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How to reduce cotton fiber damage in the Xinjiang China

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ABSTRACT

The Xinjiang Uyghur Autonomous Region in northwest China accounted for 73% of China's total cotton production in 2014. However, Xinjiang's cotton is difficult to market due to poor lint quality and become increasingly acute. The objectives of this study were to determine changes of fiber quality and to investigate the reasons for poor lint quality in the Xinjiang Region. Field production conditions and harvesting methods caused more variability in fiber damage than cleaning processes. Under field production conditions, fiber strength of 35% of the cultivars was reduced by more than 2 cN/tex and fiber length of 12% was reduced by more than 2 mm machine harvesting reduced fiber length by more than 2 mm at 17% of the experimental sites. Cleaning processes caused fiber damages that fiber quality reduced one to two units accounted for 84% of samples. Cotton fiber damage as influenced by field production conditions, harvesting methods, and cleaning processes. But field production conditions increased fiber strength of 27% of the cultivars compared with variety trial reports, machine harvesting increased fiber length and fiber strength at 48% and 33% of the experiment sites compared with hand harvesting. The crucial point about the phenomenon was that how to reduce the foreign matter content of machine harvested cotton.

1. Introduction

The cotton production has increased rapidly during the last decade in the Xinjiang Uygur Autonomous Region of northwest China. The Xinjiang Region produced 451 × 10^4 t of cotton (*Gossypium hirsutum* L.) in 2014, accounting for 73% of China's total. Hence, the Xinjiang Region has a major influence on China's cotton production. The cotton harvesting period is relatively short in the Xinjiang Region (Xu and Diao, 2006). Furthermore, increasing labor costs in China have caused hand-harvested cotton prices to rise, pushing up the price of cotton lint and reducing China's competitiveness in the international cotton market (Wang and Du, 2006). For these reasons, the use of machine harvesters has increased in recent years to reduce cotton production costs and to elevate China's competitiveness in the international cotton market.

The area of machine-harvested cotton has increased by about 10% per year from 2008. In 2014, 65% of cotton land was machine-harvested in the Xinjiang Region. However, the lint grade of machine-harvested cotton in the Xinjiang Region is more than two grades lower than that of hand-harvested cotton (Wang and Xu, 2011; Dong, 2013). Furthermore, machine harvesting reduces fiber length by 0.30–1.0 mm and fiber strength by 0.80–2.5 cN/tex (Xu and Xia, 2009; Zhang, 2013; Tian et al., 2016). These reductions in fiber quality have caused declines in the sale of machine-harvested cotton from Xinjiang. Sixty percent of cotton trading companies and textile factories in the Xinjiang Region will not buy or use machine-harvested cotton (Zhang et al., 2015). This has seriously impacted the development of Xinjiang's cotton production.

Machine harvesting is a once-over operation, occurring when 85% of cotton bolls are open and all of the leaves are desiccated. The machines generally harvest 90% of seed cotton from plants (Hughs et al., 2008). However, machine-harvested seed cotton typically has 10–30% more foreign matter than hand-harvested seed cotton (Kerby et al., 1986; Hughs and Gillum, 1991; Faulkner et al., 2011). The foreign matter content of machine-harvested seed cotton is the most important factor influencing lint quality (Barker et al., 1973). Machine-harvested cotton is subjected to intense cleaning to improve ginning efficiency and increase lint turnout (Baker and Laird, 1982; Li et al., 2012). Seed

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cotton cleaning mainly removes large foreign matter from cotton, its efficiency ranges from 54% to 83% (Gillum and Armijo, 1997). Bale value increases with additional cleaning due to continued improvement in color grade with no change in turnout (Gillum and Armijo, 1997; Holt et al., 2002). Lint cleaning, which follows seed cotton cleaning, removes small foreign matter from lint to improve high volume instrument (HVI) color and leaf grade (Gillum and Armijo, 1997; Li et al., 2012). However, many studies show that lint cleaning significantly reduces fiber length (Dever and Gannaway, 1988; Zurek et al., 1999; Li et al., 2012; Krifa and Holt, 2013) and increases short fiber index (Griffin, 1979; Dever and Gannaway, 1988; Sui et al., 2010; Li et al., 2012; Xu et al., 2014). Some researchers report that lint cleaning reduces fiber strength (Xu et al., 2014), whereas others report that lint cleaning increases (Ethridge et al., 1995) or has no effect on fiber strength (Dever and Gannaway, 1988; Krifa and Holt, 2013).

Cotton fiber quality is determined by three interrelated, but different factors: (i) field production conditions, (ii) harvesting methods, and (iii) cleaning processes (Dong, 2013; Yang et al., 2015). Many studies have examined the effects of these three factors on fiber quality; however, few reports have considered all three at the same time. The primary objective of this study was to systematically determine changes of fiber quality affected by field production conditions, harvesting methods, and cleaning processes. A secondary objective was to investigate the reasons for poor lint quality in the Xinjiang Region.

2. Materials and methods

2.1. Sampling

2.1.1. Fiber samples as influenced by field production conditions

The effects of field production conditions on fiber quality were determined using samples from twenty-six cultivars growing at eight locations (six regimental farms, Shihezi University, and Wulanwusu Agro-meteorological Experiment Station) in the Xinjiang Region from 2003 to 2004 and from 2007 to 2015 (Tables 1 and 2). Three plots (i.e., replications) were selected in each field where open bolls from approximately ten consecutive plants were collected and mixed. These were samples in the field conditions. Information about fiber quality was obtained from the Xinjiang Crop Variety Approval Committee. These listed data of fiber quality in variety trials.

2.1.2. Fiber samples as influenced by harvesting methods

The effects of harvesting methods on fiber quality were determined using samples from prominent growers at five regimental farms in the Xinjiang Region between 2013 and 2015 (Table 2). Fibers were collected from one to six cotton cultivars at each farm. Before machine harvesting, three plots (i.e., replications) were selected in each field where open bolls from approximately ten consecutive plants were collected and mixed. These were samples of hand-harvested cotton. The fields were then harvested with either a John Deere 7760 round module harvester (in the Seventh Division) or a Case IH CXP420 square module harvester (in the First Division and the Eight Division). Three samples (i.e., replications), sample weighed approximately 1.0 kg, were randomly collected from the machine-harvested cotton and each. These samples were used to determine the fiber quality of machine-harvested cotton.

2.1.3. Fiber samples as influenced by cleaning processes

The effects of cotton cleaning on fiber quality were determined using Cotton samples from prominent growers at five regimental farms in the Xinjiang Region between 2013 and 2015 (Table 3). Up to three cotton cultivars were selected from each farm. The cotton was harvested with either a John Deere 7760 round module harvester (in the Seventh Division) or a Case IH CXP420 square module harvester (in the First Division and the Eighth Division). The harvesters were operated according to the manufacturer's instructions. All of the seed cotton was ginned under standard commercial conditions at one of seven local ginneries.

Some ginneries (No. C, H, I, and J) were equipped with four seed cotton cleaners and two or three lint cleaners. The cleaning equipment included two tower dryers, two cylinder cleaners, two stick machines, and a conveyor distributor that fed the saw gin stands. Each gin stand was followed by one air-type and one or two saw-type lint cleaners. Other ginneries (No. D, E, F, G, and K) were equipped with three seed cotton cleaners and two lint cleaners. The cleaning equipment included two tower dryers, two cylinder cleaners, one stick machine, and a conveyor distributor. Each gin stand was followed by one air-type cleaner and one saw-type lint cleaner. The remaining ginneries (No. A, B, L, and M) were equipped with two seed Cotton cleaners and two lint cleaners. The cleaning equipment included a tower dryer, a cylinder cleaner, a stick machine, and a conveyor distributor. Each gin stand was followed by one air-type and one saw-type lint cleaner. The cylinder cleaners were gravity-fed six-drum inclines with 9.5 mm diameter grids spaced 9.5 mm apart. The inclines were 3.45 m wide and rated at 4348 kg/h per meter per width. The stick machine was gravity fed, with two 0.349 m diameter channel saws and one reclaimer saw. The Little David's were 2.65 m wide and were rated at 5660 kg/h per meter per width. The first tower dryer was set at a 107 °C mix point. The second tower driver was at an ambient temperature. The saw gin was 406 mm in diameter and had 171 saws. The ginning rate ranged from 2200 to

Table 1
Description of the growing locations and cotton cultivars used for testing the effect of hand harvesting on cotton fiber.

Year	Experimental site	Cultivar
2003	Xiayedi, Shihezi	Xinluzao 10, Xinluzao 13, Xinluzao 16
	Mosuowan, Shihezi	Xinluzao 10, Xinluzao 13, Xinluzao 16
2004	Xiayedi, Shihezi	Xinluzao 10, Xinluzao 13, Xinluzao 16
	Mosuowan, Shihezi	Xinluzao 10, Xinluzao 13, Xinluzao 16
2007	Agricultural Experimental Station, Shihezi University	Xinluzao 26
2008	Agricultural Experimental Station, Shihezi University	Xinluzao 10, Xinluzao 12, Xinluzao 13, Xinluzao 16, Xinluzao 24, Xinluzao 33, Xinluzao 36
2009	Agricultural Experimental Station, Shihezi University	Xinluzao 13
	Wulanwusu Agro-meteorological Experiment Station	Xinluzao 33
2010	Agricultural Experimental Station, Shihezi University	Xinluzao 13
	Wulanwusu Agro-meteorological Experiment Station	Xinluzao 33
2011	Regimental Farm 149, the Eighth Division, the Xinjiang	Xinluzao 33, Xinluzao 43
2012	Agricultural Experimental Station, Shihezi University	Xinluzao 33, Xinluzao 45, Xinluzao 46
	Regimental Farm 149, the Eighth Division, the Xinjiang	Xinluzao 45
	Wulanwusu Agro-meteorological Experiment Station	Xinluzao 33
2013	Agricultural Experimental Station, Shihezi University	Xinluzao 33, Xinluzao 45
2014	Agricultural Experimental Station, Shihezi University	Xinluzao 13, Xinluzao 24, Xinluzao 33, Xinluzao 36, Xinluzao 45, Xinluzao 46, Xinluzao 48, Xinluzao 52, Xinluzao 53
	Wulanwusu Agro-meteorological Experiment Station	Xinluzao 48

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