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RESEARCH ARTICLE

Developmental and hormonal regulation of fiber quality in two natural-colored cotton cultivars

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Abstract

Cotton cultivars with brown (Xiangcaimian 2), green (Wanmian 39) and white (Sumian 9) fiber were investigated to study fiber developmental characteristics of natural-colored cotton and the effect of hormones on fiber quality at different stages after anthesis. Fiber lengths of both natural-colored cottons were lower than the white-fibered control, with brown-fibered cotton longer than green. Fiber strength, micronaire and maturation of natural-colored cotton were also lower than the control. The shorter fiber of the green cultivar was due to slower growth during 10 to 30 days post-anthesis (DPA). Likewise, the lower fiber strength, micronaire and maturation of natured-colored cotton were also due to slower growth during this pivotal stage. Indole-3-acetic acid (IAA) content at 10 DPA, and abscisic acid (ABA) content at 30 to 40 DPA were lower in the fibers of the natural-colored than that of the white-fibered cotton. After applying 20 mg L^{-1} gibberellic acid (GA_3), the IAA content at 20 DPA in the brown and green-fibered cottons increased by 51.07 and 64.33%, fiber ABA content increased by 38.96 and 24.40%, and fiber length increased by 8.13 and 13.96%, respectively. Fiber strength, micronaire and maturation were also enhanced at boll opening stage. Those results suggest that the level of endogenous hormones affect fiber quality. Application of external hormones can increase hormone content in natural-colored cotton fiber, improving its quality.

Keywords: natural-colored cotton, fiber development, fiber quality improving

1. Introduction

Natural-colored cotton, with natural pigment in the fiber, has no need of dyeing and bleaching during fiber processing (Kohel 1985), making it eco-friendly and favored by environment-conscious people (Kimmel and Day 2001; Tan and Zhou 2015). So it is very valuable to enlarge the planting area of the natural colored cotton (Zhu *et al*. 2006).

Natural-colored cotton cultivars have been bred *via* the integration of biotechnology and traditional technology. Green and brown natural-colored cotton cultivars are

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currently grown by farmers to a limited degree. However, widespread commercialization of natural-colored cotton has been restricted due to its inferior fiber quality relative to standard white-fibered cotton (Zhan *et al*. 2006; Matusiak and Frydrych 2014) and lower lint yield (Qian *et al*. 2015). In the last several decades, people have paid more attention than in the past to brightness and color stability, and to methods of enhancing fiber quality through genetic improvement of natural-colored cotton (Dutt *et al*. 2004; Matusiak and Frydrych 2014; Cuming 2015). However, the differences in fiber development characteristics between natural-colored and white cotton are not clear. There are many fiber quality indexes, such as fiber length, fiber strength, fiber micronaire, and fiber maturation. They codetermined the final fiber quality. Textile enterprises have different requirements for different fiber quality indexes. For example, the fiber with higher fiber strength is better, but with optimization fiber micronaire is more favored by consumers. The past researches have concluded that the development of these fiber quality indexes is different. Fiber length usually is determined about from 0 to 30 days post-anthesis (DPA). The development of fiber strength is about from 30 DPA to boll opening stage. There are many descriptive works on white cotton (Wendy *et al*. 2001; Ruan 2005), but considerably less information on the characteristics of natural-colored cotton. Thus, a comparative analysis of characteristics of fiber development may provide insight into differences in fiber qualities between natural-colored and white cottons, and lead to improved colored cotton. That results also can help us to study when and how to improve fiber quality indexes depend on the textile enterprises' requirement.

The past researches have pointed out that endogenous hormone played very important roles in increasing fiber development. Some kinds of hormone can improve the final fiber quality (Zhang *et al*. 2012). For example, IAA could increase the fiber length, but it had negative effects on fiber strength. But there are few reports on the differences of hormone content in fiber between natural colored and white cotton. Regulation of fiber development in natural-colored cotton is also not clear. Exogenous hormone applications can influence white cotton development and fiber quality (Copur *et al*. 2010). Gibberellic acid (GA_3) application improved fiber elongation, increased fiber cell wall thickness and increased the weight of individual fibers of white cotton (Dixon 1993; Guo and Xu 1993). In addition, foliar application of abscisic acid can improve fiber quality in insect-resistant cotton (Zhang and Li 2004). In the natural colored cotton, there are some investigations about improving fiber quality of natural-colored cotton by regulation of its physiology and exogenous hormone application. The application of the exogenous hormone also could be beneficial to increase the value of fiber quality indexes (Zhang *et al*. 2009). Fiber quality for white and natural colored cotton could be improved by application phosphorus, but their response was different (Song 2015). However, they didn't illustrate how to improve different indexes of fiber quality for natural colored cotton respectively. Currently, there is no systematic and comprehensive coverage on improving fiber quality for colored cotton.

Thus, clarifying characteristics of fiber quality and their hormone regulation may guide adoption of appropriate agronomic practices to improve fiber quality in natural-colored cotton. In this study, characteristics of fiber quality development among different cotton cultivars, the dynamics of endogenous hormone levels in fiber, and the influence of exogenous hormones on different indexes of fiber quality were investigated in natural brown cotton, natural green cotton and standard white cotton. Spraying with hormones improved the fiber quality of natural-colored cotton. Elucidating the effects of endogenous and exogenous hormones on fiber quality guides practical applications, utilizing hormones to improve different indexes of fiber quality for natural-colored cotton.

2. Materials and methods

2.1. Field experiments

The experiment was conducted at the Yangzhou University Farm, Jiangsu Province, China (32°30´N, 119°25´E), during the 2009 and 2010 growing seasons (April–November). Cotton (*Gossypium hirsutum*) cultivars included a brown fibered cultivar, Xiangcaimian 2 (XM2); a green fibered cultivar, Wanmian 39 (WM39) and a standard white-fibered cotton cultivar as control, Sumian 9 (SM9). Seeds of the three cotton cultivars were planted in a warm room and covered with plastic film. The sowing date was April 5th in both years. Seedlings were transplanted to the field on May 16th at 0.75 m row spacing and 0.30 m plant distance. The soil type was a sandy loam (typical fluvaquents, Entisols (U.S. taxonomy)), which contained 24.5 g kg^{-1} organic matter, 108 mg kg^{-1} available N, 40.5 mg kg^{-1} available P, and 82.0 mg kg^{-1} available K. The three cultivars flowered on July 6th through July 8th, and the bolls opened after August 27th. Cultivation practices, including irrigation and application of fertilizers and insecticides, were consistent with standard practices for the region.

In 2009, XM2, WM39 and SM9 were selected in this experiment. The experiment was arranged in a randomized complete block design (the cultivar as factors) with three replications. Each plot was 7.5×6.0 m^2. In order to collect samples of cotton fiber at different developmental stages, white flowers on the first and second fruiting nodes on July