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GENETIC CONTRIBUTIONS TO UPLAND COTTON IN CHINA SINCE 1950

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Abstract

Average cotton yield per hectare in China has been increased at a rate of 16.14 kg·ha^{-1}year^{-1} since 1950, to which cotton breeding has made tremendous contributions. The objectives of the present study were to compare the performance of selected cotton cultivars released since the 1950s in order to estimate the genetic gain for lint yield, fiber quality, and other major agronomic traits. The results indicated that the yield gain due to cultivar improvement was 8.75 kg·ha^{-1}year^{-1} for spring-sow cultivars grown in the Yellow River Valley, 8.16 kg·ha^{-1}year^{-1} for spring-sow cultivars grown in the Yangtze River Valley, and 7.92 kg·ha^{-1}year^{-1} for short season cultivars, which accounted for 46-54% of annual yield increase. The increase in yield potential in later released cultivars was attributed to the increase in number of bolls per plant and lint percentage. Furthermore, modern cultivars had improved fiber strength, earliness, and resistance to *Fusarium* wilt and *Verticillium* wilt diseases. However, they were significantly taller with slightly smaller boll, smaller seed, and coarse fiber. No significant improvement in fiber length was detected.

Introduction

In China, there are three ecotypes of cotton cultivars for different cotton growing regions: (1) the northern extra early ecotype, which fits to North (extra early) and North West Inner Land, such as Liaomian and Xiluzao series of cultivars; (2) Yellow River Valley ecotype, such as cultivars developed by China Cotton Research Institute (CRI series), Shandong (Lumian series), Hebei (Jimian series), and Henan (Yumian series) provinces; and (3) Yangtze River Valley ecotype, which adapts inter-cropping and inter-planting with wheat or rape. More than 500 upland cotton cultivars have been developed and released for commercial production in China since 1950. Lint yield has been increased at an average rate of 16.14 kg·ha^{-1}year^{-1} calculated based on the data from the National Bureau of Statistics of China , which was lower than the estimated rate of 21.26 kg·ha^{-1}year^{-1} based on the data from USDA-Foreign Agriculture Service. The average yield increase rate was much higher than that in the United State of America (7.89-8.82 kg·ha^{-1}year^{-1}) and India (4.35-6.42 kg·ha^{-1}year^{-1}) in the same statistic period.

The increase in cotton lint yield involves genetic and non-genetic effects. Genetic improvement has made dramatic impacts on cotton productivity and fiber quality of upland cotton (*Gossypium hirsutum* L.) in China since the 1950s. Many studies on the comparison between obsolete and modern cotton cultivars have been conducted in the U.S. (Bridge and Meredith, 1983; Bridge et al., 1971; Culp and Green, 1992; Meredith et al., 1997; Moser and Percy, 1999; Well and Meredith, 1984a, b, c). However, little work has been reported in the similar area in China (Zhang et al., 1993). Our objectives were, (1) to estimate the rate of genetic gain for lint yield, fiber quality, and other main agronomic traits in the Chinese upland cotton cultivars released from 1949 though 2000, and (2) to determine the changes in yield components associated with the increased lint yield in modern cultivars.

Materials and Methods

Forty-five upland cotton cultivars developed and released between 1949 and 2000 were selected in the present studies. Ten representative cultivars were grown at nine locations in the Yellow River Valley in 1996 and 1997. The cultivars were planted in three or five row plots arranged in a randomized complete block design with four replications. Eleven selected varieties were arranged in the same experimental design at seven locations in the Yangtze River Valley in 2000 and 2001. The other 24 short season upland cotton cultivars were planted at five locations in 2001 and 2002. Stand agricultural practices for the Central-lower Yangtze River Valley sub-region and the Yellow River Valley region were adopted. The following traits were measured: lint yield, lint percentage, number of bolls, boll weight, seed and lint index, fiber length, strength, elongation, uniformity, and Micronaire. At the same time, yield and other agronomic data from the National Cotton Variety Regional Trials in the Yangtze River Valley and Yellow River Valley from 1950 through 2000 were collected and analyzed.

Results

Genetic Improvement in Spring-Sowing Cotton Cultivars Grown in the Yellow River Valley Since the 1950s

The results can be summarized as the following: (1) The current cultivars have the genetic potential to produce higher lint yield than the old ones. The average annual increase in lint yield attributable to the genetic improvement from 1950~1994 was 8.75 kg·ha^{-1}year^{-1}, equivalent to 54.12% of the annual average yield gain during the same period. (2) There was a significant increase in number of boll per plant ant lint percentage, while boll size was slightly decreased over years. However, the relative contributions to yield from the three yield components varied in different periods. (3) There was a significant increase in fiber strength. No significant improvement for fiber length was made, while fiber fineness had been slightly decreased. (4) The negative correlation between lint yield and fiber strength was weakened under the Chinese cotton breeders' selection pressure. (5) Some agronomic characteristics, such as maturity and plant height, had been increased in that the current cultivars have earlier maturity and higher plant height than the obsolete ones. However, the seed index remains at the same level as the old ones. (6) Significant differences among these cotton varieties in both stability and disease resistance were noted in that newly developed cultivars were high yielding, stable and disease resistant.

Genetic Improvement in Spring-Sowing Cotton Cultivars Grown in the Yangtze River Valley Since the 1950s

In the Yangtze River Valley, the yield gain due to the genetic improvement averaged at the rate of 8.16 kg·ha^{-1}year^{-1} since 1950, equivalent to 46.53% of the average annual yield increase during the same period. Genotype and genotype-environment interaction contributed 41.5% and 21.5% to the yield gain, respectively. In comparison with old cultivars, the current cultivars increased lint yield by 23.83%, number of bolls by 3.1 per plant, and lint percentage by 2.49%. However, the boll size in the current cultivars was decreased by 0.36g per boll. The yield increase in the current varieties was mainly accounted by the improvements of bolls per plant and lint percentage. No change was detected in fiber length, while fiber fineness showed a slight decrease trend. Fiber strength in the current cultivars was increased by 1.56cN/tex. Maturity in the current cultivars was shortened by 2 days. The current cultivars had increased plant height by 6-12cm. The current cultivars had slightly reduced seed index. The direct correlation between bolls per plant and yield had a down trend, while the direct correlation between Micronaire and yield increased. Disease index of *Fusussium* wilt and *Verticillum* wilt in the cultivars released in 1998 was decreased by 3.1 and 11.89, respectively, compared with that in cultivars released in 1987. The improvement in yield stability for the current cotton cultivars was not significant.

Genetic Improvement in Short Season Upland Cotton in China Since the 1950s

Short season upland cotton plays an important role in the cultivation reform of cotton in China. Twenty four obsolete short season upland cotton cultivars and 4 current commercial cultivars were evaluated for lint yield, other main agronomic characteristics, earliness, and fiber properties over a 2-year period. The current commercial cultivars had 396.0kg/ha higher in mean lint yield than the obsolete ones grown in the 1950's, with the yield gain of 7.92 kg·ha^{-1}year^{-}. The increased yield potential was accompanied by higher lint percentage, higher lint index, lower seed index, and higher fiber strength. The increase in lint percentage played a major role in the yield gain. The cultivars currently grown were better in fiber qualities than the old early maturing ones, but they are still inferior to the spring sown cultivars. Even though the progress in improving fiber properties has not been as rapid as that made for lint yield, the current short season cultivars has obtained resistance to *Fususium* wilt, and the resistance to *Verticillum* wilt has also been improved. The maturity had been further shortened by 2.5 days due to the reduction in the reproductive stage.

The genetic diversity analysis based DNA molecular marker technologies (RAPDs and SSRs) revealed that polymorphism among the short season upland cotton cultivars was limited. Among 900 random 10-mer primers screened on 29 cultivars, only 122 primers (13.6%) amplified polymorphic fragments. Among 302 pairs of SSR primers, only 41 primers (13.6%) produced polymorphism. The genealogical classification of more than two hundred cultivars and breeding lines proved that the King was the main earliness gene pool in genetic improvement of the short-season upland cotton in China in the past fifty years.

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Table 1. Comparative lint yield gain in different decades.

	Decades							
Countries	**1950s**	**1960s**	**1970s**	**1980s**	**1990s**	**2000s**	**Average**	**Data Source**
China	16.47[a]	21.01	1.65	25.60	-14.40	/	16.14	Liu(1995)
	0.752[b]	*0.791*	*0.018*	*0.396*	*0.087*	/	*0.881*	
	16.02	35.36	1.55	25.66	31.96	42.00	17.40	NBSC(2002)
	0.749	*0.855*	*0.016*	*0.403*	*0.610*	*0.871*	*0.906*	
	/	/	1.17	25.95	32.55	-37.91	21.26	USDA-FAS(2003)
	/	/	0.009	0.400	0.617	0.240	0.843	
USA	27.01	1.07	5.18	21.50	-2.60	/	7.89	Liu(1995)
	0.920	*0.006*	*0.100*	*0.508*	*0.012*	/	*0.734*	
	/	/	5.14	21.50	-2.99	25.78	8.82	USDA-FAS(2003)
	/	/	*0.098*	*0.508*	*0.022*	*0.538*	*0.672*	
India	0.21	0.49	3.75	12.92	7.80	/	4.35	Liu(1995)
	0.005	*0.024*	*0.639*	*0.695*	*0.411*	/	*0.801*	
	/	/	3.14	13.32	4.01	12.44	6.42	USDA-FAS(2003)
	/	/	*0.461*	*0.747*	*0.333*	*0.814*	*0.874*	
Global	9.04	6.51	1.74	16.41	-4.30	/	7.82	Liu(1995)
	0.930	*0.723*	*0.088*	*0.800*	*0.087*	/	*0.941*	

Note: [a]: Average lint yield gain (kg) per ha per year, [b]: Value of R^2;
NBSC: National Bureau of Statistics of China; USDA-FAS: USDA-Foreign Agriculture Service.

Table 2. Genetic contributions to upland cotton in China since the 1950s.

Region	**Ecotype**	**Genetic Contribution $kg \cdot ha^{-1} year^{-1}$**
Yangtze River Valley	Spring-sowing	8.16
Yellow River Valley	Spring-sowing	8.75
Yangtze and Yellow River Valleys	Short season	7.92
Average		8.28

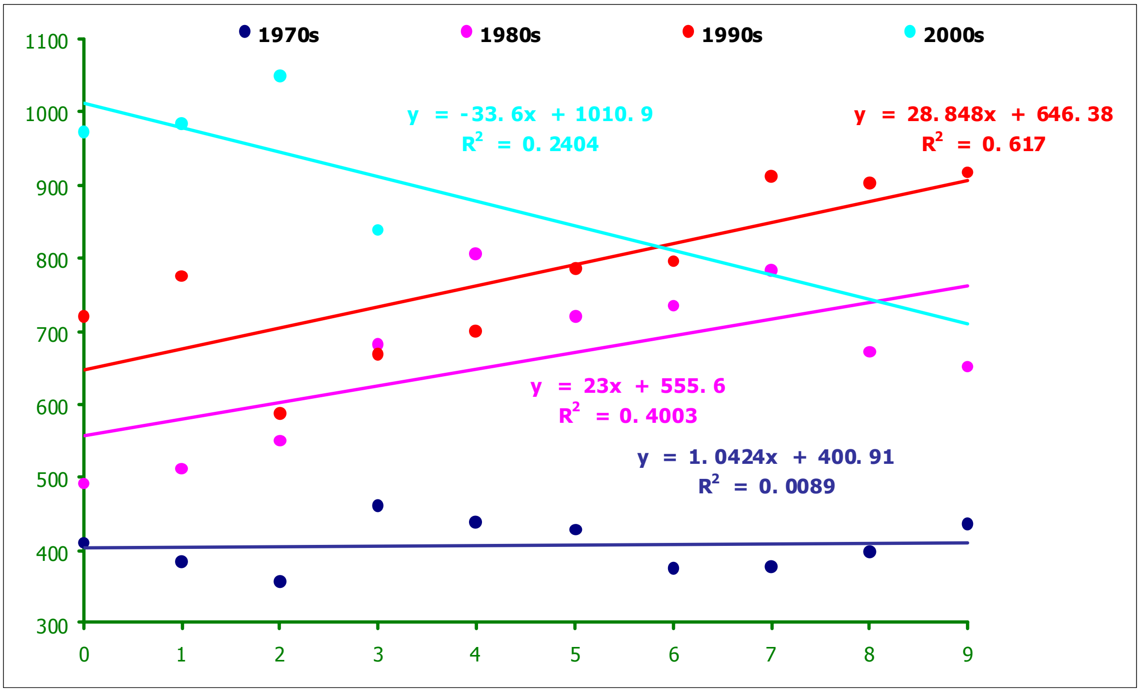

Figure 1. Lint yield per hectare in different decades in China in the past 30 years.

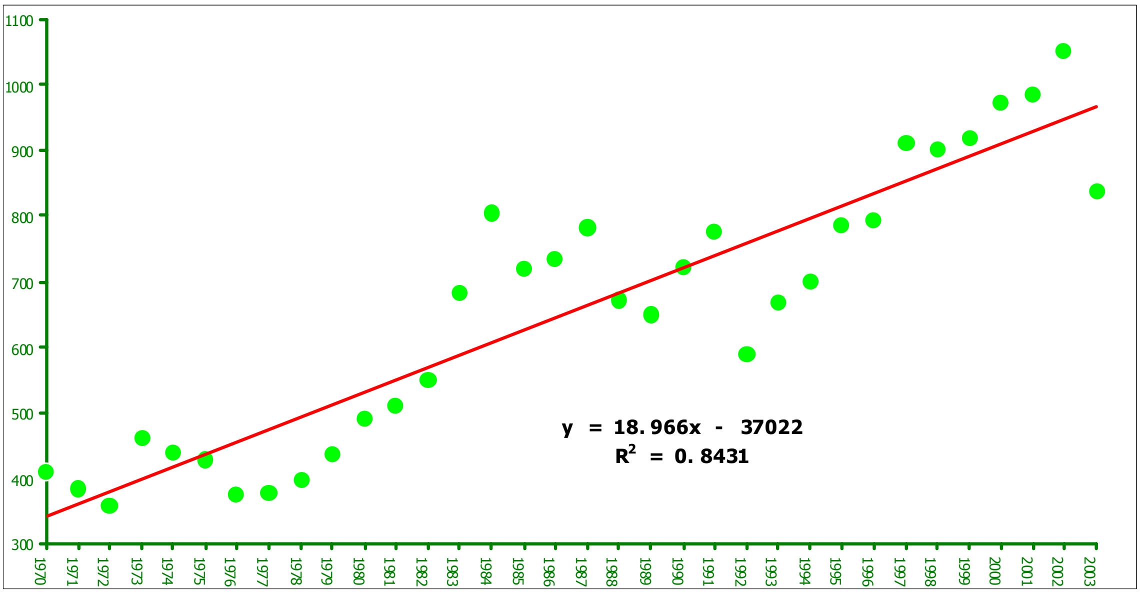

Figure 2. Lint yield per hectare changes in China during 1970 and 2003.