Proceedings of the 7th International Conference on Functional-Structural Plant Models, Saariselkä, Finland, 9 - 14 June 2013. Eds. Risto Sievänen, Eero Nikinmaa, Christophe Godin, Anna Lintunen & Pekka Nygren. http://www.metla.fi/fspm2013/proceedings. ISBN 978-951-651-408-9.

Cotton fiber quality determined by fruit position, temperature and management

Xuejiao Wang[1], Jochem B. Evers[2], Lizhen Zhang[1]*, Lili Mao[3], Xuebiao Pan[1], Zhaohu Li[3]
[1]College of Resources and Environmental Sciences, PO Box 10,0193 China Agricultural University, China
[2]Centre for Crop Systems Analysis, PO Box 430 Wageningen University, The Netherlands
[3]College of Agronomy and Biotechnology, PO Box 10,0193 China Agricultural University, China
**correspondence: zhanglizhen@cau.edu.cn*

Highlights: CottonXL is a tool to explore cotton fiber quality in relation to fruit position, to improve cotton quality by optimizing cotton plant structure, as well as to help farmers understand how the structure of the cotton plant determines crop growth and quality.

Keywords: Cotton development, fiber length, fiber strength, micronaire, simulation model

INTRODUCTION

Cotton fiber quality is a critical factor determining fiber price and the quality of textile products. Fiber quality is measured mainly as fiber length, strength and micronaire (fineness). The textile industry has a preference for longer, stronger and moderate micronaire for producing high quality yards (Mishra et al. 2001). The quality of cotton fiber results from an interaction between environmental (Yeates et al. 2010), genetic (Richard et al. 2006) and management factors (Girma et al. 2007), determined by the position of and the resources obtained by each fruit. Cotton fiber quality shows a significant spatial distribution in China.

Fiber growth and development of single fruits is informative. However cotton fiber quality for all fruits depending on their position in the plant in relation to environmental factors (e.g. temperature, sowing date, pruning management, and the interaction with genetics) have not been addressed well quantitatively, due to the structural complexity of the cotton plant. The objective of this study was to quantify cotton fiber quality in response to sowing date, cut-out (removal of the shoot tip), and environment, using a functional-structural plant model (FSPM) of cotton development.

SIMULATIONS

Simulation of cotton fiber quality was implemented in CottonXL (Gu et al. 2013, this conference) by extending fruit development with routines for fiber length, strength and micronaire of each fruit. For simulation of fiber quality, the potential increase of fiber length, strength and micronaire was developed and calibrated based on field experiments. The effects of environmental factors such as daily average temperature, and the difference between maximum and minimum temperature was derived from literature.

Field experiments were conducted in 2005, 2007 and 2009 in Yangtze River region of China with different sowing dates. Potential fiber quality of cotton for single fruits was developed by using above field experiments (Fig.1). The actual increase of fiber quality was calculated by multiplying with effects of temperature.

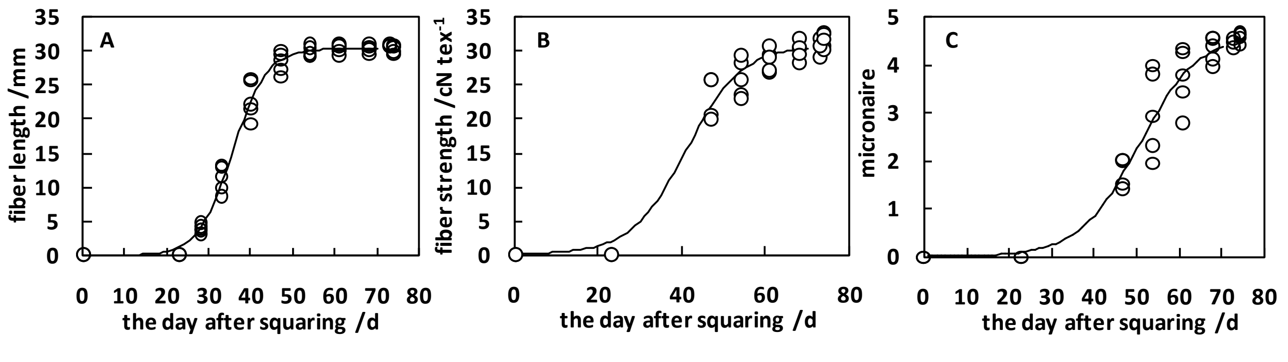

Fig.1 Relationship between fiber length (A), strength (B), micronaire (C) and fruit age in cotton

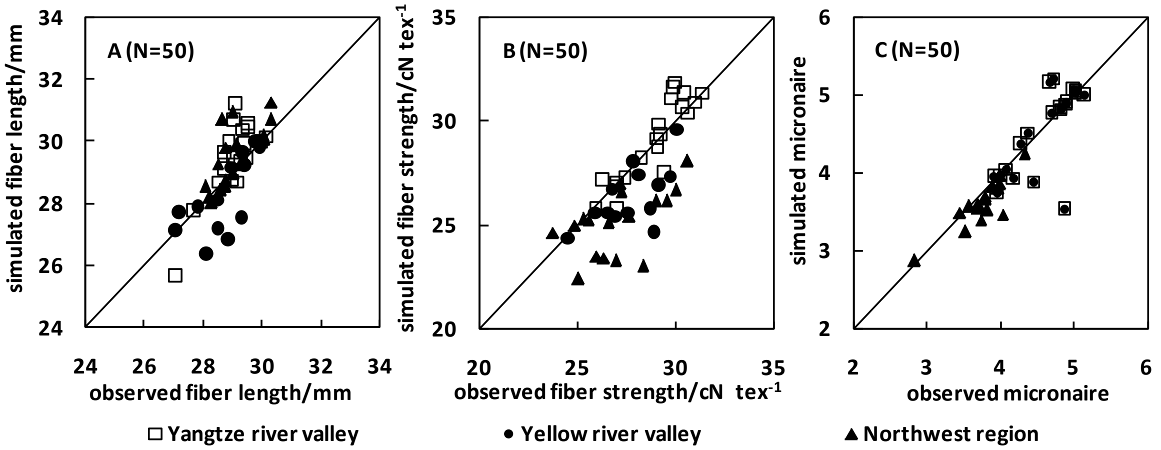

Fig.2 Comparison of observed and simulated cotton fiber length (A), strength (B) and micronaire (C)

The national-wide survey of cotton fiber quality in three cotton producing regions in China were used for model validation (Fig.2). The RMSEs between the simulated and observed values of fiber length, strength and micronaire were 1.26 mm, 2.18cN tex^{-1}, and 0.28. The REs between the simulated and observed values of fiber length, strength and micronaire were 4.45%, 7.78% and 6.8%.

The scenarios used to address the objectives included three locations at Xinjiang, Yellow River region and Yangtze River region, five sowing dates, six cut-out dates, removal versus maintenance of vegetative branches. Distribution of fiber length, strength and micronaire within the cotton crop was expressed visually as well as against cumulative phytomer rank (CPN), which is the phytomer rank of a fruit counted from the bottom of the plant.

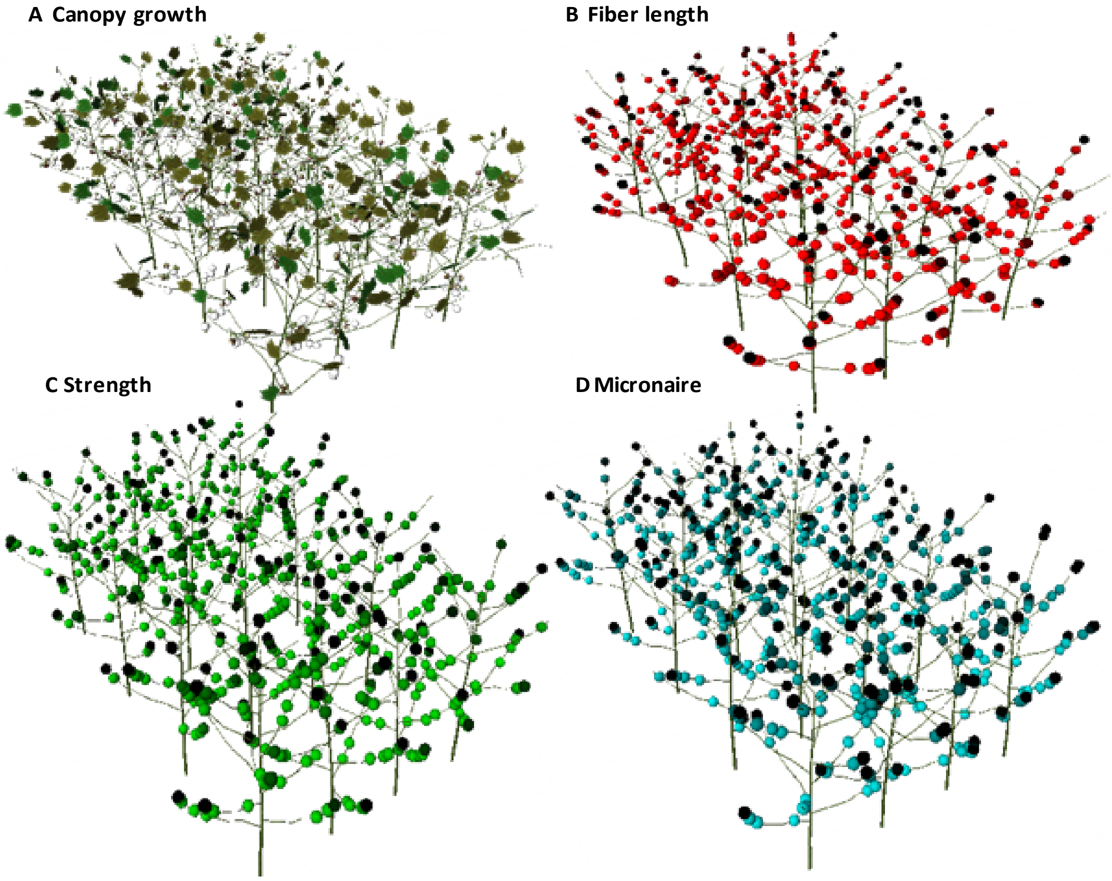

Fig.3 Output of CottonXL for canopy development (A), fiber length (B), strength (C) and micronaire (D). The scenario shown here is fort Anyang in 2002, mepiquat chloride applied, top cut at 30 July and side cut at 30 August, at a population density of 3.6 plants m^{-2}

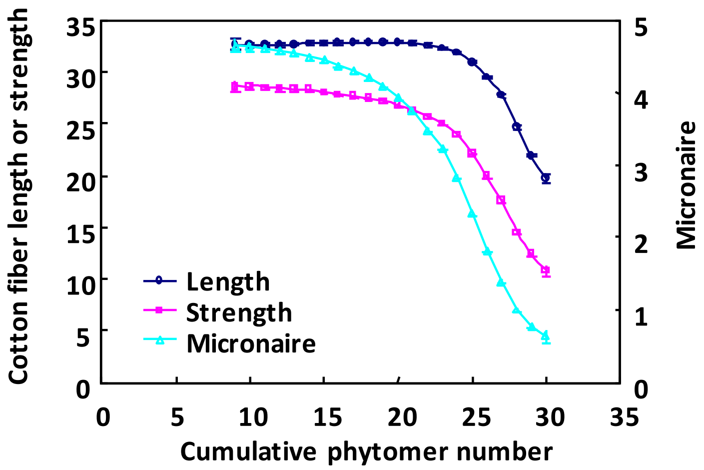

Fig.4 Cotton fiber length (mm), strength (cN tex^{-1}) and micronaire versus different cumulative phytomer number

RESULTS AND DISCUSSION

The model simulated the 3D distribution of fiber length, strength and micronaire according to their age, position in the canopy and prevailing temperature during development (Fig. 3). Fruits at CPN lower than 20 had similar values for fiber quality. Fruits developed at higher ranks, especially above CPN values of 25, had very low fiber quality (Fig. 4).

Cotton fiber quality responded to ecological zone, temperature and agronomical practices (not shown), e.g. sowing date and pruning time (cut-out date). CottonXL is a useful tool to explore cotton fiber quality related to fruit positions and improve cotton quality by optimizing plant structure, as well as to help farmers understand how the plant structure determines crop growth and quality. Forthcoming publications will present model validation and detailed scenario analyses.

LITERATURE CITED

Campbell B T, Jones M A. 2005. Assessment of genotype × environment interactions for yield and fiber quality in cotton performance trials. *Euphytica,* **144:** 69-78.

Girma K, Teal R K, Freeman K W, Boman R K, Raun W R. 2007. Cotton lint yield and quality as affected by applications of N, P, and K fertilizers. *The Journal of Cotton Science,* **11:** 12-19.

Mishra R, Yadav N R, Wilkin T A. 2001. Manipulation of fiber quality in transgenic cotton via ectopic expression of fibre gene. *In, Proceedings of Beltwide Cotton Conference,* 1437-1439.

Richard G P, Roy G C, Jinfa Z. 2006. Genetic variation for agronomic and fiber properties in an introgressed recombinant inbred population of cotton. *Crop Science,* **46:** 1311-1317.

Yeates S J, Constable G A, McCumstie T. 2010. Irrigated cotton in the tropical dry season. III: Impact of temperature, cultivar and sowing date on fibre quality. *Field Crops Research,* **116:** 300-307.