, resulted because drying at 103°C for 72 hr for the determination of moisture (ASAE 1986) did not remove water as completely from whole grain as from BCFM. Also, some plant material in the BCFM samples was scorched by the oven moisture method, which suggested that volatile material other than water was removed.

The difference in moisture contents as determined by the T-H and the oven reflects the distribution of water in the kernel (Fig. 2). Most BCFM fell between the T-H roll electrodes without being detected. Thus, the distribution gradient in freshly wet corn was highest in corn with 0% BCFM and decreased as the percentage of BCFM increased from 3 to 5%. In corn containing no BCFM, almost complete equilibration was attained after about 8 hr, whereas corn with 3 or 5% BCFM required a longer time. Those findings are confirmed by plotting AG-SD (Fig. 3). The AG-SD of freshly wet 15.5% moisture corn was higher (over 3.4 V) than the AG-SD of equilibrated high-moisture grain (about 0.5 V in 17–20% moisture corn) (Martin et al 1987).

Initial D-J measurements were affected less than T-H measurements by the addition of water (compare Fig. 2 and Fig. 4) because BCFM moisture was detected. T-H and D-J measurements were both affected for at least 8 hr after the addition of water. But whereas in the case of measurements made 144 hr after adding water there was no effect of BCFM (a single point for corn with 0, 3, or 5%) on T-H determinations, there was a small effect (about 0.15%) for the 5% BCFM in the D-J measurements. The results point to the relative effect of BCFM in determination of moisture by the D-J method as compared to the T-H method.

The time necessary to achieve no significant difference in moisture distribution was estimated for both electric meters (Fig. 2). This time may also be estimated by observing the difference between two electric meters because the T-H meter responds to the kernel moist surface whereas the D-J responds to kernel average moisture (Fig. 4).

CONCLUSIONS

Added water was absorbed more rapidly by BCFM than by grain kernels. BCFM fell between the fixed gap of roll electrodes, and its moisture content was not detected by the AG-SD determinations. However, any moisture absorbed by the surface of kernels created a moisture gradient large enough to affect the standard deviation of the aquagram signal. The moisture equilibrium status of corn can be determined from analysis of a AG-SD signal.

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