Differences Among Lines and Varieties of Maize in Susceptibility to Damage by Storage Fungi

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Scientific Journal Series Paper No. 7558, Minnesota Agricultural Experiment Station, University of Minnesota, St. Paul 55101.

Accepted for publication 19 July 1971.

ABSTRACT

After storage for 63 days at 85% relative humidity and 20-25 C, samples of 15 varieties of maize previously inoculated with a mixture of storage fungi ranged from 25% to 97% in germinability. After storage for 44 days at 85% relative humidity and 26 C, germination percentage of 65 lines that had been previously inoculated with a mixture of storage fungi ranged from 0 to 91%. At the end of the storage tests, kernels of the varieties and lines of high viability were bright and sound, and those of low viability were decayed. Inherent differences may exist among varieties and lines of corn in susceptibility to invasion by, and damage from, storage fungi.

Phytopathology 61: 1498-1500.

At moisture contents and temperatures that permit them to grow, storage fungi can cause loss in germinability and other kinds of damage in stored grains and seeds (2). Seeds of maize (*Zea mays* L.), for example, retained a germinability of nearly 100% for more than 90 days at moisture contents between 16 and 17% (wet wt basis), and for 150-160 days at moisture contents between 15 and 16%, and temperatures of 20-25 C. On the other hand, maize seeds of similar quality, inoculated with a mixture of storage fungi and stored under similar conditions, were reduced to 20-25% germinability in 3 months at 25 C (1, 6). Peas free of storage fungi retained their original germinability (about 97%) for 6 months at 85% relative humidity and 30 C, whereas samples inoculated with various storage fungi and stored under the same conditions were reduced to zero germinability within 3-8 months (4). At present, the only practical control of this damage is to store the grains under conditions unfavorable to the development of the fungi concerned (either at a low temperature, at a low moisture content, or both). In many regions of the world where maize is a major food crop, facilities for drying or cooling the freshly harvested grain are not available; thus, varieties resistant to damage by storage fungi would have considerable value. The present work was undertaken to determine whether differences might exist among lines and varieties in susceptibility to damage, especially as measured by decrease in germinability, when kept under conditions favorable for growth of storage fungi.

MATERIALS AND METHODS.—The lines and varieties of maize were obtained from the Entomology section of the International Center for Corn and Wheat Improvement in Mexico. The lines were from Poza Rica 69 S_1, and were grown under uniform conditions at Poza Rica, Veracruz, Mexico. The varieties were grown at several locations, chiefly in tropical areas. All lots were dried to a uniform moisture content of ca. 13% until they were used in the tests, and all had germination of 95-100% at the beginning of the tests, indicating that they were

TABLE 1. Germination percentage of 15 varieties of maize after storage at 75% relative humidity for 152 days and at 85% relative humidity for 63 days at 20-25 C

Variety	75% Relative humidity for 152 days	85% Relative humidity for 63 days
Antigua	97	93
Harinosa	97	97
Flint	96	63
High amylose	92	45
Reventador	90	75
Floury	89	70
Dulce P.L.	88	75
Tuxpeno crema	85	57
Flint amarillo	80	62
Waxy	79	58
Chalqueno	77	55
Mezcla caribe	77	55
Dentado	76	50
Opaco	73	50
Dulce	47	25

sound and had not been exposed to damaging storage conditions.

Germinability was determined by placing 100 kernels on moist paper toweling, which was then rolled loosely and kept at 25 C until no more seeds germinated (usually 7-8 days). To determine the percentage of surface-disinfected kernels that yielded fungi, 50 kernels were shaken in 1.5% NaOCl for 1 min, rinsed in sterile distilled water, placed on MS-6 agar (Difco agar, 20 g; malt extract, 20 g; NaCl, 60 g; distilled water, 900 ml) in petri dishes, and incubated at 25 C until the fungi which grew out could be identified. Moisture contents were measured by drying samples of ca. 5 g at 103 C for 72 hr, and are expressed on a wet weight basis.

The storage tests were made as follows: Duplicate samples of the different varieties in small open containers were placed in plastic boxes in which the desired relative humidities were maintained by means of saturated salt solutions (NaCl and KCl for 75% and 85% relative humidity, respectively). Duplicate samples of different lines were kept in a growth chamber in which the relative humidity was maintained at 85 ± 2%. All samples were sprayed lightly with a water suspension of spores of the group species *Aspergillus restrictus, A. glaucus, A. candidus, A. ochraceus, A. versicolor, A. flavus, A. tamarii* (listed in ascending order of moisture content required for growth), and *Pencillium*. The samples in plastic boxes were kept in a laboratory where the temperature was 20-25 C; the temperature in the growth chamber was 25-26 C.

RESULTS AND DISCUSSION.—At the test periods selected, there were great differences in the germinability (and also in appearance, as shown in Fig. 1) among the lines and varieties. After 152 days at 75% relative humidity, germination of the 15 varieties (Table 1) ranged from 97 to 47%; after 63 days at 85% relative humidity, the germination ranged from 97 to 25%. With a few exceptions, the varieties that were of highest germination at 75% relative humidity after 152 days were also highest after 63 days at 85% relative humidity, and the ones that were lowest in the one test schedule were also lowest in the other. Complete agreement would not be expected, as to some extent different storage fungi were involved in the two sets of conditions. In the samples stored at 75% relative humidity, only *A. restrictus* and *A. glaucus* grew from the surface-disinfected kernels; in the samples stored at 85% relative humidity, *A. glaucus* was the major fungus, but *A. candidus* grew from many kernels of some samples, and *A. ochraceus, A. flavus,* and *Penicillium* grew from kernels of some samples.

Germination percentages of the lines after the samples had been stored for 44 days at 85% relative humidity and 26 C ranged from 0 to 91%. They were grouped as follows: germination 0-10%, lines 3227, 3362, 3364, 3405, 3420, 3439, 3451; 11-20%, 3310, 3402, 3458, 3461, 3471; 21-30%, 3224, 3278, 3407, 3414, 3438, 3442, 3448; 31-40%, 3245, 3254, 3258, 3265, 3338, 3357, 3379, 3416, 3425, 3450, 3454; 41-50%, 3222, 3280, 3263, 3312, 3358, 3398, 3435, 3441; 51-60%, 3239, 3282, 3283, 3400, 3411, 3418; 61-70%, 3229, 3247, 3255, 3269, 3341, 3370, 3462, 3475; 71-80%, 3244, 3252, 3261, 3302, 3339, 3351, 3447; 81-90%, 3287, 3313, 3372, 3383, 3419; 91%, 3384.

Fig. 1. Relative fungus growth on lines 3455 (top), 3419 (middle), and 3227 (bottom) after inoculation with storage fungi and incubation at 26 C and 85% relative humidity for 44 days.

Differences in percentages of surface-disinfected kernels that yielded fungi were not so great as were differences in germination percentage. Line 3384, for example, which germinated 91% after 44 days at 85% relative humidity and 26 C, yielded *A. restrictus* from 32% of the surface-disinfected kernels, *A. glaucus* from 74%, *A. flavus* from 2%, and *Penicillium* from 2%. Line 3287, which also retained a high germinability (82%) after 44 days at 85% relative humidity and 26 C, yielded *A. restrictus* from 42% of the surface-disinfected kernels, *A. glaucus* from 14%, *A. candidus* from 26%, and no other fungi. Line 3450, which germinated 31% after 44 days at 85% relative humidity and 26 C, yielded *A. restrictus* from 30% of the surface-disinfected kernels, *A. glaucus* from 2%, and *A. candidus* from 76%. Invasion of the embryos of wheat and maize by *A. candidus* results in more rapid death of the embryos than does invasion by *A. restrictus* or *A. glaucus* (5, 6). The same is true of invasion of peas by these fungi (4). Growth of a given fungus from a surface-disinfected kernel gives no information on the degree to which the embryo of the kernel has been invaded or damaged.

Comparisons of germinability agreed generally with the differences in amount of fungal invasion observed visually among lines or varieties. The kernels of some lines and varieties at the end of the storage tests appeared sound and bright, but the kernels of others were severly decayed.

The evidence submitted here does not prove that genetic differences to invasion by storage fungi exist, but it strongly suggests this possibility. Rice is considered more resistant to damage from invasion by storage fungi than are some other cereal grains (3). It is possible that this resistance is a result of natural selection in environments favorable to the growth of storage fungi. The invasion of tissues of viable embryos by storage fungi is similar to invasion of other living tissues by fungi. Differences among individuals, lines, and varieties in susceptibility to such invasion would be expected. No one, however, has attempted to find such resistance to storage fungi and to incorporate it into otherwise desirable varieties. From the evidence presented here, it seems that such an approach might be worthwhile.

LITERATURE CITED

1. CHRISTENSEN, C. M. 1964. Effect of moisture content and length of storage period upon germination percentage of seeds of corn, wheat, and barley free of storage fungi. Phytopathology 54:1464-1466.
2. CHRISTENSEN, C. M., & H. H. KAUFMANN. 1969. Grain storage: the role of fungi in quality loss. Univ. Minn. Press., Mpls. 153 p.
3. CHRISTENSEN, C. M. & L. C. LOPEZ. 1965. Relation of moisture content and length of storage to changes in the microflora and germination of rough rice. Phytopathology 55:953-956.
4. FIELDS, R. W., & T. H. KING. 1962. Influence of storage fungi on deterioration of stored pea seed. Phytopathology 52:336-339.
5. PAPAVIZAS, G. C., & C. M. CHRISTENSEN. 1957. Grain storage studies. 12. Effect of invasion by storage fungi upon germination of wheat seeds and upon development of sick wheat. Cereal Chem. 34:350-359.
6. QASEM, S. A., & C. M. CHRISTENSEN. 1958. Influence of moisture content, temperature, and time on the deterioration of stored corn by fungi. Phytopathology 48:544-549.