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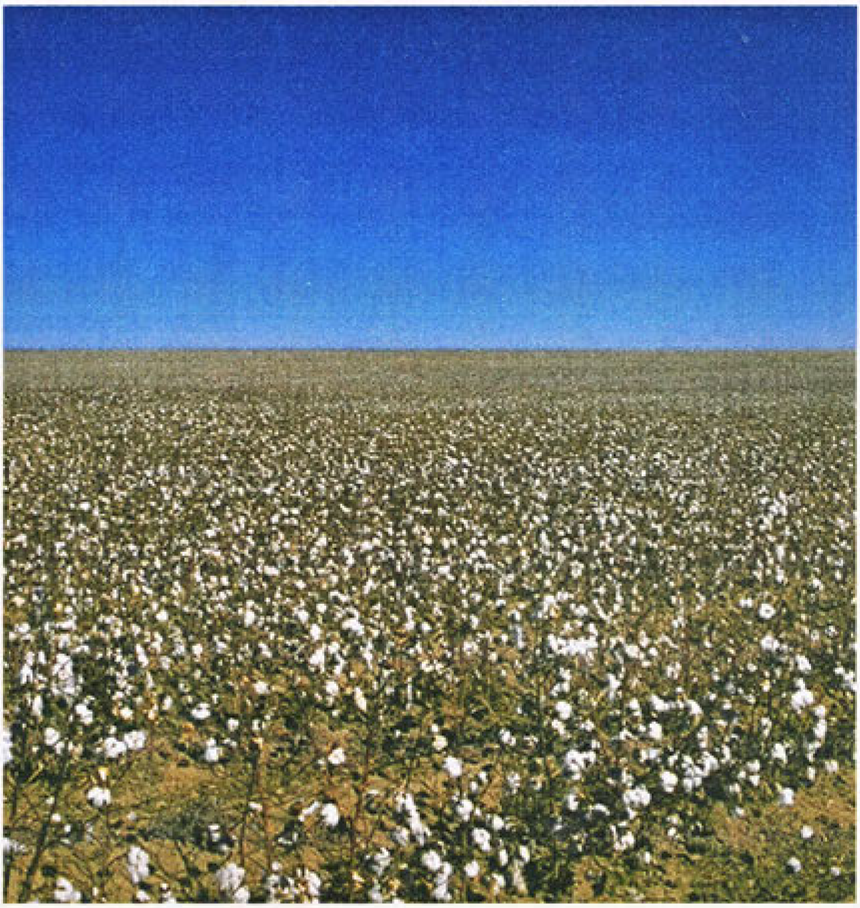
Impacts of Field Cleaning on Cotton Quality

A Survey on Cotton Quality from Field to Bale

Master Thesis of Werner Liechtenhan
in Environmental Sciences
at the Institute of Textile Machinery and Textile Industry



supervised by:
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Roland Graf proofread the thesis for context.

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0 Summary

Stripper harvesting causes a lot of trash in the cotton and requires a long chain of cleaning processes in the gin. Cotton quality is affected by all these processes. Recently, an additional step of cleaning is carried out already in harvesting, with a field cleaner.

The impact of a field cleaner on cotton quality is investigated. Cotton harvested with field cleaner is compared with cotton harvested without field cleaner. Samples were taken at several locations in the ginning process. By this, also the effects of gin machinery on cotton quality could be studied. Additionally, a second gin was surveyed. AFIS (Advanced Fiber Information System) and HVI (High Volume Instrument) measurements for quality parameters were carried out.

The field cleaner turned out to reduce immature fibers in the cotton by about 7% and the amount of neps by about 10%. Both parameters are important for spinning performance and yarn quality. However, field cleaning showed very little effect on parameters determining the price of cotton. Neither an influence on the trash content in the bale nor a significant influence on color or length could be found. A small deterioration due to field cleaning was found for yellowness as well as for strength and elongation. Micronaire values were significantly influenced due to the reduced immature fiber content. The effect was not price relevant, though.

Adjustments in the cleaning configuration of the gin are required for field cleaned seed cotton. Less seed cotton cleaning will be necessary in order to reduce the mechanical stress on the fiber. Perhaps, bur and stick machines can be bypassed.

Furthermore, attention has to be paid to the gin stand. The results of this study indicate that speed might be a critical factor for fiber damage. In addition, improvements in cotton quality can be reached through less lint cleaning and by the implementation of process control systems in the gins.

1 Introduction

Cotton undergoes a long chain of processes on its way from the plant in the field to the lint in the bale. In these processes important quality parameters are affected. The quality of the cotton in the bale determines the possible applications in further processes and therefore plays a very important role in marketing considerations. Especially for the spinning industry the quality of the raw material is of critical importance, since spinning performance as well as yarn quality depend on it.

In the United States the quality of nearly every bale of cotton is specified according to the Official Standards of the USA. The cotton classification is performed by High Volume Instrumentation (HVI) which performs quality measurements in a matter of seconds. The current classification consists of measurements of fiber length, length uniformity, strength, micronaire, color, preparation, leaf and extraneous matter [USDA 1995]. The classification system of the United States is still unique in the world. It assures uniform cotton standards all over the country and helps the producer to market his product.

The quality of the cotton fiber is best on the field, the day a cotton boll opens. Weathering, harvesting, ginning, and manufacturing impair the natural quality of the cotton (Mayfield et al. 1994).

Handpicking is the most gentle way of harvesting which is still done in most cotton growing countries. In the USA, labor today is too expensive for this, and practically all the cotton is harvested by machine, either with spindle picker or with stripper harvesters [Munro 1987]. The spindle picker works with a number of rotating spindles which tangle with the seed cotton in the open bolls, pulling it away from the husk. This type of machine is used for all good quality cotton. The cotton stripper is a non-selective harvester that removes not only the well-opened bolls but also the cracked and unopened bolls along with the burs and other foreign matter (Williford et al. 1994). The plant is literally brushed off and only the stem and some branches remain on the field.

In Lubbock, Texas, where this study was carried out, all cotton is harvested with stripper harvesters. Stripping is a very efficient way of harvesting, it is cheaper and quicker than spindle picking. However, it results in additional foreign matter in the cotton and causes a long chain of cleaning, subsequently. Even with elaborate cleaning equipment in the gin it produces a much poorer quality of lint [Munro 1987].

Traditionally, the color of the cotton is a main factor for the price. The whiter the cotton the better the price. Therefore, intensive cleaning seems to be essential. But the more cleaning is performed, the more damage is done to the fiber. Fibers can break by mechanical treatment, especially if they are dry. This reduces length and creates short fibers. They can also get entangled with each other and form little knots, called neps, which may cause thick and thin places in the yarn. It is difficult for the ginner to find the right compromise between trash removal and a minimum reduction in fiber quality [Mayfield et al. 1994].

Klein & Schneider (1992) complain that there is no increase in quality value in the first process steps of the cotton industry - as the spinner would need it - but a reduction in value for practical application. According to the spinning industry, the quality of the raw material decreased in recent years, although continuously better grades have been measured [Klein & Schneider 1992, Demuth 1993].

Unfortunately, this reduction in value for the spinner does not have an impact on the market price of the cotton. The specific quality parameters affected in cleaning are not represented in the current classification system. The High Volume Instrument is constructed to measure short fibers, neps or immature fibers. A very precise instrument able to measure these fiber properties is the AFIS (Advanced Fiber Information System). But it doesn't work as fast as the HVI and therefore can not be used for cotton classification.

The longer the more, the first step of cleaning is done already on the field in harvesting. The field cleaner is installed on the harvester. It breaks up bolls and sorts burs, leafs and sticks out. All this trash is left behind on the field.

While most of the effects of gin machinery on cotton quality are well known and described, for example in Anthony & Mayfield (1994), hardly anything has been done to study the effect of a field cleaner.

Bennett & Misra (1996) showed that a field cleaner should be used as a first step of cleaning to get the least cost cleaning configuration across the harvesting, ginning, and textile mill stages. They found that field cleaning did not affect the quality parameters measured in cotton classification. AFIS measurements were not carried out in this study.

Baker (1998) investigated fiber quality, yarn processing and yam quality for 48 cotton samples harvested with and without field cleaner and ginned with different ginning settings. He carried out HVI and AFIS measurements. For the field cleaned cotton he found clearly higher micronaire values, slightly better color, less neps, and less immature fibers. In terms of yarn quality, the field cleaned cotton showed more thin and thick places and lower values for count strength product (Ring spun 30Ne, Openend spun 24Ne). Because of some contradicting findings the study was not published and will be concluded with the crop of 1998.

Aim

The primary aim of this thesis is to investigate the impact of a field cleaner on cotton quality with AFIS and HVI measurements. Secondary, effects of ginning machinery on cotton quality will be shown.

Research Questions

1. How far does field cleaning affect quality parameters not measured in the classification system, but important for spinning performance and yarn quality?
2. What is the impact of field cleaning on quality parameters measured in the classification system and determining the price of cotton?
3. How do seed cotton cleaning, the ginning process, and lint cleaning in the gin, affect cotton quality?
4. What changes are required in the gin for field cleaned seed cotton and for improved cotton quality in general?

2 Procedures and Methods

2.1 System

The system for this thesis is the region of Lubbock in the High Plains of Texas. The area is dominated by cotton production. By acres, it is the largest cotton production area of the United States.

Cotton is grown in four major geographic areas in the United States - the Southeast, Mid-South, Southwest and West. The area of Lubbock belongs to the Southwest region which is comprised of Kansas, Oklahoma and Texas (figure 1). This region produces about 24 percent of the total crop of the U.S.. Approximately 30 percent is irrigated and the average staple length is below 1-1/16 inches. In the region of Lubbock, planting starts in mid-April and harvesting begins in mid-October and lasts through December.

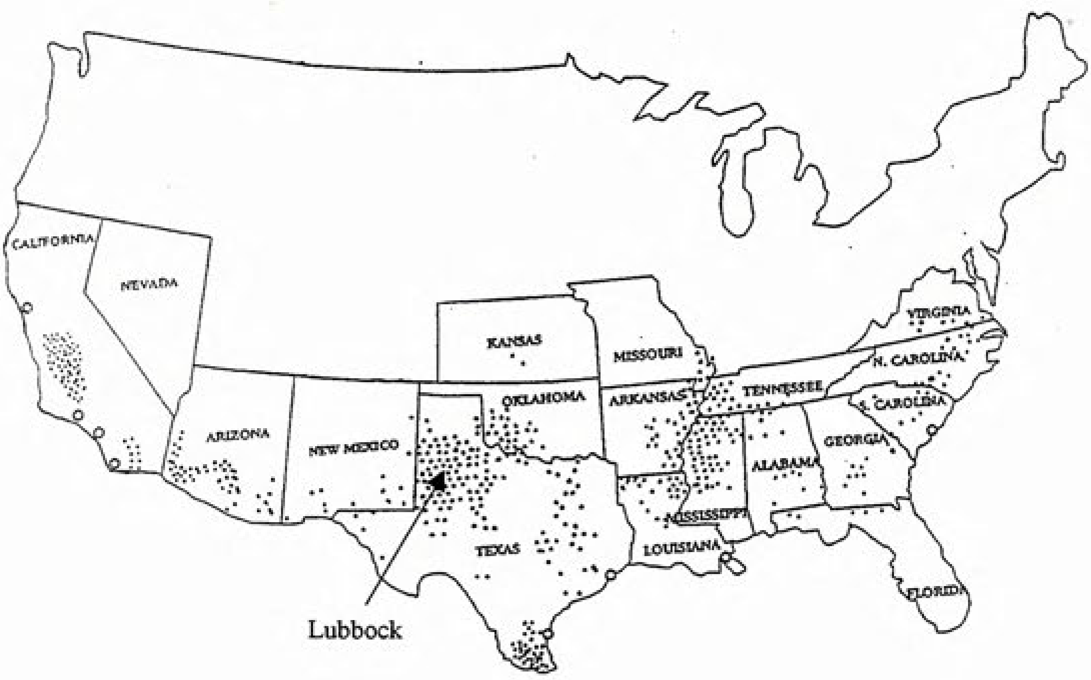


Figure 1: United States cotton production [International Textile Center 1998].

The city of Lubbock is in the heart of this large production area. Many important institutions and companies for the cotton industry are located in or around Lubbock. Therefore it provides a perfect infrastructure for research projects.

The data collection for this thesis was carried out at the International Textile Center in Lubbock (an auxiliary of Texas Tech University) with the help of farmers and ginners in the region. Other important institutions for this thesis were the USDA Ginning Laboratory and the Department of Agricultural & Applied Economics of Texas Tech University.

2.2 Scope

The scope for this study was set on the processes before the bale, on raw material production. The effects in these processes on cotton quality are very important for later stages of production. Especially in yarn production the cotton quality is of critical importance.

Figure 2 gives an overview of the chain of apparel production. The raw cotton is spun into yarns and yarns are woven or knitted into fabrics. In a series of processes the fabrics are finished and thereafter manufactured into clothing for the consumer.

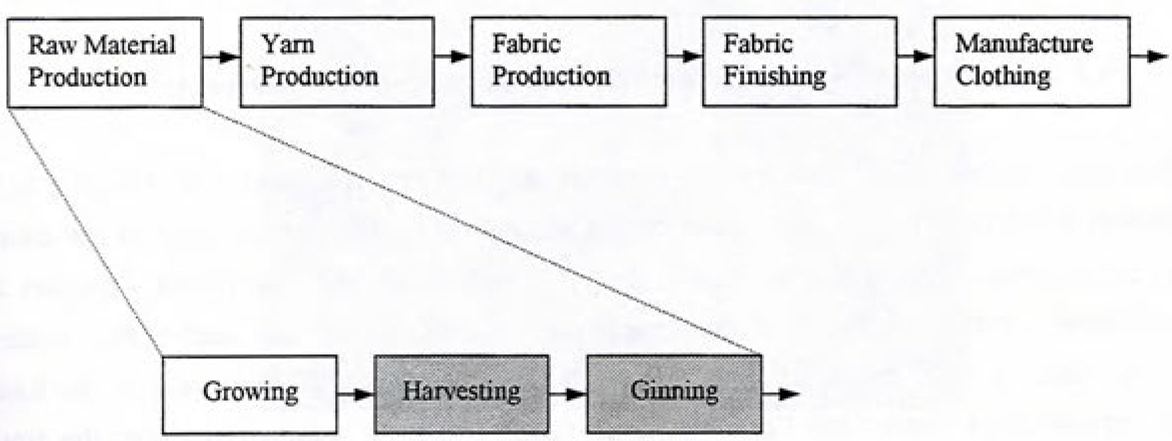


Figure 2: Overview of the value-added chain of apparel production and the three sub processes of raw material production.

The process 'raw material production' can be sub divided into 'growing', 'harvesting' and 'ginning'. The process 'growing' includes all the steps from the seed to the fully grown plant. The choice of variety, planting of the seed, cultivation, and the environmental conditions during growth, all are of great importance for the quality of the cotton. However, these aspects are not considered in this thesis. The focus of this study is set on the processes 'harvesting' and 'ginning'.

2.2.1 *The Process 'Harvesting'*

The process 'harvesting' includes not only the actual process of removing the cotton from the plant, but also the processes 'module building' and 'storing'. Recently, a first step of cleaning is performed straight in harvesting with a field cleaner (figure 3).

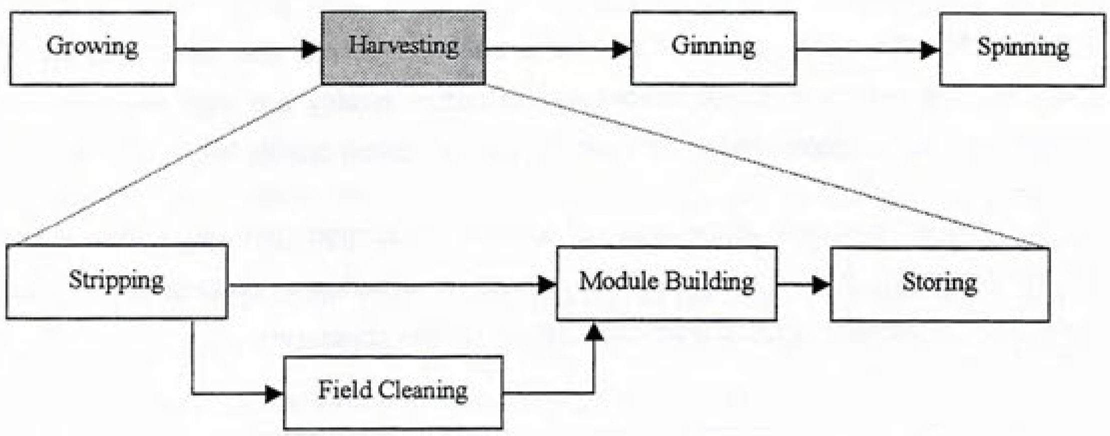


Figure 3: The main processes of cotton production and sub processes for 'harvesting'.

The field cleaner is installed on the harvester and the cotton passes it on the way to the basket at the back (figure 4). It bases on the principle of a bur machine used as pre cleaner in the cotton gin (Williford et al. 1994). Cotton flows through two saw drums – primary and reclaimer – that catch fibers on drum teeth and separate trash from seed cotton. Cleaned seed cotton is then delivered by a doffer into an air current that conveys it to the basket [Brochure 'John Deere 7455 Cotton Stripper' 1998]. The trash is going back onto the ground and remains in one row in the field (figure 5).

In most areas harvesting capacities in peak times are greater than ginning capacities. Therefore, the seed cotton often has to be stored for a couple of days before it gets to the gin. To avoid a loss of quality by weathering, an adequate way of storage is necessary. A very common method is the high density module system which allows storage in the field. A stack of seed cotton is formed directly on the ground with a module builder that compresses the seed cotton mechanically (figure 6) [Colwick et al. 1984]. Then the top of the module is covered with a tarp.

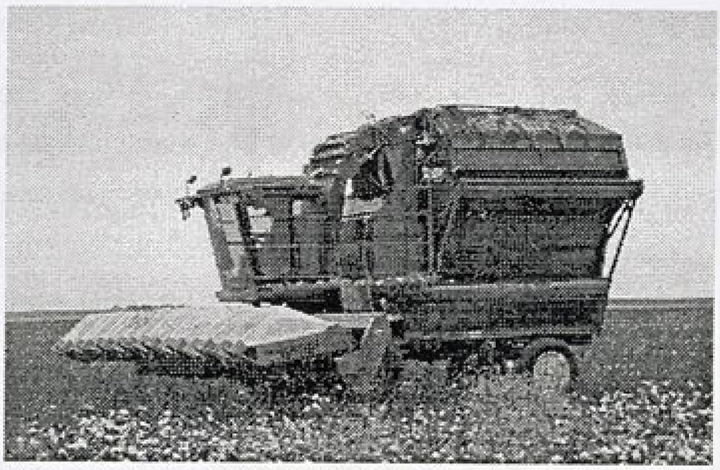


Figure 4: Glen Brosch's John Deere 7455 cotton stripper with onboard field cleaner.

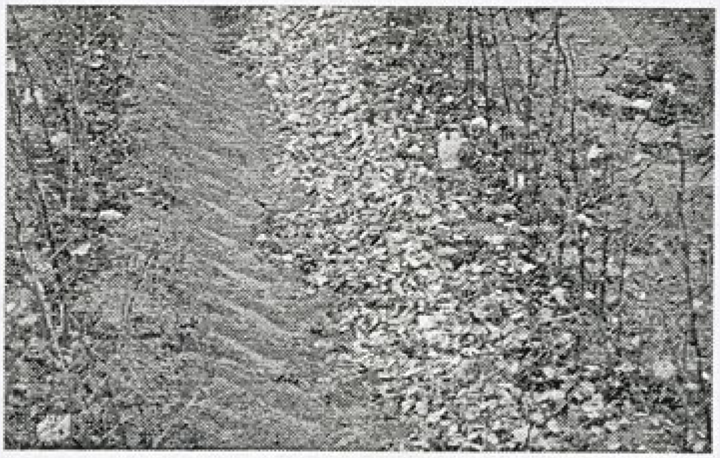


Figure 5: Trash sorted out by the field cleaner remains in one row in the field.

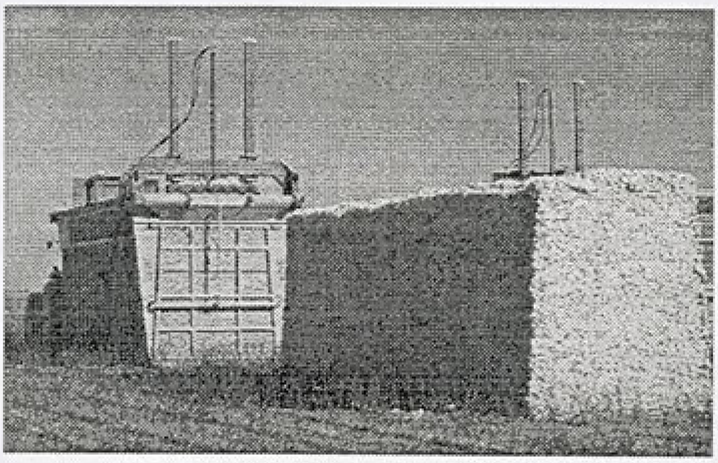


Figure 6: High density module system.

2.2.2 *The Process 'Ginning'*

The principle function of the cotton gin is to separate lint from the seed, but a gin also performs much cleaning to remove foreign matter that would reduce the value of the cotton. Finally it presses the lint in a bale for storage and shipping. The process of ginning can be subdivided into 'seed cotton cleaning', 'ginning process', 'lint cleaning' and 'baling' (figure 7).

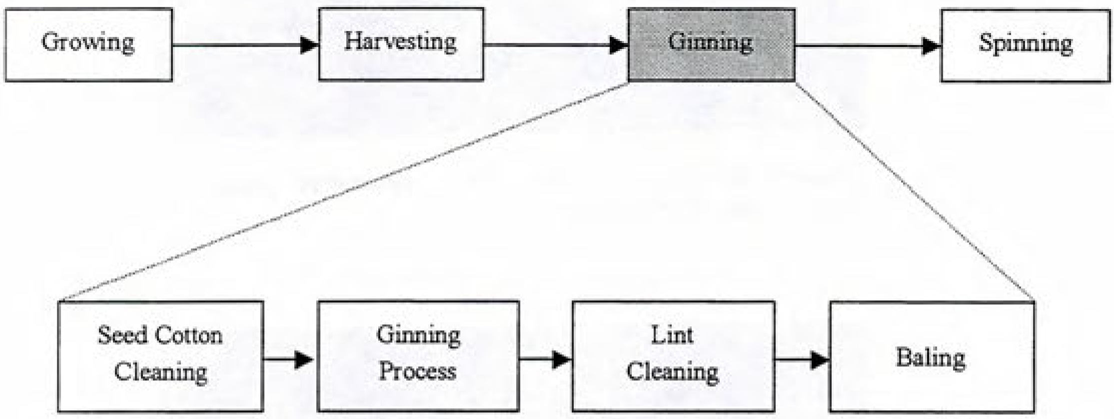


Figure 7: The main processes of cotton production and sub processes for ginning.

In the process 'seed cotton cleaning' the seed cotton is dried and pre cleaned in several stages. Large trash such as burs and sticks is extracted from the seed cotton so that the gin stand operates without problems. This cleaning is necessary to obtain optimal grades and market value.

The actual ginning process – the separation of lint from seed – takes place in the gin stand. The separation is performed by a set of saws rotating between ginning ribs. The saw teeth pull the fibers from the seeds, which are too large to pass between the ribs. The seeds are conveyed into a storage facility, while the lint enters two more cleaning processes.

In the process 'lint cleaning' particles that remained in the cotton after 'seed cotton cleaning' and 'ginning' are removed. There are two types of lint cleaners. One is a flow-through air type lint cleaner, which is very gentle to the fiber but shows only little cleaning efficiency. The other is the controlled-batt saw lint cleaner, which is most common in the ginning industry, very efficient, but fairly rough to the fiber.

In the process 'baling', the cleaned cotton is compressed into bales and thereafter covered for protection from contamination during transportation and storage.

Figure 8 shows the machinery in a gin for stripper harvested cotton. Detailed descriptions are given in appendix II.

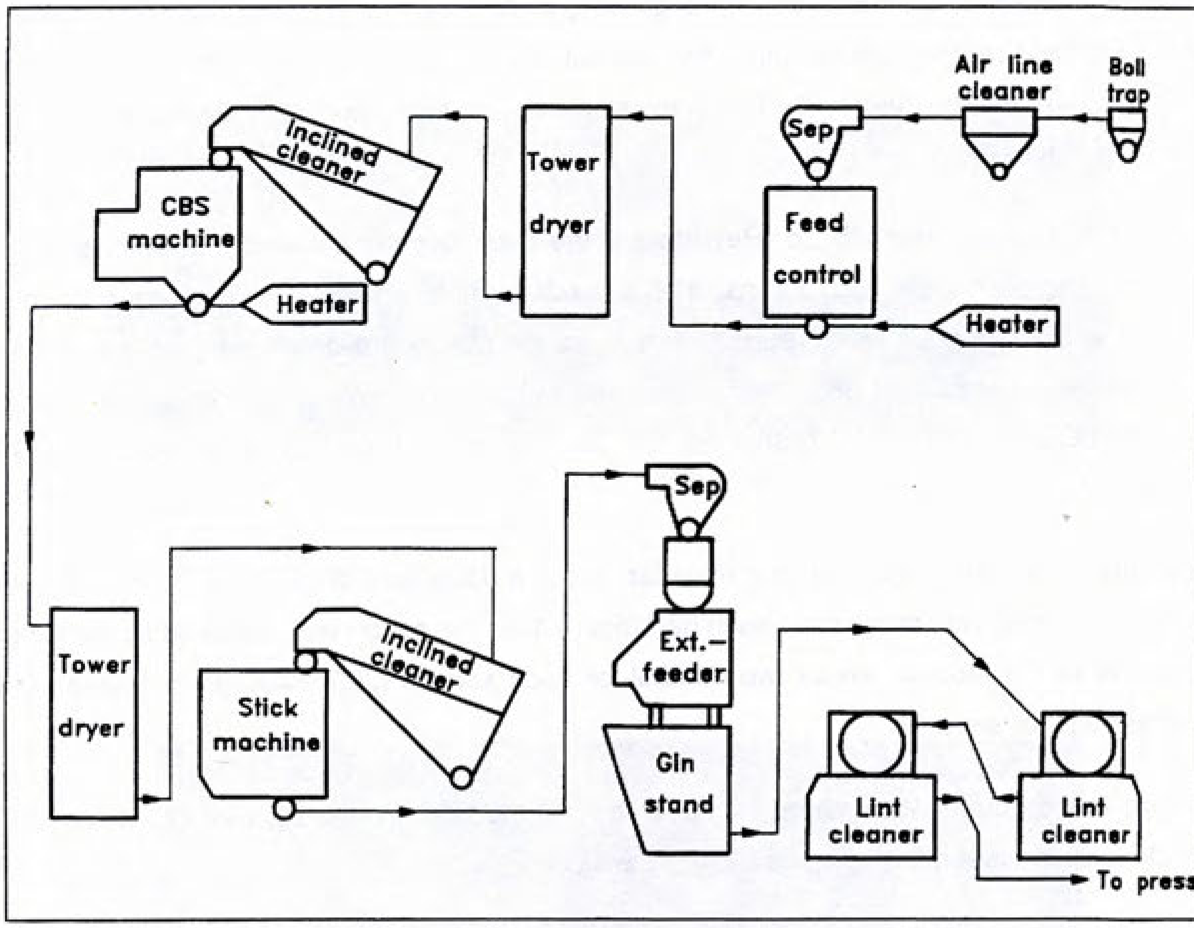


Figure 8: Recommended gin machinery for machine-stripped cotton [Baker 1994].

2.3 *Experimental Design*

2.3.1 *Harvesting with and without Field Cleaner*

The primary aim of this thesis was to investigate the impact of a field cleaner on cotton quality. Therefore, Glen Brosch who is growing cotton south of Lubbock harvested half of a field with field cleaner and the other half without. He built two modules each as starting point for this experiment (figure 9). The harvester was an eight-row John Deere 7455 cotton stripper (figure 4).

The cotton variety was HS 26 (Paymaster), the most popular conventional stripper cotton variety planted on the High Plains. It is a medium maturing variety with a medium plant height and a very good storm resistance, well adapted to dry growing conditions. Fiber length ranges between 1.06 - 1.08 inches, micronaire ranges between 4.2 - 4.3 and fiber strength ranges between 28.6 - 30.7 grams per tex. [all information from Paymaster brochure '1999 Stripper']

Samples were taken from all four modules. Each module was divided into eighths by eye, and one sample was taken from each part (figure 10). The cotton was removed by hand from the side of the module, about two handful for each sample (200 - 400 grams), and put in paper bags for storage.

These four modules were stored for three days on the field and then ginned at Farmer's Gin of Douglas Neugebauer, which is a gin in the vicinity.

2.3.2 *Farmer's Gin*

Farmer's Gin of Douglas Neugebauer is a small gin with a productivity of about eight to ten bales per hour. It is a rather old gin.

The four modules of this experiment were ginned with the following machinery:

- Boll trap
- Feed control
- Tower dryer
- Inclined cleaner (7 cylinder, 2 parallel)
- Bur extractor

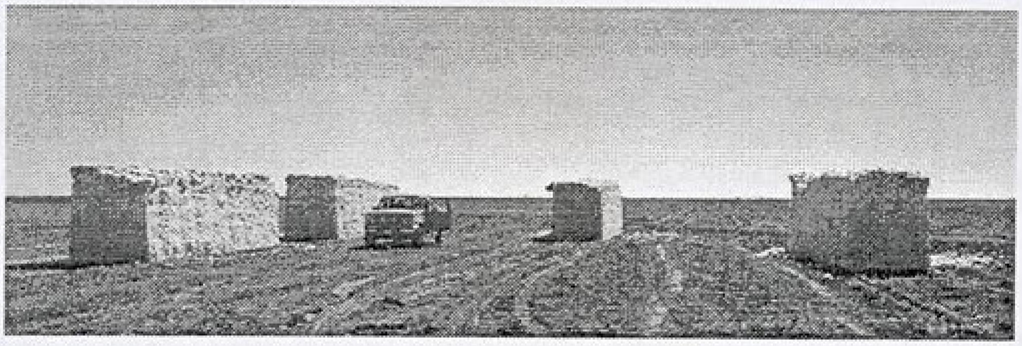


Figure 9: Four modules were the starting point for the experiment.

Figure 10: Each module was divided into eighths for sampling.

- Tower dryer
- Inclined cleaner (7 cylinder)
- Extractor-feeder (3 parallel)
- Saw gin stand (3 parallel)
- Saw-cylinder lint cleaner (split-stream)
- Saw-cylinder lint cleaner (split-stream)
- Bale press

The two modules with the field cleaned cotton were ginned first, the other two straight afterwards. The temperature of the dryers was set at about 230° Fahrenheit (110° Celsius). No settings were changed in the gin for the whole time.

The modules were fed into the gin quarter by quarter, with a manually operated telescope suction system, and for each quarter, samples were taken at five locations in the gin (table 1). The sampling locations were determined by the accessibility of cotton in the system.

Table 1: Sampling locations in Farmer's Gin and terminology for the presentation of the results.

	Sampling Location in Gin	Terminology in Results
1	module	seed cotton (module)
2	before gin stand (from overflow of conveyor-distributor)	cleaned seed cotton
3	before first lint cleaner	lint after gin stand
4	before second lint cleaner	lint after 1 lint cleaner
5	bale	lint after 2 lint cleaners

For every sample about two or three handful of cotton were picked out of the cotton flow in the system and put into a paper bag for storage. Seed cotton samples weighed 200 – 400 grams, lint samples weighed 100 – 300 grams.

Eight samples were taken at each location in the gin for field cleaned as well as for not field cleaned cotton (table 2). Additionally, eight seed cotton samples per module had been taken on the field, straight after harvesting (see above).

Table 2: Amount of replications at each location in Farmer's Gin.

Farmer's Gin	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Field Cleaner (FC)	24	8	8	8	8
Without Field Cleaner (WOFC)	24	8	8	8	8

2.3.3 Buster's Gin

The secondary aim of this thesis was to investigate the effects of gin machinery on cotton quality. The samples taken at Farmer's gin give an indication of these effects. Additionally, samples were taken at Buster's Gin of Dan Taylor.

Buster's Gin is a modern and fast operating gin with a throughput of 25 – 30 bales per hour. The modules are broken up mechanically with a moving-head-type module feeder system and the cotton is delivered on a conveyor to the suction pickup point. Green bolls, rocks, and other heavy foreign matter, are separated with a type of trap at this point, which makes the use of a boll trap in the gin unnecessary.

Buster's Gin consists of the following machinery:

- Air line cleaner
- Tower dryer
- Inclined cleaner (7 cylinder, 2 parallel)
- CBS machine (Combined Bur and Stick machine)
- Inclined cleaner (7 cylinder, 2 parallel)
- Extractor-feeder (4 parallel)
- Saw gin stand (4 parallel)
- Air Jet lint cleaner (4 parallel)
- Saw-cylinder lint cleaner (split-stream)
- Saw-cylinder lint cleaner (split-stream)
- Bale press

Different from Farmer's Gin, Buster's Gin performs only one step of drying, and instead of a bur extractor, it has a combined bur and stick machine. It performs three steps of lint cleaning. The first step is an Air Jet lint cleaner installed right behind the gin stand. Air and cotton change direction abruptly as they pass across a narrow trash-ejection slot. 'Foreign matter that is heavier than the cotton fibers and not too tightly held by fibers is ejected through that slot by inertial force. The amount of trash taken out by the air jet is controlled by opening and closing this cleaning slot, which can be completely closed.' [Mangialardi et al. 1994, p 102]

Samples were taken at six locations in the gin (table 3). Out of two modules four series of samples were collected, one series for each half module. For each sample about two or three handful of cotton were seized out of the process and put into a paper bag for storage. Seed cotton samples weighed 200-400g, lint samples weighed 100-300g. The humidity of the seed cotton in the modules before ginning was about 7.5%, the seed cotton before the gin stand showed a moisture content of about 5% (both measured with a portable moisture meter).

Table 3: Sampling locations in Farmer's Gin and terminology for the presentation of the results.

	Sampling Location in Gin	**Terminology in Results**
1	module	seed cotton (module)
2	before ginning (from front of gin stand)	cleaned seed cotton
3	before Air Jet cleaner	lint after gin stand
4	before first saw lint cleaner	lint after Air Jet cleaner
5	before second saw lint cleaner	lint after 1 lint cleaner
6	bale	lint after 2 lint cleaners

The cotton for these samples was harvested without field cleaner from Dan Taylor's home field. The variety was HS 26, the same as in the 'field cleaner'-experiment (see above). Table 4 shows the amount of replications at each location in Buster's Gin.

Table 4: Amount of replications at each location in Buster's Gin.

Buster's Gin	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Air Jet Cleaner	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
WOFC	4	4	4	4	4	4

2.4 Ginning of Seed Cotton Samples

A total of 136 samples was collected, 72 of them were seed cotton samples. Quality can not be measured on seed cotton, therefore those samples had to be ginned first. They were ginned with an automatic eight-saw mini gin provided by the USDA ARS South Plains Ginning Research Laboratory (figure 11).

The samples had to be coarsley cleaned before ginning. To do this, they were spread out on a table and large trash like sticks, burs and leaves were removed by hand.

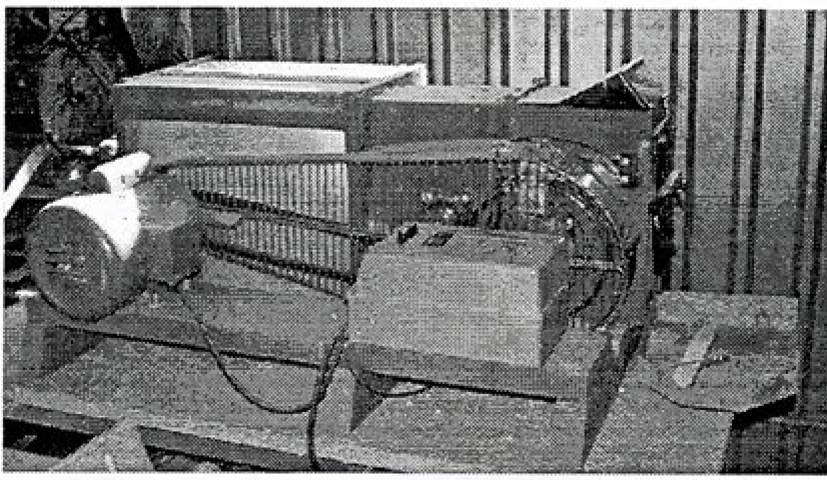


Figure 11: Eight-saw mini gin used for ginning of the seed cotton samples.

2.5 Quality Measurements

All 136 samples were analyzed at the International Textile Center (ITC) in Lubbock. Cotton quality parameters were measured with the HVI (High Volume Instrument) and the AFIS (Advanced Fiber Information System).

Atmospheric conditions influence the measurements of cotton fiber properties. Therefore, the samples were conditioned for more than 24 hours at a temperature of 70° Fahrenheit (21°Celsius) and a relative humidity of 65 percent. After conditioning the moisture content of the samples lies within the range of 6.25% to 8.25% [USDA 1995].

2.5.1 HVI (High Volume Instrument)

The High Volume Instrument is fast and easy to use. It has its name because of the ability to process a high volume of samples in a short time, which is important for the classification of cotton bales in the U.S.. At the peak time of the season, USDA classes and provides data on as many as 2 million bales per week, nationwide [USDA 1995]!

The HVI consists of three different units which work independently. A detailed description of the instrument and the procedure to measure the samples is given in appendix III.

Quality parameters measured with the HVI are summarized in table 5.

Table 5: Quality parameters measured by the High Volume Instrument (HVI).

Quality Parameter	Unit	Explanation
Trash	% area	Measure of non-lint material in the cotton; correlates with the classer's leaf grade.
Reflectance	Rd	Indicates how bright or dull a sample is.
Yellowness	+b	Indicates the degree of color pigmentation.
Color Grade		Three-digit code. Point of intersection of yellowness and reflectance in the Nickerson-Hunter color chart for Upland cotton.
Micronaire		Measure of air permeability through a constant mass of compressed cotton. Indication for fiber fineness and maturity.
Upper Half Mean Length	Inches	Average length of the longer one-half of the fibers.
Length Uniformity Index	%	Ratio between mean length and upper half mean length of the fibers.
Strength	g/tex	Force required to break a bundle of fibers.
Elongation	%	Indication of elasticity of the fiber. Ratio of increase in length before breakage and original length.

Two replications were carried out for color (reflectance, yellowness) and trash, two for micronaire and six for length and strength. The trash measured in % area was automatically transferred into leaf grade by the HVI. The leaf grade was considered in the results. Color Grade could not be included in the statistics because of the three-digit code.

The four modules of the field cleaner experiment resulted in 45 bales which all were classified at the USDA Classing Office in Lubbock. Those data were included in the analysis of the results.

2.5.2 AFIS (Advanced Fiber Information System)

The samples were measured with an AFIS multi data module version 4.22. AFIS measurements take much more time than HVI measurements. Other than the HVI the AFIS individualizes the fibers and measures each single fiber. Also, the cotton has to be prepared into slivers by hand before measuring. A detailed description of the Instrument and of the procedure to measure samples is given in appendix IV.

Three replications were carried out for each sample. Table 6 gives an overview of the quality parameters measured by the AFIS.

2.6 Statistical Analysis

Differences between the cotton harvested with field cleaner and the cotton harvested without field cleaner were verified with Mann-Whitney U tests. Because of the few replications at the locations in the gin, normal distributions – a requirement for t-tests - could not be presupposed. The Mann-Whitney test is the non parametric analog of the two-sample t test. The values of a variable are transformed to ranks to test that the centers of the two groups do not differ. This analysis is less influenced by far outlying values. The statistical analysis was carried out with Systat 8.0.

An overview of the results of the Mann-Whitney U tests is given in appendix VI. Box plots showing the distribution of the values are attached in appendix V.

Table 6: Quality parameters measured by the AFIS.

Quality Parameter	Unit	Explanation
Nep Size	µm	Mean nep size per sample. Neps are entanglements of fibers.
Nep Count	cnt/g	Neps per gram
Seed Coat Nep Size	µm	Mean seed coat nep size. Seed coat neps are entanglements of fibers around a seed coat fragment.
Total Particle Count	cnt/g	Particles per gram.
Mean Particle Size	µm	Mean particle size
Dust Count	cnt/g	Particles < 500µm per gram
Trash Count	cnt/g	Particles > 500µm per gram
Visible Foreign Matter	%	Conversion of the total particle count into percent.
Length (w)	inches	Length reached by 50% of the fibers.
CV Length (w)	%	Coefficient variation of fiber length.
Upper Quartile Length (w)	inches	Length exceeded by 25% of the fibers.
Short Fiber Content (w)	%	Percent of fibers < 0.50 inches.
Length (n)	inches	Length reached by 50% of the fibers.
CV Length (n)	%	Coefficient variation of fiber length.
Short Fiber Content (n)	%	Percent of fibers < 0.50 inches.
Length 5% (n)	inches	Length exceeded by 5% of the fibers.
Length 2.5% (n)	inches	Length exceeded by 2.5% of the fibers.
Fineness	mtex	Mean fineness of the fibers in the sample.
Immature Fiber Content	%	Percent of fibers with maturity < 0.25. The AFIS determines the maturity of the fibers between 0 and 1.
Maturity Ratio		Ration of fibers with maturity > 0.25 and total amount of fibers.

3 Results

In this chapter the results of the AFIS and HVI measurements are presented. The cotton harvested with field cleaner and the cotton harvested without field cleaner is compared in bar diagrams. This cotton was ginned at Farmer's gin. Parallel, the data of Buster's Gin will be presented. Only the most interesting quality parameters are considered. An overview of all parameters is given in appendices V and VII in the form of box plots. A balance of weight, turnout and ginning costs for field cleaned and not field cleaned cotton is put at the beginning of this chapter.

3.1 Weights, Turnouts and Costs

Weights, turnout and ginning costs are compared for field cleaned and not field cleaned cotton (table 7). The four modules of the experiment resulted in 45 bales of cotton lint: 25 bales of cotton harvested with the field cleaner and 20 bales of cotton harvested without field cleaner. The turnout of lint was 26.5 percent respectively 24.6 percent. For every bale an amount of 800 pounds of seeds was assumed [Willcutt & Mayfield 1994].The average amount of trash per bale was 467 pounds for the field cleaned seed cotton and 675 pounds for the not field cleaned seed cotton. Hence, the field cleaner removed 183 pounds of trash from every bale in average. Ginning costs per bale were 3.16 dollar smaller for field cleaned cotton.

The difference between the seed cotton harvested with field cleaner and the seed cotton harvested without field cleaner was clearly visible by eye (figure 12).

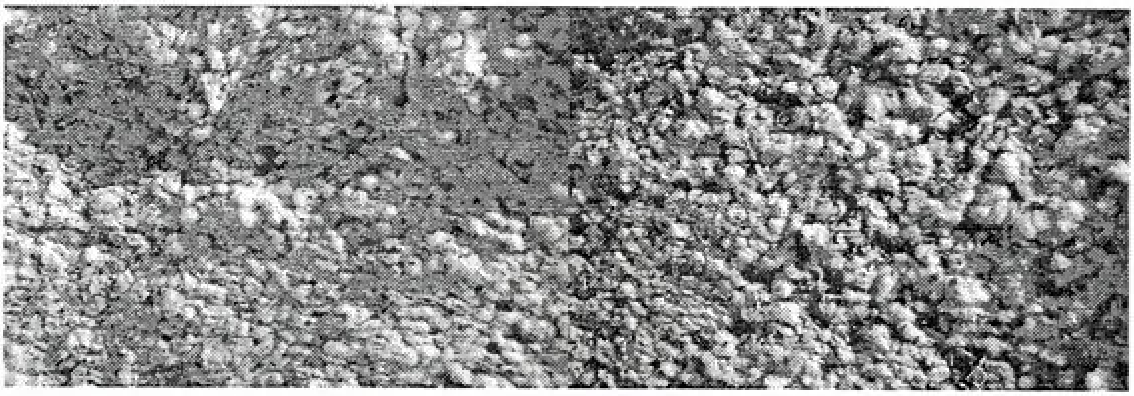


Figure 12: Comparison of seed cotton harvested with field cleaner (left) and harvested without field cleaner (right).

Table 7: Comparison of turnout and trash content of field cleaned and not field cleaned seed cotton. Data from Farmer's Gin.

		Field Cleaned	Without Field Cleaner
Seed Cotton (two modules)	[lb]	43980	39140
Ginned Lint	[lb]	11675	9645
Turnout of Lint	%	26.5	24.6
Ginning Costs	[$]	703.68	626.24
Bales	No	25	20
Lint/Bale	[lb]	467	482
Ginning Costs/Bale	[$]	28.15	31.31
Seed Cotton/Bale	[lb]	1759	1957
Seeds/Bale	[lb]	800*	800*
Trash/Bale	[lb]	492	675

*assumption of average amount of seeds per bale [Willcutt & Mayfield 1994]

3.2 AFIS Data

3.2.1 Trash Count & Dust Count

The AFIS separates all foreign matter from the lint and measures it. Trash particles are defined as bigger than 500 micrometers, dust particles are defined as smaller than 500 micrometers.

Effect of Field Cleaner

No significant difference in trash or dust content can be observed between the field cleaned and not field cleaned cotton at the end of the process in the bale (figures 13a and 14a and table 8). Presumably, trash and dust content are already the same after seed cotton cleaning. The cleaning system of the gin levels the original difference out.

Because the seed cotton samples ('seed cotton' and 'cleaned seed cotton') were cleaned by hand before ginning in the eight-saw mini gin, these results are not comparable.

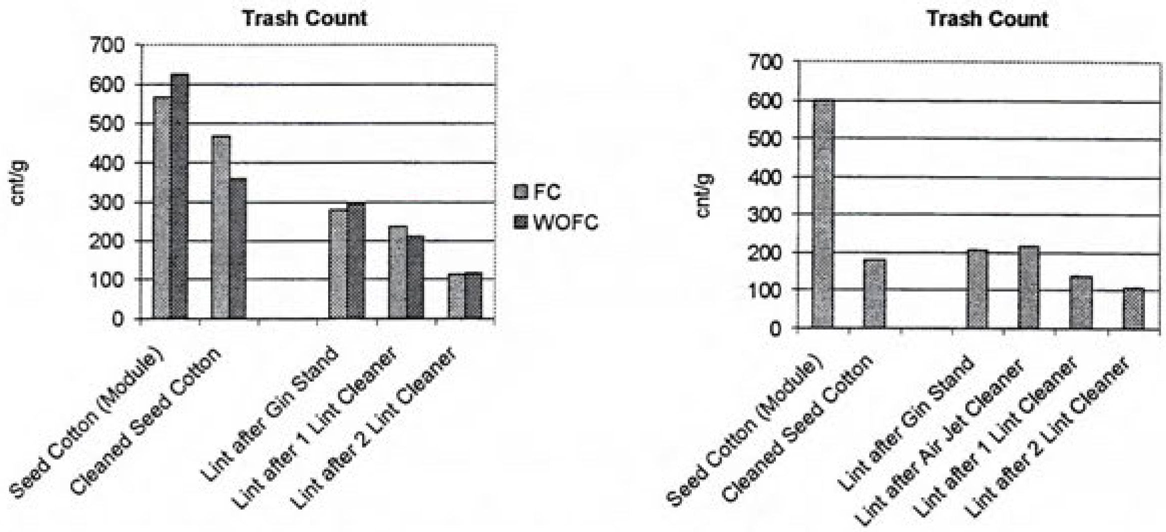


Figure 13: AFIS Trash Count: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

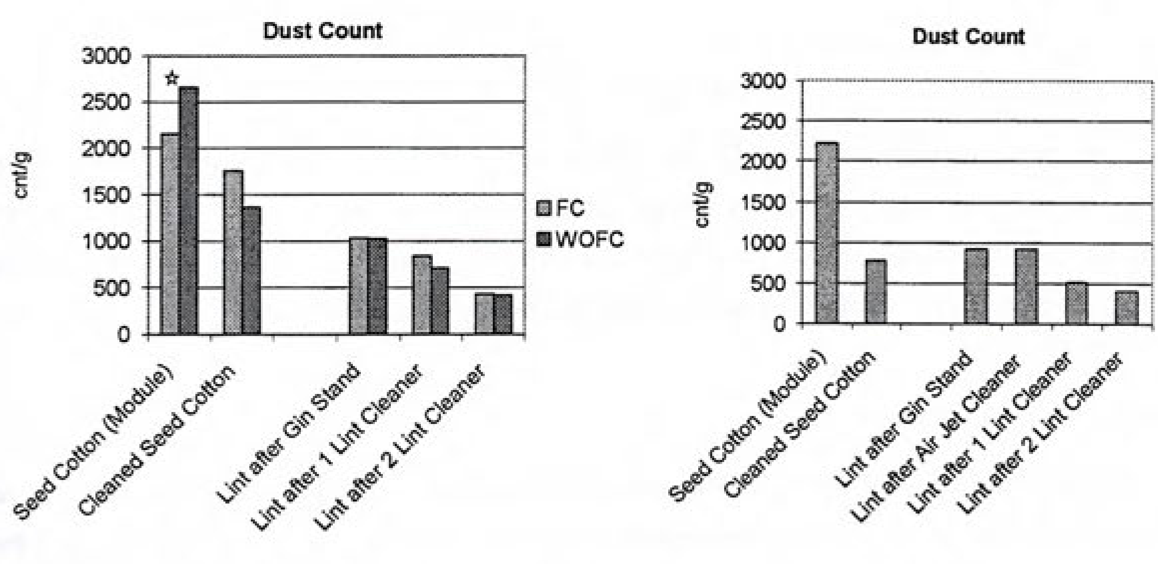


Figure 14: AFIS Dust Count: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

Obviously, more trash and dust was removed from the cotton harvested without field cleaner than from those harvested with field cleaner and the difference was leveled out.

Effect of Ginning Process

The results of Farmer's Gin show very well how trash and dust content become smaller with every process step (figures 13a and 14a). Again, the seed cotton samples which were pre cleaned by hand and ginned in the mini gin can not be compared with the lint samples. The seed cotton cleaning at Buster's Gin is obviously very effective. Surprisingly, the Air Jet cleaner at Buster's Gin seems not to have any effect on trash and dust content (figure 13b and 14b).

Table 8: AFIS Trash Count and Dust Count. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Trash Count	0.128	0.156	0.293	0.294	0.916
Dust Count	**0.049**	0.074	0.958	0.462	0.529

3.2.2 Nep Count & Seed Coat Nep Count

Neps are little entanglements of fibers, little knots. The AFIS distinguishes between two different kinds of neps: 'ordinary' neps and seed coat neps. Seed coat neps are entanglements of fibers around little seed coat fragments which mostly originate from the ginning process. The 'ordinary' neps are often caused by immature fibers.

Effect of Field Cleaner

At the first two locations in the process ('seed cotton' and 'cleaned seed cotton') no significant difference in nep count between the cotton harvested with field cleaner and the cotton harvested without field cleaner can be found (figure 15a and table 9). But in the following stages, after the ginning process, a clear difference can be shown. Surprisingly, the cotton harvested with the field cleaner showed lower values, even though the field cleaner is an additional mechanical process and therefore higher amount of neps would be expected. In the bale ('lint after two lint cleaners') a reduction of about 25 neps per gram (10 percent) was found.

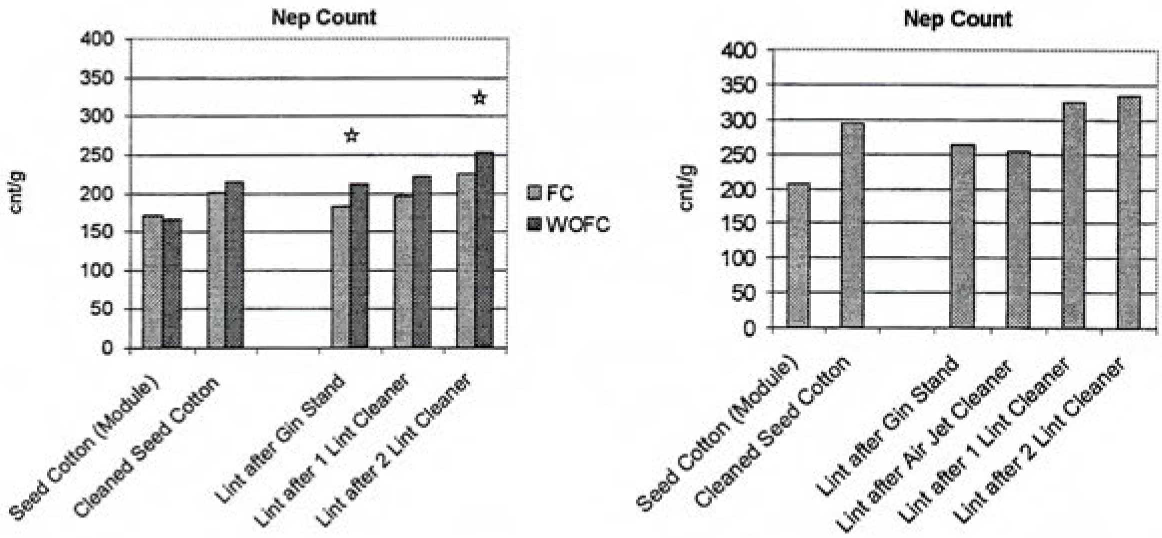


Figure 15: AFIS Nep Count: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

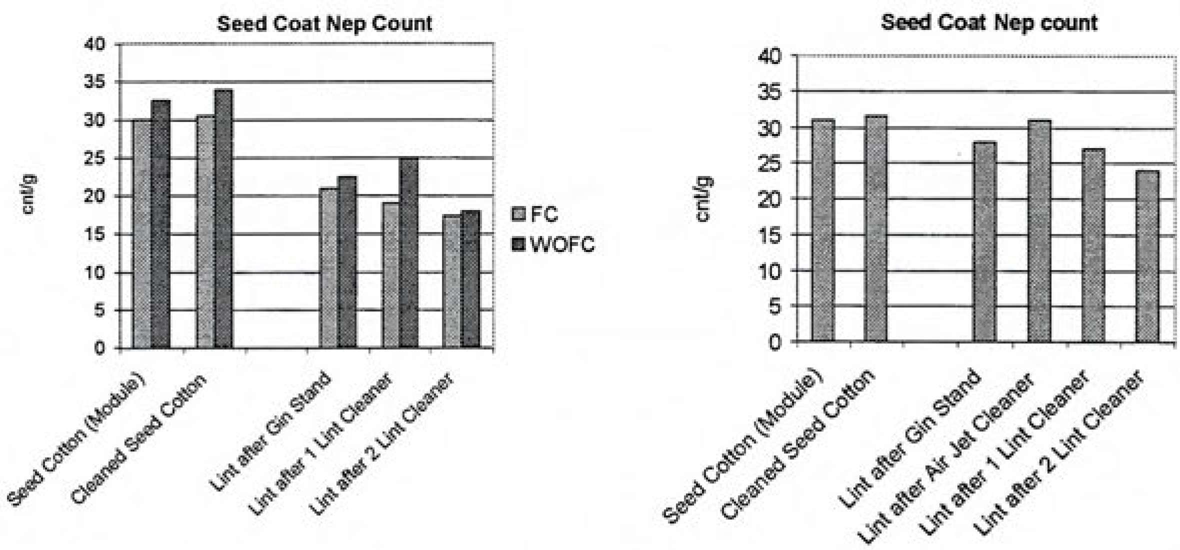


Figure 16: AFIS Seed Coat Nep Count: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

For seed coat neps no significant difference between cotton harvested with field cleaner and cotton harvested without field cleaner can be shown (figure 16a and table 9).

Effect of Ginning Process

Figure 15 shows that the nep count increases step by step through the process. An exception represents the Air Jet cleaner at Buster's Gin which does not show an impact on nep count. The nep count of the 'seed cotton (module)' samples represent the values after ginning with the eight-saw mini-gin and not the nep count of cotton in the field. The nep count of cotton in the field would be around 20 neps per gram.

Figure 16 shows that the 8 saw mini-gin produced more seed coat neps than the industrial gin (comparison of 'cleaned seed cotton' and 'lint after gin stand').

Table 9: AFIS Nep Count and Seed Coat Nep Count. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Nep Count	0.733	0.401	**0.001**	0.189	**0.006**
SCN Count	0.311	0.342	0.493	0.317	0.750

3.2.3 *Immature Fiber Content & Fineness*

Immature fibers show a thin secondary wall and a comparably large lumen. Due to the fact that on the cotton plant not all the bolls mature at the same time there is always a certain amount of immature fibers in raw cotton. The fineness of the fibers is mainly determined by variety. But the higher the immature fiber content (more fine fibers) the lower the mean value for fineness.

Effect of Field Cleaner

Figures 17a and 18a show a difference between the field cleaned and not field cleaned cotton. In those samples harvested with the field cleaner the immature fiber content is lower and the values for fineness are higher (which means the fibers are coarser). The seed cotton

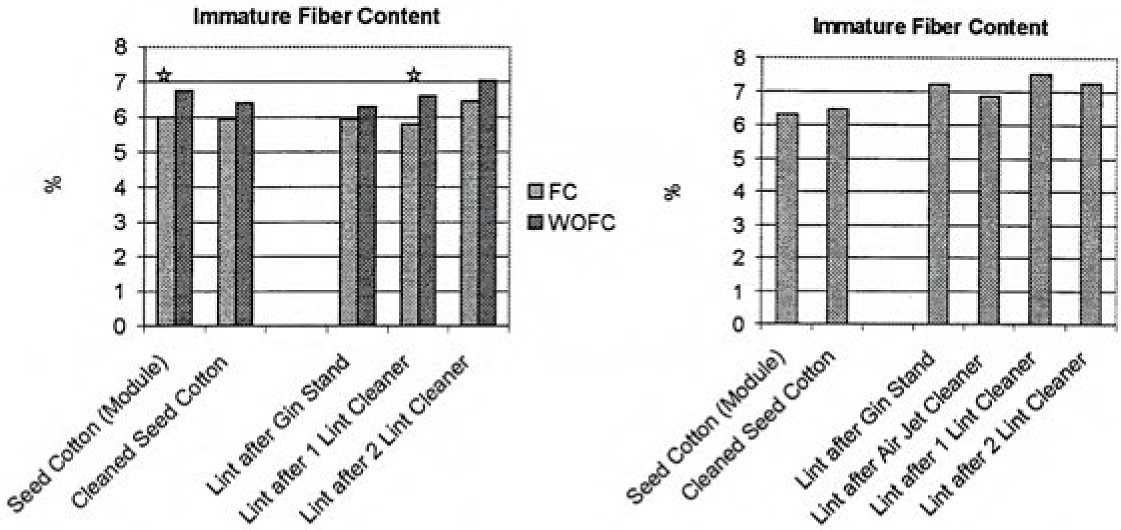


Figure 17: AFIS Immature Fiber Content: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

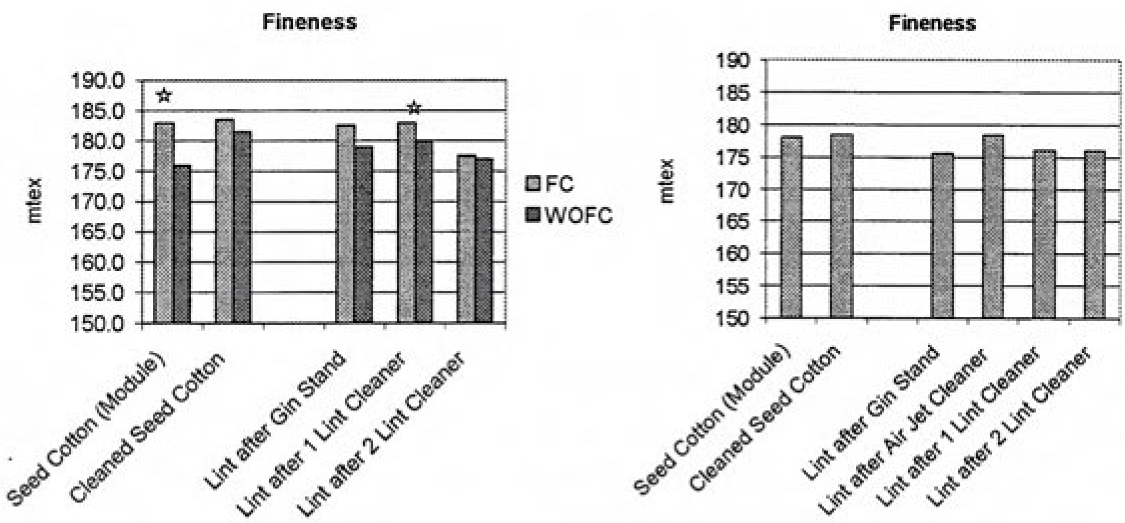


Figure 18: AFIS Fineness: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

samples from the module and the samples after one lint cleaner show statistically significant differences (table 10). For the cotton in the bale ('lint after two lint cleaners') a difference between 0.5 percent and 1.0 percent can be observed. This is a reduction of immature fibers of about 7%.

Effect of Ginning Process

The ginning process seems not to have an effect either on immature fiber content nor on fineness. The differences visible in the diagrams are little and most probably due to variations in data (figures 17 and 18).

Table 10: AFIS Immature Fiber Content and Fineness. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Immature Fiber Content	**0.001**	0.528	0.140	**0.013**	0.114
Fineness	**0.000**	0.268	0.089	**0.001**	0.671

3.2.4 Length (w) & Short Fiber Content (w)

The AFIS measures the length of each fiber and produces a staple diagram in which the fibers are arranged by size. The length output indicates the length 50 percent of the fibers reached. The short fiber content indicates the amount of short fibers smaller than 0.5 inches.

Effect of Field Cleaner

Figure 19a shows a very small but highly significant difference in length (about 1/100 inch) between field cleaned and not field cleaned cotton for the samples from the modules ('seed cotton') (table 11). Correspondingly, the short fiber content seams to be higher ($p = 0.056$) (figure 20a). The effect is not significant in further process steps, but there seems to be a trend (box plots appendix V).

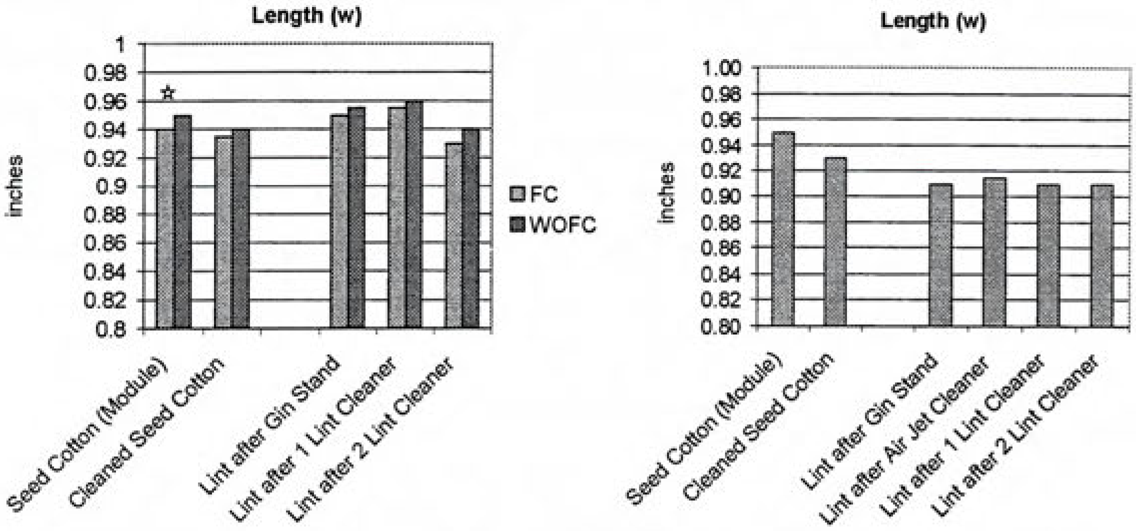


Figure 19: AFIS Length (w): a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

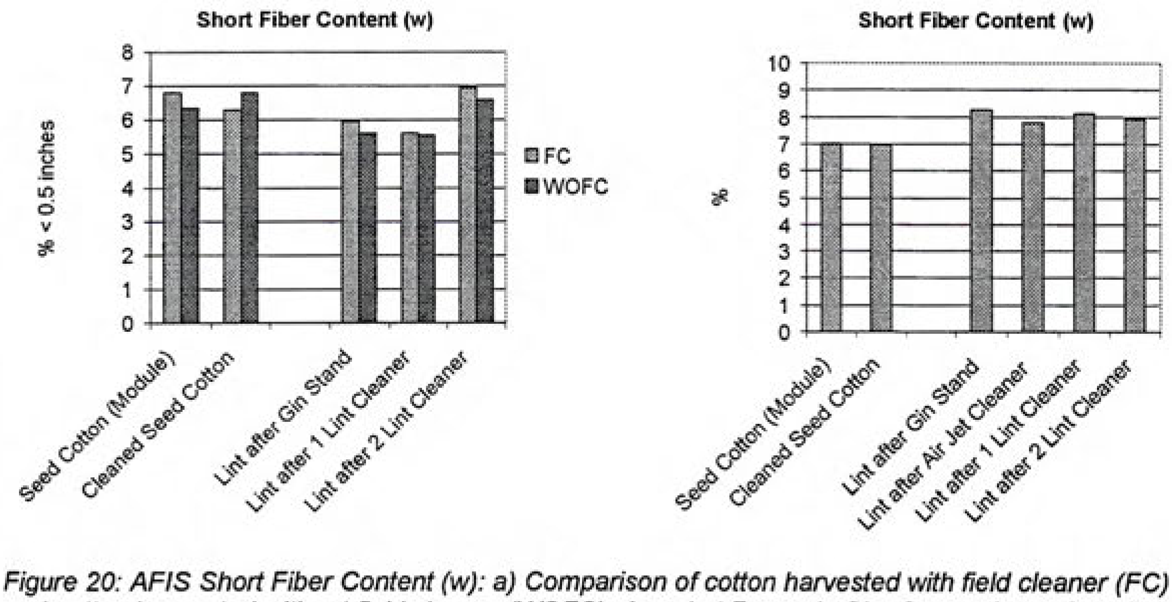


Figure 20: AFIS Short Fiber Content (w): a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

Effect of Ginning Process

Two effects are remarkable: 1) While the first lint cleaner of Farmer's Gin does not show a damaging effect, the second lint cleaner reduces length and increases short fiber clearly (figures 19a and 20a). In comparison, the lint cleaning at Buster's Gin seems not to have any negative effect (figure 19b and 20b). 2) The diagrams show that at Farmer's Gin the length of 'cleaned seed cotton' is shorter than the length of 'lint after gin stand' which indicates that the actual ginning process at Farmer's Gin is gentler to the fiber than the ginning with the eight-saw mini gin (figure 19a). For Buster's Gin the opposite is the case, the ginning process is rougher than the mini gin (figure 19b). The corresponding effect can be seen for the short fiber content (figure 20a and 20b).

Table 11: AFIS Length (w) and Short Fiber Content (w). Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Length (w)	**0.004**	0.788	0.187	0.871	0.396
Short Fiber Content (w)	0.056	0.170	0.563	0.632	0.712

3.3 HVI Data

3.3.1 Leaf Grade

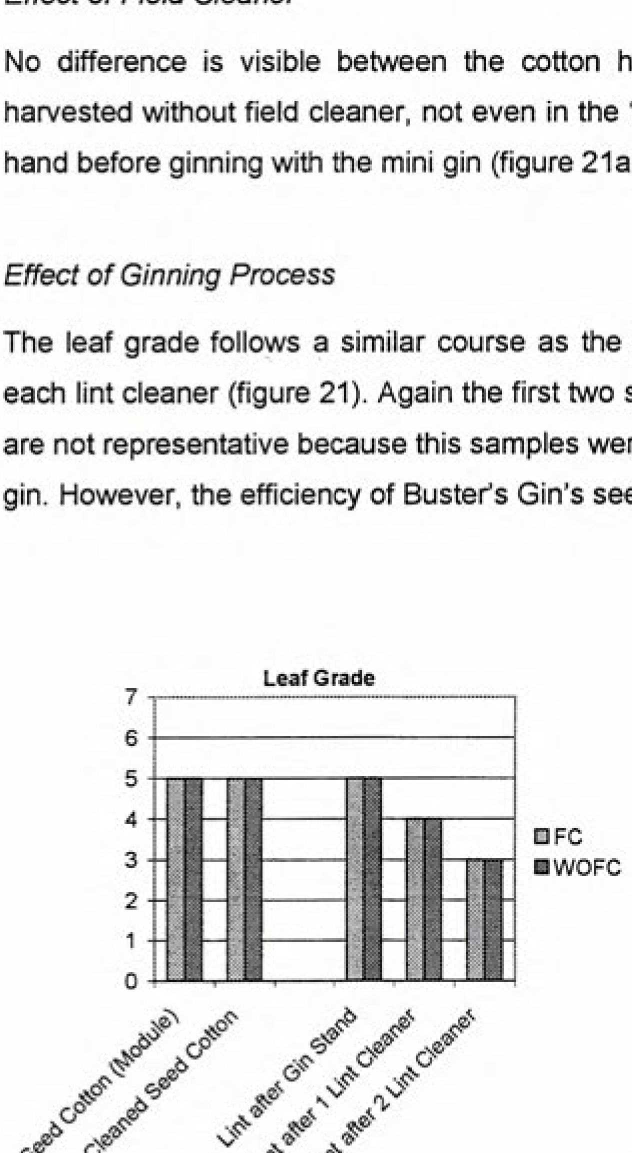
The HVI scans the surface of the cotton sample with a video camera. The output is percent area of non-lint material. This measurement correlates with the classer's leaf grade [USDA 1995]. A conversion of percent area to leaf grade is done automatically by the HVI.

Effect of Field Cleaner

No difference is visible between the cotton harvested with field cleaner and the cotton harvested without field cleaner, not even in the 'seed cotton' samples due to the cleaning by hand before ginning with the mini gin (figure 21a and table 12).

Effect of Ginning Process

The leaf grade follows a similar course as the AFIS trash measurements. It improves with each lint cleaner (figure 21). Again the first two steps 'seed cotton' and 'cleaned seed cotton' are not representative because this samples were cleaned by hand before ginning in the mini gin. However, the efficiency of Buster's Gin's seed cotton cleaning is well visible (figure 21b).



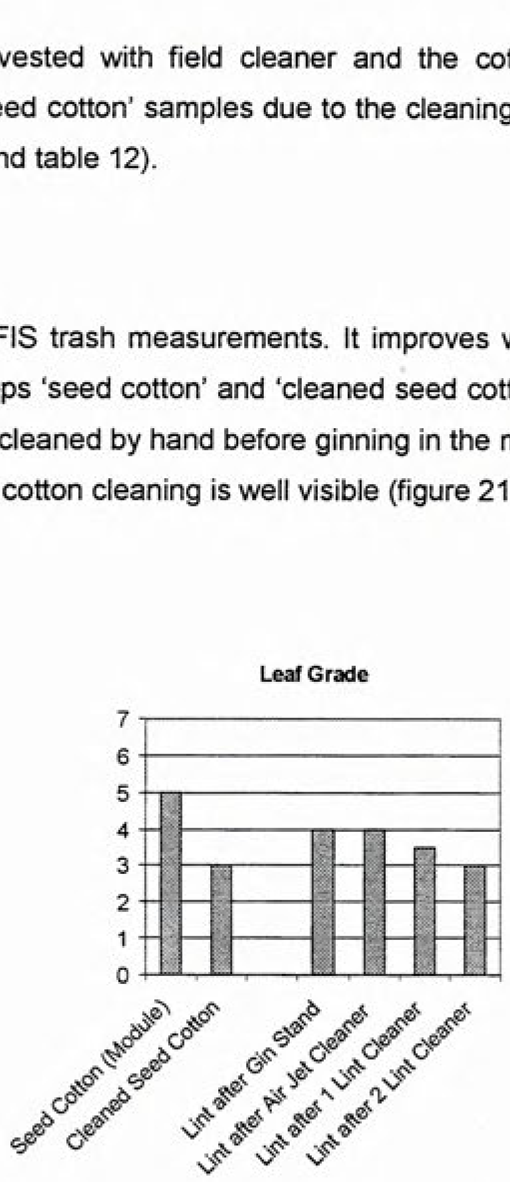


Figure 21: HVI Leaf Grade: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

Table 12: HVI Leaf Grade. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Leaf Grade	1.000	1.000	0.602	0.090	0.300

3.3.2 Reflectance & Yellowness

The color of cotton is determined by the degree of reflectance and yellowness. Reflectance indicates how bright or dull a sample is, and yellowness indicates the degree of color pigmentation.

Effect of Field Cleaner

For reflectance no significant differences can be observed between the field cleaned and not field cleaned cotton (figure 22a). However, there seems to be a trend for slightly higher values in yellowness in the samples harvested with the field cleaner (figure 23a). The differences are significant in 'seed cotton (module)' and in 'lint after two lint cleaners' (table 13).

Effect of Ginning Process

Reflectance improves continually through the process in Farmer's Gin as well as in Buster's Gin (figure 22). Surprisingly, a slight increase in yellowness can be found. This would mean that the cotton becomes more yellow through the process which was not expected. The effect is more distinct in Farmer's Gin (figure 23a).

Table 13: HVI Reflectance and Yellowness. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Reflectance	0.264	0.225	0.916	0.207	0.082
Yellowness	**0.017**	0.410	0.146	0.593	**0.021**

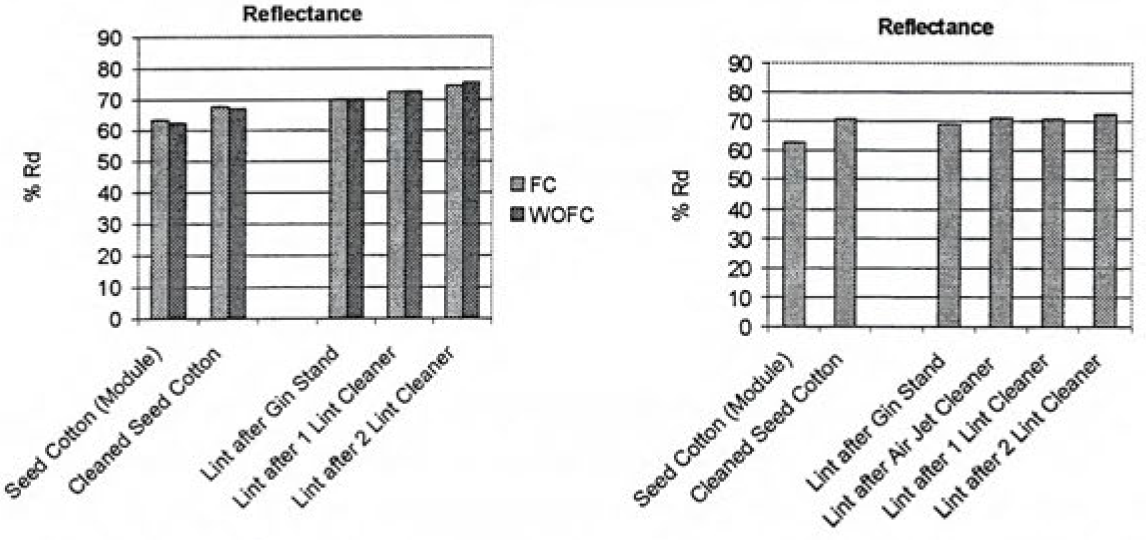


Figure 22: HVI Reflectance: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

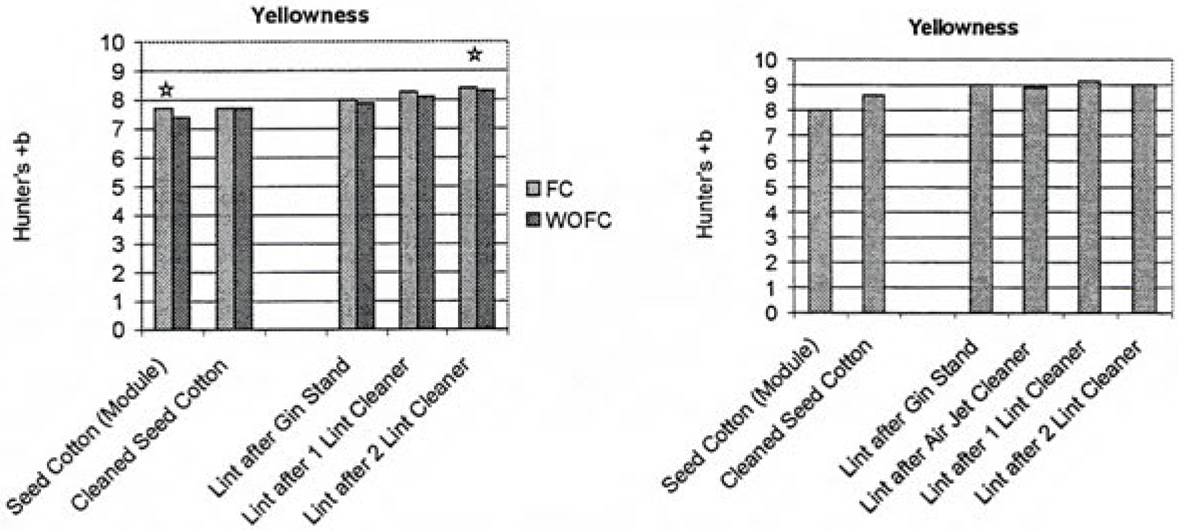


Figure 23: HVI Yellowness: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

3.3.3 *Micronaire*

Micronaire is an airflow measurement through a fixed mass of cotton. Therefore, the micronaire is determined by the total surface of the sample. The surface is big if there are lots of fine or immature fibers. The bigger the surface the bigger the resistance for the airflow and the lower the micronaire reading.

The crop of 1998 showed high micronaire readings in the area of Lubbock due to rain in a late stage of the season leading to extensive growth of the secondary wall of the fibers. Hence, the fibers were fairly coarse.

Effect of Field Cleaner

For 'seed cotton' and 'cleaned seed cotton' the samples harvested with the field cleaner show significant higher readings, but this effect is not visible in the other process steps (figure 24a and table 14). Just looking at the medians might not give a correct impression in this case. The box plots indicate that there might actually be a difference over all stages between the two compared cottons (figure 25a). This assumption is supported by the data of the USDA Classing Office which show a statistically significant difference between the bales of field cleaned cotton and those with not field cleaned cotton (figure 25b and table 14).

Effect of Ginning Process

No distinct changes in micronaire show up due to the ginning process (figure 24).

Table 14: HVI Micronaire. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners	Classing Data Bales
Micronaire	0.011	0.021	0.286	0.866	0.354	**0.000**

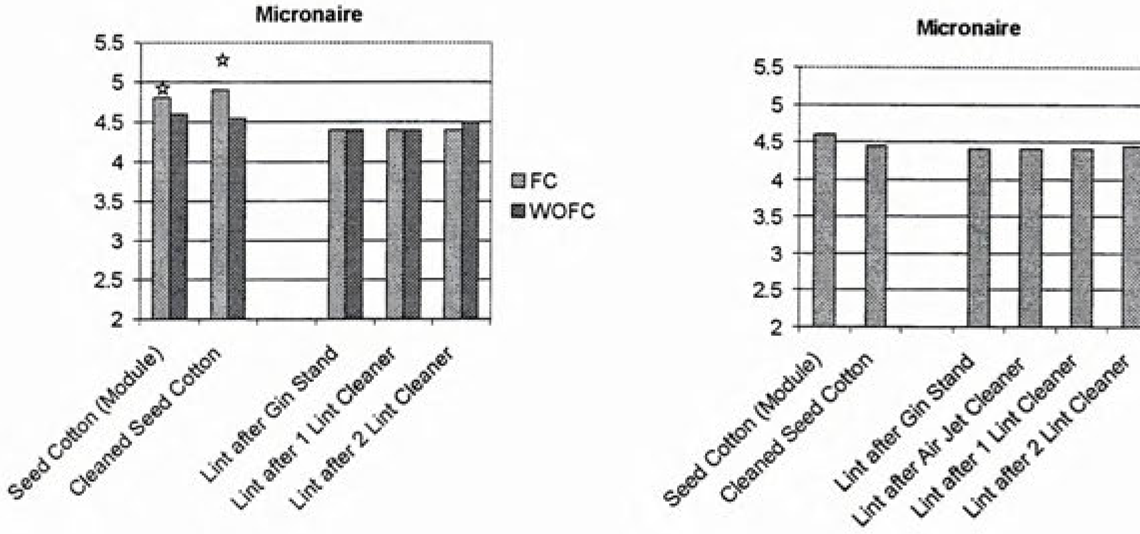


Figure 24: HVI Micronaire: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

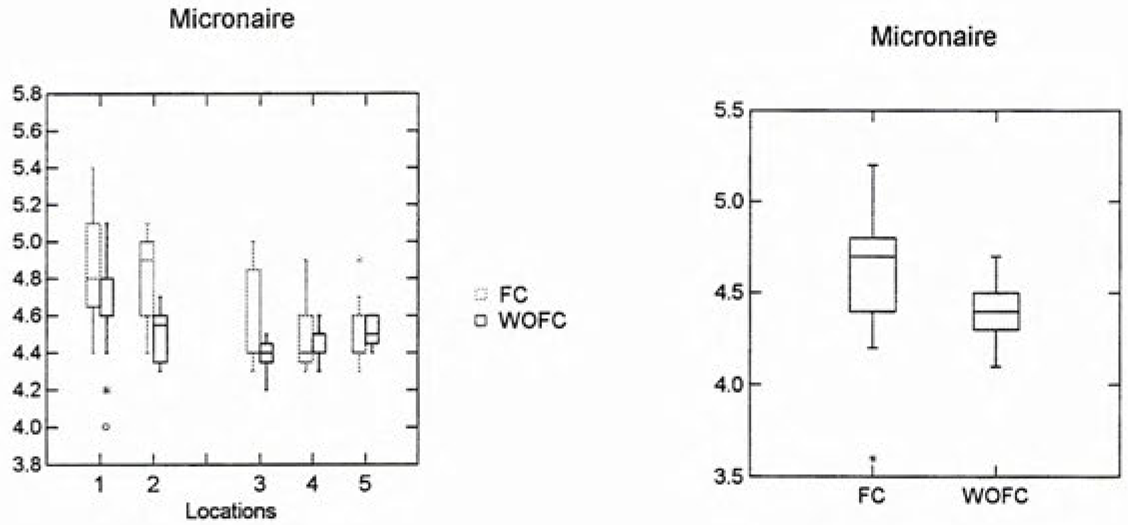


Figure 25: HVI Micronaire: Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. a) Locations one to five are 'seed cotton', 'cleaned seed cotton', 'lint after gin stand', 'lint after one lint cleaner', 'lint after two lint cleaners'. b) USDA Classing Office data of all the bales of the experiment.

Box plots indicating medians (horizontal line in the center), upper and lower quartile (edges of the box), range of values inside 1.5 times Hspread (whiskers), values inside 3 times Hspread (asterisks), far outside values (empty circles).

3.3.4 *Length & Uniformity*

The HVI measures the average length of the longer one-half of the fibers (upper half mean length, UHML). Uniformity is the ratio between mean length and upper half mean length. Values between 80 and 82 percent are considered as 'intermediate', values from 83 to 85 percent as 'high' [USDA 1995].

Effect of Field Cleaner

Figure 26a shows a picture identical to the AFIS length measurement (figure 19a). The cotton harvested with the field cleaner is significantly shorter in the seed cotton samples, but no such effect is visible in further stages (table 15).

Uniformity seems to follow a similar pattern. It seems that uniformity is slightly lower in the cotton harvested with field cleaner which can only be found in the seed cotton samples (figure 27a).

Effect of Ginning Process

A reduction in length can be observed through lint cleaning in Farmer's Gin. In Buster's Gin the effect is not as clear (figure 26). The degree of uniformity decreases through lint cleaning in both gins (figure 27).

Table 15: HVI Upper Half Mean Length and Uniformity. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
UHM Length	**0.006**	0.419	0.332	0.870	0.161
Uniformity	0.063	0.792	0.124	0.525	0.457

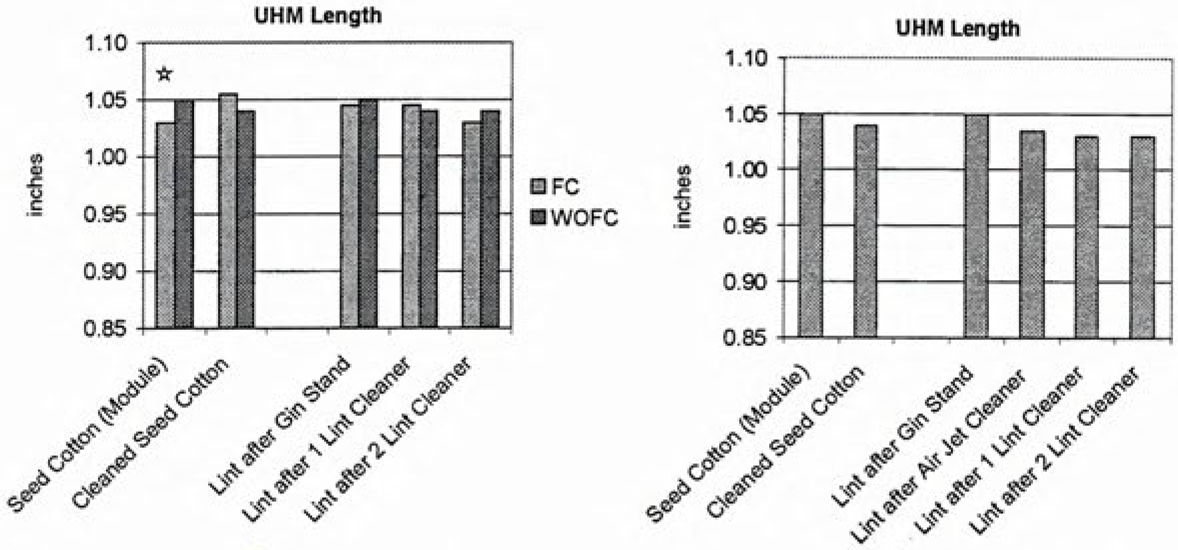


Figure 26: HVI Upper Half Mean Length: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

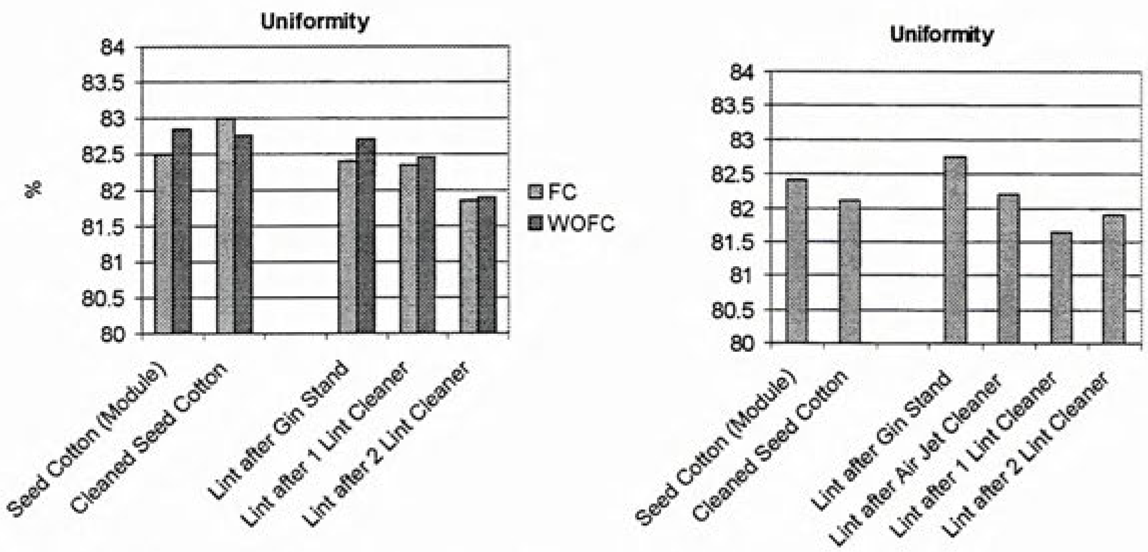


Figure 27: HVI Uniformity: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

3.3.5 Strength & Elongation

The HVI measurement of strength is a measurement of bundle strength, which determines the force required to break a bundle of fibers. Elongation describes the degree of elasticity before breakage in percent.

Effect of Field Cleaner

For strength the results do not show a clear difference between field cleaned and not field cleaned cotton (figure 28a). However, it seems that the cotton harvested with the field cleaner is slightly weaker. The samples 'lint after gin stand' are significantly different. The 'cleaned seed cotton' samples are nearly significantly different with $p = 0.051$ (table 16).

The field cleaned cotton shows slightly lower values in elongation (figure 29a). The samples 'lint after gin stand' are significantly different. The 'cleaned seed cotton' and 'lint after two lint cleaners' samples are nearly significantly different with $p = 0.055$ respectively $p = 0.052$ (table 16).

Effect of Ginning Process

Strength and elongation do practically not change through the ginning process.

Table 16: HVI Strength and Elongation. Probabilities of Mann-Whitney U test statistics. Significant results ($p < 0.05$) are bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Strength	0.117	0.051	**0.013**	0.636	0.189
Elongation	0.087	0.055	**0.018**	0.283	0.052

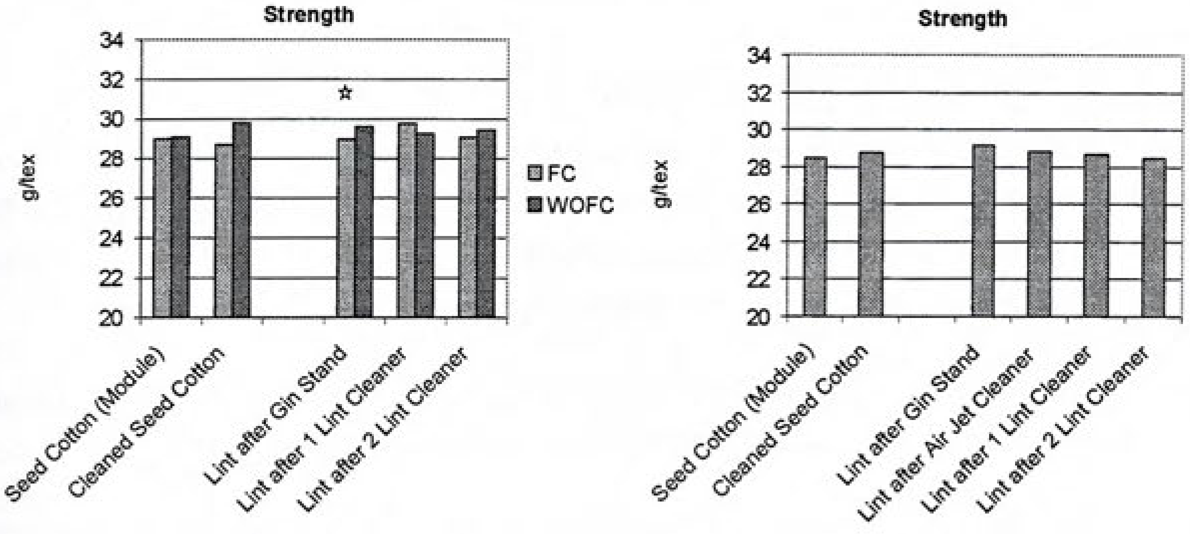


Figure 28: HVI Strength: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

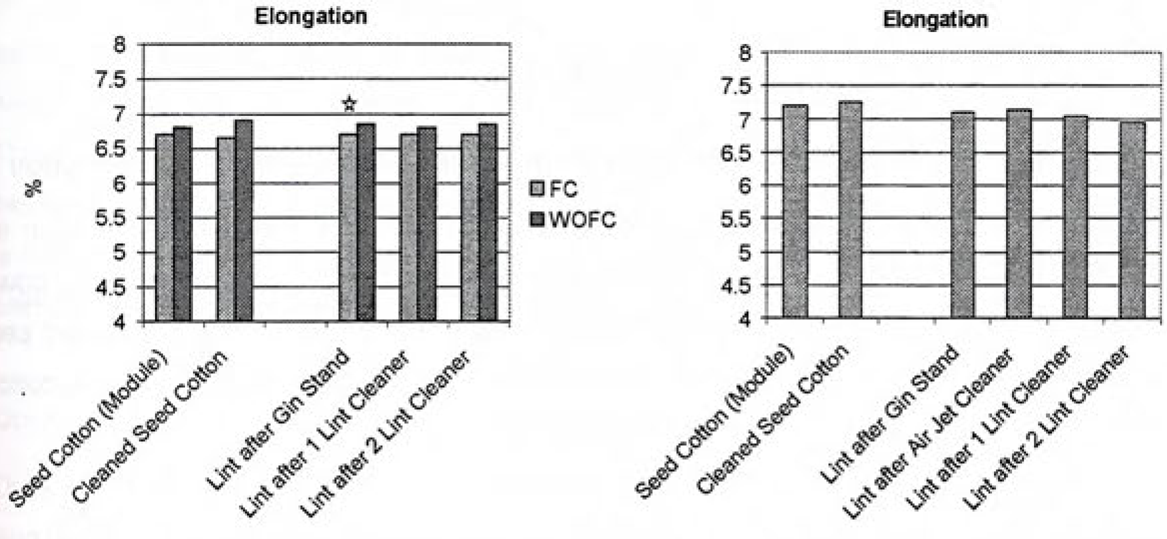


Figure 29: HVI Elongation: a) Comparison of cotton harvested with field cleaner (FC) and cotton harvested without field cleaner (WOFC) ginned at Farmer's Gin. Comparison of medians, stars mark significant differences. b) Cotton ginned at Buster's Gin. Values represent medians.

4 Discussion

The interpretation of the results follows the research questions given in the introduction. Furthermore, the experimental design of the study will be discussed in terms of reliability.

4.1 Reliability of Experimental Design

This study on the effect of a field cleaner on cotton quality is a small scale study. It is focussing on one variety of cotton (HS 26) and on only four modules from one field. Furthermore, the amount of replications was fairly low. Therefore, it has the status of a case study. Further investigations should include several varieties and different regions.

However, the effect of the field cleaner on cotton quality could well be shown and the results of Baker (1998) are similar to those presented in this report to a large extent.

The data of the 'field cleaner'-experiment (Farmer's Gin) are compared with similar measurements in Buster's Gin. The cotton processed in those two gins was not the same. Even though the variety was HS 26 in both cases, the seeds were not the same, the environment for growing was different and the farming practices were different as well. Additionally, only four replications out of two modules were taken at each location at Buster's Gin.

4.2 Effect of Field Cleaning on Cotton Quality

4.2.1 Parameters Important for Spinning but not Measured in Cotton Classification

The focus of this chapter is set on those quality parameters that are not measured in the classification system but are important for spinning performance (numbers of ends down) and yarn quality: namely, immature fiber content, neps, short fiber content, dust and seed coat fragments. These fiber properties do not have an impact on the price of the cotton, although they have a great importance for the spinner.

Immature Fiber Content

Textile manufacturers desire mature cotton because of its dyeability in the finished fabric. Immature fibers cause neps and show up as small, white specks that are clearly visible in the fabric. Cleaning processes in the gin have very little control over these immature fibers. Variety, environment, and crop management are more important in eliminating these fibers than ginning practices [Werber & Backe 1994]. Therefore, the most interesting finding of this study is that the field cleaner significantly reduces the immature fiber content (figure 17a). Obviously, the field cleaner removes immature bolls and green bolls more efficient than the cleaning equipment in the gin does. This is in accord with Baker (1998) who found the same effect.

Neps

Neps are hard to dye and show up as white specks in the fabric. Normally, every mechanical process increases the amount of neps which can also be observed in the results of this study (figure 15a). The field cleaner represents an additional mechanical process. But surprisingly, the cotton harvested with the field cleaner shows significantly less neps and not more as expected. The most probable reason for this is the smaller amount of immature fibers in the cotton harvested with the field cleaner (Figure 17a) which leads to less neps in the cotton. Also this effect was found by Baker (1998).

Short Fiber Content

Hequet (1999) found a high correlation between AFIS short fiber content (w) and yarn uniformity. He also found that the higher the short fiber content, the higher the number of thin places in the yarn. In this study slightly more short fibers (about 0.5 %) were found in the seed cotton samples of the field cleaned cotton, which is complementary to the observation of a little shortage in length (figures 19a and 20a). But in the bale no significant effect could be found. It is possible that fibers break in the mechanical process of field cleaning, which would reduce the average length of the cotton and increase the amount of short fibers. Through the ginning process this little difference might be leveled out or not be visible because of the fewer replications. However, the result is surprising because the field cleaner is not an aggressive step of cleaning and is not expected to harm the individual fiber [Baker, personal information]. Baker (1998) did not find an effect on short fiber content.

Dust

Dust, often referred to as pepper trash, causes problems for the machines in a spinning mill and makes cleaning an often necessity [Schlafhorst 1991]. Furthermore, it can cause unevenness and imperfections in the yarn [Werber & Backe 1994]. The results of this study show that the field cleaner does not have an impact on the dust content in the bale (figure 14a). Initially more dust of cotton harvested without field cleaner was leveled out in seed cotton cleaning and lint cleaning in the gin.

Seed Coat Fragments

Seed coat fragments can cause seed coat neps which cause problems in processing and are visible in the finished fabric. As expected, the field cleaner does not show a significant influence on this parameter (figure 16a), because seed coat fragments originate mainly in the ginning process, when lint is removed from the seed.

4.2.2 Parameters determining the Price of Cotton

The price of cotton is influenced by those quality parameters measured in cotton classification. Traditionally, staple length, color and leaf grade are main factors. Premiums and discounts are given for micronaire, for strength as well as for bark and extraneous matter.

Color & Leaf Grade

The current system encourages the ginner to clean the cotton as much as possible. The whiter the cotton the better the price. The expectation of better color and leaf grades might be a reason for the introduction of a field cleaner in harvesting (beside the economical advantage due to smaller ginning costs). In this study no significant effect of the field cleaner on color grade or leaf grade could be found which is in accord with Bennett & Misra (1996) who did not find an effect of the field cleaner either (figures 21a, 22a and 23a). But it is contrary to Williford et al. (1994) who state that the field cleaner really does improve the color grade of cotton.

Actually, a little difference in color was found. Yellowness shows slightly higher values for cotton harvested with field cleaner (figure 23a). Yellowness can be affected by rainfall, freezes, insects and fungi, and by staining through contact with soil, grass, or the cotton plant's leaf [USDA 1995]. The latter could be the case for the cotton harvested with the field cleaner. The cleaning process following stripping leads to an intensified contact of cotton with other parts of the plant which could lead to staining and slightly higher values in yellowness. However, this stands in contradiction to Baker (1998) who found slightly higher values for the cotton harvested without field cleaner.

Length

The finding of a slightly reduced length in cotton harvested with the field cleaner is surprising. The field cleaner is actually not aggressive enough to harm the individual fiber [Roy Baker, personal information]. However there is a clear, although little, difference in length between the field cleaned and not field cotton (figures 19a and 26a). The difference of 1/100 – 2/100 inches is not automatically price relevant, because the price categories are in 32nds (about 3/100) but in some cases such a little difference will make the difference into the next category.

Micronaire

The field cleaner showed a clear effect on micronaire. The values were higher for field cleaned cotton (figure 24a) and also the USDA Classing Office data of all the bales showed a highly significant difference between cotton harvested with field cleaner and cotton harvested without field cleaner (figure 25b). The same effect was found by Baker (1998). The higher micronaire values for field cleaned cotton can be explained by the smaller amount of immature fibers. Immature fibers are fine and reduce micronaire values. Because micronaire readings were generally high in the 1998 season due to hot weather and water stress, immature fibers improved micronaire readings. Cotton with more immature fibers is more likely to get premiums than cotton with less immature fibers (figure 30).

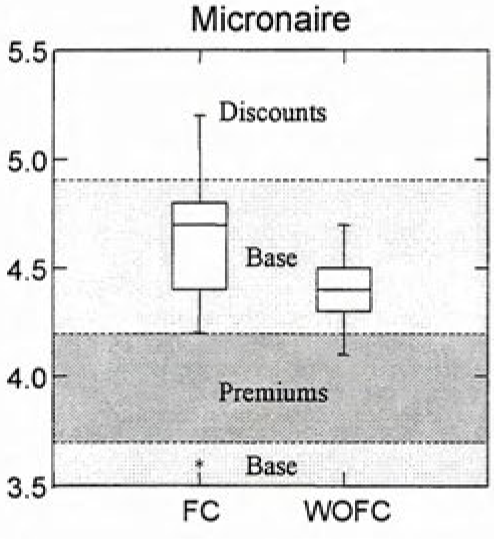


Figure 30: Micronaire USDA Classing Office Data of 25 bales harvested with field cleaner (FC) and 20 bales harvested without field cleaner (WOFC). Box plots show medians (horizontal line in the center), upper and lower quartile (edges of the box), range of values inside 1.5 times Hspread (whiskers), values inside 3 times Hspread (asterisks), far outside values (empty circles).

Strength & Elongation

The spinning industry has undergone a dramatic transformation in the last decades. Processing speed has increased and new technologies such as rotor spinning became a major market share. This changes called for enhanced fiber strength, for cotton that will hold together under rough treatment [National Cotton Council 1992]. The most important factor for strength is the variety of the cotton, the effects of ginning on fiber strength are minimal except in the case of excessive heating [National Cotton Council 1992]. However, this investigation shows for field cleaned cotton slightly reduced strength and slightly reduced elongation (figures 28a and 29a). Baker (1998) did not find such an effect, but he found reduced yarn strength for the field cleaned cotton. Probably, also this effect is related to the difference in immature fibers in field cleaned and not field cleaned cotton.

4.3 Effect of Gin Machinery on Cotton Quality

Some of the most important effects of gin machinery on cotton quality could be shown in this study. They are discussed in the following.

Seed Cotton Cleaning

Seed cotton cleaning refers to the process steps before the gin stand. The efficiency of cleaning depends on machine design, cotton moisture level, processing rate, adjustments and speed of the machine, the amount of trash in the cotton, distribution of cotton across the machine, and the cotton variety [Baker et al. 1994].

Both gins surveyed in this study reduced trash and dust significantly in the seed cotton cleaning process. Trash and dust levels are half as high at Buster's Gin than at Farmer's Gin before the gin stand (figures 13 and 14). Obviously, Buster's gin has a very efficient cleaning system although it is running with 20 – 30 bales per hour. The cleaning system has parallel inclined cleaners which halves the through put for each cleaner. Additionally, Buster's Gin did a lot of work to improve the system with machinery adjustments [personal information Dan Taylor].

On the other hand, Buster's Gin's efficient seed cotton cleaning leads to a bigger increase in neps (figure 15). It seems that efficiency and neps are positively correlated.

Except for an increase in neps no fiber damage could be found. Baker et al. (1994) state that incline cleaners slightly decrease yarn strength but that yarn appearance improves.

However, using more than 14 cylinders in a gin can cause quality problems. Both gins in this study used exactly 14 cylinders for their cleaning (two seven-cylinder inclined cleaners).

Figure 31 shows the correlation between fiber quality and cleaning in the gin. Generally, cleaning reduces most of the important fiber quality characteristics other than trash content and reduces the turnout (loss of fibers). The ginner always has to compromise between trash removal and fiber damage. [Mayfield et al. 1994]

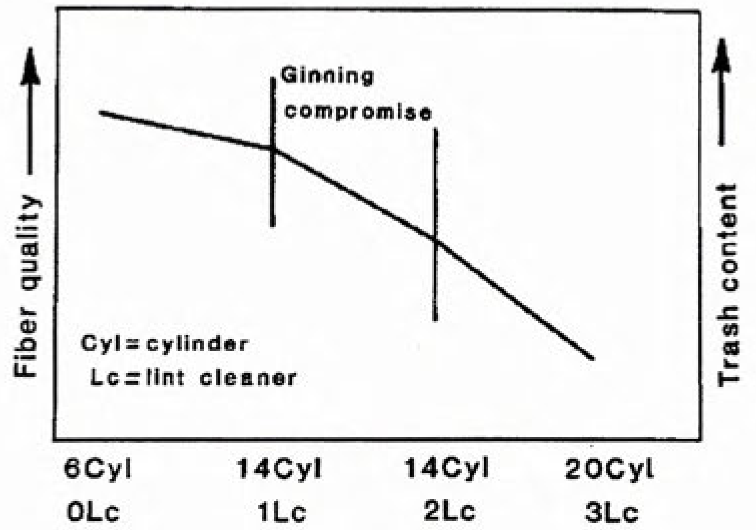


Figure 31: Fiber quality and trash content in relation to different cleaning configurations. [Mayfield et al. 1994]

Gin Stand

The gin stand is the heart of the ginning system. For a good quality of lint it is of great importance to maintain gin stands in good condition and to gin at recommended speed and moisture levels [Columbus et al. 1994].

The results of this study show that Farmer's Gin removes fibers gentler from the seeds than Buster's Gin does. Length reduction (figures 19 and 26) and short fiber production (figure 20) are smaller at Farmer's gin and the amount of seed coat neps is lower (figure 16). Most probably this is an effect of the different speeds of the two gins. Farmer's Gin is running fairly slow with eight to ten bales per hour (three gin stands) while Buster's Gin produces 20-30 bales per hour (four gin stands). This findings are in accord with Griffin (1979) who found that short fiber content increased as saw speed increased. Mangialardi et al. (1988) found that increasing the ginning rate resulted in increases in Uster yarn imperfections.

Ginning also showed an impact on the nep count and on seed coat neps. The eight saw mini-gin which is supposed to gin gentle turned out to be worse than Farmer's gin and only slightly better than Buster's gin for neps (figure 15). In terms of seed coat neps it is the worst (figure 16).

The nep count of cotton in the field is about 20 neps per gram. After ginning it is about 250 for Buster's gin and about 200 for Farmer's gin. This increase is partly, due to seed cotton cleaning and partly due to the ginning process itself.

Lint Cleaning

Lint cleaning is one of the most important steps of the whole ginning process (Baker et al. 1992). Lint cleaners were developed specifically for removing leaf particles, motes, grass, and bark that remain in cotton after seed cotton cleaning and ginning [Mangialardi et al. 1994].

Buster's Gin uses an Air Jet Cleaner as a first step of lint cleaning. But the results show that it had practically no effect on the cotton. It hardly removed any trash (figure 13) which indicates that the ejection slot was probably too much closed. Anyway, it did not harm the fiber in terms of length or neps which is in accord with Griffin & McCaskill (1957) and St. Clair & Roberts (1958) who showed that fiber length, fiber strength, and neps are unaffected by flow-through air lint cleaner.

The controlled-batt saw cleaner is the most common lint cleaner in the ginning industry. Both gins of this study used two steps of saw lint cleaning which is recommended by the USDA [Baker 1994]. The amount of trash and dust decreases step by step (figures 13 and 14). In Farmer's Gin the typical reduction in length (figure 19a) and an increase in short fibers (figure 20a) is visible. Characteristically, the effect of the second lint cleaner is stronger than the effect of the first. Baker & Brashears (1999) proved in a 5-year study on lint cleaning with over twenty test cottons that the adverse effects of the first lint cleaner were relatively small and often statistically insignificant while multiple stages of lint cleaning tended to adversely affect fiber length, short fiber content, and nep level.

The lint cleaning system of Buster's Gin seems not to reduce fiber length and increase short fibers. Buster's Gin is adding moisture to the fibers before lint cleaning which might be the reason for this finding [Dan Taylor, owner of Buster's Gin, personal information].

A slight increase in yellowness due to lint cleaning was found at Farmer's Gin (figure 23a). At first, this seems to be a very peculiar result, but Baker & Brashears (1999) found the same effect in their study. It might be an effect of altering the sample surface by smoothing the fibers and by removing trash [Baker, personal information]. Small increases in yellowness are not necessarily bad, they can lead to higher color grades in some cases, especially if reflectance is high (figure 32).

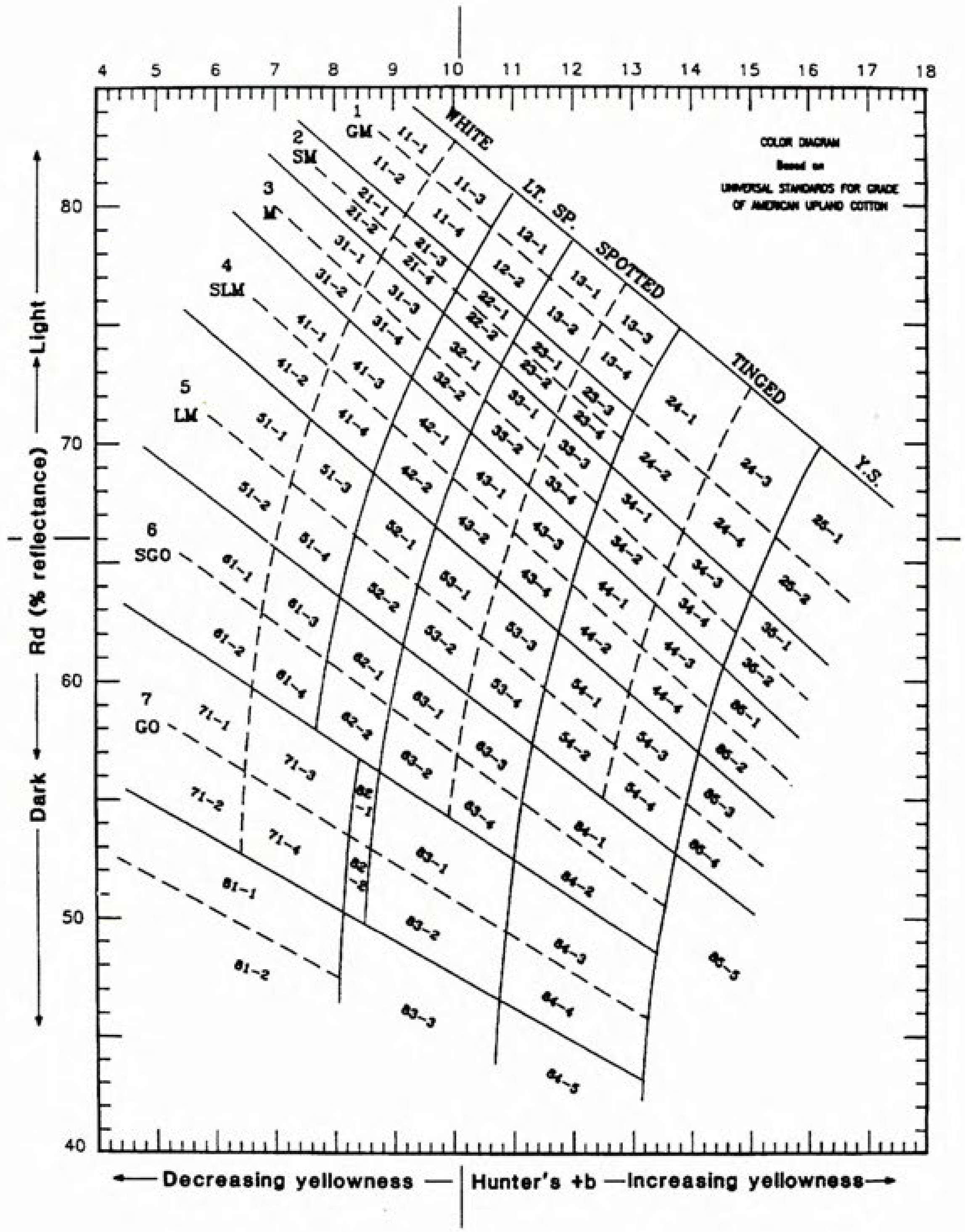


Figure 32: Official cotton color chart for American upland cotton. [USDA 1995]

4.4 Required Changes in the Gin

In this chapter required changes in the gin due to the use of field cleaning in harvesting and due to impacts of gin machinery on cotton quality are discussed.

Seed Cotton Cleaning

This study suggests that the cleaning effort in the gin should be reduced for field cleaned cotton. Due to cleaning in the gin the initial difference in trash and dust content between field cleaned and not field cleaned cotton was leveled out completely (figures 13 and 14). This indicates that the same result could be reached with less cleaning for field cleaned cotton. Field cleaners are similar to stick or bur machines used as pre cleaners in the cotton gin [Williford et al. 1994]. If all (or most) of the cotton will be harvested with the use of field cleaners in future, this machinery may be bypassed.

Lint Cleaning

Currently, it is a standard practice to employ two lint cleanings in the gin [Bennett & Misra 1996]. But Baker & Brashears (1999) could show that in most cases only one stage of lint cleaning is required to maximize bale market value. Further lint cleaning tended to improve color grade and market premiums but they were partially offset by discounts due to shorter fiber length and a reduction in bale weight. Baker & Bragg (1988) stated that although additional stages of lint cleaning further clean fiber, they do so at a slower rate than they increase fiber damage. Furthermore, Bennett & Misra (1996) found that the ideal cleaning configuration includes field cleaning and only one step of lint cleaning for best yarn qualities.

Schlichter et al. (1995) investigated if lint cleaning should rather take place in the spinning mill or in the gin. Arguments in favor of cleaning in the gin are:

- higher classification of the clean cotton,
- lower transport costs from the gin to the spinning mill,
- and easier disposal of the impurities in the gin than in the spinning mill.

Arguments in favor of cleaning in the spinning mill are:

- controlled cleaning conditions,
- lower cleaner throughput and hence a higher cleaning capacity,
- and a positive influence on fiber and yarn values if stress on cotton in spinning mills is lower than in gins.

They recommended that due to the big disadvantages of high trash contents in the bale (lower classing, higher transport costs, waste disposal in the mill) the current practice of cleaning in the gin should be continued.

4.5 Conclusions and Outlook

This study was focussing on the processes before the bale - field cleaning, seed cotton cleaning, ginning and lint cleaning – and their effect on cotton quality.

The field cleaner turned out to be a valuable cleaning step for spinning performance and yarn quality due to the reduction of immature fibers and neps. These factors can hardly be influenced with the machinery in the gin.

However, field cleaning has no effect on color grade and staple length and therefore practically no effect on the price of cotton. Due to the impact on immature fibers an influence on micronaire was found. But in a year like 1998 (hot and dry weather) the effect on the price is negative, if there is one at all.

Most important, the field cleaner saves ginning costs for the grower due to less trash in the seed cotton and therefore less weight. If a significant loss of fibers takes place in field cleaning has to be assessed in further studies.

Summarizing, the field cleaner is a cost saving cleaning equipment which reduces the amount of immature fibers and neps significantly without negative effects on fiber quality. For this reasons the use of a field cleaner in harvesting can be recommended. Certainly it will become more frequent in future.

A new step of cleaning in the field requires changes in the cleaning configuration of the cotton gin. Field cleaners are similar to stick or bur machines. Hence, this machinery should be bypassed in the gin for field cleaned seed cotton. Less cleaning means a reduction in mechanical stress for the fiber which benefits quality. The effect of reduced seed cotton cleaning in the gin should be investigated in further studies.

Further changes in the gin can bring additional improvements in cotton quality. Baker & Brashears (1999) found that one lint cleaner is sufficient in most cases. Currently, most gins use two steps of lint cleaning.

The implementation of process control systems to gins will further optimize cotton quality. Moisture, trash and color (in future probably also neps, short fibers and strength) are monitored at several locations in the ginning process [Williams 1998]. Based on this measurements cleaning performance and drying were adjusted automatically. Hence, the gin becomes more flexible and able to react on differences in incoming seed cotton. The aim for the future is to customize cotton quality to the buyer's specifications.

Some spinning mills already buy the cotton straight from the gin and specify their wishes in contracts. They determine such things as maximal drying temperatures or the number of lint cleaning to perform [Frye 1998]. This way, they bypass the classifications system. Their cotton is less cleaned, less white, but important fiber properties for spinning can be preserved.

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Appendices

- Appendix I: Task of Thesis
- Appendix II: Description of Gin Machinery
- Appendix III: Description of High Volume Instrument (HVI)
- Appendix IV: Description of AFIS (Advanced Fiber Information System)
- Appendix V: Overview of Results of Field Cleaner Study: Box Plots
- Appendix VI: Overview of Mann-Whitney U Test Statistics (Field Cleaner Study)
- Appendix VII: Overview of Results of Buster's Gin: Box Plots

Appendix I

Task of Thesis

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ETH Diploma thesis

Quality Assessment of Cotton Harvesting and Ginning
Fiber quality of cotton is primarily determined by the interaction of genetic and environmental realities. Fundamental environmental factors include water, soil, weather, length of the season as well as pest and weed management and harvesting methods. The first stages of the fiber cleaning process may occur either in harvesting (with field cleaners or picker harvesters) and in ginning, intrinsic fiber properties are frequently damaged at these stages. Of particular concern are fiber length, short fiber content, uniformiy and exessive neps. In the last years this damages are increasing, as can be shown in spinning processes and in yarn testing. There is some evidence that mechanical treatments in in some stages of lint cleaning processes, together with high temperatures in gin drying may cause fiber damage. Moisture control seems to be a critical factor (Anthony 1998). A recent investigation at Texas Tech in Lubbock University in Lubbock, Texas, reveals some relationships between quality and market pricing mechanisms (Bennet 1997). Although an appropriate instrument (AFIS) is available to measure these fiber qualities, parameters like short fiber content and neps are usually not tested in HVI cotton classification. As a consequence these parameters are not adequately represented in the price system.

Objectives of the diploma thesis:
The aim is to assess the impact of the individual processes in harvesting and ginning upon fiber quality parameters that are relevant to textile processing.

1. Relevant quality parameters for fiber processing of cotton, that are not currently tested in HVI cotton classification, have to be identified.

2. Weakpoints in harvesting and ginning equipment causing fiber damages have to investigated compared with the selected quality parameters. Thereafter, relevant processes for the investigation have to be defined.

3. The available data from harvesting and gin processing has to be collected and evaluated considering the selected fiber quality parameters and textile processes as well as the growing conditions and cultural practices of the cotton.

4. According to the results of step 2 and 3 a set up for collection of missing data in a comparable system has to be developed. Cotton will be processed with the same equipment and the missing samples will be tested.

5. A final assessment will show which processes can lower cotton fiber quality and how alterations could improve fiber quality.

6. A feasability study will have to indicate which alternative processes can compete with existing processes regarding cost.

The main part of this ETH diploma thesis will be carried out in Lubbock, TX in cooperation with USDA Gin lab (Alan Brashears, Roy Baker) and the in Agricultural and Applied Economic Department at Texas Tech University in Lubbock, TX (Dr.Sukant Misra). For testing of new samples the AFIS at the ITC can be used. Industrial input will be available from Consolidated Ginning Company and the Samuel Jackson Company, both in Lubbock.

Appendix II

Description of Gin machinery

Description of Gin machinery

The first step of ginning is to bring the seed cotton from the module (or trailer) into the ginning system. 'There are two types of seed cotton unloading systems: (1) pneumatic suction through swinging telescopes that remove cotton from a trailer of module and (2) module disperser systems that break up the module mechanically and deposit the seed cotton onto a conveyor hat delivers it to a fixed suction pickup point.' [Laird 1994]

The cotton then is transported into a green boll-trap, which removes heavy materials like green bolls or rocks at an early stage in the gin to prevent damage to the machinery (figure 1).

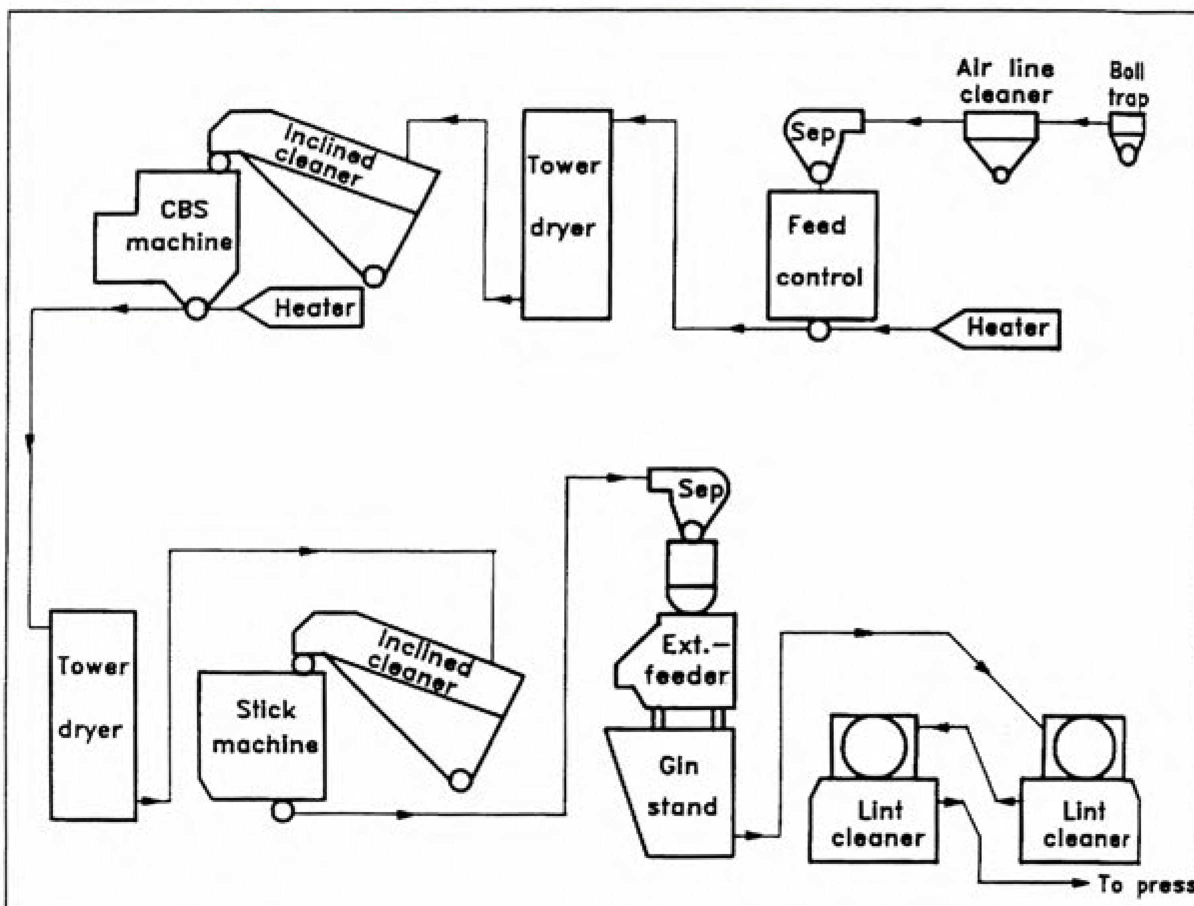


Figure 1: Recommended gin machinery for machine-stripped cotton [Baker 1994].

Air line cleaners consist of rotating spiked cylinders that scrub the cotton over grid bars. They have gained wide acceptance in stripper areas as a means for removing soil particles from seed cotton and for opening partially closed bolls and wads of seed cotton for further cleaning [Baker et al. 1994].

Cotton gins use the movement of air to transport cotton through conveying pipes much like the wind blows leaves and dirt in nature. The automatic feed control provides a well-dispersed flow of cotton in the system.

Mostly, there are two stages of drying. In a time of 10-15 seconds, heated air conveys the cotton through the shelves of the tower dryer. Temperature to which the cotton is exposed should never exceed 300° Fahrenheit (150° Celsius) [Anthony 1994].

Inclined cleaners consist of six or seven revolving spiked cylinders, which scrub the cotton over a series of grid rods or screens. Trash particles fall through small openings or slots. Inclined cleaners are used for removing finely divided particles and for opening and preparing the seed cotton for further processing.

Cotton gins that process stripper-harvested cotton are frequently equipped with a combination bur and stick machine (CBS machine). It removes larger foreign matter, such as burs and sticks from the cotton. The upper part of the machine resembles a bur machine with its large diameter saw cylinder. The lower part is very similar to a stick machine.

Stick machines work with the sling-off action off high-speed saw cylinders to remove trash from the cotton.

The extractor-feeder is located above the gin stand and feeds the cotton uniformly to the ginning process at controllable rates. As a secondary function it cleans the seed cotton. At this point the moisture content of the seed cotton is critical. If the cotton is too dry, fibers will break in the ginning process, which results in a higher short fiber content. This leads to more waste at the textile mill, which is not desirable. The ideal moisture content lies between six and seven percent at the outlet of the extractor-feeder.

All these steps are part of the process 'seed cotton cleaning'. Only now the seed cotton is entering the gin stand, which separates the lint from the seed.

The ginning action is caused by a set of saws rotating between ginning ribs. The saw teeth pull the fibers from the seeds, which are too large to pass between the ribs. The seeds are conveyed into a storage facility, while the lint enters two more cleaning processes.

Lint cleaners were developed specifically for removing particles that remain in cotton after seed cotton cleaning and ginning. Most common is the controlled-batt saw lint cleaner. A batt of fibers is fed onto a saw cylinder. The cleaning action is a combination of centrifugal force, scrubbing action between saw cylinder and grid bars, and gravity assisted by an air current. Most gins have two lint cleaners.

The cleaned cotton is compressed into bales and then covered for protection from contamination during transportation and storage. In 1992, about 90 percent of the bales in the United States were gin universal density bales, compressed to about 40 lb/ft^3 [Anthony 1994] and a weight of about 480 pound.

Appendix III

Description of High Volume Instrument (HVI)

Description of High Volume Instrument (HVI)

A cotton sample for the use in the HVI should weigh at least four ounces (114 grams). The HVI consists of three parts, which have to be served by an operator. They work independently and cotton can be processed parallel at all three parts.

The procedure for the three parts is as follows:

- A part of the sample is pressed on a screen and a video camera measures the area covered with trash, yellowness and reflectance of the sample. It is important that the whole screen is covered with cotton. Else the sample is rejected and the measurement has to be repeated. This procedure takes about 15 seconds.
- About 10 grams of cotton (between 9.5 grams and 10.5 grams) are weighed up, stuffed into a tube and locked up by closing the cover. Air is pressed through the sample and the air permeability is measured for the micronaire reading. The measurement takes about 15 seconds.
- A handful of cotton is fed into a machine that measures length, length uniformity, strength and elongation in the same process. A bunch of fiber is gained from the sample, grasped by a clamp and paralleled with a comb. The resulting beard of fibers is scanned and the length frequency curve is gained. The reported data are upper half mean length and mean length. Strength and elongation are measured afterwards with the same beard of fibers. It is clamped in two jaws one-eighth inch apart, and the amount of force required to break the fibers is determined. The HVI measures bundle strength and not the strength of a single fiber. The instrument does two measurements simultaneously.

Appendix IV

Description of AFIS (Advanced Fiber Information System)

Description of AFIS (Advanced Fiber Information System)

Cotton samples of exactly 0.5 grams have to be formed in slivers of about one foot length. The samples are stretched carefully to ribbons, bit by bit, until they reach the desired length (figure 1). Now, the ribbons were folded and rolled into slivers. The slivers were put in a cassette, ready to be automatically fed to the AFIS for measurement.

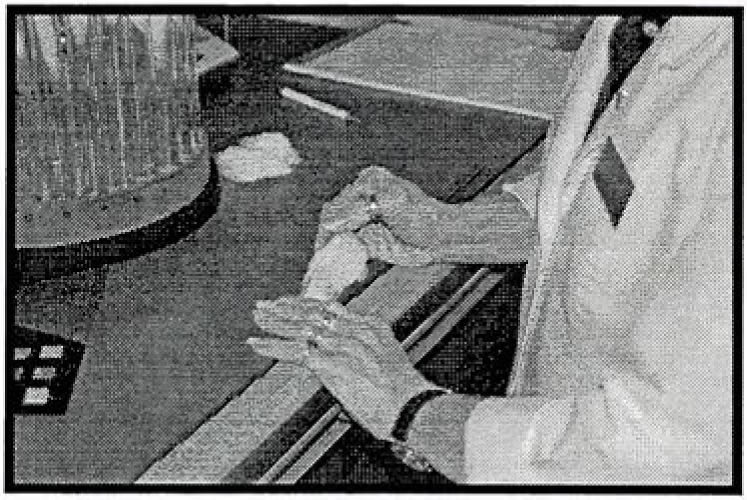


Figure 1: Preparation of sliver for AFIS measurement.

The slivers are sucked, one at a time, into the AFIS system and enter a mechanical process similar to opening and carding (figure 2). This means that the fibers are measured after having been mechanically stressed. The system separates trash and dust particles from the cotton and individualizes the fibers.

The individualized fibers are transported in a high velocity air stream to the fiber sensor. They enter the sensor through a nozzle which presents them in proper orientation to a near infra-red ribbon beam. As the fibers pass through the ribbon beam, they scatter light in relation to their size and cross sectional shape. This light is detected and translated into characteristic waveforms which can be interpreted by the AFIS. In the second sensor trash measurements are carried out the same way. [Information source: International Textile Center 1998]

The AFIS can be loaded with up to 30 slivers and theoretically let running on its own. However, in praxis checks from time to time are necessary because of quite frequent interruptions in the process.

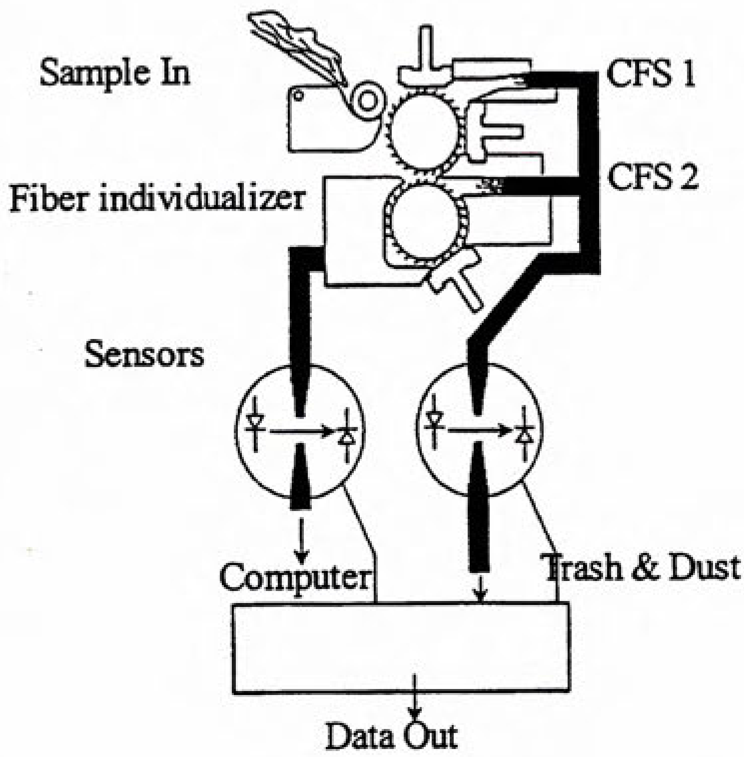


Figure 2: AFIS General Schematic [International Textile Center 1998]

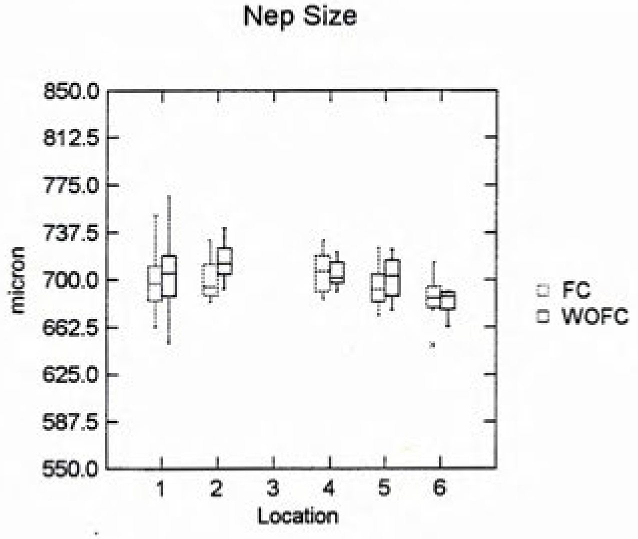
Appendix V

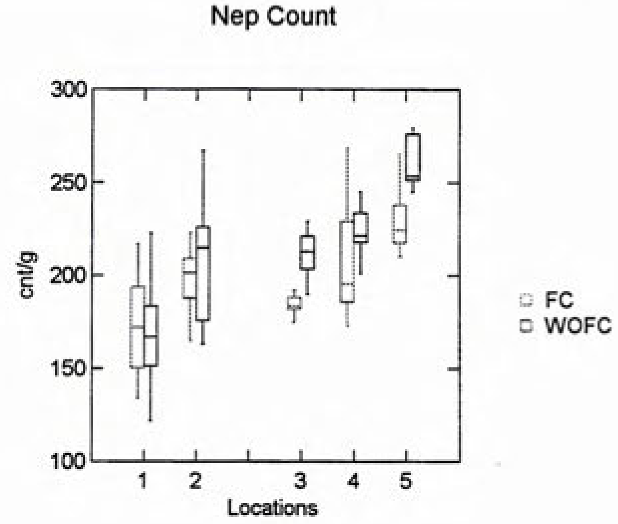
Overview of Results of Field Cleaner Study: Box Plots

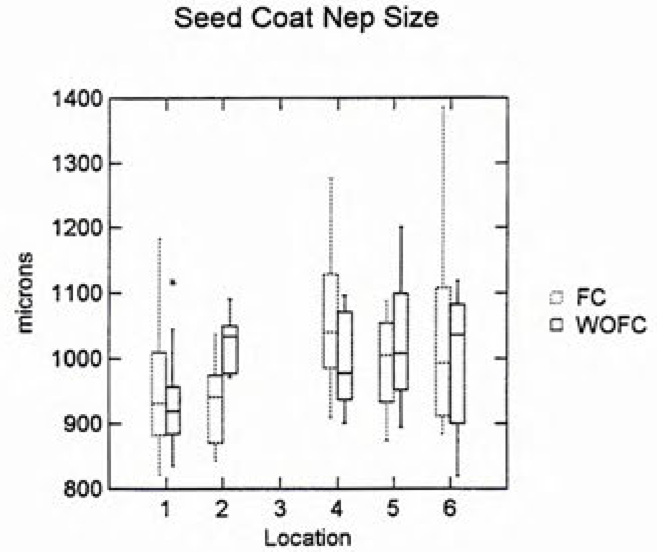
Overview of Results of Field Cleaner Study: Box Plots

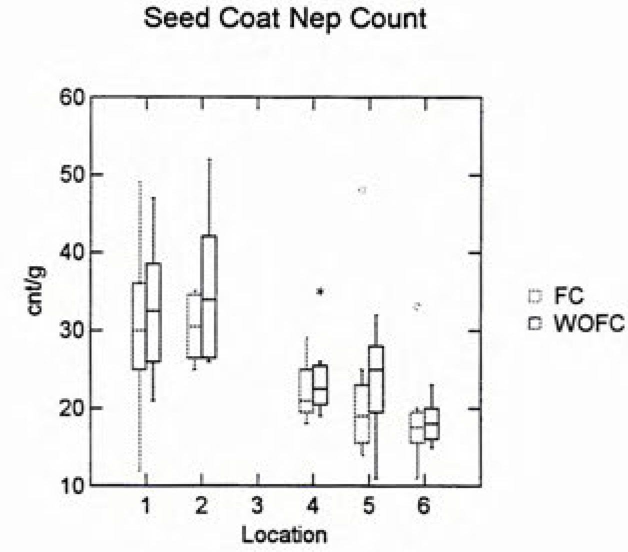
The five locations through the gin are 1) seed cotton (module) 2) cleaned seed cotton 3) lint after gin stand 4) lint after 1 lint cleaner 5) lint after 2 lint cleaners.

1. AFIS Data

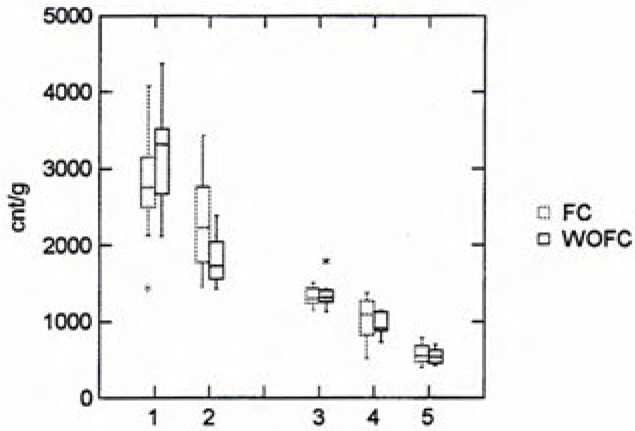




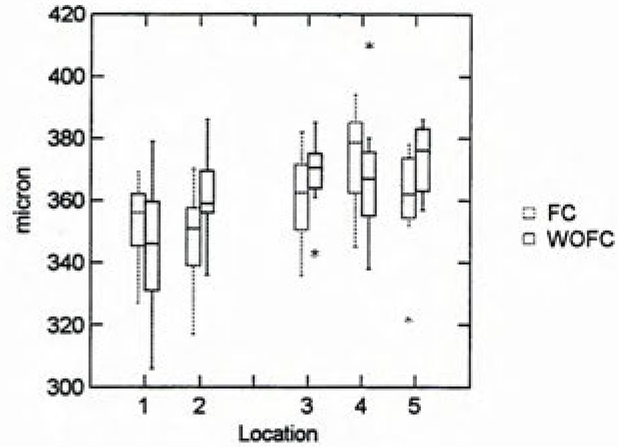




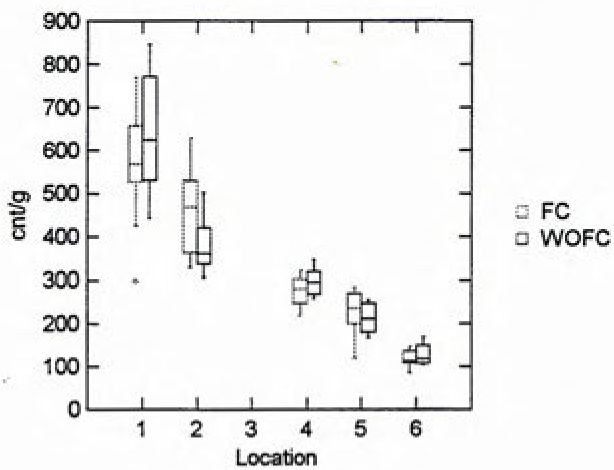
Total Particle Count



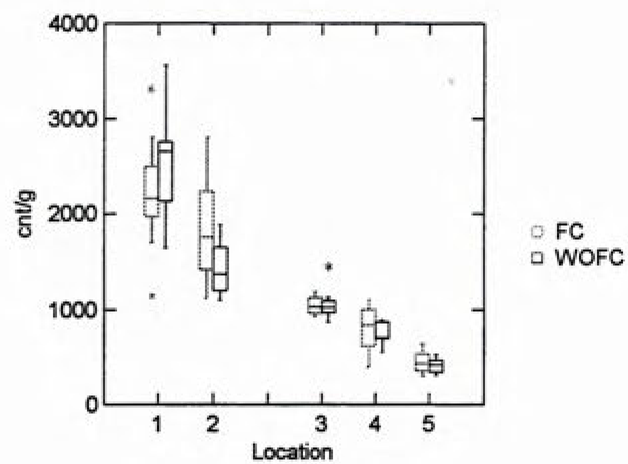
Mean Particle Size



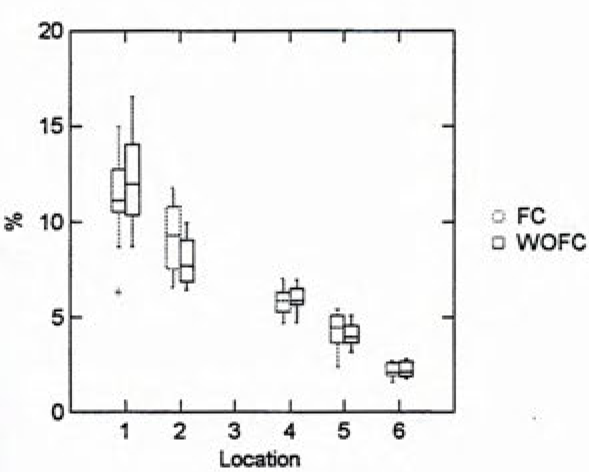
Trash Count



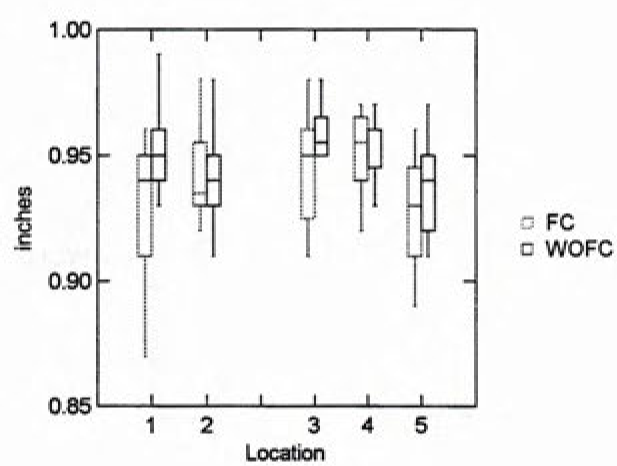
Dust Count



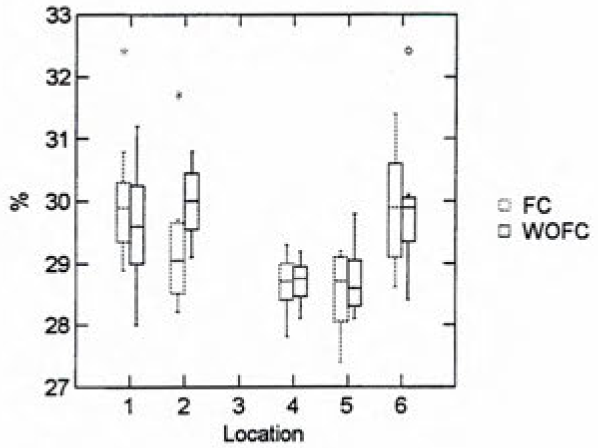
Visible Foreign Matter



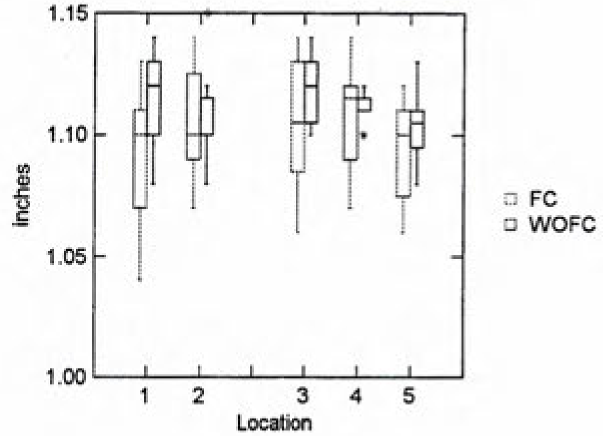
Length (w)



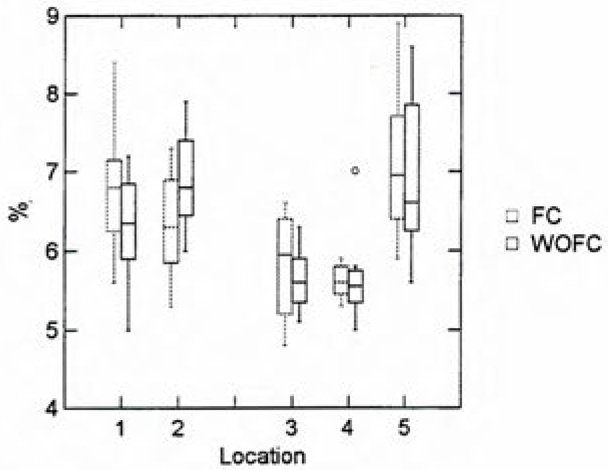
CV Length (w)



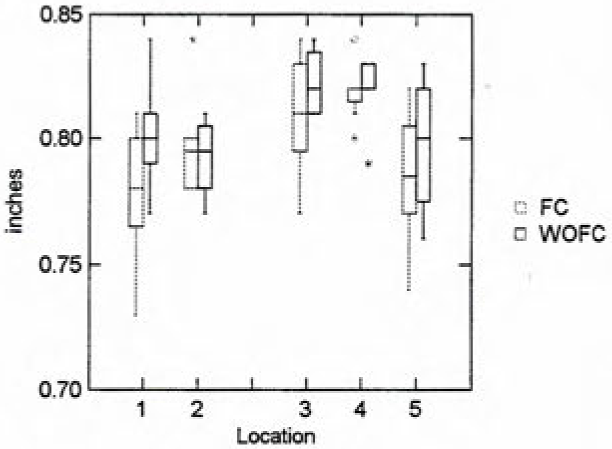
Upper Quartile Length (w)



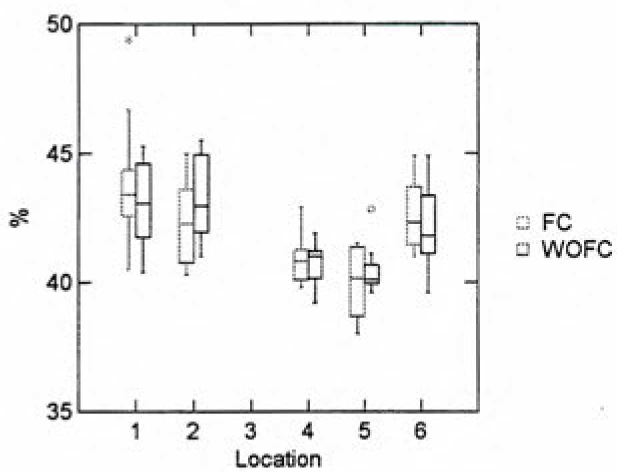
Short Fiber Content (w)



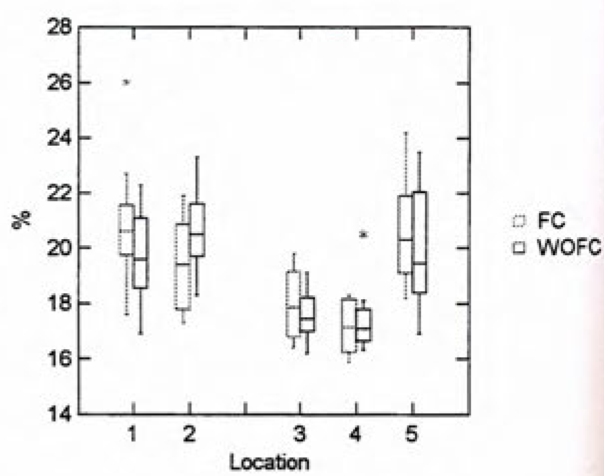
Length (n)



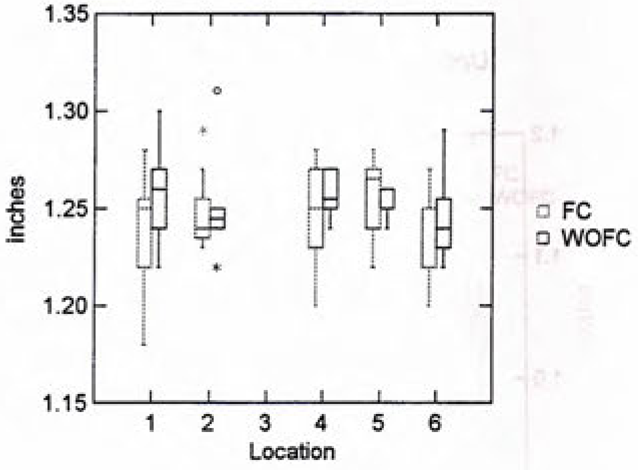
CV Length (n)



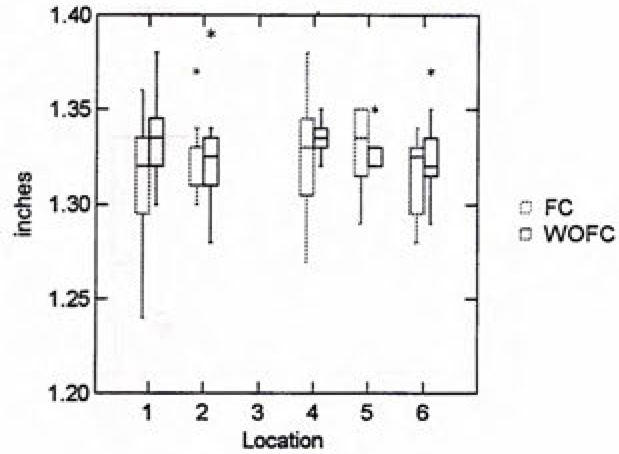
Short Fiber Content (n)



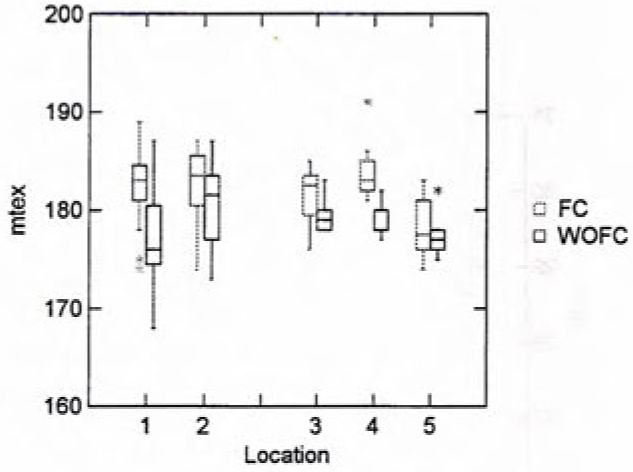
Length 5% (n)



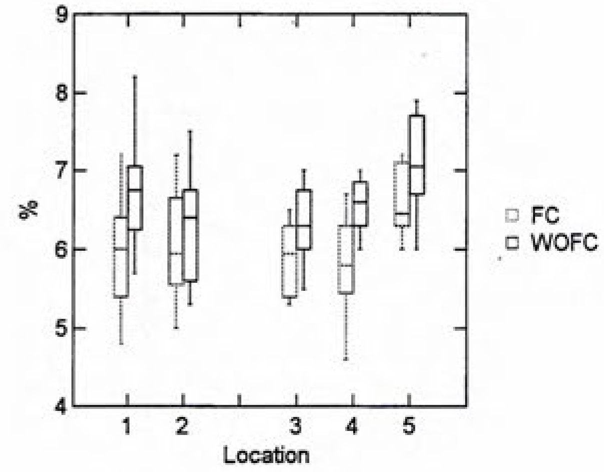
Length 2.5% (n)



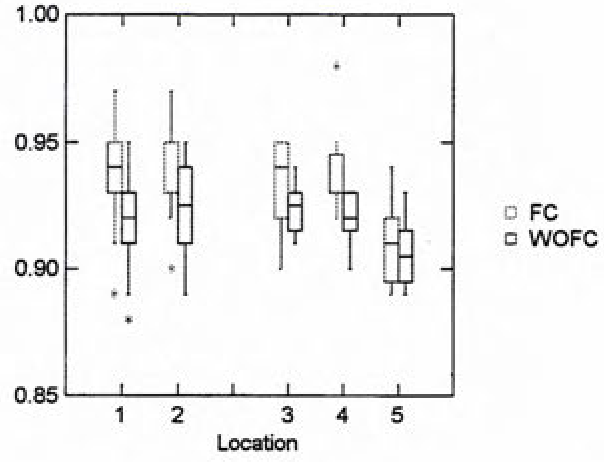
Fineness



Immature Fiber Content

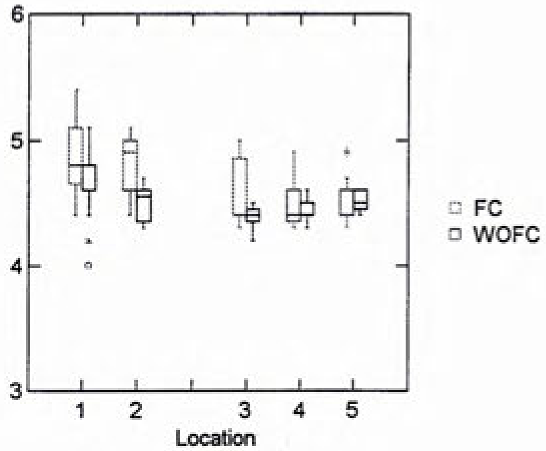


Maturity

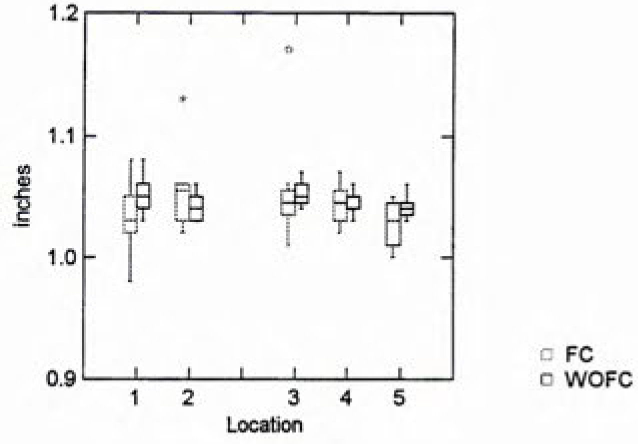


2. HVI Data

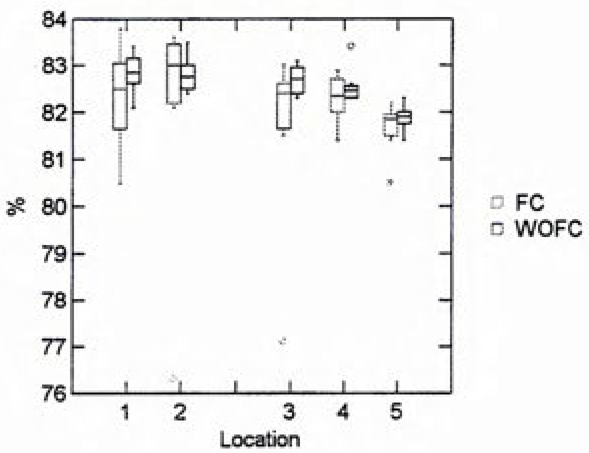
Micronaire



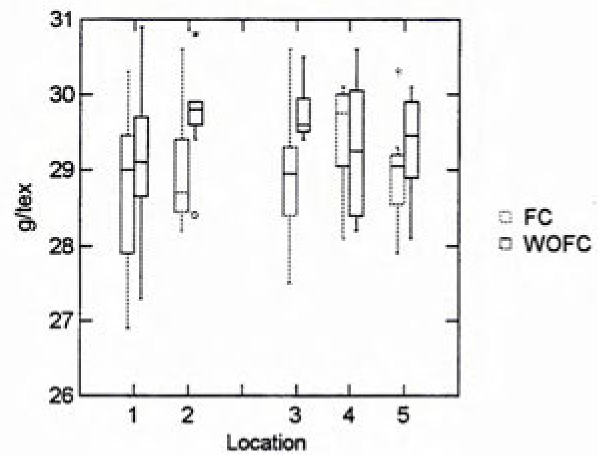
Upper Half Mean Length



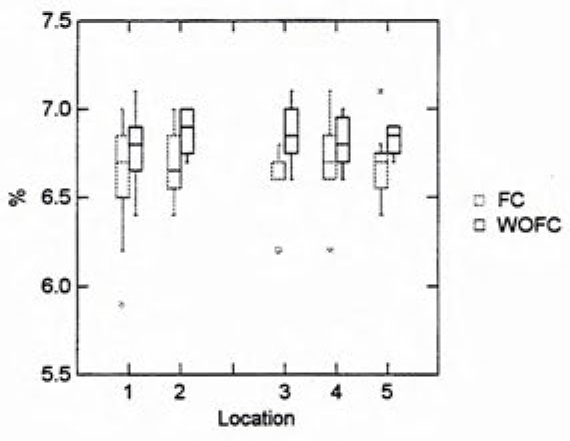
Length Uniformity



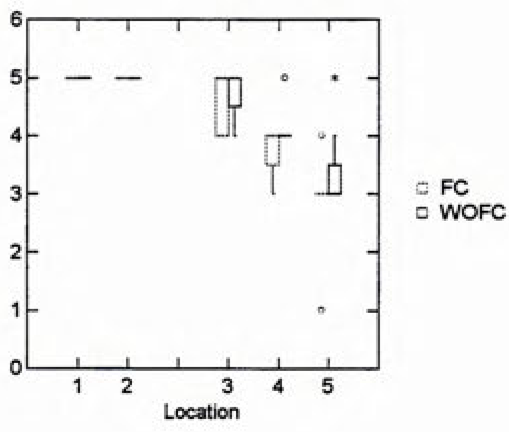
Strength

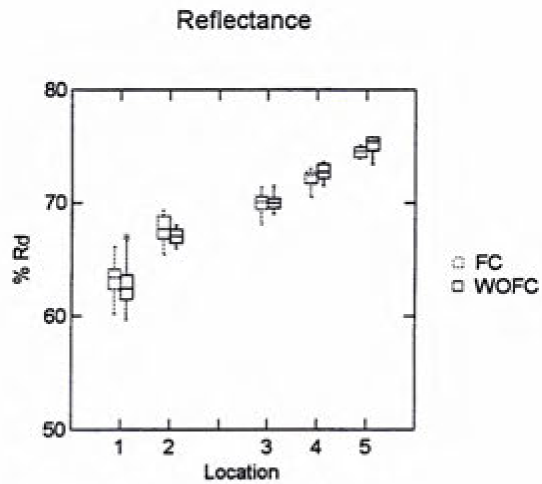


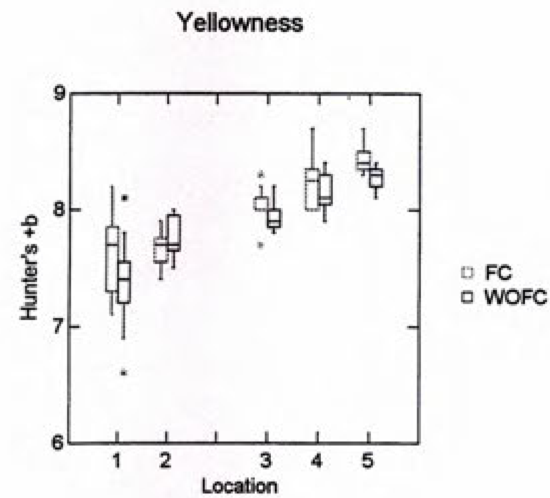
Elongation



Leaf Grade




Reflectance
80
70
60
50
% Rd
1
2
3
4
5
Location
FC
WOFC


Yellowness
9
8
7
6
Hunter's +b
1
2
3
4
5
Location
FC
WOFC

Appendix VI

Overview of Mann-Whitney U Test Statistics for the Field Cleaner Study

Overview of Mann-Whitney U Test Statistics for the Field Cleaner Study

Statistical significant differences between field cleaned and not field cleaned cotton ($p < 0.05$) are marked bold.

	Seed Cotton (Module)	Cleaned Seed Cotton	Lint after Gin Stand	Lint after 1 Lint Cleaner	Lint after 2 Lint Cleaners
Nep Size	0.469	0.093	0.916	0.431	0.430
Nep Count	0.733	0.401	**0.001**	0.189	**0.006**
SCN Size	0.463	**0.006**	0.294	0.528	1.000
SCN Count	0.311	0.342	0.493	0.317	0.750
Total Particle Count	0.055	0.074	0.916	0.462	0.600
Mean Particle Size	0.115	0.074	0.293	0.401	0.073
Dust Count	**0.049**	0.074	0.958	0.462	0.529
Trash Count	0.128	0.156	0.293	0.294	0.916
Visible Foreign Matter	0.395	0.141	0.834	0.495	0.753
Length (w)	**0.004**	0.788	0.187	0.871	0.396
CV% Length (w)	0.224	0.052	0.916	0.916	0.834
UQL (w)	**0.004**	0.627	0.365	0.956	0.420
Short Fiber Content (w)	0.056	0.170	0.563	0.632	0.712
Length (n)	**0.001**	1.000	0.285	0.416	0.367
CV% Length (n)	0.495	0.226	0.958	0.599	0.636
Short Fiber Content (n)	0.101	0.246	0.563	0.713	0.494
Length 5% (n)	**0.021**	0.509	0.520	0.421	0.915
Length 2.5% (n)	**0.037**	0.517	0.358	0.665	0.789
Fineness	**0.000**	0.268	0.089	**0.001**	0.671
Immature Fiber Content	**0.001**	0.528	0.140	**0.013**	0.114
Maturity Ratio	**0.001**	0.077	0.165	**0.017**	0.706
Micronaire	**0.011**	**0.021**	0.286	0.866	0.354
Length	**0.006**	0.419	0.332	0.870	0.161
Uniformity	**0.063**	0.792	0.124	0.525	0.457
Strength	0.117	0.051	**0.013**	0.636	0.189
Elongation	0.087	0.055	**0.018**	0.283	0.052
Leaf Grade	1.000	1.000	0.602	0.090	0.300
Reflectance	0.264	0.225	0.916	0.207	0.082
Yellowness	**0.017**	0.410	0.146	0.593	**0.021**

Appendix VII

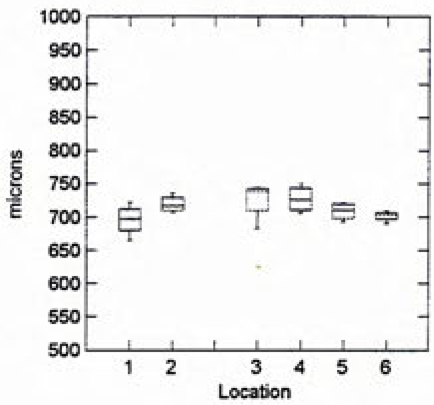
Overview of Results of Buster's Gin: Box Plots

Overview of Results of Buster's Gin: Box Plots

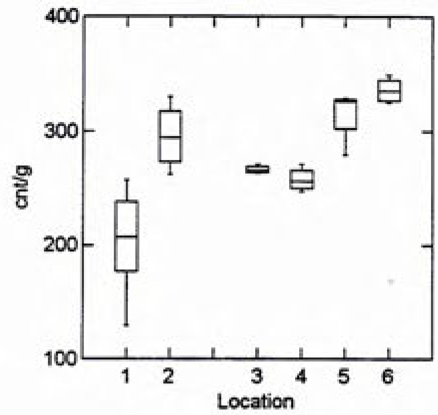
The six locations through the gin are 1) seed cotton (module), 2) cleaned seed cotton, 3) lint after gin stand, 4) lint after Air Jet cleaner, 5) lint after one lint cleaner, 6) lint after two lint cleaners.

1. AFIS Data

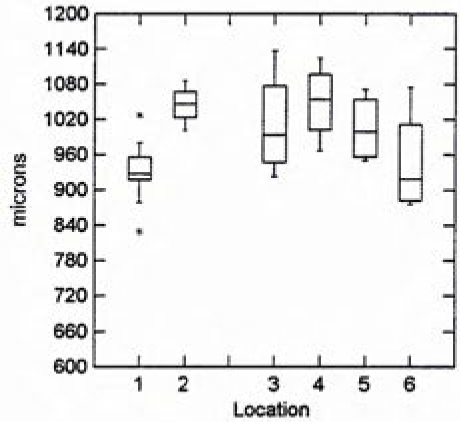
Nep Size



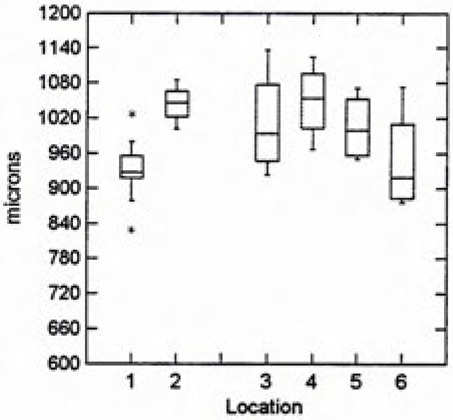
Nep Count

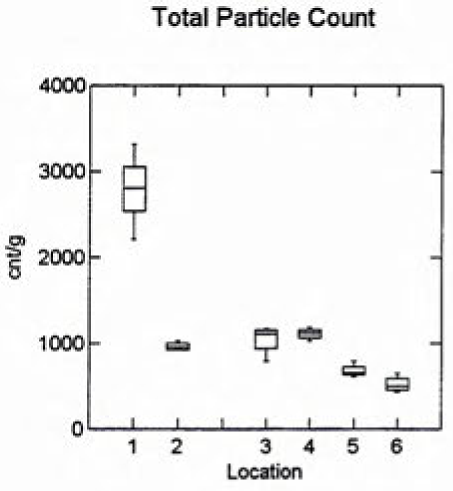


Seed Coat Nep Size

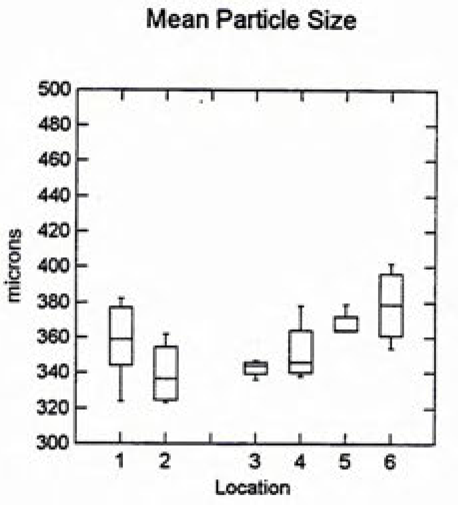


Seed Coat Nep Size

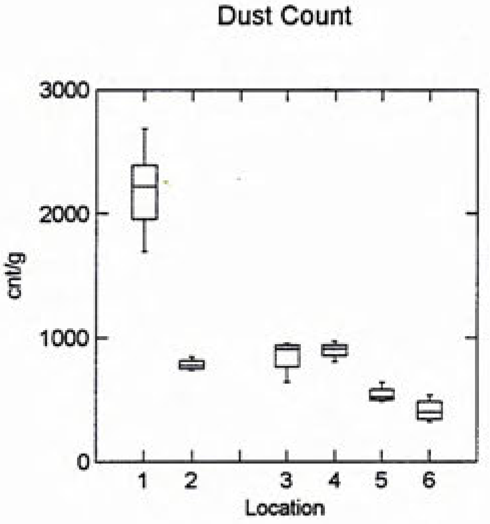




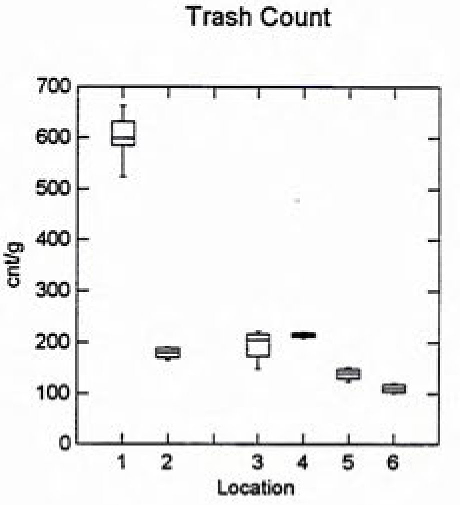
Total Particle Count
4000
3000
2000
1000
0
cnt/g
1
2
3
4
5
6
Location



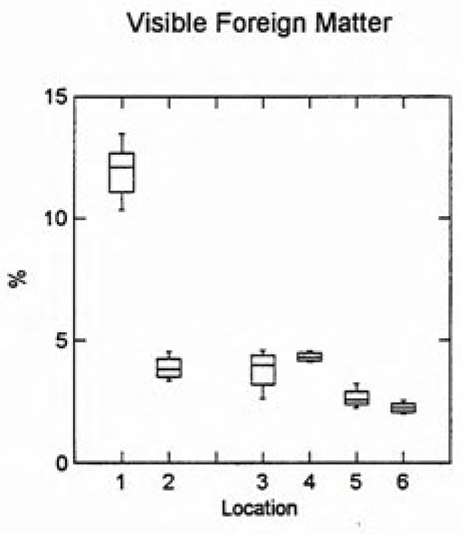
Mean Particle Size
500
480
460
440
420
400
380
360
340
320
300
microns
1
2
3
4
5
6
Location



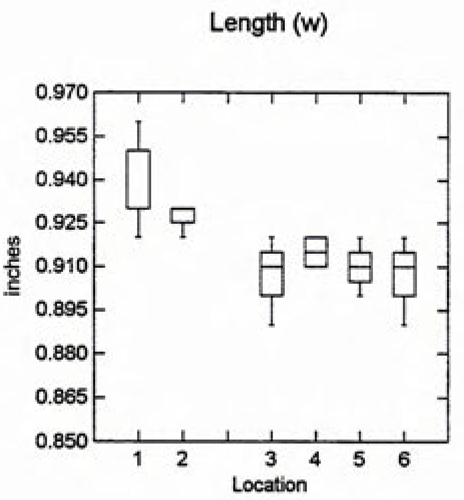
Dust Count
3000
2000
1000
0
cnt/g
1
2
3
4
5
6
Location



Trash Count
700
600
500
400
300
200
100
0
cnt/g
1
2
3
4
5
6
Location

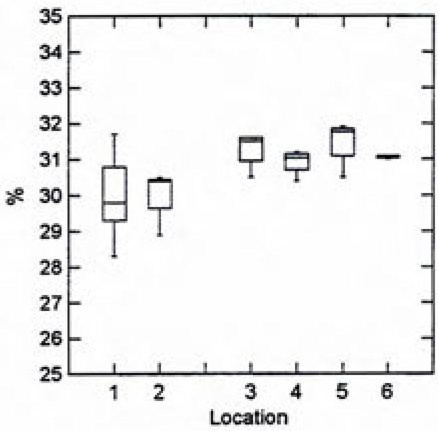


Visible Foreign Matter
15
10
5
0
%
1
2
3
4
5
6
Location

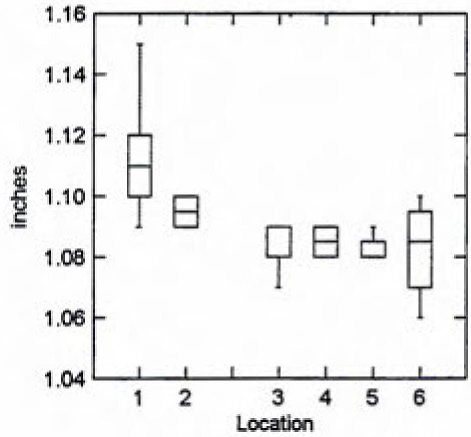


Length (w)
0.970
0.955
0.940
0.925
0.910
0.895
0.880
0.865
0.850
inches
1
2
3
4
5
6
Location

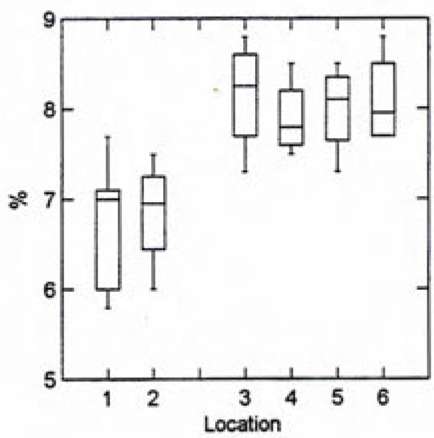
CV Length (w)



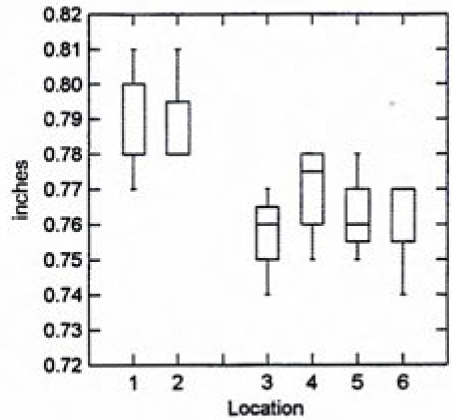
Upper Quartile Length (w)



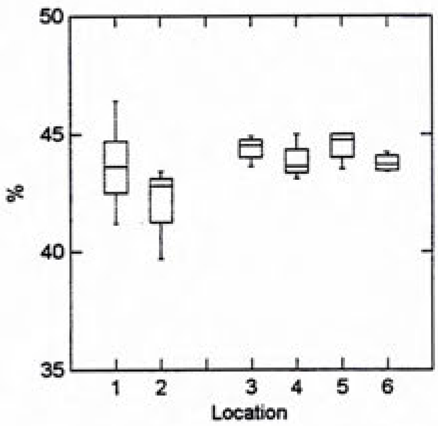
Short Fiber Content (w)



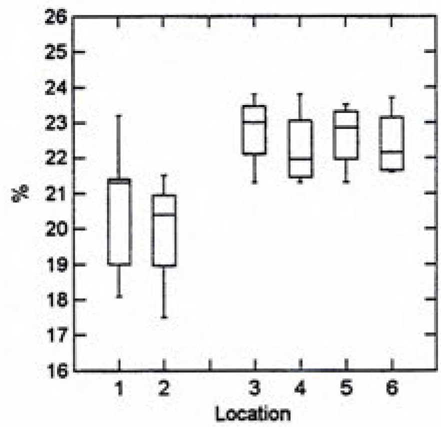
Length (n)



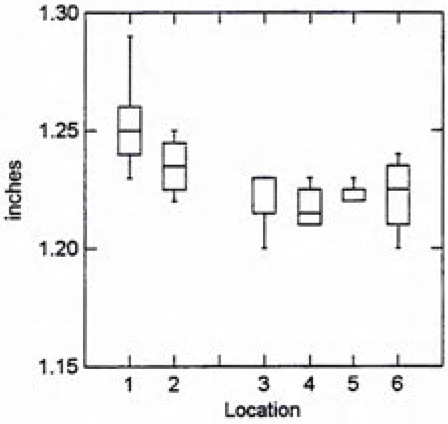
CV Length (n)



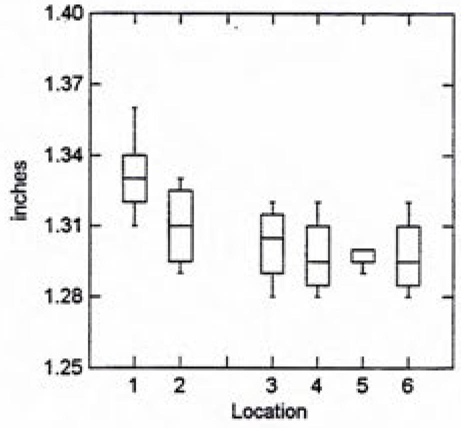
Short Fiber Content (n)



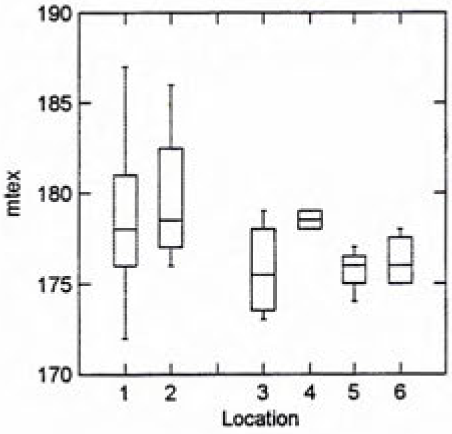
Length 5% (n)



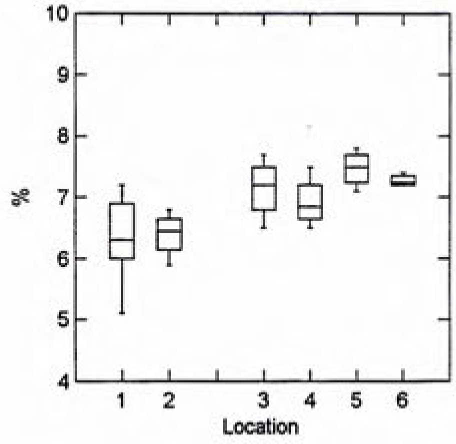
Length 2.5% (n)



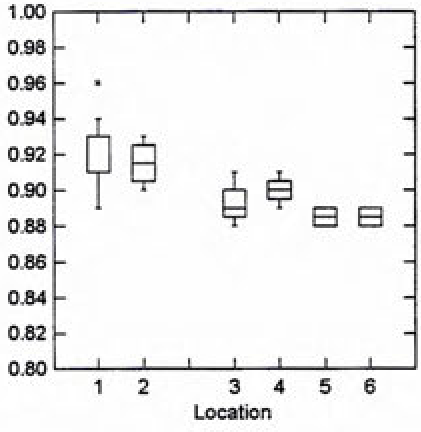
Fineness



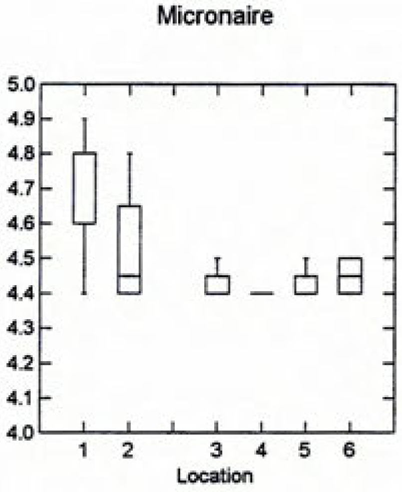
Immature Fiber Content

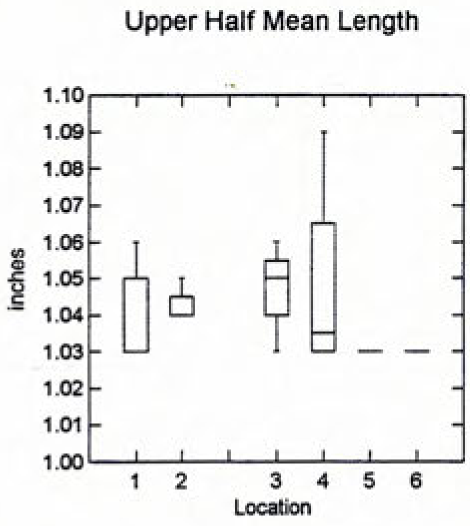


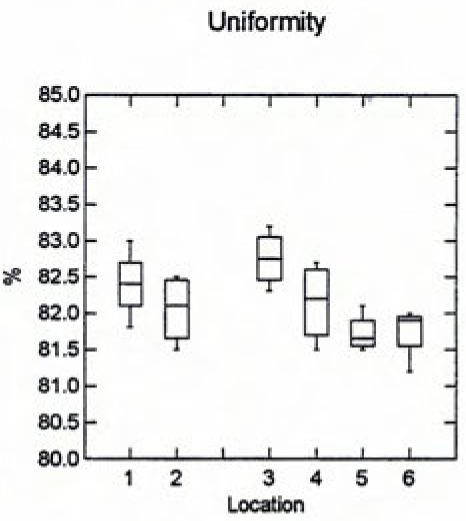
Maturity Ratio

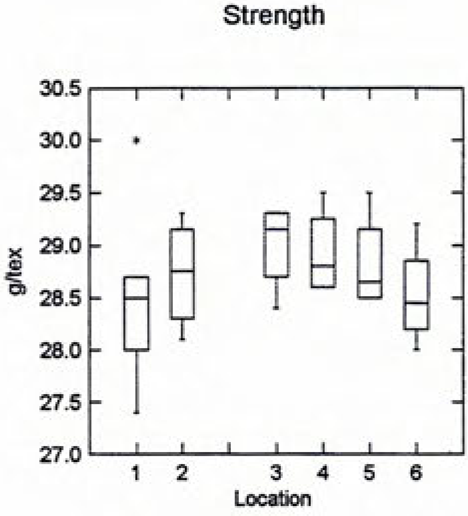


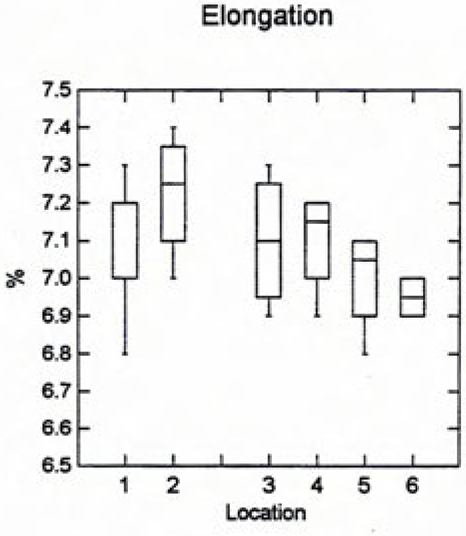
2. HVI Data


Micronaire
5.0
4.9
4.8
4.7
4.6
4.5
4.4
4.3
4.2
4.1
4.0
1 2 3 4 5 6
Location

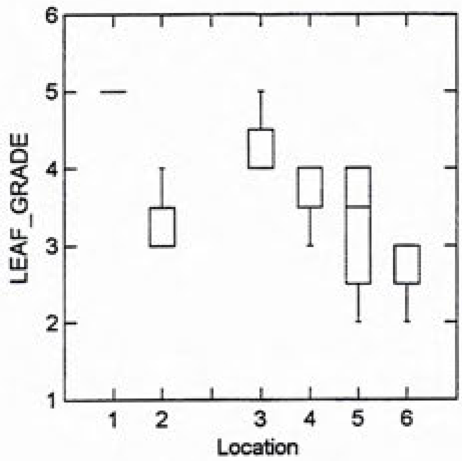

Upper Half Mean Length
inches
1.10
1.09
1.08
1.07
1.06
1.05
1.04
1.03
1.02
1.01
1.00
1 2 3 4 5 6
Location


Uniformity
%
85.0
84.5
84.0
83.5
83.0
82.5
82.0
81.5
81.0
80.5
80.0
1 2 3 4 5 6
Location

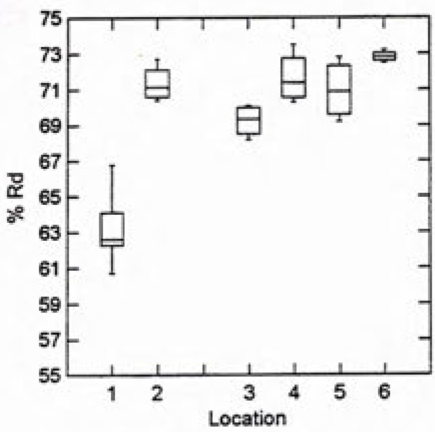

Strength
g/tex
30.5
30.0
29.5
29.0
28.5
28.0
27.5
27.0
1 2 3 4 5 6
Location


Elongation
%
7.5
7.4
7.3
7.2
7.1
7.0
6.9
6.8
6.7
6.6
6.5
1 2 3 4 5 6
Location

Leaf Grade



Reflectance



Yellowness