1864 Fiber neps generation in cotton processing

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Abstract

Neps, formed by tight and dense entanglements of fibers, are among the most disruptive structures found in cotton lint. Although they are essentially fibrous, they are universally treated as contaminants within the useful cotton fibers. This research challenges this view and treats neps and nep formation as a quality defect (material and/or processing defect). Neps formation was quantified on lint samples obtained from hand-ginned cotton (with minimum mechanical handeling) and from industrially-ginned cotton with varied cleaning treatments. This paper presents a preliminary report on these trials with a focus on the factors determining neps formation potential.

Introduction

The ASTM (ASTM , 1994, 1995) defines a nep as, "one or more fibers occurring in a tangled and unorganized mass." Neps are created when fibers become tangled in the process of harvesting, ginning and other operations. They can cause difficulty for mills and detract from the appearance of yarns and fabrics (Davidonis, 2003). Over the years neps have been classified in several ways.

Pearson (1933) discussed a "nep classification" including various neplike structures and tangled knots of fibers. Her classification of neps was based on four groups of fibers: thick-walled fibers, medium-walled fibers, thin-walled fibers and fuzz fibers. From these four fiber types, fifteen nep categories were defined according to the types of fibers that are in the tangle. The same author (Pearson, 1937) later discussed the following four structures: naps, neps, motes, and seed-coat fragments. The distinction between naps and neps is based on a difference in size. Neps, in contrast to naps, are very small tangles of fibers. Naps are large tangles of fibers which are visible when the lint is viewed as a whole. The Bureau of Agricultural Economics considers neps to include all fiber tangles up to those that are twice the size of a pinhead (Pearson, 1937). A more recent classification defines neps as biological or mechanical. Mechanical neps are entirely composed of fibers and are created during mechanical processing. Biological neps contain foreign materials, such as seed, leaf, and grit, with fiber attached (Van der Sluijs 1999).

There is general agreement that neps are affected by most mechanical processing stages in the cotton production chain. Souther (1954) observed that the majority of neps were created within the ginning process; subsequent operations such as opening and cleaning almost doubled the amount of neps. Mangialardi (1985) found that the gin machinery affected nep content, with the gin stand and saw cylinder lint cleaners being the major contributors to the formation of neps.

Many fiber properties such as elongation, fineness, length, maturity, strength, and short fiber content, along with contaminants such as stickiness and seed coat fragments have been cited as possible predictors or as related to nep formation. Mangialardi & Meredith (1990) found that among varieties, neps were highly correlated with maturity-fineness measurements. They also found significant correlations between nep counts and fiber strength, elongation, mote counts, and funiculi. Van der Sluijs (1999) reported a study where Micronaire emerged as the most significant fiber property in terms of determining nep levels and nep size. Van der Sluijs (1999) also reported that the number of neps per grams decreased as micronaire, length uniformity ratio, strength, and span length increased. The review of literature (Van der Sluijs, 1999) for neps extensively covers the occurrence of neps and processes for neps removal, yet rarely does the literature deal with the prevention of nep formation.

Neps: Contaminants or Quality Defects?

The current paradigm views neps as contaminants rather than quality defects. This view steers research into the detection and removal of neps. A paradigm shift in viewing neps as quality defects is needed in order to focus on controlling and minimizing nep formation all along the production, harvesting and processing chain.

If neps are treated as contaminants then they are one of the most difficult to remove through cleaning. Figure 1 shows that after several cleaning treatments the percentage of neps remaining is anywhere from 60% to 70%. While other contaminants, such as seed coat neps, dust and trash particles tend to remain at about 2% to 15%. The key reason neps are difficult to remove is that in the process of cleaning neps one creates neps as well.

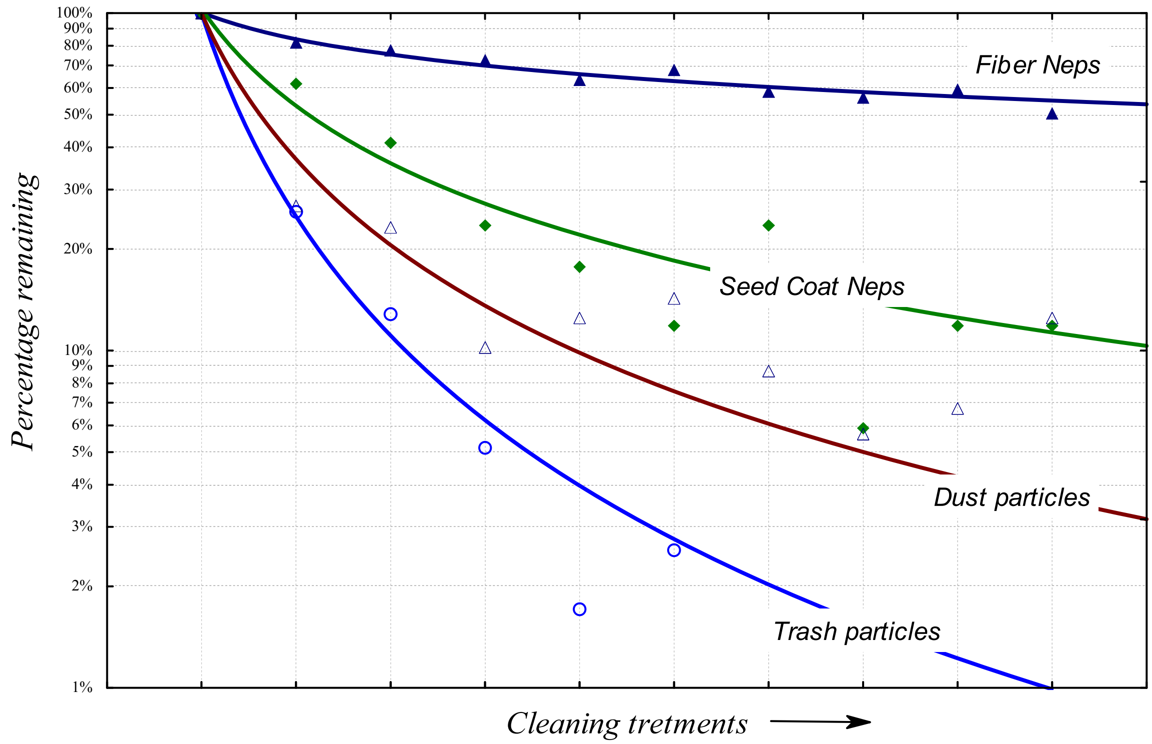

Figure 1: Cleaning Treatments vs. Percentage Remaining of Contaminants

Figure 2 is a chart of sixty seven cottons in which nep content was measured using the AFIS. The bottom line plot is that of Raw Cotton (bale samples). One can see the initial variability in neps per gram. The Open/Clean line plot indicates the level of neps per gram after the blowroom. Opening and cleaning is a process which combines nep generation and removal. Yet, the final nep count is still greater across the board. The combination of nep generation and removal makes it difficult to measure the actual nep potential of a cotton. Thus, one of the objectives of this research is to separately quantify the nep formation phenomenon without the cleaning effect typically combined to it in mechanical processing of cotton fiber. Another important objective is to establish a reference neppiness level which will serve as a baseline for quantifying neps creation due to mechanical processing. Hand-ginned lint, i.e., with minimal mechanical handling, was used to that end.

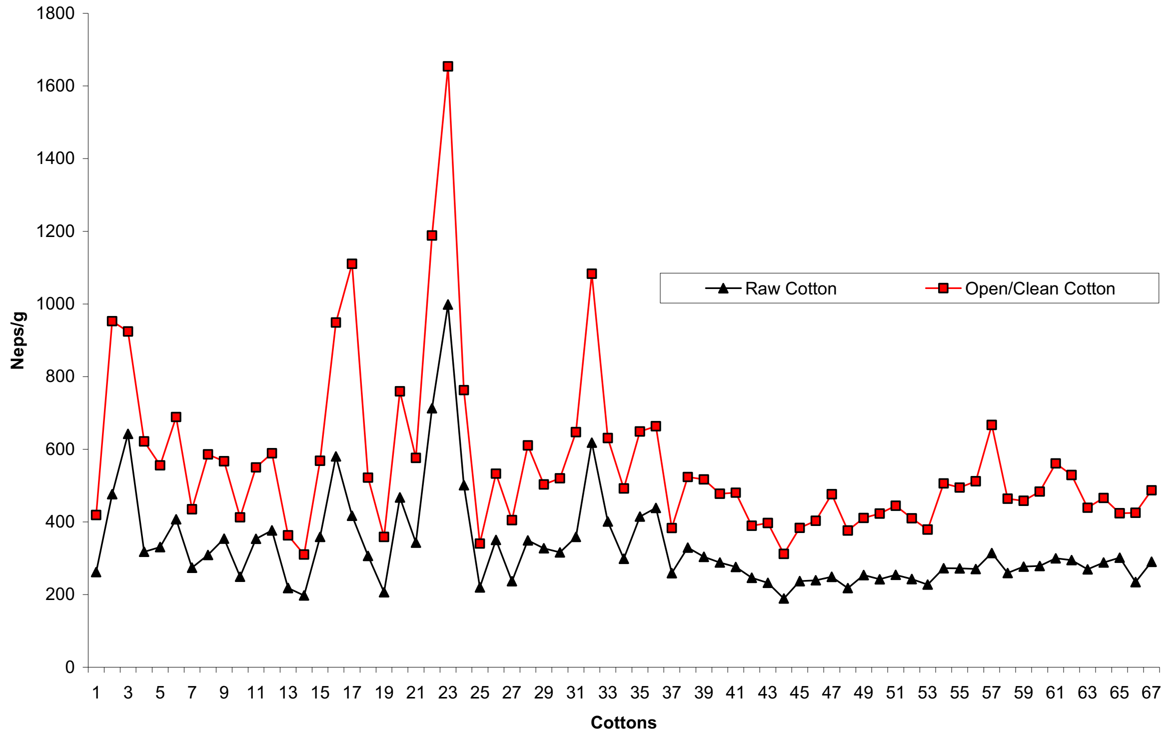

Figure 2: Nep Content in Raw Cotton vs. Opened and Cleaned Cotton

Materials and Methods

The lint and seed cotton samples used in this research were obtained from field and ginning trials conducted in collaboration with the USDA-ARS Gin Lab in Lubbock, TX (Krifa & Holt, 2007). The samples came from five varieties grown in the 2005 and 2006 season. The cotton was stripper-harvested, saw-ginned, and submitted to varied cleaning intensities at the gin (0, 1, 2, and 3 lint cleaners). Seed cotton samples were collected prior to ginning from all varieties over both seasons. The individual samples consisted of clusters of seeds weighing approximately 3 to 4 grams (all seed cotton being stripper-harvested). Ten clusters from each variety and season were collected at random. After the one-hundred clusters were collected, each sample was hand ginned and the following data recorded: weight of the cluster, number of seeds per cluster, weight of the seeds, and the weight of the lint. Hand-ginning was done in order to provide lint with minimum mechanical handling which will serve as reference in assessing the effects of mechanical processing on neppiness.

The hand-ginned samples along with the mechanically ginned lint were tested on AFIS (3 replications with 3000 fibers each) for neps and individual fiber properties. Instrument calibration was checked daily. The samples were conditioned in the laboratory at 65% relative humidity and 21˚C (standard laboratory conditions) for at least 48 hours before testing. The data was analyzed using ANOVA to evaluate the variation of AFIS nep count inherent to the variety and growing season effects. Homogeneity of slopes model (Krifa, 2006) was then used to evaluate the relationships among neppiness potential, mechanical processing and fiber characteristics, maturity in particular.

Results and Discussion

We first examine the variation of nep counts among varieties and growing seasons based on the hand-ginned samples. Results of the analysis of variance (Table 1) show that the number of neps in hand-ginned lint varied significantly between the two seasons. On the other hand there is no significant main effect of variety, but a significant interaction between variety and season.

Table 1: ANOVA Results of Hand-Ginned Samples (Neps/g vs. Season and Variety)

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Season	1	21580	21580	21580	8.85	0.004
Variety	4	19383	19383	4846	1.99	0.103
Season*Variety	4	39074	39074	9769	4.01	0.005
Error	90	219391	219391	2438		
Total	99	299427				

Observations of the associated means show that, overall, the number of neps detected in hand-ginned cotton is rather significant and varies substantially among cottons. On average, the 2005 season had more neps than the 2006 season. This remains the case when considering the individual variety means as well (Figure 3), except for the variety labeled V5 for which the 2006 growth appears to have slightly more neps than the 2005 one (Figure 3). The results observed for V5 may have contributed to the significant interaction effect observed between variety and season. However, a more substantial contribution appears to be that of the variety labeled V4 which had the greatest number of neps in 2005 but yielded the least amount of neps in 2006.

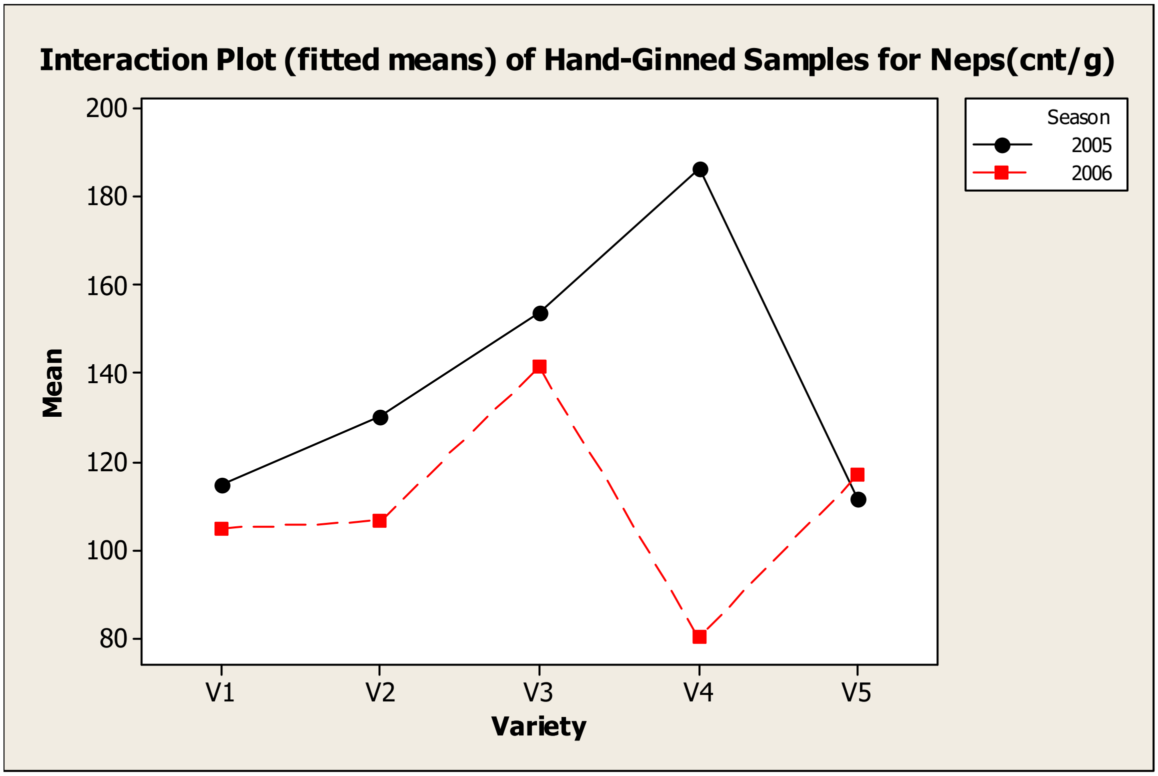

Figure 3: Interaction Plot of Season*Variety of Hand-Ginned Samples

The results observed above suggest that the propensity to neppiness of the tested cottons varied between the two seasons. Examination of the fiber properties related to neppiness revealed that variations in maturity from 2005 to 2006 may be at the origin of the variations observed on neps. Figure 4 shows the relationship between the number of neps per gram and the fiber's maturity ratio as measured by AFIS. The samples from 2005 and 2006 are represented using two different point-markers. The scatter plot clearly shows that the cottons grown in 2006 have a higher maturity ratio then those grown in 2005. The figure also shows a significant negative relationship between neps count and maturity ratio. Thus, the cottons in 2006 have less neps than those grown in 2005. Variety V5 shows a limited difference between the 2005 and 2006 maturity ratios, while variety V4 shows the largest difference in maturity from one season to the next. The neps per gram also follow a similar pattern with variety V5 having rather similar nep counts in 2005 and 2006 while variety V4 has significantly different counts. Thus the variation of maturity of V4 appears to be at the origin of the pattern seen in Figure 3 and of the significant interaction effect it represents.

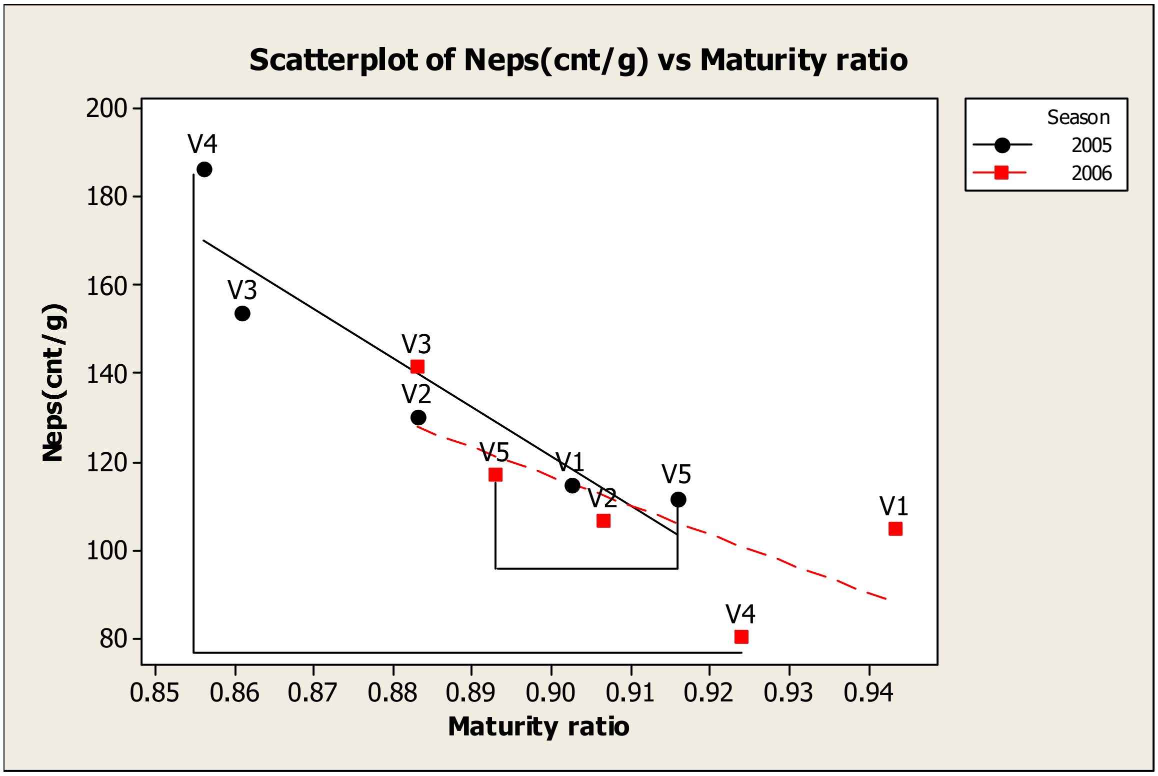

Figure 4: Scatter plot of Neps/g vs. Maturity Ratio

The results observed above suggest that fiber maturity is a primary factor in determining the number of neps detected in hand-ginned cotton, i.e., prior to any major mechanical processing of the lint. We now examine the impact of maturity on mechanically-ginned and cleaned lint.

As previously stated, the mechanical treatments consist of a varied number of lint-cleaning passages (Treatment 1: no lint cleaner; treatment 2: one lint cleaner, treatment 3: 2 lint cleaners, and treatment 4: 3 lint cleaners). The relationship between maturity ratio and nep counts obtained for the four treatments is represented on Figure 5, along with that of the hand-ginned samples (data from the two seasons were combined). Figure 5 shows how saw ginning and subsequent lint cleaning significantly increase the number of neps detected in the lint, with each additional lint-cleaning passage shifting the scatter plot upward along the nep-count axis. Maturity remains negatively related to neps count across the examined treatments. However, the slopes of the regression lines appear to vary. This would suggest that the relationship between treatments and maturity ratio alters neps generation. For instance, the difference between nep counts of mature and immature cottons depends on the processing history of the cotton.

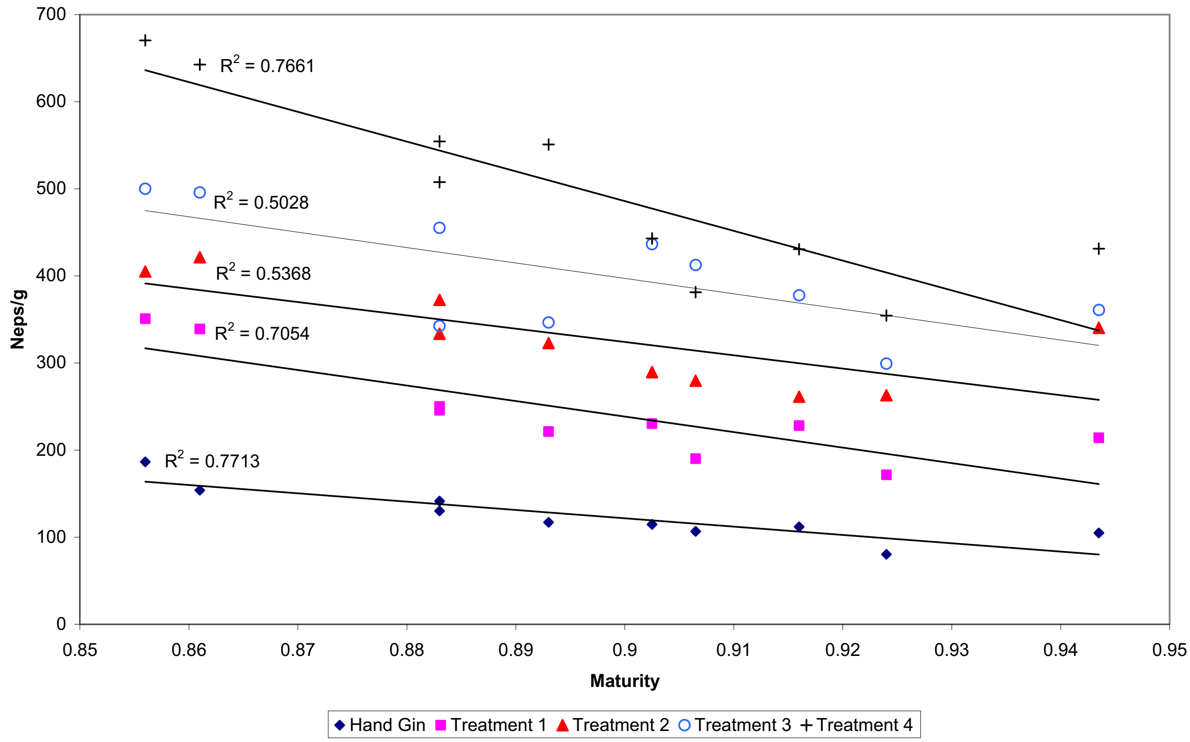

Figure 5: 2005 and 2006 Combined Treatment Data vs. Neps/g

The homogeneity of slopes model (Krifa, 2006) was used to examine the interaction mentioned above (involving categorical and continuous predictors). Results are reported in Table 2. One can observe that the effects of treatment and maturity ratio are both significant. The interaction term 'treatment*maturity ratio' is also found to be significant. Based on these results, we can conclude that the effects of treatment and maturity ratio on neps count are interdependent.

Table 2: Homogeneity of Slopes Model Results for Neps/g vs. Treatment, Maturity Ratio

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	4	820101	30106	7527	4.34	0.005
Maturity Ratio	1	120747	120747	120747	69.59	0.000
Treatment*Maturity Ratio	4	22709	22709	5677	3.27	0.021
Error	40	69401	69401	1735		
Total	49	1032958				

Thus, both fiber maturity and the processing history (ginning lint cleaning) of the cotton appear determinant of the neppiness potential of the raw lint. More importantly, the interaction between the two factors is significant and could represent opportunities for nep generation prevention through process optimization based on fiber properties.

Conclusions

Using five varieties grown over two seasons, we evaluated the nep content in hand and mechanically ginned cotton. The mechanically ginned cotton was exposed to varied cleaning treatments while the hand-ginned cotton was used to obtain lint with minimal mechanical handling. Our experiment suggests interactions between season and variety impacting the number of neps found in hand-ginned lint. These interactions were explained by the impact of maturity and its variation between the two seasons. Varieties that showed consistent maturity levels (i.e., were robust to the growth conditions variation between 2005 and 2006) were those showing consistent nep counts.

When considering saw ginned and cleaned lint, a significant interaction was shown between mechanical treatment and maturity ratio. Fiber maturity and processing history (ginning, lint cleaning) of the cotton appear determinant of the neppiness potential of the raw lint. More importantly, the interaction between the two factors is significant and could represent opportunities for process optimization based on fiber properties in order to limit neps generation.

Acknowledgment

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References

ASTM, 1994. Standard Test Method for Neps, Vegetable Matter, and Colored Fiber in Wool Top. Annual Book of ASTM standards, American Society for Testing and Materials, Ed. Philadelphia, PA (USA). D 1770-94.

ASTM, 1995. Standard Test Method for Neps in Cotton Fibers (AFIS-N Instrument). Annual Book of ASTM standards, American Society for Testing and Materials, Ed. Philadelphia, PA (USA). D 5866-95.

Bell, P. 2005. Neps in U.S. Cottons. p. 2431-2442. *In* Proc. Beltwide Cotton Conf., New Orleans, LA

Davidonis, G., Juan Landivar, Carlos Fernandez, 2003. Effects of Growth Environment on Cotton Fiber Properties and Motes, Neps, and White Speck Frequency. Textile Research Journal Vol. 73 No. 960

Krifa, M., M. Dean Ethridge 2006. Compact Spinning Effect on Cotton Yarn Quality: Interaction with Fiber Characteristics. Textile Research Journal Vol. 76(5)

Krifa, M. and Holt G. 2007. Impacts of Ginning Treatments on Spinning Preparation. Beltwide Cotton Conferences – Cotton Utilization: Textile Technology Symposium, January 9-12, New Orleans, LA, National Cotton Council of America. Memphis, TN, USA, pp. 1869-1877

Mangialardi, G.J. 1985. An Evaluation of Nep Formation at the Cotton Gin. Textile Research Journal Vol. 55 No. 12

Mangialardi, G.J., W.R. Meredith. 1990. Relationship of Fineness, Maturity, and Strength to Neps and Seed-Coat Fragments in Ginned Lint. Transaction of the ASAE Vol.33 No. 4

Pearson, N.L. 1933. Neps and Similar Imperfections in Cotton. USDA Technical Bulletin No. 396

Pearson, N.L. 1937. Naps, Neps, Motes, and Seed-Coat Fragments. USDA Bureau of Agricultural Economics.

Souther, R.H. 1954. Influence of Processing on Nep Formation. Textile Research Journal Vol.14 No. 6

Van der Sluijs, M.H.J., L. Hunter, 1999. Neps in Cotton Lint. Textile Progress Vol. 28 No.4