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Storage of Cottonseed for Planting Purposes

TEXAS AGRICULTURAL EXPERIMENT STATION
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Summary

Research was conducted by the Texas Agricultural Experiment Station to determine the effectiveness of aeration in maintaining viability and preventing an increase in the free fatty acid content of cottonseed stored for planting purposes.

Cottonseed used in these tests were stored in 160-ton capacity steel bins, each 26 feet in diameter and 24 feet high. All of the bins were equipped with air distribution systems for aerating the stored seed.

To aerate seed with low air flow rates, full advantage should be taken of all favorable cooling weather. This was done most effectively by using small fans permanently installed to each bin.

With permanently installed fans, an air flow rate as low as 5.4 cubic feet per minute (cfm) per ton of cottonseed was effective in preventing a loss in germination and an increase in free fatty acid content of cottonseed with a maximum moisture content of 12 percent.

The time required to move a cooling zone through an entire depth of seed ranged from 110 to 120 hours of fan operation with an air flow rate of 5.4 cfm per ton, as compared with 50 to 55 hours with an air flow rate of 12.5 cfm per ton.

Aeration fans were operated manually and with automatic controls. Both methods were satisfactory, but more attention by the operator was required for manual operation.

A comparison was made of pushing and pulling air through the seed. Both methods were effective in reducing seed temperatures.

The average moisture content of cottonseed aerated during storage ranged from no change to a decrease of 1.3 percent.

Under the weather conditions encountered in these tests, an average of 50 days was required to reduce seed temperatures from 95 to 65°F. with permanently installed fans supplying air at a rate of 5.4 cfm per ton, as compared with 60 days with a portable fan supplying air at a rate of 12.5 cfm per ton.

A chart was developed from the results obtained in these tests to aid in the determination of air, static pressure and horsepower requirements to aerate cottonseed with the recommended minimum air flow rate of 5.4 cfm per ton. To use this chart an operator needs to know only the floor area of a bin and the depth of seed to be stored.

Contents

The Cover Picture

Aerial view of the Texas Planting Seed Association cottonseed storage installation in Bryan, Texas. Approximately 2,000 tons of cottonseed for planting purposes are stored annually in 14 round steel bins.

Storage of Cottonseed for Planting Purposes

J. W. Sorenson and L. H. Wilkes*

PRESERVATION OF QUALITY is a major problem confronting organizations which produce and store cottonseed for planting purposes. To help solve this problem, studies were conducted by the Texas Agricultural Experiment Station to determine the effectiveness of aeration in maintaining viability and preventing an increase in the free fatty acid content of cottonseed stored in large quantities. Aeration is defined as the moving of small amounts of outside air through stored seed, for purposes other than drying, to maintain or improve the value of the seed.

EQUIPMENT AND TEST PROCEDURE

Facilities of the Texas Planting Seed Association in Bryan, Texas, shown on the cover page, were used for these tests. Approximately 2,200 tons of cottonseed for planting purposes are stored annually in 14 steel bins at this installation. Each bin is 26 feet in diameter and 24 feet high and has a capacity of 160 tons of cottonseed. All bins are equipped with lateral wood ducts to distribute the forced air.

Air was provided by the use of two sizes of centrifugal-type fans. Prior to the 1955-56 storage season, a portable, 34-inch wheel diameter fan, powered by a 15-horsepower electric motor, was used to aerate seed in four or five bins by alternating from one bin to another. In 1955, three storage bins were equipped with permanently installed, 12 ¼-inch wheel diameter fans. Two of these fans were operated by 1-horsepower electric motors. The third fan was driven by a 2-horsepower electric motor. A comparison of pushing and pulling air through the seed was made with these fans.

Two of the 12 ¼-inch wheel diameter fans were calibrated for air flow measurements in the Fan Testing Laboratory at College Station. Calibration curves obtained from these tests were used to determine the volume of air supplied by each fan. The volume of air supplied by the other fans used was measured by a hot wire anemometer.

An inclined manometer, with scale graduations of .01 inch of water, was used to measure static pressures at various depths of seed in some of the bins. These measurements indicated the resistance of cottonseed to air flow.

A portable potentiometer and copper-constantan thermocouples were used to determine temperatures at various locations in the seed during the storage period. A typical arrangement of the thermocouples in a storage bin is shown in Figure 2.

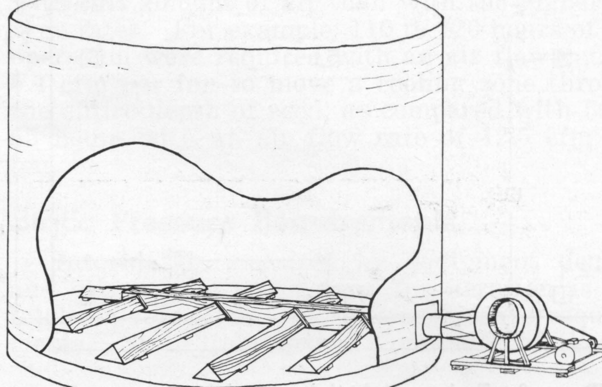

Figure 1. Bins used in these tests were equipped with wooden aeration ducts, arranged as shown here.

Samples for moisture content, germination and free fatty acid were taken at three levels in each bin as the seed were stored. To insure obtaining seed from the same area at the start and end of storage, wire cages were filled and placed in each sample area. These cages were removed as the bins were unloaded and comparative analyses were made.

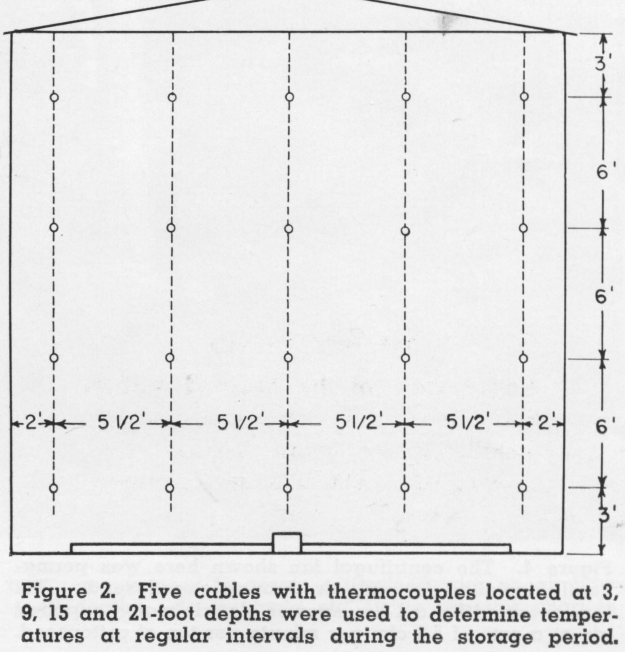

Figure 2. Five cables with thermocouples located at 3, 9, 15 and 21-foot depths were used to determine temperatures at regular intervals during the storage period.

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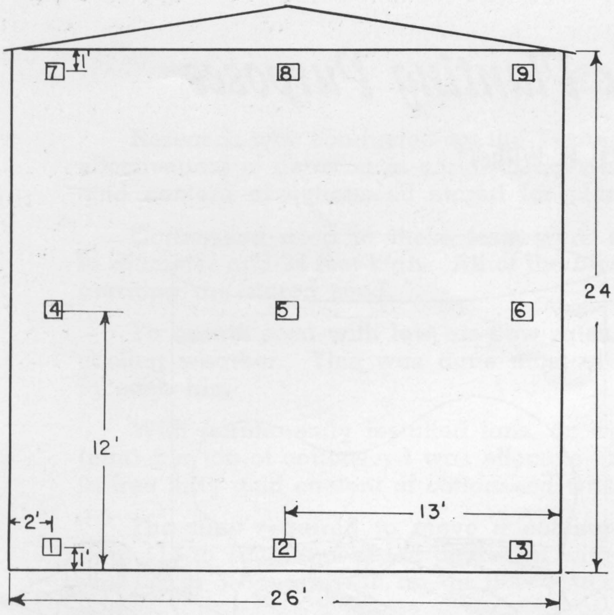

Figure 3. To insure obtaining seed from the same area at the start and end of storage, wire cages holding approximately 3/4 bushel of seed were placed in each bin at the locations shown. These cages were removed as the bins were unloaded and each sample was checked for moisture content, germination and free fatty acid content.

RESULTS AND RECOMMENDATIONS

Air Distribution Systems

An air distribution system for aeration usually consists of air ducts installed on the floor of the storage structure. In these tests wood ducts, arranged as shown in Figure 1, gave good results. Half-round, perforated metal ducts have been used in some installations with satisfactory results. Excessive losses occur in improperly designed systems. These losses can be reduced by providing ducts of adequate cross-section and surface area. Recommendations on duct design are discussed in detail in USDA Marketing Research Report No. 178, "Aeration of Grain in Commercial Storages."

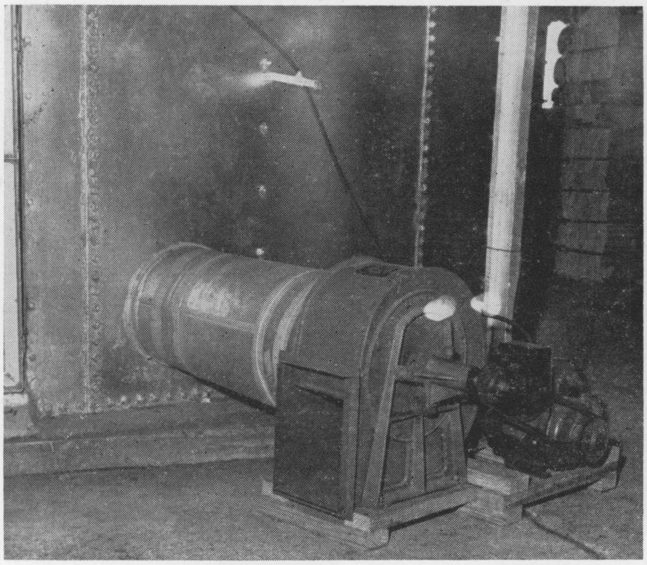

Figure 4. The centrifugal fan shown here was permanently installed to pull air through stored seed. This fan, operated by a 1-horsepower electric motor, supplied air at a rate of 5.4 cfm per minute per ton of cottonseed.

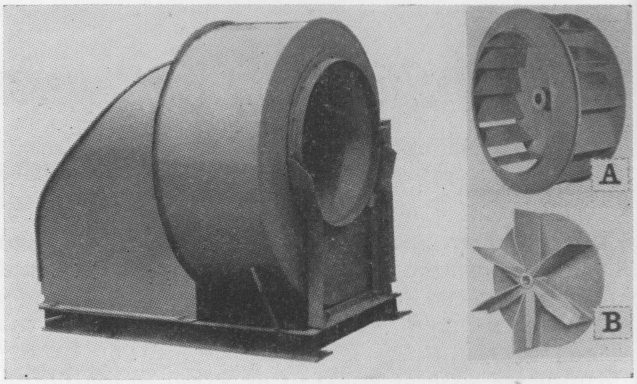

Figure 5. Centrifugal fan types are based on wheel blading. The two types used in these tests are shown here. A. Wheel with "backward-curved" blades. B. Wheel with radial blades.

Fans

Two types of centrifugal fans were used in these tests. The permanently installed fans, as shown in Figures 4 and 6, were equipped with "backward-curved" blades. The portable fan, shown in Figure 6, was equipped with radial or straight blades.

A "backward-curved" blade fan offers the advantage of a self-limiting horsepower characteristic. This means that the maximum horsepower for a given speed and air density is reached in the usual operating range. The practical advantage is that it is unnecessary to provide excess motor capacity beyond that necessary to carry the normal load. These fans are designed to

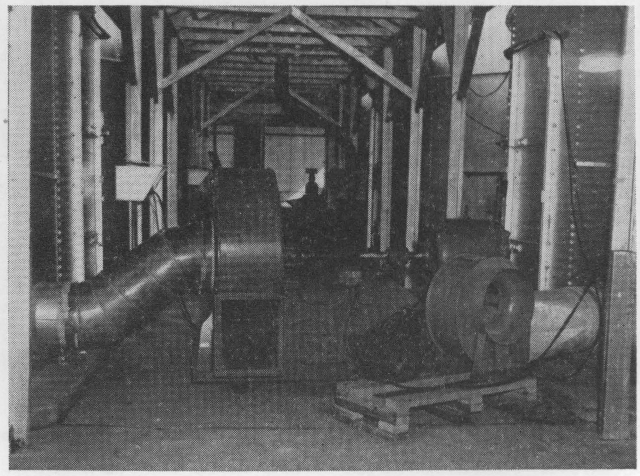

Figure 6. The portable fan (left) was used to aerate seed in four or five bins by alternating from one bin to another. The permanently installed fan (right) was used to push air through stored seed.

move air over a wide range of volumes and pressures.

A radial blade fan, often referred to as a materials handling fan, is designed to move medium volumes of air against high static pressures. If the system resistance is less than the design estimate, the fan and motor on a "backward-curved" fan will not be overloaded. In contrast, the radial blade fan would require a moderate horsepower increase.

Air Flow Requirements

Three rates of air flow were obtained with the fans used in these tests. The portable fan supplied air at a rate of 12.5 cubic feet per minute (cfm) per ton through a 24-foot depth of cottonseed. Cfm per ton is a term which expresses the amount of air per unit quantity of seed. It is obtained by dividing the total volume of air in cfm by the bin capacity in tons. The capacity in tons is determined on the basis of volume occupied by the cottonseed.

The permanently installed fans operated by 1-horsepower electric motors supplied air at a rate of 5.4 cfm per ton through a 23-foot depth of seed, as compared with 10 cfm per ton through a 22-foot depth of seed for the fan operated by the 2-horsepower motor.

An air flow rate of 5.4 cfm per ton was effective for cooling cottonseed in these tests. However, more time was required to cool the seed with this amount of air than with the higher air flow rates. For example, 110 to 120 hours of fan operation were required with an air flow rate of 5.4 cfm per ton to move a cooling zone through the entire depth of seed, as compared with 50 to 55 hours with an air flow rate of 12.5 cfm per ton.

Static Pressure Requirements

Information required by equipment dealers and others who select fans for aeration is the total air volume and the static pressure requirements. Static pressure is a measure of the re-

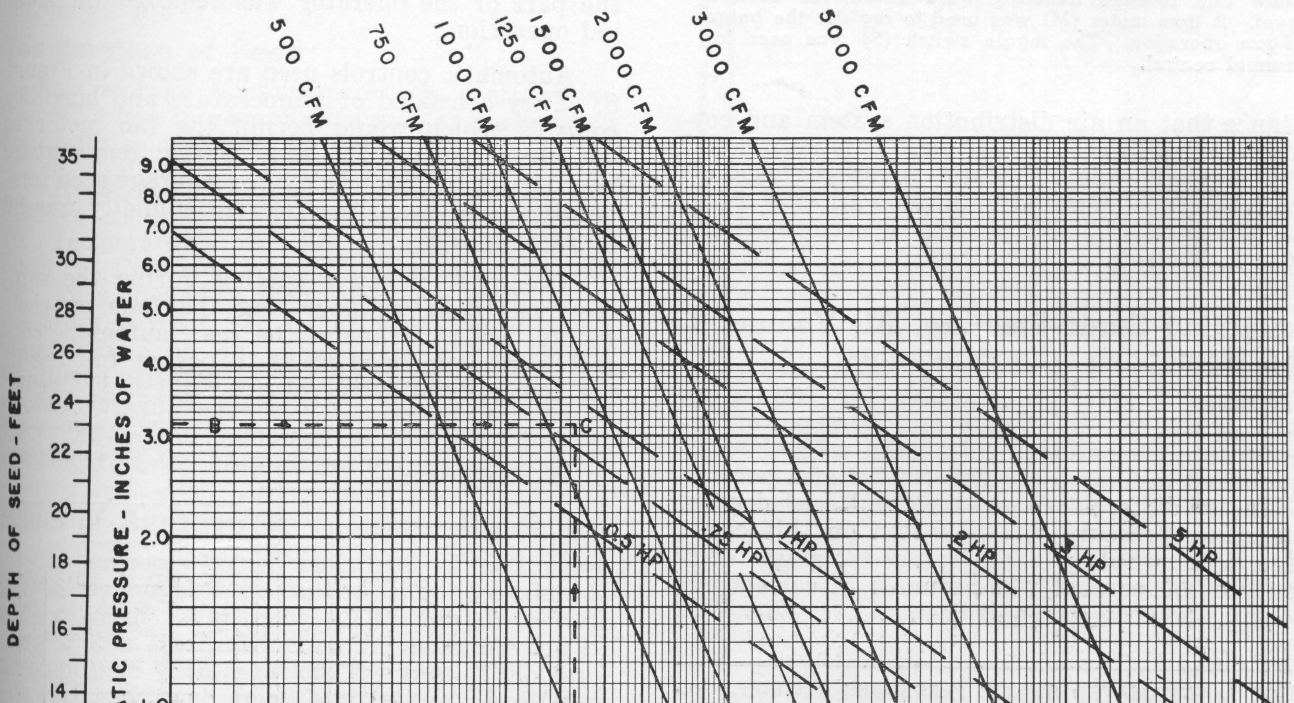

Figure 7. Static pressure, air volume and fan horsepower requirements used to aerate cottonseed with an air flow rate of 5.4 cfm per ton in bins of different floor areas and seed depths. An example of how to use this chart is given on page 6.

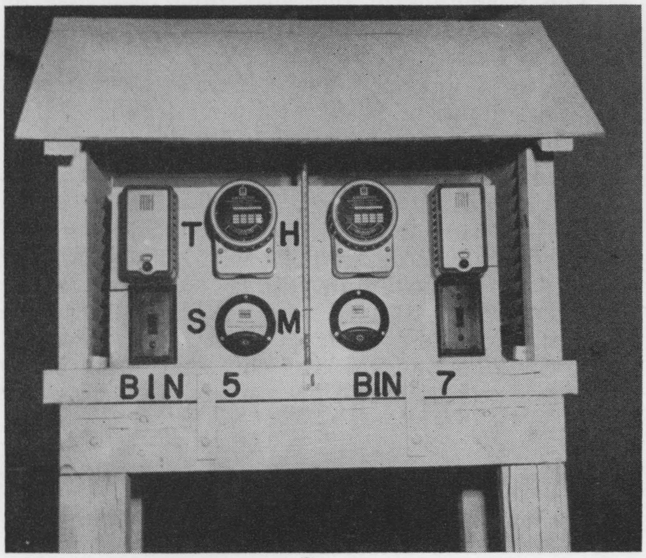

Figure 8. Two sets of controls for automatic operation of fans. Humidistat (H) and temperature control (T) permitted the fan motor to operate only when the temperature and relative humidity were below the desired level. A time meter (M) was used to register the hours of fan operation. The toggle switch (S) was used for manual control.

sistance that an air distribution system and cottonseed offer to the flow of air. It is designated in inches of water. Static pressures against which the fans operated to develop air flow rates of 5.4, 10 and 12.5 cfm per ton of cottonseed are given in Table 1.

Estimating Static Pressure, Air Volume and Horsepower Requirements

Figure 7 gives information for estimating static pressure, air volume and horsepower requirements for aerating cottonseed with the recommended minimum air flow of 5.4 cfm per ton in bins of different floor areas and seed depths. The static pressure values shown on this chart were determined in these tests. A static efficiency of 50 percent was assumed in calculating the fan horsepower requirements.

TABLE 1. ESTIMATED STATIC PRESSURES REQUIRED TO DEVELOP AIR FLOW RATES THROUGH VARIOUS DEPTHS OF COTTONSEED

Depth of cottonseed, feet	Static pressures at various air flow rates, inches of water column[1]		
	Cubic feet per minute per ton		
	5.4	10.0	12.5
10	.60	1.00	1.20
12	.80	1.40	1.80
14	1.07	2.00	2.50
16	1.35	2.60	3.35
18	1.80	3.50	4.50
20	2.20	4.40	5.65
22	2.80	5.60	7.25
24	3.45	6.85	8.90

[1]The pressures shown include an estimated 0.25-inch pressure drop in the air distribution system.

To use the chart, find the area of the bin on the horizontal scale (point A) and the depth of the seed on the vertical scale (point B). At point C, where lines projected from point A and B intersect, read the air volume and horsepower requirements. The static pressure against which the fan must operate is given on the vertical scale (point B).

In the example shown in Figure 7, an aeration system designed to supply air at a rate of 5.4 cfm per ton through cottonseed stored in a bin 26 feet in diameter (531 square feet) and 23 feet deep would require a fan that would supply approximately 850 cfm against a static pressure of 3.2 inches of water and a motor to deliver 0.85 horsepower (a 1-horsepower motor would be used).

Fan Operation

Aeration fans used in these tests were operated manually and with automatic controls. Both methods were satisfactory, but more attention on the part of the operator was required for manual operation.

Automatic controls used are shown in Figure 8. They consisted of temperature and humidity controls which would permit the fan motor to operate any time the atmospheric temperature was 10° F. or more below the average seed temperature and when the relative humidity was 80 percent or less.

The most effective cooling during the summer was done by operating the fans on clear nights. At this time of the year, automatic control is recommended so as to permit full use of the cooler night temperatures.

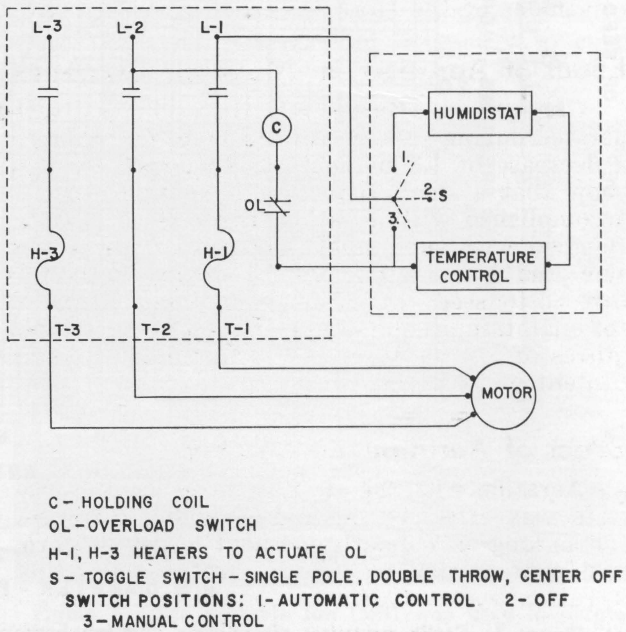

Figure 9. Wiring diagram for automatic control of fan motors equipped with magnetic starters.

Direction of Air Flow

Air was pushed through seed in some bins and pulled through in others. Both methods were effective in reducing seed temperatures. There was no indication of condensation in any of the bins. However, in some areas, there may be problems from condensation in the cooler seed at the surface or on the bin roof when air is pushed upward. This may happen in any area, but it is more likely to occur in cold, rather than in warm climates. Pulling air downward avoids condensation since the warm humid air leaving the seed does not come in contact with the cool surface area or the bin roof. It also provides an opportunity to smell the air coming out of the bin. The presence of any "off" odor is a warning of unsatisfactory storage conditions.

Air temperatures in the top of the bin were extremely high during the summer. Under these conditions, it was best to push air upward through the seed. This prevented warm air at the top of the bin from being pulled down through the seed.

Temperature of Seed

Low storage temperatures are desirable to prevent a loss in germination and an increase in free fatty acid content.

Typical temperatures of seed aerated with different rates of air flow are shown in Figure 10. Temperatures were not reduced much below 80 to 85° F. during August and most of September. They started to drop below this level during the latter part of September when there was a significant drop in atmospheric temperature. Continued aeration during the fall and winter reduced average temperature to about 55° F. by December. They remained at this level for the remainder of the storage period.

Effect of Aeration on Moisture Content

Changes in average moistures of cottonseed aerated during storage ranged from no change to a decrease of 1.3 percent. Although these tests show that a small reduction in moisture can be accomplished with aeration, the rate of moisture removal with such small amounts of air is very slow and is not sufficient for drying high-moisture cottonseed. Aeration is intended primarily for maintaining the quality by reducing temperatures of low-moisture seed (maximum moisture content of 12 percent).

Effect of Aeration on Quality

Aeration with the air flow rates used in these tests was effective in holding sound cottonseed for as long as 7 months without a loss in germination or an increase in free fatty acid content. Aeration was not effective, however, in any of the tests for maintaining germination and preventing an increase in free fatty acid content in seed which were high in moisture and fat acidity at the time of storage. For this reason, cottonseed which have received field damage and are high in free fatty acid should not be stored for planting purposes.

Comparison of the Systems

As shown in Figure 13, an average of 50 days was required to reduce seed temperatures from an average of 95° F. to an average of 65° F. with permanently installed fans supplying air at a rate of 5.4 cfm per ton, as compared with 60 days with the portable fan supplying air at a rate of 12.5 cfm per ton. Although there was little difference in the total number of days required for each system, approximately 100 more fan operating hours were required with the permanently installed fans.

Since more fan hours are required to cool with low air flow rates, it is necessary to take

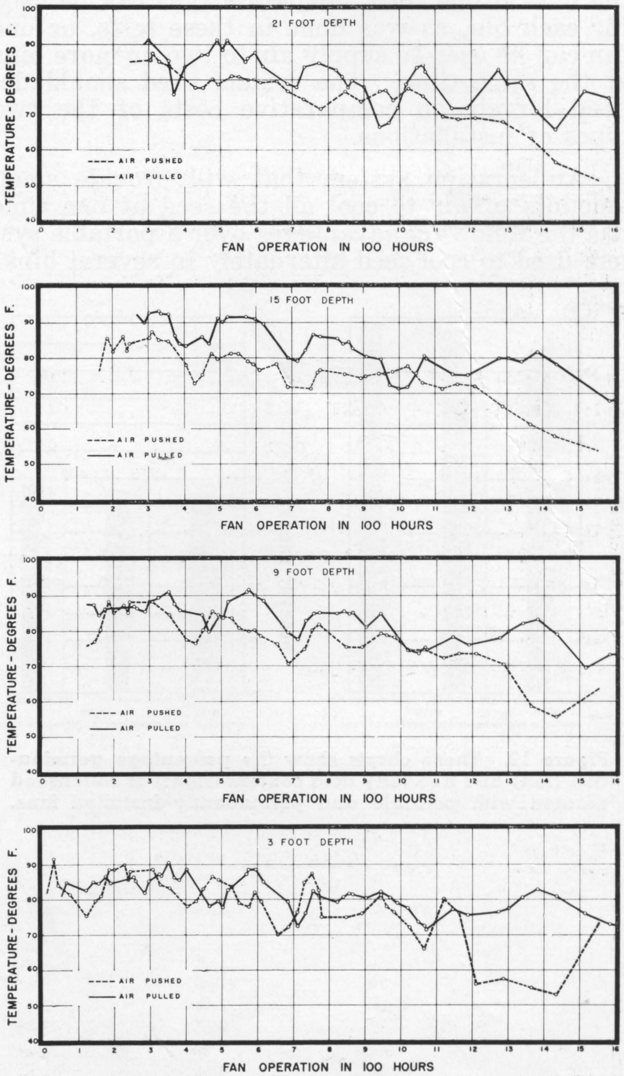

Figure 10. Temperatures of cottonseed, at four depths, stored in 26-foot diameter steel bins from July to December 1956. The seed were aerated by permanently installed fans supplying air at a rate of 5.4 cfm per ton of seed.

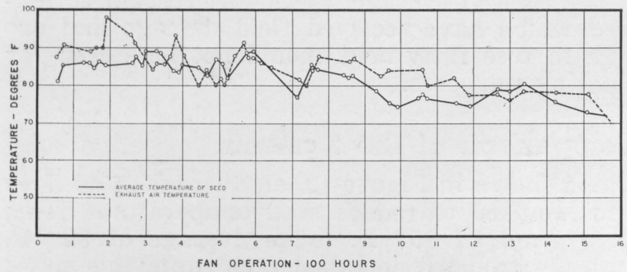

Figure 11. When cottonseed were aerated by pulling air down, there was a close relationship between the temperature of the air leaving the bin (exhaust air) and the average seed temperature, as shown in this graph. The exhaust air temperature can be used as a guide for operating aeration fans. This temperature should be taken by placing a good quality thermometer in the duct between the fan and seed close to the bin wall.

full advantage of all favorable cooling weather. This can be done most effectively by providing an aeration system that will cool seed in all of the bins at one time. Separate fans can be used for each bin, as was done in these tests, or one fan can be used to supply air to two or more bins at the same time. The system used should depend largely on comparative costs of the two types of installations.

An aeration system that will provide small amounts of air to cool all the seed at one time has the following advantages over a portable system used to cool seed alternately in several bins:

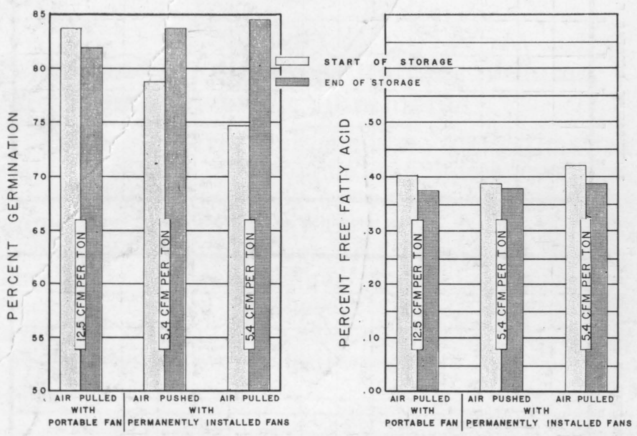

Figure 12. These charts show the percentage germination (left) and free fatty acid content (right) of cottonseed aerated with portable and permanently installed fans.

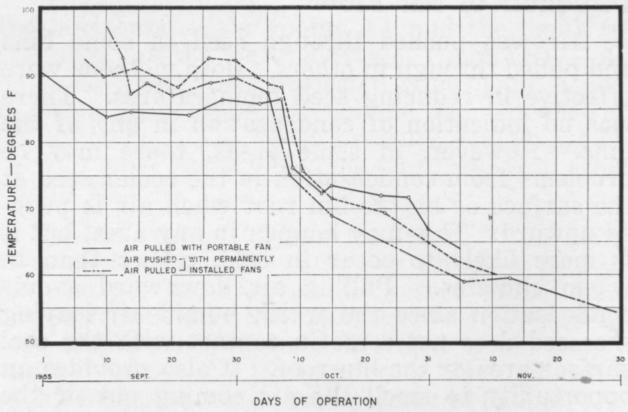

Figure 13. Average temperatures of seed aerated with permanently installed and portable fans. The permanently installed fans supplied air at a rate of 5.4 cfm per ton, as compared with 12.5 cfm per ton with the portable fan. Although the total number of days required to cool the seed were about the same, approximately 100 more fan operating hours were required with the permanently installed fans.

it permits full use of all favorable cooling weather, thus reducing the risk of unequal cooling of seed in some of the bins; it reduces the labor involved in handling and operating equipment; and it provides greater flexibility in the use and operation of equipment.

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