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Effects of Acid On The Germination of Cottonseeds (Gossypium Hirsutum, L.) Delinted at Various Levels of Moisture Content and Process Temperature

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EFFECTS OF ACID ON THE GERMINATION OF COTTONSEEDS (*Gossypium hirsutum*, L.) DELINTED AT VARIOUS LEVELS OF MOISTURE CONTENT AND PROCESS TEMPERATURE

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Gas-acid delinting, which involves brief exposure of seed to HCl gas, has some advantages over other methods of delinting but can cause problems with high moisture seeds and in humid climates where the sulfuric acid method is preferred (3). Data, however, to provide explanations as to why this occurs are limited, although producers believe the idea that an interaction between seed moisture content and hydrochloric gas is the major cause of the problems (7).

The overall objective of this study was to define conditions associated with HCl delinting which caused seed damage and to suggest how commercial-size operators could utilize the techniques. Specific objectives were:

1. To evaluate the influence of moisture content (mc) upon the quality of cottonseeds delinted by the acid gas process.

2. To determine the influence of the presence of HCl gas during the high temperature phase of the delinting process versus the effect of temperature alone.

Seed Material

One lot each of three cultivars of gin run seed was used for experiment I, whereas two different lots of one cultivar were used for experiment II.

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Special Equipment

I. A seed delinting unit (Figure 1), consisting of the following items, was built so as to simulate commercial plant (9):

1. 10-gallon rotating metal drum with variable speed control used as a reactor.
2. Barbecue grill used to provide heat for the reactor.
3. One hydrochloric acid tank.
4. Gas flow meter kit.
5. Pressure regulators and plastic tubing.

II. The neutralization chamber used was the same as described by Hopper (23) (Figure 2).

III. Scrubber/lint collector. A Hart-Carter^{R} Laboratory Precision Grader (Figure 3), fitted with a cardboard suction box and a wet-dry vacuum cleaner controlled by a photographic timer, was used to remove and collect the lint.

Gas Acid Delinting Procedures

A flow chart of the gas acid experiments is shown in Figure 4.

1. Pre-heating phase - 15 minutes.
   Experiment I - Delinting seeds of different moisture contents.

   Samples of about 1 kg of seeds each at moisture contents of 8, 10, 12 and 14% were placed in the reaction chamber. About 6 to 9 minutes were necessary for the temperatures to reach 60C and the temperature was maintained at that level for a total reaction time of 15 minutes.

2. Reaction phase - 10 minutes. After pre-heating, gas was introduced into the reactor at about 4000/cc/min for 15 seconds. The chamber was rotated and temperatures maintained at 60C during the reaction phase.

3. Purge phase - After the 10-minute reaction phase, the reactor was stopped, the inlet valve opened, and the chamber purged with pressurized air for about two minutes.

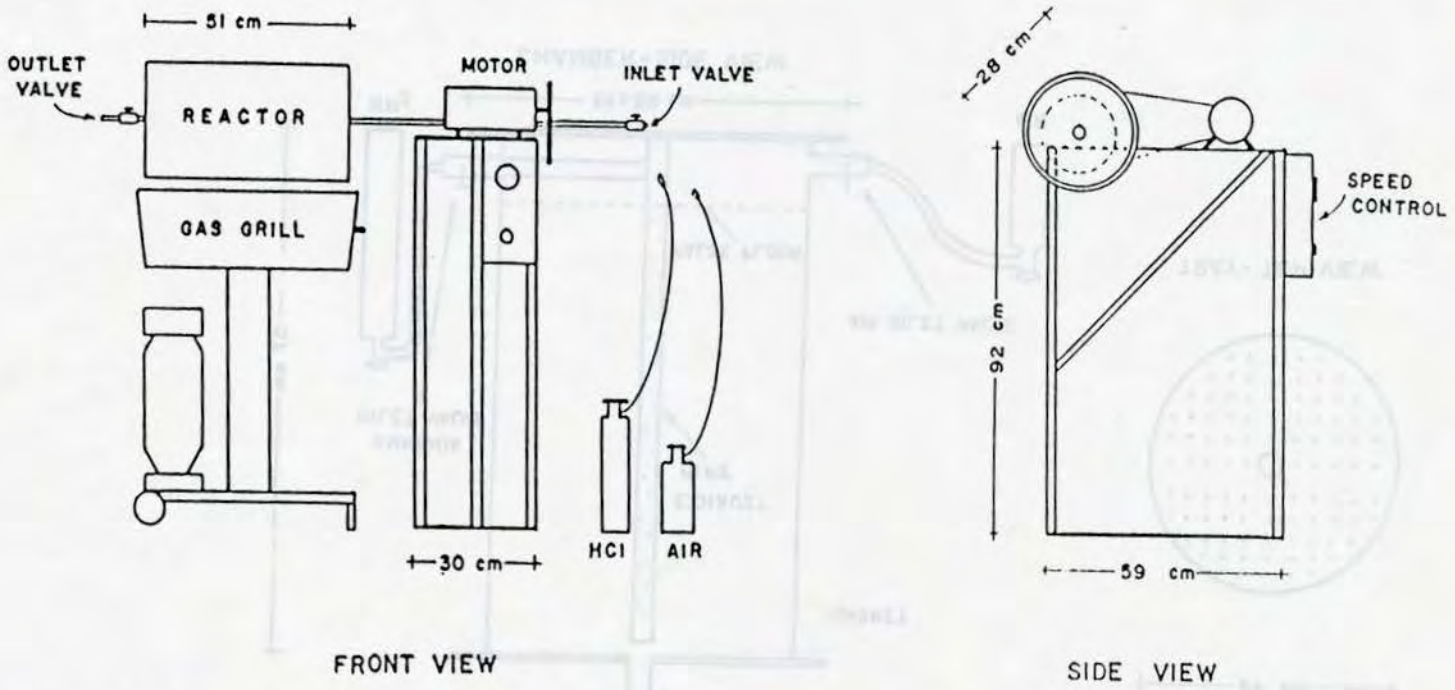

Figure 1. Seed delinting unit.

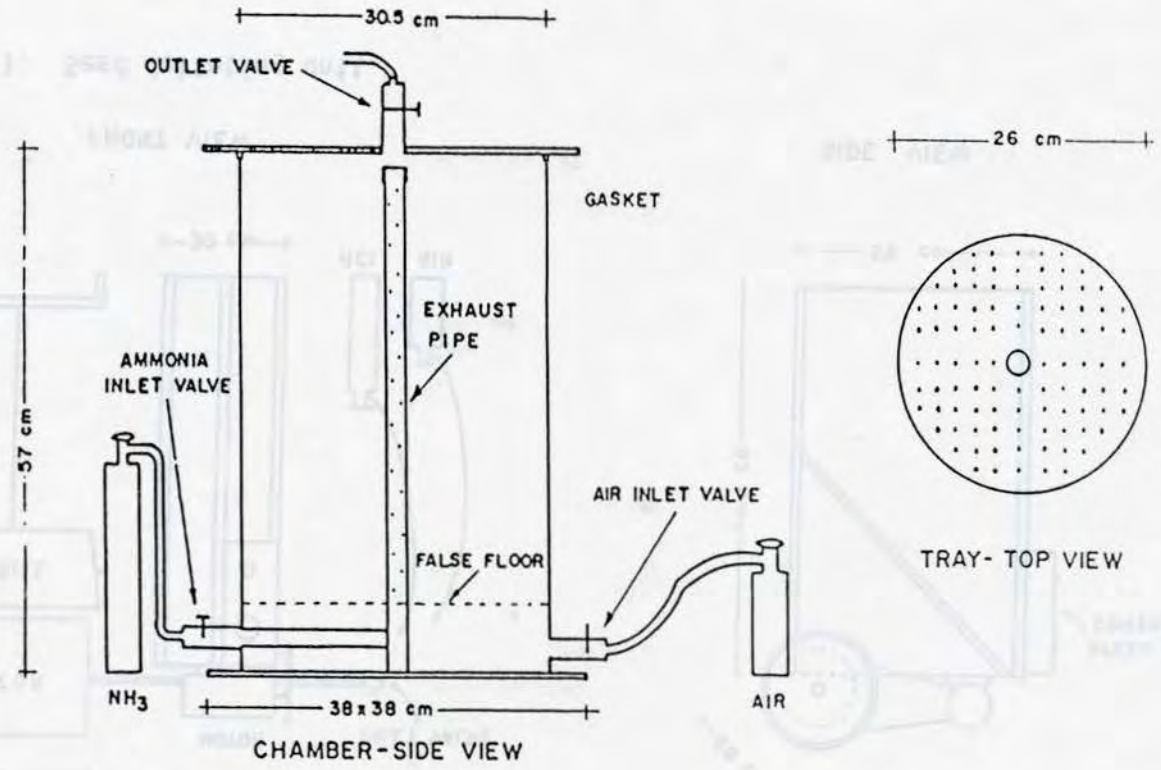

Figure 2. Neutralizing chamber.

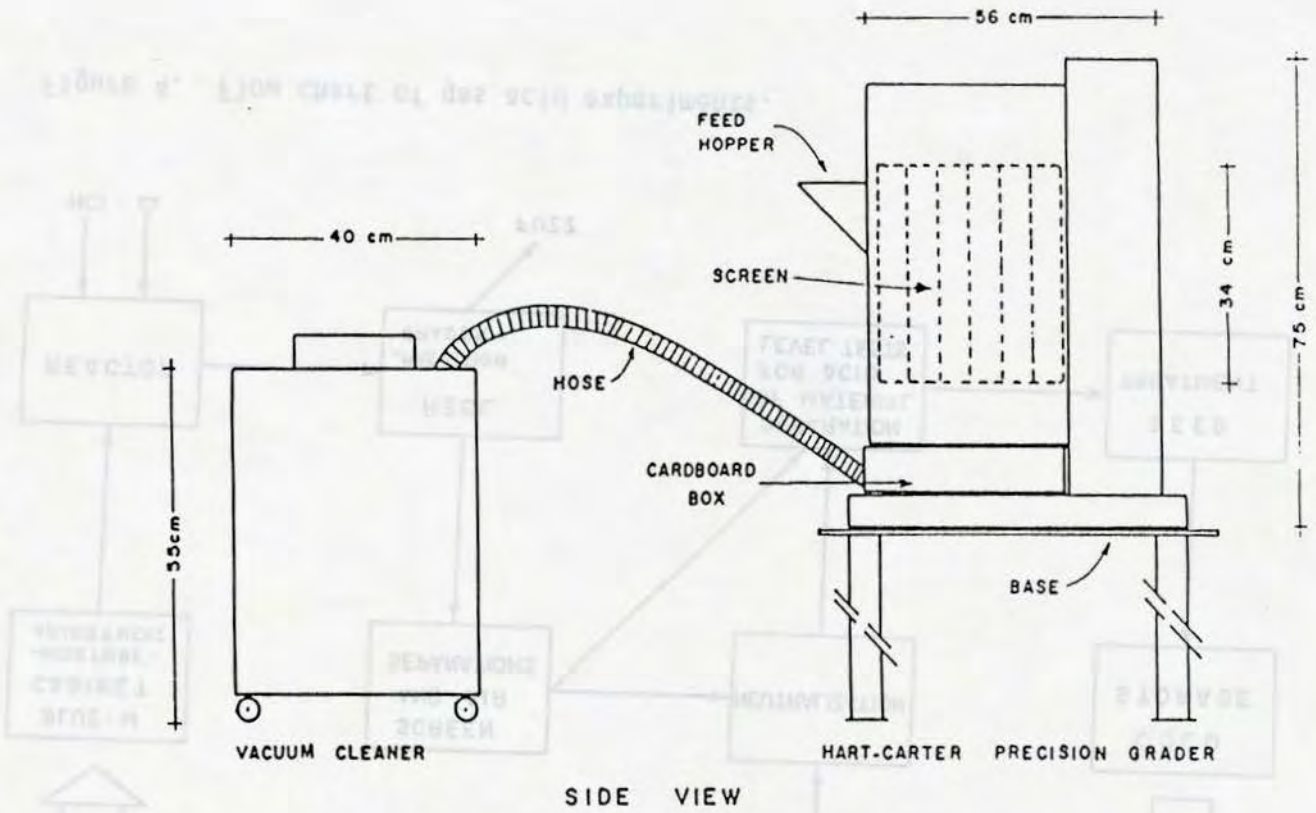

Figure 3. Scrubber/lint collector.

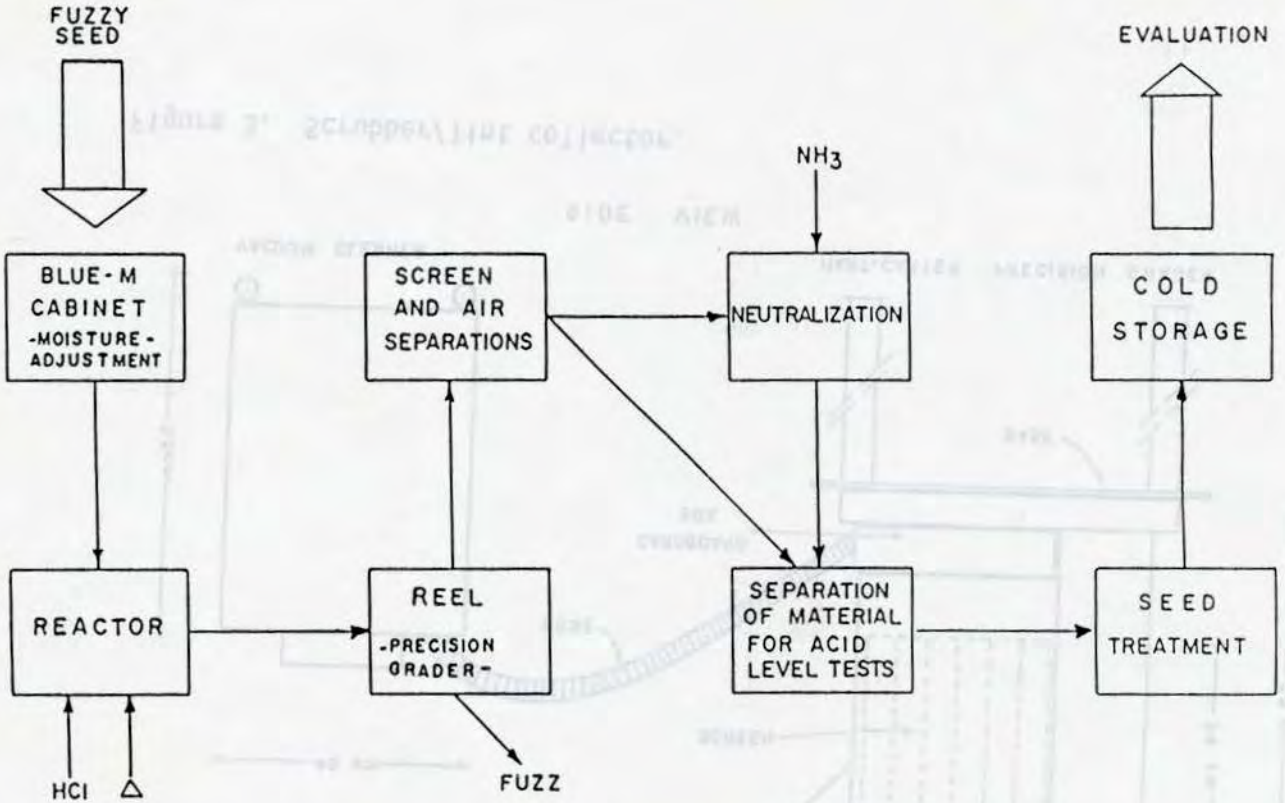

Figure 4. Flow chart of gas acid experiments.

4. Finishing phase - The reactor was opened and the seeds transferred to the scrubber/lint collector. The seeds were tumbled in the apparatus for 10 minutes.

After delinting, the seeds were graded using hand screens and an aspirator. The sample was then divided into two parts with one half going to the neutralization process. The seeds to be neutralized were placed in the reaction chamber and subjected to a short burst (about 5 seconds) of ammonia. The chamber was then purged with air before the seeds were removed. After the delinting procedures were completed, all samples were held at 10C and 50% R.H. for about one week until quality tests were conducted.

Experiment II - Effects of process temperature and moisture content on seed quality. Procedures for this experiment were the same with the following exceptions:

1. 500 g of seeds were used for each sample.

2. 60, 70 and 80C process temperatures were used.

3. Tests were made at each moisture content and temperatures with HCl gas in the chamber and with no HCl gas in the chamber.

4. No division of samples and all of the HCl treated samples were neutralized.

Quality Tests

Acid residue was determined by the procedure recommended by Boyd and Stonsaovopak (3). Standard germination and Accelerated Aging (AA) tests were made in accordance with the Association of Official Seed Analysts "Rules for Testing Seed" (1) and Seed Vigor Testing Handbook (2) respectively.

Experiment I

Moisture Content

Differences in germination percent of cottonseed of different moisture content delinted at 60C were small (Table 1). This was surprising because commercial operators expect to have lower germination with moisture contents over 10%. An important difference in this experiment is the methodology as compared to commercial practices. This experiment was designed to measure differences due to M.C. per se, with other factors isolated. The seeds were tempered to the required moisture level, immediately subjected to treatment, and returned to storage (4C and 50% R.H.) for no more than 1 week

Table 1. Effect of neutralization on germination of cottonseed delinted with hydrochloric acid.

Moisture	Germination (%)	
	Neutralized	Non-neutralized
8	83.4a	76.2b
10	88.3a	84.3a
12	82.6a	75.5b
14	88.3a	78.4b

Means in the same row not sharing a common letter differ significantly at the 5% level of probability as determined by DMRT.

before germination tests were made. Those conditions are seldom possible in a commercial delinting operation. Seeds arriving at a commercial delinter at 12-14% M.C. in all probability have been stored for some time at that moisture content and already decreased in viability and vigor. Lower quality seeds do not survive any delinting process as well as higher quality seeds as was demonstrated by both Aung (3) and Boyd and Stonsaovapak (4).

Other reasons for loss of germination in commerical operations may be related to time of exposure to process temperatures and/or the effects of adding gas into the reaction chamber near the end of the reaction to insure complete delenting. Hopper and Hinton (6) recommended delinting with 10 minutes exposure to gas and a temperature of about 60C. Under high relative humidity conditions and/or with high M.C. seed, delinting in this study was not adequate for a commercial delinter. When delinter operators disregard those limits and resort to leaving the seeds longer in the reactor, increasing the temperature, injecting more gas, or a combination of all these actions, seed damage is almost inevitable. These adjustments in the process are often done to increase the capacity of the delinting facility or insure clean delinting. Cabrera and Boyd (5) showed very clearly that only short extensions of time at the process temperatures used had a devastating effect on seed germination.

Effect of Neutralization

Acid delinted seeds which had been neutralized had higher germination percentages than non-neutralized seeds (Table 1). Cabrera (5), working with sulfuric acid delinting, noted that the non-neutralized seeds supported more mold growth than neutralized seeds even though all seeds were treated with a fungicide. The lower germination percentage of non-neutralized HCl delinted seeds was apparently the result of mold growth instead of permanent damage caused by acid.

Effect of Acid Residue

Hydrochloric acid left on the seeds increased significantly as moisture content increased. However, there was no difference in acid residue on the seeds with hydrochloric acid+ammonia (Table 2). Although acid concentration did not correlate with germination loss at the acid levels studied, there were noticeable differences between delinting with HCl versus previous experience with sulfuric acid (3, 4, 5). Boyd and Stonsaovapak (4) showed that sulfuric acid remains more in the seedcoat. Hydrochloric acid was more readily absorbed by the internal parts of the seeds. An observation during the study was that, when HCl concentration in the internal parts of the seeds exceeded .05%, internal seed parts exhibited a burned appearance; whereas, seeds delinted with sulfuric acid in the previously-mentioned study always had a normal color even at higher acid concentrations.

Table 2. Acid residue on the whole cottonseeds (percent of whole sample) which were delinted at four moisture contents by two different methods.

Moisture (%)	HCl	$HCl+NH_3$
8	.065B	.011A
10	.129AB	.027A
12	.169A	.064A
14	.174A	.029A

Within each column, means not sharing a common letter differ significantly at the 5% level of probability as determined by DRMT.

Experiment II

Seed Moisture Content, Process Temperature and Exposure to HCl Gas

No attempt was made to study the effect on delinting or seed quality of different amounts of gas used in the process. However, a comparison between a normal amount (maximum .05% hydrochloric acid residue before neutralization) and air only was made to determine possible differences caused by HCl gas under the conditions studied and on the long term viability of seeds by use of the accelerted aging (AA) test. Seeds exposed to 80C in the presence of HCl germinated 58% lower than those exposed to 60C in the presence of HCl. Seeds exposed to air only at 80C were 21.8% lower than those in air only at 60C (Table 3).

Since 10, 12 and 14% moisture seeds had similar responses, their data were pooled giving two ranges: low M.C. seed - those below 8%, and high M.C. seeds - those above 10%. The prediction lines and equations are presented in Figure 5 for seeds exposed to HCl and in Figure 6 for those exposed to air only.

Seed viability was maintained near the same level at all moisture contents for the lower temperatures in air and HCL. At each moisture level, the higher the temperature, the greater the negative effect on viability with a dramatically greater reduction in the presence of HCl above 70C. Seeds at 8% moisture showed some reductions, but not as great as at the higher moisture levels. Seeds processed at 60C germinated at about the same levels regardless of M.C.

Summary

At the reaction time and temperature (10 minutes and 60C) used, there was no decrease in germination in seeds with moisture contents up to 14%. However, when seed moisture or RH was high, commercially acceptable delinting could not be accomplished. An increase in moisture content resulted in an increase in acid absorption, but neutralization was effective under conditions of this study.

Hydrochloric acid penetrated easily to the internal parts of the seeds while sulfuric acid as shown in previous studies concentrated on the seedcoat. Hydrochloric acid proved to be very harmful when experimental mismanagement occurred.

Process temperatures proved to be the most damaging factor studied. Seed samples delinted at 60C were always higher in germination than the ones delinted at 70C, and dramatically higher than those delinted at 80C when moisture content was above 8%.

Table 3. Germination percentage of cottonseeds before and after accelerated aging, either exposed or not exposed to HCl at three temperatures.

Germination	Temperature (C) 60 HCl	60 Air Only	70 HCl	70 Air Only	80 HCl	80 Air Only
Standard	87.9a	76.9a	82.6a	74.6a	29.9e	58.1cd
A.A.	62.7bc	55.6cd	47.6d	47.1d	15.6f	27.6ef

Means not sharing a common letter differ significantly at the 5% level of probability as determined by DMRT.

Low m.c. ---- $Y=112.29-0.38X$ $r^2=.65$

High m.c. —— $Y=-1178.08+39.72X-0.31X^2$ $r^2=.98$

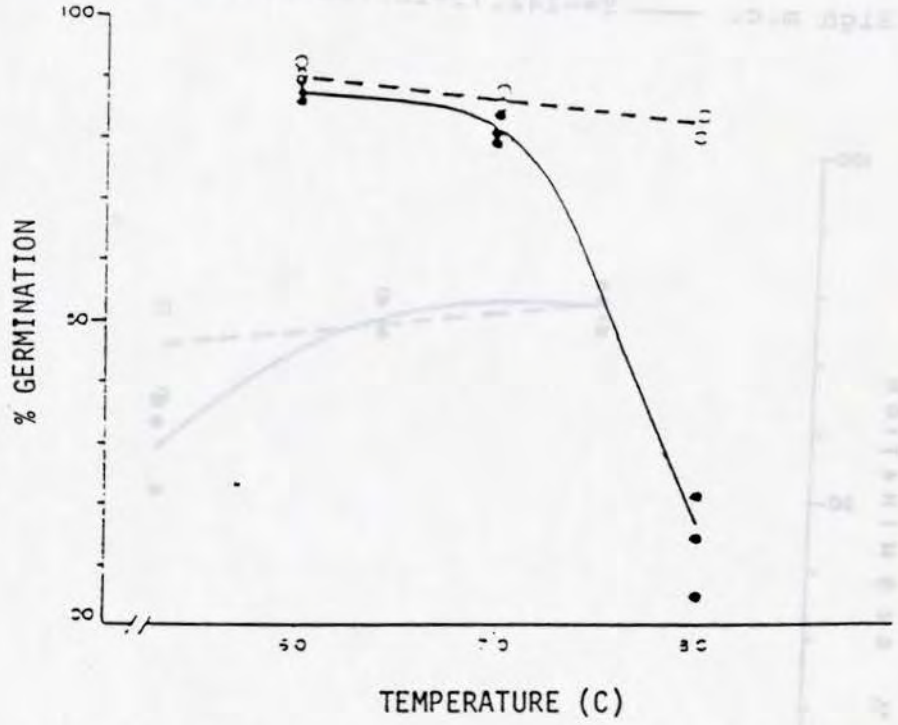

Figure 5. Germination percentages of low and high moisture content cottonseed processed with hydrochloric gas at 60, 70, and 80C.

Low m.c. ----

High m.c. —— $Y=-242.75+10.75X-0.804X^2$ $r^2=.87$

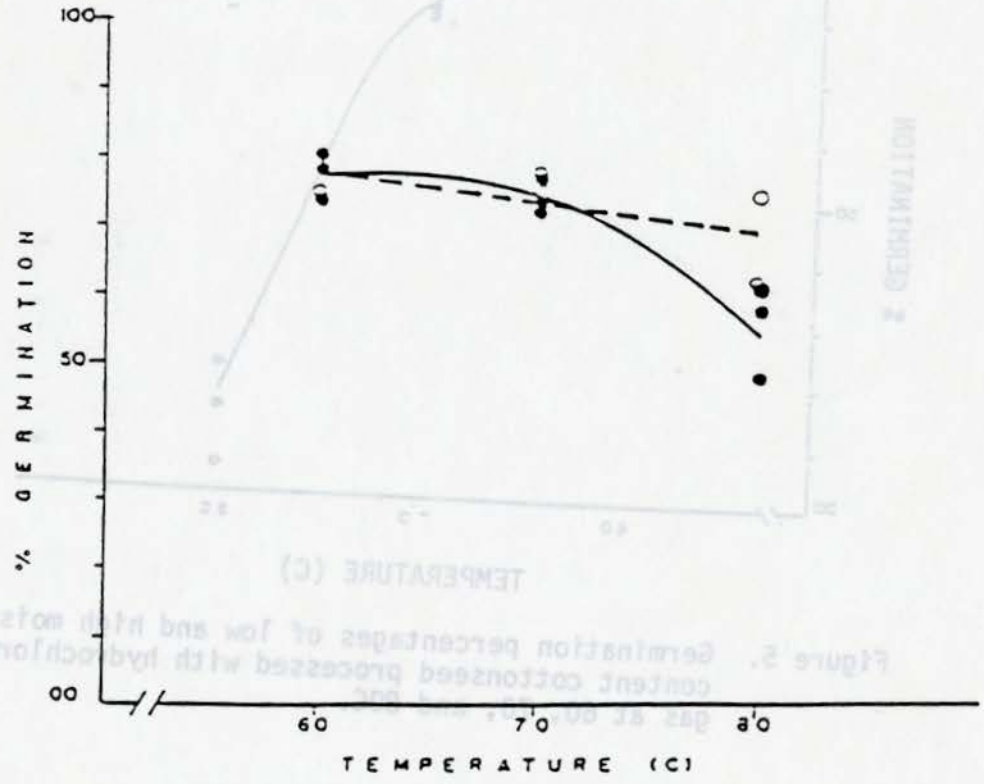

Figure 6. Germination percentages of low and high moisture content cottonseed processed with air at 60, 70 and 80C.

From investigations of the effect of moisture content and acid residue on seed quality, we conclude:

1. Germination percent was higher for neutralized seeds as compared to non-neutralized seeds.

2. The higher the seed moisture content, the greater the absorption of hydrochloric acid in both seedcoat and embryo.

3. Hydrochloric acid is absorbed by the internal parts of the seeds more easily than sulfuric acid.

4. At 60C and 10 minutes process time, moisture content alone is not a problem up to 14% moisture.

5. At moisture contents of 10% and above, temperatures above 60C result in decreases in germination percent.

6. In the presence of HCl gas, the effect of temperature is much greater than when no gas is present.

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