*Journal of Integrative Agriculture 2018, 17(5): 1120–1127*

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RESEARCH ARTICLE

# Fiber damage of machine-harvested cotton before ginning and after lint cleaning

**TIAN Jing-shan[1], ZHANG Xu-yi[1], ZHANG Wang-feng[1], LI Jian-feng[1], YANG Yan-long[1], DONG Heng-yi[2], JIU Xing-li[2], YU Yong-chuan[3], ZHAO Zhan[4], XU Shou-zhen[1], ZUO Wen-qing[1]**

[1] *Key Laboratory of Oasis Eco-Agriculture, Xinjiang Production and Construction Corps/College of Agronomy, Shihezi University, Shihezi 832003, P.R.China*

[2] *Regimental Farm 149, Division Eight, Xinjiang Production and Construction Corps, Changji 832052, P.R.China*

[3] *Regimental Farm 133, Division Eight, Xinjiang Production and Construction Corps, Changji 832064, P.R.China*

[4] *Regimental Farm 12, Division One, Xinjiang Production and Construction Corps, Alaer 843301, P.R.China*

**Abstract**

Machine harvesting increases the foreign matter content of seed cotton. Excessive cleaning causes fiber damage and economic loss. Most trading companies in the Xinjiang Uygur Autonomous Region, China have indicated reluctance to use machine-harvested cotton. The first objective was to determine how the fiber quality was affected by the ginning and lint cleaning and how the fiber damage during levels of lint cleaning changed. The second objective was to determine the optimum number of lint cleaners for machine-harvested cotton based on fiber damage. Cotton samples were collected from 13 fields and processed in seven ginneries between 2013 and 2015. The results indicated that ginning and lint cleaning didn't have significant effect on fiber strength and significantly affected both fiber length and short fiber index. Fiber length was reduced by more than 1.00 mm from six of 13 fields after lint cleaning, then the damage rate on short fiber index from 11 of 13 fields was more than 20%. The third lint cleaning caused great fiber damage, reducing fiber length by 0.35 mm and increasing short fiber index by 0.65%. So, the lint should be cleaned by one lint cleaner in the Xinjiang, however, the stage of lint cleaning was sometimes omitted when the foreign matter content of lint was little.

**Keywords:** Xinjiang, machine-harvested cotton, lint cleaning, foreign matter

## 1. Introduction

Cotton grows well in the Xinjiang Uygur Autonomous Region, China, whose total cotton production was $451\times10^4$ t, that accounting for 73% of China's total in 2014. Increasing labor costs in China have caused the price of hand-harvested cotton to rise, reducing China's competitiveness in the international cotton market (Wang and Du 2006). The use of machine harvesters has increased in recent years in an attempt to reduce cotton production costs. Machine harvesting is a once-over operation, occurring when 85% of

Received 21 June, 2017 Accepted 10 July, 2017
TIAN Jing-shan, E-mail: tjshan1983@sina.com; Correspondence ZHANG Wang-feng, Tel: +86-993-2057326, Fax: +86-993-2057999, E-mail: zhwf_agr@shzu.edu.cn


doi: 10.1016/S2095-3119(17)61730-1

cotton bolls is in open and all of 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). Seed cotton cleaning mainly removes large foreign matter from seed cotton (Anthony *et al*. 1990), while lint cleaning improves lint appearance by removing small foreign matter from lint, including neps, small leaves, seed coats, small sticks, and funiculi (Mangialardi 1992; Boykin *et al*. 2009).

Lint cleaners reduce availably the foreign matter content of machine-harvested cotton while improve high volume instrument (HVI) color grade and leaf grade, but damage fiber (Baker and Brashears 1999; Li *et al*. 2012). Many studies showed that lint cleaners significantly decreased fiber length (Dever and Grannaway 1988; Zurek *et al*. 1999; Li *et al*. 2012; Krifa and Holt 2013; Xu *et al*. 2014) and increased short fiber content (Griffin 1979; Sui *et al*. 2010; Li *et al*. 2012; Xu *et al*. 2014). There are mixed reports about the effect of lint cleaners on fiber strength. Some researchers reported that lint cleaners reduce fiber strength (Xu *et al*. 2014), whereas others reported that lint cleaners increased fiber strength (Ethridge *et al*. 1995) or did not affect on fiber strength (Dever and Grannaway 1988; Krifa and Holt 2013). Fiber maturity is closely associated with fiber damage during lint cleaning. Mature cotton has less potential for fiber damage and is less affected by lint cleaning than immature cotton (Wanjura *et al*. 2012; Krifa and Holt 2013). Many studies were conducted to evaluate the impact of the amounts of lint cleaners. In general, increased amounts of lint cleaners tended to improve HVI color and leaf grade (Gillum and Armijo 1997; Baker and Brashears 1999), however, these consistently decreased net returns (Mangialardi *et al*. 1993; Bennett *et al*. 1997; Nelson *et al*. 1999; Holt *et al*. 2002) and adversely affected fiber quality (Ethridge *et al*. 1995; Baker and Brashears 1999; Whitelock *et al*. 2011; Hughs *et al*. 2013).

From 2008, the area of machine-harvested cotton has increased by about 10% per year in Xinjiang. In 2014, 65% of cotton area was machine-harvested. However, the lint grade of machine-harvested cotton in Xinjiang was more than two grades lower than that of hand-harvested cotton (Wang and Xu 2011; Dong 2013). Fiber quality deterioration had seriously impacted the development of Xinjiang's cotton production. Approximately 60% cotton trading companies and textile factories in the Xinjiang indicated reluctance to buy or use machine-harvested cotton (Zhang *et al*. 2015).

We selected 13 cotton samples from fields that were processed in seven ginneries. The first objective was to determine how the fiber quality was affected by the ginning and lint cleaning and how the fiber damage during levels of lint cleaning changed. The second objective was to determine the optimum number of lint cleaners for machine-harvested cotton based on fiber damage.

## 2. Materials and methods

### 2.1. Sampling

Seed cotton modules for this trial were obtained from prominent growers in five regimental farms in Xinjiang between 2013 and 2015. One to three cotton varieties (each in a separate module) were selected from each farm. The growers had used standard management practices for drop-irrigated upland cotton. The cotton was harvested with either a John Deere 7760 round module harvester (in Division Seven) or a Case IH CXP420 square module harvester (in Division One and Eight). The harvesters were operated according to the manufacturer's instructions. The modules were ginned under standard commercial conditions at one of seven local ginneries. The farm sites, cultivars, ginneries, and seed cotton and lint cleaning stages are described in Table 1.

The gin was equipped with standard drying and seed cotton cleaning equipment, which included tower dryer, cylinder cleaner, stick machine, and conveyor distributor, which fed the saw gin stands, with each gin stand followed by the air-type and saw-type lint cleaners. The tower dryer was set at a 107°C mix point. The saw gin, whose ginning rate ranged from 2 200 to 3 000 kg $h^{-1}$, was 406 mm in diameter and it had 171 saws. Some ginneries (sites C and J) were equipped with one air-type and two saw-type lint cleaners. The others (sites A, B, D, E, F, G, H, I, K, L, and M) were equipped with one air-type cleaner and one saw-type lint cleaner.

The seed cotton was ginned immediately after harvest. Seed cotton samples were continuously collected every 30 s before the saw gin stands and three samples (i.e., replications) were collected. Each replication contained approximately 1 000 g seed cotton. Lint samples were continuously collected every 30 s after each lint cleaners (i.e., after the first, second, or third lint cleaner) and each replication contained approximately 500 g lint. The samples collected in the gin were taken to laboratory. The burrs and sticks were removed from the seed cotton samples, which were then ginned with a minor gin rated at 80 to 100 kg $h^{-1}$. All of the lint samples, which were collected after each lint cleaner and ginning by the minor gin, were weighed, and then 100 g subsamples were removed from each replication to test fiber quality. The remainder of each sample was analyzed to determine the foreign matter content.