

Regional Distribution of Cotton Fiber Quality in China

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Abstract: The fibre quality status is very important for super quality cotton production and diverse requirements of textile industry in China. In this study, the quality of cotton fiber samples which are collected from 13 major cotton production provinces between 2001 and 2005 were analyzed. Eight quality traits including fiber length, uniformity index, specific strength, elongation, micronaire, reflectance degree, yellow degree, and spinning consistency index were tested. The data indicated that the cotton fiber length ranged around 28 to 29 mm, the fiber uniformity index ranged from 82% to 84%, fiber strength ranged from 27 to 29 cN · tex⁻¹, micronaire ranged from 4.0 to 5.0. These fibres could satisfy the requirements of middle and low grade spinning. The fibers from the Yangtze River Valley (Jiangxi, Hubei, and Hunan Province) were superior in length, strength, and uniformity index. However, the micronaire was a little higher, the color, character was not good enough, and, the grade was lower. The fiber qualities of the Northwest Inland Region (Xinjiang) were the best in terms of micronaire, color and grade. As for the Yellow River Valley Region, the index of its fibre qualities was between the above two regions.

Key words: cotton; fiber quality; regional distribution

Introduction

Cotton fiber quality and yield are two key factors which are influencing the textile industry. The fiber demand for textile industry increase very fast in China. The total demand reached 9.5 million tons in 2005, while the total yield was only 5.5 million tons in 2005. The status and regional distribution of fiber quality in China are not clear till now. In order to improve the super cotton quality production, optimize the layout of cotton production and meet the diversification requirement of textile better, it is necessary to analyse cotton samples which are collected from different regions in China.

1 Materials and Methods

1.1 The method of sampling

Cotton fibre samples were collected from 13 major cotton production provinces in the Northwest Inland Region, the Yellow River Valley

and the Yangtze River Valley in China. In each province, 5 to 10 cotton ginning factories which represent the local fiber quality were chosen, and cotton fiber of one or two major cultivars were sampled randomly. In total, 1524 samples were collected, which covered 150 cultivars and more than 200 cotton cultivation counties.

1.2 Quality test

Eight quality traits including upper half mean length (Len), uniformity index (Un), breaking tenacity (Str), breaking elongation (EI), micronaire (Mic), reflectance degree (Rd), yellowness (+b), and spinning consistency index (SCI) of the samples were measured by High Volume Instruments (HVI) with the HVI Calibration Cotton (HVICC). Before measurement, samples were put in the constant temperature and humidity laboratory (temperature on 20°C ± 2°C and humidity on 65% ± 3%) for 48 hours.

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2 Results and Analysis

2.1 The general distribution of fiber quality index

2.1.1 The upper half mean length (*Len*). In 2001—2005, the fiber length of the dominant cultivars ranged between 26 mm and 32 mm. The main distribution ranked at 28 mm and 29 mm with the percentage of 30% or 35.8%. Samples of 26 mm, 31 mm, and 32 mm (or longer) account for 2.3%, 5.9% and 2.3%, respectively. No cultivar was found that its fibre was at the 25 mm grade. The results indicated that the fibre length increased a little from 2001 to 2005, and the average length of the fibers reached to 29.2 mm during the past five years.

2.1.2 The distribution of fiber strength. The fiber strength was in the range of 24 cN · tex⁻¹ and 37 cN · tex⁻¹. Total of 60.3% of the fibers ranked at 27 cN · tex⁻¹, 28 cN · tex⁻¹ and 29 cN · tex⁻¹, with the percentage of 18.0%, 20.8% and 21.5%, respectively. The average fiber strength in the five years was 29.2 cN · tex⁻¹. This indicated that most of the fibers were ranked to upper-middle grade and suitable for the 32-count (32S) or finer yarn spinning.

2.1.3 The uniformity index. In 2001—2005, the uniformities of most fibres ranged between 83.0% and 85.9%, and the percentage is 65.4% of them. The average of the five years' uniformity index was 83.3%. These data showed that the majority of the cotton fibre uniformity was fine in China.

2.1.4 The fiber micronaire (*MIC*). In 2001—2005, 29.2% of the fibers ranked at Grade A, 4.1% at Grade B1, 48.9% at Grade B2, 5.2% at Grade C1, 12.6% at Grade C2, which meant 82.2% ranked at Grade A or B grade in total. These indicated that the maturity of fibers were good and the fineness were moderate.

2.1.5 The fiber elongation index (*EI*). In 2001—2005, the EIs were about 6.5% (account for 35.3%), and 7.0% (account for 31.5%). The

average EI of the five years was 6.9%. These indicated that the fiber elongation was ranked at middle to high grade.

2.1.6 The reflectance degree (*Rd*). In 2001—2005, 89.0% Rd of the fiber samples were in the range between 74% and 80% with the average percentage of 78%.

2.1.7 The yellowness (*+b*). In 2001—2005, the yellowness of the fiber samples were mostly around 8.0, which occupied 57%.

2.1.8 The color character. According to the latest national fiber criteria, the color character in China is divided into three types and 13 grades. Fiber color characters are expressed by a double-digit number, the first number stands for its grade and the second stands for its type. Common fibers are classed into three types as white fiber, stained fiber and yellow stained fiber. White fiber is classed into six grades which separately encoded as 11, 21, 31, 41, 51, and 61. Stained fiber is classed into four grades as 12, 22, 32, and 42, and yellow stained fiber is classed into three grades as 13, 23, and 33. The "31" grade defines as the standard grade. According to our results, the fiber samples in 2001—2005 mainly distribute over 21, 31 and 41 grade in color character.

2.1.9 Spinning consistency index (*SCI*). Only a few portion of the fiber samples was higher than 160 in SCI, which fits for 60~80S yarn spinning, while most of the fibers was between 130 and 150, which fits for the 32~40 S yarn spinning.

2.2 The distribution of fiber indexes in the major cotton production provinces

Quality of the fibers from the 13 major cotton production provinces was investigated (Table 1).

The range of fiber length was 27.7 mm to 29.9 mm and the average length was 29.2 mm among the 13 provinces. Compared with other provinces, fibers from Hunan, Zhejiang and Jiangxi were longer, and their length closed to 30 mm. Most cultivars such as Xiangza family

and Ganmian family belonged to super quality varieties. The shortest fibers were from Shanxi province with the average length of only 27.7 mm, and was 1.5 mm shorter than the average of the total samples. Obvious variations in fibre length were found among provinces; the longest from Jiangxi, followed by Zhejiang, Hunan, Hubei, Hebei, Henan, Anhui, Shandong, Jiangsu, Sichuan, Shaanxi, Xinjiang, and Shanxi.

The uniformity indexes of fibers ranged

from 82.2% to 84.6% in the 13 provinces with the mean of 83.3%. The fiber uniformity indexes in Hubei, Hunan, Zhejiang, Jiangxi, and Sichuan were good, while that in Shanxi was the lowest (82.2%). Significant difference in the uniformity indexes was observed among the 13 provinces; the highest was Zhejiang, followed by Jiangxi, Hunan, Sichuan, Hubei, Henan, Shandong, Shaanxi, Xinjiang, Jiangsu, Anhui, Hebei and Shanxi.

Table 1 The average values of fiber quality for different provinces from 2001 to 2005

Province	Upper half mean length/mm	Uniformity index /%	Strength /($\text{cN} \cdot \text{tex}^{-1}$)	Elongation/%	Micronaire	Reflectance/%	Yellowness	Spinning consistency index
Anhui	29.2	83.0	29.3	6.6	4.5	76.9	8.9	134
Hebei	29.3	82.9	29.2	6.7	4.4	76.9	8.7	134
Henan	29.3	83.4	29.3	6.8	4.1	77.0	8.7	139
Hubei	29.3	83.7	30.1	6.8	4.5	75.5	9.3	139
Hunan	29.7	84.1	30.2	6.8	4.7	74.9	9.2	139
Jiangsu	29.2	83.0	28.1	7.1	4.2	77.2	9.3	132
Jiangxi	29.9	84.3	30.3	6.6	4.7	75.5	8.9	141
Shandong	29.2	83.3	28.8	6.9	4.3	77.5	8.7	135
Shanxi	27.7	82.2	28.2	7.1	4.1	75.8	8.8	127
Shaanxi	29.1	83.2	30.7	7.2	4.2	77.8	8.6	141
Sichuan	29.1	83.8	29.0	6.4	4.6	75.4	9.2	136
Xinjiang	28.9	83.1	27.5	7.3	4.1	78.6	8.4	133
Zhejiang	29.9	84.6	30.9	6.6	4.9	77.5	9.0	143
Mean value	29.2	83.3	28.9	6.9	4.4	76.9	8.9	135

The fiber strength ranged from 27.5 $\text{cN} \cdot \text{tex}^{-1}$ to 30.9 $\text{cN} \cdot \text{tex}^{-1}$ and the average of the 13 provinces was 28.9 $\text{cN} \cdot \text{tex}^{-1}$. The fiber strength in Hubei, Hunan, Zhejiang, Jiangxi and Shaanxi was higher than the others. Most of the cotton cultivars such as Xiangza family in Hunan and Hubei, Ganmian family in Jiangxi and Deltapine Line family in Shaanxi were quite higher in fiber quality, which may belong to high quality varieties. Fiber strength in Xinjiang was the lowest, which was only 27.5 $\text{cN} \cdot \text{tex}^{-1}$ and was 1.4 $\text{cN} \cdot \text{tex}^{-1}$ lower than the average of the 13 provinces. The differences in the fiber strength among the different provinces were significant.

The fiber MICs ranged between 4.1 and 4.9, and the average was 4.4. Fiber micronaire grade was B2 in Hubei, Hunan, Zhejiang, Jiangxi, and Anhui, and especially in Hunan, Zhe-

jiang, Jiangxi provinces, the fiber MIC was 4.7, which was higher than the other provinces, and the fibers were thicker. In Jiangsu, Henan, Shaanxi, Shanxi and Xinjiang, the average of MIC was in graded A and the fibers were moderate in fineness.

Reflectance (Rd) ranged from 74.9% to 78.6% with the average of 76.9%. In Xinjiang, Shaanxi, Shandong, Zhejiang, Jiangsu, the Rd was more than 77.0%, which was higher than the other provinces. The Rd in Xinjiang was 78.6%, which was the highest, and followed by Shaanxi, Shandong, Zhejiang, Jiangsu, Henan, Hebei, Anhui, Shanxi, Jiangxi, Hubei, Sichuan and Hunan.

SCI in China ranged from 127 to 143 with the average of 135. In Zhejiang, Jiangxi, Shaanxi, the SCIs were more than 140, which were higher than the other provinces and could

be defined as very good in fiber spin character. However in Shanxi, the SCI was the lowest among the 13 provinces. In Zhejiang, Jiangxi and Shaanxi, the SCIs were the highest, followed by Hunan, Hubei, Henan, Sichuan, Shandong, Anhui, Hebei, Xinjiang, Jiangsu and Shanxi.

3 Discussion and Conclusions

3.1 The distribution of the fiber quality during the period of "the Tenth Five-Year Plan"

The fiber length increased from 2001 to 2005, and most of the samples reached to the rank of 29 mm. 8.2% of the fibres reached or exceeded 31 mm. There was no fibre ranked to the 25 mm. The fibre uniformity value was good and the strength mainly could rank to the middle and high grade. The MICs of the fibres were around 4.6. These indicated the fiber maturity was good and the fiber fineness was very suitable for spinning. The color character was mainly graded 21, 31 and 41. Generally speaking, the fibers in China are satisfied with the 32~40S yarn spinning and a few of the fibers are satisfied with the 60~80S yarn spinning.

3.2 The differences of the fiber quality among the major cotton production provinces

The fiber from Hunan showed good quality in terms of fiber length, strength, uniformity and SCI, but the MIC was improperly high and the color character was bad. In general, the fibres here satisfied with the 40~50S yarn spinning or even higher. In cotton breeding procedure, decreasing the MIC is the major task. The cultivars of Xiangza 4 and Xiangza 5 are the commendatory cultivars. Besides, cotton should be picked in time in case of raining.

Fibers from Hubei could be considered as the good quality, which were preferable in terms of fiber strength and fiber uniformity. The fibre length was situated as upper-middle level among the 13 provinces. The major cultivars have high fiber MICs and thick fiber fineness. Therefore, the fibers from Hubei can be defined good in quality, which are suitable for 50S or higher

yarn spinning. However, the MIC should be reduced and the color grade should be improved in the cotton breeding. More than 20 cultivars were planted in Hubei, including the members from the Eza family, the E-pest-resistance family, the Xiangza family, the Huaza family, the CCRI family and so on. Therefore there were many differences between these cultivars. The planted cultivars should be selected carefully. The super quality cultivars as Eza 1, Eza 9, Huaza 2, Jing 3517, Xiangza 4 and Xiangza 5 are recommended.

Fibers from Jiangxi were considered good in terms of length, strength and uniformity, but they were considered bad in MIC, reflectance, yellowness, and color character. They suited for 40~50S yarn spinning because they ranked at high in SCI and be defined good in fiber qualities. Optimizing macronaire and improving the color character grade should be focused on in the breeding task. The fiber length values of Ganmian 12 and Honghe 1 were both above 31 mm, the strength values were above $32 \text{ cN} \cdot \text{tex}^{-1}$, the MICs were 4.5 (Grade B) and SCIs were above 160. So the fibers were good in length, strength and fiber fineness, which could meet the requirement for 60~80S high quality yarn spinning.

Fibers from Zhejiang were good while considering the quality of length, strength, uniformity, and color character. But they were in high MICs and thick fiber fineness. They could suit for 40~50S yarn spinning. The major cultivars in Zhejiang, which were mainly introduced from the adjacent provinces, were Xiangza 2, Sumian 12, and Simian 3, as Cikangza 3 was bred in Zhejiang. The disadvantage of these cultivars in fibre qualities was that the fiber fineness was too thick. Therefore, some cultivars in thinner fineness should be introduced in the future.

Because of high fraction of open-handicapped boll, low reflectance, high yellowness and bad color character, the fibers from Sichuan are graded low. The major cultivars in Sichuan

are bred locally and their fibers are not good in quality, which only qualified for 32S yarn spinning. Therefore, the high quality cotton cultivars should be introduced or bred.

Anhui Province lies between the Yellow River and the Yangtze River valleys. In the south area, the major cultivars are hybrid ones, while in the north are the conventional cultivars. These cultivars included members from the Wanmian family, the Simian family, the Sumian family, the Emain family and the CCRI family. In general, fibers are middle in quality and fit for 32~40S yarn spinning.

Fibers from Jiangsu showed good quality in terms of macronaire and fineness, but they were generic in length, weak in strength, low in reflectance, and a little high in yellowness. The average fiber strength was only $28.1 \text{ cN} \cdot \text{tex}^{-1}$ during 2001–2005, only a little higher than the fibers from Xinjiang (the lowest). Then the fiber quality was not good, for the 50S or higher yarn spinning. However, the varieties which were introduced in the latest years such as Yumian 1, Yumian 3, and the local bred as Kemian 1, Kemian 3, and Kemian 4 showed good fiber quality. Their length were around 31 mm with strength exceeding $35.0 \text{ cN} \cdot \text{tex}^{-1}$, and grade A in MIC. Their integrative quality in terms of length, strength, and fineness was qualified for 60~80S yarn spinning.

The predominant cultivars in Shandong are Lumian family and CCRI family. The fibers are good in MIC, fineness and color character, but very common in fiber length and strength. Their integrative quality is just OK, so the fibres are qualified for the 32~40S yarn spinning.

The fibers from Henan are graded A in MIC. They are good in fineness and color character, but they are middle in length and strength. Their integrative fiber quality is a little higher than the average, and fit for the 32~40S yarn spinning.

Hebei is the major cotton production province where produce the high quality cotton. The

major cultivars are DP 99B, DP 33B, Siyuan 345, Han 284, SGK 321, Jifeng 197 and Ji 668, which are local bred or introduced from the Deltapine Line family. The fibers are very good in fineness and color character, but middle in length, strength as well as the integrative fiber quality. The fibres satisfy for the 32~40S yarn spinning.

The integrated quality of the dominant cultivars (DP99B and DP33B) in Shaanxi is good. The macronaire is classified into grade A. Although they are common in length, they are fine in strength, fineness and color character. The fibres can be used in the 32~40S yarn spinning.

The fiber quality from Shanxi was lower than those from other provinces in fiber length, uniformity, strength, and SCI, though the MIC is graded A. The fibre here can be only used for the 20S yarn spinning or as subsidiary material for spinning.

Fibers from Xinjiang were fit for the 32S yarn spinning. They are good in fiber fineness, MIC, and color character. Their reflectance and yellowness are the best among the 13 provinces. However, their length and strength were the lowest and the SCI was also very low. In the recent two years, cotton of long fiber from the Xinjiang increased quickly. Some local bred varieties, such as Xinluzao 24 and so on, were planted. The fiber length of Xinluzao 24 is around 32 mm, the strength is above $35 \text{ cN} \cdot \text{tex}^{-1}$ and MIC is 3.8~4.4, these indicated that it can be used in the 50S yarn spinning.

3.3 Adjust the configuration of fiber quality

As to the cotton variety breeding in China, we should pay more attention to select the varieties with harmonious fiber quality. In the breeding of cultivars for 32~40 S yarn spinning (length at 27~29 mm rank), the main task is to increase the fiber strength and fineness. In the breeding of cultivars for 50~60S yarn spinning (fiber length at 30~31 mm rank), the main task is to reduce the MIC. And in the breeding of the cultivars for 32S or lower yarn spinning (fiber

length at the 26 mm or lower ranks), the main task is to improve the fibre yield. During 2001—2005, the fibers used for the 60S or higher yarn spinning were badly off. More of this kind of cotton should be planted in the future.

3.4 Adopt a correct attitude to the commercial quality of raw cotton

Cotton commercial quality is determined by the native genetic quality, the production quality, and the primarily processing quality. The local cotton production administration should help select the the local ecological conditions, the quality goal, and the local agricultural belt. The number of planted cotton cultivars should be improved until the fibre quality are harmonious. Quality supervision is needed during the raw cotton collections. The mixing with different grades and classes of cotton should be forbidden. The exterior qualities such as fibre length and color characters are very useful during the collection procedure, which could be helpful to enhance the general quality of the fibres.

According to this survey, there are also some problems in the configuration of fiber quality. Some indexes such as the fiber strength should be improved. The predominance in the fiber fineness has reduced. The scientific and

technology researches should help to improve the cotton quality and solve some quality questions.

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