Published September, 1963

Prevention of Field Deterioration of Cottonseed by an Impermeable Seedcoat[1]

M. N. Christiansen and Norman Justus[2]

FIELD deterioration of cottonseed is directly related to pre-harvest moisture conditions. Several workers, including Simpson and Stone (6) and O'Kelly and Hull (5), have established the relation between rainfall or high humidity and loss of planting and milling quality of cottonseed. Recently it was suggested that an impermeable seedcoat might be valuable in reducing field deterioration of cottonseed (2).

A heritable impermeable seedcoat is a common characteristic of wild species and unimproved forms of cultivated Gossypium species. It is likely requisite for survival of wild forms. Stevens (7) suggested that an impermeable seedcoat could have been important in the movement of the genus across ocean barriers. The trait is of occasional occurrence in commercial upland cottons (*G. hirsutum* L.) even though cultural methods apply selection against slow-germinating seed. It is a problem in Pima S-1, a western commercial variety of *G. barbadense* L. Walhood (8) developed a hot-water treatment which renders Pima cottonseed water permeable. The treatment is also effective on seed of other strains.

The value of an impermeable seedcoat in prevention of high humidity-induced cottonseed deterioration in storage was previously reported (4). This paper presents results of research on the value of an impermeable seedcoat in preventing field deterioration of cottonseed.

MATERIALS AND METHODS

The strains of *G. hirsutum* L. used in these studies were M-8, a doubled haploid from Deltapine, and 16B-7, a selection of Hopi-upland genetic constitution. M-8 normally produces water-permeable seeds, and 16B-7 produces primarily impermeable seeds. Fruiting habit and boll maturity period are similar for the two strains. Prior to planting, all seeds were given a hot-water treatment consisting of a 2-minute immersion in water at 85° C.

Four replicates of plots of M-8 and 16B-7 were planted in sufficient quantity to allow 3 harvests at monthly intervals. Harvesting was initiated after all bolls had matured and opened. Harvests were made November 10, December 4, and January 2 from the 1961–62 test and November 15, December 15, and January 15 from the 1962–63 test.

[1] Joint contribution from the Crops Research Division, ARS, USDA and the Delta Branch of Mississippi State Experiment Station. Journal Paper 1099, of the Mississippi Agr. Exp. Sta. Supported in part by a grant from the National Cottonseed Products Association, Inc. Received Apr. 1, 1963.

[2] Research Plant Physiologist and Research Agronomist, respectively, Crops Research Division, ARS, USDA.

In the 1961–62 test the entire plot was harvested for quality studies. The 1962–63 test had a high incidence of boll-rot in both M-8 and 16B-7 resulting from rank growth and high humidity during the boll-maturation period. Boll-rot materially reduced seed quality of both M-8 and 16B-7. Two harvests were made from each plot to determine the influence of boll-rot on seed quality and eliminate it as a factor. One was composed of all bolls from a section of row, and the other of only bolls with no evidence of previous rot.

After each harvest the seed cotton was immediately dried at 40–45° C. for 48 hours and roller ginned. Germination tests were made on 100 chipped seeds from each of the 4 field replications. The germination tests involved placing 25 seeds between 2 germination papers, wetting with 60 ml. of distilled water, and rolling with a waxed-paper outer covering. Thus, each 100-seed sample required 4 rolls. Germination counts of normal seedlings were taken after 3 days at 31° C.

Milling quality of the seeds was estimated by determining the free fatty acid content. Oil was hydraulically expelled and free fatty acid content determined by titration with NaOH solution following a modification of A.O.A.C. method 26.30 described by Christiansen and Moore (3).

Studies were made to exclude the possibility that factors other than an impermeable seedcoat are implicated in the observed quality preservation. Samples of seed were harvested on March 28, 1962, from the 1961 study. Germination percentage of chipped seed was determined for the M-8 and 16B-7 in the manner previously described. Seed were soaked in water 4 days to determine the impermeable seed remaining after approximately 6 months of field exposure. The seed which imbibed water were removed each day and tested for germination. Impermeable seed remaining after four days soaking were chipped and tested for germination.

Field moisture and temperature conditions are important in seed deterioration. The 1961 season was extremely dry from mid-September through October. No appreciable rainfall occurred while temperatures were sufficiently high to support rapid seed deterioration. The 1962 harvest season was moderately wet during the peak boll maturation period in September with 8 days of rainfall. Ten days with rainfall occurred in October. Temperature maximums of 85–95° F. were common. Thus, during the boll-maturation period in 1962 micro-environmental conditions were conducive to boll rotting and seed deterioration.

RESULTS

Viability was high in both M-8 and 16B-7 seed from the November 1961 harvest (Table 1). Only a slight loss of germination had occurred in M-8 by December and no loss was noted for 16B-7. A considerable loss in germination of M-8 occurred by January. The 16B-7 seed quality remained high. The germination data from the 1962–63 test reflect the adverse weather conditions prevalent during the boll opening period in September and October. The M-8 seed from entire-plant harvests in November germinated 34% as compared to 59% from harvests of M-8 bolls showing no evidence of early season rot. Comparable figures for the December harvest were 23 and 40%, and for January were 10 and 16%. The 16B-7 seed were of considerably better qnality than M-8, but boll rotting also caused a drop in over-all seed quality. Germination rates for seed from entire-plant harvests in November, December, and Jannary were 80, 84, and 74%, respectively. Comparable data from harvest of good 16B-7 bolls were 91, 93, and 85%, respectively.

Seed of 16B-7 harvested on March 28, 1962, which were impermeable after 4 days water soaking (60% of total) germinated 97%. The 16B-7 seed which imbibed water (naturally broken, impermeable seed) germinated 63%. Germination percentage of chipped seed was 84% on the original 16B-7 sample prior to subdividing into impermeable and permeable.

Free fatty acid data (Table 1) indicate the same trends as the germination figures. The dry September–October boll opening period in 1961 resulted in seed with low free fatty acid. Rainfall did not occur until temperatures fell below a level which supports rapid seed oil hydrolysis. The level of free fatty acid measured in January was quite low in comparison to levels measured in the 1962–63 test. In the latter test, seed oil from M-8 entire-plant harvests had 10.54% free fatty acid in November, 11.57% in December, and 13.38% in January. Oil from M-8 seed of good bolls contained 4.00, 5.71, and 10.42% for comparable harvest dates. The 16B-7 seed from entire-plant harvests of November, December, and January contained 2.03, 1.98, and 2.72% free fatty acid. When rotted bolls were excluded the 16B-7 seed oil was of excellent quality.

Table 1—Germination and free fatty acid in the extracted oil of cottonseed of permeable and nonpermeable seedcoat selections after field weathering.

Harvest date	Germination, %		% free fatty acid in oil	
	M-8, Permeable	16B-7, Impermeable	M-8, Permeable	16B-7, Impermeable
1961–62 Season, entire plant				
November 10	96	94	0.45	0.17
December 4	89	95	0.63	0.31
January 2	51	91	2.41	0.39
1962-63 Season, entire plant				
November 15	33	80	10.54	2.03
December 15	22	84	11.57	1.98
January 15	8	74	13.38	2.72
1962-63 Season, rotted bolls excluded				
November 15	59	91	4.00	0.61
December 15	40	93	5.71	0.95
January 15	16	85	10.42	1.26

DISCUSSION AND CONCLUSIONS

Data from two harvest seasons indicate that an impermeable seedcoat affords excellent protection from field deterioration. Normal freely permeable cottonseed (M-8) degenerated quite rapidly when subjected to frequent rainfall and high humidity. Seed-quality loss for normal cottonseed agreed in general with that previously reported by Simpson and Stone (6).

Weather conditions during the boll-maturation and opening period appeared to have considerable influence on seed quality. Boll rotting, which depends on high moisture and temperature, also greatly reduced seed quality. It is possible that subsequent loss of seed quality was caused by activity of fungi which gained entrance during incidence of boll rot. Cottonseed deterioration due to internal infection by fnngi has been suggested by Christensen et al. (1).

Unknown genetic differences between the two strains may well exist which have an influence upon seed quality preservation. Time of maximum boll opening, which could influence length of field exposure and thus seed quality is the same for 16B-7 and M-8. Neither strain has a pendulant boll which has been suggested as affording seed and fiber protection from rainfall damage. On the basis of the present findings, and previously reported results of controlled laboratory studies with the same genetic lines (4), it is concluded that a heritable impermeable seedcoat characteristic can materially reduce the loss of cottonseed quality under unfavorably high moisture conditions in the field or in storage.

SUMMARY

A comparison was made of the resistance to field deterioration of an impermeable seedcoat seed (hard seed) and normally permeable seed of cotton (*Gossypium hirsutum* L.). Seed cotton was harvested at intervals after boll maturity. Quality of the seed was determined in terms of germination and free fatty acid in the seed oil.

Quality of hard seed remained high after extended periods of exposure to moist field conditions, while quality of normally permeable seed was greatly reduced.

LITERATURE CITED

1. CHRISTENSEN, C. M., OLAFSON, J. H., and GEDDES, W. F. Grain storage studies, VIII. Relation of molds in moist stored cottonseed to increased production of carbon dioxide, fatty acids and heat. Cereal Chem. 16:109–128. 1949.
2. CHRISTIANSEN, MERYL N., and MOORE, R. P. Seedcoat structnral differences that influence water uptake and seed quality in hard seed cotton. Agron. J. 51:582–584. 1959.
3. ————, and ————. Temperature influence on the *in vivo* hydrolysis of cottonseed oil. Crop Sci. 1:385–386. 1961.
4. ————, ————, and RHYNE, C. L. Cottonseed quality preservation by a hard seedcoat characteristic which restricts internal water nptake. Agron. J. 52:81–84. 1960.
5. O'KELLY, J. F., and HULL, W. W. Effects of delayed harvest by picking and snapping on six varieties. Mississippi Agr. Exp. Sta. Bul. 316. 1936.
6. SIMPSON, D. M., and STONE, B. M. Viability of cottonseed as affected by field conditions. J. Agr. Res. 50:435–447. 1935.
7. STEVENS, S. G. Salt water tolerance of seeds of *Gossypium* species as a possible factor in seed dispersal. Am. Nat. 92: 83–92. 1958.
8. WALHOOD, V. T. A method of reducing the hard seed problem in cotton. Agron. J. 48:141–142. 1956.