[Source: SRRC New Orleans]

# Analysis of 1998 Cotton Quality Trial

CRDC Project NEC3C

# Analysis of 1998 Cotton Quality Trial

by

Grant Roberts, PhD, BEng(Ag)
National Centre for Engineering in Agriculture
Toowoomba Q, Australia

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# Executive Summary

The study underlying this report was concerned with taking samples of seedcotton from the field and tracking them through the stages of ginning, spinning, and fabric production. Data on various attributes of the cotton was collected at several stages. The study has been designed from the standpoint that cotton is ultimately valued at the consumer product level, so the best way to gauge the effects of a particular factor in cotton processing is to analyze its effect on realised quality, that is, quality seen at the fabric stage.

Prediction is one of the most important parts of the results of this project. Tbe vision is to have a historical record of various lint attributes and the resulting realised quality (particularly white speck neppiness) that will allow the prediction of the realised quality of current day lint at the gin loadout door. This would bave the effect of removing much of the uncertainty in a multi-million dollar production chain that might involve several changes of ownership as well as long distances and long periods to produce a finisbed product.

The study supports the following conclusions:

- The instrumentation currently used to class raw cotton has the potential to be useful in predicting fabric quality at the gin load-out door;
- When combined with more advanced instrumentation currently under development, there is now a real prospect of being able to reduce the uncertainty currently involved in buying raw cotton, reducing the associated risk margin in pricing and also the incentive to substitute synthetic chemical fibres;
- For the same reasons, sellers of raw cotton will be able to know more about their cotton, and so have more scope to direct it to suitable markets according to its particular quality, for better returns;
- One year's worth of results is sufficient to answer general questions but a deeper pool of data from future years is needed to refine the numerical answers;
- Australian cotton does score lower than USA cotton (a convenient benchmark) in terms of white speck neps. The difference is not large enough to cause immediate problems, but it is clear;
- White speck neps are not currently in the customary classing regime but they are clearly in the minds of buyers. In combination with the white speck nep results of this report, this indicates a need for further research in the areas of breeding, agronomy, and processing addressed particularly at immature fibre and pbysical damage to fibre.

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# 1. Introduction

## 1.1 History

This report was foreshadowed in, and is in addition to, a report forwarded to the CRDC in September 2000 titled "Cotton ginning with emphasis on cotton quality" NCEA publication 179713/1.

At that time the data for the 1998 trial was only recently received, and the necessary analysis could not be done properly in time for the deadline. In the event, there have been further revisions to the data as a result of a preliminary analysis. These changes were related mainly to adjustment factors for different coverage ratios in different fabric constructions. There were also changes brought about by re-testing under computer image analysis. The data presented in this report was received by the author in late October 2000 (1998 trial data) and mid November 2000 (comparative USA data).

Some of the results reported in the September 2000 report have changed in this report. This has occurred both as a result of changes in the data and a review of the statistical methods.

## 1.2 Project description

The study underlying this report was concerned with taking samples of seedcotton from the field and tracking them through the stages of ginning, spinning, and fabric production. Data on various attributes of the cotton was collected at several stages. The study has been designed from the standpoint that cotton is ultimately valued at the consumer product level, so the best way to gauge the effects of a particular factor in cotton processing is to analyze its effect on realised quality, that is, quality seen at the fabric stage.

This data is analysed here in two main ways:

- Taking data for single attributes (*e.g.* HVI micronaire, AFIS nep counts, 'percent area of fabric taken up by white speck neps') and seeing if groups within that data (*e.g.* the region in which it was grown, the number of lint cleaners used during ginning, the type and fineness of the spinning) have statistically significant differences in their averages;
- Taking one or more attributes and relating them to another attribute from later in the production chain to see if the former can accurately predict the latter.

Unless specified otherwise, the data used here is for Ring spun 36's yarns or the fabric made from them, that were made from lint that had gone through one lint cleaner in the gin. The sample size is 30, except where lint cleaner treatments are compared in which case the sample size is 60.

# 2. Results

## 2.1 International comparisons

This section compares the 1998 Australian data with two studies in the USA.

- 1987 data from a study that produced cotton with a wide range of neppiness for a mechanical processing study (Bel-Berger *et al.*, 1996) (the 'Extreme Varieties Study' or EVS);
- 1993 data from a periodic USA study that describes a selection of cotton bales from the USA cotton industry (Bel-Berger *et al.*, 1997) (the 'Leading Varieties Study' or LVS).

In each case, the yarn construction, dyeing method, fabric construction and method of white speck nep analysis is comparable or the data can be simply adjusted to make it so.

**Figure 1** shows the data sets side by side for comparison. The data relates to the 'percent area of fabric taken up by white speck neps'. From the left, the data sets are:

- the single carded group from the EVS;
- a control group from the LVS, grown under identical field treatments;
- the standard group from the LVS;
- a group of samples from the LVS that were combed prior to analysis;
- a group of samples from the LVS that were known to have undergone aggressive cleaning in the gin, due to the fact that they were stripper harvested and/or had gone through three lint cleaners;
- the 1998 Australian data.

The USA data that is most comparable to the Australian data is the LVS standard group. The averages for 'percent fabric area taken up by white speck neps' were 0.025% and 0.040% respectively, and the difference was significant with $p < 1\%$.

It is worth noting that the USA samples were pre-selected for inclusion in the original study in a manner that precluded 'outliers'. The Australian samples were not preselected, and it is possible that some of the higher scores in 'percent fabric area taken up by white specks' might not have arisen had the same pre-selection taken place. The average for the Australian data may be slightly elevated by this difference.

## 2.2 Comparisons between groups

In this section, the significance level for analysis of variance is fixed at 5%. Where significance is indicated by analysis of variance, subsequent comparisons of averages use a more stringent level of significance of 2.5%, to reduce the chance of 'false positives' when many tests are involved.

### 2.2.1 Comparing Regions on the basis of white speck neps

Samples had been obtained from the Emerald, St George, and eastern Darling Downs regions. There were no statistically significant differences between regions on the basis of 'percent area of fabric taken up by white speck neps'. The data is shown graphically in **Figure 2.**

### 2.2.2 Comparing Regions on the basis of Uster yarn non-uniformity

**Figure 3** shows the result of comparing growing regions on the basis of the yarn non-uniformity attribute (UNU) reported by the widely used Uster yarn tester. UNU is a coefficient of variation, so the lower the number, the better the yarn.

There were statistically significant differences in average UNU. St George had lower UNU than Emerald (17.9 to 19.2) with p=2%. The eastern Darling Downs had lower UNU than Emerald also (18.1 to 19.2) with p=1%. The difference between St George and the eastern Downs was not statistically significant.

### 2.2.3 Comparing Regions on the basis of HVI results

Table 1 shows the region averages for ten HVI attributes, from testing carried out by the USDA AMS in Memphis TN.

Table 1

| **HVI attribute** | **Emerald** | **St George** | **e. Darling Downs** |
|---|---|---|---|
| **Colour grade** | 22.3 | 12.4 | 21.7 |
| **Trash grade** | 2.1 | 1.7 | 2.3 |
| **Staple grade** | 37.1 | 37.9 | 36.9 |
| **UHML** | 1.16 | 1.18 | 1.15 |
| **Length uniformity** | 81.0 | 82.5 | 81.9 |
| **Strength** | 30.1 | 32.6 | 31.6 |
| **Micronaire** | 4.24 | 4.20 | 4.15 |
| **Trash area** | 0.259 | 0.183 | 0.262 |
| **Reflectance** | 81.3 | 82.8 | 80.0 |
| **Yellowness** | 8.21 | 8.62 | 8.61 |

Some of the differences between the region averages in the above table were statistically significant. Table 2 presents the results of comparing all three regions with each other on the basis of the ten HVI attributes. Tests were carried out using the one way ANOVA procedure and Student's t-test. Across the top are the three possible tests within regions. A dash (-) in a cell indicates the differences were not statistically significant, while a smiling face (☺) on one side of a cell indicates that that region scored better for that attribute versus the other region, and that the difference was statistically significant at the 5% level.

Table 2

| | Emerald | StGeorge | Emerald | Downs | StGeorge | Downs |
|---|---|---|---|---|---|---|
| Colour grade | - | - | - | - | - | - |
| Trash grade | - | - | - | - | - | - |
| Staple grade | ☹ | ☺ | - | - | - | - |
| UHML | ☹ | ☺ | - | - | ☺ | ☹ |
| Length Unif. | ☹ | ☺ | ☹ | ☺ | - | - |
| Strength | ☹ | ☺ | ☹ | ☺ | ☺ | ☹ |
| Micronaire | - | - | - | - | - | - |
| Trash area | - | - | - | - | - | - |
| Reflectance | - | - | - | - | - | - |
| Yellowness | - | - | - | - | - | - |

Only 8 out of the 30 comparisons were statistically significant. Those that were showed that the St George region scored better than both the Downs and Emerald, and the Downs scored better than Emerald.

### 2.2.4 Comparing Regions on the basis of AFIS results

Comparisons were made between regions on the basis of the following attributes reported by the AFIS device:

- lint Nep count (neps/g) (ABN);
- immature fibre content (%) (ABIFC);
- maturity ratio (%) (ABMR);
- short fibre content (%) (ABSW);

Only ABSW showed statistically significant differences. The data is shown graphically in **Figure 4**.

The Downs produced lower SFC than Emerald (9.8% to 11.2%). The difference between St George and the Downs, and between St George and Emerald, was not statistically signficant.

This testing was carried out at the Cotton Incorporated research facility in the USA, as the AFIS devices at the SRRC in New Orleans have not become available to this project as yet.

### 2.2.5 Comparing Varieties on the basis of white speck neps

There were no statistically significant differences between varieties on the basis of 'percent area of fabric taken up by white speck neps'. Tbe data is shown graphically in **Figure 5**.

### 2.2.6 Comparing Varieties on the basis of Uster yarn non-uniformity

Table 3 shows the results of comparing varieties on the basis of the non-uniformity attribute (UNU) reported by the widely used Uster yarn tester. UNU is a coefficient of variation, so the lower the number, the better the yarn.

Table 3

| Variety | UNU (avg) |
|---|---|
| **V2** | 17.2 |
| **V15** | 17.4 |
| **V15i** | 17.9 |
| **V2i** | 18.0 |
| **CS50** | 18.3 |
| **Si189** | 18.5 |
| **D Pearl** | 19.7 |
| **NuC37** | 19.7 |

The data is shown graphically in **Figure 6**.

Some of the differences between the UNU averages in Table 3 are significant, as shown in Table 4 by the symbol '✓'.

Table 4

| | **V2** | **V15** | **V15i** | **V2i** | **CS50** | **Si189** | **D Pearl** | **NuC37** |
|---|---|---|---|---|---|---|---|---|
| **V2** | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| **V15** | | | | | | ✓ | ✓ | ✓ |
| **V15i** | | | | | | | ✓ | ✓ |
| **V2i** | | | | | | | ✓ | ✓ |
| **CS50** | | | | | | | | |
| **Si189** | | | | | | | ✓ | ✓ |
| **D Pearl** | | | | | | | | |
| **NuC37** | | | | | | | | |

If one variety is listed ahead of another in table 3 and the difference is significant (✓) in table 4, then the former can be said to have performed better in this trial than the latter in terms of Uster Yarn non-uniformity index.

## 2.2.7 Comparing Varieties on the basis of HVI results

The eight varieties were compared for differences in averages of three HVI attributes:

- Upper half mean length (HUHML);
- Length uniformity (HLU);
- micronaire (HMIC).

Only the HLU attribute showed statistically significant differences between the varieties.

Table 5

| Variety | HLU (avg) |
|---|---|
| **V2i** | 82.5 |
| **V2** | 82.4 |
| **V15** | 82.4 |
| **V15i** | 82.0 |
| **Si189** | 81.8 |
| **CS50** | 81.3 |
| **NuC37** | 81.0 |
| **D Pearl** | 80.8 |

Some of the differences in average HLU in Table 5 are significant, as shown in Table 6 by the symbol '✓'.

Table 6

| | **V2i** | **V2** | **V15** | **V15i** | **Si189** | **CS50** | **NuC37** | **D Pearl** |
|---|---|---|---|---|---|---|---|---|
| **V2i** | | | | | | | ✓ | ✓ |
| **V2** | | | | | | ✓ | ✓ | ✓ |
| **V15** | | | | | | ✓ | ✓ | ✓ |
| **V15i** | | | | | | | | |
| **Si189** | | | | | | | | ✓ |
| **CS50** | | | | | | | | |
| **NuC37** | | | | | | | | |
| **D Pearl** | | | | | | | | |

If one variety is listed ahead of another in table 5 and the difference is significant (✓) in table 6, then the former can be said to have performed better in this trial than the latter in terms of length uniformity.

### 2.2.8 Comparing Varieties on the basis of AFIS results.

Comparisons were made between regions on the basis of the following attributes reported by the AFIS device:

- lint Nep count (neps/g) (ABN);
- immature fibre content (%) (ABIFC);
- maturity ratio (%) (ABMR);
- short fibre content (%) (ABSW);

Only ABSW was found to produce statistically significant results. The data is shown graphically in **Figure 7**.

Table 7 shows the results of comparing varieties on the basis of ABSW. The lower the number, the better the quality of the lint.

Table 7

| **Variety** | **ABSW** |
|---|---|
| V2 | 8.3 |
| V15 | 9.1 |
| V2i | 9.3 |
| V15i | 9.8 |
| Si189 | 10.3 |
| NuC37 | 10.8 |
| CS50 | 10.9 |
| D Pearl | 12.1 |

Some of the differences in average ABSW in Table 7 are significant, as shown in Table 8 by the symhol '✓'.

Table 8

| | V2 | V15 | V2i | V15i | Si189 | NuC37 | CS50 | D Pearl |
|---|---|---|---|---|---|---|---|---|
| **V2** | | | | | | ✓ | | ✓ |
| **V15** | | | | | | | | ✓ |
| **V2i** | | | | | | | | ✓ |
| **V15i** | | | | | | | | |
| **Si189** | | | | | | | | ✓ |
| **NuC37** | | | | | | | | ✓ |
| **CS50** | | | | | | | | |
| **D Pearl** | | | | | | | | |

If one variety is listed ahead of another in table 7 and the difference is significant (✓) in table 8, then the former can be said to have performed better in this trial than the latter in terms of the short fibre content reported by the AFIS device.

### 2.2.9 Comparing lint cleaner treatments in the gin on the basis of white speck neps

The field samples of seedcotton were split at the gin, with one half going through one lint cleaner and the other through two lint cleaners.

It was found that there were no statistically significant differences between the two gin treatments in the 'percent area of fabric taken up by white speck neps'.

The data is shown graphically in **Figure 8**.

### 2.2.10 Comparing lint cleaner treatments in the gin on the basis of Uster yarn non-uniformity

The yarn made from the two gin treatments was compared on the basis of the non-uniformity attribute (UNU) reported by the widely used Uster yarn tester. It was found that there were no statistically significant differences in the UNU attribute between the two gin treatments.

The data is shown graphically in **Figure 9**.

## 2.2.11 Comparing lint cleaner treatments in the gin on the basis of HVI results

The ginned lint arising from the two gin lint cleaner treatments was compared on the basis of the following HVI attributes:
- Upper half mean length (HUHML);
- Length uniformity (HLU);
- micronaire (HMIC).

It was found that there were no statistically significant differences in any of these HVI attributes on the basis of the lint cleaner treatment.

## 2.2.12 Comparing lint cleaner treatments in the gin on the basis of AFIS results

There were two lint cleaner treatments. One half of each sample went through one lint cleaner, the other half went through two lint cleaners. The data arising from the two treatments was compared on the basis of the following AFIS attributes:
- lint Nep count (neps/g) (ABN);
- short fibre content (%) (ABSW);
- immature fibre content (%) (ABIFC);
- total trash (ug) (ABT);
- trash average size (um) (ABTS);
- Dust content (ug) (ABD);
- Visible fine matter (ABVFM).

The occurrence of lint neps (ABN) (neps as defined by the counting algorithm of that particular device) was the only attribute to produce a statistically significant difference between lint cleaner treatments. The 'one lint cleaner' treatment produced 243 neps/g on average, while the 'two lint cleaner' number was 25% higher at 303 neps/g.

The ABN data is shown graphically in **Figure 10.**

## 2.2.13 Comparing spinning treatments on the basis of white speck neps

A two way ANOVA analysis was carried out on the data for 'percent area of fabric taken up by white speck neps', comparing ring versus open end yarns at the same time as the finer versus coarser yarns for each spinning format.

The data is shown graphically in **Figure 11.**

It was found that the ring versus open end effect was strongly significant (p << 5%).

Table 9

| WSA (%) | |
|---|---|
| **Ring** | 0.04328 |
| **Open end** | 0.00955 |

Neither the 'finer versus coarser' effect nor the interaction were statistically significant (p >> 5%).

**In addition**, the 22's Ne yarns were common to both formats (Ring and Open Ended), and were compared on the basis of 'percent area of fabric taken up by white speck neps'.

It was found that the 22's open ended yarns produced 76% lower white speck neps than the 22's ring spun yarns, 0.04104 to 0.00969. This difference was strongly statistically significant, with p << 5%.

## 2.2.14 Comparing spinning treatments on the basis of Uster yarn non-uniformity

A two way ANOVA analysis was also carried out on the data for the non-uniformity attribute (UNU) reported by the widely used Uster yarn tester. The data is shown graphically in **Figure 12.**

It was found that the ring versus open end effect, the finer versus coarser effect, and the interaction term were all highly significant, with p << 5%.

Table 10

| UNU (CV%) | Finer | Coarser |
|---|---|---|
| **Ring** | 18.3 | 15.2 |
| **Open end** | 13.4 | 11.4 |

## 2.3 Prediction

### 2.3.1 Predicting Uster data given HVI data

The ten available HVI attributes were examined to test their ability to predict (a) the Uster non-uniformity attribute (UNU) and (b) the 'Thin places per 1000 yards' (UTN) attribute.

*UNU*

The following HVI attributes were found to be the most useful for predicting UNU (significance for inclusion 0.10, removal 0.11):

- length uniformity (HLU);
- trash grade (HTG);
- colour grade (HCG);
- yellowness (HY);
- micronaire (HMIC);
- staple grade (HSG).

These attributes produced the following relationship with an $R^2$ (percent of variation explained) of 85%:

$$UNU = 69.8 - 0.646*HLU - 0.843*HTG + 0.327*HCG - 0.393*HY + 0.804*HMIC + 0.199*HSG$$

This relationship is shown graphically in **Figure 13**.

*UTN*

The following HVI attributes were found to be the most useful for predicting UTN (significance for inclusion 0.10, removal 0.11):

- length uniformity (HLU);
- micronaire (HMIC);
- staple grade (HSG);
- upper half mean length (HUHML);

These attributes produced the following relationship with an $R^2$ (percent of variation explained) of 81%:

$$UTN = 4550 - 64.0*HLU - 55.4*HMIC + 65.9*HSG - 1640*HUHML$$

This relationship is shown graphically in **Figure 14**.

### 2.3.2 Predicting white speck neps given Uster data

All four Uster attributes (UNU, UTK, UTN, UNR) were examined, but it was found that none had anything approaching a meaningful relationship to 'percent area of fabric taken up by white speck neps' (WSA), based on values of significance.

### 2.3.3 Predicting white speck neps given HVI data

All ten HVI attributes were analysed to determine their ability to predict the 'percent area of fabric taken up by white speck neps' (WSA). It was found that two had a relationship to WSA that was non-random (significance for inclusion 0.10, removal 0.11). These were:

- micronaire (HMIC);
- length uniformity (HLU).

These attributes used together produced a relationship with an $R^2$ (percent of variation explained) of 76%:

WSA = -0.760 - 0.0618*HMIC + 0.00465*HLU

This relationship is shown graphically in **Figure 15**.

### 2.3.4 Predicting white speck neps given AFIS data

There were 21 AFIS attributes available for analysis. When all were used to examine their ability to predict the 'percent area of fabric taken up by white speck neps' (WSA), only the following were found to have a meaningful relationship with WSA, based on the values of significance(sig. for inclusion 0.10, removal 0.11):

- fineness (mtex) (ABF);
- seed coat nep size (um) (ABNSS);
- visible fine matter (%) (ABVFM);

These attributes used together produced a relationship with an $R^2$ (percent of variation explained) of 78%:

WSA = 0.550 - 0.00271*ABF - 0.0000727*ABNSS + 0.0116*ABVFM

This relationship is shown graphically in **Figure 16**.

## 2.3.5 Predicting white speck neps given AFIS data and HVI data

All of the available HVI and AFIS lint data was analysed simultaneously to see if the combination produced better results than the two types analysed separately.

There were a total of 31 AFIS and HVI attributes available for analysis. When they were examined for their ability to predict the 'percent area of fabric taken up by white speck neps' (WSA), the following were found to have a meaningful relationship with WSA, based on the values of significance (sig. for inclusion 0.10, removal 0.11):

- micronaire (HMIC);
- length uniformity (HLU).
- lint Nep count (neps/g) (ABN);
- seed coat nep size (um) (ABNSS).

These attributes used together produced a relationship with an $R^2$ (percent of variation explained) of 83%:

WSA = -0.405 - 0.0430*HMIC + 0.00791*HLU + 0.000170*ABN - 0.0000577*ABNSS

This relationship is shown graphically in **Figure 17**.

# 3. Discussion

## 3.1 International comparisons

In summary: both samples are classified as being low in white speck neps, the Australian cotton was higher in fabric white speck neps than the USA cotton, and this difference was clearly significant. The difference is probably not as great as it first looks, because of the different ways in which samples were included in the studies. However, this is unlikely to have changed the ranking of the countries.

## 3.2 Comparisons between groups

### 3.2.1 Comparing Regions on the basis of white speck neps.

The data did not show up any statistically significant differences between the regions.

1998 was a universally good year for cotton, with late season and harvest conditions near perfect. As a result, the effect of some regions having poor conditions during fibre maturation, and others not, was not seen. In a more 'average' year the differences would be expected to be more clearly visible.

### 3.2.2 Comparing Regions on the basis of Uster yarn uniformity

It appears that Emerald scores poorer than St George and the Downs on the basis of yarn non-uniformity. The reason is unlikely to be 'high mic' because there were no statistically significant differences between the regions on the basis of micronaire (see below). However, there were statistically significant differences on the basis of length uniformity, and length uniformity turns out to be relatively important in predicting yarn non-uniformity (see below).

### 3.2.3 Comparing Regions on the basis of HVI results

St George scored clearly better that Emerald on staple grade and upper half mean length, and also on strength and length uniformity. St George scored better than the Downs on upper half mean length, strength, and length uniformity. The Downs scored better than Emerald on length uniformity and strength.

Staple grade and upper half mean length are related in their physical basis, and the same applies for strength and length uniformity. These results indicate that statistically significant differences also occur according to that pattern.

In addition, it can be seen from Table 2 that the HVI attributes that showed statistically significant differences between regions are those in which the Australian crop is usually expected to do well. This suggests some variability (even in a good year) in those attributes on which the Australian industry relies.

### 3.2.4 Comparing Regions on the basis of AFIS results

Only the short fibre content attribute showed statistically significant differences, which is probably related to the results in the HVI section immediately above. The AFIS device was unable to show up statistically significant differences between regions on the basis of lint nep count (ABN), immature fibre content (ABIFC) and maturity ratio.

1998 was a universally good year for cotton, with late season and harvest conditions near perfect. In a more 'average' year the differences would be expected to be more clearly visible.

### 3.2.5 Comparing Varieties on the basis of white speck neps

The data did not show any statistically significant differences between the varieties. On Figure 5 there appears to be at least one variety that performs relatively well but the differences overall are not distinct enough that a reliable judgement can be made.

As before, 1998 was a universally good year for cotton, with late season and harvest conditions near perfect. It is expected that different varieties possess different abilities to compensate for less than perfect conditions, so a more 'average' year the differences would be expected to be more clearly visible.

### 3.2.6 Comparing Varieties on the basis of Uster yarn non-uniformity

Figure 6 displays the relative performance of the varieties.

V2 was the clear winner in yarn non-uniformity, while Delta Pearl and NuCOTN37 (varieties which have some shared lineage) were at the opposite end of this particular scale. Other differences were less clear.

### 3.2.7 Comparing Varieties on the basis of HVI results

Of the three attributes examined, only length uniformity showed statistically significant differences, and then only between some of the varieties.

### 3.2.8 Comparing Varieties on the basis of AFIS results.

Of the four attrihutes examined, only short fibre content showed statistically significant differences, and then only between some of the varieties. This was similar to the HVI section (above). Note that short fibre content is related to length uniformity in its physical hasis.

### 3.2.9 Comparing lint cleaner treatments in the gin on the basis of AFIS results

The only AFIS attribute to show statistically significant differences between lint cleaner treatments was the nep count (ABN) as defined by AFIS counting algorithm.

It is interesting to note that ABN was not found to show statistically significant differences elsewhere in this analysis. The only other section that ABN was found to be useful was when the AFIS and HVI attributes were analysed simultaneously for prediction (see below).

The result indicates that the samples which had the extra stage of lint cleaning produced fabric of a lower quality in terms of white speck neps. There were no statistically significant differences in colour grade, trash grade, or trash area (HVI attributes) or total trash, trash average size, dust, and visible fine matter (AFIS attributes) that might be judged to compensate for the 'percent area of fabric taken up by white speck neps' result.

### 3.2.10 Comparing spinning treatments on the basis of white speck neps

The analysis showed that the two spinning treatments used produced clearly significant differences in the resulting fabric, a result not unexpected in the industry.

There are two possible reasons for this. Firstly, open ended spinning equipment has a device immediately before the rotor that individualizes the fibres so that they will wrap properly in the rotor. This process works as a kind of comb and will tend to send clumps of fibres (*i.e.* latent neps) in a different direction to fibres, so that the former are lost as dust. Secondly, the differing mass density of clumps compared to fibres will tend to place the former in the centre of a yarn, largely hidden from view.

In addition, the 22's Ne yarn size (common to ring and open ended spinning) when directly compared showed a similar clear difference.

### 3.2.11 Comparing spinning treatments on the basis of Uster yarn non-uniformity

The Uster yarn non-uniformity data showed a clear difference between ring and open-ended spinning and the between the finer and coarser yarns in a simultaneous comparison. The differences were much more significant than some of the other comparisons, which isn't surprising considering a yarn instrument is being used to compare yarn treatments rather than treatments elsewhere in the production chain.

## 3.3 Prediction

### 3.3.1 Multivariate regression

Prediction is one of the most important parts of the results of this project. The vision is to have a historical record of various lint attributes and the resulting realised quality (particularly white speck neppiness) that will allow the prediction of the realised quality of current day lint at the gin loadout door. This would have the effect of removing much of the uncertainty in a multi-million dollar production chain that might involve several changes of ownership as well as long distances and long periods to produce a finished product.

In this section the technique used is termed 'multivariate regression', where a collection of candidate attributes are analysed along with the selected dependent variable to test their ability as a group to predict it. The software application used was 'SPSS™' (ver 10.0).

Because in certain cases the number of candidate attributes is large relative to the number of data points, which causes problems with insufficient degrees of freedom for the analysis, the particular technique used is 'stepwise regression'. Where attributes are listed, the order is the order in which they were added to the model. The earlier an attribute is added, the less random is its relationship to the dependent variable.

The relationships that were investigated are all linear.

The absolute size of a coefficient for an attributes in a model is dependent on the units in which the data is presented for analysis, and says nothing about the reliability of the relationship.

The sign of a coefficient is important, because it says whether an increase in an attribute decreases or increases the dependant variable.

The $R^2$ values that are quoted nominate what percentage of the variation in the dependent variable has been explained by the prediction equation. It therefore describes its usefulness. One caveat on this is that individual attributes must not be included in that equation if their relationship to the dependant variable is principally random, as described by the 'significance' or 'p' term. Not including such attributes may in fact <u>decrease</u> the $R^2$ value but will improve the predictive power of the equation.

Another way of interpreting $R^2$ is to look at the percentage <u>not</u> explained and expressing this as the proportion of instances that will be predicted wrongly. For example, an $R^2$ of 87.5% is only moderately reliable because it will be outside of the previously nominated margin of error once in every eight predictions, on average.

### 3.3.2 Predicting Uster data from HVI data

A lot of cotton is traded in the form of yarn, so Uster data is widely referred to in the industry during trading negotiations. At this stage in the production chain, HVI data is the only widely available data and so that is what is used in this particular analysis.

The relationships that were established include a wide selection of the available HVI attributes. They are of moderate reliability with an $R^2$ of 85% for the non-uniformity attribute and 81% for the 'thin places per 1000 yards' attribute.

Note that on these results, higher micronaire makes yarn non-uniformity worse, but it also improves the 'thin places per 1000 yards' attribute.

### 3.3.3 Predicting white speck neps given Uster data.

The level of white speck neps is the realised quality attribute preferred in this project because it represents quality in the form that all cotton is ultimately valued, *i.e.* the consumer item.

The Uster data isn't useful for predicting white speck nep levels. This suggests that although Uster data is useful for predicting utility and efficiency during weaving or knitting (on anecdotal evidence), it has no relevance to predicting the quality of the finished product in terms of white speck neps.

### 3.3.4 Predicting white speck neps given HVI data

HVI data is of particular interest because all Australian cotton is priced at least in part on the basis of HVI results. The infrastructure is in place and the practice is accepted in the industry.

The two HVI attributes that were found to have a non-random relationship to white speck nep levels were micronaire and length uniformity. The prediction equation had an $R^2$ of 76%, which means it will be wrong one in every four instances, on average.

It is reassuring that the colour, trash and simple length attributes were not found suitable for inclusion as they have little or no relevance to the current understanding of nep formation.

Micronaire is adversely affected by immaturity and immature fibre affects the level of white speck neps, so micronaire would be expected to have some power to predict white speck neps. The sign of the coefficient is negative, which means that the higher the micronaire number, the lower the 'percent area of fabric taken up by white speck neps' number. This agrees well with the current understanding of nep formation.

However, length uniformity is difficult to explain. It is difficult to find a physical reason for length uniformity being linked to the 'percent area of fabric taken up by white speck neps'. It is usually taken to be associated with other problems like spinning losses and 'hairy yarn'. In addition, the coefficient has a positive sign. This suggests that the higher the length uniformity number (usually somewhere in the low 80's) the higher the number for 'percent area of fabric taken up by white speck neps', and so the worse the outcome. Length uniformity is an attribute of cotton lint that buyers usually want to maximise, along with micronaire within limits. This result suggests that these attributes are to some extent mutually exclusive.

### 3.3.5 Predicting white speck neps given AFIS data

AFIS data is of particular significance because it is a laboratory device that can produce a wider range of data than the HVI, particularly immature and short fibre content which are required in the industry to answer important questions.

The model arrived at by the analysis has an $R^2$ of 78% which means it will be wrong approximately one in every five instances, on average.

The inclusion of the fineness attribute suggests that the AFIS device is detecting immature fibre by its fineness. This agrees with the current understanding of nep formation where the ultra-fine immature fibre breaks and recoils upon itself due to a lack of longitudinal rigidity.

Most seed coat neps (a kind of biological nep) are removed by wet processing when the offending material is softened and/or dissolved, and so most do not show up as dyeing imperfections (*i.e.* white speck neps). However, some clumps of biological material (*i.e.*

potential seed coat neps) are also associated with immature fibres (Verschraege, 1989), which are not removed by wet processing. This would explain the relationship demonstrated here with white speck neps .

### 3.3.6 Predicting white speck neps given HVI and AFIS data

The same two HVI attributes were suitable for inclusion here as in the case of prediction from HVI attributes alone. The two AFIS attributes found to be suitable for inclusion were nep count per gram (ABN) and seed coat nep size (ABNSS), which is different to the case of prediction from AFIS attributes only.

Lint nep count (neps/g) has direct relevance because the device is attempting to count phenomena in its optical sensor representing entanglements of immature fibre. Seed coat nep size is relevant for the reasons outlined in the previous sub-section.

The prediction equation has an $R^2$ of 83% which is better than either of the HVI or AFIS data sets used alone. This demonstrates the benefits of using as wide a range of data as possible as long as its inclusion is justifiable on physical and statistical grounds.

# 4. Conclusions

Some of the differences between groups within the data set were not statistically significant. There are three possible explanations for this:

- the differences between the groups are negligible;
- the instrumentation is inadequate to discriminate between the groups.
- the uncontrolled nature of this design of trial has resulted in too much 'noise' in the data for the size of the differences;

In addition, the graphs that are listed in the Results section show several instances where particular samples deviate strongly from the predicted numbers, showing that there are other influences that were not included in the analysis that can have a strong effect.

This was to be expected given the design of the project. This study was explicitly designed to be 'uncontrolled', in that most influences on the cotton were left up to the grower providing that they were representative of typical industry practice. This has the advantage that the external validity of the results are improved.

However, this study has shown several important conclusions:

- The instrumentation currently used to class raw cotton has the potential to be useful in predicting fabric quality at the gin load-out door;
- When combined with more advanced instrumentation currently under development, there is now a real prospect of being able to reduce the uncertainty currently involved in buying raw cotton, reducing the associated risk margin in pricing and also the incentive to substitute synthetic chemical fibres;
- For the same reasons, sellers of raw cotton will be able to know more about their cotton, and so have more scope to direct it to suitable markets according to its particular quality, for better returns;
- One year's worth of results is sufficient to answer general questions but a deeper pool of data from future years is needed to refine the numerical answers;
- Australian cotton does score lower than USA cotton (a convenient benchmark) in terms of white speck neps. The difference is not large enough to cause immediate problems, but it is clear;
- White speck neps are not currently in the customary classing regime but they are clearly in the minds of buyers. In combination with the white speck nep results of this report, this indicates a need for further research in the areas of breeding, agronomy, and processing addressed particularly at immature fibre and physical damage to fibre.

# 5. References

Bel-Berger PD, Von Hoven TM, Goynes WR, 1997, 'Varietal effects on the white speck phenomenon', proc. 1997 Beltwide Cotton Conference Vol 1 p 565, National Cotton Council, Memphis TN

Bel-Berger PD, Goynes WR, Von Hoven TM, 1996, 'Mechanical Processing Effects on the White Speck Phenomena' proc. 1996 Beltwide Cotton Conference Vol 2, p 1268, National Cotton Council, Memphis TN

Verschraege L, 1989, 'Cotton Fibre Impurities: Neps, Motes and Seed Coat Fragments', ICAC Review Articles on Cotton Production Research No.1. C.A.B. International. Wallingford, UK.

# 6. Appendix A - Figures

Figure 1

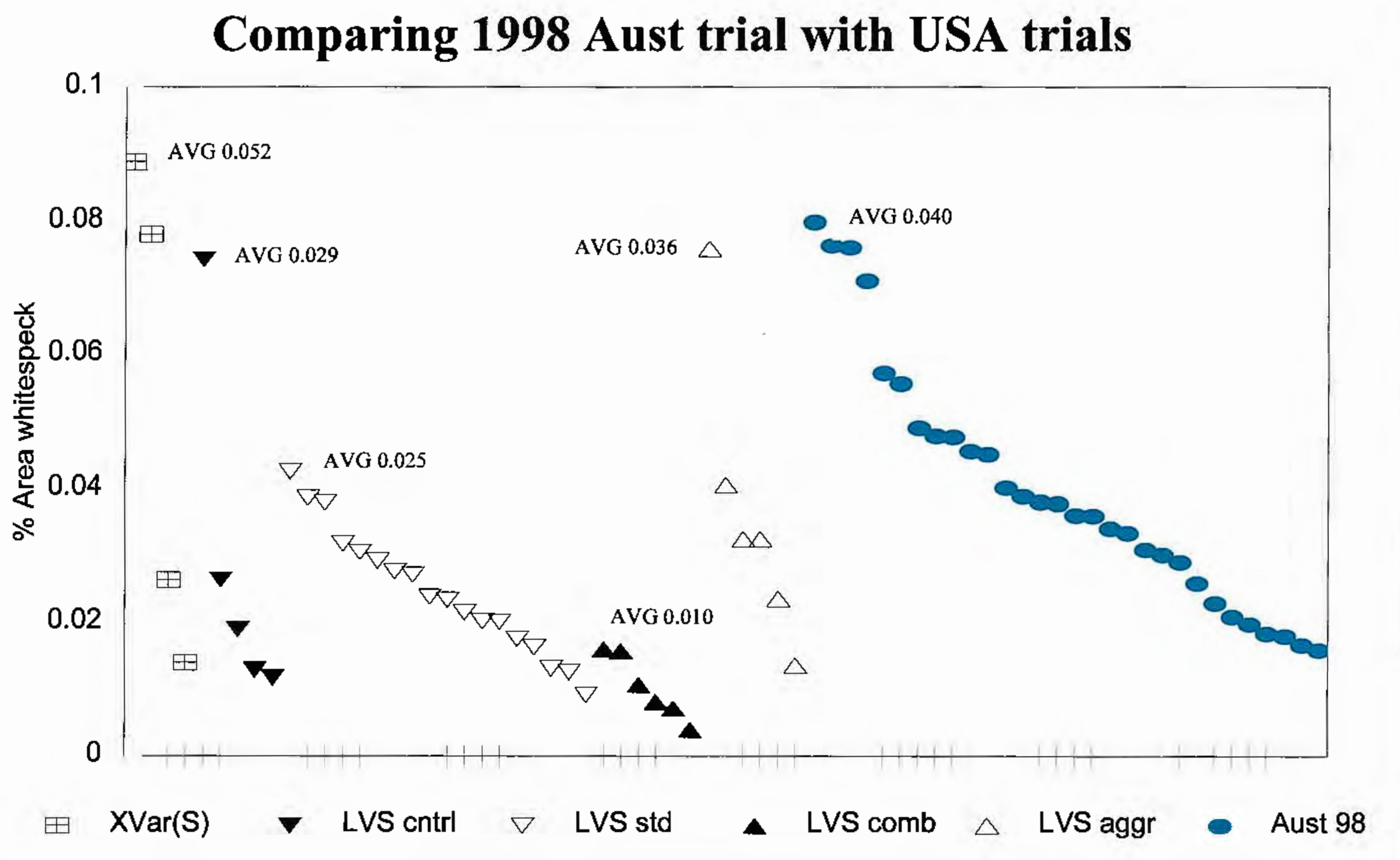
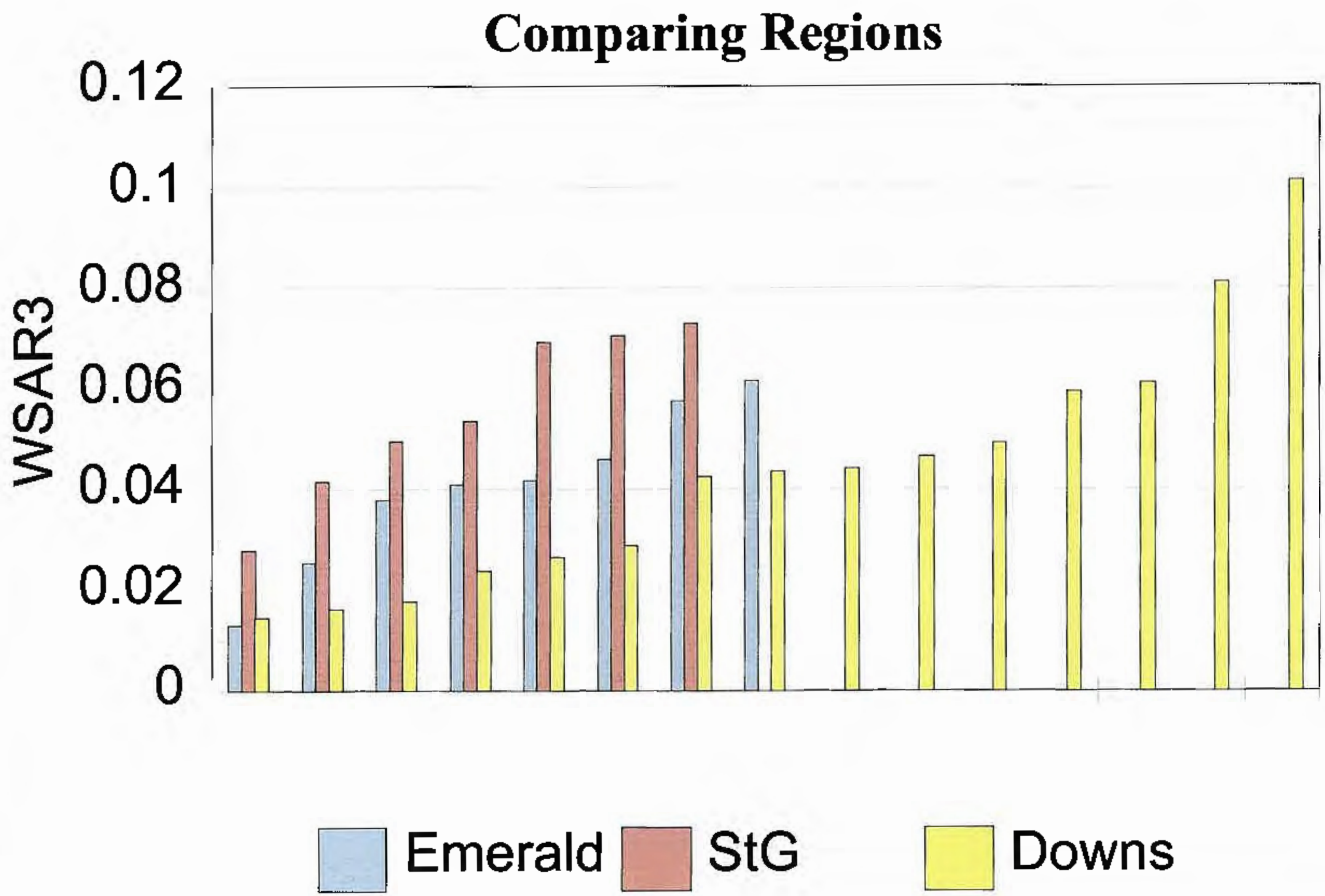

Comparing 1998 Aust trial with USA trials
% Area whitespeck
0.1
0.08
0.06
0.04
0.02
0
AVG 0.052
AVG 0.029
AVG 0.025
AVG 0.010
AVG 0.036
AVG 0.040
XVar(S)
LVS cntrl
LVS std
LVS comb
LVS aggr
Aust 98

Figure 2


Comparing Regions
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0.1
0.08
0.06
0.04
0.02
0
WSAR3
Emerald
StG
Downs

Figure 3

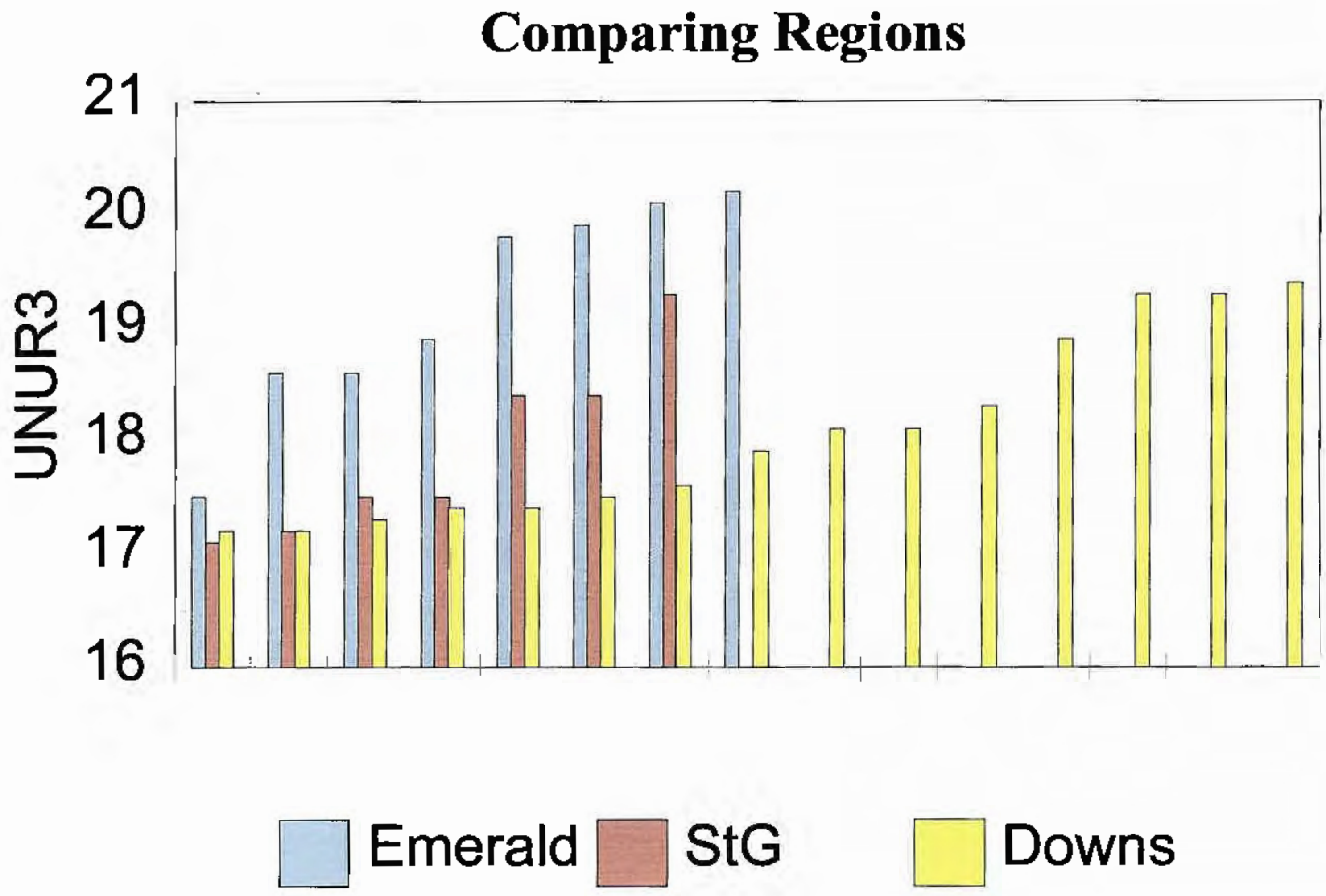


Figure 4

**Comparing Regions**

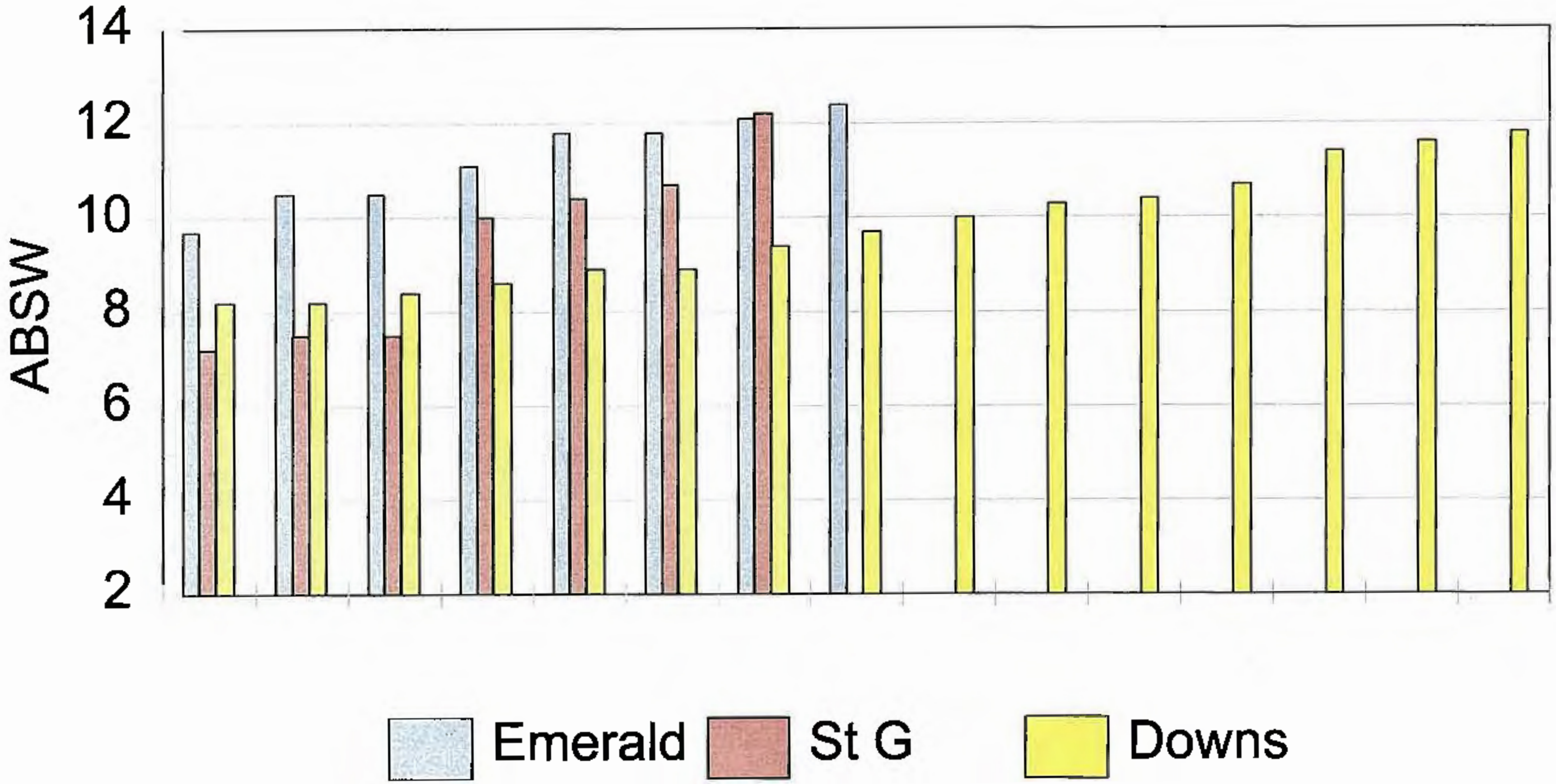
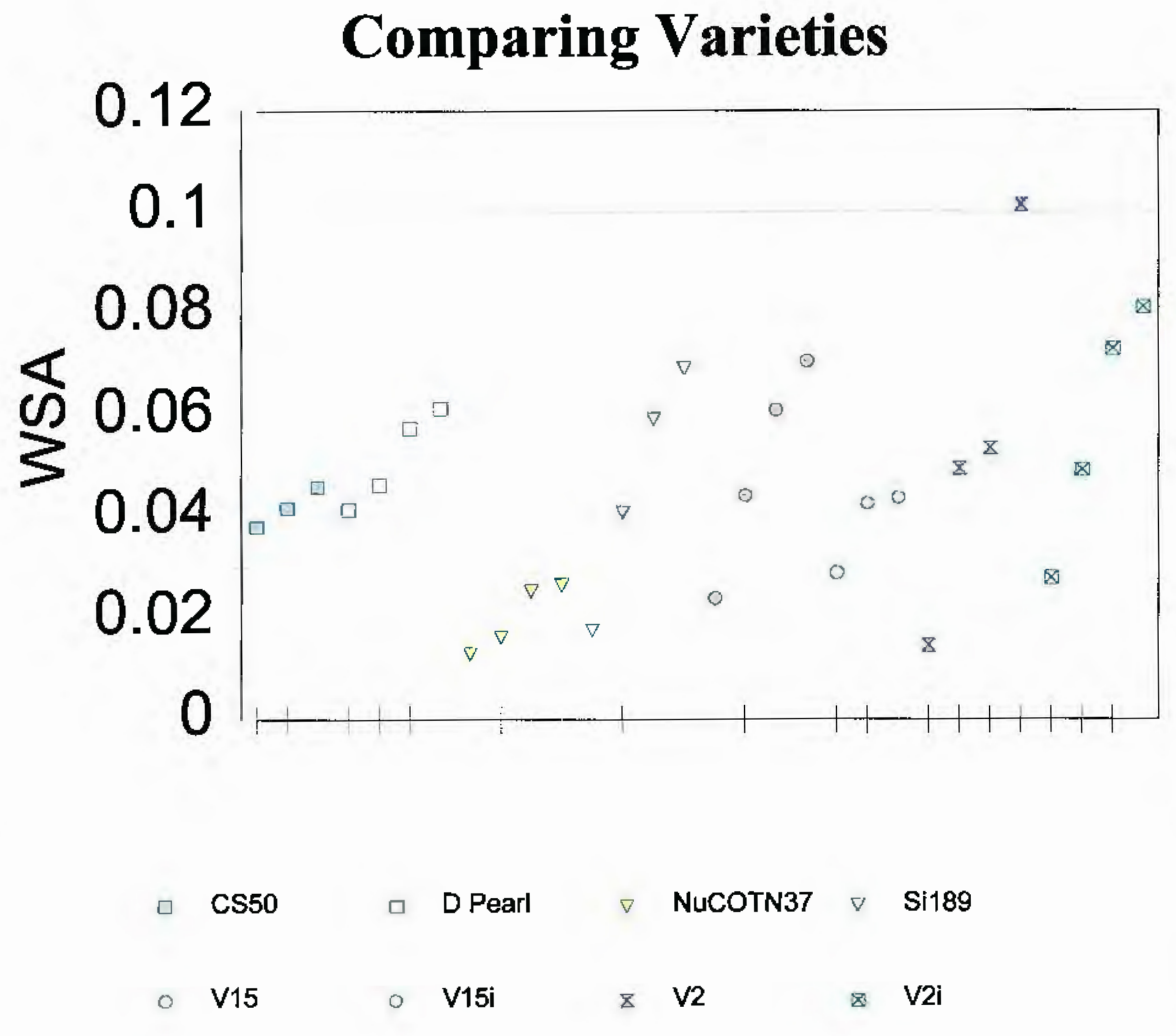


Figure 5


Comparing Varieties
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0.1
0.08
0.06
0.04
0.02
0
CS50
D Pearl
NuCOTN37
Si189
V15
V15i
V2
V2i

Figure 6

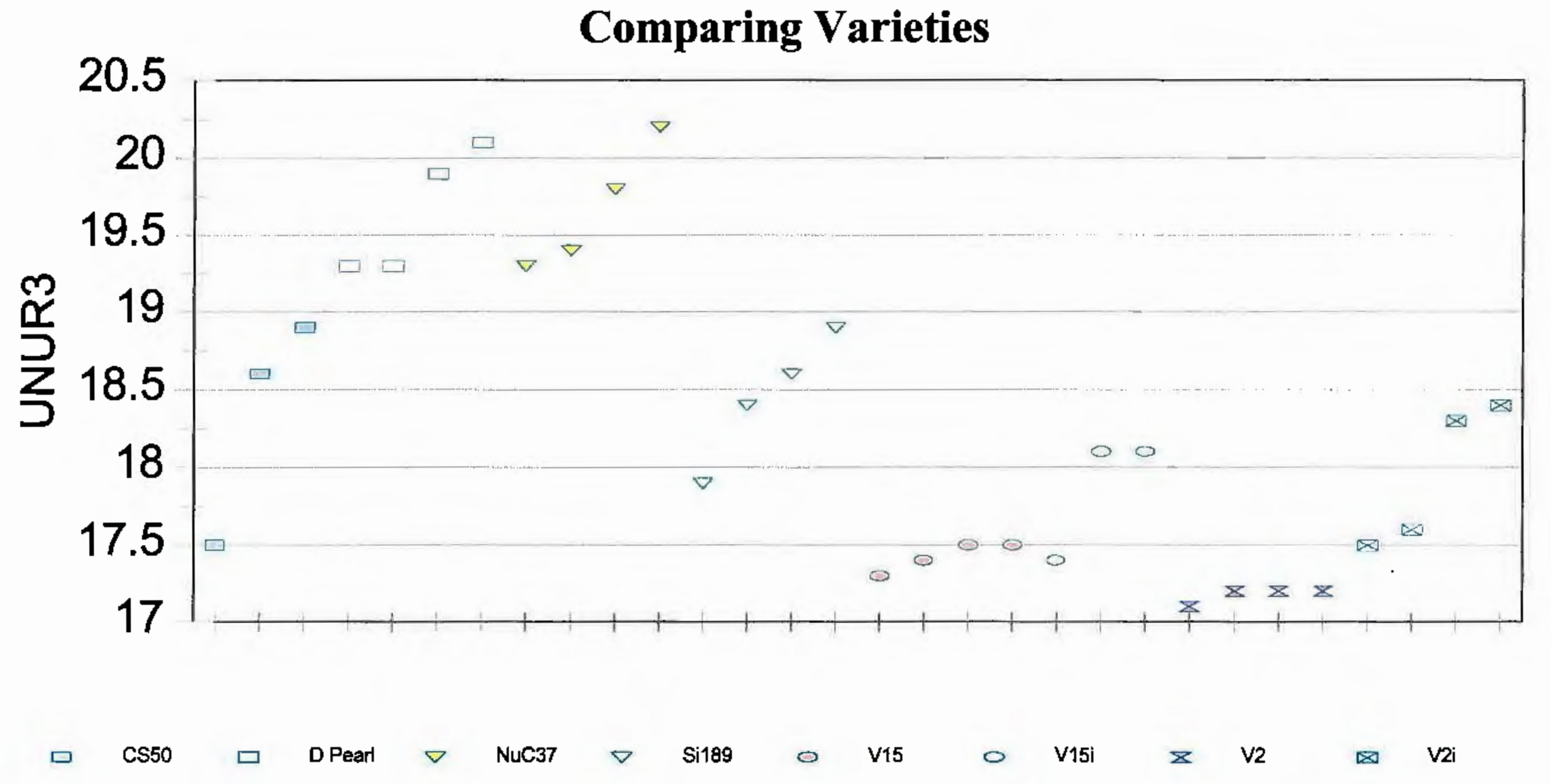

Comparing Varieties
UNUR3
20.5
20
19.5
19
18.5
18
17.5
17
CS50
D Pearl
NuC37
Si189
V15
V15i
V2
V2i

Figure 7

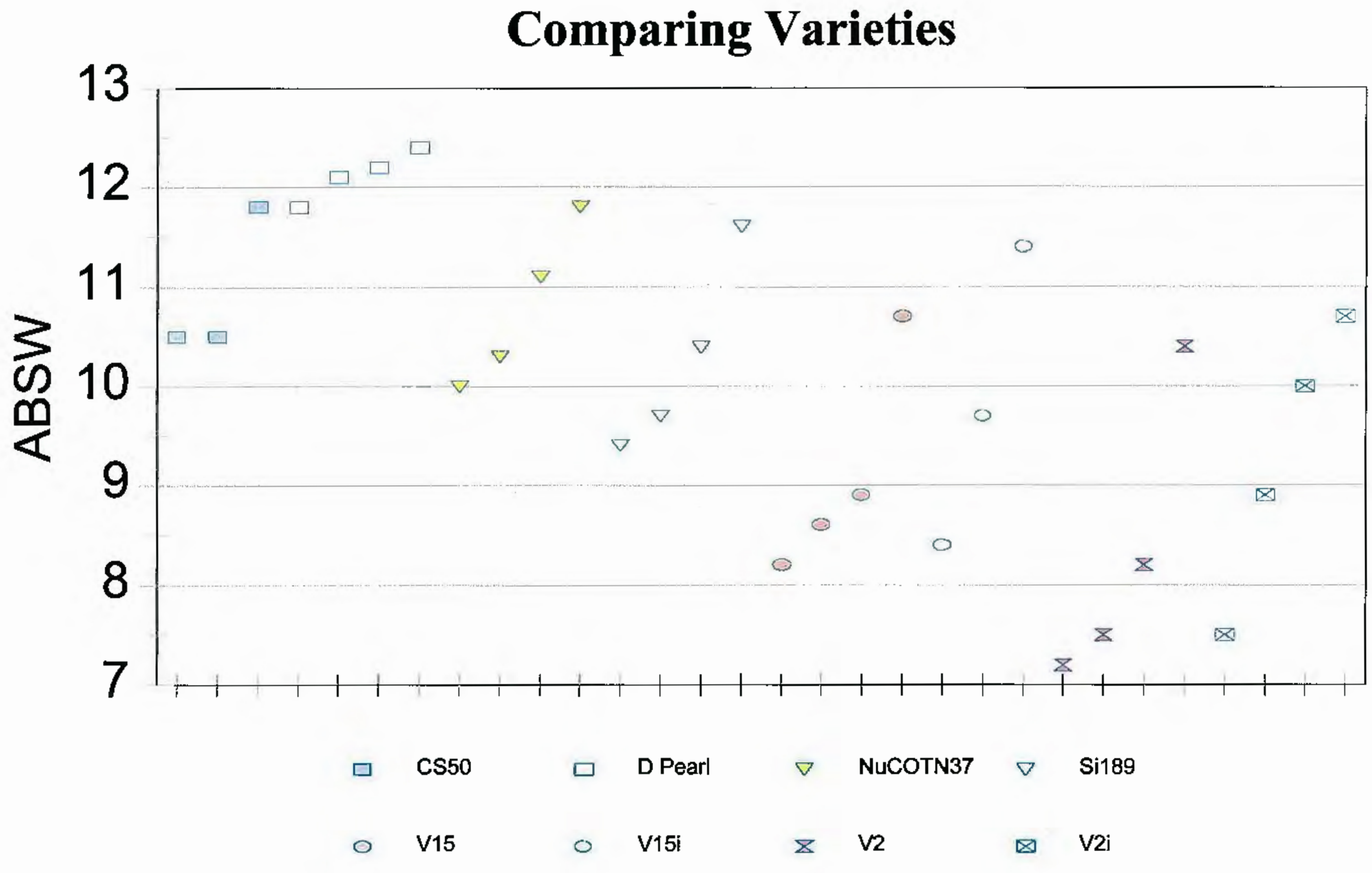
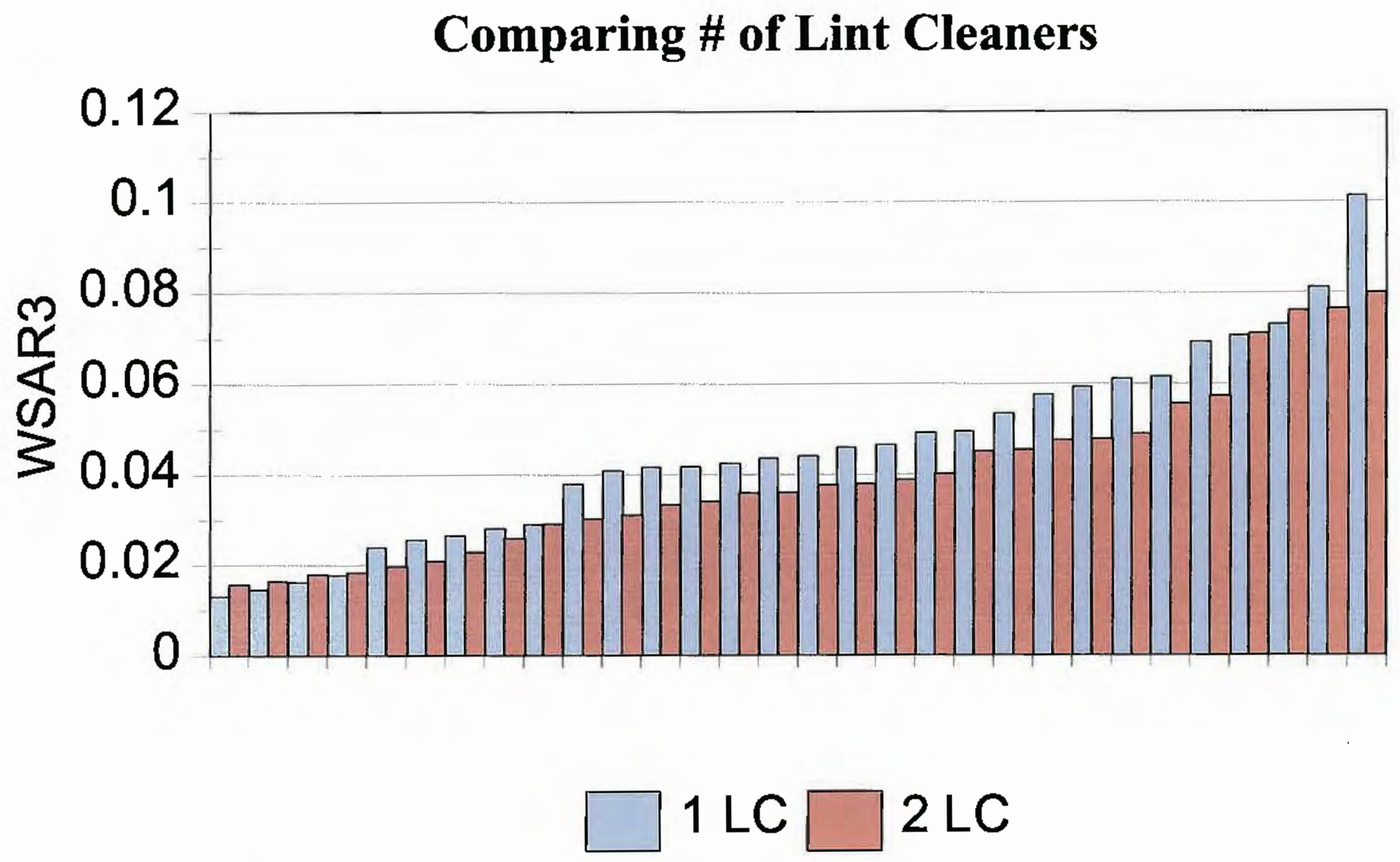

Comparing Varieties
ABSW
13
12
11
10
9
8
7
CS50
D Pearl
NuCOTN37
Si189
V15
V15i
V2
V2i

Figure 8



Comparing # of Lint Cleaners
0.12
0.1
0.08
0.06
0.04
0.02
0
WSAR3
1 LC
2 LC

Figure 9

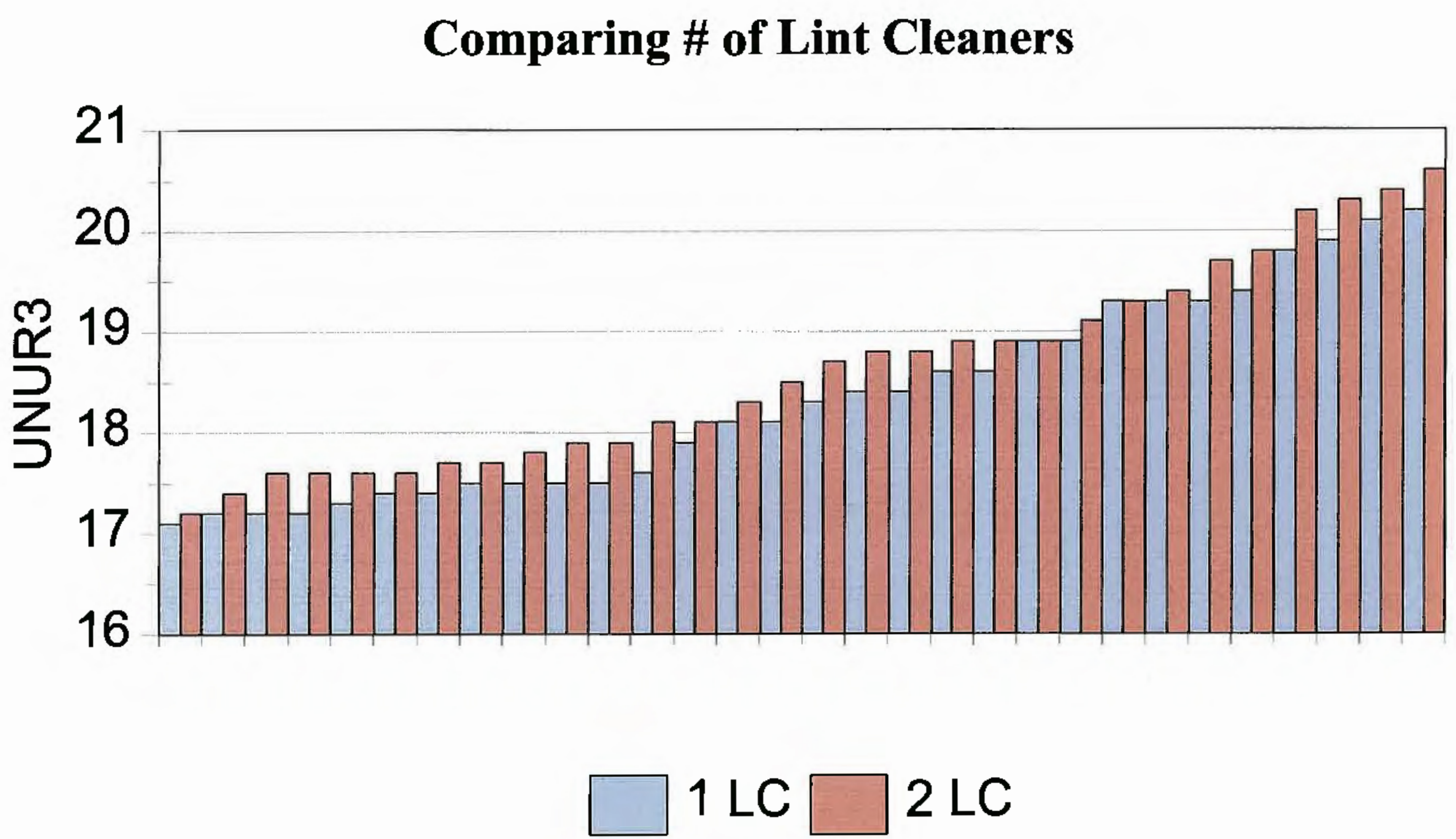


Figure 10

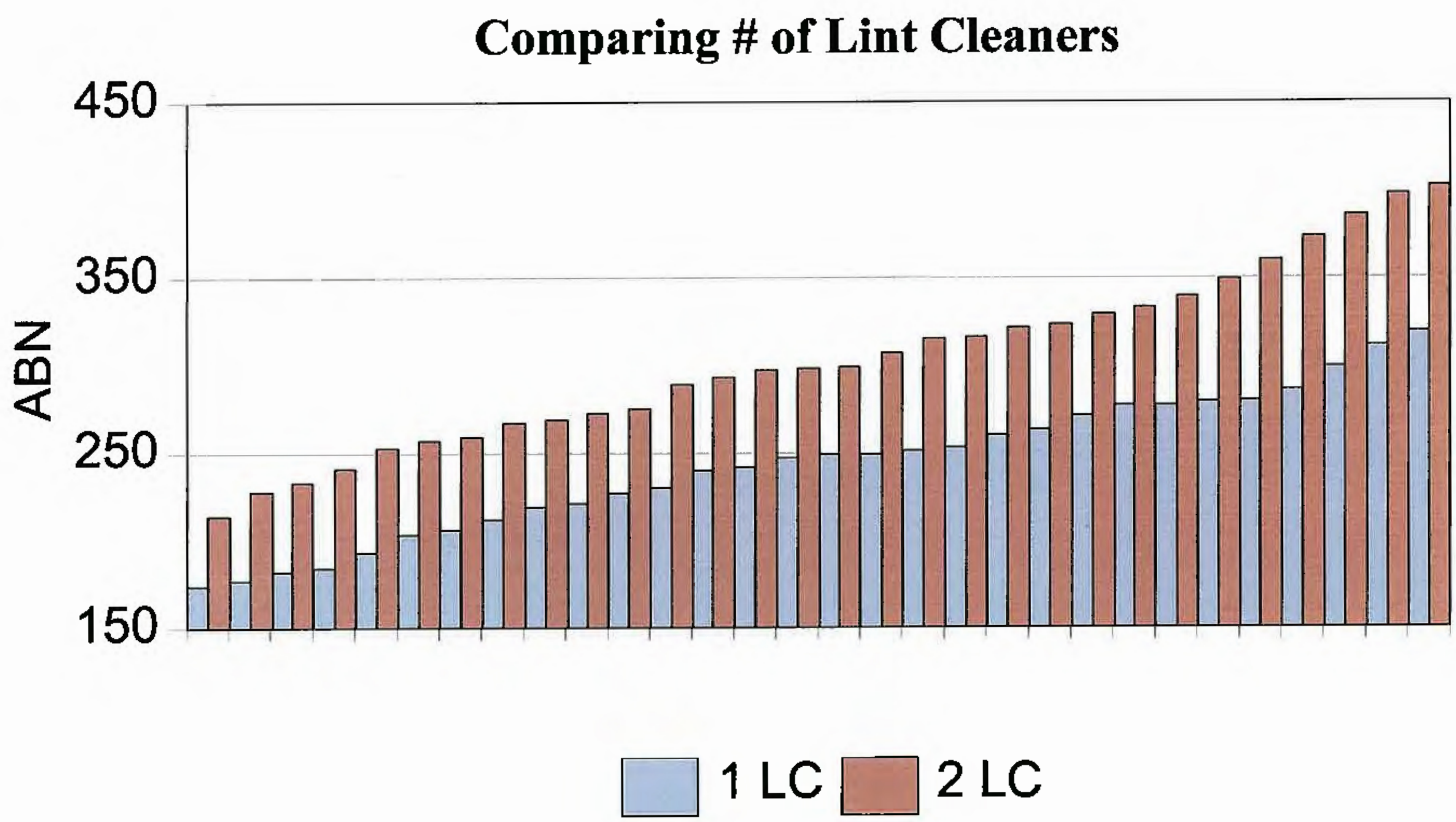


Figure 11

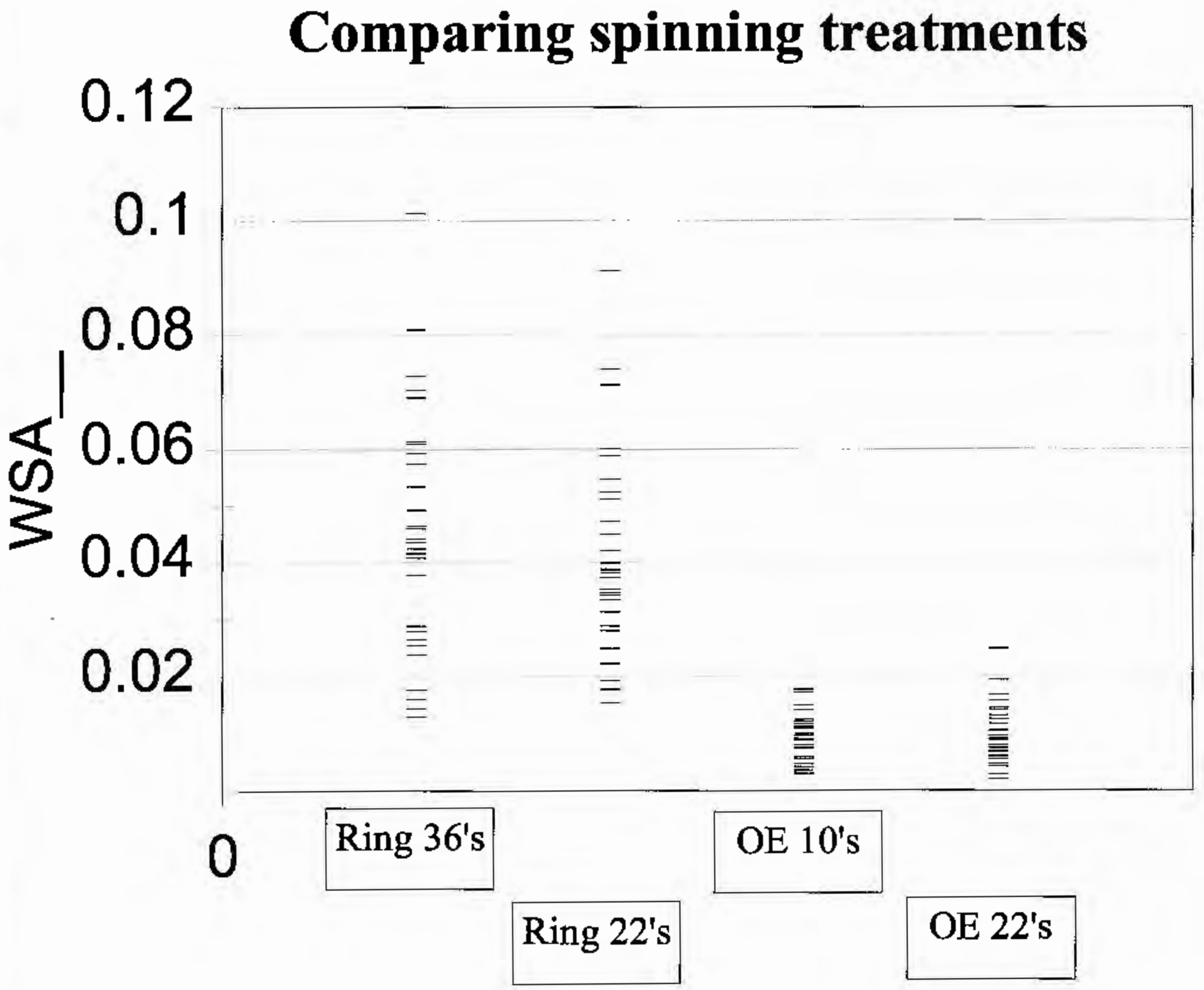

Comparing spinning treatments
WSA
0.12
0.1
0.08
0.06
0.04
0.02
0
Ring 36's
Ring 22's
OE 10's
OE 22's

Figure 12

**Comparing spinning treatments**

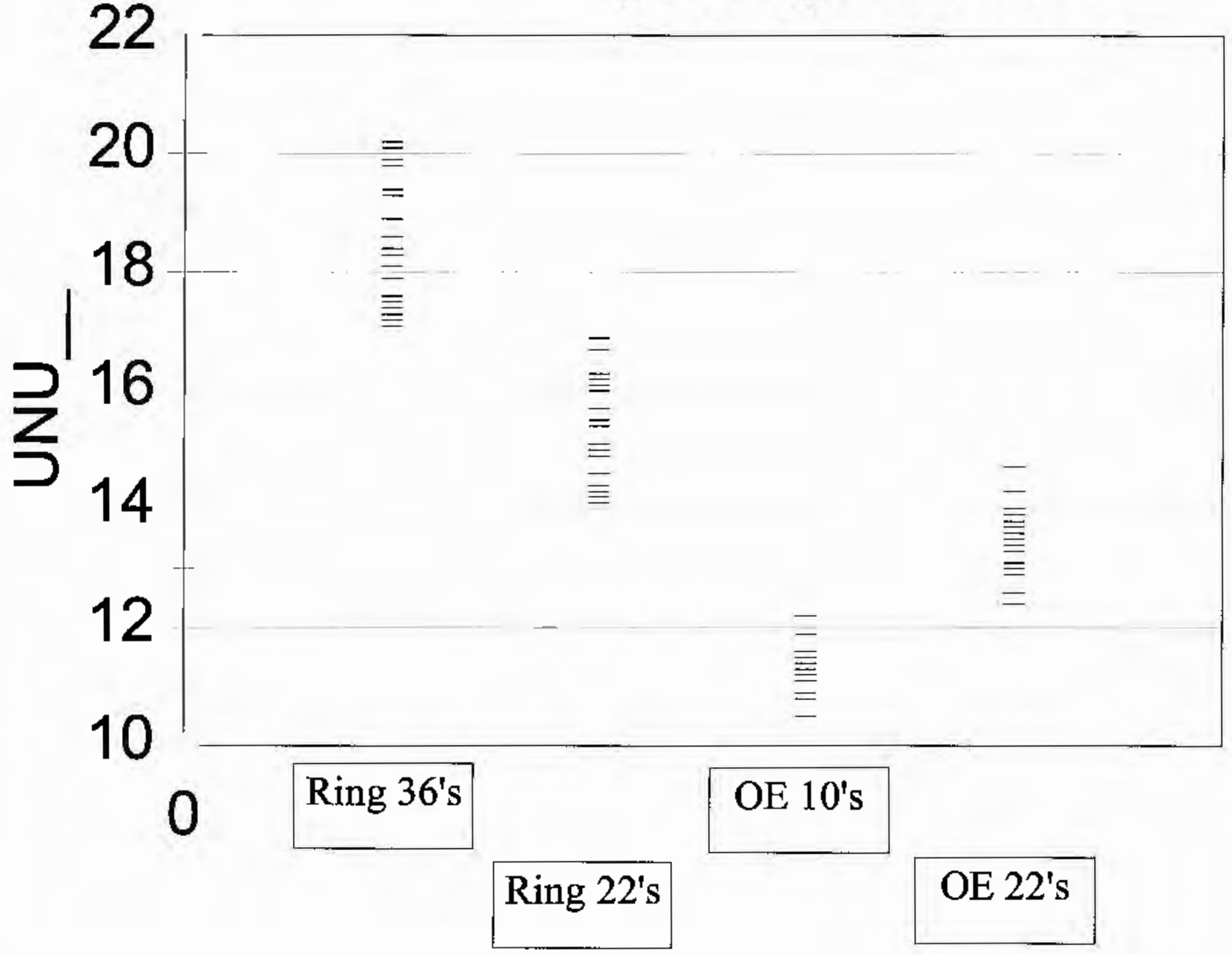
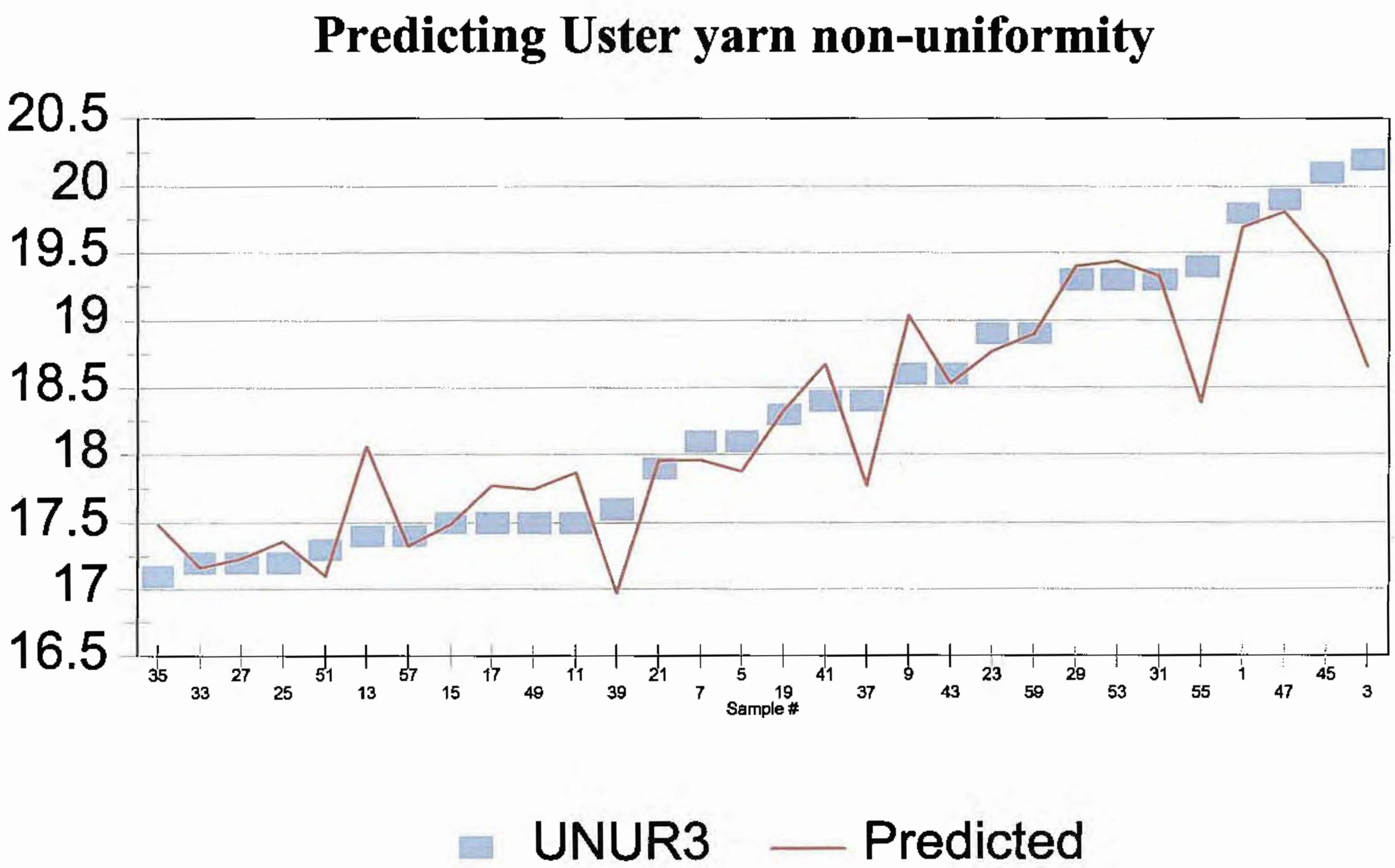


Figure 13



Predicting Uster yarn non-uniformity
20.5
20
19.5
19
18.5
18
17.5
17
16.5
35 33 27 25 51 13 57 15 17 49 11 39 21 7 5 19 41 37 9 43 23 59 29 53 31 55 1 47 45 3
Sample #
UNUR3
Predicted

Figure 14

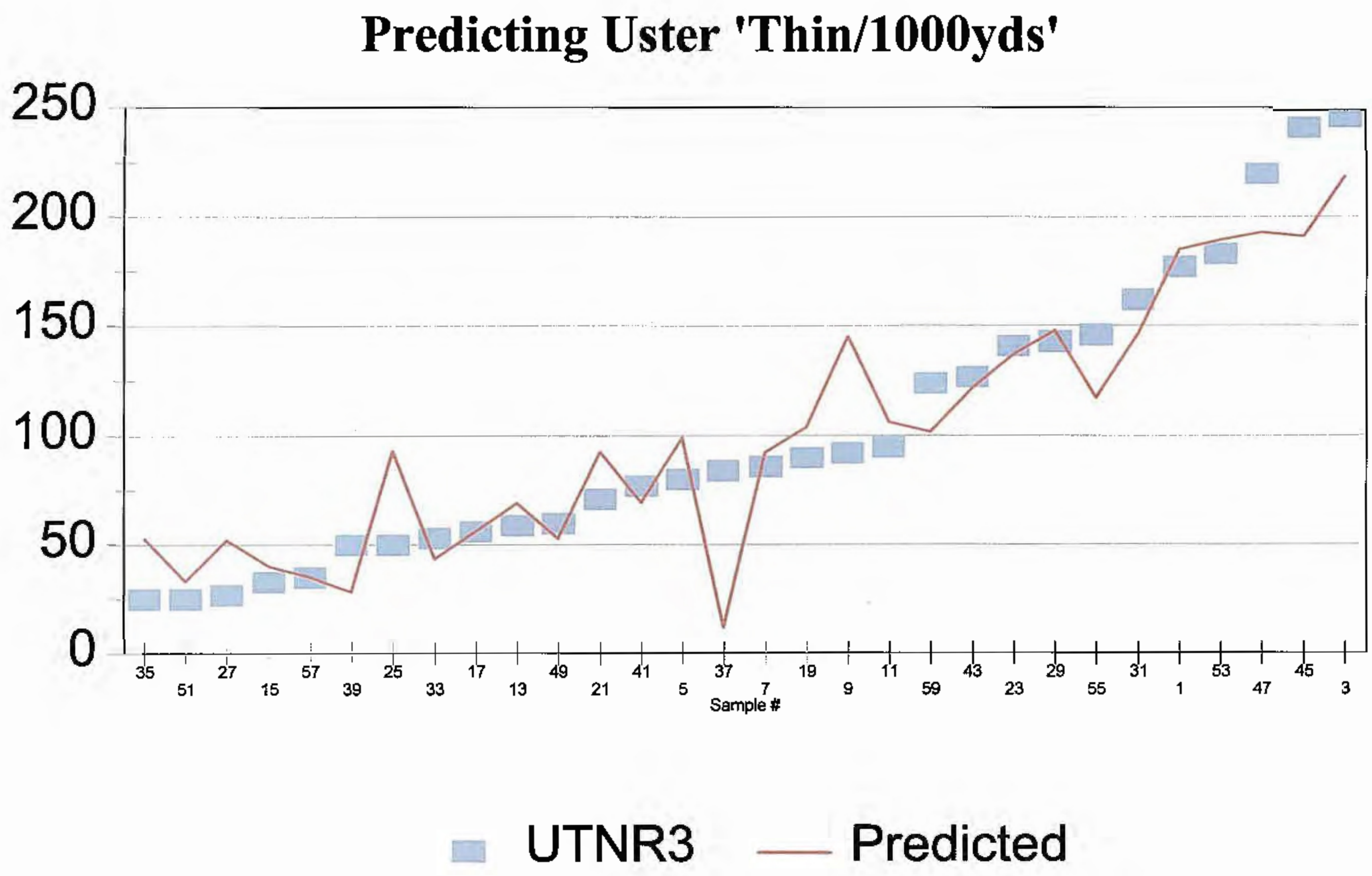

Predicting Uster 'Thin/1000yds'
250
200
150
100
50
0
35
51
27
15
57
39
25
33
17
13
49
21
41
5
37
7
19
9
11
59
43
23
29
55
31
1
53
47
45
3
Sample #
UTNR3
Predicted

Figure 15

**Predicting white speck neps**

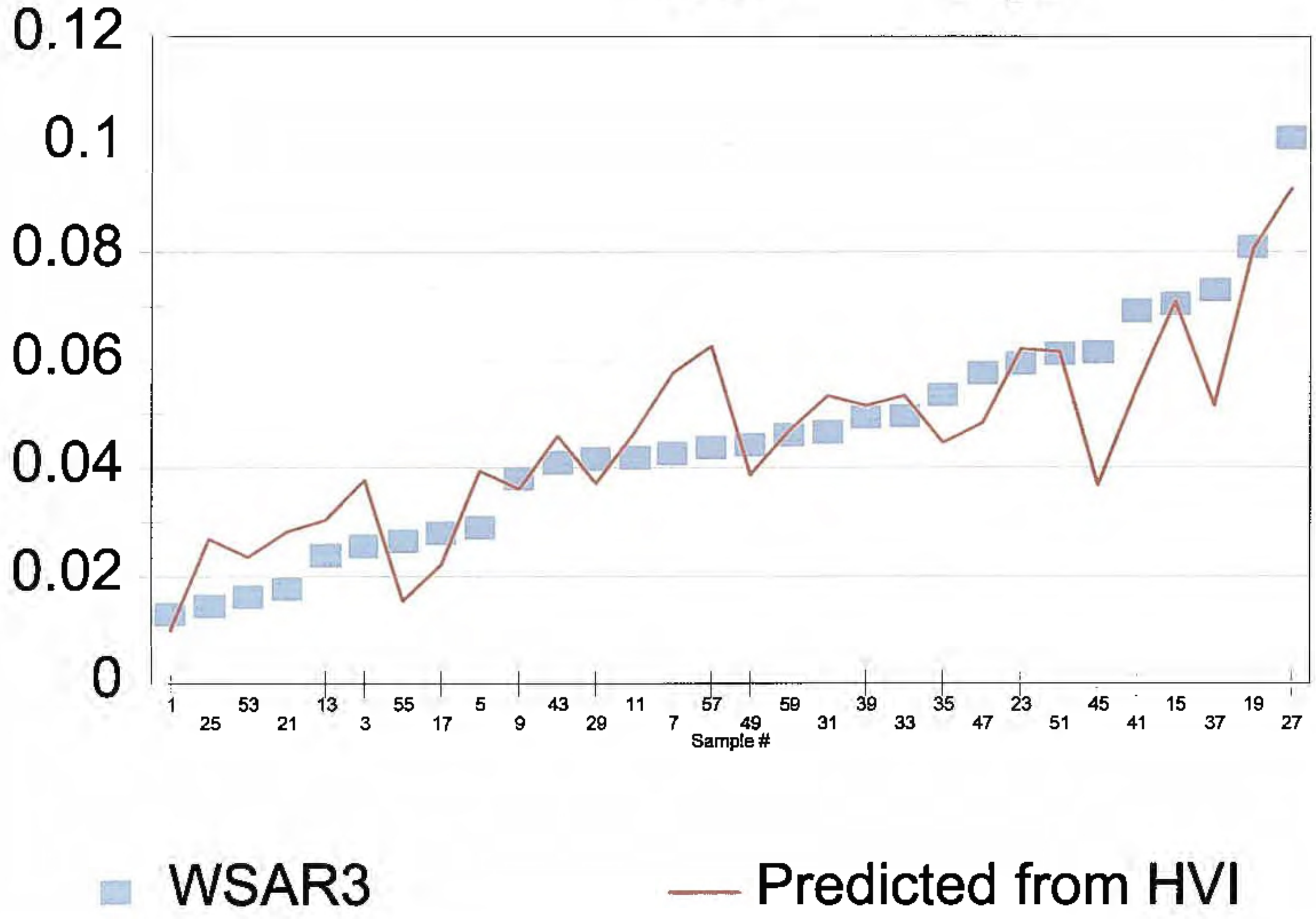


Figure 16

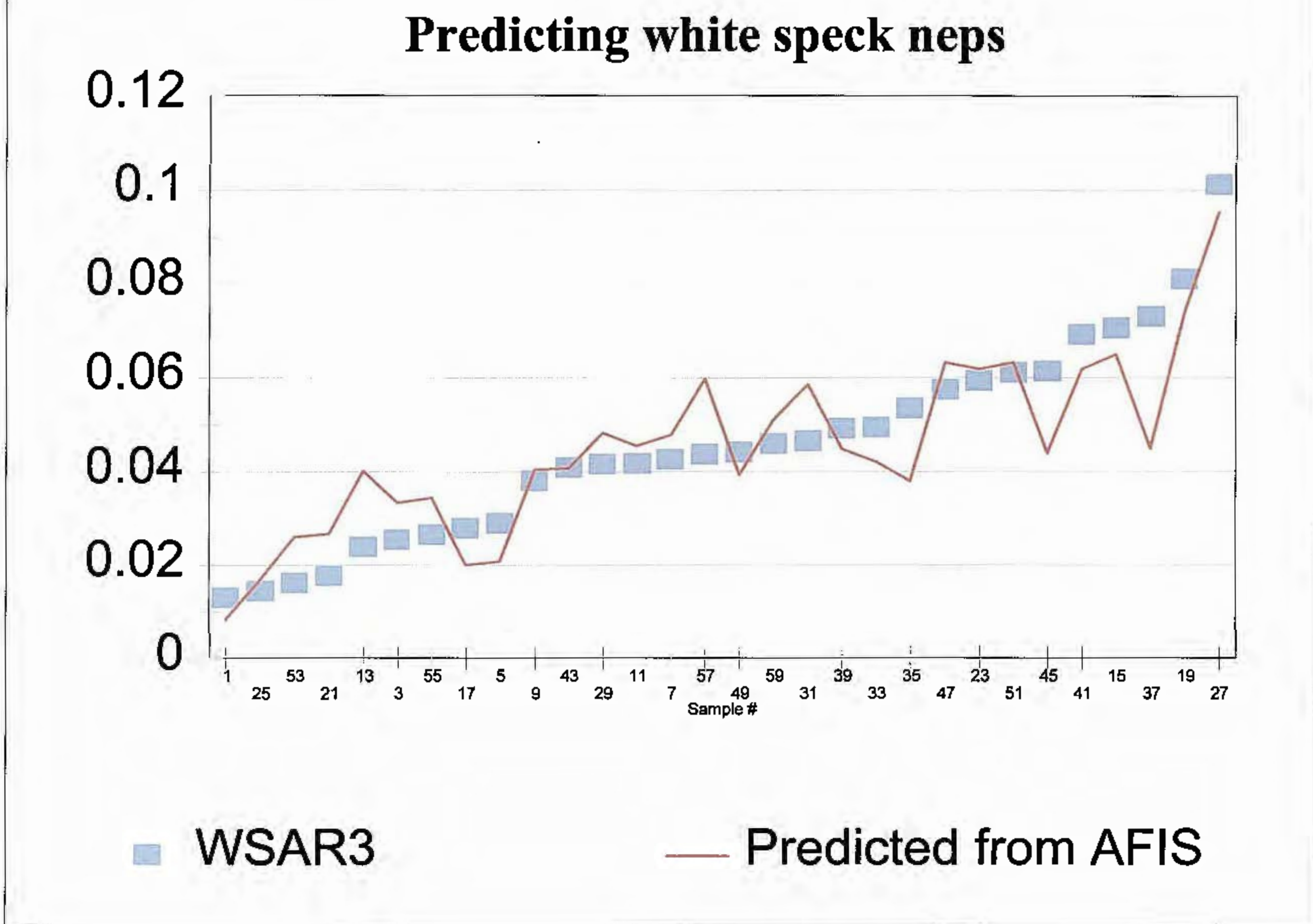
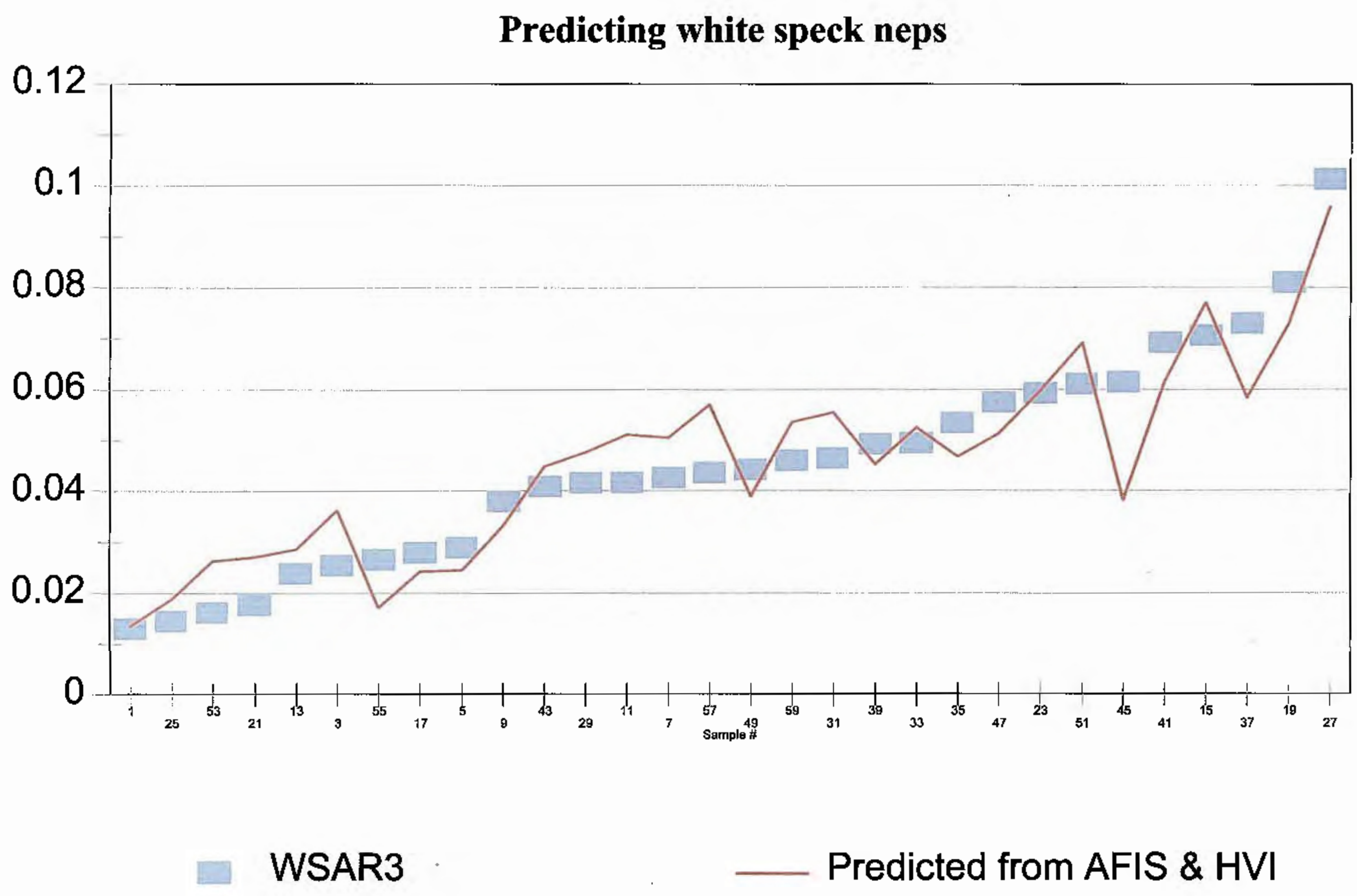

Predicting white speck neps
0.12
0.1
0.08
0.06
0.04
0.02
0
1 25 53 21 13 3 55 17 5 9 43 29 11 7 57 49 59 31 39 33 35 47 23 51 45 41 15 37 19 27
Sample #
WSAR3
Predicted from AFIS

Figure 17


Predicting white speck neps
0.12
0.1
0.08
0.06
0.04
0.02
0
1
25
53
21
13
3
55
17
5
9
43
29
11
7
57
49
59
31
39
33
35
47
23
51
45
41
15
37
19
27
Sample #
WSAR3
Predicted from AFIS & HVI

Library

**FINAL REPORT**

Date: 26Sep00

CRDC Project Number: **NEC3C**

# Cotton ginning with emphasis on cotton quality

CRDC Program No. 7.1, 7.2 & 7.3

**Admin Contact:** Matthew Durack
Director
National Centre for Engineering in Agriculture
USQ campus
Toowoomba Qld Australia
**Phone:** 07 4631 1873 **Fax:** 07 4631 1870 **E-mail:** durackm@usq.edu.au

**Project Supervisor:** Grant Roberts
National Centre for Engineering in Agriculture
USQ campus
Toowoomba Qld Australia
**Phone:** 07 4631 1394 **Fax:** 07 4631 1870 **E-Mail:** grantrob@usq.edu.au

**Principal Researcher:** Grant Roberts
National Centre for Engineering in Agriculture
USQ campus
Toowoomba Qld Australia
**Phone:** 07 4631 1394 **Fax:** 07 4631 1870 **E-Mail:** grantrob@usq.edu.au

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# Summary

The major part of this project is concerned with cotton quality. Neps are a major factor in cotton quality, and their impact on the industry has always been large. Another major factor is short fibre content. Due to recent advances in instrumentation, it is now possible on a small to medium scale to measure these attributes of raw cotton. As further advances are made, particularly in throughput, the effect of this previously absent information at time of sale is expected to be felt by the raw cotton sector.

The Australian industry has strong claims to the quality of its cotton in some respects, particularly strength, length, lack of contamination and reliability of supply. However, it is less assured in respect of neps and short fibre content, and this project came about in recognition of this.

The question of these quality factors is also recognized in cotton industries in other countries that are similarly highly mechanized and capital intensive, for example the United States of America. As a result, this research has taken place cooperatively between those two countries, with the competition between them subordinated to the need to compete with other types of fibre.

Cotton has been taken from the field all the way through its phases of processing to a finished dyed fabric. Then the data gathered along the way has been connected together and analyzed to see what it says about the manner in which cotton is processed and marketed. The data has also been used to see where Australian cotton stands in relation to the cotton of other countries.

The data suggests that Australian cotton is on a par with USA cotton in terms of neps in fabric. Australia compares less well with other countries where older, less efficient but slower equipment does less damage to cotton fibre and does less to manifest immature fibre as neps.

The project has produced data to show the effects of region, variety, ginning (*i.e.* the number of lint cleaners) on the realized quality of the cotton.

The project has also developed the expertise and linkages to industry (pre- and post- farm gate) necessary for the Australian cotton industry to carry out the basic work for this kind of research. The cooperative link to researchers in the USA that made this project possible is still the only means available to carry out the laboratory analysis of the lint and fabric. That cooperative link in any case should continue on the basis that one of the major effects of research into cotton quality is to improve the competitive position of all cotton versus synthetic fibres.

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# 2. Background

## 2.1 Topics within the project

This project was initially designed to cover three main topics:
- Trash use/ disposal;
- Moisture control and short fibre content;
- Neps.

## 2.2 Trash use/ disposal

Trash use and disposal has the potential to become a headache to ginners. In previous times it was neither a problem nor an asset, but rather a minor nuisance. It was either stockpiled and allowed to compost or burn by itself, or it was made available for free to anyone who wanted to collect it.

The recent 'Helix'™ controversy resulted in an industry policy of not releasing trash at all. Release has now resumed although there is residual anxiety about pesticide.

Environmental regulations regarding smoke mean that allowing trash to burn has a limited future as a disposal strategy, particularly where townships and neighbours are close to a gin. Although most gins have room for large stockpiles, sooner or later that must run out.

In addition, trash in large volumes represents a sizeable fertilizer equivalent, and very likely an unrealized opportunity to develop a valuable product from it once its chemical residue and pathogen status is established.

As a consequence, the development and adoption of new methods of using and disposing of cotton gin trash is indicated.

Trash as a topic became CRDC project NEC5C.

## 2.3 Moisture control

Moisture control in ginning is important for a number of reasons.

If the moisture content of the seedcotton coming into the gin is too high:
- The seedcotton will not 'fluff up' and release trash during cleaning. The trash content of the baled lint will rise, which may cause discounts when the lint is sold. (Often heat is applied for this purpose alone, even when the seedcotton is already more than dry enough to gin);
- For similar reasons, the seedcotton will tend to clump together during transport, possibly causing blockages in the pneumatic transport system;
- the strength of the cotton fibre (which varies with moisture content) may be greater than the

strength of its attachment to the seed. As a result, instead of the fibre breaking off at a certain point close to the seed, a portion of seedcoat may come away instead. These seedcoat fragments are very resistant to physical removal during later processing, but most are removed during wet processing during fabric formation;
- It may be necessary to reduce the seedcotton flowrate at the gin stand to cope with the extra work required to break the stronger fibres.

If the moisture content of the seedcotton coming into the gin is too low:
- Static electricity may build up in the seedcotton, causing clumping and blockages. These blockages may in turn cause binding on moving parts and eventually fire;
- the strength of the cotton fibre (which varies with moisture content) decreases as moisture content decreases. During mechanical cleaning, more fibre will break, shortening the average length of the lint and increasing the short fibre content. Both of these cause discounts when the lint is sold;
- Even if a fibre doesn't break, latent damage to its internal structure may occur, causing an increased susceptibility to damage during later mechanical processing.

Within the gin, difficulties with accurately determining the moisture content of incoming seedcotton using existing technology mean that giuners find it difficult to find the optimum settings to balance the above issues. The acute discounts (particularly on trash) that arise from overshooting the ideal moisture content for ginning (5.5% to 6.5%) means that typically cotton is chronically over-dried as a precaution. This is because the 'very dry' region on a cotton drying curve is easier to find than a particular number, particularly when the instrumentation indicates relative movements in moisture content far better than it reports an accurate number.

If the moisture content of the cotton lint leaving the gin is too high, the available water content within the bale may be sufficient to support microbiological activity, fibre breakdown and the associated cavitoma phenomenon in yarns and fabrics.

If the moisture content of the cotton lint leaving the gin is too low, then the value of some of the cotton is not realized. This is because the weight of a cotton bale is quoted at a nominal moisture content of 8%. If the moisture content is lower than this when it is weighed, and it regains moisture in the buyer's possession (as it will if for example it is trucked to a coastal climate for storage), in effect the extra weight was given away by the grower.

For example, if a bale weighed exactly 227kg when its moisture content is 4%, it will weigh 237kg if its moisture content rises to 8% after sale. At an indicative price of $495 per 227kg_bale, that is a lost opportunity of $22 per bale for the grower. For every 1% of the 3,000,000 bales produced in Australia annually that match this example, $645,652 of value would be lost to growers.

Automatic control of the ginning process is a concept that offers to improve efficiency and to aid the preservation of fibre quality. Development is dependent on the availability of an accurate means of measuring moisture content at selected points. At present, first generation systems exist but they are heavily qualified and lack close control over the process because the moisture sensors used are only indicators of state, and are not accurate means of measuring moisture. Automatic control of the ginning process therefore awaits the development of new means of measuring moisture content in cottonb (Roberts, 1997).

The effect on realised quality of various heat levels at various moisture levels in seedcotton was the subject of the 2000 trials at the Queensland Cotton Corporation gin at Dalby.

## 2.4 Neps

The topic of neps was the major part of this project.

### 2.4.1 Cooperating staff and organizations

The detailed nep studies in this project relied on a cooperative research agreement negotiated between:

- National Centre for Engineering in Agriculture in Toowoomba, Qld; and
- United States Department of Agriculture, Agricultural Research Service, Southern Regional Research Centre in New Orleans LA.

The principal researchers are as follows:

- **Australia:** Dr Grant Roberts, National Centre for Engineering in Agriculture, Toowoomba Qld (corresponding author);
- **USA:** Patricia Bel-Berger, USDA ARS Southern Regional Research Centre, New Orleans LA.

The contribution of the USA cooperators has been primarily in-kind, including Patricia Bel-Berger's salary, processing of the 1998 lint samples to yarn and then to fabric, and laboratory analysis. The exception to this was an amount of US$6,000 that was paid from Cotton Incorporated funds to increase the size of the lint samples in 1998 to allow a comparison of two lint cleaner treatments in the gin.

### 2.4.2 Cotton fibre maturity

Cotton fibre is mainly cellulose, in the form of irregular hollow tubes. The fibre is produced attached to a seed found in groups within bolls on the perennial cotton plant.

Fibre growth commences soon after flowering when the seed begins to form. After approximately three weeks it has grown out to its full final length but with only its calcium-rich primary wall present. During the next four weeks or so, the inner cellulosic secondary wall is laid down. There is little overlap of the two stages.

This secondary wall is not uniform, but has a microstructure. When viewed via microscopy so that an individual fibre takes on the appearance of a thick pipe, that 'pipe' itself appears to be made of fibres. These are termed microfibrils, and reflect the way that the cellulosic material is laid down by the plant. The presence of this microstructure clearly differentiates cotton from synthetic fibres, and it is important in determining the behaviour of cotton during processing and in use.

The pipe analogy is also useful to explain the process of maturity. Early in the period from three to seven weeks post flowering, the fibre has the appearance of 'layflat' irrigation pipe. It lacks rigidity so that when dried and viewed in cross-section it adopts various collapsed circle shapes. If the process of maturity proceeds normally, it begins to take on the appearance of a slightly battered 'Class 12 poly' pipe, until when fully mature and before drying it looks like a roughly circular extremely thick walled pipe with its internal diameter less than half the overall diameter (see **Figure 1**).

If the process of maturity of the cotton fibre within the boll in the field is interrupted (*e.g.* by direct insect attack on the boll, or by plant stress due to drought, waterlogging, chemical damage, hail, etc) then some seeds may be aborted and the attached fibre will stop maturing. Unless the entire boll is dropped the seed will carry to harvest and be mixed with the rest of the seedcotton flow in the gin. Most of that fibre will carry through the ginning process.

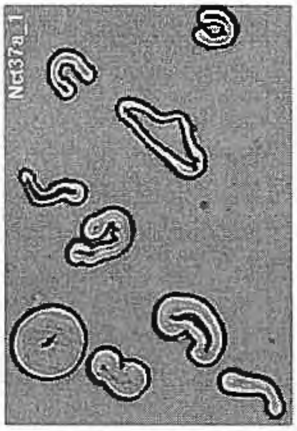



**Figure 1 - Photomicrograph of mature and immature cotton fibres (Source: SRRC New Orleans)**

### 2.4.3 What is a Nep?

In a very broad sense a nep is a small site of imperfect cotton, and most discussions on the quality of cotton involve discussion of neps. However an exact definition and classification of neps is difficult, because terminology tends to be loose in an industry like the cotton industry, and tends to differ between industry sectors and regions.

Things called neps arise at different points in the production chain, and something called a nep in one stage of that chain may be only indirectly linked to something else called a nep at another stage, if at all. Other things may be present in latent form at early stages and only manifest themselves as neps at a late stage.

In the example of a single selection of cotton:

- lint plucked from seeds in the field may be combed out to produce a card web (American Society for Testing Materials, 1977) and a nep value reported;
- the AFIS™ Nep module or equivalent may be used to report neps as the number of neps per unit mass of ginned lint;
- the AFIS™ Nep module or equivalent may also be used to report neps as the number of neps per unit mass of yarn sliver (the very loose continuous product of a carding machine);

– when that lint is spun into yarn, neps may be reported via a number representing the number of sites on the yarn per unit length with irregular thickness and other attributes, known as 'Uster neps';
– when that yarn is woven into textile, and an image of that textile is analysed by computer, the percentage of textile area having 'whiteness' above a certain threshold may be reported as 'whitespeck neps';
– that textile might also have a subjective judgement made on its physical uniformity and smoothness, which is an indication of the presence or otherwise of mechanical neps.

So in different stages of production there are different types of neps manifested, which are measured in distinct ways. The numbers that are reported at each stage have an uncertain relationship to each other.

One of the outcomes of this complicated picture is that directly comparing levels of neppiness through different stages in the cotton production chain is difficult because it is likely that the analysis is not comparing 'apples with apples'.

The scheme of classification of neps preferred by the authors is as follows:

**Biological Neps**
These are caused by components of the cotton plant becoming entangled in the cotton fibre, remaining there through cleaning in the gin and the mill. They can cause dark specks in yarn and fabric but most are removed by wet processing. They can cause irregularities in the yarn, and are sometimes connected with white speck nep formation (see below). This includes seedcoat fragments and trash, and also aborted seeds that are sometimes called 'motes'. (NB This differs from the ASTM standards book (American Society for Testing Materials, 1978) which specifically defines motes separately. However this separation is artificial because they are only one kind of biological fragment. For the purposes of this discussion motes will be included in the nep definition.)

**Mechanical Neps**
When people in the cotton ginning sector speak of neps, it is usually mechanical neps. The 'Cotton Ginner's Handbook' (Anthony & Mayfield eds, 1994) defines a nep as "a small, pinhead-sized entanglement of fibres in cotton that show up in ginned lint, card web, yarns and cloth". This definition strictly only covers mechanical neps.

These are the neps that for many years were counted by producing a card web and hand counting them over a black background (American Society for Testing Materials, 1977).

When the boll opens, the fibre begins to dry and loose some of its roundness. In doing so it convolutes and some mechanical neps are formed. During every mechanical handling from then on, the number of neps increases, except in machines designed to remove them (*e.g.* lint cleaners, carding machines and combs) (see below for caveats). The physical basis for this according to Alon & Alexander (1978) is that fibres, particularly immature ones with little longitudinal rigidity, when stretched will recoil back on themselves, becoming like a snapped barbed wire. The more mature the fibre in an early stage entanglement, the more likely it is to uncoil during processing. The more immature the fibre, the more likely it is to tighten into a nep.

Mechanical neps are responsible for physical defects in fabric, which are the defects that experienced seamstresses are looking for when they run their fingers over a fabric. They are a problem particularly in premium fine fabrics. They are also responsible for loss of cotton fibre during combing, because when a nep is removed a certain amount of good fibre goes also.

However, biological and mechanical neps are not the worst type of nep in terms of dollars lost by the industrial customers of raw cotton (*i.e.* the spinning mills and the textile mills).

**White Speck Neps**

White speck neps are the biggest problem in dollar terms, primarily because they are seen only after all production costs have been incurred. It has been estimated that in the US textile industry, white speck neps are responsible for $200M in losses per year (Goynes *et al.*, 1996).

White speck neps are unsightly white or pale specks in a dyed fabric. They are not seen in undyed or lightly dyed fabrics.

Primarily whitepseck neps are an <u>immature</u> <u>fibre</u> problem. Immature fibres have little or no cellulose in their wall structure, and hence do not adsorb the dyes that are designed to bind to cellulose. In addition, immature fibres collapse into ribbon-like forms during drying, and are flattened further when 'ironed' by the drying cans after dyeing a fabric, and consequently have a higher reflectance. In an early study by Hebert (1988), 96% of all neps in cotton fabric contained some immature fibres, and 50% contained only immature fibres.

White speck neps may be associated with biological neps. If the foreign matter is an aborted seed or part thereof that was small enough to fit between the ribs of a ginstand, the fibre that is attached to it will be immature. When the dark speck is removed, the immature fibre is left in a clump as a ready made whitepeck nep.

Whitespeck neps may also be associated with mechanical neps. The immature fibres that have little longitudinal rigidity tend to entangle themselves and adjacent mature fibres, particularly during mechanical cleaning.

## 2.4.4 Removing neps by mechanical cleaning

Industry practice has been that cotton is mechanically cleaned before and after the ginstand in an effort to produce a uniform white product that has minimum trash and is highly combed.

It now appears that all or most of this effort is wasted. Several studies going back a decade or so have shown that this has a bad effect on cotton in terms of fibre length, length uniformity, and short fibre content. It is also expensive to buy and run the equipment, and some good fibre goes out with the bad.

The clean, uniform lint is actually inferior in realised quality terms to trashier, lumpier lint if it means that the latter has undergone less mechanical action and has consequently suffered less mechanical damage. The ginner's paradox is that the former is required to produce the best short-term economic result for his customer (the grower) but objectively the latter is required to produce the best economic result for the cotton industry as a whole.

If the fine trash is not removed in the gin, it will go through to the carding machine in the spinning mill. The carding machine is required in any spinning process to separate the lint into individual fibres and arrange them linearly. The latter parts of a card operate similarly to a gin lint cleaner, but the throughput of a card is typically 25kg to 75kg per hour, compared with ≈15,000kg for a lint cleaner. The clearances within a card are typically set to closer tolerances (reflecting the differences in throughputs) and these clearances are checked at closer intervals, in part because the effects of problems are seen immediately in downstream processes.

A change from low to moderate levels of trash can be handled by simple changes to settings within the carding machine. The extra weight of trash in a bale need not be a problem in marketing terms if a bale is priced according to the actual weight of lint (*e.g.* if a bale is 97% lint then the price would be 97% of the nominal price).

The role of the gin in this ideal scenario therefore is to dry the seedcotton if necessary, remove the gross trash (dust, rocks, sticks, bracts, green leaf, large leaf etc) by less aggressive pre-cleaners, remove and handle the logistics of the seed, and then bale the lint and remaining impurities for further processing. The implementation of this ideal scenario awaits changes to the customary marketing arrangements that have been mooted recently.

## 2.4.5 Effects of Neps on the cotton industry

**Substitution by synthetic fibres**
Cotton is the product of a natural system and has a greater degree of variability compared to synthetic fibres which come from an industrial process. That variability cannot be reliably predicted at present. If a buyer is in a market where synthetic fibres can be substituted for cotton to some extent, and he is balancing the better 'wearability' of cotton against the lesser risks of production of synthetics, then the greater the unpredictability of cotton the more he will substitute synthetics. The proportion of the world fibre market held by cotton has historically been falling (Townsend 1998), indicating that substitution is a growing problem for the cotton industry.

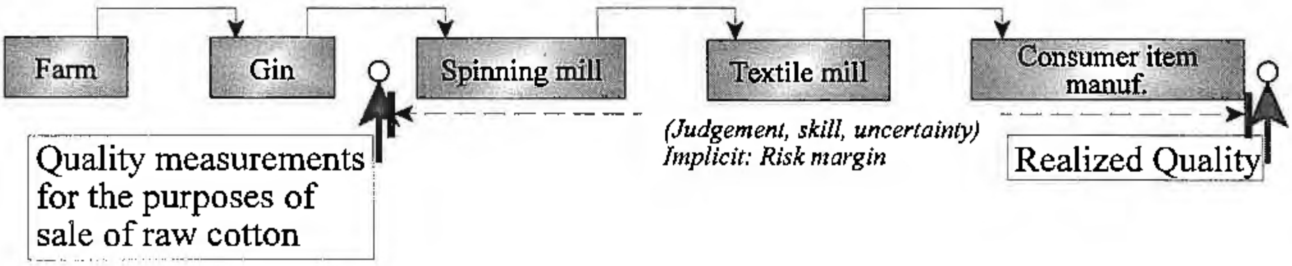
**Discounting - Implicit**
Whitespeck neps are responsible for losses in the spinning industry worldwide estimated to be in the hundreds of millions of dollars because they are only manifested in the finished product, after all production costs have been incurred. The product must then be rejected for high quality uses, and has little value.

Often contracts for the sale of raw cotton have clauses setting out processes for claiming these losses back up the production chain, for example back to the original merchant. However, these claims do not reach back to the grower. This represents a breakdown in the feedback link to growers about the realised quality of the cotton they grow.

However, in a sense cotton neps have to date been an implicit discount on all raw cotton. Although buyers have known that neps of various types were likely to be present to a greater or lesser degree, there has been no objective way to know ahead of time exactly what the degree of neppiness was.

Raw cotton is described by customary classing information, plus information about variety, and region. In the absence of further information, buyer judgement is used to arrive at a perceived value for the raw cotton, as shown in **Figure 2**.

**Figure 2 'Quality as measured at gin' vs. 'Quality as measured at end of product chain'**




Whether stated or not, during that procedure the buyer has included a risk margin, an amount taken off what the value would otherwise have been, to cater for the uncertainty about neppiness and the periodic costs of finding high levels of neps in the finished product. This must be so for the buyer to be in business in any given season after the uncertainties of the previous seasons.

**Discounting - Explicit**
As a result of research in the US in the last few years, detailed knowledge of the physical basis of neps has increased. Various means of measuring immature fibre and potential neppiness have been developed.

Initially these instruments were only suitable for laboratory use. Buyers of raw cotton have used them to analyse some lots of cotton and, in conjunction with their experiences with nep problems in finished fabric, to establish heuristic measures to manage the risk. These measures may not result in an actual discount in a sale, but the effect may be there nonetheless by the buyer being absent from a certain market.

Recently at least two of these means (Zellweger AFIS™, Shaffner Technologies RapidTester™ and their variants) have been trialed for producing continuous real-time data in a commercial classing operation. It is possible (although not demonstrated yet) that an entire national crop could be analysed for immature fibre and potential neppiness using these, in a similar manner to the way that the HVI instrument is used currently. This would offer a means to have immature fibre and potential neppiness included in the current 'P&D' (premium and discount) system.

**Future effects**
If explicit discounting on the basis of immature fibre and potential neppiness became a part of the customary marketing arrangements, it would be a two-edged sword for the cotton industry.

On the one hand, neps would be less of an unknown risk to a buyer and the risk margin would be reduced. Everything else being equal, this would result in a higher price for the cotton grower.* The cotton industry would also be in a better position to compete with synthetic fibres.

On the other hand, objective information on immature fibre and potential neppiness would be a strong determinant of price. Consequently, cotton growers would have to manage their cotton for immature fibre in addition to yield, costs, insects and diseases, water availability, etc. Almost certainly there would be anxiety in some growers about the effect of this on their profitability.

Concern has been demonstrated within the Australian cotton industry about coping with these recent and potential changes. This has led to a move to conduct research into neps and related topics.

The project detailed in this report is one result of that.

> * While the view might be that the margin would stay exactly where it is, this would be an unnecessarily dark view of the cotton market. If a buyer was able to offer an arbitrary low price (by maintaining the margin in the absence of the risk) then he would already be offering an arbitrary low price. That buyers don't demonstrates that they are prevented from doing this other than in the short term, if other buyers are in the market acting independently and the market is sufficiently liquid.
>
> An important caveat on this is that the cotton grower must be fully aware of the level of neps in the cotton and the effect on the value of that cotton. If not, the cotton grower would have to rely on information coming from the buyer.

# 3. Objectives

**1997/ 1998**

1. **Locate growers in selected areas at or soon after planting, and set up documentation of cotton during growing and harvest (Tasks 1.1 & 1.1A).**

Completed.

2. **Locate suitable gin and negotiate receipt of cotton samples (Tasks 1.1 & 1.1A).**

Completed.

3. **Collect samples at harvest time as growers require (Tasks 1.1 & 1.1A).**

Completed.

4. **Gin samples in one line under commercial conditions with cooperation of participating gin (Tasks 1.1 & 1.1A).**

Completed.

5. **Industry technical note on Neps (Task 0).**

Completed.

6. **Industry survey of means of measuring moisture (Task 2.1).**

Completed.

**1998/ 1999**

1. **In collaboration with staff at ARS Fiber Lab, New Orleans, analyze data from lint, yarn and textile tests (Tasks 1.1 & 1.1A).**

Incomplete. See Section 6.1: Discussion.

2. **Report on neppiness and other quality measures of Australian cotton (Tasks 1.1 & 1.1A).**

Complete.

3. **Report on means of predicting cotton textile quality from lint attributes (Tasks 1.1 & 1.1A).**

Incomplete. See Section 6.1: Discussion.

**4. Establish suitable variety to use in Tasks 1.2 & 1.2A.**
Complete.
**5. Report on new methods of measuring moisture under development overseas (Task 2.2).**
Incomplete. Substituted for new project NEC5C, and the duplication of the 1998 trial in 1999.
**6. Report on methods of trash use/ disposal (Task 3.1).**
Complete. This became CRDC project NEC5C.

**1999/ 2000**
**1. Locate grower in selected areas (Tasks 1.2 & 1.2A).**
Complete.
**2. Locate suitable gin to process cotton samples (Tasks 1.2 & 1.2A).**
Complete.
**3. Collect samples at harvest time as growers require (Tasks 1.2 & 1.2A).**
Complete.
**4. Gin samples under proper conditions with cooperation of participating gin (Tasks 1.2 & 1.2A).**
Complete. Due to the timing of the ginning season, this took place in early July 2000, nominally after the end of this project but included in the new project NEC7C.
**5. Literature review on ginning operations (Task 4.1)**
Incomplete. Substituted for new project NEC5C, and the duplication of the 1998 trial in 1999.
**6. Report on Tasks 1.2 & 1.2A.**
Incomplete. See Section 6.1: Discussion.

# 4. Method

## 4.1 Overview of Method

The studies into neps and cotton quality were broken down as follows:

– 1998 harvest and 1999 harvest
  - Baseline data
  - Quality Prediction
  - Effect of Lint Cleaning
– 2000 harvest - Effects of Heating and Drying

All of the studies in this project have been designed from the standpoint that research into the behaviour of cotton gins is best done using full sized gins, using procedures as close as practicable to the usual, and using samples that are sufficiently large to make the machinery behave as designed.

The studies have also been designed from the standpoint that cotton is ultimately valued at the consumer product level, so the best way to gauge the effects of a particular factor in cotton processing is to analyze its effect on quality at the fabric stage.

In the 1998 trial and the similar 1999 trial, there was no attempt to control the treatment of the seedcotton prior to collection in the field. The reasons for this are as follows:

- It was not possible to collect enough samples to make a 'factorial' experimental design possible, both for budgetary reasons and because the logistic task of such a trial would be huge;
- One of the desired outcomes of this study was knowledge of the most important set of influences on the attributes on the cotton, so that set could not be known beforehand;
- To hold all other influences constant would be an unacceptable restriction on the growers who might be cooperating in the study;
- To hold all other influences constant would mean the results would not be representative of typical industry practice (*e.g.* Inguard™ varieties being sprayed as per conventional varieties);
- One of the stated aims of this study is to produce the beginnings of a statistical model as a means of predicting fabric quality given information on cotton in lint form. Necessarily, for it to be useful to the cotton industry in its usual operations the model must accept cotton 'as it comes', as long as it can be said that it is representative of typical industry practice. Any approach that requires all treatments outside those used in the model to be standardized, or that would not cater for the effect of this, would not be feasible.

In statistical terms, the design of these trials is a matter of 'internal validity' vs. 'external validity'. Internal validity enables the researcher to know more about the behaviour of the artificial system that he set up but less about the wider system, and *vice versa* for external validity. Given the nature of the proposed application of the results of this project, external validity is far more important than internal validity. The statistical model mentioned will use the same field of statistical theory as for the commonly used ANOVA procedure and related analyses, but in the generalized form.

## 4.2 1998 trial

Cotton samples were identified on-farm with cooperation with local growers. The full list of growers who participated is contained in **Appendix C**.

The growers came from the following regions:

| | | |
|---|---|---|
| – | Emerald | (Warm start, hot finish) |
| – | St George | (Cool start, hot finish) |
| – | eastern Darling Downs | (Cool start, warm finish) |

By using these regions it is assumed that, for a study of this size, the widest practicable range of Australian growing regions has been represented.

The treatment in each case was held constant post-harvest. The most important aspect of this was that it was ncecessary to gin the cotton in one line at one gin, lest different ginning effects overwhelm the other effects on cotton quality (Bel-Berger *et al.*, 1997).

This meant that many samples would have to be freighted between the growing regions. It had been established that this ruled out using full-sized modules (*e.g.* 14 tonnes) as the basic sample size, on the grounds of freight cost. The only feasible way was to collect samples of seedcotton that were smaller but would still travel through a gin in a manner representative of the typical operation of a gin.

It was decided to collect 1.5 tonnes of seedcotton direct from the picker pressed into 10 woolpacks for each sample. Although the details were only sorted out once harvest and collection had commenced, this ultimately proved successful, albeit labourious (see **Appendix A**, Collection of samples in-field).

A total of 30 samples of seedcotton were collected between $24^{th}$ February and $30^{th}$ April 1998 (8 from

Emerald, 7 from St George, and 15 from the eastern Darling Downs)). The total weight was 44.4 tonnes.

The use of the Queensland Cotton Corp gin at Emerald was negotiated with the local manager Don Cooper. Each seedcotton sample was split into two, with both halves being processed one after the other, and a running change from 1 to 2 lint cleaners at the midpoint.

A total of 60 samples of lint resulted, for a total weight of 1550kg. Each sample had associated smaller samples for laboratory analysis. The lint that was not required for samples went into 62 conventional 227kg bales for sale via the usual channels, again courtesy of Queensland Cotton Corporation.

The 60 samples of lint and the laboratory analysis samples were subsequently freighted by sea and land to the Cotton Quality Research Station at Clemson SC, a laboratory of the United States Department of Agriculture, Agricultural Research Service (USDA, ARS).

After being spun into four types of yarns (10's and 22's open ended, 22's and 36's ring spun), they were sent to the International Textile Centre in Lubbock TX to be woven into a plain fabric and dyed. The details of the dyeing process are in Bel-Berger *et al.* (1997).

## 4.3 1999 trial

The 1999 trial arose in late 1998 as a response to industry interest in seeing the 1998 trial repeated. Co-operation came particularly from Michael Ford from Goenka Impex Pty Ltd, who provided contacts for half of the eventual 36 seedcotton samples. These contacts were all in the western part of the Gwydir valley within easy trucking distance of Namoi Co-op's Wathagar gin. After consultation with Graham Washington and John Woods from Namoi Co-op, it was therefore decided to use that area only, and that gin. It was then feasible to use the standard module as the seedcotton sample size and reduce the logistical problems of collecting seedcotton.

The ginning was carried out similarly to 1998, except that the lint cleaner treatment was a split between zero and two lint cleaners.

By 1999 it had been decided that as much as practicable of the processing of the samples should be carried out in Australia, for two reasons.

- To develop the expertise and linkages within Australia;
- To better manage the complicated and scattered process of producing experimental samples of fabric from a large number of samples of lint.

Therefore the 72 25kg lint samples were sent to the International Fibre Centre in Melbourne to be processed to roving, then to the Rocklea Spinning Mills plant in Bendigo to be made into yarn (one type).

## 4.4 2000 trial

The 1998 and 1999 trial held the ginning treatment constant (other than lint cleaners) and varied the variety, growing area, etc. The 2000 trial did the opposite, in that the sample was one module of Sicala 40, and the heating and in-coming moisture contents at the gin were varied. The module was provided by Paul McVeigh, Lock Eaton, Dalby.

In late May and early June 2000, 60 woolpacks of seedcotton were taken from the module and stacked in 30's in two shipping containers, with dividers and fans to allow full airflow around them. The shipping containers were initially located at the Dunavant gin at Dalby, until space became available at the Queensland Cotton Corp gin at Dalby where the ginning was to take place.

In the first container, an evaporative airconditioner was mounted, recirculating the air around the woolpacks so the atmosphere was maintained at 100% relative humidity. To stop condensation during the night a small extractor fan was fitted to slowly replace the air, without reducing the relative humidity. This seedcotton was termed the Moist samples.

In the second container, a refrigerated airconditioner was mounted, with the thermostat locked so the compressor operated continuously. The resulting condensation water was removed to the outside environment. The floor and lower sides of the container were lined with a tarpaulin to minimize intrusion of moisture from outside. This seedcotton was termed the Dry samples.

The remainder of the module, of approximately equal weight, was left alongside the shipping containers to represent seedcotton kept in ambient conditions. This seedcotton was termed the Ambient samples.

The seedcotton was left to equilibrate for the last six weeks of the ginning season, then removed on 17th July 2000.

The ginning was carried out at the Queensland Cotton Corp gin at Dalby, following negotiations with manager Ian Sharpe. Stuart Gordon (CSIRO TFT, Geelong) was present.

Each of the Dry, Moist and Ambient samples was further divided into thirds, and ginned at three heat settings in the gin. The lowest setting was zero heat, where the burners were off and the system had cooled by running with fans only for approximately five minutes. The middle setting was 55°C, judged typical for the ginning season by gin staff,. The highest setting was 90°C, the highest that gin staff were prepared to go in view of the risk of fire.

All other gin settings were kept constant.

This resulted in the following matrix. Each sample is approximately 1,500kg.

**Table 1 2000 heating and drying study matrix**

| | | |
|---|---|---|
| **Moist seedcotton / No heat** | **Moist seedcotton / Standard heat** | **Moist seedcotton / Maximum heat** |
| **Ambient seedcotton / No heat** | **Ambient seedcotton / Standard heat** | **Ambient seedcotton / Maximum heat** |
| **Dry seedcotton / No heat** | **Dry seedcotton / Standard heat** | **Dry seedcotton / Maximum heat** |

The moisture contents of each sample during ginning were measured via the fixed conductance-type instruments in the gin.

**Table 2 2000 heating and drying study moisture contents**

| | No heat | | Standard heat | | Maximum heat | |
|---|---|---|---|---|---|---|
| | **At feed hoppers** | **At top of #2 ginstand** | **At feed hoppers** | **At top of #2 ginstand** | **At feed hoppers** | **At top of #2 ginstand** |
| **Moist** | 12% | 9.5% | 10% | 7.5% | 11% | 4.5% |
| **Ambient** | 6% | 6% | 6% | 4% | 6% | 3% |
| **Dry** | off scale low | 5% | off scale low | 4.5% | off scale low | 3.5% |

At the bale press, different sized samples were taken (see **Appendix B**). This was because there are another two trials running off the field work for this trial:

- A CRDC project at CSIRO TFT Geelong concerned with fibre processing lubricants (per Stuart Gordon);
- A CRDC trial at CSIRO TFT Geelong concerned with Murata vortex spinning (per Stuart Gordon);
- parallel spinning trials by Schlafhorst in Germany (per Gary Robinson).

# 5. Results - 1998

## 5.1 Industry survey of means of measuring moisture

The results of this survey are in **Appendix D**.

## 5.2 Listing of data

The full listing of data is in **Appendix C**.

The data consists of the following:

- Sample ID, including grower, variety, geographic location, US sequence number
- Lint data
    - Number of lint cleaners used in the gin;
    - HVI data (carried out at AMS Memphis, TN);
    - RapidTester™ data;
    - AFIS™ lint and sliver data;
    - FMT Micromat data;
    - Shirley Analyser non-lint data.

- Yarn data (for each of four spinning treatments: 22's and 36's Ne ring, 10's and 22's Ne open ended
  - Opening and carding waste;
  - Yarn and skein strength tests;
  - Uster evenness tester data.
- Fabric data
  - Whitespeck nep data;

## 5.3 Comparing averages

The following data was grouped under the following headings to test for statistically significant differences in averages.

### 5.2.1 Whitespeck nep (fabric) data

**Number of lint cleaners** - No statistically significant differences ($p>>5\%$).

**Spinning treatments** - A very strong difference ($p<0.1\%$) between open ended and ring spinning. The open ended spun had an average of 25% of the fabric whitespeck neps of the ring spun (for counts per square metre and for percent area white).

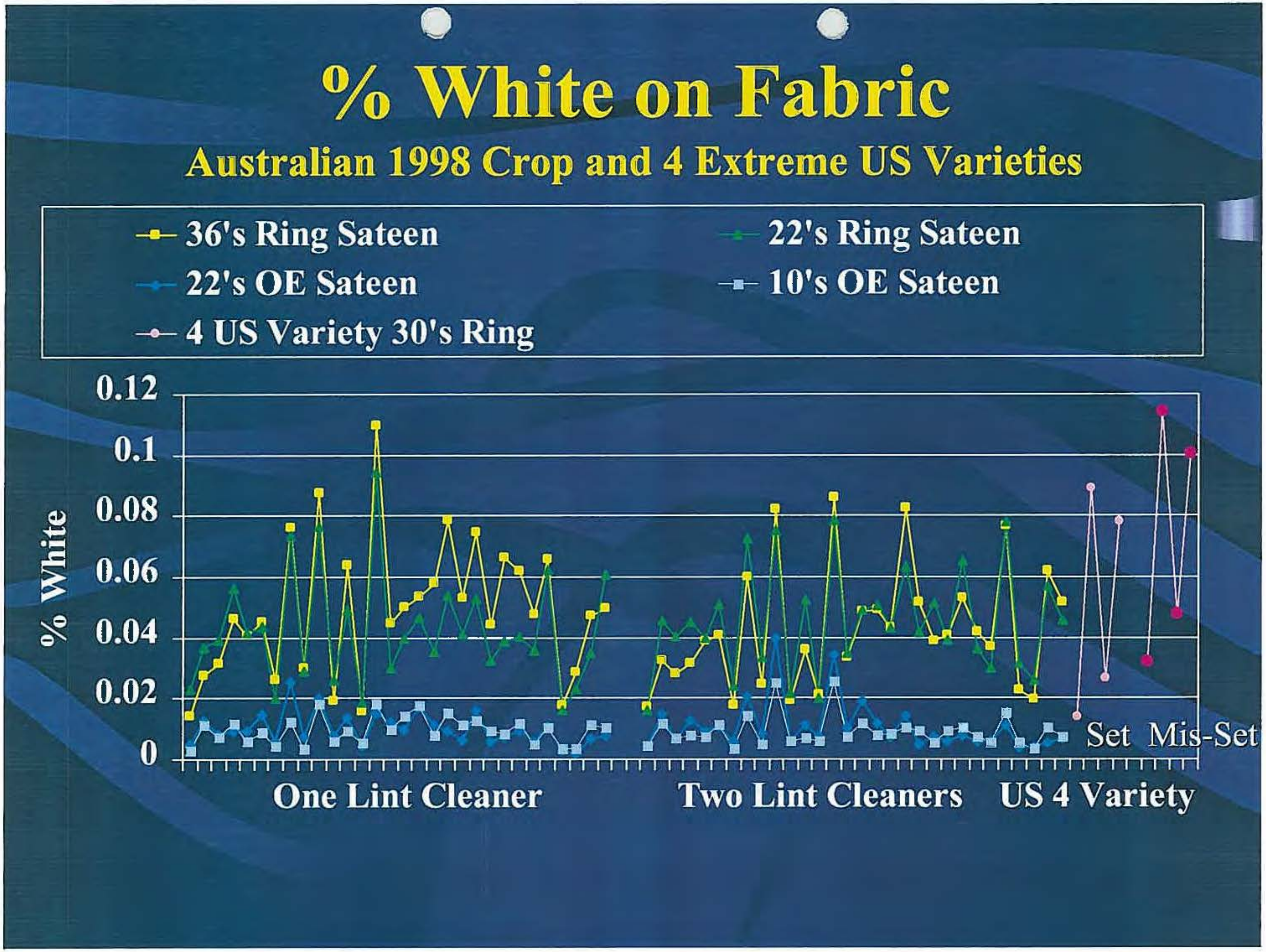
**Growing regions** - No statistically significant differences ($p>>5\%$).

**Seed Variety** - There were statistically significant differences between varieties, but only on the finer (36's Ne) ring spun yarns ($p=1.3\%$). This was so for counts per square metre and for percent area white. Presenting the variety data as a ranking, where best = 10 and worst = 1:

**Table 3 Australian varieties ranked**

| Variety | Ranking, (Whitespeck, /m$^2$) | Ranking, (Whitespeck, Area%white) |
|---|---|---|
| CS50 | 5.4 | 4.9 |
| Delta Pearl | 4 | 3.6 |
| NuCOTN37 | 10 | 10 |
| Sicot 189 | 5.9 | 5.4 |
| V15 | 4.4 | 3.4 |
| V15i | 6.3 | 5.7 |
| V2 | 2.7 | 2.6 |
| V2i | 1 | 1 |

**All InGuard varieties vs. all conventional varieties** - No statistically significant differences ($p>>5\%$).


% White on Fabric
Australian 1998 Crop and 4 Extreme US Varieties
36's Ring Sateen
22's Ring Sateen
22's OE Sateen
10's OE Sateen
4 US Variety 30's Ring
0.12
0.1
0.08
0.06
0.04
0.02
0
% White
Set
Mis-Set
One Lint Cleaner
Two Lint Cleaners
US 4 Variety

### 5.2.2 AFIS lint data

**Length (by number), Short fibre content (by number), Length of top 5 percentile** - These measures all showed the expected relativities, in that the two lint cleaner samples were shorter and had more short fibre. However, because of the variability in the data the differences were not statistically significant ($p >> 5\%$).

**Trash weight** - The trash weight for the two lint cleaner samples was lower on average (220µg vs 254µg), and this difference was marginally significant ($p = 6.8\%$).

**AFIS nep count** - The two lint cleaner samples had higher lint neps as defined by the AFIS counting method, (304 vs 243 neps per gram) and this difference was very significant ($p < 0.1\%$).

## 5.4 Baseline summary

**Figure 3** is taken from Bel-Berger & Roberts (2000). It presents the fabric whitespeck nep (percent area white) data from the 1998 trial alongside a 1997 USA trial (Bel-Berger *et al.*, 1999) designed to show the best and worst results from USA varieties. Two of the varieties are mainstream, one is an experimental long season variety that produced high levels of immature fibre, and one is an experimental short season variety that produced low levels of immature fibre. The USA trial can therefore be thought of as the full spectrum of results in that country.

There is no direct match on yarn thicknesses used to make the fabrics. The closest comparison that can be made is between the data for the Australian 36's ring yarns made from lint cleaned by two lint cleaners (RHS), and the data for the USA 30's ring yarns marked 'Set'. This comparison will favour the USA varieties slightly because the finer the yarn the more the neppiness in the cotton is manifested (*e.g.* comparing the 36's Australian data with the 22's Australian data).

It can be seen that, in this data, on average, the Australian varieties have slightly lower whitespeck than the USA varieties. The USA samples averaged 0.052%, the Australian cotton 0.043%.

The cotton from the 1998 study was examined using electron microscopy, and compared with objective data on fibre maturity. This confirmed anecdotal evidence and HVI data from the industry that the 1998 harvest was a particularly good one, with an ideal hot and fine finish to the season resulting in good micronaire results.

It can therefore be said that in this very good year, the Australian cotton compared very well with USA cotton in terms of whitespeck neps.

The Australian data will be built upon in future years to provide a body of data to show the quality of Australian cotton under a range of growing conditions.

It was proposed that the Australian results would be compared with the results of the 'Leading Varieties' studies in the USA. However, some problems have been discovered with the available data for the USA research that cannot be resolved at present.

Anecdotal evidence collected as part of the Bel-Berger & Roberts (2000) paper at the 10th Australian Cotton Conference suggests that in less mechanized industries where older gin equipment operates at lower rotational speeds the cotton is less harshly handled. This has the effect of reducing fibre damage and the related nep formation. The particular country was Peru where AFIS nep counts were reported to average around 100 neps/g. This compares with around 243 neps/g for the best half (1 lint cleaner) of the Australian samples for 1998 which was a good year in terms of immature fibre. It is worth noting however that subjectively the 1998 Australian cotton is still relatively good and produces quality fabric.

# 6. Discussion

## 6.1 Outcomes not delivered

The 1998 and 1999 studies in this project were the first of their kind anywhere. Although similar work has taken place in the USA and elsewhere, there were important differences. None of them attempted to link all of the phasis in cotton production end-to-end, so that data could be directly linked. The closest study was Bel-Berger *et al.* (1997) which did not follow cotton from the field but only from the merchant stage with many assumptions about region, variety, and gin treatment. That study in fact led to the recognition of the requirement to complete the chain and to the cooperative link to Australian researchers.

Because there were no precedents, many assumptions had to be made well in advance about how it would proceed, both in the method and the time frames required.

Not all of these assumptions were correct. All of the assumptions about method were proved out or worked around, but the assumptions about time frames were only partly proved out.

The particular problems related firstly to transporting lint from an Australian gin the mills in the USA in mid- to late-1998, and to the coordination of different agencies involved in the complicated and scattered processing from seedcotton to dyed fabric, much of it being done on an 'in-kind' basis rather than on a paying basis.

The delays had a cascading effect, where one delay meant that a place in a queue to use laboratory equipment or a mill line was lost causing further delays.

In addition, there were two sets of staff changes in USA cooperating agencies that caused some delays. One staff change in particular showed up a weakness in the method of computer image analysis of dyed fabric samples at the SRRC in New Orleans. The method was found to be operator dependant, and after the staff change the first lot of data received in Australia in January 2000 were found to be questionable.

The problem has now been solved by several iterations of software changes, re-testing of fabrics and analysis of outputs. The method has now been shown to correlate well with physical counting of whitespeck neps via microscopy.

Both to minimize the complexity of the task of managing the fabric formation process across two hemispheres and many timezones, and to make the Australian industry less reliant on the research infrastructure of the USA, work was done to do more of the processing in Australia, for subsequent analysis in the USA.

At the time of writing, only the 1998 trial results have been obtained in full, and then only since mid-August 2000. The analysis of this data has been restricted by the approaching deadline for this report, plus the other project work associated with the visit of Patricia Bel-Berger from mid-August to mid-Sept 2000 for the 10th Australian Cotton Conference.

The 1999 lint samples have been in Melbourne and Bendigo since late 1999. Although it is clear that the Australian cooperating agencies were familiar with the individual operations required, they were not familiar with the particular nature of this project. As a result, the coordination and in some cases the best machinery is only now being put in place.

The equipment at the International Fibre Centre in Melbourne had not been used on this scale before. Software problems with the Reiter roving frame were found, which dragged out that process from mid-Feb to mid-June 2000, and were only solved when the manufacturer forwarded a revised manual for the machine. There were also smaller delays associated with confusion at the IFC about the connection between the this trial and some Rocklea internal research, and with the need to source extra bobbins from Europe.

In addition, commercial pressures have resulted in substantial periods of delays getting onto machinery from processing. The latest delays have been connected with the delivery and commissioning of new machinery that is better suited to trial work on this scale.

Given that most of the processing in this project has been done on a volunteer basis, there was little opportunity to force a faster pace.

The ginning for the 2000 trial did not take place until mid-July 2000 because that was when the ginning season ended and a gin became available. With hindsight, this trial was never going to be completed in time for the deadline for this report, and it should not have been included in NEC3C. It was more a task for the new project NEC7C, in that although the ground work was laid during the former project, the actual ginning and subsequent processing took place or is to take place during the latter. However, had it not been included in NEC3C, it would not have taken place until the following year and a ginning season would have been lost.

It is worth noting that extra work has been included in this project, over and above that detailed in the original proposal:

- the 1998 trial was repeated in a modified form in 1999 as a result of interest from the industry;
- the trash component of the original proposal was beefed up into a separate project as a result of a suggestion from Ron Jett and the Australian Cotton Ginners Association, and became, after some consultation with the CRDC, project NEC5C. That project had no salary component, relying on NEC3C for Dr Robert's time.

It is also worth noting that no tasks have been abandoned, apart from minor tasks listed in the original proposal that elicited little interest within the industry once the project was underway. These were substituted by project NEC5C and the extra trial in 1999.

The project has also grown in the sense that it was a major part of the 'Fibre Plus' meetings in Narrabri in Feb and March 2000, and in the linkage that resulted with the CSIRO TFT group in Geelong.

## 6.2 Outcomes delivered

The people, the basic equipment, the linkages and the expertise now exist in Australia to carry out the basic work involved in research into whitespeck nep and other realised quality attributes of Australian cotton.

The link to the cooperating personnel in the USA (*i.e.* Patricia Bel-Berger) is still required for almost all of the laboratory analysis. In any case, this link will remain into the future in the interests of furthering the competitive position of the international cotton industry versus the international synthetic fibre industry(s).

Baseline data from two trials (1998 and 1999) exist to show the levels of neppiness in Australian cotton.

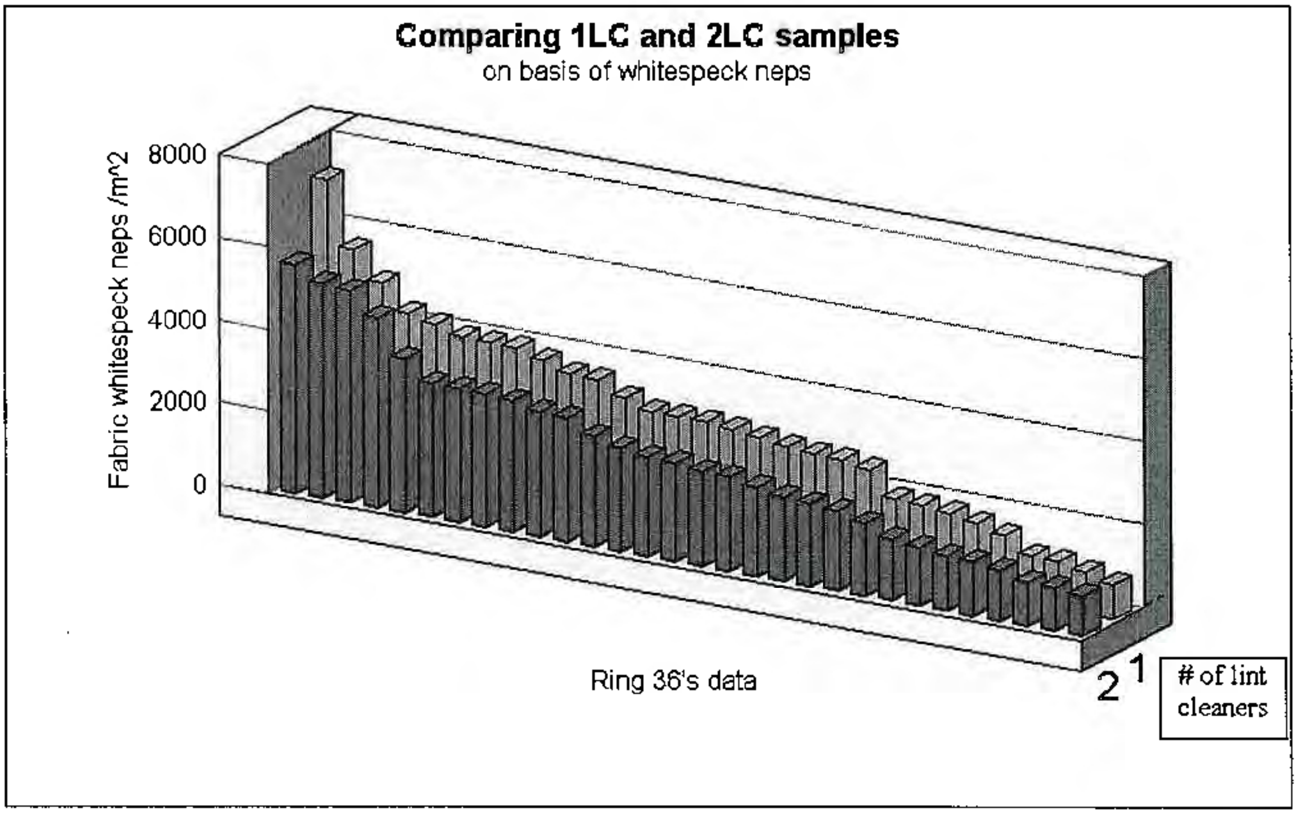
Evidence now exists to show that existing equipment such as HVI, AFIS™, RapidTester™ and variants have the capacity to provide information on lint at exit from the gin that can be used to predict whitespeck neps at exit from the fabric mill. This was not assured prior to this project which linked field samples directly with fabric samples.

Early and basic versions of these predictive relationships will be trialed in an Australian spinning mill during 2000 to test the ability to flag in advance problems with incoming lint, and to show up any false positives.

The analysis of differences in the 1998 data when the data is grouped in various ways has shown the following:

- Lint cleaners (whitespeck data): The number of lint cleaners in the gin did not produce statistically significant differences. This may be due to the number of other influences that were operating in this 'uncontrolled' trial, and the resulting variation in the data. In any case the relativities between the 1LC and the 2LC groups were as expected, in that the 2LC had lower levels of neps (see **Figure 4**).

**Figure 4 - Comparison of Fabric Whitespeck neps/m², 1 lint cleaner vs. 2 lint cleaner**




- Regions (whitespeck data): There were no statistically significant differences between the Emerald, St George or eastern Darling Downs growing regions. This was not expected, as the eastern Downs has a 'low mic' year (*i.e.* difficult growing conditions causing lower maturity) from time to time and is not considered to be a 'quality' growing area to compared with for example St George. However, 1998 was a universally good year and clearly in such a year the eastern Downs produces cotton as good as the other regions.
- Spinning treatments (whitespeck data): From this data, open ended spinning reduces neppiness expressed in the fabric to one quarter of the levels of ring spinning. The difference was very significant.
- In the analysis, it became clear that fabric from Ring spun 36's produce the highest neppiness expressed in the fabric. Data from Ring spun 36's fabric also produces the clearest picture of the patterns within the data, and is therefore the best of the yarn types for future research work.
- Varieties (whitespeck data): There were statistically significant differences between the varieties, and these are expressed as a ranking in Table 3. This data is of a 'first pass' nature,

and probably does not make a solid basis for planting or breeding purposes. However, it is useful to know that this analysis is capable of bringing out differences of this type, and this will become very useful in future as a more complete data set is collected.

- Lint cleaners (AFIS data): The AFIS data that is currently to hand showed statistically significant differences only for the AFIS nep results, where the two lint cleaner samples had higher lint neps as defined by the internal counting method than the one lint cleaner samples. This is the reverse of the expected result, in that generally lint cleaners are expected to remove neps (regardless of their other effects on the cotton). Other AFIS data is pending from USA laboratories.

## 6.3 Outcomes to be delivered

The 1998 data will be analysed fully in time for the report for project NEC7C in February 2001.

It now appears likely that the 2000 trial samples will catch up with the 'pioneer' 1999 samples so they can be processed together. Half of the resulting yarn will go as planned to the USA for weaving as per the 1998 trial, under the control of Patricia Bel-Berger. The other half that was to be made into a different count yarn will now be identical to the yarn going to the USA, and will be going to CSIRO TFT in Geelong to be knitted.

The woven fabrics and the knitted fabrics will therefore be available to cross-reference the two methods of fabric formation. If the knitted yarns produce meaningful data, this will be the preferred method in future research. This is because weaving has extra time and cost overheads (*e.g.* associated with making warps).

Current indications are that spinning of the 1999 samples will commence in late October 2000, with the 2000 samples following on shortly after. If knitting can be done without problems, that will mean that fabrics will be sent to Patricia Bel-Berger at SRRC in December 2000.

The timetable from then on is a function of progress at SRRC. Given the delays with getting the weaving done for the 1998 samples, Patricia Bel-Berger may not receive her woven samples back from the USA mill until March 2001. However, it is planned to report the results to the CRDC in the mid-year 2001 report.

# 7. Conclusions

- This project has, in the nomenclature of the 'Fibre Plus' meeting in Narrabri on 1st - 2nd February 2000, laid the foundations of a cotton quality pipeline, where samples with a known history are taken from field to fabric and / or other points of interest in between. Many kinds of research that have previously not been done in Australia can now take place, and vital questions for the cotton industry can now be answered. At the very least, a better class of question can now be asked and research properly directed.
- The Australian cotton industry is therefore better prepared for future changes in the way that raw cotton is marketed, and has the means on which to base the improvements in quality that are necessary to maintain its position in a competitive commodity market.

- Baseline data from two harvests now exists for Australian cotton. The data ranges from basic lint data to quality of finished fabric. Much of this data (*e.g.* AFIS data beyond nep counts) has not been known for Australian cotton before, on a useful scale.
- The method used in this project has produced meaningful data so that the effects on cotton quality of for example ginning treatments, varieties, and spinning treatments can now be shown objectively.
- There is now evidence that existing instruments can provide data that will, when taken as a group, provide the building blocks of a means of predicting the quality of fabric ('realised quality') given the attributes of ginned lint.
- Much more is now known about the practicalities of the complex and scattered process of converting medium scale (1.5 tonne) experimental samples of lint into samples of fabric suitable for analysis. The familiarity, the linkages between researchers and the machinery now exist to speed up this process substantially.

# 8. Publications arising from the research project


Roberts DG, *Cotton Nep$ Cost Dollars*, Australian Cottongrower magazine, 18(6): 72-80, Nov-Dec 1997, Greenmount Press, Toowoomba

Bel-Berger PD, Roberts DG, 1998, *Fibre to Fabric Research - Cotton Quality*, Society for Engineering in Agriculture meeting attended by approximately15 staff and managers from the ginning industry, NCEA, Toowoomba, 6th August 1998

Bel-Berger PD, Roberts DG, 1998, *Neps - How do they impact cotton quality?*, proc. 9th Australian Cotton Conference, Broadbeach, Australian Cotton Growers Research Association, Narrabri

Bel-Berger PD, Roberts DG, 1999, *Neps: The silent killer of fabric quality*, RMIT Textiles Industry Breakfast, Royal Melbourne Institute of Technology, Brunswick, 29th June 1999

Bel-Berger PD, Roberts DG, *Neps devalue cotton*, speaker's paper, proc. 10th Australian Cotton Conference, Brisbane, Australian Cotton Growers Research Association, Narrabri


In addition:

On 9th September 1997, Grant Roberts spoke at the 'Fibre Forum', sponsored by the CRDC and held at the Queensland Cotton offices in Newstead, Brisbane. The talk was to outline this project and its background, and to hear from industry people their views on neps and cotton quality.

On 1st - 2nd February 2000,and 9th March 2000, Grant Roberts spoke at the 'Fibre Plus' meetings, sponsored by CRDC and held at the ACRI near Narrabri. The first meeting was between researchers in the broad field of cotton post harvest, the second meeting was an industry forum to 'ground truth' the plans developed at the first meeting. It also served as an update and progress report on this project.

An article for The Australian Cottongrower magazine, based on the paper delivered at the 2000 Australian Cotton Conference, is in preparation.

# 9. References


Alon G & Alexander E, 1978, Mechanisms of nep formation, 'Melliand Textilberichte 59, Internationalen Baumwolltest Tagung 1978, Bremen

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Flury B, Riedwyl H, 1990, 'Multivariate Statistics - A practical approach', Chapman and Hall, Melbourne

Goynes WR, Bel-Berger PD, Blanchard EJ, Ingber BF, Graves, HH, Dastoor P, Von Hoven TM, 1996, *'Identification, Quantification and Elimination of White Speck Defects on Dyed Cotton Fabrics'*, proc. American Association of Textile Chemists and Colorists conference, 1996

Hebert JJ, Boylston EK, Thibodeaux DP, 1988, *Anatomy of a Nep*, Textile Research Journal 58, No. 7, pp 380-382

Roberts DG, 1997, *Potential for Improved Cotton Moisture Measurement*, a report to the CRDC, National Centre for Engineering in Agriculture, Toowoomba, February 1997, Section 4

Townsend TP, 1998, *Improving the Market Share of Cotton*, speaker's paper, proc. 9th Australian Cotton Conference, Broadbeach, Australian Cotton Growers Association, Narrabri

# Appendix A: Collection of seedcotton samples in-field

## A.1 1998 trial

As a starting point, opinions were canvassed from several gin operators as to what might be the minimum mass of seedcotton that could be fed into a commercial-sized gin and that would still allow the gin to behave normally.

The opinions varied from 1 tonne to 5 tonnes, depending on the degree of certainty about the success of the gin operations. The size settled upon was 1.5 tonnes, because there was a reasonable likelihood that it would be processed properly and be representative of typical industry practice, and because such a mass was physically feasible for the one or two people who would be moving the samples.

A means of collecting this seedcotton on-farm and transporting it to the gin was required. Seedcotton is awkward to handle for several reasons.

(a) easily damaged using mechanical means;
(b) low density;
(c) high degree of cohesion, meaning it resists flowing uniformally, and work must be done to keep it from aggregating into clumps and drop out of flow;
(d) fibrous, meaning that every action of separating (e.g. scooping) requires power, may only deform the fibre (not separate) and be defeated;
(e) elastic, meaning it tends to spring back after compression and is difficult to keep compressed during packaging;
(f) liable to moisture damage, so it must be collected, packed and transported as soon as reasonably practicable.

The overarching concern was that whatever the means of handling, it must not introduce any confounding factors into the analysis.

The method of handling the cotton settled upon was as follows:

- A 30' square lightweight tarp is spread on the ground, the edges held down by star pickets laid along its edge;
- the picker drives onto the tarp and dumps an estimated 1.5 tonnes of seedcotton. To lessen the effect of wind (common at harvest time), the picker is positioned along the windward edge of the tarp;
- a conventional hydraulic wool press(1) on a trailer(2) is reversed up to the resulting large heap of seedcotton, and a length of ____ mm PVC pipe laid so one end is high on the heap and the other leads to the collection box on the press;
- a length of 90mm PVC pipe is laid to lead from a backpack blower(3) to the mouth of the large diameter pipe, directing high velocity air up the pipe to the lip of the press;
- This causes an airflow in the large diameter pipe sufficiently strong to carry seedcotton pushed to the mouth of the pipe up into the top of the press. When the collection part of the press is full, the blower is set to idle and the press cycled. The blower is then run up to speed and the process is repeated;
- After approximately 12 presses the press reaches the limit of its performance. At this point 150kg is packed into the standard woolpack. The press is paused in the down position, which allows the cotton time to lose some of its elasticy, so that when the ram is lifted the woolpack

can be closed without too much difficulty. The packed woolpack is removed, a replacement is positioned, and the process is repeated.

(1) It was eventually decided to use a conventional wool press to pack seedcotton into 'woolpacks'. A press was budgeted for during the planning phase and subsequently purchased second hand. It is a 'Stevlyon Minimatic' with a 9 hp petrol engine driving a dual range hydraulic pump.

(2) A custom trailer was manufactured for the press. Its primary features are that it has low profile tyres and is the maximum legal width of 2.5m, has a particularly long drawbar, and stiff springing. It can therefore carry the 750kg top heavy press over marginal country roads without stability problems. The press trailer is a chassis only, and has plywood sheets for a floor and no sides. The press is operated while its trailer is attached to the towing vehicle for stability. The trailer traveled approximately 13,000km during the harvest period without incident.

(3) The problem of raising the 1.5 tonnes of seedcotton up into the press was solved by using an off-the-shelf backpack blower to provide a portable means of pneumatic transport. The 'Shindaiwa' 45cc blower is coupled to 90mm stormwater piping so that it injects a high velocity air stream into the mouth of a _____ m length of _____ mm PVC pipe. The blower was not much faster than manually lifting and throwing the cotton, but it did mean that the collection process could go on over several days continuously.

There were early problems with the seals in the hydraulic rams in the press. Cotton requires a higher force to pack into an acceptably dense bale than wool. As a result the press had to be run to the limits of its capability, i.e. when the rams had stalled for several seconds then the bale was fully packed. This brought out an existing problem with one ram, which had spread in diameter and the seals kept blowing when maximum force was developed. Once identified, the problem was fixed in a specialist workshop by heating and shrinking back to specification.

Intermittent early problems with the blower were traced to strong winds recirculating exhaust gas and hot air from the cylinder head back through the carburrettor of the blower, causing partial loss of power. The method of blowing seedcotton from the level of the tarp up into the press only worked when maximum power was being developed, so the blower had to be positioned strictly according to the wind direction.

## A.2 1999 trial

Because the 1999 trial was restricted to the 'catchment' of one gin (Namoi Cooperative, Wathagar gin), the logistics of gathering seedcotton samples that were ginnable in a commercial-sized gin were simplified. Modules from nominated fields were identified at harvest and marked with a highly visible tag. At the gin weighbridge, the modules were separated and unloaded to sit in a row of their own.

## A.3 2000 trial

The 2000 trial was the reverse of the 1998 and 1999 trials in that field effects were held constant and some ginning effects were varied. One module was kindly provided by Paul McVeigh, Lock Eaton, Dalby. The module was parked at a convenient spot at the Queensland Cotton Corp gin at Dalby, and partly broken up using the seed shed loader. The module was divided into thirds, one each going into two shipping containers, the last third left alongside to represent normal conditions.

The shipping containers were initially located at the Dunavant gin at Dalby, until space became available at the Queensland Cotton Corp gin at Dalby where the ginning was to take place.

# Appendix B: Ginning of Seedcotton Samples

## B.1 1998 Trial

The woolpacks of seedcotton samples gathered between 24th February and 30th April 1998 were initially stored at the nearest Queensland Cotton Corp gin using their equipment (either St George, Cecil Plains, or Emerald). In early July 1998 the seedcotton samples were freighted to the Qld Cotton gin in Emerald to join the rest of the samples in storage there, making a total of 44.4 tonnes. A good freight rate was negotiated because Qld Cotton allowed the road train to carry lint bales to Brisbane on the return trip.

The Emerald gin was settled on because it has the narrowest total cleaning width of all the candidate gins. This meant it was the most likely to process the samples of seedcotton from this study which were estimated to be the minimum useable (see Appendix A).

Ginning began on Monday 20th July and ended on 22nd July. The gin had undergone some minor fabrication work on the pneumatic transport prior to starting, so that it could run for extended periods on one ginstand only.

The procedure worked out with the gin staff was as follows:

- The 10 woolpacks making up each seedcotton sample were unpacked onto the moving bed conveyor at the module feeder;
- The conveyor was run at maximum speed and the gin machinery began to process enough cotton to fully supply one Lummus 116 ginstand;
- When the first third of the seedcotton sample had been accumulated on one side of Lummus ________ press, the press was rotated under manual control and the tramper (pneumatic ram taking very low density cotton from the lint slide and precompressing it for the hydraulic bale press) cycled four times, which delivered the desired 25kg of lint;
- The lint was pressed and then the ram was lifted without the floor being dropped. (This particular kind of press can apply full force to this small thickness of cotton which meant the 25kg of cotton was compressed to 50mm and was 'well behaved' once removed from the press. This was an important feature given the adhesive, cohesive and overall 'fly-away' nature of cotton lint.);
- The lint sample was then slid off onto a sheet of plywood and taken away for the extraction of small laboratory samples and the balance pressed into layers in new woolpacks for later processing into test samples of textile;
- The bale press was rotated back to resume processing the nominal 227kg cotton bales.
- When the first half of the seedcotton sample had been processed, there was a change from one lint cleaner being used to two lint cleaners being used, or vice versa. (In some gins this change requires a stop to the flow of seedcotton, but in this gin it could be done without interruption.);
- The pressing of nominal 227kg cotton bales resumed until two thirds of the seedcotton sample had been processed;
- The bale press was then rotated as before and another 25kg sample of lint extracted;
- The press was rotated back and the remaining third of the seedcotton sample was then run out.
- Without interrupting the flow of seedcotton through the gin, the next seedcotton sample was fed into the module feeder, and the process repeated.

During the operations there were 60 running changes to lint cleaner use, plus 60 pressings of samples and the emptying by hand of 296 woolpacks of compressed cotton, while the gin ran on. Most of this work fell to the gin staff as the researchers were fully occupied handling, recording, marking, compressing and bagging 300 samples of various sizes. Ginning of this many samples of this size in this way had not been done before. That the ginning went without a hitch was a credit to the gin staff concerned. Despite tying up the entire permanent staff (including manager) for 2½ days, the ginning was done without even the usual per bale charges.

The production rate was approximately 0.5 bales per hour for the 2½ days, compared to approximately 6 bales/hr for usual operations. A total of 62 bales of lint resulted, plus approximately 1550kg of samples for spinning and weaving, plus two other small amounts for AFIS and other laboratory lint analysis.

The 62 bales were marketed by Qld Cotton, and the proceeds distributed to the relevant growers via cheque from the CRDC in Sept 1998. Around the same time, the cotton that had been diverted for testing was paid for via cheque from the NCEA as per the project budget.

## B.2 1999 trial

The 1999 trial used modules so the amount of cotton to be processed but not sampled was much greater. To minimize variation in ambient conditions, it was planned to process the modules in three consecutive dayshifts. The first day's ginning was 25th May 1999, when the first thirteen modules (all of the Keytah samples) were put through. There was a shift change for the last two modules.

Overnight there was a change in the weather from hot and dry to cool and lightly raining. It was decided to postpone the remaining samples. Ginning recommenced on 15th June 1999 and went through until 16th June 1999.

One difference between the 1998 and 1999 ginning was that the lint cleaners at Wathagar could not be switched in and out while the equipment ran on. To carry out the split between the two lint cleaner treatments (two lint cleaners vs. zero lint cleaners), the gin ran three of the four ginstands with two lint cleaners for most of each sample module. After the '2LC' sample had been extracted, the other ginstand with the lint cleaners behind it switched out was brought into service and the other three switched out. Sufficient cotton was then ginned to empty the bale press slide, fill it up again with known '0 LC' lint, and press it on one side of the bale press. While the press was rotated and the lint extracted the three ginstands were restored to action and the fourth switched out. The rest of the module was then ginned normally.

## B.3 2000 trial

The woolpacks were unloaded on the morning of the ginning, and segregated outside the module feeder bay. They were brought in in 10's, removed from the woolpacks and loaded onto the module feeder conveyor. This was then turned on and the cotton held up in the feed control hopper. When it came time to process the last third still in module form, this was brought in by moonbuggy and processed as usual, although after all the handling it was less stable than usual.

The rest of the gin was then readied for the particular run. The burners were turned up/down/off as required, with the fans running to bring the equipment up to the nominated temperature. When this was stable, the flow of seedcotton was begun. Care was taken as there was only enough cotton to run the equipment properly for a few minutes. The feedrate was kept up to all ginstands, with overflows from time to time emerging to accumulate on the floor past the line of ginstands. This was pushed into the scavenge chute and brought around to the top of the ginstands again, to go through without extra cleaning.

In the middle of each sample, the lint samples were extracted from the bale press by manually controlling its top and bottom rams. These were marked and kept aside from the usual marketing system. The remainder of the cotton went through into the usual system for credit of the grower. An arrangement had been negotiated with the grower where any discounts brought about by the unorthodox heating and drying settings would be made good from a specific item in the project budget.

The highlighted samples in Table 1 of the main report were sampled as follows - one full 227kg bale for spinning trials by Schlafhorst in Germany (for Gary Robinson, CSIRO TFT Geelong), one 150kg sample for the CRDC project concerned with Murata airjet spinning (for Stuart Gordon, CSIRO TFT Geelong) and one 30kg sample for this project. The last two were included in one 180kg short bale. For the non-highlighted samples, one 30kg sample for this project was taken out by manually operating the press and packed in a layered woolpack.

The full bales were freighted direct to Schlafhorst in Germany, while the short bales and the woolpack were sent to IFC Melbourne to be processed.

# Appendix C - Data Tables

## C.1 1998 trial

The following growers provided cotton and related logistic help during the 1998 trial:

1. Allan Saunders, St George
2. Doug Elsden, eastern Downs
3. Mike Thomas, eastern Downs
4. Ian Howse, St George
5. Kevin Anderson, St George
6. Kev Baker, eastern Downs
7. Lyn Brazil, eastern Downs
8. Bill Knights, St George
9. Graham Volck, Emerald
10. John Thompson, eastern Downs
11. Warren Bazley, eastern Downs
12. Ralph Bazley, eastern Downs
13. Ian Thomas, St George
14. Bill Arthur, eastern Downs
15. Peter Enkelmann, Murgon
16. Trevor Elsden
17. Dougal Millar, Emerald
18. Noel Brosnan, Emerald
19. Graham Clapham, eastern Downs

From Cotton Incorporated (Mike Watson's FILE work) Zellweger have had

| | | | | | RapidNep | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS SLV | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Orig. Grower Code | Variety | Clemson Mill Run # | Geo Location Code | # Lint Cleaners | Neps (/g) | Neps (/g) | AvSz Neps (um) | SeedCt Neps (/g) | SeedCt Neps (um) | L(n) (in) | L(n) (CV%) | SFC(n) (%) | L2.5%(n)> (in) | L5%(n)> (in) | L(w) (in) | L(w) (CV%) | SFC(w) (%) | UQL(w) (in) | Mat Ratio | IFC (%) | Fineness (mtex) | Neps (/g) | AvSz Neps (um) | SeedCt Neps (um) | SeedCt Neps (/g) | L(w) (in) | L(w) (CV%) | UQL(w) (in) |
| GC | V | # | LOC | LC | RN | ASN | ASNS | ASNS | ASNSS | ASLN | ASLVH | ASSN | ASL2N | ASL5N | ASLN | ASLVH | ASSH | ASUQH | ASHR | ASTFC | ASF | ABN | ABNZ | ABNSS | ABNS | ABLN | ABLVH | ABUQH |
| E7_1 | NuCOTN3 | 1 | 1 | 1 | 167 | 81 | 499 | 13 | 650 | 0.768 | 51 | 28 | 1.511 | 1.396 | 0.968 | 38 | 11.4 | 1.21 | 0.895 | 9.0 | 172.6 | 206 | 756 | 946 | 20 | 0.95 | 36.9 | 1.18 |
| E7_2 | NuCOTN3 | 2 | 1 | 2 | 183 | 99 | 505 | 14 | 658 | 0.764 | 51 | 29 | 1.522 | 1.399 | 0.962 | 39 | 11.6 | 1.21 | 0.865 | 9.3 | 171.6 | 241 | 759 | 1127 | 15 | 0.96 | 38.5 | 1.21 |
| E5_1 | NuCOTN3 | 3 | 1 | 1 | 217 | 69 | 498 | 10 | 675 | 0.755 | 52 | 30 | 1.521 | 1.394 | 0.960 | 40 | 12.0 | 1.21 | 0.859 | 10.7 | 163.4 | 260 | 758 | 990 | 14 | 0.95 | 38 | 1.19 |
| E5_2 | NuCOTN3 | 4 | 1 | 2 | 203 | 107 | 489 | 10 | 639 | 0.748 | 53 | 31 | 1.524 | 1.394 | 0.953 | 40 | 12.5 | 1.20 | 0.858 | 10.5 | 163.9 | 329 | 760 | 1016 | 19 | 0.95 | 38.1 | 1.19 |
| B1_1 | V15i | 5 | 3 | 1 | 176 | 79 | 491 | 7 | 689 | 0.805 | 50 | 28 | 1.587 | 1.435 | 1.009 | 38 | 10.0 | 1.25 | 0.895 | 9.4 | 165.1 | 177 | 750 | 1108 | 15 | 1.01 | 35.2 | 1.23 |
| B1_2 | V15i | 6 | 3 | 2 | 184 | 84 | 487 | 10 | 662 | 0.793 | 51 | 27 | 1.581 | 1.435 | 1.000 | 38 | 10.4 | 1.24 | 0.892 | 9.6 | 166.1 | 267 | 740 | 932 | 17 | 0.98 | 37 | 1.21 |
| B17_1 | V15i | 7 | 3 | 1 | 203 | 90 | 494 | 8 | 619 | 0.761 | 51 | 28 | 1.514 | 1.366 | 0.955 | 39 | 11.4 | 1.18 | 0.879 | 9.7 | 160.0 | 242 | 751 | 988 | 18 | 0.93 | 37.3 | 1.15 |
| B17_2 | V15i | 8 | 3 | 2 | 198 | 77 | 476 | 4 | 524 | 0.751 | 51 | 28 | 1.497 | 1.357 | 0.945 | 39 | 11.8 | 1.18 | 0.885 | 8.4 | 162.3 | 316 | 764 | 1022 | 22 | 0.91 | 38.5 | 1.14 |
| E6_1 | CS50 | 9 | 1 | 1 | 216 | 89 | 494 | 9 | 676 | 0.798 | 51 | 27 | 1.584 | 1.451 | 1.009 | 39 | 10.3 | 1.26 | 0.891 | 9.7 | 162.1 | 249 | 774 | 1047 | 27 | 0.99 | 37.8 | 1.24 |
| E6_2 | CS50 | 10 | 1 | 2 | 198 | 117 | 497 | 15 | 671 | 0.773 | 53 | 29 | 1.587 | 1.432 | 0.987 | 40 | 11.2 | 1.23 | 0.896 | 9.4 | 164.8 | 299 | 746 | 931 | 15 | 0.96 | 37.4 | 1.22 |
| E9_1 | CS50 | 11 | 1 | 1 | 194 | 115 | 499 | 15 | 678 | 0.780 | 53 | 30 | 1.588 | 1.448 | 1.003 | 40 | 11.2 | 1.26 | 0.894 | 9.3 | 163.1 | 277 | 755 | 963 | 22 | 0.97 | 38.7 | 1.22 |
| E9_2 | CS50 | 12 | 1 | 2 | 207 | 121 | 491 | 11 | 603 | 0.783 | 53 | 29 | 1.581 | 1.441 | 1.001 | 40 | 11.0 | 1.25 | 0.888 | 9.7 | 161.8 | 373 | 760 | 972 | 33 | 0.98 | 38.5 | 1.23 |
| B3_1 | V15 | 13 | 3 | 1 | 170 | 82 | 491 | 8 | 601 | 0.819 | 48 | 23 | 1.573 | 1.418 | 1.005 | 37 | 8.4 | 1.22 | 0.903 | 8.5 | 164.6 | 182 | 749 | 925 | 16 | 0.97 | 35.2 | 1.18 |
| B3_2 | V15 | 14 | 3 | 2 | 176 | 87 | 490 | 7 | 586 | 0.806 | 49 | 25 | 1.597 | 1.430 | 1.003 | 38 | 9.3 | 1.22 | 0.895 | 9.4 | 162.7 | 275 | 751 | 943 | 25 | 0.97 | 35 | 1.18 |
| SG8_1 | V15 | 15 | 2 | 1 | 172 | 298 | 1509 | 10 | 547 | 0.839 | 52 | 27 | 1.673 | 1.521 | 1.068 | 38 | 9.4 | 1.33 | 0.877 | 10.4 | 157.9 | 277 | 759 | 935 | 13 | 1.02 | 38.2 | 1.29 |
| SG8_2 | V15 | 16 | 2 | 2 | 191 | 417 | 1801 | 16 | 659 | 0.839 | 52 | 27 | 1.658 | 1.517 | 1.067 | 38 | 9.4 | 1.33 | 0.875 | 10.5 | 157.4 | 349 | 761 | 1036 | 20 | 1.04 | 36.8 | 1.31 |
| SG4_1 | V2i | 17 | 2 | 1 | 157 | 301 | 2050 | 10 | 531 | 0.834 | 49 | 24 | 1.580 | 1.452 | 1.033 | 38 | 8.7 | 1.27 | 0.905 | 9.3 | 170.4 | 174 | 740 | 852 | 10 | 1.04 | 33.9 | 1.26 |
| SG4_2 | V2i | 18 | 2 | 2 | 161 | 299 | 2019 | 7 | 458 | 0.843 | 48 | 23 | 1.582 | 1.456 | 1.040 | 38 | 8.3 | 1.27 | 0.899 | 9.5 | 169.5 | 228 | 769 | 963 | 33 | 1 | 34.8 | 1.23 |
| B2_1 | V2i | 19 | 3 | 1 | 203 | 149 | 674 | 7 | 671 | 0.780 | 52 | 29 | 1.560 | 1.431 | 0.994 | 39 | 11.4 | 1.25 | 0.839 | 11.8 | 157.9 | 251 | 755 | 928 | 16 | 0.98 | 37.8 | 1.23 |
| B2_2 | V2i | 20 | 3 | 2 | 195 | 84 | 479 | 6 | 654 | 0.763 | 53 | 30 | 1.543 | 1.413 | 0.977 | 40 | 12.0 | 1.23 | 0.838 | 11.8 | 159.8 | 289 | 753 | 965 | 21 | 0.94 | 38.1 | 1.19 |
| B8_1 | Si189 | 21 | 3 | 1 | 167 | 63 | 489 | 5 | 680 | 0.813 | 51 | 26 | 1.579 | 1.453 | 1.018 | 38 | 9.6 | 1.26 | 0.872 | 10.6 | 166.5 | 193 | 748 | 973 | 12 | 1 | 35 | 1.23 |
| B8_2 | Si189 | 22 | 3 | 2 | 174 | 68 | 492 | 5 | 661 | 0.798 | 51 | 27 | 1.564 | 1.438 | 1.006 | 38 | 10.1 | 1.25 | 0.845 | 11.8 | 163.5 | 233 | 751 | 1028 | 16 | 1.01 | 35.2 | 1.25 |
| B14_1 | Si189 | 23 | 3 | 1 | 189 | 69 | 483 | 6 | 621 | 0.784 | 54 | 31 | 1.577 | 1.443 | 0.986 | 40 | 12.3 | 1.25 | 0.817 | 13.2 | 158.1 | 240 | 753 | 898 | 15 | 0.99 | 38.8 | 1.25 |
| B14_2 | Si189 | 24 | 3 | 2 | 196 | 80 | 485 | 4 | 600 | 0.759 | 54 | 31 | 1.554 | 1.427 | 0.980 | 40 | 12.4 | 1.24 | 0.813 | 13.6 | 157.8 | 297 | 741 | 855 | 16 | 0.98 | 38.4 | 1.24 |
| B11_1 | V2 | 25 | 3 | 1 | 154 | 67 | 491 | 6 | 668 | 0.806 | 48 | 24 | 1.522 | 1.389 | 0.989 | 37 | 8.9 | 1.29 | 0.846 | 11.7 | 164.5 | 164 | 771 | 1075 | 21 | 0.99 | 33.7 | 1.2 |
| B11_2 | V2 | 26 | 3 | 2 | 169 | 64 | 491 | 6 | 680 | 0.817 | 48 | 23 | 1.535 | 1.389 | 0.993 | 38 | 8.3 | 1.20 | 0.855 | 11.3 | 165.3 | 214 | 749 | 973 | 14 | 0.98 | 34.1 | 1.18 |
| B15_1 | V2 | 27 | 3 | 1 | 191 | 103 | 485 | 8 | 628 | 0.818 | 51 | 27 | 1.624 | 1.483 | 1.035 | 38 | 9.9 | 1.29 | 0.803 | 14.1 | 154.4 | 311 | 752 | 897 | 19 | 1 | 38.6 | 1.27 |
| B15_2 | V2 | 28 | 3 | 2 | 176 | 124 | 487 | 8 | 605 | 0.823 | 51 | 28 | 1.617 | 1.482 | 1.039 | 38 | 9.6 | 1.29 | 0.800 | 14.2 | 153.7 | 402 | 744 | 891 | 21 | 1.01 | 37 | 1.28 |
| SG2_1 | D Pearl | 29 | 2 | 1 | 171 | 110 | 509 | 14 | 708 | 0.777 | 53 | 30 | 1.564 | 1.443 | 0.995 | 39 | 11.5 | 1.26 | 0.849 | 11.4 | 164.8 | 263 | 752 | 869 | 12 | 0.98 | 39.4 | 1.24 |
| SG2_2 | D Pearl | 30 | 2 | 2 | 181 | 97 | 495 | 10 | 645 | 0.766 | 54 | 31 | 1.588 | 1.444 | 0.991 | 40 | 12.3 | 1.26 | 0.838 | 11.9 | 164.4 | 321 | 753 | 1000 | 19 | 0.97 | 39.1 | 1.24 |
| B10_1 | D Pearl | 31 | 3 | 1 | 191 | 113 | 505 | 13 | 725 | 0.743 | 56 | 34 | 1.557 | 1.435 | 0.977 | 41 | 13.4 | 1.25 | 0.825 | 12.0 | 163.8 | 280 | 749 | 859 | 15 | 0.97 | 38.4 | 1.25 |
| B10_2 | D Pearl | 32 | 3 | 2 | 195 | 122 | 497 | 10 | 743 | 0.745 | 55 | 33 | 1.548 | 1.431 | 0.970 | 41 | 13.3 | 1.25 | 0.813 | 12.9 | 160.7 | 365 | 755 | 913 | 15 | 0.96 | 37.8 | 1.25 |
| SG6_1 | V2 | 33 | 2 | 1 | 168 | 82 | 488 | 8 | 647 | 0.833 | 50 | 25 | 1.604 | 1.470 | 1.042 | 37 | 8.9 | 1.28 | 0.836 | 12.8 | 160.3 | 247 | 762 | 1075 | 27 | 1.07 | 33.7 | 1.3 |
| SG6_2 | V2 | 34 | 2 | 2 | 170 | 101 | 490 | 9 | 649 | 0.821 | 52 | 27 | 1.609 | 1.474 | 1.040 | 38 | 9.6 | 1.29 | 0.854 | 11.7 | 161.7 | 298 | 754 | 960 | 27 | 1.02 | 35.1 | 1.27 |
| SG3_1 | V2 | 35 | 2 | 1 | 146 | 63 | 491 | 7 | 582 | 0.825 | 52 | 27 | 1.613 | 1.481 | 1.049 | 37 | 9.5 | 1.29 | 0.843 | 12.0 | 163.0 | 219 | 751 | 862 | 12 | 1.05 | 33.4 | 1.28 |
| SG3_2 | V2 | 36 | 2 | 2 | 162 | 78 | 495 | 8 | 656 | 0.817 | 51 | 27 | 1.585 | 1.455 | 1.029 | 37 | 9.8 | 1.27 | 0.847 | 11.5 | 163.0 | 289 | 757 | 1032 | 21 | 1.03 | 34.7 | 1.27 |
| SG1_1 | V2i | 37 | 2 | 1 | 191 | 99 | 508 | 12 | 694 | 0.779 | 54 | 30 | 1.573 | 1.443 | 1.005 | 39 | 11.3 | 1.26 | 0.840 | 12.1 | 163.7 | 249 | 756 | 955 | 18 | 0.99 | 35.6 | 1.23 |
| SG1_2 | V2i | 38 | 2 | 2 | 200 | 105 | 490 | 9 | 651 | 0.761 | 54 | 32 | 1.536 | 1.417 | 0.986 | 40 | 12.1 | 1.24 | 0.837 | 11.8 | 162.1 | 307 | 752 | 929 | 32 | 0.99 | 37.9 | 1.24 |
| B7_1 | V2i | 39 | 3 | 1 | 186 | 75 | 483 | 6 | 548 | 0.816 | 56 | 26 | 1.584 | 1.448 | 1.023 | 37 | 9.4 | 1.26 | 0.824 | 12.9 | 163.1 | 203 | 746 | 1050 | 13 | 1.01 | 35.2 | 1.24 |
| B7_2 | V2i | 40 | 3 | 2 | 184 | 80 | 487 | 8 | 642 | 0.801 | 51 | 27 | 1.557 | 1.429 | 1.009 | 38 | 10.1 | 1.25 | 0.816 | 13.4 | 162.1 | 259 | 740 | 864 | 20 | 1 | 35.5 | 1.23 |
| SG7_1 | Si189 | 41 | 2 | 1 | 184 | 107 | 487 | 8 | 630 | 0.795 | 53 | 29 | 1.595 | 1.488 | 1.018 | 39 | 10.9 | 1.28 | 0.841 | 12.1 | 159.2 | 271 | 756 | 927 | 16 | 1.01 | 37.4 | 1.27 |
| SG7_2 | Si189 | 42 | 2 | 2 | 179 | 93 | 495 | 9 | 711 | 0.807 | 53 | 28 | 1.624 | 1.487 | 1.037 | 39 | 10.2 | 1.30 | 0.832 | 12.9 | 160.9 | 323 | 754 | 930 | 19 | 1.02 | 36.3 | 1.27 |
| E8_1 | Si189 | 43 | 1 | 1 | 185 | 95 | 497 | 8 | 645 | 0.781 | 55 | 30 | 1.609 | 1.489 | 1.013 | 40 | 11.3 | 1.28 | 0.838 | 12.5 | 162.0 | 227 | 758 | 963 | 16 | 1.01 | 38.5 | 1.26 |
| E8_2 | Si189 | 44 | 1 | 2 | 194 | 97 | 493 | 8 | 718 | 0.763 | 55 | 31 | 1.579 | 1.448 | 0.991 | 41 | 12.1 | 1.25 | 0.829 | 12.9 | 160.2 | 315 | 755 | 1123 | 19 | 1.01 | 37.3 | 1.28 |
| E1fw_1 | D Pearl | 45 | 1 | 1 | 210 | 101 | 493 | 6 | 756 | 0.705 | 56 | 36 | 1.505 | 1.371 | 0.928 | 42 | 14.8 | 1.19 | 0.822 | 12.5 | 161.4 | 288 | 748 | 1036 | 15 | 0.95 | 39 | 1.21 |
| E1fw_2 | D Pearl | 46 | 1 | 2 | 204 | 117 | 490 | 7 | 717 | 0.710 | 56 | 35 | 1.509 | 1.377 | 0.931 | 42 | 14.6 | 1.19 | 0.825 | 12.6 | 162.0 | 397 | 748 | 947 | 15 | 0.94 | 39.6 | 1.19 |
| E1lr_1 | D Pearl | 47 | 1 | 1 | 199 | 122 | 481 | 7 | 616 | 0.725 | 55 | 34 | 1.521 | 1.387 | 0.943 | 41 | 13.8 | 1.20 | 0.811 | 13.2 | 158.9 | 299 | 762 | 988 | 27 | 0.96 | 38.5 | 1.21 |
| E1lr_2 | D Pearl | 48 | 1 | 2 | 215 | 121 | 493 | 9 | 749 | 0.731 | 54 | 33 | 1.510 | 1.388 | 0.944 | 41 | 13.4 | 1.20 | 0.811 | 13.5 | 160.5 | 350 | 751 | 1068 | 14 | 0.94 | 38.9 | 1.2 |
| B16_1 | V15 | 49 | 3 | 1 | 183 | 68 | 485 | 7 | 629 | 0.784 | 50 | 26 | 1.539 | 1.390 | 0.989 | 38 | 9.6 | 1.21 | 0.850 | 11.8 | 159.6 | 230 | 769 | 1042 | 19 | 0.99 | 33.9 | 1.2 |
| B16_2 | V15 | 50 | 3 | 2 | 176 | 79 | 482 | 5 | 606 | 0.798 | 49 | 25 | 1.525 | 1.388 | 0.987 | 37 | 9.4 | 1.20 | 0.852 | 11.8 | 160.0 | 257 | 754 | 1026 | 11 | 0.97 | 35.9 | 1.19 |
| B5_1 | V15 | 51 | 3 | 1 | 184 | 97 | 484 | 7 | 667 | 0.815 | 52 | 27 | 1.611 | 1.477 | 1.035 | 39 | 9.9 | 1.29 | 0.830 | 12.9 | 156.1 | 319 | 768 | 1057 | 26 | 1.04 | 36.3 | 1.29 |
| B5_2 | V15 | 52 | 3 | 2 | 190 | 116 | 487 | 9 | 663 | 0.838 | 52 | 26 | 1.645 | 1.502 | 1.065 | 38 | 9.1 | 1.32 | 0.825 | 13.4 | 156.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B13_1 | NuCOTN3 | 53 | 3 | 1 | 174 | 77 | 493 | 10 | 627 | 0.777 | 52 | 29 | 1.522 | 1.403 | 0.983 | 38 | 11.1 | 1.23 | 0.832 | 12.4 | 166.7 | 221 | 756 | 932 | 18 | 0.97 | 35.7 | 1.21 |
| B13_2 | NuCOTN3 | 54 | 3 | 2 | 190 | 91 | 494 | 11 | 589 | 0.753 | 53 | 30 | 1.522 | 1.398 | 0.965 | 39 | 12.0 | 1.21 | 0.825 | 12.6 | 167.2 | 253 | 771 | 1015 | 29 | 0.96 | 37.8 | 1.2 |
| B12_1 | NuCOTN3 | 55 | 3 | 1 | 189 | 70 | 494 | 7 | 609 | 0.767 | 51 | 29 | 1.512 | 1.391 | 0.967 | 38 | 11.3 | 1.21 | 0.821 | 13.1 | 165.8 | 212 | 758 | 1007 | 23 | 0.96 | 36.8 | 1.2 |
| B12_2 | NuCOTN3 | 56 | 3 | 2 | 208 | 89 | 500 | 10 | 699 | 0.756 | 52 | 30 | 1.493 | 1.383 | 0.960 | 39 | 11.8 | 1.20 | 0.826 | 12.4 | 167.1 | 293 | 755 | 977 | 27 | 0.95 | 37 | 1.19 |
| Bsp_1 | V15i | 57 | 3 | 1 | 180 | 94 | 496 | 9 | 690 | 0.793 | 53 | 29 | 1.598 | 1.458 | 1.017 | 39 | 10.9 | 1.28 | 0.833 | 12.5 | 157.3 | 253 | 763 | 1128 | 22 | 1.03 | 36.8 | 1.28 |
| Bsp_2 | V15i | 58 | 3 | 2 | 194 | 127 | 486 | 8 | 658 | 0.800 | 53 | 28 | 1.602 | 1.465 | 1.023 | 39 | 10.6 | 1.28 | 0.830 | 13.0 | 155.3 | 333 | 763 | 897 | 27 | 1.03 | 36.3 | 1.28 |
| E3_1 | CS50 | 59 | 1 | 1 | 214 | 116 | 486 | 10 | 851 | 0.758 | 54 | 31 | 1.559 | 1.431 | 0.981 | 40 | 12.2 | 1.24 | 0.840 | 12.0 | 159.2 | 279 | 747 | 933 | 18 | 0.99 | 37 | 1.23 |
| E3_2 | CS50 | 60 | 1 | 2 | 234 | 99 | 489 | 7 | 583 | 0.764 | 54 | 31 | 1.570 | 1.435 | 0.991 | 40 | 11.7 | 1.25 | 0.841 | 12.2 | 160.3 | 339 | 762 | 987 | 23 | 0.98 | 36.5 | 1.22 |

nt samples since August 1999, got go ahead after 2000 Beltwide once questions of which version to use had been answered (V5?) (with new one piece nozzle)

| AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | AFIS LINT | XS | XS | XS | XS | XS | HVI | HVI | HVI | HVI | HVI | HVI | HVI | HVI | HVI | HVI | FMT/Micromat |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SFC(w) (%) | L(n) (in) | L(n) (CV%) | SFC(n) (%) | L5%(n)> (in) | L2.5%(n)> (in) | Fineness (mtex) | IFC (%) | Mat Ratio | Trash Total (ug)? | Trash AvSz (um)? | Dust (ug)? | tshgm? | Visible Fine Matter? | Cellulose Perimeter (um) | Cellulose Area (um^2) | Lumen Perimeter (um) | Lumen Area (um^2) | Cell Wall Thicknes (um) | Colour Grade | Trash Grade | Staple Grade | UHML (in) | Length uniform.( | Strength (g/tex) | icronair (rdg) | Trash (%area) | eflectanc (%) | ellownes (#) | Fineness (mtex) |
| ABSW | ABLN | ABLVN | ABSN | ABL5N | ABL2N | ABF | ABIFC | ABMR | ABT | ABTS | ABD | AB? | ABVFM | XCP | XCA | XLP | XLA | XCT | HCG | HTG | HSG | HUHML | HLU | HS | HMIC | HTA | HR | HY | FF |
| 11.1 | 0.76 | 49 | 27.7 | 1.35 | 1.46 | 179 | 4.9 | 0.96 | 272 | 353 | 215 | 57 | 1.05 | 52.93 | 113.0 | 30.14 | 17.32 | 3.035 | 31 | 2 | 37 | 1.15 | 81.0 | 29.5 | 4.70 | 0.25 | 77.0 | 8.25 | 180.5 |
| 12 | 0.75 | 51.9 | 30.1 | 1.38 | 1.49 | 176 | 5.4 | 0.94 | 165 | 396 | 125 | 39 | 0.6 | 52.93 | 113.0 | 30.14 | 17.32 | 3.035 | 31 | 3 | 36 | 1.13 | 81.0 | 28.7 | 4.70 | 0.20 | 78.0 | 8.25 | 183.7 |
| 11.8 | 0.75 | 51.3 | 29.7 | 1.38 | 1.47 | 168 | 6.4 | 0.92 | 236 | 355 | 193 | 45 | 0.91 | 52.47 | 103.2 | 29.24 | 15.36 | 2.829 | 11 | 2 | 37 | 1.14 | 80.3 | 29.8 | 4.20 | 0.20 | 82.0 | 9.35 | 163.7 |
| 11.1 | 0.75 | 50.9 | 28.6 | 1.37 | 1.47 | 167 | 6.8 | 0.91 | 131 | 356 | 104 | 27 | 0.55 | 52.47 | 103.2 | 29.24 | 15.36 | 2.829 | 31 | 2 | 37 | 1.14 | 80.3 | 29.4 | 4.10 | 0.10 | 82.0 | 9.50 | 166.3 |
| 8.4 | 0.83 | 46.3 | 22.6 | 1.4 | 1.52 | 169 | 5.3 | 0.95 | 184 | 375 | 153 | 41 | 0.79 | 52.25 | 113.3 | 27.06 | 14.57 | 3.028 | 11 | 2 | 37 | 1.15 | 82.0 | 31.6 | 4.30 | 0.18 | 83.3 | 8.73 | 158.0 |
| 10.9 | 0.77 | 49.7 | 27.7 | 1.38 | 1.48 | 165 | 5.6 | 0.94 | 185 | 434 | 143 | 41 | 1.23 | 52.25 | 113.3 | 27.06 | 14.57 | 3.028 | 11 | 1 | 37 | 1.15 | 81.8 | 32.0 | 4.30 | 0.15 | 84.0 | 8.78 | 163.0 |
| 11.4 | 0.75 | 49.2 | 28.3 | 1.33 | 1.44 | 162 | 6.5 | 0.93 | 232 | 339 | 190 | 42 | 0.73 | 51.48 | 102.1 | 28.22 | 14.64 | 2.898 | 11 | 2 | 35 | 1.10 | 81.0 | 31.1 | 3.93 | 0.20 | 82.8 | 8.40 | 155.1 |
| 12.7 | 0.72 | 50.7 | 30.6 | 1.5 | 1.41 | 165 | 5.7 | 0.93 | 263 | 388 | 211 | 52 | 1.06 | 51.48 | 102.1 | 28.22 | 14.64 | 2.898 | 11 | 2 | 35 | 1.09 | 80.8 | 30.7 | 4.03 | 0.20 | 83.0 | 8.50 | 148.2 |
| 10.5 | 0.79 | 50.8 | 27.7 | 1.41 | 1.51 | 165 | 6 | 0.94 | 294 | 400 | 226 | 65 | 1.41 | 49.18 | 101.1 | 25.25 | 13.33 | 3.036 | 21 | 2 | 37 | 1.16 | 81.0 | 30.1 | 4.28 | 0.30 | 82.8 | 8.23 | 155.2 |
| 10.7 | 0.78 | 50.5 | 27.9 | 1.39 | 1.5 | 167 | 5.5 | 0.94 | 182 | 423 | 143 | 48 | 0.99 | 49.18 | 101.1 | 25.25 | 13.33 | 3.036 | 21 | 2 | 37 | 1.15 | 81.0 | 29.8 | 4.30 | 0.23 | 82.0 | 8.03 | 158.5 |
| 11.8 | 0.78 | 52.5 | 30.2 | 1.4 | 1.5 | 164 | 6.1 | 0.94 | 304 | 361 | 242 | 62 | 0.96 | 49.84 | 101.7 | 26.99 | 14.15 | 2.943 | 21 | 3 | 37 | 1.16 | 81.5 | 30.4 | 4.15 | 0.28 | 82.0 | 7.93 | 151.4 |
| 11.7 | 0.77 | 52.5 | 30.2 | 1.41 | 1.51 | 162 | 6.6 | 0.92 | 301 | 381 | 236 | 65 | 1.14 | 49.84 | 101.7 | 26.99 | 14.15 | 2.943 | 21 | 2 | 37 | 1.17 | 81.3 | 30.5 | 4.20 | 0.28 | 82.0 | 8.13 | 152.0 |
| 6.6 | 0.8 | 46 | 23 | 1.38 | 1.48 | 165 | 5.3 | 0.96 | 289 | 387 | 223 | 66 | 1.09 | 48.55 | 95.5 | 25.85 | 14.07 | 2.874 | 42 | 3 | 35 | 1.10 | 81.8 | 31.6 | 4.43 | 0.40 | 72.8 | 8.25 | 154.8 |
| 6.6 | 0.8 | 46.5 | 23.2 | 1.36 | 1.47 | 166 | 5 | 0.96 | 274 | 433 | 193 | 81 | 1.54 | 48.55 | 95.5 | 25.85 | 14.07 | 2.874 | 42 | 3 | 36 | 1.13 | 81.3 | 31.8 | 4.28 | 0.35 | 73.0 | 8.23 | 149.4 |
| 10.7 | 0.8 | 52.8 | 28.8 | 1.47 | 1.59 | 157 | 7.1 | 0.82 | 267 | 320 | 225 | 43 | 0.73 | 47.79 | 88.1 | 26.03 | 13.51 | 2.713 | 11 | 2 | 39 | 1.22 | 82.8 | 32.7 | 3.85 | 0.23 | 83.0 | 8.50 | 144.8 |
| 9.5 | 0.82 | 51.2 | 26.8 | 1.47 | 1.58 | 159 | 6.5 | 0.92 | 214 | 346 | 171 | 43 | 0.74 | 47.79 | 88.1 | 26.03 | 13.51 | 2.713 | 11 | 1 | 39 | 1.22 | 83.0 | 32.6 | 3.90 | 0.15 | 83.8 | 8.60 | 141.5 |
| 7.5 | 0.88 | 45.9 | 21.5 | 1.43 | 1.53 | 172 | 5.6 | 0.95 | 149 | 327 | 129 | 21 | 0.46 | 51.71 | 109.5 | 28.10 | 16.08 | 3.079 | 11 | 2 | 37 | 1.16 | 82.7 | 32.8 | 4.63 | 0.20 | 83.0 | 8.53 | 173.2 |
| 9.1 | 0.81 | 47.8 | 24.9 | 1.39 | 1.49 | 171 | 5.8 | 0.95 | 223 | 389 | 178 | 45 | 0.91 | 51.71 | 109.5 | 28.10 | 16.08 | 3.079 | 11 | 1 | 37 | 1.16 | 82.8 | 33.2 | 4.63 | 0.13 | 83.5 | 8.78 | 175.5 |
| 10.7 | 0.79 | 50.1 | 27.3 | 1.41 | 1.53 | 156 | 7.8 | 0.89 | 333 | 440 | 235 | 98 | 1.71 | 54.03 | 101.8 | 31.83 | 16.41 | 2.720 | 41 | 3 | 37 | 1.15 | 81.3 | 31.3 | 3.56 | 0.43 | 74.0 | 7.60 | 142.3 |
| 12.4 | 0.74 | 51 | 30.4 | 1.37 | 1.47 | 160 | 8 | 0.89 | 381 | 408 | 291 | 90 | 1.78 | 54.03 | 101.8 | 31.83 | 16.41 | 2.720 | 41 | 3 | 36 | 1.13 | 81.0 | 30.6 | 3.70 | 0.40 | 73.7 | 7.47 | 143.8 |
| 9.4 | 0.81 | 48.3 | 25.1 | 1.41 | 1.51 | 169 | 5.4 | 0.95 | 151 | 340 | 123 | 28 | 0.48 | 53.14 | 106.9 | 31.14 | 16.70 | 2.834 | 11 | 2 | 37 | 1.16 | 82.0 | 33.0 | 4.48 | 0.18 | 82.3 | 8.90 | 170.5 |
| 8.5 | 0.83 | 47.7 | 23.8 | 1.43 | 1.53 | 170 | 5.8 | 0.94 | 143 | 388 | 113 | 29 | 0.67 | 53.14 | 106.9 | 31.14 | 16.70 | 2.834 | 11 | 2 | 37 | 1.16 | 82.5 | 32.1 | 4.50 | 0.20 | 81.5 | 8.88 | 163.8 |
| 11.6 | 0.77 | 53 | 30.2 | 1.42 | 1.53 | 161 | 6.6 | 0.91 | 315 | 385 | 240 | 75 | 1.16 | 51.86 | 100.7 | 28.63 | 14.83 | 2.848 | 41 | 3 | 38 | 1.18 | 81.3 | 32.0 | 3.68 | 0.38 | 75.0 | 7.60 | 147.1 |
| 11.1 | 0.78 | 51.7 | 28.7 | 1.41 | 1.52 | 162 | 6.5 | 0.91 | 181 | 440 | 113 | 47 | 0.84 | 51.86 | 100.7 | 28.63 | 14.83 | 2.848 | 41 | 2 | 37 | 1.17 | 80.8 | 31.9 | 3.98 | 0.30 | 78.3 | 7.93 | 153.7 |
| 8.2 | 0.82 | 45.3 | 22.3 | 1.37 | 1.48 | 171 | 5.6 | 0.94 | 247 | 319 | 204 | 43 | 0.72 | 53.52 | 114.7 | 29.54 | 15.42 | 3.115 | 11 | 2 | 38 | 1.12 | 82.0 | 30.4 | 4.50 | 0.15 | 81.5 | 9.95 | 164.9 |
| 7.9 | 0.82 | 44.5 | 21.3 | 1.35 | 1.45 | 171 | 5.9 | 0.94 | 165 | 359 | 141 | 23 | 0.68 | 53.52 | 114.7 | 29.54 | 15.42 | 3.115 | 11 | 2 | 38 | 1.12 | 81.7 | 31.4 | 4.43 | 0.13 | 82.0 | 9.83 | 163.3 |
| 10.4 | 0.8 | 51.4 | 27.2 | 1.45 | 1.56 | 152 | 8.6 | 0.87 | 373 | 417 | 274 | 99 | 1.94 | 52.31 | 91.7 | 30.32 | 15.01 | 2.586 | 11 | 2 | 38 | 1.19 | 82.0 | 31.4 | 3.45 | 0.25 | 83.0 | 9.15 | 140.3 |
| 9.6 | 0.81 | 49.5 | 25.5 | 1.44 | 1.55 | 156 | 8.1 | 0.89 | 207 | 415 | 147 | 61 | 0.92 | 52.31 | 91.7 | 30.32 | 15.01 | 2.586 | 11 | 2 | 38 | 1.19 | 82.0 | 32.1 | 3.48 | 0.20 | 83.0 | 9.03 | 138.8 |
| 12.2 | 0.76 | 53.2 | 30.8 | 1.42 | 1.54 | 167 | 6.4 | 0.92 | 243 | 396 | 185 | 48 | 1.33 | 52.31 | 104.3 | 28.93 | 14.95 | 2.933 | 11 | 1 | 38 | 1.18 | 81.5 | 30.8 | 4.30 | 0.10 | 84.5 | 8.35 | 160.0 |
| 12 | 0.76 | 52.8 | 30.4 | 1.42 | 1.52 | 165 | 6.2 | 0.91 | 159 | 351 | 135 | 24 | 0.66 | 52.31 | 104.3 | 28.93 | 14.95 | 2.933 | 11 | 2 | 37 | 1.16 | 81.3 | 30.4 | 4.30 | 0.15 | 84.3 | 8.23 | 160.9 |
| 11.8 | 0.77 | 51.5 | 29.3 | 1.43 | 1.52 | 156 | 7.9 | 0.87 | 138 | 351 | 115 | 23 | 0.56 | 55.58 | 108.8 | 31.87 | 15.77 | 2.897 | 11 | 1 | 38 | 1.19 | 81.0 | 30.4 | 4.00 | 0.13 | 84.0 | 8.75 | 151.9 |
| 11.1 | 0.78 | 50.6 | 28.1 | 1.42 | 1.51 | 163 | 7.5 | 0.89 | 177 | 349 | 148 | 29 | 0.74 | 55.58 | 108.8 | 31.87 | 15.77 | 2.897 | 11 | 1 | 37 | 1.16 | 81.3 | 29.6 | 3.98 | 0.10 | 84.5 | 8.63 | 158.6 |
| 7.2 | 0.88 | 46.7 | 21.4 | 1.47 | 1.57 | 164 | 6.6 | 0.94 | 193 | 423 | 147 | 46 | 1.27 | 50.52 | 99.5 | 26.34 | 13.78 | 3.027 | 11 | 2 | 38 | 1.18 | 83.0 | 32.5 | 4.15 | 0.10 | 82.0 | 9.10 | 155.2 |
| 8.8 | 0.83 | 47.9 | 24.1 | 1.43 | 1.53 | 166 | 6.3 | 0.93 | 197 | 353 | 182 | 35 | 1.1 | 50.52 | 99.5 | 26.34 | 13.78 | 3.027 | 11 | 2 | 38 | 1.18 | 82.5 | 32.4 | 4.10 | 0.20 | 81.5 | 9.15 | 157.4 |
| 7.5 | 0.87 | 46.1 | 21.6 | 1.44 | 1.53 | 167 | 6.5 | 0.93 | 181 | 401 | 146 | 35 | 0.91 | 52.83 | 110.0 | 28.03 | 15.02 | 3.070 | 11 | 2 | 38 | 1.19 | 82.7 | 33.8 | 4.27 | 0.17 | 82.3 | 9.00 | 160.1 |
| 8.5 | 0.84 | 48.2 | 24 | 1.44 | 1.55 | 170 | 5.9 | 0.96 | 171 | 382 | 135 | 35 | 0.61 | 52.83 | 110.0 | 28.03 | 15.02 | 3.070 | 11 | 1 | 38 | 1.18 | 83.0 | 33.7 | 4.30 | 0.10 | 83.0 | 9.03 | 162.3 |
| 10 | 0.8 | 49.4 | 26.7 | 1.4 | 1.5 | 166 | 6.2 | 0.93 | 264 | 383 | 221 | 63 | 1.23 | 53.13 | 109.3 | 27.95 | 14.64 | 3.054 | 21 | 2 | 37 | 1.16 | 83.0 | 32.4 | 4.18 | 0.33 | 80.8 | 7.95 | 161.7 |
| 11.1 | 0.78 | 51.8 | 29 | 1.41 | 1.53 | 161 | 6.6 | 0.92 | 253 | 360 | 207 | 45 | 0.99 | 53.13 | 109.3 | 27.95 | 14.64 | 3.054 | 21 | 2 | 37 | 1.15 | 82.3 | 31.4 | 4.10 | 0.20 | 81.0 | 8.03 | 155.8 |
| 8.9 | 0.83 | 46.6 | 23.2 | 1.41 | 1.52 | 161 | 7.5 | 0.89 | 161 | 354 | 131 | 29 | 0.65 | 54.72 | 112.8 | 30.47 | 15.92 | 2.964 | 11 | 2 | 37 | 1.15 | 83.0 | 32.0 | 4.18 | 0.13 | 82.0 | 9.15 | 163.4 |
| 9.2 | 0.82 | 47.2 | 24.1 | 1.41 | 1.5 | 165 | 7.1 | 0.9 | 216 | 414 | 165 | 51 | 1.18 | 54.72 | 112.8 | 30.47 | 15.92 | 2.964 | 11 | 2 | 37 | 1.15 | 82.0 | 32.2 | 4.13 | 0.15 | 81.6 | 9.03 | 163.8 |
| 10.4 | 0.8 | 51 | 27.5 | 1.45 | 1.55 | 159 | 6.8 | 0.91 | 204 | 335 | 174 | 30 | 0.87 | 50.16 | 101.8 | 27.30 | 14.43 | 3.020 | 11 | 1 | 38 | 1.20 | 82.0 | 33.1 | 4.05 | 0.15 | 83.6 | 8.88 | 162.2 |
| 9.4 | 0.82 | 49.5 | 25.6 | 1.45 | 1.56 | 163 | 6.5 | 0.92 | 138 | 388 | 111 | 25 | 0.76 | 50.16 | 101.8 | 27.30 | 14.43 | 3.020 | 11 | 1 | 39 | 1.21 | 81.8 | 32.7 | 4.25 | 0.13 | 84.0 | 8.83 | 155.0 |
| 9.7 | 0.81 | 50.1 | 28.4 | 1.44 | 1.53 | 167 | 6.3 | 0.93 | 317 | 356 | 258 | 59 | 1.15 | 50.30 | 98.6 | 27.99 | 14.57 | 2.854 | 21 | 2 | 38 | 1.18 | 81.8 | 32.0 | 4.18 | 0.28 | 81.0 | 8.50 | 159.3 |
| 10.1 | 0.8 | 50.8 | 27.1 | 1.44 | 1.55 | 161 | 7.5 | 0.91 | 265 | 360 | 216 | 49 | 1.12 | 50.30 | 98.6 | 27.99 | 14.57 | 2.854 | 21 | 3 | 37 | 1.17 | 81.0 | 31.6 | 4.23 | 0.28 | 81.0 | 8.63 | 164.2 |
| 12.4 | 0.75 | 52.2 | 30.8 | 1.38 | 1.48 | 165 | 6.2 | 0.92 | 381 | 358 | 310 | 71 | 1.42 | 52.97 | 110.8 | 27.90 | 14.88 | 3.176 | 21 | 2 | 37 | 1.15 | 80.5 | 29.9 | 4.23 | 0.28 | 81.0 | 7.90 | 163.5 |
| 13 | 0.73 | 53.3 | 32.1 | 1.37 | 1.48 | 166 | 6 | 0.92 | 401 | 329 | 341 | 61 | 1.12 | 52.97 | 110.8 | 27.90 | 14.88 | 3.176 | 21 | 3 | 36 | 1.13 | 79.8 | 29.1 | 4.13 | 0.28 | 80.3 | 8.10 | 160.5 |
| 12.1 | 0.75 | 52.4 | 30.7 | 1.38 | 1.49 | 158 | 7.6 | 0.88 | 220 | 375 | 178 | 42 | 1.02 | 53.00 | 99.1 | 30.76 | 16.31 | 2.727 | 31 | 2 | 37 | 1.15 | 80.3 | 28.6 | 4.03 | 0.28 | 80.8 | 7.73 | 154.3 |
| 12.7 | 0.74 | 52.7 | 31.5 | 1.37 | 1.48 | 163 | 6.6 | 0.91 | 233 | 385 | 182 | 51 | 1.27 | 53.00 | 99.1 | 30.76 | 16.31 | 2.727 | 21 | 2 | 38 | 1.13 | 80.0 | 28.3 | 4.18 | 0.25 | 81.0 | 7.90 | 151.4 |
| 8.2 | 0.82 | 44.6 | 21.8 | 1.35 | 1.45 | 164 | 5.9 | 0.94 | 270 | 334 | 227 | 43 | 0.82 | 50.80 | 100.0 | 28.15 | 14.67 | 2.920 | 21 | 2 | 36 | 1.12 | 82.5 | 32.1 | 4.35 | 0.18 | 82.0 | 8.68 | 154.9 |
| 9.2 | 0.8 | 48.8 | 23.8 | 1.35 | 1.47 | 167 | 5.4 | 0.95 | 217 | 380 | 182 | 35 | 0.88 | 50.80 | 100.0 | 28.15 | 14.67 | 2.920 | 11 | 2 | 36 | 1.11 | 82.0 | 32.3 | 4.30 | 0.20 | 82.3 | 8.68 | 155.8 |
| 6.9 | 0.84 | 49.4 | 24.8 | 1.47 | 1.58 | 169 | 6.9 | 0.91 | 357 | 417 | 268 | 91 | 1.81 | 51.25 | 103.0 | 29.39 | 15.43 | 2.937 | 41 | 4 | 38 | 1.20 | 82.5 | 33.0 | 3.98 | 0.53 | 74.0 | 7.90 | 143.3 |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51.25 | 103.0 | 29.39 | 15.43 | 2.937 | 41 | 3 | 38 | 1.20 | 83.0 | 32.4 | 3.90 | 0.40 | 72.8 | 7.98 | 145.0 |
| 10 | 0.79 | 48.4 | 26.1 | 1.37 | 1.47 | 172 | 5.7 | 0.93 | 151 | 374 | 127 | 25 | 0.86 | 55.13 | 121.9 | 30.05 | 16.20 | 3.236 | 11 | 1 | 37 | 1.14 | 81.0 | 31.1 | 4.48 | 0.18 | 81.3 | 8.95 | 177.5 |
| 11.2 | 0.77 | 49.8 | 28.1 | 1.37 | 1.49 | 167 | 6.3 | 0.92 | 297 | 356 | 241 | 56 | 1.18 | 55.13 | 121.9 | 30.05 | 16.20 | 3.236 | 11 | 2 | 38 | 1.13 | 80.8 | 31.2 | 4.48 | 0.20 | 81.0 | 9.08 | 177.2 |
| 10.3 | 0.78 | 48.8 | 26.1 | 1.38 | 1.48 | 168 | 6.5 | 0.91 | 253 | 374 | 201 | 52 | 1.11 | 54.28 | 111.6 | 31.72 | 17.67 | 2.926 | 21 | 2 | 38 | 1.13 | 81.5 | 30.7 | 4.65 | 0.13 | 82.5 | 9.30 | 172.9 |
| 11.2 | 0.77 | 49.4 | 28.1 | 1.36 | 1.45 | 170 | 6 | 0.93 | 167 | 343 | 139 | 28 | 0.58 | 54.28 | 111.6 | 31.72 | 17.87 | 2.926 | 11 | 1 | 38 | 1.13 | 81.3 | 30.4 | 4.53 | 0.10 | 82.5 | 9.23 | 172.9 |
| 9.7 | 0.82 | 50.1 | 26.2 | 1.45 | 1.57 | 160 | 6.6 | 0.82 | 377 | 433 | 279 | 98 | 2.17 | 49.79 | 93.7 | 28.75 | 14.67 | 2.676 | 31 | 3 | 38 | 1.18 | 83.0 | 31.6 | 4.00 | 0.48 | 77.0 | 7.88 | 150.9 |
| 6.9 | 0.83 | 48.7 | 24.2 | 1.45 | 1.58 | 159 | 7 | 0.91 | 293 | 349 | 241 | 52 | 0.95 | 49.79 | 93.7 | 28.75 | 14.67 | 2.676 | 31 | 3 | 37 | 1.17 | 83.0 | 31.2 | 3.98 | 0.38 | 77.6 | 7.90 | 148.1 |
| 10.5 | 0.79 | 50.1 | 27.3 | 1.41 | 1.51 | 164 | 6.7 | 0.92 | 231 | 390 | 186 | 45 | 1.15 | 51.10 | 110.2 | 26.03 | 13.76 | 3.257 | 21 | 2 | 37 | 1.17 | 81.3 | 30.8 | 4.13 | 0.20 | 83.5 | 7.78 | 150.3 |
| 10.1 | 0.79 | 49.7 | 26.8 | 1.4 | 1.5 | 165 | 5.9 | 0.93 | 198 | 403 | 149 | 49 | 0.8 | 51.10 | 110.2 | 26.03 | 13.76 | 3.257 | 21 | 2 | 37 | 1.16 | 81.5 | 29.9 | 4.23 | 0.20 | 84.0 | 7.83 | 150.9 |

| cromat Maturity ratio (FM) | SA non-lint Visible Waste (%) (WV) | SA non-lint Total Waste (%) (WT) | Sugar Content (%) (SUG) | Ring, 22s Opening & Cardin Waste (%) (CWR2) | Yarn Skein Strength Test: Yarn no. (Ne) (SKYR2) | Yarn no. CV% (SKYCVR2) | Count X Strength (SKCSPR2) | CSP CV% (SKCSPCVR2) | Elongation (%) (SKER2) |
|---|---|---|---|---|---|---|---|---|---|
| 1.014 | 1.40 | 0.77 | 0.13 | 10.14 | 21.9 | 1.1 | 2573 | 3.0 | 5.7 |
| 0.987 | 1.23 | 0.81 | 0.16 | 8.76 | 22.1 | 1.2 | 2514 | 2.8 | 5.5 |
| 0.933 | 1.52 | 0.90 | 0.21 | 11.33 | 22.1 | 1.0 | 2606 | 3.2 | 5.8 |
| 0.937 | 1.44 | 0.87 | 0.19 | 10.60 | 21.6 | 0.7 | 2621 | 3.0 | 5.9 |
| 1.015 | 1.29 | 0.66 | 0.46 | 10.20 | 21.6 | 1.0 | 2963 | 5.5 | 6.1 |
| 1.009 | 0.96 | 0.78 | 0.38 | 9.38 | 21.6 | 0.9 | 2956 | 3.2 | 5.8 |
| 0.936 | 1.32 | 0.82 | 0.34 | 9.32 | 21.8 | 0.7 | 2962 | 2.2 | 5.9 |
| 0.991 | 1.14 | 1.22 | 0.28 | 9.87 | 22.0 | 0.9 | 2843 | 3.8 | 5.9 |
| 1.060 | 1.49 | 0.95 | 0.24 | 9.85 | 21.7 | 1.4 | 2827 | 3.0 | 5.9 |
| 1.018 | 1.39 | 0.93 | 0.24 | 9.59 | 21.7 | 0.8 | 2754 | 3.0 | 5.6 |
| 1.040 | 1.60 | 1.03 | 0.21 | 9.42 | 21.2 | 2.0 | 2854 | 2.4 | 5.9 |
| 1.041 | 1.15 | 0.91 | 0.17 | 9.16 | 21.3 | 2.2 | 2900 | 3.9 | 5.9 |
| 1.071 | 1.80 | 0.87 | 0.13 | 10.49 | 21.6 | 0.9 | 2998 | 2.9 | 6.0 |
| 1.072 | 1.41 | 0.77 | 0.14 | 10.17 | 21.8 | 1.1 | 3037 | 1.9 | 5.8 |
| 0.973 | 1.51 | 0.65 | 0.40 | 8.75 | 21.9 | 2.7 | 3228 | 4.0 | 6.5 |
| 1.005 | 1.00 | 0.77 | 0.33 | 8.01 | 21.0 | 2.5 | 3234 | 3.7 | 6.4 |
| 1.036 | 1.56 | 0.67 | 0.36 | 9.76 | 21.7 | 1.0 | 2973 | 3.5 | 6.0 |
| 1.008 | 1.25 | 0.65 | 0.40 | 8.70 | 21.9 | 1.4 | 3020 | 3.2 | 5.6 |
| 0.897 | 1.60 | 0.98 | 0.18 | 9.98 | 21.4 | 2.3 | 2947 | 3.1 | 5.9 |
| 0.905 | 1.41 | 0.77 | 0.14 | 10.43 | 21.6 | 1.7 | 2879 | 3.4 | 5.7 |
| 0.996 | 1.46 | 0.65 | 0.37 | 11.00 | 21.8 | 1.6 | 2974 | 3.1 | 6.3 |
| 1.032 | 1.20 | 0.69 | 0.35 | 8.58 | 21.9 | 1.1 | 2916 | 2.9 | 6.0 |
| 0.951 | 1.85 | 1.01 | 0.20 | 10.67 | 21.5 | 1.9 | 2857 | 4.9 | 6.4 |
| 0.955 | 1.20 | 1.06 | 0.25 | 10.87 | 21.5 | 2.0 | 2879 | 2.6 | 6.3 |
| 1.009 | 1.16 | 0.80 | 0.48 | 9.24 | 21.7 | 1.3 | 3008 | 2.9 | 6.0 |
| 1.019 | 0.86 | 0.62 | 0.41 | 9.77 | 22.1 | 0.9 | 2977 | 4.2 | 6.0 |
| 0.888 | 1.36 | 1.07 | 0.37 | 9.77 | 21.3 | 1.3 | 3068 | 5.6 | 6.6 |
| 0.877 | 1.13 | 1.11 | 0.39 | 10.16 | 22.2 | 3.0 | 3105 | 3.5 | 6.5 |
| 0.985 | 1.25 | 0.66 | 0.39 | 11.42 | 21.9 | 0.8 | 2697 | 2.3 | 6.0 |
| 0.996 | 1.15 | 0.94 | 0.38 | 8.80 | 21.6 | 1.3 | 2690 | 4.2 | 6.2 |
| 0.945 | 1.14 | 1.09 | 0.45 | 10.13 | 21.9 | 1.1 | 2671 | 2.3 | 6.5 |
| 0.923 | 1.04 | 0.94 | 0.52 | 9.57 | 21.9 | 1.4 | 2632 | 2.6 | 6.5 |
| 0.979 | 1.40 | 2.28 | 0.40 | 9.12 | 23.3 | 2.4 | 3164 | 4.0 | 6.5 |
| 0.975 | 1.39 | 2.47 | 0.38 | 8.56 | 21.9 | 2.2 | 3198 | 3.1 | 6.0 |
| 0.999 | 1.33 | 2.20 | 0.41 | 8.78 | 21.6 | 1.1 | 3099 | 1.8 | 5.9 |
| 0.998 | 1.06 | 2.04 | 0.39 | 8.45 | 21.3 | 1.6 | 3092 | 3.3 | 6.3 |
| 0.933 | 1.37 | 2.71 | 0.34 | 9.53 | 20.9 | 2.3 | 2976 | 6.1 | 6.4 |
| 0.966 | 1.04 | 2.09 | 0.29 | 8.78 | 21.3 | 2.5 | 2956 | 3.7 | 6.1 |
| 0.956 | 1.44 | 2.46 | 0.43 | 9.05 | 21.5 | 2.3 | 3095 | 2.7 | 6.9 |
| 0.946 | 1.36 | 2.06 | 0.45 | 9.01 | 21.7 | 2.2 | 3037 | 3.7 | 6.5 |
| 0.938 | 1.35 | 2.08 | 0.34 | 10.13 | 21.9 | 2.5 | 3007 | 2.1 | 6.5 |
| 0.998 | 1.01 | 1.68 | 0.37 | 9.18 | 21.9 | 2.0 | 2972 | 3.9 | 6.5 |
| 0.987 | 1.40 | 2.36 | 0.19 | 9.44 | 21.4 | 2.4 | 3013 | 3.2 | 7.3 |
| 0.970 | 1.43 | 2.40 | 0.21 | 10.11 | 21.8 | 1.5 | 2969 | 2.1 | 6.6 |
| 0.978 | 1.75 | 2.66 | 0.27 | 10.00 | 21.6 | 0.9 | 2565 | 3.1 | 6.0 |
| 0.958 | 1.72 | 2.61 | 0.22 | 10.86 | 22.5 | 0.9 | 2476 | 2.9 | 5.8 |
| 0.950 | 1.56 | 2.47 | 0.21 | 8.98 | 22.2 | 0.9 | 2542 | 2.8 | 6.0 |
| 0.992 | 1.20 | 2.03 | 0.22 | 8.81 | 22.2 | 2.8 | 2524 | 4.0 | 5.6 |
| 1.032 | 1.40 | 2.15 | 0.48 | 9.44 | 21.8 | 1.4 | 3097 | 4.5 | 5.8 |
| 1.040 | 1.20 | 1.83 | 0.46 | 11.26 | 21.7 | 0.8 | 3033 | 2.3 | 6.1 |
| 0.990 | 2.31 | 3.22 | 0.28 | 10.45 | 21.9 | 1.4 | 3125 | 2.9 | 6.0 |
| 0.999 | 1.53 | 3.04 | 0.32 | 8.13 | 22.0 | 2.8 | 3095 | 2.8 | 5.7 |
| 0.999 | 1.20 | 1.96 | 0.37 | 9.60 | 21.9 | 1.2 | 2625 | 3.6 | 5.9 |
| 0.972 | 1.57 | 2.43 | 0.35 | 10.05 | 22.0 | 0.9 | 2581 | 2.6 | 5.7 |
| 1.004 | 1.70 | 2.54 | 0.37 | 9.94 | 22.1 | 0.8 | 2599 | 3.7 | 6.1 |
| 1.009 | 1.18 | 2.02 | 0.33 | 9.38 | 22.3 | 1.2 | 2606 | 2.9 | 5.8 |
| 0.986 | 1.51 | 2.75 | 0.17 | 10.09 | 22.2 | 1.4 | 3025 | 2.8 | 6.0 |
| 0.972 | 1.54 | 2.45 | 0.20 | 10.47 | 21.3 | 2.1 | 2993 | 3.8 | 6.1 |
| 1.014 | 1.39 | 2.42 | 0.37 | 9.73 | 21.2 | 2.2 | 2800 | 2.6 | 6.0 |
| 1.034 | 1.17 | 2.11 | 0.28 | 8.75 | 21.9 | 1.0 | 2752 | 3.2 | 5.8 |

| Maturity ratio (FM) | Single Yarn Strength Test: Tenacity (mN/tex) (Y1TR2) | Tenacity (CV%) (Y1TCVR2) | Force (N) (Y1FR2) | Elongation (%) (Y1ER2) | Elongation (CV%) (Y1ECVR2) | Spec.WR (cm.N) (Y1WR2) | Spec.WR (CV%) (Y1WCVR2) | Uster Yarn Evenness: Non-unif. (CV%) (UNUR2) | #Thick/ 1000yd (UTKR2) | #Thin/ 1000yd (UTNR2) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.014 | 93 | 9.2 | 4.24 | 5.90 | 7.22 | 3.35 | 14.7 | 16.7 | 452 | 68 |
| 0.987 | 94 | 8.5 | 4.25 | 5.88 | 6.26 | 3.39 | 12.8 | 16.8 | 429 | 69 |
| 0.933 | 97 | 8.9 | 4.37 | 6.17 | 6.75 | 3.61 | 13.3 | 16.9 | 433 | 86 |
| 0.937 | 94 | 9.7 | 4.33 | 6.05 | 7.88 | 3.50 | 15.1 | 16.9 | 464 | 87 |
| 1.015 | 109 | 8.4 | 5.05 | 6.32 | 6.90 | 4.12 | 12.7 | 14.9 | 168 | 15 |
| 1.009 | 109 | 9.5 | 5.02 | 6.23 | 6.35 | 4.08 | 13.1 | 16.1 | 192 | 17 |
| 0.936 | 111 | 9.0 | 5.09 | 6.39 | 5.83 | 4.23 | 12.8 | 15.0 | 183 | 27 |
| 0.991 | 100 | 9.2 | 4.54 | 6.01 | 7.14 | 3.88 | 13.1 | 15.9 | 288 | 35 |
| 1.060 | 102 | 7.4 | 4.70 | 5.93 | 7.19 | 3.58 | 11.6 | 15.1 | 226 | 17 |
| 1.018 | 101 | 8.5 | 4.63 | 5.68 | 7.50 | 3.61 | 13.3 | 15.8 | 272 | 29 |
| 1.040 | 105 | 8.9 | 4.95 | 6.17 | 6.10 | 3.84 | 13.4 | 15.4 | 254 | 21 |
| 1.041 | 102 | 8.9 | 4.80 | 6.06 | 6.88 | 3.60 | 13.2 | 15.3 | 288 | 16 |
| 1.071 | 105 | 8.2 | 4.85 | 5.93 | 6.15 | 3.79 | 11.8 | 14.4 | 144 | 18 |
| 1.072 | 111 | 8.6 | 5.09 | 6.10 | 7.22 | 4.08 | 12.6 | 14.8 | 155 | 16 |
| 0.973 | 120 | 8.5 | 5.48 | 6.53 | 6.48 | 4.54 | 12.9 | 15.0 | 221 | 13 |
| 1.005 | 120 | 7.8 | 5.73 | 6.69 | 6.35 | 4.83 | 12.1 | 14.4 | 194 | 10 |
| 1.036 | 110 | 8.9 | 5.05 | 5.98 | 5.98 | 3.87 | 12.7 | 14.0 | 134 | 8 |
| 1.008 | 113 | 9.1 | 5.18 | 5.89 | 6.85 | 3.94 | 12.9 | 15.0 | 188 | 16 |
| 0.897 | 108 | 8.5 | 5.07 | 6.43 | 6.05 | 4.19 | 12.5 | 14.9 | 214 | 20 |
| 0.905 | 107 | 9.7 | 4.95 | 6.26 | 9.04 | 4.07 | 15.1 | 15.3 | 235 | 24 |
| 0.996 | 109 | 7.4 | 5.00 | 6.34 | 9.66 | 4.20 | 13.0 | 15.0 | 157 | 19 |
| 1.032 | 110 | 8.4 | 5.03 | 6.59 | 6.36 | 4.34 | 12.5 | 14.9 | 183 | 15 |
| 0.951 | 104 | 9.5 | 4.83 | 6.42 | 7.22 | 4.10 | 13.9 | 15.1 | 231 | 16 |
| 0.955 | 104 | 8.0 | 4.82 | 6.37 | 8.66 | 4.07 | 12.5 | 15.4 | 243 | 13 |
| 1.009 | 111 | 8.3 | 5.11 | 6.30 | 6.73 | 4.14 | 12.9 | 14.3 | 108 | 15 |
| 1.019 | 109 | 8.3 | 4.94 | 6.10 | 6.43 | 3.93 | 12.1 | 14.8 | 151 | 17 |
| 0.888 | 118 | 7.6 | 5.53 | 6.87 | 6.03 | 4.83 | 11.8 | 14.2 | 174 | 3 |
| 0.877 | 112 | 9.1 | 5.05 | 6.53 | 6.30 | 4.25 | 13.2 | 15.4 | 201 | 35 |
| 0.985 | 98 | 8.9 | 4.40 | 5.90 | 6.65 | 3.48 | 13.4 | 16.0 | 347 | 32 |
| 0.996 | 103 | 8.7 | 4.78 | 6.36 | 6.48 | 3.98 | 13.5 | 16.0 | 304 | 34 |
| 0.945 | 100 | 9.8 | 4.58 | 6.67 | 7.61 | 4.10 | 15.6 | 16.7 | 285 | 36 |
| 0.923 | 95 | 9.2 | 4.34 | 6.54 | 6.74 | 3.81 | 14.1 | 16.1 | 330 | 27 |
| 0.979 | 121 | 7.0 | 5.65 | 6.07 | 5.68 | 4.29 | 10.7 | 14.1 | 162 | 2 |
| 0.975 | 117 | 8.1 | 5.19 | 5.87 | 5.85 | 3.86 | 12.1 | 14.5 | 196 | 7 |
| 0.999 | 117 | 8.7 | 5.03 | 5.98 | 6.14 | 3.87 | 12.4 | 15.5 | 180 | 32 |
| 0.998 | 117 | 8.7 | 5.35 | 6.24 | 5.90 | 4.18 | 12.3 | 15.2 | 152 | 27 |
| 0.933 | 110 | 7.9 | 5.08 | 6.09 | 6.54 | 3.97 | 12.1 | 15.0 | 173 | 12 |
| 0.966 | 111 | 9.3 | 5.23 | 6.26 | 6.62 | 4.17 | 13.8 | 15.4 | 273 | 29 |
| 0.956 | 119 | 7.6 | 5.71 | 6.61 | 6.46 | 4.93 | 12.1 | 14.1 | 142 | 1 |
| 0.946 | 115 | 7.3 | 5.40 | 6.74 | 5.92 | 4.62 | 11.1 | 14.0 | 169 | 12 |
| 0.938 | 116 | 7.6 | 5.39 | 6.80 | 6.11 | 4.52 | 10.0 | 15.4 | 260 | 7 |
| 0.998 | 113 | 8.5 | 5.23 | 6.38 | 6.66 | 4.28 | 14.0 | 15.2 | 228 | 11 |
| 0.987 | 109 | 8.4 | 4.97 | 6.32 | 6.87 | 4.11 | 13.4 | 15.1 | 219 | 13 |
| 0.970 | 110 | 7.6 | 5.04 | 6.34 | 6.02 | 4.16 | 12.2 | 15.8 | 247 | 17 |
| 0.978 | 93 | 8.5 | 4.34 | 5.91 | 7.83 | 3.47 | 13.6 | 16.3 | 361 | 60 |
| 0.958 | 86 | 9.5 | 4.01 | 5.76 | 7.59 | 3.18 | 13.9 | 17.0 | 490 | 85 |
| 0.950 | 98 | 9.1 | 4.45 | 6.34 | 8.37 | 3.76 | 14.4 | 16.1 | 322 | 46 |
| 0.992 | 89 | 8.1 | 3.97 | 5.90 | 6.44 | 3.20 | 11.7 | 16.7 | 420 | 63 |
| 1.032 | 110 | 9.0 | 4.95 | 6.28 | 6.77 | 4.02 | 13.3 | 14.4 | 137 | 14 |
| 1.040 | 108 | 8.8 | 4.88 | 6.12 | 6.61 | 3.96 | 12.7 | 14.7 | 142 | 16 |
| 0.990 | 109 | 7.4 | 5.00 | 6.16 | 7.57 | 4.10 | 12.2 | 14.4 | 194 | 0 |
| 0.999 | 112 | 8.1 | 5.15 | 6.20 | 6.79 | 4.24 | 13.1 | 14.9 | 213 | 8 |
| 0.999 | 97 | 8.3 | 4.44 | 6.27 | 6.47 | 3.70 | 13.0 | 15.7 | 280 | 28 |
| 0.972 | 96 | 8.9 | 4.37 | 6.18 | 6.66 | 3.64 | 13.9 | 16.3 | 355 | 55 |
| 1.004 | 93 | 9.3 | 4.22 | 6.14 | 6.77 | 3.53 | 13.9 | 16.2 | 345 | 42 |
| 1.009 | 93 | 10.6 | 4.16 | 6.19 | 7.66 | 3.49 | 14.6 | 16.4 | 356 | 66 |
| 0.986 | 107 | 6.9 | 4.61 | 5.98 | 6.47 | 3.84 | 11.5 | 14.6 | 229 | 2 |
| 0.972 | 107 | 9.3 | 5.04 | 6.31 | 7.02 | 4.21 | 14.3 | 14.9 | 213 | 6 |
| 1.014 | 101 | 7.8 | 4.76 | 5.98 | 7.16 | 3.73 | 12.0 | 15.0 | 233 | 10 |
| 1.034 | 102 | 7.5 | 4.67 | 5.90 | 5.96 | 3.61 | 11.4 | 15.1 | 259 | 19 |

| Maturity ratio (FM) | #Neps/ 1000yd (UNR2) | Yarn Appearance Index (YAIR2) | Whitespeck CIA sateen: Count /m^2 (MSCR2) | AvSz (um^2) (MSSR2) | AreaWh (%)?? (MSAR2) | Ring, 36s Opening & Cardin Waste (%) (CWR3) | Yarn Skein Strength Test: Yarn no. (Ne) (SKYR3) | Yarn no. CV% (SKYCVR3) | Count X Strength (SKCSPR3) | CSP CV% (SKCSPCVR3) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1.014 | 57 | 100 | 1474 | 87146 | 0.01825 | 10.14 | 35.0 | 1.6 | 2343 | 2.5 |
| 0.987 | 42 | 100 | 997 | 90213 | 0.0128 | 8.76 | 35.6 | 0.9 | 2369 | 1.9 |
| 0.933 | 38 | 97 | 2373 | 85402 | 0.029075 | 11.33 | 35.8 | 1.2 | 2479 | 3.7 |
| 0.937 | 53 | 90 | 2915 | 88037 | 0.03645 | 10.60 | 35.7 | 1.2 | 2378 | 2.1 |
| 1.015 | 27 | 100 | 2427 | 90750 | 0.031325 | 10.20 | 35.6 | 1.1 | 2771 | 3.2 |
| 1.009 | 31 | 97 | 2427 | 91831 | 0.0319 | 9.38 | 35.6 | 0.9 | 2735 | 2.5 |
| 0.936 | 20 | 100 | 3478 | 91473 | 0.045 | 9.32 | 35.1 | 1.0 | 2732 | 2.5 |
| 0.991 | 17 | 100 | 2633 | 94980 | 0.03585 | 9.87 | 35.9 | 1.0 | 2842 | 2.5 |
| 1.060 | 34 | 97 | 2557 | 88995 | 0.032975 | 9.85 | 35.0 | 1.0 | 2607 | 2.9 |
| 1.018 | 35 | 90 | 2319 | 96500 | 0.031625 | 9.59 | 35.7 | 1.0 | 2587 | 3.9 |
| 1.040 | 38 | 93 | 2384 | 100891 | 0.0346 | 9.42 | 35.3 | 1.9 | 2677 | 3.0 |
| 1.041 | 19 | 97 | 2904 | 97631 | 0.04065 | 9.16 | 35.1 | 2.1 | 2639 | 2.5 |
| 1.071 | 26 | 100 | 1203 | 92267 | 0.015925 | 10.49 | 35.7 | 1.0 | 2765 | 2.8 |
| 1.072 | 33 | 100 | 1452 | 91537 | 0.01895 | 10.17 | 35.7 | 1.0 | 2851 | 2.9 |
| 0.973 | 42 | 90 | 4432 | 93717 | 0.0587 | 8.75 | 36.2 | 1.8 | 3082 | 2.7 |
| 1.005 | 37 | 100 | 4009 | 100877 | 0.057675 | 8.01 | 35.4 | 1.5 | 3093 | 1.8 |
| 1.036 | 32 | 110 | 1517 | 106208 | 0.023075 | 9.76 | 35.1 | 1.7 | 2878 | 2.6 |
| 1.008 | 36 | 100 | 1961 | 94918 | 0.026525 | 8.70 | 35.3 | 0.9 | 2938 | 2.2 |
| 0.897 | 21 | 100 | 4930 | 86329 | 0.0609 | 9.98 | 35.5 | 1.7 | 2794 | 3.4 |
| 0.905 | 16 | 100 | 5136 | 81092 | 0.0596 | 10.43 | 35.6 | 1.3 | 2700 | 2.8 |
| 0.996 | 17 | 110 | 1571 | 91086 | 0.0205 | 11.00 | 35.9 | 0.9 | 2751 | 3.1 |
| 1.032 | 16 | 103 | 1268 | 85910 | 0.01715 | 8.58 | 36.0 | 1.2 | 2695 | 2.9 |
| 0.951 | 23 | 100 | 3023 | 89684 | 0.038875 | 10.67 | 35.3 | 1.9 | 2665 | 2.7 |
| 0.955 | 13 | 100 | 3132 | 94711 | 0.0418 | 10.87 | 35.6 | 1.6 | 2628 | 3.6 |
| 1.009 | 16 | 110 | 1192 | 84956 | 0.01465 | 9.24 | 35.8 | 1.0 | 2849 | 1.9 |
| 1.019 | 20 | 107 | 1235 | 91937 | 0.016075 | 9.77 | 36.3 | 1.5 | 2777 | 2.6 |
| 0.888 | 14 | 100 | 6263 | 83641 | 0.0749 | 9.77 | 35.6 | 1.0 | 2947 | 2.4 |
| 0.877 | 18 | 100 | 5158 | 84646 | 0.062475 | 10.16 | 36.3 | 1.4 | 2962 | 2.5 |
| 0.985 | 16 | 97 | 1766 | 93932 | 0.023725 | 11.42 | 35.9 | 1.1 | 2498 | 2.5 |
| 0.996 | 19 | 100 | 2124 | 91576 | 0.027775 | 8.80 | 36.7 | 1.1 | 2491 | 4.5 |
| 0.945 | 24 | 100 | 2492 | 88624 | 0.031625 | 10.13 | 36.0 | 2.7 | 2413 | 2.7 |
| 0.923 | 23 | 100 | 3012 | 90428 | 0.03895 | 9.57 | 35.2 | 1.1 | 2406 | 1.9 |
| 0.979 | 20 | 110 | 2666 | 96943 | 0.03695 | 9.12 | 35.1 | 3.7 | 2985 | 2.8 |
| 0.975 | 26 | 100 | 3099 | 90425 | 0.04025 | 8.58 | 34.8 | 2.4 | 3054 | 2.1 |
| 0.999 | 24 | 100 | 2156 | 92595 | 0.028275 | 8.78 | 35.9 | 1.9 | 2955 | 3.2 |
| 0.998 | 22 | 100 | 2601 | 92538 | 0.034225 | 8.45 | 35.0 | 2.7 | 2988 | 3.1 |
| 0.933 | 21 | 103 | 3316 | 90581 | 0.043075 | 9.53 | 36.2 | 1.2 | 2704 | 2.8 |
| 0.966 | 28 | 100 | 3879 | 90636 | 0.050325 | 8.78 | 36.2 | 1.1 | 2728 | 2.9 |
| 0.956 | 21 | 100 | 2785 | 82140 | 0.032675 | 9.05 | 35.1 | 2.1 | 2823 | 2.7 |
| 0.946 | 21 | 100 | 2850 | 81256 | 0.033125 | 9.01 | 35.3 | 3.0 | 2788 | 3.4 |
| 0.938 | 18 | 100 | 3067 | 96941 | 0.04215 | 10.13 | 35.7 | 2.6 | 2826 | 2.4 |
| 0.998 | 25 | 100 | 3056 | 93140 | 0.040825 | 9.18 | 35.8 | 2.6 | 2779 | 1.9 |
| 0.987 | 35 | 97 | 1983 | 90525 | 0.0258 | 9.44 | 35.6 | 1.8 | 2752 | 2.6 |
| 0.970 | 27 | 100 | 2276 | 95789 | 0.0313 | 10.11 | 36.1 | 1.5 | 2707 | 2.2 |
| 0.978 | 13 | 97 | 2156 | 99411 | 0.030725 | 10.00 | 35.4 | 1.7 | 2319 | 2.4 |
| 0.958 | 32 | 100 | 3738 | 96658 | 0.0518 | 10.86 | 36.2 | 1.0 | 2248 | 2.9 |
| 0.950 | 14 | 100 | 2536 | 87936 | 0.0319 | 8.98 | 36.0 | 1.0 | 2359 | 2.4 |
| 0.992 | 25 | 100 | 2080 | 97448 | 0.028925 | 8.81 | 36.0 | 0.8 | 2324 | 2.3 |
| 1.032 | 26 | 100 | 2048 | 100031 | 0.028625 | 9.44 | 35.6 | 1.2 | 2608 | 3.0 |
| 1.040 | 18 | 110 | 1745 | 95440 | 0.023825 | 11.26 | 35.9 | 1.3 | 2776 | 3.7 |
| 0.990 | 37 | 100 | 3771 | 91690 | 0.0494 | 10.45 | 35.4 | 2.3 | 2889 | 3.0 |
| 0.999 | 34 | 100 | 4562 | 94864 | 0.061925 | 8.13 | 35.4 | 4.1 | 2893 | 3.0 |
| 0.999 | 28 | 100 | 1019 | 87424 | 0.012725 | 9.60 | 36.2 | 1.1 | 2401 | 2.8 |
| 0.972 | 27 | 100 | 1907 | 92683 | 0.02485 | 10.05 | 35.6 | 1.0 | 2359 | 2.4 |
| 1.004 | 41 | 100 | 1463 | 87273 | 0.0184 | 9.94 | 36.1 | 1.0 | 2380 | 2.3 |
| 1.009 | 41 | 100 | 1354 | 106289 | 0.0207 | 9.38 | 36.5 | 2.3 | 2302 | 3.0 |
| 0.986 | 39 | 100 | 1885 | 102593 | 0.02755 | 10.09 | 34.2 | 2.4 | 2757 | 5.0 |
| 0.972 | 30 | 100 | 3240 | 98470 | 0.0454 | 10.47 | 35.3 | 2.0 | 2778 | 2.7 |
| 1.014 | 23 | 100 | 3413 | 98981 | 0.046275 | 9.73 | 36.6 | 1.4 | 2562 | 4.2 |
| 1.034 | 26 | 100 | 2601 | 96357 | 0.0361 | 8.75 | 36.2 | 1.1 | 2557 | 3.0 |

| Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | Ring, 30s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s | OES, 10s |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Single Yarn Strength Test | | | | | | | Uster Yarn Evenness | | | | Yarn | Whitespeck CIA sateen | | | Opening | Yarn Skein Strength Test | | | | | Single Yarn Strength Test | | | | | | | Uster Yarn |
| Elongation (%) | Tenacity (mN/tex) | Tenacity (CV%) | Force (N) | Elongation (%) | Elongation (CV%) | Spec.WR (cm.N) | Spec.WR (CV%) | Non-unif. (CV%) | #Thick/ 1000yd | #Thin/ 1000yd | #Neps' 1000yd | Appearance Index | Count /m^2 | AvSz (um^2) | AreaWh (%)?? | & Cardin Waste (% | Yarn no. (Ne) | Yarn no. CV% | Count X Strength | CSP CV% | Elongation (%) | Tenacity (mN/tex) | Tenacity (CV%) | Force (N) | Elongation (%) | Elongation (CV%) | Spec.WR (cm.N) | Spec.WR (CV%) | Non-unif. (CV%) |
| SHER3 | Y1TR3 | Y1TCVR3 | Y1FR3 | Y1ER3 | Y1ECVR3 | Y1WR3 | Y1WCVR3 | UNUR3 | UTKR3 | UTNR3 | UNR3 | YAIR3 | WSCR3 | WSSR3 | WSAR3 | CMO1 | SKYO1 | SKYCVO1 | SKCSPO1 | SKCSPCVO1 | SKEO1 | Y1TO1 | Y1TCVO1 | Y1FO1 | Y1EO1 | Y1ECVO1 | Y1WO1 | Y1WCVO1 | UNUO1 |
| 5.0 | 90 | 9.8 | 2.56 | 5.74 | 6.68 | 1.93 | 13.9 | 19.8 | 1188 | 177 | 334 | 90 | 834 | 87298 | 0.010575 | 10.14 | 9.8 | 0.9 | 2418 | 3.4 | 5.8 | 138 | 7.0 | 8.33 | 6.48 | 6.82 | 7.38 | 12.4 | 12.2 |
| 5.5 | 88 | 9.1 | 2.46 | 5.72 | 6.60 | 1.86 | 13.1 | 20.3 | 1345 | 248 | 374 | 90 | 964 | 92204 | 0.012775 | 8.78 | 9.8 | 1.5 | 2386 | 2.8 | 6.3 | 135 | 6.7 | 8.12 | 6.78 | 5.45 | 7.43 | 10.9 | 11.7 |
| 5.5 | 93 | 11.1 | 2.60 | 5.96 | 7.25 | 2.03 | 15.6 | 20.2 | 1301 | 247 | 422 | 80 | 1712 | 83162 | 0.020675 | 11.33 | 9.8 | 1.8 | 2428 | 3.9 | 6.3 | 142 | 5.4 | 8.55 | 6.66 | 5.66 | 7.83 | 10.0 | 11.8 |
| 5.4 | 93 | 11.1 | 2.61 | 5.92 | 7.09 | 2.02 | 16.2 | 20.4 | 1405 | 228 | 423 | 70 | 1983 | 86426 | 0.024475 | 10.60 | 9.8 | 1.6 | 2468 | 3.2 | 7.2 | 138 | 6.0 | 8.29 | 7.02 | 15.44 | 7.75 | 13.8 | 11.5 |
| 5.5 | 106 | 8.6 | 2.97 | 6.13 | 5.75 | 2.31 | 12.4 | 18.1 | 775 | 80 | 197 | 80 | 1896 | 87087 | 0.02345 | 10.20 | 9.7 | 1.1 | 2754 | 4.8 | 6.8 | 156 | 6.2 | 9.49 | 6.86 | 5.75 | 8.69 | 10.6 | 11.2 |
| 5.6 | 102 | 11.3 | 2.85 | 5.98 | 7.84 | 2.19 | 16.3 | 18.1 | 812 | 62 | 183 | 80 | 1506 | 97184 | 0.02095 | 9.38 | 9.7 | 1.4 | 2745 | 3.1 | 6.7 | 155 | 5.3 | 9.45 | 6.68 | 6.51 | 8.50 | 10.7 | 11.3 |
| 5.6 | 105 | 9.5 | 2.98 | 6.13 | 6.48 | 2.34 | 14.0 | 18.1 | 728 | 66 | 153 | 80 | 2731 | 88196 | 0.0345 | 9.32 | 9.9 | 1.5 | 2735 | 2.8 | 5.8 | 150 | 12.5 | 8.84 | 6.80 | 6.67 | 8.32 | 15.8 | 11.2 |
| 5.5 | 98 | 9.6 | 2.74 | 5.93 | 6.05 | 2.11 | 14.0 | 18.9 | 917 | 122 | 217 | 80 | 1755 | 93083 | 0.023525 | 9.87 | 9.9 | 1.5 | 2735 | 2.8 | 6.7 | 153 | 5.5 | 9.14 | 6.83 | 5.45 | 8.47 | 9.8 | 11.3 |
| 5.5 | 97 | 9.4 | 2.78 | 5.84 | 6.81 | 2.08 | 13.3 | 18.6 | 910 | 92 | 251 | 90 | 2538 | 84500 | 0.030775 | 9.85 | 9.8 | 1.3 | 2576 | 3.1 | 6.4 | 145 | 5.4 | 8.72 | 6.29 | 6.40 | 7.46 | 10.6 | 11.5 |
| 5.5 | 97 | 10.5 | 2.72 | 5.76 | 7.69 | 2.02 | 15.4 | 18.8 | 976 | 63 | 274 | 80 | 2276 | 90379 | 0.02915 | 9.59 | 9.8 | 1.0 | 2541 | 2.8 | 6.5 | 147 | 5.4 | 8.84 | 6.45 | 5.67 | 7.73 | 10.1 | 11.1 |
| 5.5 | 100 | 9.2 | 2.84 | 5.79 | 6.67 | 2.11 | 12.6 | 17.5 | 913 | 95 | 256 | 80 | 2644 | 89668 | 0.03385 | 9.42 | 9.7 | 1.4 | 2604 | 2.2 | 6.6 | 150 | 5.6 | 9.15 | 6.42 | 6.31 | 7.90 | 10.7 | 11.2 |
| 5.4 | 99 | 11.4 | 2.83 | 5.81 | 7.16 | 2.13 | 16.1 | 18.9 | 969 | 103 | 273 | 80 | 2286 | 92887 | 0.030625 | 9.16 | 9.8 | 1.9 | 2558 | 3.7 | 6.7 | 149 | 4.5 | 8.96 | 6.49 | 15.29 | 7.73 | 13.3 | 11.3 |
| 5.5 | 104 | 9.7 | 2.92 | 5.89 | 6.51 | 2.21 | 13.8 | 17.4 | 608 | 59 | 161 | 90 | 1539 | 88166 | 0.0194 | 10.49 | 9.8 | 0.8 | 2712 | 2.1 | 6.7 | 157 | 5.4 | 9.46 | 6.41 | 5.98 | 8.23 | 10.7 | 11.3 |
| 5.6 | 107 | 9.7 | 3.00 | 6.00 | 6.22 | 2.30 | 13.7 | 17.4 | 594 | 56 | 168 | 90 | 1028 | 90289 | 0.013375 | 10.17 | 9.9 | 3.1 | 2882 | 4.2 | 9.2 | 159 | 5.0 | 9.46 | 6.28 | 12.99 | 8.06 | 14.5 | 11.7 |
| 6.0 | 112 | 9.5 | 3.10 | 6.05 | 6.69 | 2.38 | 14.1 | 17.5 | 692 | 33 | 216 | 80 | 3966 | 101299 | 0.0572 | 8.75 | 9.8 | 1.2 | 2859 | 1.8 | 7.0 | 163 | 5.8 | 9.82 | 6.85 | 6.25 | 8.93 | 11.7 | 10.9 |
| 6.0 | 114 | 7.4 | 3.22 | 6.15 | 6.19 | 2.50 | 11.9 | 17.6 | 763 | 24 | 238 | 67 | 3207 | 97999 | 0.045075 | 8.01 | 9.8 | 1.0 | 2785 | 4.8 | 6.7 | 164 | 5.3 | 9.69 | 6.86 | 6.63 | 8.94 | 11.0 | 10.8 |
| 5.5 | 106 | 9.6 | 3.06 | 5.80 | 7.43 | 2.23 | 14.4 | 17.5 | 577 | 68 | 146 | 90 | 1831 | 86786 | 0.022675 | 9.76 | 9.8 | 1.7 | 2688 | 2.6 | 6.5 | 159 | 5.0 | 9.56 | 6.48 | 6.23 | 8.08 | 10.1 | 11.5 |
| 5.8 | 107 | 10.4 | 3.04 | 5.95 | 6.42 | 2.27 | 14.2 | 17.6 | 646 | 81 | 184 | 90 | 1430 | 90387 | 0.018525 | 8.70 | 9.9 | 2.2 | 2786 | 4.1 | 6.7 | 161 | 5.1 | 9.56 | 6.43 | 4.87 | 8.03 | 9.4 | 11.5 |
| 5.8 | 100 | 10.4 | 2.88 | 6.36 | 6.23 | 2.41 | 14.9 | 18.3 | 785 | 80 | 224 | 80 | 5624 | 81533 | 0.0657 | 9.98 | 9.8 | 1.4 | 2628 | 5.1 | 7.0 | 152 | 5.5 | 9.14 | 6.66 | 6.36 | 8.16 | 11.1 | 11.2 |
| 5.7 | 101 | 6.7 | 2.82 | 6.25 | 5.97 | 2.27 | 12.8 | 18.7 | 834 | 119 | 241 | 80 | 5212 | 82582 | 0.06165 | 10.43 | 9.9 | 2.6 | 2609 | 3.5 | 6.6 | 155 | 4.3 | 9.24 | 6.73 | 5.66 | 8.33 | 9.5 | 11.5 |
| 6.0 | 105 | 9.7 | 2.93 | 6.45 | 7.21 | 2.43 | 14.8 | 17.9 | 700 | 71 | 139 | 90 | 1159 | 86570 | 0.0144 | 11.00 | 9.7 | 1.0 | 2809 | 3.3 | 7.3 | 153 | 5.4 | 9.33 | 7.01 | 5.00 | 8.70 | 9.5 | 11.6 |
| 5.6 | 102 | 9.6 | 2.82 | 6.19 | 6.85 | 2.28 | 14.3 | 18.1 | 728 | 70 | 167 | 90 | 1051 | 96550 | 0.014525 | 8.58 | 9.9 | 1.3 | 2602 | 4.0 | 7.0 | 148 | 6.1 | 8.81 | 6.80 | 6.17 | 8.08 | 11.3 | 11.4 |
| 5.6 | 102 | 10.5 | 2.89 | 6.36 | 7.09 | 2.39 | 14.6 | 18.9 | 985 | 141 | 220 | 80 | 3955 | 85521 | 0.048125 | 10.67 | 9.8 | 1.2 | 2622 | 3.0 | 7.2 | 151 | 5.4 | 9.07 | 6.93 | 5.80 | 8.39 | 10.1 | 11.1 |
| 5.9 | 101 | 10.6 | 2.83 | 6.28 | 7.61 | 2.31 | 15.6 | 18.9 | 959 | 123 | 240 | 80 | 2048 | 91688 | 0.027075 | 10.87 | 9.7 | 1.4 | 2609 | 3.7 | 7.2 | 151 | 5.0 | 9.17 | 7.08 | 6.17 | 8.60 | 9.9 | 11.1 |
| 5.9 | 104 | 9.0 | 2.80 | 6.09 | 6.54 | 2.23 | 13.0 | 17.2 | 514 | 50 | 110 | 90 | 1008 | 81057 | 0.011775 | 9.24 | 9.8 | 1.3 | 2695 | 4.0 | 7.4 | 159 | 4.8 | 9.56 | 6.82 | 5.27 | 8.52 | 9.0 | 11.3 |
| 5.9 | 107 | 9.3 | 2.84 | 6.09 | 6.58 | 2.28 | 13.9 | 17.7 | 615 | 59 | 123 | 90 | 1311 | 85187 | 0.015975 | 9.77 | 9.9 | 1.8 | 2663 | 3.9 | 7.2 | 155 | 6.6 | 9.23 | 6.85 | 5.69 | 8.31 | 11.0 | 11.7 |
| 6.5 | 109 | 6.8 | 3.08 | 6.43 | 6.88 | 2.49 | 13.9 | 17.2 | 632 | 27 | 131 | 80 | 7195 | 80341 | 0.082125 | 9.77 | 9.7 | 1.3 | 2809 | 3.2 | 7.7 | 160 | 5.0 | 9.75 | 7.33 | 5.17 | 9.25 | 9.1 | 10.5 |
| 6.2 | 110 | 9.2 | 3.02 | 6.24 | 6.82 | 2.41 | 14.4 | 17.2 | 661 | 27 | 124 | 80 | 5548 | 82370 | 0.06475 | 10.16 | 9.6 | 0.8 | 2803 | 3.3 | 7.4 | 162 | 5.2 | 9.99 | 7.59 | 5.90 | 9.80 | 10.4 | 10.7 |
| 5.7 | 99 | 10.1 | 2.77 | 5.98 | 6.57 | 2.16 | 14.2 | 19.3 | 1037 | 143 | 269 | 80 | 2666 | 86268 | 0.0337 | 11.42 | 9.7 | 1.0 | 2543 | 3.3 | 6.8 | 147 | 5.6 | 8.94 | 6.58 | 6.59 | 7.95 | 11.2 | 11.4 |
| 5.8 | 95 | 10.1 | 2.80 | 5.79 | 7.37 | 1.98 | 15.3 | 19.4 | 1068 | 135 | 299 | 80 | 1940 | 90727 | 0.0251 | 8.80 | 9.8 | 4.0 | 2488 | 4.8 | 6.8 | 146 | 4.9 | 8.81 | 6.47 | 5.34 | 7.72 | 9.1 | 11.7 |
| 6.0 | 94 | 9.4 | 2.60 | 6.35 | 6.38 | 2.18 | 14.0 | 19.3 | 1054 | 152 | 231 | 90 | 2980 | 89675 | 0.0377 | 10.13 | 9.7 | 0.9 | 2531 | 2.4 | 7.4 | 144 | 4.8 | 8.76 | 7.09 | 5.95 | 8.54 | 10.2 | 11.5 |
| 6.1 | 92 | 10.2 | 2.80 | 6.33 | 7.93 | 2.17 | 15.9 | 19.3 | 1117 | 154 | 225 | 80 | 3023 | 84731 | 0.036575 | 9.57 | 9.7 | 0.8 | 2522 | 3.4 | 7.6 | 145 | 4.8 | 8.82 | 7.23 | 4.97 | 8.75 | 8.3 | 11.1 |
| 5.5 | 113 | 6.3 | 3.21 | 5.84 | 6.66 | 2.37 | 12.4 | 17.2 | 531 | 53 | 149 | 90 | 3197 | 87816 | 0.040125 | 9.12 | 10.0 | 0.9 | 2752 | 6.9 | 8.0 | 158 | 7.0 | 9.31 | 7.48 | 6.64 | 8.54 | 11.1 | 10.6 |
| 5.4 | 113 | 6.0 | 3.27 | 5.82 | 6.20 | 2.38 | 12.1 | 17.7 | 709 | 42 | 222 | 90 | 3002 | 86016 | 0.036925 | 8.56 | 9.8 | 0.8 | 2770 | 5.6 | 6.5 | 164 | 6.2 | 9.87 | 6.45 | 5.47 | 8.39 | 10.5 | 11.3 |
| 5.7 | 116 | 8.8 | 3.23 | 5.95 | 7.11 | 2.42 | 13.4 | 17.1 | 541 | 25 | 134 | 90 | 3522 | 86873 | 0.043375 | 8.78 | 9.7 | 1.1 | 2810 | 4.1 | 7.0 | 163 | 5.1 | 9.90 | 7.29 | 10.64 | 9.04 | 10.7 | 11.5 |
| 5.7 | 113 | 6.8 | 3.23 | 5.94 | 7.09 | 2.40 | 13.1 | 17.6 | 657 | 67 | 138 | 80 | 2514 | 91975 | 0.03255 | 8.45 | 9.7 | 0.6 | 2854 | 3.5 | 7.0 | 166 | 5.1 | 10.11 | 6.75 | 5.78 | 8.82 | 9.2 | 11.3 |
| 5.6 | 104 | 10.4 | 2.88 | 5.89 | 7.23 | 2.16 | 15.6 | 18.4 | 632 | 64 | 198 | 80 | 4930 | 84028 | 0.059175 | 9.53 | 9.8 | 0.7 | 2847 | 5.8 | 6.6 | 157 | 5.2 | 9.47 | 6.76 | 5.10 | 8.36 | 9.6 | 11.5 |
| 5.6 | 105 | 11.1 | 2.89 | 5.93 | 6.93 | 2.18 | 16.1 | 18.3 | 809 | 62 | 218 | 80 | 5147 | 84618 | 0.0619 | 8.78 | 9.8 | 0.8 | 2632 | 5.0 | 7.3 | 155 | 5.2 | 9.33 | 6.80 | 5.81 | 8.13 | 9.9 | 11.3 |
| 6.0 | 107 | 8.5 | 3.05 | 6.40 | 6.33 | 2.47 | 13.2 | 17.6 | 635 | 50 | 132 | 90 | 3543 | 79748 | 0.039925 | 9.05 | 9.6 | 0.9 | 2659 | 5.2 | 7.2 | 160 | 4.7 | 8.64 | 7.17 | 6.11 | 9.02 | 8.9 | 11.5 |
| 5.7 | 110 | 9.2 | 3.11 | 6.42 | 6.86 | 2.52 | 14.7 | 17.9 | 693 | 65 | 167 | 90 | 3251 | 82857 | 0.038675 | 9.01 | 9.7 | 1.9 | 2706 | 3.6 | 7.5 | 156 | 5.2 | 9.62 | 7.04 | 5.61 | 8.94 | 9.5 | 11.9 |
| 5.6 | 104 | 9.2 | 2.90 | 5.97 | 6.52 | 2.24 | 13.0 | 18.4 | 871 | 77 | 210 | 80 | 4313 | 91473 | 0.0561 | 10.13 | 9.7 | 0.8 | 2774 | 3.0 | 7.2 | 158 | 5.3 | 9.63 | 7.18 | 5.25 | 8.93 | 9.8 | 11.4 |
| 5.6 | 106 | 10.9 | 2.97 | 6.14 | 6.82 | 2.34 | 15.7 | 18.5 | 793 | 90 | 179 | 80 | 2406 | 85644 | 0.029225 | 9.18 | 9.8 | 0.9 | 2734 | 3.5 | 6.9 | 155 | 7.1 | 9.33 | 6.65 | 6.69 | 8.28 | 11.8 | 11.0 |
| 5.7 | 103 | 9.8 | 2.89 | 6.10 | 7.12 | 2.28 | 14.3 | 18.6 | 640 | 127 | 234 | 90 | 2817 | 82177 | 0.033125 | 9.44 | 9.8 | 0.8 | 2672 | 5.1 | 7.0 | 155 | 5.7 | 9.37 | 6.87 | 5.42 | 8.59 | 10.2 | 11.4 |
| 5.6 | 100 | 11.8 | 2.77 | 5.90 | 8.18 | 2.14 | 16.2 | 19.1 | 1029 | 109 | 281 | 80 | 2384 | 90114 | 0.0308 | 10.11 | 9.8 | 0.6 | 2893 | 3.7 | 7.0 | 150 | 7.0 | 9.01 | 6.67 | 5.69 | 8.03 | 11.1 | 11.4 |
| 5.4 | 92 | 9.9 | 2.59 | 6.02 | 6.89 | 2.06 | 13.8 | 20.1 | 1277 | 242 | 300 | 80 | 4161 | 83848 | 0.04985 | 10.00 | 9.7 | 1.4 | 2398 | 4.7 | 7.2 | 139 | 5.4 | 8.46 | 6.65 | 6.61 | 7.80 | 10.5 | 11.6 |
| 5.4 | 87 | 9.6 | 2.41 | 5.76 | 6.64 | 1.65 | 14.6 | 20.6 | 1423 | 301 | 404 | 80 | 3175 | 87752 | 0.039775 | 10.66 | 9.9 | 0.9 | 2329 | 3.1 | 6.0 | 138 | 5.6 | 8.12 | 6.53 | 6.45 | 7.28 | 10.3 | 11.6 |
| 5.4 | 93 | 8.7 | 2.56 | 6.00 | 9.37 | 2.05 | 15.6 | 19.9 | 1236 | 220 | 328 | 80 | 3771 | 85620 | 0.04665 | 8.98 | 9.8 | 1.3 | 2399 | 3.8 | 7.0 | 138 | 12.4 | 8.19 | 6.81 | 7.38 | 7.61 | 16.8 | 11.8 |
| 5.5 | 90 | 9.6 | 2.51 | 5.94 | 6.55 | 1.99 | 13.5 | 20.2 | 1279 | 226 | 330 | 80 | 2687 | 82292 | 0.031525 | 8.81 | 9.9 | 1.3 | 2434 | 3.2 | 7.0 | 134 | 8.9 | 7.88 | 6.61 | 7.40 | 7.30 | 14.6 | 11.4 |
| 5.7 | 108 | 8.8 | 3.03 | 6.08 | 6.09 | 2.35 | 12.2 | 17.5 | 595 | 60 | 154 | 90 | 2991 | 84296 | 0.0358 | 9.44 | 9.9 | 1.9 | 2733 | 4.8 | 7.2 | 158 | 6.1 | 9.42 | 6.95 | 6.39 | 8.65 | 11.3 | 11.2 |
| 5.8 | 108 | 10.9 | 3.00 | 6.05 | 6.86 | 2.32 | 15.4 | 17.8 | 566 | 87 | 152 | 90 | 2156 | 89373 | 0.027625 | 11.26 | 9.8 | 1.2 | 2777 | 3.2 | 7.2 | 156 | 7.6 | 9.41 | 6.84 | 6.85 | 8.55 | 12.6 | 11.2 |
| 6.0 | 109 | 9.1 | 3.07 | 6.13 | 6.53 | 2.43 | 13.5 | 17.3 | 660 | 25 | 186 | 90 | 3944 | 88324 | 0.049525 | 10.45 | 9.9 | 1.4 | 2681 | 3.0 | 6.9 | 158 | 5.3 | 9.31 | 6.87 | 6.22 | 8.57 | 9.9 | 11.3 |
| 5.6 | 110 | 8.0 | 3.11 | 6.00 | 6.48 | 2.44 | 12.4 | 17.6 | 729 | 24 | 184 | 80 | 4616 | 87756 | 0.057575 | 8.13 | 9.9 | 1.4 | 2627 | 2.8 | 7.0 | 150 | 7.0 | 8.97 | 6.57 | 6.42 | 7.99 | 11.5 | 11.0 |
| 5.4 | 90 | 8.6 | 2.50 | 5.88 | 6.78 | 1.94 | 13.2 | 19.3 | 1056 | 183 | 247 | 80 | 1170 | 78534 | 0.01315 | 9.60 | 9.8 | 1.1 | 2418 | 2.7 | 7.1 | 140 | 5.1 | 8.44 | 6.85 | 6.85 | 7.76 | 10.7 | 11.9 |
| 5.3 | 93 | 10.5 | 2.60 | 5.99 | 7.03 | 2.07 | 15.3 | 19.8 | 1182 | 207 | 280 | 80 | 1333 | 87505 | 0.016875 | 10.05 | 9.8 | 0.8 | 2363 | 5.1 | 6.9 | 156 | 5.3 | 9.31 | 6.87 | 6.22 | 8.57 | 9.9 | 11.7 |
| 5.5 | 92 | 11.1 | 2.55 | 5.96 | 7.45 | 2.00 | 16.3 | 19.4 | 1042 | 146 | 225 | 80 | 1929 | 79386 | 0.021525 | 9.94 | 9.9 | 0.8 | 2449 | 2.9 | 6.6 | 145 | 5.5 | 8.63 | 6.93 | 6.52 | 8.11 | 10.6 | 12.2 |
| 5.5 | 92 | 10.1 | 2.52 | 5.95 | 6.43 | 1.97 | 14.4 | 19.7 | 1118 | 216 | 254 | 73 | 1235 | 83491 | 0.014825 | 9.38 | 9.9 | 1.5 | 2382 | 4.9 | 6.4 | 137 | 6.5 | 8.20 | 6.81 | 6.28 | 7.63 | 12.1 | 11.7 |
| 5.6 | 108 | 12.3 | 3.09 | 6.08 | 7.54 | 2.44 | 16.9 | 17.4 | 721 | 35 | 147 | 87 | 2915 | 84962 | 0.035375 | 10.09 | 9.8 | 1.2 | 2677 | 3.8 | 6.6 | 156 | 5.6 | 9.42 | 6.90 | 5.95 | 8.67 | 10.1 | 11.3 |
| 5.4 | 108 | 8.3 | 3.00 | 6.06 | 6.21 | 2.34 | 12.4 | 17.9 | 807 | 58 | 225 | 80 | 3728 | 86582 | 0.046375 | 10.47 | 9.8 | 1.1 | 2664 | 3.2 | 7.0 | 152 | 8.0 | 9.17 | 6.80 | 6.01 | 8.41 | 11.1 | 11.1 |
| 5.4 | 97 | 9.9 | 2.85 | 5.71 | 7.39 | 1.96 | 15.4 | 18.9 | 992 | 124 | 288 | 80 | 2991 | 87348 | 0.0373 | 9.73 | 9.8 | 1.4 | 2552 | 3.1 | 6.6 | 146 | 6.6 | 8.76 | 6.52 | 6.56 | 7.56 | 11.6 | 10.8 |
| 5.5 | 96 | 10.2 | 2.64 | 5.60 | 6.76 | 1.93 | 14.4 | 18.8 | 945 | 106 | 265 | 80 | 3240 | 83775 | 0.0388 | 8.75 | 9.8 | 0.6 | 2570 | 3.6 | 7.0 | 145 | 5.1 | 8.76 | 6.37 | 6.62 | 7.46 | 11.3 | 11.3 |

| ster Yarn Evenness | | | Yarn | Whitespeck CIA | | | OES, 22a Opening | Yarn Skein Strength Test | | | | | Single Yarn Strength Test | | | | | | | Uster Yarn Evenness | | | | Yarn | Whitespeck CIA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| #Thick/ 1000yd | #Thin/ 1000yd | #Neps' 1000yd | Appearance Index | Count /m^2 | AvSz (um^2) | AreaWh (%)?? | & Cardin Waste (% | Yarn no. (Ne) | Yarn no. CV% | Count X Strength | CSP CV% | Elongation (%) | Tenacity (mN/tex) | Tenacity (CV%) | Force (N) | Elongation (%) | Elongation (CV%) | Spec.WR (cm.N) | Spec.WR (CV%) | Non-unif. (CV%) | #Thick/ 1000yd | #Thin/ 1000yd | #Neps' 1000yd | Appearance Index | Count /m^2 | AvSz (um^2) | Area (%)?? |
| UTK01 | UTN01 | UN01 | YAI01 | WSC01 | WSS01 | WSA01 | CNO2 | SKY02 | SKYCV02 | SKCSP02 | SKCSPCV02 | SKE02 | Y1T02 | Y1TCV02 | Y1F02 | Y1E02 | Y1ECV02 | Y1W02 | Y1WCV02 | UNU02 | UTK02 | UTN02 | UN02 | YAI02 | WSC02 | WSS02 | WSA02 |
| 28 | 0 | 8 | 120 | 249 | 72244 | 0.002575 | 10.14 | 21.8 | 1.9 | 2031 | 3.0 | 5.3 | 75 | 8.8 | 3.44 | 5.73 | 6.64 | 2.76 | 15.0 | 14.7 | 92 | 28 | 5 | 100 | 336 | 82488 | 0.0039 |
| 22 | 5 | 4 | 120 | 303 | 88517 | 0.003650 | 8.78 | 21.7 | 1.6 | 2042 | 2.6 | 5.3 | 74 | 8.6 | 3.39 | 5.82 | 6.20 | 2.76 | 12.8 | 14.2 | 72 | 12 | 3 | 100 | 347 | 74228 | 0.003675 |
| 18 | 1 | 9 | 110 | 921 | 77054 | 0.009425 | 11.33 | 21.8 | 1.2 | 2096 | 2.4 | 5.6 | 76 | 7.0 | 3.48 | 5.86 | 7.68 | 2.86 | 12.1 | 13.5 | 55 | 3 | 0 | 100 | 943 | 76442 | 0.010325 |
| 19 | 3 | 14 | 120 | 845 | 82869 | 0.010000 | 10.80 | 21.5 | 1.2 | 2109 | 2.8 | 5.5 | 76 | 8.0 | 3.53 | 5.88 | 8.14 | 2.91 | 14.0 | 13.5 | 39 | 8 | 0 | 100 | 954 | 84687 | 0.011750 |
| 35 | 0 | 29 | 110 | 466 | 100369 | 0.006375 | 10.20 | 21.5 | 0.9 | 2421 | 2.8 | 5.7 | 85 | 8.0 | 3.97 | 6.06 | 6.85 | 3.28 | 13.6 | 13.0 | 21 | 6 | 0 | 110 | 520 | 88094 | 0.006475 |
| 21 | 0 | 20 | 110 | 477 | 85505 | 0.005750 | 9.38 | 21.6 | 1.1 | 2390 | 2.8 | 5.8 | 88 | 7.9 | 3.99 | 6.13 | 5.80 | 3.31 | 12.2 | 13.0 | 28 | 7 | 0 | 110 | 401 | 86736 | 0.004975 |
| 21 | 0 | 16 | 113 | 769 | 91999 | 0.010175 | 9.32 | 21.7 | 1.5 | 2375 | 2.7 | 5.8 | 85 | 6.1 | 3.92 | 6.07 | 6.49 | 3.29 | 10.0 | 13.0 | 24 | 1 | 0 | 100 | 596 | 88167 | 0.007425 |
| 23 | 0 | 6 | 110 | 596 | 85793 | 0.006850 | 9.87 | 21.7 | 1.4 | 2351 | 3.4 | 5.7 | 82 | 9.5 | 3.79 | 5.98 | 8.30 | 3.17 | 15.5 | 13.3 | 38 | 0 | 1 | 100 | 802 | 86769 | 0.009950 |
| 23 | 0 | 8 | 110 | 433 | 82740 | 0.005175 | 9.85 | 21.8 | 1.1 | 2219 | 3.8 | 5.7 | 81 | 8.8 | 3.71 | 5.72 | 7.61 | 2.96 | 14.2 | 13.1 | 30 | 7 | 1 | 110 | 607 | 85013 | 0.007350 |
| 13 | 0 | 7 | 110 | 477 | 94206 | 0.006475 | 9.59 | 21.6 | 1.3 | 2225 | 2.3 | 5.6 | 79 | 7.6 | 3.65 | 5.64 | 6.73 | 2.88 | 11.8 | 12.9 | 20 | 5 | 0 | 103 | 607 | 87018 | 0.007575 |
| 25 | 9 | 19 | 120 | 661 | 80138 | 0.007700 | 9.42 | 21.3 | 1.1 | 2277 | 3.6 | 6.2 | 80 | 7.8 | 3.73 | 5.84 | 7.79 | 2.90 | 13.6 | 12.9 | 46 | 8 | 1 | 100 | 954 | 85033 | 0.011650 |
| 27 | 0 | 19 | 120 | 802 | 83674 | 0.009575 | 9.16 | 21.5 | 1.1 | 2304 | 3.4 | 6.0 | 82 | 8.4 | 3.82 | 5.83 | 7.91 | 3.08 | 14.5 | 12.9 | 24 | 4 | 0 | 100 | 683 | 89820 | 0.008600 |
| 24 | 0 | 14 | 120 | 347 | 72356 | 0.003600 | 10.49 | 21.6 | 1.6 | 2371 | 3.8 | 5.5 | 87 | 8.6 | 4.04 | 5.70 | 7.93 | 3.20 | 13.9 | 12.9 | 41 | 3 | 2 | 110 | 401 | 84016 | 0.004775 |
| 19 | 10 | 16 | 110 | 217 | 99529 | 0.003025 | 10.17 | 21.8 | 1.4 | 2458 | 3.2 | 5.7 | 89 | 6.2 | 4.09 | 6.10 | 5.73 | 3.38 | 9.7 | 13.7 | 38 | 13 | 3 | 110 | 401 | 79282 | 0.004550 |
| 28 | 0 | 20 | 120 | 824 | 88703 | 0.010575 | 8.75 | 21.7 | 1.7 | 2526 | 2.5 | 6.0 | 82 | 7.6 | 4.23 | 6.17 | 6.42 | 3.53 | 11.9 | 12.6 | 31 | 3 | 2 | 100 | 1755 | 81092 | 0.020450 |
| 17 | 0 | 12 | 120 | 899 | 94974 | 0.012250 | 8.01 | 21.8 | 2.7 | 2528 | 3.8 | 6.2 | 91 | 6.9 | 4.19 | 6.17 | 6.74 | 3.48 | 11.8 | 12.8 | 27 | 6 | 0 | 100 | 1367 | 81375 | 0.016300 |
| 21 | 0 | 12 | 120 | 249 | 87481 | 0.003125 | 9.76 | 21.5 | 1.5 | 2370 | 2.9 | 5.8 | 85 | 8.6 | 3.95 | 5.61 | 8.04 | 3.03 | 14.5 | 14.0 | 74 | 15 | 5 | 100 | 498 | 79458 | 0.005675 |
| 17 | 0 | 11 | 120 | 368 | 75589 | 0.003975 | 8.70 | 21.8 | 1.5 | 2319 | 5.5 | 5.8 | 85 | 7.7 | 3.88 | 5.57 | 7.14 | 2.92 | 13.1 | 13.7 | 45 | 9 | 2 | 97 | 563 | 83921 | 0.006825 |
| 9 | 0 | 9 | 120 | 1441 | 74353 | 0.015275 | 9.98 | 21.6 | 3.1 | 2353 | 2.3 | 6.3 | 88 | 7.5 | 3.96 | 6.07 | 6.76 | 3.30 | 12.0 | 13.5 | 31 | 5 | 1 | 100 | 1452 | 77253 | 0.015975 |
| 33 | 0 | 13 | 120 | 1907 | 77229 | 0.021150 | 10.43 | 21.6 | 1.5 | 2301 | 2.8 | 6.1 | 85 | 8.2 | 3.93 | 6.08 | 7.62 | 3.26 | 13.6 | 13.4 | 41 | 6 | 1 | 110 | 3023 | 73321 | 0.031725 |
| 28 | 0 | 6 | 120 | 401 | 86168 | 0.004875 | 11.00 | 21.6 | 1.5 | 2345 | 3.9 | 6.3 | 83 | 7.7 | 3.84 | 6.11 | 6.21 | 3.24 | 12.1 | 13.8 | 50 | 15 | 4 | 110 | 542 | 80501 | 0.006250 |
| 20 | 0 | 12 | 120 | 423 | 86021 | 0.005050 | 8.58 | 21.9 | 1.8 | 2244 | 3.3 | 6.0 | 82 | 6.7 | 3.73 | 6.10 | 6.63 | 3.15 | 11.2 | 13.6 | 38 | 9 | 1 | 100 | 390 | 87496 | 0.004825 |
| 17 | 0 | 10 | 120 | 737 | 75678 | 0.007800 | 10.67 | 21.6 | 1.6 | 2278 | 2.6 | 6.5 | 82 | 7.7 | 3.77 | 6.12 | 8.63 | 3.21 | 13.7 | 13.0 | 30 | 6 | 1 | 110 | 943 | 79523 | 0.010825 |
| 16 | 0 | 9 | 110 | 531 | 78427 | 0.005900 | 10.87 | 21.5 | 1.3 | 2292 | 3.1 | 6.4 | 82 | 8.4 | 3.80 | 6.22 | 6.98 | 3.28 | 13.6 | 13.1 | 32 | 5 | 1 | 110 | 759 | 84999 | 0.009125 |
| 14 | 0 | 9 | 120 | 433 | 74625 | 0.004775 | 9.24 | 21.5 | 1.2 | 2384 | 2.4 | 6.3 | 84 | 6.7 | 3.90 | 5.97 | 6.15 | 3.15 | 11.3 | 13.6 | 45 | 11 | 1 | 100 | 293 | 82348 | 0.003475 |
| 15 | 0 | 8 | 117 | 477 | 75259 | 0.005150 | 9.77 | 21.7 | 1.2 | 2310 | 3.6 | 6.4 | 84 | 7.4 | 3.88 | 6.10 | 6.30 | 3.20 | 11.6 | 13.5 | 47 | 7 | 1 | 110 | 455 | 92030 | 0.005975 |
| 11 | 0 | 8 | 120 | 1474 | 73492 | 0.015475 | 9.77 | 21.5 | 1.7 | 2455 | 2.8 | 6.5 | 90 | 7.8 | 4.18 | 6.62 | 7.29 | 3.73 | 13.0 | 12.4 | 19 | 5 | 1 | 103 | 1149 | 72188 | 0.011925 |
| 19 | 0 | 15 | 120 | 2102 | 71511 | 0.021625 | 10.16 | 21.5 | 3.0 | 2456 | 4.9 | 6.2 | 92 | 7.1 | 4.26 | 6.43 | 6.54 | 3.69 | 11.3 | 12.7 | 35 | 4 | 1 | 100 | 2568 | 74402 | 0.027425 |
| 22 | 0 | 13 | 120 | 661 | 93743 | 0.008425 | 11.42 | 21.8 | 2.9 | 2142 | 3.2 | 5.8 | 79 | 7.5 | 3.64 | 5.70 | 6.87 | 2.93 | 12.6 | 13.7 | 50 | 14 | 0 | 110 | 813 | 82911 | 0.009625 |
| 26 | 1 | 12 | 120 | 563 | 79016 | 0.006375 | 8.80 | 22.0 | 2.6 | 2189 | 2.9 | 6.4 | 79 | 8.1 | 3.60 | 5.81 | 7.36 | 2.89 | 13.3 | 13.8 | 51 | 12 | 1 | 110 | 596 | 97108 | 0.008275 |
| 17 | 0 | 7 | 120 | 1116 | 78011 | 0.012325 | 10.13 | 21.5 | 0.9 | 2167 | 2.4 | 6.7 | 80 | 7.6 | 3.72 | 6.52 | 7.87 | 3.39 | 13.8 | 13.3 | 27 | 1 | 3 | 110 | 607 | 90183 | 0.007825 |
| 10 | 0 | 2 | 120 | 824 | 84236 | 0.009975 | 9.57 | 21.6 | 2.1 | 2154 | 3.0 | 6.5 | 79 | 7.4 | 3.67 | 6.48 | 6.51 | 3.31 | 11.7 | 13.5 | 38 | 7 | 1 | 100 | 1269 | 84358 | 0.015250 |
| 26 | 0 | 30 | 120 | 1333 | 77945 | 0.014950 | 9.12 | 21.7 | 1.5 | 2497 | 4.4 | 6.2 | 89 | 6.7 | 4.10 | 5.83 | 6.48 | 3.18 | 13.4 | 13.4 | 42 | 10 | 2 | 100 | 1224 | 78643 | 0.013825 |
| 24 | 0 | 10 | 120 | 574 | 82511 | 0.008825 | 8.56 | 21.8 | 0.9 | 2480 | 3.6 | 6.0 | 88 | 10.0 | 4.01 | 5.81 | 7.36 | 3.11 | 14.6 | 13.5 | 41 | 11 | 0 | 103 | 715 | 91070 | 0.009450 |
| 14 | 0 | 5 | 130 | 607 | 75673 | 0.008550 | 8.78 | 21.5 | 1.3 | 2455 | 4.1 | 6.2 | 84 | 10.5 | 3.90 | 5.77 | 6.81 | 2.98 | 14.5 | 13.6 | 27 | 6 | 3 | 110 | 628 | 99212 | 0.008800 |
| 22 | 0 | 12 | 120 | 607 | 82283 | 0.007100 | 8.45 | 21.8 | 1.6 | 2448 | 3.3 | 6.2 | 88 | 10.9 | 3.99 | 5.88 | 7.66 | 3.10 | 16.5 | 13.1 | 33 | 5 | 1 | 110 | 477 | 89039 | 0.006025 |
| 21 | 0 | 10 | 127 | 1138 | 79863 | 0.013050 | 9.53 | 21.7 | 1.7 | 2282 | 2.5 | 6.0 | 86 | 8.4 | 3.96 | 6.03 | 6.73 | 3.22 | 13.5 | 13.7 | 50 | 6 | 4 | 110 | 628 | 83886 | 0.007575 |
| 17 | 0 | 4 | 130 | 813 | 74022 | 0.008725 | 8.78 | 21.8 | 1.4 | 2319 | 3.2 | 6.1 | 88 | 7.5 | 3.92 | 5.93 | 6.69 | 3.12 | 12.2 | 13.8 | 42 | 7 | 2 | 110 | 964 | 83434 | 0.011475 |
| 22 | 0 | 5 | 120 | 889 | 75946 | 0.009600 | 9.05 | 21.5 | 1.2 | 2344 | 2.8 | 6.3 | 83 | 7.6 | 3.87 | 6.11 | 6.61 | 3.19 | 12.6 | 13.9 | 44 | 12 | 2 | 110 | 412 | 86259 | 0.004950 |
| 20 | 0 | 5 | 120 | 760 | 72299 | 0.008125 | 9.01 | 21.7 | 1.5 | 2269 | 3.4 | 6.7 | 89 | 6.9 | 4.08 | 6.46 | 6.54 | 3.56 | 11.6 | 14.1 | 60 | 20 | 2 | 100 | 325 | 82848 | 0.003925 |
| 18 | 0 | 6 | 120 | 921 | 81995 | 0.010800 | 10.13 | 21.6 | 1.1 | 2414 | 2.6 | 6.8 | 88 | 6.9 | 4.07 | 6.27 | 6.10 | 3.44 | 11.0 | 13.5 | 48 | 10 | 1 | 100 | 1040 | 86223 | 0.012850 |
| 13 | 0 | 5 | 120 | 423 | 74957 | 0.004550 | 9.18 | 21.9 | 1.9 | 2400 | 2.5 | 6.3 | 86 | 7.3 | 3.92 | 5.98 | 7.16 | 3.21 | 11.6 | 13.1 | 34 | 7 | 1 | 103 | 433 | 92805 | 0.005725 |
| 18 | 0 | 3 | 100 | 650 | 85643 | 0.007900 | 9.44 | 21.7 | 3.2 | 2309 | 4.8 | 6.3 | 82 | 11.7 | 3.76 | 6.00 | 7.67 | 3.13 | 15.8 | 13.8 | 52 | 12 | 1 | 100 | 390 | 79301 | 0.004525 |
| 36 | 0 | 23 | 120 | 661 | 83245 | 0.007875 | 10.11 | 21.8 | 1.3 | 2318 | 4.4 | 6.1 | 88 | 9.2 | 4.00 | 6.25 | 7.71 | 3.42 | 14.7 | 13.5 | 37 | 6 | 1 | 100 | 412 | 80040 | 0.004650 |
| 27 | 0 | 7 | 120 | 628 | 77701 | 0.006975 | 10.00 | 21.4 | 1.8 | 2062 | 2.8 | 6.0 | 74 | 9.5 | 3.45 | 5.78 | 6.70 | 2.83 | 14.2 | 13.6 | 37 | 8 | 0 | 110 | 444 | 89797 | 0.005675 |
| 16 | 0 | 3 | 120 | 748 | 81365 | 0.008675 | 10.86 | 21.8 | 1.0 | 2015 | 2.3 | 5.8 | 70 | 9.7 | 3.22 | 5.77 | 6.69 | 2.64 | 14.1 | 13.9 | 71 | 16 | 3 | 100 | 509 | 81298 | 0.006150 |
| 29 | 0 | 6 | 120 | 932 | 75380 | 0.010225 | 8.98 | 21.8 | 1.3 | 2038 | 4.1 | 6.2 | 73 | 9.1 | 3.34 | 5.70 | 7.68 | 2.72 | 13.6 | 13.8 | 41 | 4 | 1 | 100 | 585 | 86049 | 0.007300 |
| 22 | 0 | 6 | 120 | 542 | 79863 | 0.006200 | 8.81 | 22.0 | 1.3 | 2070 | 3.3 | 6.0 | 75 | 8.3 | 3.42 | 5.78 | 6.14 | 2.81 | 13.6 | 14.0 | 36 | 9 | 1 | 100 | 423 | 74208 | 0.004575 |
| 20 | 0 | 13 | 120 | 303 | 92372 | 0.004025 | 9.44 | 21.7 | 1.2 | 2433 | 2.7 | 6.4 | 87 | 7.7 | 4.01 | 6.05 | 6.66 | 3.30 | 12.4 | 13.3 | 40 | 4 | 0 | 110 | 444 | 75269 | 0.004775 |
| 16 | 0 | 10 | 120 | 347 | 93836 | 0.004525 | 11.26 | 21.8 | 1.5 | 2417 | 3.3 | 6.3 | 85 | 9.3 | 3.90 | 5.94 | 6.59 | 3.21 | 13.2 | 13.2 | 28 | 4 | 1 | 110 | 325 | 96995 | 0.004500 |
| 16 | 0 | 7 | 120 | 802 | 75874 | 0.008650 | 10.45 | 21.8 | 1.4 | 2385 | 2.3 | 5.4 | 85 | 7.1 | 3.92 | 6.00 | 6.93 | 3.24 | 11.8 | 12.9 | 21 | 4 | 2 | 110 | 683 | 87029 | 0.008525 |
| 20 | 0 | 12 | 120 | 1019 | 94189 | 0.012975 | 8.13 | 22.0 | 1.5 | 2299 | 2.2 | 6.0 | 81 | 9.9 | 3.69 | 5.91 | 7.43 | 3.05 | 14.4 | 12.8 | 22 | 2 | 0 | 110 | 759 | 85180 | 0.009100 |
| 22 | 1 | 7 | 120 | 260 | 75356 | 0.002825 | 9.60 | 21.7 | 1.2 | 2045 | 2.4 | 6.3 | 76 | 7.8 | 3.48 | 6.01 | 7.32 | 2.94 | 12.7 | 14.0 | 48 | 26 | 3 | 100 | 173 | 94892 | 0.002375 |
| 23 | 0 | 8 | 120 | 455 | 74102 | 0.004725 | 10.05 | 21.8 | 1.1 | 2069 | 1.9 | 6.1 | 76 | 8.8 | 3.47 | 5.94 | 10.58 | 2.91 | 15.5 | 14.3 | 52 | 20 | 0 | 100 | 249 | 85373 | 0.003150 |
| 29 | 0 | 8 | 110 | 314 | 71435 | 0.003100 | 9.94 | 21.9 | 1.9 | 2076 | 3.4 | 5.7 | 73 | 10.0 | 3.35 | 5.72 | 6.69 | 2.73 | 15.5 | 14.3 | 60 | 20 | 3 | 110 | 141 | 76421 | 0.001650 |
| 19 | 0 | 6 | 110 | 260 | 84173 | 0.003100 | 9.38 | 22.0 | 1.2 | 2017 | 4.3 | 5.8 | 74 | 7.2 | 3.35 | 5.87 | 7.38 | 2.78 | 12.3 | 14.2 | 81 | 21 | 1 | 100 | 228 | 86828 | 0.002950 |
| 23 | 0 | 5 | 120 | 769 | 85842 | 0.009675 | 10.09 | 21.8 | 1.4 | 2382 | 2.6 | 6.0 | 87 | 7.8 | 3.97 | 6.25 | 6.15 | 3.39 | 10.8 | 12.9 | 24 | 5 | 4 | 110 | 444 | 87242 | 0.005575 |
| 20 | 0 | 14 | 120 | 791 | 76972 | 0.008800 | 10.47 | 21.8 | 2.1 | 2382 | 2.5 | 6.1 | 83 | 12.6 | 3.82 | 6.13 | 6.34 | 3.24 | 16.3 | 12.9 | 28 | 1 | 3 | 100 | 379 | 76725 | 0.004175 |
| 13 | 0 | 11 | 120 | 791 | 75967 | 0.008625 | 9.73 | 21.6 | 1.7 | 2236 | 2.9 | 6.3 | 81 | 8.5 | 3.76 | 5.76 | 6.59 | 2.98 | 13.2 | 13.3 | 28 | 5 | 6 | 110 | 477 | 87921 | 0.006100 |
| 16 | 0 | 13 | 120 | 531 | 83200 | 0.006200 | 8.75 | 21.7 | 1.8 | 2222 | 3.2 | 6.3 | 80 | 7.6 | 3.68 | 5.48 | 6.81 | 2.84 | 13.8 | 13.7 | 35 | 8 | 3 | 110 | 379 | 91678 | 0.005275 |

## C.2 1999 trial

The following growers provided seedcotton and related logistic help during the 1999 trial:
1. David Statham (per Andrew Parkes)*
2. Jim Cush
3. Chris Humphries
4. Claude Johnston
5. Peter Glennie
6. Rueben Melville
7. Peter Harris (per Peter Saunders)
8. David Ward

* These samples saw double duty, firstly for Cotton CRC 'early stage' variety trials, secondly for this trial. Several of the varieties are not commercial releases.

# Appendix D - Industry survey of methods of measuring moisture

This survey was designed to sound out ginners about how they measured moisture content for the purposes of the day-to-day operation of their gin, their opinion of the adequacy of their current means of doing this, and what means they would like to see available to them in the future to do it better.

This survey was prompted by conflicting opinions from ginners about the adequacy of current methods. This was typified by a conversation about moisture measurement and control in the gin where the initial response was that things were "OK",but on enquiring further the response changed to "Well now that you mention it, we would like to see..." and fundamental concerns with current methods were then brought out.

Twenty eight questionaires and covering letters went out, and twelve responses were received.

**Q1. How important is moisture measurement in your operations?**
The universal response was that moisture control is the key to proper operation of a gin, making up about 90% of the critical control work.

**Q2. Suppose that the cotton classing system changed, so that qualities which can suffer due to heat damage and marginal moisture control (like short fibre content) had a more severe effect on hale value at present. Would you feel comfortable with your present means of measuring moisture?**
The majority response (8/12) was that the present system is "very hit and miss" and would not do in such a situation. Four others said they would cope, by keeping the ability of staff to sense moisture problems as part of the gin controls. Two said things were OK.

**Q3. How much of the decision regarding burner setting is based on the actual number produced by the meter, and how much on the skill of the person doing the reading?**
Responses varied from 90% / 10% to 20% / 80%, with the most common response being 50% / 50%. The average was 58% / 42%.

**Q4. How long does it take someone to learn how to operate the meter and properly interpret its reading?**
The responses echoed those to Q3, basically saying that it took 10 minutes to get a number and at least one ginning season to know what it meant.

**Q5. Do you have plans to change the way you measure moisture in your gin(s)?**
Two responses said they had work underway. Five said they were looking for alternatives but had nothing before them to put into use. Three said they had no plans, and three others said they had no plans but thought that in the future this might change.

**Q6. How much would you expect to pay for an ideal system? (A set-and-forget system that overcame all your present problems, and gave you the information when you wanted it).**
Responses varied, from $5,000 to $500,000, and some did not respond. This suggests that some are thinking in terms of better versions of what they have now, while some are thinking in terms of a full automatic control system throughout the gin.