The Effect of the Different Transgenic *BT* Cotton Technology on the Fiber Quality

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Abstract: Transgenic crops that contain *Cry* genes from *B. thuringiensis* (*Bt*) were commercialized in many countries and widely adopted by farmers over the last 17 years. The cultivation of transgenic crops expressing *B. thuringiensis* (*Bt*) toxins to control insect pests provides both economical and environmental benefits from reductions in chemical insecticide use, effective control of pests and minimal impact on non-target organisms. The objective of this research was to know the effect of different transgenic *Bt* cotton on the fiber quality of different *Bt* cotton varieties. Three transgenic *Bt* cotton varieties CCR141, CCRI79 and Bollgard II were planted in the field of Institute of Cotton Research Chinese Academy of Agricultural Sciences during 2012 and 2013. Randomly 50 bolls lint sample were collected from top, middle and bottom of the cotton plants. The fiber obtained from the boll samples was used to measure the cotton fiber staple length (mm), staple elongation (%), staple micronaire value, staple strength (cN/tex) and staple uniformity (%) by using HVI equipment at Supervision, Inspection and Testing Center of cotton Quality, China. The result shows that lint quality characters of transgenic cotton varieties were not significantly affected compared with conventional non *Bt* variety during 2012 and 2013 but fiber strength is significantly affected during 2013. In conclusion there was no effect of transgenic *Bt* cotton on the fiber quality of cotton during 2012 and 2013.

Keywords: Transgenic *Bt* cotton, Lint quality, Fiber characters, Cry gene.

INTRODUCTION

Many farmers have been widely adopted to cultivate transgenic crops that have Cry genes from *B. thuringiensis* (*Bt*) in many countries more than the last 17 years. A number of research proved that *Bt* crops are not only resistant to lepidopteran and coleopteran insect pest, but also helped to decrease the use of pesticide and boost up the yield [1-7]. The transgenic crops expressing *B. thuringiensis* also provide economical and environmental benefits by reducing the use of insecticide [8, 9], effectual control of pests and negligible effect on beneficial organisms [10]. It was also revealed that *Bt* cotton contributed to lessen the poverty and broader the rural area development in India and Pakistan [11, 12].

In 2014, India cultivated *Bt* cotton over 11.6 million hectares from 11.0 million hectares in 2013 with an adoption rate of 95%, by 7.7 million small farmers. Remarkably, the boost up of *Bt* cotton from 50,000 hectares in 2002 to 11.6 million hectares in 2014, represented an extraordinary increase (230-fold) in thirteen years. Brookes and Barfoot's newest provisional estimate report indicated that in the twelve year era i.e., 2002 to 2013, the farm income of India had improved from cultivation of *Bt* cotton by US$16.7 billion and US$2.1 billion in 2013 in comparison to 2012 [13].

The attractiveness of transgenic cotton varieties is due to management of insect pest and additional options in control of grass and weed. An examination from safety point of view indicates that transgenic cotton does not pretense any risks to human and animal health. Moreover, there are no undesirable effects on the environment than conventional cotton [14, 15]. Nevertheless, the questions arise at the same time that weather the fiber quality is affected by transgenic technology or not. The objective of this research was to know the effect of different transgenic *Bt* cotton on the fiber quality of different *Bt* cotton varieties.

MATERIAL AND METHODS

Cotton Varieties

Three *Bt* cotton varieties CCRI 79(Cry1Ac), CCRI 41(Cry1Ac+CpTI), US cotton 639020 Bollgard II(Cry1Ac+Cry2Ab) and one non *Bt* variety CCRI 49 were planted in a Completely Randomized Block Design with three replications in the field of China Institute of Cotton Research, Chinese Academy of Agricultural Sciences, Anyang, Henan Province, China during early May 2012 and 2013. CCRI 49 variety is

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the general non *Bt* variety which is mostly planted in China. Fertilization rates and general agronomic practices were followed according to the recommended doses.

Collection of Samples

Prior to harvest, we handpicked a random 50-boll sample from top, middle and bottom of the three replications at each plot. These samples were weighed and then ginned on a 10-saw laboratory gin. The fiber obtained from the boll samples was analyzed at Supervision, Inspection and Testing Center of cotton Quality, Ministry of Agriculture, Anyang, Henan Province China for measuring the cotton fiber staple length (mm), staple elongation (%), staple micronaire value, staple strength (cN/tex) and staple uniformity (%) by using HVI equipment. Analysis of Variance (ANOVA) was done for all the transgenic *Bt* fiber tests, each having five replicates compared with the control. Least Significant Difference (LSD) of fiber was compared at 5% level of significance to know that they were statistically significant or not by using Statistix 8.1.

RESULTS

Effect of *Bt* Cotton on Lint Quality Characters during 2012

Lint quality characters of different transgenic cotton varieties were not significantly affected compared with conventional non *Bt* variety. The Staple Length of transgenic varieties were not significantly different (F=1.15; DF=3:12; P=0.3694) from conventional non *Bt* variety. Among all *Bt* cotton, the staple length ranges from 29 to 31 mm. The reduction % in staple length was maximum (4.26%) in CCRI 41. Staple Elongation of different transgenic varieties was also not significantly different from conventional varieties (F=1.46, DF= 3:12, P=0.2748). However staple elongation of Bollgard II was slightly greater (6.6%) than conventional variety. The reduction in staple elongation was greater in CCRI 79 variety (1.87%) followed by Bollgard II (1.06) and CCRI 41 (0.46%). Although micronaire values of all the transgenic and conventional varieties were less than 5.0 but the micronaire value of Bollgard II was the highest in the test (4.95) followed by CCRI 79 (4.82), CCRI 41 (4.74) and Non *BT* CCRI 49 (4.73). Micronaire value of all the varieties was not significantly different from each other (F= 0.53, DF= 3:12, P=0.6674). The micronaire value of transgenic varieties was slightly greater than conventional non *Bt* variety. The staple strength of cotton fiber indicate that there was no significant effect of transgenic cotton on fiber strength (F=1.63, DF= 3:12, P=0.235). The fiber strength remained between 29-32 CN/tex. The transgenic cotton varieties showed reduction in staple strength compared with conventional Non *Bt* variety. This reduction was greater in CCRI 41 (7.34%) followed by Bollgard II (5.18%) and lower in Cry 1 Ac (3.69%). Fiber uniformity varied between 83 to 85% but not significant (F=2.09, DF= 3:12, P=0.1552). Transgenic cotton varieties showed reduction in staple uniformity compared with conventional non *Bt* variety. The maximum reduction in fiber uniformity was recorded in Bollgard II (1.66%) followed by CCRI 41 (1.23%) and CCRI 79 (0.43%).

Effect of *Bt* Cotton on Lint Quality Characters during 2013

During 2013, the cotton fiber quality characters again tested to know the effect of different transgenic Bt cotton on the lint. Lint quality characters of transgenic cotton varieties were not significantly different with conventional non *Bt* variety except fiber strength. The Staple Length of transgenic varieties ranges 28 to 31 mm were not significantly different (F=40.09; DF=3:12; P=0.297) from conventional non *Bt* variety CCRI 49. The reduction% in staple length was maximum in CCRI 79 (6.6%), CCRI 41 (5.6) and in Bollgard II (5.3%). Staple Elongation of different transgenic varieties was also not significantly different from conventional varieties (F=16.37, DF= 3:12, P=0.373). However staple elongation of CCRI 79 was slightly greater (6.46%) than conventional variety. The reduction in staple elongation in CCRI 41 variety was (-1.1%), CCRI 79 (-3.69%) and in Bollgard II (0%). The micronaire values of all the transgenic Bt cotton was more than 5 and conventional varieties were less than 5.0. The micronaire value of Bollgard II was the highest in the test (5.7) followed by CCRI 79 (5.4), CCRI 41 (5.33) and Non *Bt* CCRI 49 (4.57). Micronaire value of all the varieties was not significantly different from each other (F= 228.73, DF= 3:12, P=0.685). The staple strength of cotton fiber indicate that there was significant effect of transgenic cotton on fiber strength (F=37.75 DF= 3:12, P=0.0003). The fiber strength remained between 26-32 CN/tex. The transgenic cotton varieties showed reduction in staple strength compared with conventional non Bt variety. This reduction was greater in CCRI 79 (15.00%) followed by CCRI 41 (11.01%) and lower in Bollgard II (5.23%). Fiber uniformity varied between 84 to 86% but not significant (F=3.71, DF= 3:12, P=0.0806). Transgenic cotton varieties showed reduction in staple uniformity

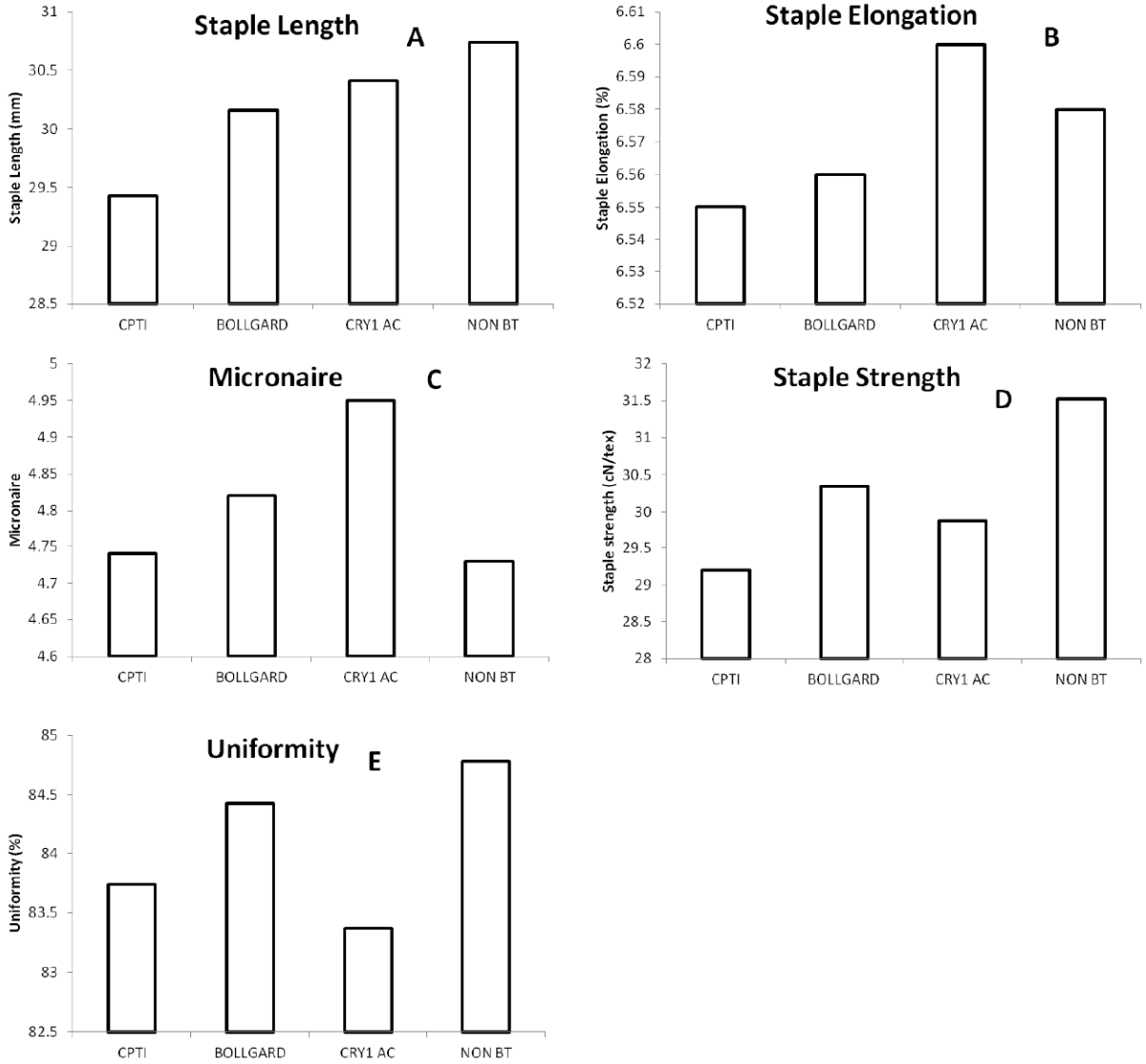

Figure 1: Transgenic *Bt* cotton varieties comparison of Mean (**A**) Staple length, (**B**) Staple elongation, (**C**) Micronaire value, (**D**) Staple strength and (**E**) Staple uniformity during 2012.

compared with conventional non *Bt* variety. Maximum reduction %of fiber uniformity was recorded in CCRI 79 (1.88%) and CCRI 49 (0.50% and in Bollgard II (0.73%).

DISCUSSION

The main object of this study was to know the effect of different *Bt* cotton on the fiber quality. The ANOVA result showed that there was no significant effect of transgenic *Bt* cotton on the fiber quality of cotton during 2012 and 2013. However the strength of cotton fiber is significant in 2013. The quality of transgenic cotton fiber was not affected due to the presence of *Bt* as compared with non *Bt* cotton [16]. After extensive studies of transgenic cotton with their parents Ethridge and Hequet [17] reported that micronaire, yellowness, leaf grade, length uniformity, strength and elongation showed no major differences due to *Bt*. Those fiber lint quality parameter which were statistically significant was only reflectance; there was minor enhance in reflectance among different transgenic varieties. Ethridge and Hequet also concluded that consequence for reflectance is statistically significant, but the small variation in fiber is not important from textile point of view. Cooke *et al.* [18] reported after four years research that there were no significant differences in grade and staple length between *Bt* and non *Bt* cotton varieties. Creech [19] collected data from twenty non *Bt* varieties and twenty *Bt* varieties for comparison of yields and fiber quality. Creech reported that non *Bt* varieties exhibited minor changes in length and uniformity whereas transgenic varieties were to some extent better in micronaire. Non *Bt* varieties had about

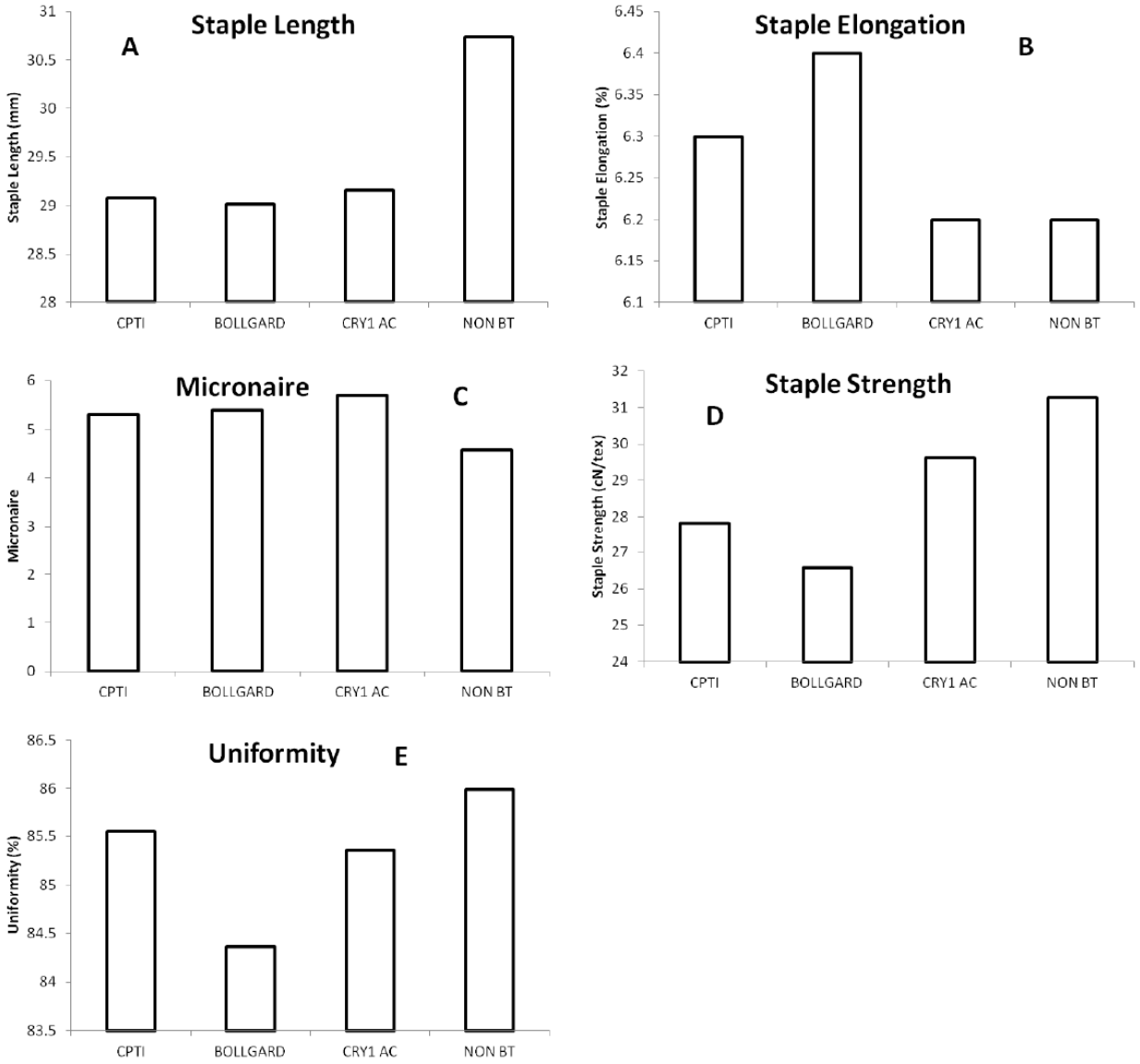

Figure 2: Transgenic *Bt* cotton varieties comparison of Mean (**A**) Staple length, (**B**) Staple elongation, (**C**) Micronaire value, (**D**) Staple strength and (**E**) Staple uniformity during 2013.

4% higher strength. Creech also tested a BxN variant with parent. The result showed there was slightly longer micronaire and higher strength. The differences are slight and not considered a useful difference. Culpepper and York [20] repotted after two-year trials that fiber quality parameters were not affected. Jordan *et al.,* [21] reported that there were no effects on staple length and strength but micronaire was decreased up to 3% in the *Bt* cotton. Many basic molecular mechanisms about cotton fiber enlargement stay to be further investigated [22].

Cotton quality is influenced by both ecological situations and genetics. Numerous other factors like environment, climate, water, soil, etc., have effects on the fiber quality. However, region to region, variety, environmental conditions can affect the staple length. Ginning and cleaning of lint can also decrease length if moisture level of lint is below 5%. Highest fiber length may possibly be achieved by moderate temperatures during the fiber elongation phase but length can be decreased by maximum temperatures, severe water stress, and potassium insufficiency (www.cotton.pi.csiro.au/). Growing conditions also affect on growth and maturity of the crop which ultimately affect fiber thickening and micronaire. Deficiency of carbohydrate results in low down micronaire while sufficient carbohydrate outcome in high micronaire. The best solution to obtain better fiber quality is to carry on breeding efforts aimed to producing cultivars with superior fiber properties. Recent advances show that biological processes associated with fiber development

stages which led to the recognition of genes which are up-regulated in fiber, during the developmental period [23].

CONCLUSION

There were no significant effects of transgenic *Bt* cotton on the fiber quality of different transgenic *Bt* cotton. In conclusion further research work will be done to know the effect of transgenic *Bt* cotton on fiber qualities.

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