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"STRESS CRACKS" in Artificially Dried Corn

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Agricultural Marketing Service
Transportation and Facilities Research Division,
in cooperation with

Purdue University
Agricultural Experiment Station

SUMMARY

Observations during shelled corn drying tests showed that nearly all the dried samples contained kernels with cracks or checks in the endosperm. These cracks appeared to be related to the stresses to which the sample was subjected by drying and were labeled "stress cracks" by the investigators. These cracks were readily visible in strong light and could be seen at a glance in a truckload of dried corn in bright sunlight.

All of the samples of dried corn observed, including those dried with unheated air, contained kernels with stress cracks. Generally, corn dried with unheated air had only single cracks in a few of the kernels, while that dried with heated air had multiple cracks, with many kernels exhibiting a checked or crazed appearance. The viability of the dried samples decreased as the number of kernels with stress cracks increased. If this relationship proves valid, stress cracks evaluation will provide a faster test than the germination tests now used for determining the effect of drying on corn being considered for wet milling and other commercial uses.

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"STRESS CRACKS" IN ARTIFICIALLY DRIED CORN

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The effect of drying methods on the suitability of artificially dried corn for wet and dry milling and other industrial uses is under study in tests in Indiana. Nearly all the corn dried in these tests exhibited a characteristic cracking of the endosperm (the starchy inside of the kernel, exclusive of germ). These were labeled "stress cracks" by Agricultural Marketing Service engineers directing the studies. The possibility of using the incidence and magnitude of stress cracks as a measure of the amount of damage done to corn during drying is being investigated further.

Stress cracks are easily visible under a strong light and can be seen at a glance in a truckload of shelled corn in bright sunlight. Visual examination for stress cracks should help spot those lots of corn that have been subjected to high drying stress.

The stress cracks develop in the endosperm--the pericarp, or seed coat, is not ruptured. When the seed coat is removed by soaking or scraping, the endosperm is easily broken at the stress cracks. Stress cracks probably account for much of the problem of broken kernels and fine material when handling artificially dried corn.

The checking of rice and its relation to drying has been widely reported 1/ and is similar to the stress cracks observed in dried corn. In other literature reviewed, there also were references to internal fissuring of the endosperm in wheat 2/ and popcorn 3/. Some investigators noted the condition in dent corn, but did not elaborate. Men engaged in grain grading and in dryer manufacturing also have reported observing this condition. Several investigations of the quality of seed corn were reviewed, but stress cracks were not reported. This may be because seed corn is traditionally dried in the ear and, under ordinary drying conditions, requires from 5 to 10 times more drying time than shelled corn.

Tests Conducted

The samples were examined for stress cracks by "candling" individual whole kernels. Each kernel was passed over a glass-covered slit in a box containing a 150-watt electric lamp. Side lighting at high intensities worked equally well. A sample of about 150 kernels was examined by candling in about 15 minutes.

1/ Agricultural Research Service, U. S. Dept. Agr., Research on Conditioning and Storage of Rough and Milled Rice. ARS 20-7. Nov. 1959.

2/ Grosh, Gordon M., and Milner, Max. Water Penetration and Internal Cracking in Tempered Wheat Grains. Cereal Chemistry, Vol. 36:260-273.

3/ Bemis, W. D., and Huelson, W. A. Dehydration and Rehydration in Relation to Endosperm Fracturing of Popcorn. American Society of Horticultural Science Proceedings, Vol. 65:371-380.

Work is continuing to devise speedier methods of determining the number and magnitude of stress cracks in a sample.

Most of the evaluation of stress cracks was made on samples taken from 15 drying tests conducted with a commercial-type continuous-flow dryer. One series of tests was conducted with shelled corn at an initial moisture content of 30 percent, another at 25 percent, and another at 20 percent. At each initial moisture level, separate tests were made using drying air at 140°, 190°, and 240° F. Also, small samples were dried in shallow trays with forced air at room temperature. The drying time was from 12 to 48 hours, depending on room atmospheric conditions. These samples, designated as initial samples, were used as a basis for evaluating the damage associated with the heated-air drying treatment.

Corn used in the drying tests was harvested with a field picker-sheller. The corn was not inspected for stress cracks until after it was dried. Subsequent inspection of wet samples immediately after harvest indicated little or no evidence of the type of checking or cracking noted in the dried samples. Sheller-damaged kernels were removed from the samples before inspection for stress cracks.

Stress Cracks in Dried Samples

Two classifications of stress cracks were apparent in the samples examined (fig. 1). The first indication of increased stress due to drying is a single longitudinal crack extending from the tip cap toward the crown of the kernel and visible on the side of the kernel opposite the embryo. As the stress increases, multiple cracks appear, and some kernels have a checked or crazed appearance.

Eighty percent or more of the kernels dried with heated air showed either single or multiple stress cracks, regardless of the drying temperature and initial moisture level of the corn (table 1). The number of multiple stress cracks increased as the drying temperature and the speed of drying increased, but the number of single stress cracks decreased. This suggests that as drying stress increases, single cracks develop into multiple cracks.

The lower the initial moisture content of the corn, the fewer were the stress cracks that developed in the dried corn. Thus, the development of stress cracks appears to be associated with the amount of water removed as well as the speed of removal.

The grain dried with heated air had a final average moisture content ranging from 13.2 percent to 17.2 percent. The lower the final moisture content of the dried corn, the higher was the number of stress cracks that developed. However, in each of the three series of tests (table 1), the test with the highest final grain moisture was dried at the lowest temperature. Therefore, it was difficult to distinguish between the effects of drying temperature and of the final grain moisture on the development of stress cracks.

The initial samples also showed stress cracks, but had more single than multiple cracks. In fact, the initial samples had more single cracks than all but one of the final dried samples (table 1). This also suggests that single

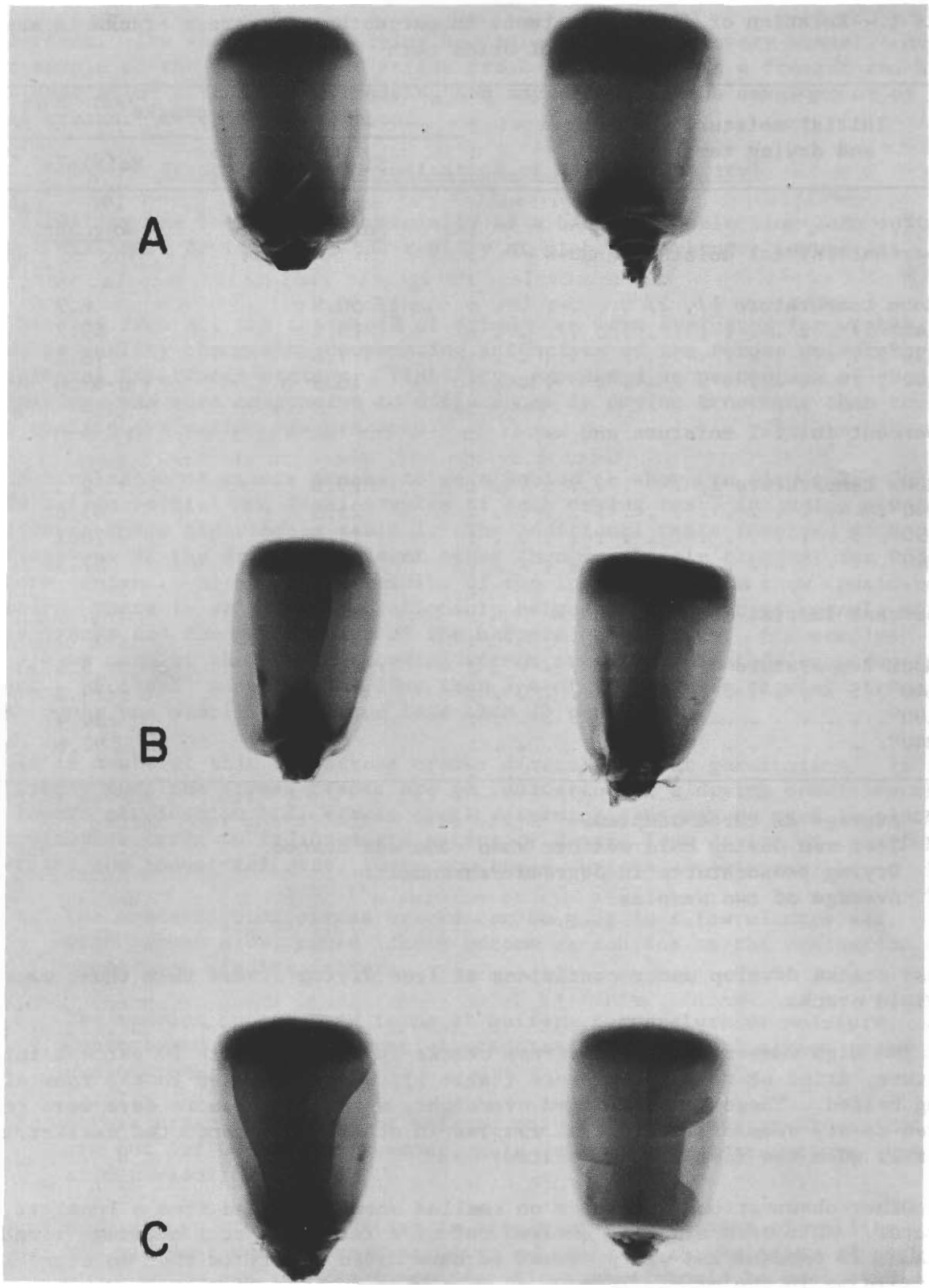

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Figure 1.--Kernels of corn with: A. No stress cracks. B. Single stress cracks. C. Multiple stress cracks.

Table 1.--Relation of drying treatment to percentage of stress cracks in samples of dried corn

Initial moisture content and drying temperature	Stress cracks	
	Single	Multiple
	Percent	Percent
20 percent initial moisture and --		
Room temperature 1/, 2/	1/ 50.9	6.9
140° 3/	19.1	63.7
190°	7.6	73.8
240°	13.9	69.4
25 percent initial moisture and --		
Room temperature 1/	19.6	2.5
140°	25.3	63.8
190°	12.4	76.7
240°	8.2	87.3
30 percent initial moisture and --		
Room temperature 4/	4/ 27.6	5.6
140°	8.5	79.2
190°	8.3	90.4
240°	0.6	97.6

1/ Average of three samples.
2/ Test run during cold weather when room was heated.
3/ Drying temperatures in degrees Fahrenheit.
4/ Average of two samples.

stress cracks develop under conditions of less drying stress than those causing multiple cracks.

The high number of single stress cracks in the corn with 20 percent initial moisture, dried at room temperature (table 1), was attributed to the room air being heated. These samples dried overnight, while two or more days were required to dry some of the initial samples in other tests conducted earlier in the fall when the room was not heated.

Other observations were made on shelled corn purchased from a local elevator. This corn had been shelled out of a farm crib at a moisture level of about 20 percent and was presumed to have dried slowly to that moisture in the field or in the crib. There were no stress cracks--single or multiple--in this corn when received from the elevator. A sample of this corn was dried for 2 hours at 190° F. in a laboratory oven and reached a moisture content of about

9.7 percent. The sample after drying had stress cracks in every kernel. Another sample of the corn without stress cracks was placed in a freezer and held for 5 days at 0° F. to see if freezing had any effect on the development of stress cracks. No cracks developed.

Stress Cracks an Indication of Milling Quality?

Viability has been used commercially as a basis for selecting corn suitable for wet milling. Drying grain too rapidly at high temperatures lowers its viability.

Samples from all the test lots of dried corn were evaluated for viability and other quality changes by cooperating scientists of the Purdue University Agricultural Experiment Station. Viability, expressed as percentage of seeds germinating, was more responsive to differences in drying treatment than to any other quality evaluation measure used.

The relation of stress cracks to germination is shown in figure 2. Included are data from initial and final samples of each drying test, including six in addition to those reported in table 1. The additional tests involved some modifications of the drying treatment other than drying air temperatures and moisture content. Although the results of the individual tests show considerable variation, there is an evident relationship between the number of kernels with stress cracks and the percentages of the kernels germinating. All samples with 3/4 or more of the kernels showing stress cracks germinated less than 75 percent. Of the 13 samples with less than 3/4 of the kernels showing stress cracks, only one sample germinated less than 75 percent.

It is doubtful that the stress cracks directly affect germination. It is more likely that the stress cracks are an indication of a drying condition which also lowers germination. If stress crack determinations can be used in place of germination tests to indicate the extent of damage from drying of corn for commercial and industrial uses, there are these obvious advantages:

1. The evaluation of stress cracks can be made in a few minutes and, with proper aids, could likely become as routine as the evaluation of commercial grading factors.

2. The samples do not need to be at uniform temperature or moisture content and require no special preparation for visual stress crack evaluation.

3. Stress cracks appear to be related only to the drying treatment and are not influenced by freezing, mold damage, and other factors that affect viability.

Although stress crack evaluation is promising as a measure of milling quality, its use must await more conclusive evidence of the validity of such a test. The following are important considerations that should be evaluated:

1. The effects of seasonal and varietal differences on the tendency of corn to develop stress cracks.

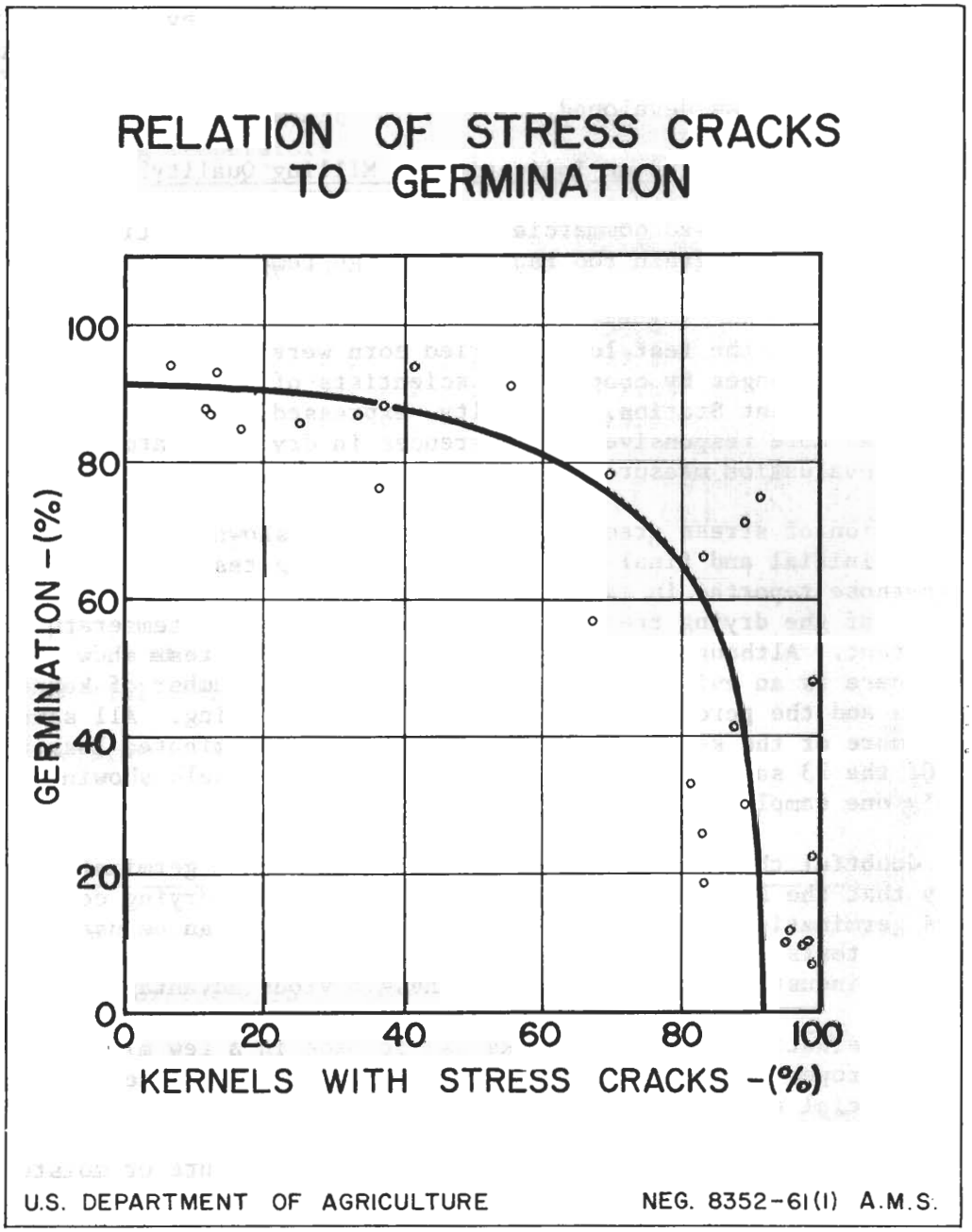

Figure 2

2. **The relation of stress cracks** in corn to the actual milling characteristics. (Some laboratory evaluations were made, but were inconclusive.)

3. The factors in the drying treatment responsible for stress crack formation.

4. The time during the drying process when the cracks develop.