Neps Devalue Cotton

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Abstract

Neps are clusters of fibres or entanglements of fibres. They are classified as biological neps, mechanical neps and white specks. Biological neps are those that contain foreign material; mechanical neps contain only fibres and are the result of mechanical manipulation during processing; and white specks are neps that are found as light or white spots on fabric due to their resistance to dyeing. Upwards of 90 % of visible neps in the dyed fabric contain immature fibre and appear as white specks. It had been estimated that the United States alone has lost as much as two hundred million dollars annually due to these dye defects. To develop predictions of white specks, large field-to-fabric studies have been undertaken jointly by the U.S. and Australia. A new image analysis system has been developed and provides quick and accurate measurements of the problem. Now, high-speed fibre measurements can be related to the fabric white speck level. Micronaire, detects extreme cases of white specks, but is more useful when the mature level of micronaire is known for an individual variety. AFIS also shows promise in detecting white speck potential. Equations using micronaire and AFIS data are being developed to predict white speck. Meanwhile, variety, micronaire and level of cleaning should be tracked for all ginned cottons along with quality data from the end buyer or at least records of bales which industry has questioned as problematic for neps. This historical data will yield databases which will let the producer/ginner know what micronaire ranges are acceptable for their varieties. The information can be then be used to estimate whether or not a particular cotton is more prone to neps.

In order to decrease the problem of neps, producers must plant cotton varieties that have good maturity, since fibre fineness and maturity determine the amount of nepping. If possible, the cotton should be completely defoliated and dry when harvesting, preferably using spindle picking which has a lower trash to cotton ratio than stripper picking, thereby minimizing gin processing. The longer and finer the fibre the more it is prone to nepping during processing. Processing settings are critical for these fibres, so it is important for gins and mills to keep their equipment set properly and keep the wires sharp. When the ginner finds he has fibre to process with a low micronaire, for it's particular variety, he should hold processing to a minimum. In the future, if the marketing system adjusts, as it should, bales like this can be put into a special class for whites only. Industry should gin for quality instead of grade, but the marketing system has to adjust to award the producer for the quality that the mills are requesting.

Introduction to Neps

What is a cotton nep – what do they look like?

A nep can be defined as a small knot (or cluster) of entangled fibres consisting either entirely of fibres (i.e. a fibre nep) or of foreign matter (e.g. a seed-coat fragment) entangled with fibres. In contrast to the loose arrangement of a worsted nep, a cotton nep generally has a tight formation. In most cases, fibrous neps are found to contain at least five fibres, with the average number being 16 or more. [1] (van der Sluijs, 1999). The structure of a raw cotton lint nep has been described by British Standards Institute as well-defined and as containing a core structure of relatively dense entangled fibres. This core typically ranges from 0.3 to 3 mm in diameter and may contain a piece of trash or seed; pieces of seed without attached fibres are not neps.[2] (Verschraege, 1989) From this core, an array of fibres extends 5 to 10 mm, sometimes even up to 25 mm, in length[1]. Due to the apparent differences of formation, there are different classifications for neps. Neps have been grouped in three ways: seed coat with entangled fibres; trash with entangled fibres, and solely entangle fibres without contaminating particles, which primarily consist of immature or dead fibres.[3] In addition, neps are defined in two distinctions as either mechanical or biological. Biological neps are neps that contain foreign material, whether the material is seed coat fragments, leaf, or stem material (Figure 1)[4] (Hebert, 1988). In unginned cotton, biological neps are typically associated with motes (malformed seed, unfertilized ovules, and dead seed), while in ginned cotton (i.e. cotton lint); they typically contain seed-coat fragments (SCF). Mechanical neps are those that contain only fibres and have their origin in the manipulation of the fibres during processing (Figure2)[1]. The last type is a shiny nep or white speck nep, found on the surface of dyed fabrics, they appear as light or white spots and are seen only in the finished fabric (Figures 3 and 4)[4].

What are the chief causes of neps?

Biological neps are caused by trash (leaf, bract and seed coat) particles entangled in the cotton during harvesting or subsequent processing and result in small dark specks in the greige fabric, but are generally removed by wet processing. Mechanical neps can be found in ginned lint, card web, yarns and cloth and are strongly influenced by mechanical processing.[456] The formation of neps has been attributed to fibre properties such as immaturity, staple length, fineness and moisture content and to handling methods in production such as over or under beating the fibres in the carding or ginning operations.[6] These entanglement of fibres are created during development, harvesting, ginning, and yarn manufacturing phases of production.[7] Other contributing factors may be once-over harvesting, early frost, plant disease, and premature use of harvesting chemicals.[8]

Wilton R. Goynes, one of several cotton scientists at USDA's Southern Regional Research Center in New Orleans, used a scanning electron microscope to study the fibre up close to confirm what researchers had suspected since the 1940s - that most neps are the result of underdeveloped cotton. "Neps can sneak up on mills: The money is spent to dye the fabric, and it comes out spattered with white specks where the dye didn't take," said Goynes.[9] Goynes et al. reported that because of low cellulose content of the undeveloped fibres, these clumps of fibres do not accept dye. Therefore, when a fabric is dyed, the mechanical and biological neps formed by immature fibres create undyed spots in the finished fabric. These undyed spots are known as white specks. [10] When immature fibres die, they collapse into flat ribbons (Figure 4). The dyed fabric is passed over steam cans, essentially polishing the already flat immature fibres to a high shine, making them even more reflective and the problem even more obvious. (The photomicrographs in this paper are from Goynes and the Cotton Fibre Quality Research Group.) Bill Meredith, USDA researcher, describes white-speck neps as tangles of fibre that virtually cannot be dyed - a sign that the fibre was not able to mature properly in the field. Meredith studies the problem through fieldwork with cotton plants at Stoneville, MS. [9]

Figure 1: Biological Nep[10]

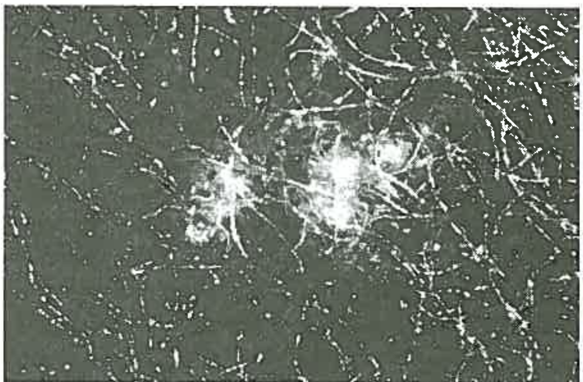

Figure 2: Mechanical Nep[10]

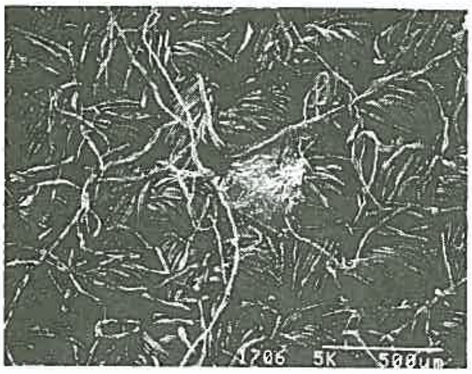

Figure 3: White speck nep on fabric

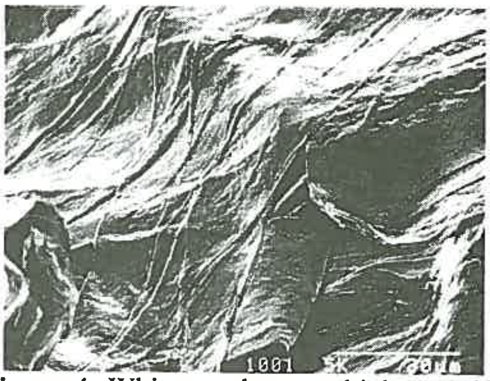

Figure 4: White speck nep – high magnification, completely flat, reflective, immature fibres. [10]

Are some varieties more prone to neps than others?

Neps can be caused by environmental factors during growth, processing and are inherent to particular varieties (Hebert, 1988).[4] Cotton variety is believed to be responsible for 30 percent of the problem, growing area 30 percent, and the remaining 40 percent is unknown.[11] Miravalle concluded that nep formation is heritable; and that nep levels are influenced by fibre fineness and maturity.[12] Breeding programs have been geared to producing longer stronger and finer cottons, and often other elements change besides the fibre property that was being manipulated. White specks, although primarily immature fibre neps, may result from seed coat fragments that have short fibres attached that resist dye. Often, these seed coats appear as dark specks in the dyed fabric with white specks encompassing the general vicinity around them, due to these short, immature fibres attached. These seed coat fragments are portions of immature or mature seeds that have disintegrated during mechanical processing. In addition, the seed coat has a weak portion at the chalazal portion of the seed, which easily peels and thus are believed to be the source of this seed coat fragment problem. Seed coat fragments are produced by cultivars with a high fibre-to-seed attachment force, a strong shank and loose tissue at the chalazal end of the seed. The genotype has an influence on the tendency of fibres to form neps and on the occurrence of seed coat fragments or motes. Motes are found in cultivars that have, to some extent, a defect in the pollination process and by bad weather conditions at anthesis.[2]

The final nep level after ginning is also greatly influenced by the nature of the cotton itself. Fibre fineness and maturity determine to a large degree the amount of nepping that occurs during the ginning process. Immature, fine-fibre cottons tend to nep more readily than do mature fibres of course fibres.[13] This can be seen in the following photomicrographs. The two varieties are from a breeding program where the EAC-30 was bred to mature early. The cottons were grown in the same field and harvested and ginned identically. These pictures show that the EAC-32 cotton has a much higher level of immature fibres than the EAC-30. EAC-32 produced very high levels of white specks in the dyed fabric while the EAC-30 had minimal levels of white specks. Given this, the producer should plant cotton varieties known to historically have good maturity.

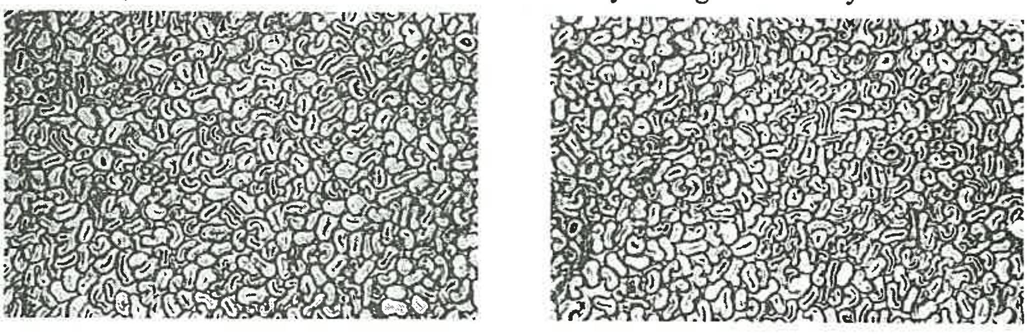

Figure 5: Cross-sections of Varieties: EAC-30 and EAC-32[10]

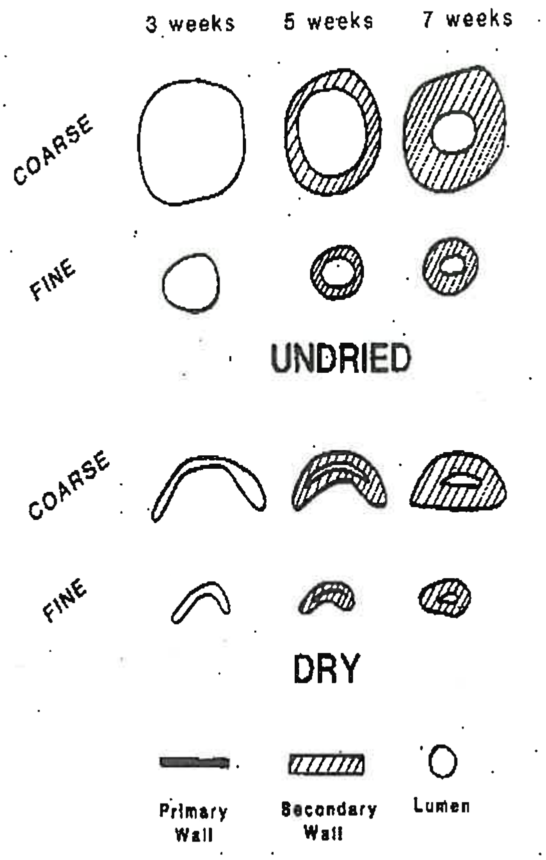

Figure 6: Representation of fibre cross-sections during growth and after they dry and collapse.

Neps are not present in the closed cotton boll. As soon as the cotton boll opens and the fibres blow up, dry, convolute and collapse some neps are formed.[2] The causes for these growth neps are climatic influences, over-watering, coalescence, maturity and pests. Growth period, which is related to growing conditions at a location and prior to harvest, has an impact on the number of neps and other imperfections found in ginned lint, yarn, and fabric.[7] The growth neps contain predominantly dead and immature fibres. When a cotton fibre first grows, its primary wall is laid down for the entire length of the fibre and then it starts to fill in the secondary wall with cellulose. The more cellulose that is laid down the more mature and circular the fibre will be. The level of maturity depends on the growth stage of the fibre when it died. This is demonstrated in figure 6. Frequently a mature, especially strong fibre is the cause for the creation of the nep. Sometimes a sack-shaped deformity of a fibre forms the center of the nep. Coalesced fibre entanglements are created as a result of the contents of the lumen escaping; the causes of this could be premature harvesting or damage due to insects. These fibres will no longer mature (Wegener, 1980)[14].

Why do neps cause problems for spinners and do they devaluate cotton?

Dyed fabrics should have a uniform color; however, this is not always the case for cotton. One of the big problems is the presence of white specks in the finished fabric. Neps are a very costly and sometimes rampant problem in the cotton industry. Jack Mauney, a cotton research consultant in Arizona, has found that it only takes one part immature fibre per million mature fibres to ruin a fabric.[15] Due to this problem, the United States textile industry alone has lost as much two hundred million dollars annually due to the dye defects of neps in lost product value.[16] Most yarns are not dyed until they are in fabric form and with today's inventory control, many items are not dyed until in garment form, so when they show up with white specks the claims back to the yarn manufacturer are substantial.[17]

In Ring spinning, in order to obtain a good parallelization of fibres, the fibres are carded. To increase uniformity, several card slivers are drawn down to the proper level and more neps can be formed. Very elastic, fine and immature fibres will, if they are stretched and suddenly released when floating in between the carding cylinders, form new entanglements. Nep formation is related to fibre buckling coefficient, defined as the ratio between 2.5% span length and micronaire.[18] The longer, finer and more flexible the fibre the more it is prone to nepping during processing. The more immature the fibre, the higher the buckling coefficient (propensity to buckle and cause a nep during processing). It has been found that a 10% difference in maturity can produce a 50% difference in card web neps. Large fragments breaking into small pieces increase the number of seed coat fragments, which are not removed by carding. In Open-ended spinning the sliver passes through the opening roller mechanism of the spinning machine. In this mechanism the fibres are separated and a lot of seed coat fragments, neps and other contaminates are eliminated or crushed into very fine fragments. These very fine fragments are potentially harmful in the rotor and reduce spinning efficiency. The nep-count increases rapidly with an increase in rotor speed and rotor diameter. The distribution of neps in yarn depends upon fineness of yarns; neps will be less visible in course yarns since they may be hidden inside the yarn.

USDA scientist have looked at conditions in processing at the cotton gin and cotton mill to learn what changes might help avoid problems with white specks. Image analysis of dyed fabric showed that fibres with extensive mechanical cleaning at the cotton gin and the mill have increased levels of white specks. Improper carding (poor settings and worn wires) in spinning can produce more neps in the ring or open-end yarns. Processing settings are critical for the very fine long fibres, so it is important for gins and mills to keep their equipment set as specified by the manufacturer and to keep the wires sharp to minimize the number of white specks. From this research on cotton from bale through fabric, we now know that gin processing and fibre properties are both necessary to predict white speck on finished fabrics. The level of lint cleaning in the gin changed the meaning of the fibre data when related to yarn and fabric properties. Without knowing the level of cleaning at the gin prediction of white speck from fibre properties was of little use.[19 20 21 22]. If the textile mills had a record of the extent of processing during ginning, along with the variety and fibre properties, they could track which bales cause problems and develop a value for white speck potential for future bales. Once these equations are developed, the mills could avoid making dyed fabrics from cotton fibre that was likely to cause white specks, or they could comb, reject or divert these lots to other uses, such as white toweling or sheeting, and significantly reduce these dye defects. The USDA and NCEA/USQ are currently working on this problem of white speck potential. USDA researchers are also studying which dyes react best with different fibres and which enzyme treatments are most effective in dealing with neps.[9]

What levels of neps create problems for spinners?
According to Jack Mauney, a cotton research consultant in Arizona, it only takes one part immature fibre per million mature fibres to ruin a fabric. He actually took the white specks out of rejected fabrics and weighed them. That's equivalent to one lock of one boll per acre of cotton getting through ginning into the bale to ruin a bale (approximately 300,000 bolls in an acre of two bale cotton).[15]

Do neps occur in man-made fibres?
Man-made fibres are uniform and consistent when they arrive at the mill, but just like cotton the longer and finer the fibres the more they are prone to nepping. If the machines, especially the card are maintained properly, neppiness will be minimal, but if the card wires are worn and the settings are improper (such as set too wide on one side of the card) the fibres will tend to roll and nep. So in all cases, man-made and natural fibres, machine maintenance is very important.

How can a ginner predict whether cotton is more prone to neps?
The U.S. and Australia have undertaken a multi-laboratory and multi-disciplinary effort to develop predictions of white specks from large field to fabric studies ($700,000 cooperative research program "Fibre Properties Relationships to Fabric Quality Joint Research Between Australia and the U.S.").[23] The fibre properties, without a processing history, will not be enough information to develop these prediction equations, so the study includes field history, variety, controlled gin and mill processing. High-speed measurements are needed to determine fibre properties so appropriate processing decisions can be made to utilize the cottons to their maximum potential and reduce defects. Before it's decided which values are good predictors of white specks, the level of white specks needs to be quantified by a consistent method. The process of counting white specks is very tedious and time consuming. Since the late 1930s, white specks were counted manually using a back light or a black background. Even today, white specks are being counted manually relying on visual inspection. [24] Several techniques have been studied under the joint proposal and a new image analysis system seems to provide relatively quick and accurate measurements of the problem. A test is also being developed to measure white specks on dyed yarns to minimize processing for

future research. With these tools available, high-speed fibre measurements can be related to the fabric white speck level.

In order to achieve the goal of consistent quality, textile mills require strong, mature, small diameter fibres for their modern processing. Cotton breeders would like to improve fibre quality for better future varieties. Mills need to know what measurable fibre properties are considered the most vital for quality in processing since with each stage of processing fibre properties change.[25] Producers and ginners need to be aware of these fibre properties as well, but often receive contradictory responses from the textile mills on the quality parameters that they need. Standard fibre tests for cotton do not completely detect the potential for the appearance of white specks in finished fabric. One exception is the micronaire rating, which detects extreme cases of white specks, but is more useful if the micronaire values are known for individual variety (mature micronaire levels). Micronaire is the primary tool by which mills can currently deduce maturity. Eince the problem is caused by only a small part of a sample, any measure of maturity that averages data across a sample (as does micronaire) will not detect problems with individual fibres. Over recent years many mills have raised their mic requirements from about3.6 to 3.9 with the top range about 4.9 to ensure high quality goods. This helps the problem but does not eliminate it.[17] A high-speed fibre test, AFIS (Figure 7), shows promise in detecting white speck potential. Equations using HVI data, such as micronaire, and AFIS data are being developed to predict white speck. Scientists hope not only to provide the fibres needed for particular processing, but to predict fabric properties from this fibre information. The goal is to use the high-speed fibre measurement data to recommend appropriate processing to improve productivity and minimize yarn and fabric defects.[26]

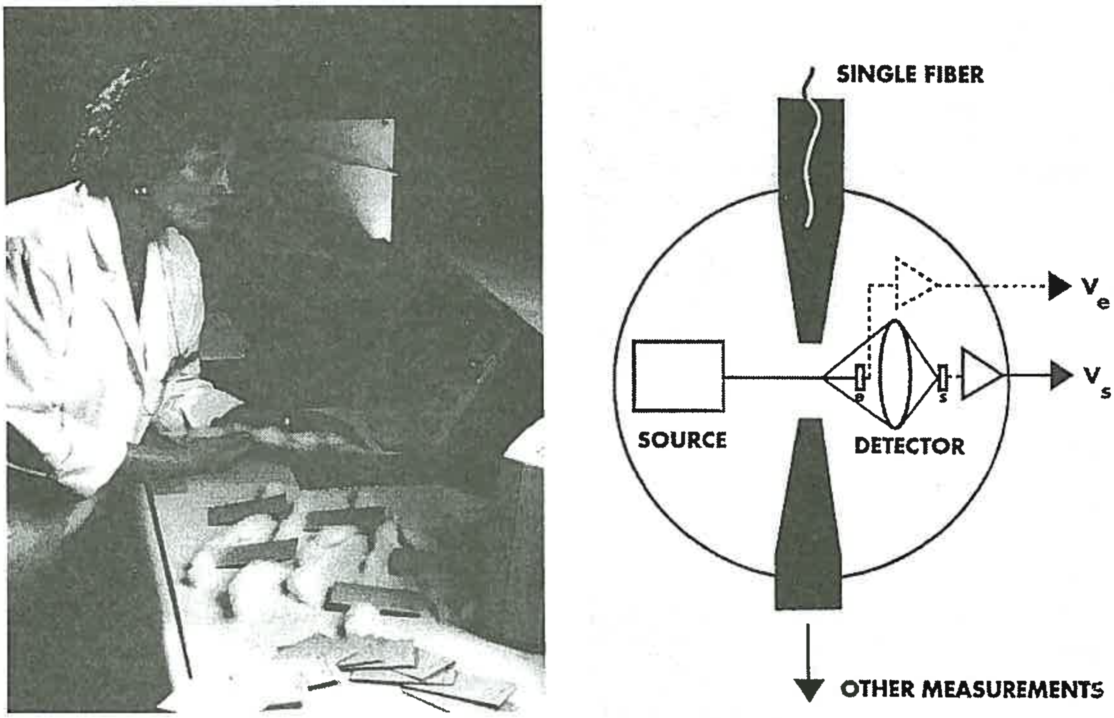

Figure 7: The Advanced Fiber Information System, AFIS, was developed to rapidly measure essential cotton fibre property distributions such as length, diameter, maturity, fineness, and neps. The instrument acquired for research purposes at SRRC was supplied with the necessary software to run fineness and maturity. The F&M (fineness and maturity) module is now available in the production models of AFIS. The basic hardware is essentially the same for Nep analyses and for F&M and L&D (Length & Diameter) measurements.

Meanwhile, the gins would be wise to track variety, micronaire and level of cleaning for all ginned cottons, along with quality data from the end buyer when possible or at least records of bales which industry has questioned as problematic for neps. Micronaire alone may not tell the ginner that there is a maturity problem, but if there is historical data available the ginner will know if the micronaire is high or low for that variety. The industry needs to decide whether to gin for quality or to gin for grade. Often the loss in weight of cotton fibre removed by adding a second lint cleaner offsets the financial gain due to increased grade. It's well known that the mills can more gently remove the trash than the gins thereby increasing the fabric quality.

What are the nep counts in other cottons around the world?
This is a very hard question to answer. There are neps in virtually all ginned cottons. White specks have been reported as early as 1874 so it's not a recent phenomena. It seems to be particularly bad during years with weather problems, like the 1987 U.S crop. The standards of acceptable numbers of white specks vary by company. What may be acceptable for one mill or even one product may produce rejection by others. [15] From my own studies, I found that bale cottons (with 2 lint cleaners) that had AFIS Nep counts/gram in the 200's produce good fabrics, but once the Neps/gram approached the mid-300's that when white speck problems started. Minimum cleaning at the gin can minimize them. The Australian Varieties from the 1998 ("best crop in 40 years") had an AFIS Nep count of 174 to 319 averaging 242 neps/gam for one lint cleaner and 214 to 402 averaging 304 for the two lint cleaner samples. Overall the fabrics were very good, but a few of the 60 fabrics that had problems.

I put a survey on the web ALIDA List – (alida@liststar.icac.org) with questions about neps and only one person answered this question. Luis Helguero said that in Peru they measure neps using AFIS; their average is lower than 100 neps/gram. He added that varieties with coarser micronaire, a Tanguis 5.4 to 5.9 mic are very low in Nep counts, also extra long varieties have lower neps due to ginning with old Plat Equipment, which is gentle and runs at slower speeds than most modern gins. He also commented that humidity of the cotton and speeds (650 maximum) are important when ginning. He suggest that the gins should be slowed down to minimize neps and that the ginner can get a good idea of his nep problem by hand pulling, AFIS Nep measurements, knowing the variety and origin.

Can we reduce neps in cotton without increased costs of ginning and processing?
Harvesting methods also have an effect on nep formation. Hand picking gives the lowest number of neps, and stripper picking the highest. As a general rule cotton harvested early in the season will produce yarn and fabric containing a lower number of the imperfections than cotton harvested late in the season in the same field. This is attributed to the earlier harvest containing a higher micronaire cotton and thus probably more mature fibres than the later harvested cotton.[27]. With increasing amounts of impurities (i.e. trash) such as husk, leaf and stalk, and seed-coat fragments, the greater the number of cleaning points required during ginning and opening. Increased drying and cleaning leads to more neps, fibre breakage, and short fibre content, decreased spinning performance and yarn and fabric quality.[28] The gin stand and saw cylinder lint cleaners are the major contributors to the formation of neps. Using three saw cylinder lint cleaners in the ginning sequence instead of one lint cleaner increases the number of neps 54%.[28] Lint cleaning does take out motes and seed coat fragments, but since the cleaning efficiency depends somewhat on the weight of the differential between cotton and trash, the heavier, larger motes and seed coat fragments are more likely to come out than smaller, pinhead motes. As the severity of the machining is increased, the smaller motes would just as likely be broken up and scattered more through the lint rather than being broken up.[29] Immature fibres naturally occur in large clusters since they are from one seed or one lock of cotton originally. If excessive cleaning takes place at the gin the one bad lock of cotton, getting through ginning that Jack Mauney spoke of, will be separated into individual fibres that the mill can't remove resulting in a white speck problem. Less aggressive cleaning at the gin would allow the clumps of immature fibre to remain and the mill still has a good chance or removing these fibres as trash.

The producer should plant cotton varieties known to historically have good maturity and apply good farming practices. The agronomists urge growers to make sure of good micronaire by adequate potassium fertility[15] and hope Mother Nature does her best. The cottons should be completely defoliated, harvested dry if possible and use only once over spindle picking (the mechanical method with the lowest trash to cotton ratio), followed by minimum lint cleaning in the gin. All mechanical equipment should be monitored and kept in good repair with the recommended settings. The settings for gin and mill equipment can be critical to final product quality. This should minimize neps appearing in fabric, the ultimate end product of the combined efforts of producers, gins and mills.

Conclusions:

Upwards of 90 % of visible neps, entangled fibres, in the dyed fabric contain immature fibre and appear as white specks. White specks on the surface of finished, dyed fabrics have been defined as small undyeable, undeveloped or immature fibre clusters that appear white on the surface of a darkly dyed fabric. Fibre properties, such as immaturity, staple length, fineness, and moisture content have been linked to the formation of neps. Variety, growing conditions, harvesting, ginning and processing contribute to the formation of more neps. Since fibre fineness and maturity are major factors in nepping, producers must plant cotton varieties that have good maturity in order to decrease the problem of neps. Since uniform surface color is a desirable aspect for fabrics, white specks are detrimental to fabric quality. Unfortunately, these defects were not recognized until after the dyeing stage of processing resulting in a fabric that was unmarketable as a first quality fabric resulting in significant financial losses to the textile industry. Some mills have been able to isolate the bales which caused them problems and they then reject bales from the same area and time period or direct them to bleached or natural products[17].

If possible, cotton should be completely defoliated and dry when harvesting, preferably using spindle picking which has a lower trash to cotton ratio than stripper picking, thereby minimizing gin processing. It is critical for gins and mills to keep their equipment set as specified by the manufacturer and keep the wires sharp if they want to minimize neps. They must also invest in gentler methods of handling cotton and minimize processing. When the ginner finds he has fibre to process with a low micronaire for it's particular variety he should hold processing to a minimum. The goal is to use HVI and AFIS data to recommend appropriate processing to improve productivity and minimize yarn and fabric defects. With the properties of individual fibres properly gathered, scientists hope not only to provide the fibres needed for particular processing, but to predict fabric properties from this fibre information.[30] In the future, if the marketing system adjusts, as it should, bales like this can be put into a special class for whites only, maximizing the fibre's potential and minimizing mill losses.

The bulk of Australia's cotton is exported, so quality becomes a very important issue for Australia. To maintain the reputation for high-quality cottons it is recommended that good breeding programs continue with closely monitored levels in maturity (white speck potential) and that cotton should be ginned be for fibre quality instead of grade 99% of the time. Minimizing processing in the gin will minimizes the level of white speck if there is a problem. Since white speck is not usually detected until dyeing, it would be best to expect it and minimize the problem at the gin, and maintain a reputation for high quality cottons internationally.

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