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CONTRIBUTED PAPERS

FIELD DETERIORATION OF SOYBEANS AS AFFECTED BY ENVIRONMENT[1]

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ABSTRACT

Mature seed on plants in adjacent fields of 'Dare' (maturity group V) and 'Lee 68' (maturity group VI) cultivars of soybeans were subjected to three environments to determine the cumulative effects of slightly different temperatures and relative humidities upon the rate and extent of field deterioration under warm, humid conditions. Treatments were initiated when seed moisture first dropped to 30% (physiological maturity) and continued until frost. For both cultivars, seed subjected to ambient environmental conditions had declined significantly in germination by four weeks after physiological maturity. Seed harvested from plots shaded to remove 50% of the incident sunlight deteriorated at a much slower rate than those from the unshaded plots. Five weeks after physiological maturity, germinations of seed produced under shade were 86 and 89% while those from the ambient plots were 55 and 75% for the Dare and Lee 68 cultivars, respectively. These differences were attributed to a more stable mirco-environment surrounding the shaded plants. Possible means of reducing the rate of deterioration are considered.

Additional index words: germination, vigor.

INTRODUCTION

Historically soybeans have been produced in the northern portion of the temperate climatic zones of China and the United States. However, with the increasing demand for vegetable oil and protein on a world wide basis, soybean production has spread rapidly into the warm, humid areas of the southern United States and, more recently into the tropical countries. Introduction of soybeans into regions where the seed mature when daily temperatures rise to 80 F (26.6 C) or more and the relative humidity may remain at 100% for several hours each day has created a serious problem in the maintenance of seed quality.

Before soybeans became a major cash crop for farmers in the southern U.S., Moorse *et al* (12) reported that unfavorable weather during the ripening period, exposure to damp periods after the seed were mature, and frost occuring while the seed were green caused soybean seed to deteriorate while still in the field. They further stated that very hot weather during seed maturation often resulted

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in the wrinkling of seed coats. Following this study, which forecast some of the difficulties of producing high quality soybean seed under warm, humid conditions, there have been very few studies concerning the causes or possible preventative measures for preharvest deterioration.

Several workers have investigated the sequential steps of post harvest soybean seed deterioration. (1, 4, 5, 6, 13, 14). These studies have revealed that the first signs of natural deterioration occur as localized, eroded or necrotic areas around the periphery of the seed; such necrotic areas gradually increase in size and depth of penetration until first the vigor and subsequently germinability of the seed is impaired. When the necrotic areas occur in regions vital to the development of the embryo, germinability is lost rapidly.

One of the few systematic expositions of field deterioration was presented by Moore (7, 8, 9, 10, 11) in a series of articles on snap beans. He found that climatic conditions which caused alternate rehydration and dehydration of the seeds, after they had reached maturity, almost always resulted in the development of localized necrotic areas in the radicle and cotyledons, which he called "natural crushing." This process frequently resulted in hairline breaks, partly or sometimes completely, across the midsection of the hypocotyl.

Moore's work strongly implied that much of the deterioration observed in the various storage studies was the result of deteriorative processes initiated while the seed were still in the field. Thus, the reduction or prevention of field deterioration from physiological maturity until the seed can be harvested and placed in a relatively stable storage environment would be of significant economic importance to seed producers and seedsmen. However, before investigating means of reducing field deterioration additional information is needed concerning its cause. The objective of this study was to observe the effects of different temperatures and relative humidities upon field deterioration of soybeans.

Materials and Methods

Adjacent fields of 'Dare' (maturity group V) and 'Lee 68' (maturity group VI) cultivars of soybeans were established on the Plant Science farm at Mississippi State, Mississippi. Both fields were prepared, planted and managed in the same manner until the treatments were initiated. The treatments were imposed when a moisture test indicated the seed had reached physiological maturity (ca 30-32% moisture), specifically September 26 for the Dare cultivar and October 7 for the Lee 68 cultivar.

The experimental plots were arranged in a randomized complete block design with three treatments and four replications in each field. Each field plot was five meters in length with six rows spaced at one meter intervals. The treatments were as follow:

1. Ambient – plants and seeds exposed to natural climatic conditions.
2. Daily water spray (DWS) – using a knapsack sprayer with the nozzle adjusted to apply a fine spray, the plants and pods of the two center rows of each plot were sprayed to water run off each day, starting at 4 P.M. central standard time.

3. 50% incident sunlight (50% sunlight) – plots were shaded by positioning a polypropylene fabric woven to exclude 50% of the incident sunlight at a height of 1.25 meters above ground level.

Continuous records of the temperature and relative humidity were maintained by placing a recording hygrothermograph 30 cm above ground level at the center of one plot receiving each treatment. Starting one week after the treatments were initiated, and at weekly intervals thereafter, random samples of 500 pods each were harvested by hand from the two center rows of each plot. Six harvests were made from plants of the Dare cultivar and five from the Lee 68 cultivar.

Harvested pods were placed in moisture proof bags until moisture determinations could be made later in the day. Moisture was determined by the air-oven method using a temperature of 100 C for 24 hours. The remaining pods were stored at 7 C and 50% R.H. until laboratory evaluations could be conducted.

Following hand threshing and removal of any split seed, the seed from each plot were evaluated using the first count, standard germination and tetrazolium stain tests. First count and germination tests were conducted using rolled paper towels at 20-30 C alternating temperature, and 50 seed in each germination test replication. The total number of normal seedlings were recorded as a percentage. The replicates of 50 seeds from each field plot were used to evaluate germination potential from TZ staining patterns. The techniques used for preparation and evaluation of the seed by TZ were those described by Delouche, *et al* (3). The percentage of germinable seed in each sample was calculated and recorded.

Data obtained from the laboratory evaluations were subjected to an analysis of variance. When significant differences were revealed by use of the F test, comparisons of the means involved were made, using the Duncan's New Multiple Range Test (DNMRT) (15).

Results and Discussion

The pertinent climatic data are given in Figure 1. Throughout the sampling period the average daily temperature in the ambient plots was 1 F (0.6 C) higher than the average in the DWS plots and 3.7 F (2.2 C) higher than the average in the 50% sunlight plots. The maximum recorded difference in temperature among the plots was 6 F (3.3 C). Sub-freezing temperatures, 27 F (–3 C), were recorded in all plots during the early morning hours of November 8.

The mean temperature for the entire test period in the ambient plots of the Dare cultivar was 68.7 F (20.2 C) and 66.7 F (19.3 C) in later maturing Lee 68 cultivar plots. The average daily variation in temperature of the ambient plots was 31.4 F (17.5 C). Mean temperature in the 50% sunlight plots was lower [65.1 F (18.4 C)] and varied less [28.4 F (15.8 C)].

Mean relative humidities of the ambient treatments were 3% lower than those of the DWS and 2% lower than the 50% sunlight treatments. The duration of 100% relative humidity varied from an average of 8 hours per day in the ambient treatments, to 8.5 hours in the DWS plots, and 10 hours per day in the 50% sunlight plots. Because of the longer period of 100% R.H. in the 50% sunlight plots the mean minimum relative humidity in these plots was 6% higher

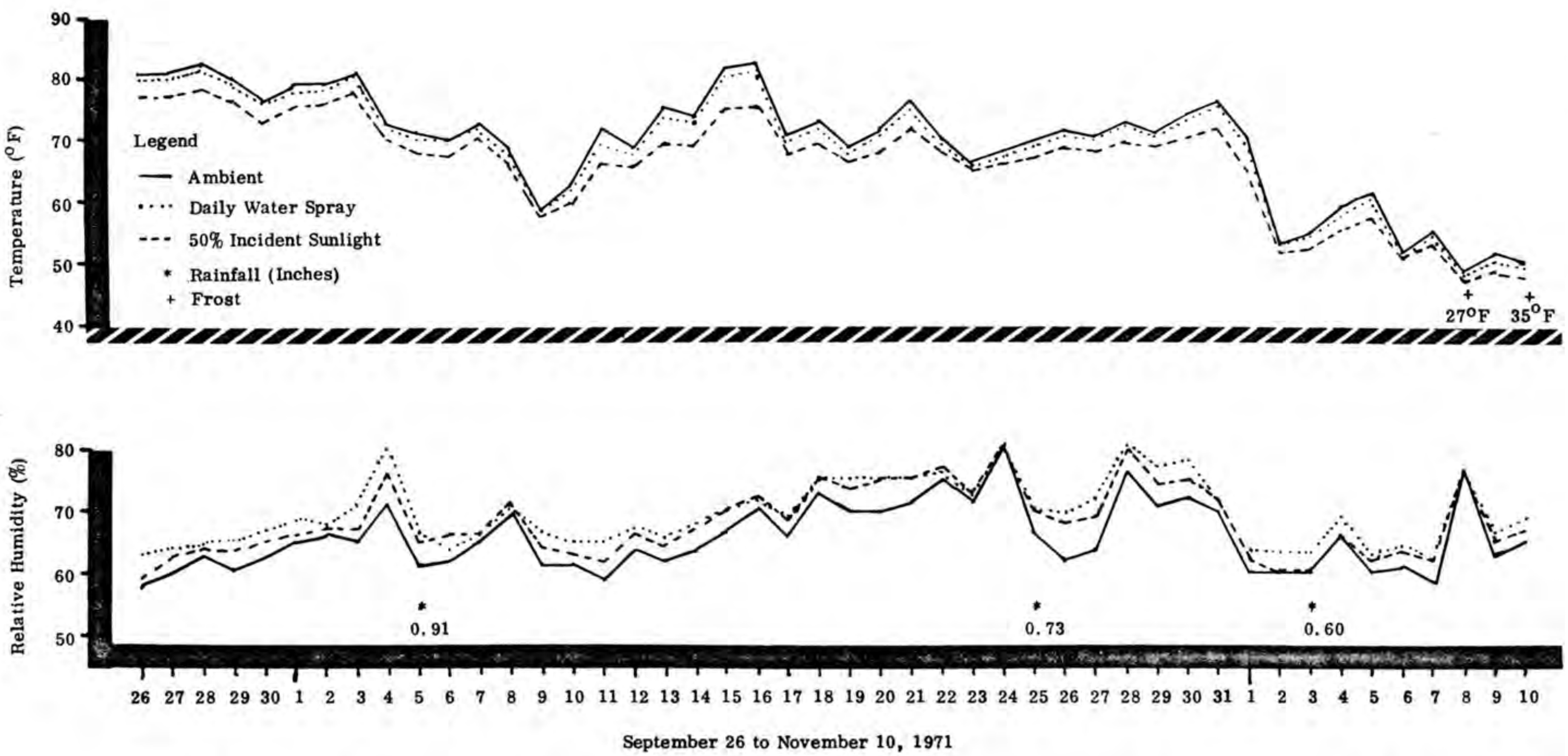

Figure 1. Daily record of mean temperatures and relative humidities.

Table 1. Mean seed moisture contents at various harvest dates.

DARE

Treatment	HARVEST DATES						
	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7	Mean
Ambient	12.50	10.94	12.39	17.44	17.52	8.48	13.21
DWS	12.60	10.85	12.83	19.83	17.55	8.73	13.72
50% Sunlight	13.12	11.30	12.51	19.47	17.59	8.66	13.78
Mean	12.74b	11.03b	12.54b	18.91a	17.55a	8.62c	

LEE 68

Treatment	HARVEST DATES					
	Oct. 14	Oct. 21	Oct. 28	Nov. 4	Nov. 10	Mean
Ambient	11.60	15.01	12.58	14.30	10.81	12.86
DWS	11.87	16.10	12.90	14.27	11.65	13.36
50% Sunlight	12.09	15.73	12.37	14.52	12.04	13.35
Mean	11.69c	15.61a	12.62c	14.36b	11.50c	

Harvest date means not followed by the same letter are significantly different at the 5% level of probability according to DNMRT.

than that of the ambient plots. Thus, there was less fluctuation in the relative humidity of the 50% sunlight plots than the other treatment plots.

Significant amounts of rainfall were recorded on October 5 and 24 and November 3; the amounts measured were 0.91 inch, 0.73 inch and 0.60 inch, respectively. Traces of rain were recorded on October 6 and 25 and November 7 and 9.

We did not detect statistically significant differences in seed moisture attributable to the various treatments in samples harvested on specific dates. However, seed from the ambient plots were almost always lower in moisture than those from other treatments (Table 1). There were significant differences in mean seed moisture among the various harvest dates which clearly, though not precisely, established significant fluctuations in seed moisture migration. It is suggested that in future studies of seed moisture migration at least bi-daily samplings be utilized, one within an hour of sunrise and another approximately three hours before sunset. An even higher sampling frequency will be necessary to accurately plot variations in seed moisture over a 24 hour period.

Responses of the seed to the various treatments are given in Table 2 and Figures 2 and 3. There was significant reduction in both germination and vigor within 21 days of physiological maturity of the Dare seed and 28 days for the Lee 68 seed harvested from the ambient and DWS treatment plots. Results from both the first count germination and TZ tests indicated the onset of seed deterioration one harvest prior to a corresponding decrease in results from the standard germination test. Thus, it seems apparent that soybeans which mature under warm, humid conditions, similar to those described, should be harvested within two weeks of field maturity (leaf drop) to minimize natural field deterioration.

Results of the first count germination tests indicated that both varieties were similiar in rate of deterioration (Figure 2). On the other hand, both visual observation of the size and location of necrotic areas and the statistical data from the TZ tests implied that seed of the Lee 68 cultivar were slightly less susceptible to natural deterioration than Dare, but this was not conclusively proven (Figure 3).

Seed harvested from the 50% sunlight plots deteriorated at a significantly slower rate than those from the other treatments. Our interpretation of these results is that within the ranges observed the cumulative effects of slightly lower and less variable temperature and the higher but more uniform relative humidity in the 50% sunlight plots retarded the rate of seed deterioration. To the extent that seed deterioration was the result of "natural crushing" as described by Moore (10) it is assumed that the more uniform ambient conditions in the 50% sunlight plots reduced the rate, not necessarily the volume, of moisture migration to a level that largely precluded a build up of damaging internal pressures. Therefore, our conclusion is that in soybean production fields it is the rate and range of fluctuation in temperature and relative humidity which determines the degree of field deterioration and not the specific temperature or relative humidity *per se*. Rain sufficient to thoroughly dampen the pods followed by high temperatures, above 70 F (21 C), and low relative humidity, below 40%, accentuates, but may not be the only cause of field deterioration of soybeans in warm, humid climates.

Table 2. Mean standard germination percentages.

DARE

Treatment	HARVEST DATES					
	Oct. 3	Oct. 10	Oct. 17	Oct. 24	Oct. 31	Nov. 7
Ambient	A 98a	A 93a	B 84b	B 77c	B 55d	B 52d
DWS	A 97a	A 94a	B 83b	B 74c	C 44d	C 43d
50% Sunlight	A 97a	A 94a	A 96a	A 91ab	A 86b	A 83bc

LEE 68

Treatment	HARVEST DATES				
	Oct. 14	Oct. 21	Oct. 28	Nov. 4	Nov. 10
Ambient	A 91a	A 88a	A 89a	B 81b	B 75c
DWS	A 93a	A 91a	A 89a	B 79b	C 61c
50% Sunlight	A 92a	A 92a	A 93a	A 93a	A 89a

Within each column means not preceded by the same capital letter and within each row means not followed by the same small letter are significantly different at the 5% level of probability according to DNMRT.

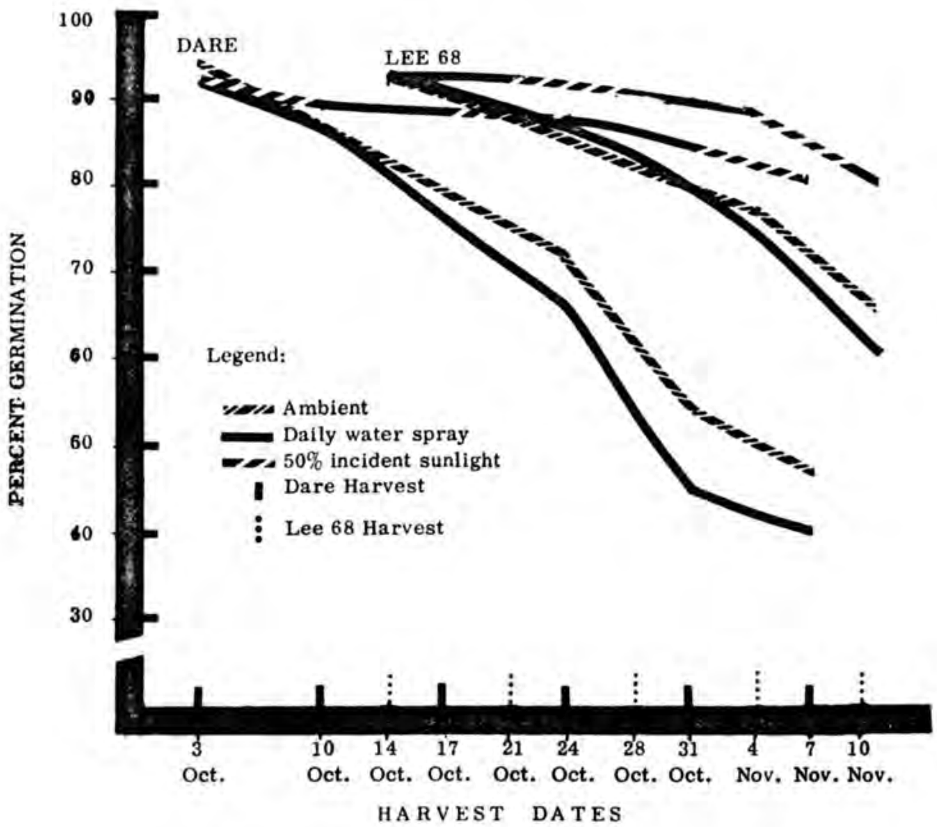

Figure 2. Normal seedlings in first count germination tests.

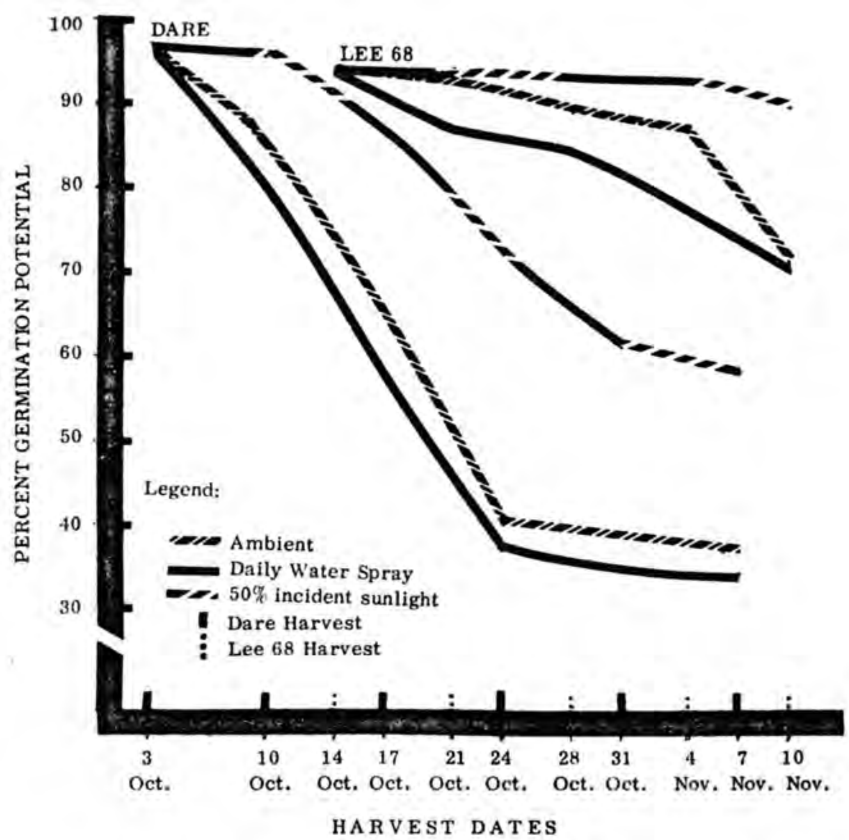

Figure 3. Germination potential as determined by TZ topographical test.

Based upon our results, the rate of field deterioration in soybeans should be retarded by any modification of the plant or seed pod micro-environment that will significantly reduce fluctuations in seed moisture. Among the existant possibilities is utilization of the hard seed characteristic. Investigations concerning the potential usefulness of this trait to maintain seed and grain quality are underway. The desired modification in moisture may also be obtained through development of varieties with pods which resist moisture reabsorption (waxy pods) or with non-deciduous leaves which would shade mature pods. Until such inovations are available from the plant breeders it is strongly recommended that soybeans for seed be harvested as soon as possible after leaf fall, particularly those fields which mature when daily air temperatures rise above 80 F (26.6 C) and relative humidities rise above 75% at night.

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