Handling and Storage of Cotton Seed in Tropical and Temperate Climates

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Cotton is a plant with an indeterminate type of growth habit and is perennial in nature; however, we cultivate it as an annual in the U.S. Historically, cotton has been grown for the lint, which is used largely in the textile industry, with the seed being considered somewhat as a by-product. World production of cotton, based upon 2005 statistics, indicates that about 114 M bales of cotton were produced where each bale consists of about 480 pounds of lint.

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Leading countries within the world in terms of cotton production, again based on 2005 data, indicate China is the leading country where they produce about 27 m bales of cotton per year. This is followed by the United States at about 23 M bales, India at about 19 million bales, Pakistani producing about 10 million bales, and Uzbekistan and Brazil each producing approximately 5 million bales each.

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If we again look at the production within the United States in 2005, we produced about 23 million bales of cotton.

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This slide shows the states in the U.S. that produce cotton. It may be noted that about 18 states along the lower tier of the United States are the leading producers of cotton. These are often referred to as the Cotton Belt States.

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This slide shows the five leading producing states of cotton in the U.S. On the y axis we have the number of bales in thousands and on the x axis the five leading states. Texas is by far the leading state, producing slightly less than 8 m bales. This is followed by Arkansas with slightly over 2 million bales, Mississippi and Georgia also at about 2 million bales, followed by North Carolina at about 1.4 million bales.

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As noted on the previous slide, by far the leading state in the US in cotton production is Texas. It may be noted from this slide that most of the production of cotton in Texas is concentrated in what is known as the Texas High Plains. This particular area is fairly dry in nature, receiving about 18 inches of annual rainfall, and is an area of low humidity. A second leading area of cotton production in Texas would be the central part of the state and the third leading area would be along the Gulf Coast or the Coastal Bend area; both of these last two areas being fairly high rainfall areas with very high humidity.

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As indicated earlier, cotton has largely historically been grown for the lint and the seed has been somewhat of a byproduct; used in the cattle feeding area, used as a source of oil as a cooking oil and a salad oil and various other uses. However, the most important use of the seed, while not the largest use, is as planting seed. Prior to the inclusion of transengenic traits into cotton, farmers for the most part often caught their own seed for planting or perhaps purchased certified seed for planting. This "farmer caught" seed would cost the average producer about $10 a bag which would include seed cost, conditioning, and treating of the seed in preparation for planting. However, if a farmer purchased certified seed from one of the seed companies, this increased the cost of the seed to about $30 per 50 pound bag. With the introduction of transgenic traits in cotton, the cost of a bag of cotton seed now has escalated to somewhere between $150 to $400 per 50 pound bag. This increased cost is due to the inclusion of the transgenic traits as well as the technology fee. When farmers caught their own seed, or used certified seed, most would plant at a rate of approximately 20 to 25 or perhaps 30 pounds of seed per acre. However, with the much more expensive transgenic seeds, farmers have reduced their planting rates to somewhere around 10 pounds of seed per acre. To get a sense of the value of this seed, using 2005 data, about 14.2 million acres of cotton were planted in the US. If we use an average cost of $200 per bag of seed, and we make the assumption that farmers will plant on the average of about 10 pounds of seed per acre, this comes out to the value of the industry well over one half a billion dollars per year. One can see now, with the high cost of seed, that seed quality becomes very important to the producer in that they want every seed to germinate and produce a seedling and a plant; hence, the reason for the reduced planting rate per acre.

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Now that we have established the value of the seed, lets look at how it is harvested and prepared for planting, as this can have a tremendous affect upon the quality of that seed. One would have to say that cotton seed takes a tremendous “beating” from the time it is being harvested until the seed reaches storage. The seed will be harvested either with a picker or a stripper. When harvested with a picker, the lint and the seed will be jerked from the burrs on the plant and then transported to the basket. This removal is a fairly violent action. For stripper cotton, the boll which consists of the burr, the lint, and the seed will literally be ripped from the plant, will then go through a burr extractor on its way to the basket.   In both of these harvesting operations, or types, the seed are exposed to fairly violent handling.

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After the basket on the stripper is full, it will be dumped into a machine called a “module builder”.

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This slide shows the inside of a module builder where the cotton has been dumped and a hydraulic cylinder is packing the seed cotton into what is referred to as a module. When completed, the seed cotton in the module will be packed to a very high density.

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You may note here that the module has been extracted from the module builder and is sitting in the field waiting to be picked up by the gin. In order for the module to remain intact it must be highly compacted and dense, and typically it will be covered with a tarp to protect it from absorbing moisture from rain or snow or from being damaged by the wind. It is very important that the cotton placed in the module be protected from the moisture in that it may be stored in this condition in the field for several weeks.

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After the module is transported to the gin it will be introduced into the ginning system through a module feeder where the very compact module is busted apart by beaters, again which subjects the seed to a rough environment.

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After the seed cotton has gone through various cleaners it will go into the gin stands where saws will separate the lint from the seed; again subjecting the seed to a harsh environment and exposing them to mechanical damage.

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After the lint is removed, the seed with attached linters, or very short fibers, will then be stored prior to conditioning. In many cases this seed may be stored outside and subjected further to unfavorable environmental conditions.

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The next step in preparing or conditioning the seed for the planting process is the delinting operation where the linters will be removed from the seed. If they are not removed, the flowability of the seed will be such that the planting operation will be very difficult. The linters are removed from the seed by exposing them to an acid environment; either a dilute liquid sulfuric acid solution or a gaseous hydrochloric acid environment. The acid will crystallize or dissolve the linters, thus removing them from the seed. After the seed are delinted, then the remaining residual acid will be neutralized with a basic type material such as ammonia. Again, ammonia is a toxic material itself and if not properly handled can inflict damage on the seed.

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After the seed have been neutralized, they will likely be treated with a fungicide, and perhaps other types of materials, then bagged and will finally come to rest in a storage area. This completes the long run from the field to storage where a number of locations in the process can be very damaging to the seed.

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This slide summarizes the number of places in the production and conditioning trip where it is very important to consider the safety of the seed. These would include the production field, as we have discussed, the harvesting and modeling stage, the storage of the seed cotton followed by the ginning and then the storage of the seed that still has to be conditioned for planting, then the conditioning process involving the delinting and treating, and then the storage environment of the seed after it has been conditioned and prior to the time that it is planted.

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The preservation of seed quality in the production field basically includes routine “good agronomic practices” including field selection, irrigation, soil fertility regime, pest control and one that is very, very important--the preparation of the plants for harvesting. Harvest preparation should be emphasized because historically cotton was not harvested from the field until after a freeze had killed the plants and the leaves had fallen. This meant that the harvesting process did not begin until late in the season. In more recent years, with the advent of harvest aid chemicals we are now able to “prepare” the plant for harvesting much earlier, thus subjecting the seed to considerably less field weathering. Harvest aid chemicals include such materials as “boll openers” which will stimulate the opening of bolls earlier than would be the case if one waited for a freeze. Also included would be “defoliants” and “desiccants” used to remove the leaves prior to the harvesting process. It is important not to harvest any leaf material with the cotton, especially if it contains any moisture which would contribute to seed deterioration. In addition, one needs to be cognizant of any plant regrowth which could introduce new high moisture material into the cotton. And lastly, the harvesting operation should not begin when there is dew or other moisture on the plants. This is largely a problem in the mornings. The objective is to harvest dry cotton.

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During the harvesting operation the machinery should be set properly so as to minimize any mechanical damage and, as we have alluded to earlier, the seed cotton that is being harvested should be dry; preferably 12% moisture or less in the seed cotton.

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Cotton is a hygroscopic material and thus will attract and retain moisture. This graph shows the relationship between relative humidity of the air and the moisture content of the fiber, the seed cotton, and the seed. As indicated earlier, the objective is to harvest the seed cotton with a moisture content of 12% or less and in order to do that the relative humidity will need to be below 70% during the harvesting operation. In many cases, the humidity in the air in the morning will be high and harvesting operations will need to be delayed until later in the day when the relative humidity has dropped to below 70%.

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Once the seed cotton is harvested, it will be transferred from the harvesting machinery to the module builder where it will be stored in a module until it is picked up by the gin. This could span several days to several weeks. Obviously, it is very important to locate and design the module to minimize any seed deterioration. First, the module should be located on high ground to insure that any moisture that is received as rain will be drained away from the cotton module. In addition, locating the module on high ground will facilitate the loading of that module onto a truck if the field is wet. Next, care should be taken in designing the module. The design of the module should be such that it has a rounded top so as to drain any moisture that falls as rain or snow and also the module should be quite dense to prevent movement of moisture into the module itself. Once the module is completed, a tarp should be placed over the module to prevent moisture absorption as well as to provide protection from the wind. This should be followed by a fairly strict monitoring procedure. One should check the interior temperature of that module on a daily basis for several days. Normally, an increase of 10 to 15 degrees F over a 3 to 5 day period should be expected followed by a gradual decline. This is ok; however, if we see an immediate 20 degree F increase, it is indicative that moisture is high inside the module and high rates of respiration are occurring. If this is the case, the module should be ginned immediately. The temperature inside the module should not exceed 110 degrees F to 120 degrees F. If it does, seed deterioration will occur.

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As previously indicated, the moisture content of the module is very important. This slide depicts the temperature inside a module as a function of days after storage under two moisture levels of the seed cotton. The dashed line indicates that with 11% moisture seed cotton, the temperature will rise, as was indicated earlier, for the first three to four days; perhaps by 10 to 15 degrees, and then will start a normal decline. However, 16% moisture seed cotton, depicted here by the solid line, will increase rapidly over a period of several days, reaching a peak in this study at about 165 degrees F before a decline starts after about 10-12 days of storage. This temperature of 160 degrees will obviously destroy the viability and vigor of the seed. So, steps need to be taken to put only dry seed cotton into a module and then further to protect that module from absorbing any moisture due to environmental events.

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These data show the effect of moisture content on the number of days that seed can be safely stored. The higher the moisture content of the seed, the shorter the safe storage time will be. Conversely, as the moisture content decreases, the number of days that the seed may be stored safely will increase.

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These data show the effects on viability and vigor of seed stored at 12% moisture and at 40 degrees C. for varying amounts of time. It may be noted that the data for standard germination test and the tetrazolium test begin to drop off after only 4 days of storage at 40 degrees C and a seed moisture content of 12%. In addition, the seed vigor, as depicted by the cold test and accelerated aging test, started to decline almost immediately. Again, it should be noted that cotton seed quality is very sensitive to temperature, especially at the higher moisture levels.

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After a period of time in the field, the modules are then carried to the gin where the ginning operation will remove the lint from the seed. Typically, the seed cotton will pass through a dryer to make it easier to gin. The equipment should be properly set to minimize any damage to the seed. In addition, seed coming out of the ginning operation will usually be around 100 degrees F, so it becomes very important to cool this seed before putting it into storage. Otherwise, the linters attached to the seed will act as insulation material and hold the heat in the seed mass for an extended period; thus damaging the seed.

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This slide shows the relationship between seed damage during the ginning process and seed moisture content. It may be noted that, in general, as the seed moisture content increases so does the mechanical damage inflicted during the ginning process. As a result, in order to keep the mechanical damage to less than 6%, seed moisture content should be below 10% before ginning.

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This slide shows the relationship between seed class damage, or the amount of seed damage, and the germination and greenhouse emergence of seed. The data indicate that as we go from seed not damaged, to seed coat being scratched, to seed coat broken but the embryo not visible, to seed coat broken but the embryo visible, and lastly, to seed coat sections removed and the embryo damaged, that the germination and greenhouse emergence are greatly reduced. It may also be noted that this is especially significant when the seed coat is broken, or sections of the seed coat is missing. These openings provide entry ports for microbes and acid which can reduce seed quality.

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Next in the seed conditioning trail is the actual delinting of the seed. This will be accomplished using either hydrochloric acid or sulfuric acid to crystallize and dissolve the linters remaining on the seed. Since these are very caustic chemicals, time of exposure, heat generation, and adequate neutralization of the seed after the acid delinting process are very important to minimize damage to the seed. Following the treatment with acid and the neutralization process, the seed will be passed across a gravity table to remove the low density and immature seed. The remaining seed will be treated and either stored in bulk or bagged.

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The main reason cotton seed is delinted is to provide for flowability of seed during the conditioning and planting processes. In addition, the delinting of the cotton seed allows for a faster imbibition rate once the seeds are planted. Further, any micro-organisms that might be on the surface of the seed will be killed as a result of the acid treatment. This slide shows the moisture content of seed with varying amounts of lint and linters after imbibing for several hours. Gin-run cotton seed, shown by the small dashed line, indicates that with the lint still on the seed, the imbibition of water goes fairly slowly. When the seed have been flame delinted, which will remove probably 60 to 80% the lint, the imbibition rate is increased and when the seed have been acid delinted where all of the linters are removed, the imbibition is much faster. Generally, with increasing amounts of lint and linters removed, imbibition will occur more rapidly, thus, allowing for faster emergence.

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After seed are delinted and treated, the next important step that affects the quality of the seed will be the conditions under which it is stored. This slide shows the germination percent of seed after several years of storage under different conditions. For seed that have been sealed in a container and stored at 10 degrees C, the germination remains relatively high through four years and then drops off fairly rapidly. When stored at room temperature in sealed glass, again the viability remained relatively high through four years before rapidly declining. With seed stored in paper envelopes, the germination percent started to drop almost immediately, declining to 8% after six years.

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This slide shows data from a long term storage study of cotton seed at a number of different locations in the US. These various locations had different environmental conditions, especially as it relates to temperature and relative humidity. It may be noted that seed quality at all locations held at a high level through the first year; however, after the first year the seed began to deteoriate. It may be noted that three categories of seed deterioration rate existed here. The seed category that maintained the slowest rate of deteoriation was mainly in those areas that had relatively low humidity where the seed equilibrated to about 8 to 9% moisture. Those in the middle category of seed deteoration had higher relative humidity values such that the seed equilibrium moisture content was around 9 to 10% and then the one location that had the most rapid seed deteoration rate had a high humidity such that the equilibration moisture content was somewhere around 11 to 12%. This again shows how detrimental high seed moisture content can be as it relates to maintaining seed quality.

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In summary, for maintaining high quality seed, the seed must be thought of as a living organism and handled in an appropriate manner such that we minimize any mechanical and chemical damage to the seed during the harvesting and conditioning stages and that we store it under good conditions. The old cliché about only storing good quality seed and keeping it cool and dry are very, very important in maintaining high seed quality.

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Thank you!