

Genetics of Fibre Elongation in Diploid Cotton

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ABSTRACT

Genetics of fibre elongation in diploid cotton was studied during 2015-16 at University of Agricultural Sciences Dharwad. Segregating population (F₂) of the cross between, Fuzzy linted (FL) x Fuzzy-lintless (Fl) of diploid cotton were evaluated to study the genetics of fibre elongation. The segregation was in the ratio 15(linted): 1(lintless) to indicating duplicate dominant gene action and lintless trait is controlled by double recessive genes. Scanning electron microscopy (SEM) at fibre initiation stage i.e., two days post anthesis (2 DPA) to observe the development of fibre initials on epidermal layer of ovules, revealed the presence of fibre cell initials in both FL and Fl line; however the fibre initials in Fuzzy-lintless (Fl) line did not elongate to become lint, unlike FL, where part of initials elongated into lint (fibre) cell.

Keywords

Fiber initiation, Fibre elongation, Fuzzy.

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Introduction

Cotton is most important textile fibre crop of India and world. Cotton fibres are unicellular trichomes originating from the outer epidermal layer of the seed coat. About 20 to 25 % of the seed epidermal cells differentiate into spinnable fibres (Arpat *et al.*, 2004; Wilkins *et al.*, 2005; Hee *et al.*, 2001; Stewart, 1975). Fibre development includes four distinct, but overlapping stages namely initiation, elongation/primary cell wall (PCW) synthesis, secondary cell wall (SCW) synthesis and maturation. The lint fibers initiate growth between anthesis and 2 days post anthesis (DPA) and can elongate 2.5–3.5 cm. Whereas, the fuzz fibers initiate growth between 5 and 10 DPA and are approximately 0.5 cm (Stewart, 1975). However, fast

elongation of fibre cell occurs between 5 to 15 DPA. Secondary cell wall synthesis starts at about 20 DPA and continues up to 45 DPA. During this period large amount of cellulose (> 90 %) deposition takes place and the fibre cell wall becomes thick. In the final maturation stage (45–50 DPA) fibres undergo dehydration and produce mature cotton lint (Arpat *et al.*, 2004; Wu *et al.*, 2006). Cotton fibre initiation has been mostly studied in upland cotton, *G. hirsutum*, although some information exists on a few wild cottons (Applequist *et al.*, 2001). Lint yield depends on number of bolls per unit area, number of seeds per boll, number of fibres per seed, number of fibres per unit area and average weight per fibre. Improvements in fibre

number per seed and thereby fibres per unit area of seed might result in increased lint yield. Therefore, in the present study from the cross (FL × FI) an attempt was made to understand the variation for number of fibres per unit area in segregating F₂ population besides genetics of fibre elongation.

Materials and Methods

The genetics of fibre elongation in cotton was studied in F₂ of population of cross between Fuzzy linted (FL) and Fuzzy-lintless (FI) during *kharif* 20015-16 at Main Agriculture Research Station (D block), University of Agricultural Sciences, Dharwad. Fuzzy-linted (FL) and Fuzzy-lintless (FI) lines (parents) and their F₁ and F₂ plants were used as genetic material in the study. About 309 F₂ plants were observed for normal linted and lintless trait. Around 5 bolls per plant were observed at fully opened boll stage. The data was analysed applying chi-square test to work out genetics of fibre elongation. Ginning outturn was calculated in all F₂ plants.

Scanning Electron Microscopy

At fibre initiation stage (2 DPA) scanning electron microscopy (SEM) was performed to observe the development of fibre initials on epidermal layer of ovules. Ovules excised from two days post anthesis flowers were collected in 3 % glutaraldehyde and dipped in 1-2 % osmium tetroxide for post-fixation. Samples were dehydrated in a graded acetone solutions and mounted on stub and allowed for metal coating with Gold using polaron sputter (E5100, Watford England) coater. The SEM images were captured by LEO 435 VP (LEO Electron microscopy Ltd., Cambridge, UK) at 15 kV EHT at Central Food Technological Research Institute (CFTRI), Mysore. The number of fibre initials was quantified in 100 µm² area using ImageJ software.

Results and Discussion

Number of fibre initials in parents

The SEM images of ovule (2 DPA) revealed that chalazal and middle parts of ovules were entirely covered with fibre initials whereas, extreme micropylar part of ovule is free from fibre initials (Fig. 1A and 1B). The absence of fibre initials at extreme micropylar end of ovules (2 DPA) and presence of fibres on outer epidermal layer of matured seeds at micropylar end indicates that, the fibre initiation in micropylar end takes a later stage. About 68 fibre initials were observed in Fuzzy-linted (FL) and 53 in Fuzzy lintless (FI) (Table 2 and Fig. 1C, 1D). However, fibre initials in Fuzzy lintless did not elongate to become fibres (lint). As per the literature (Turley *et al.*, 2007; Stewart, 1975; Joshi *et al.*, 1967 and Lang, 1938) fibre initiation at the chalazal end of the ovule and progresses towards the micropylar end. The cells which show indication of elongation by 2 DPA are said to further elongating into either fuzz (0.5 cm) and lint (2.5 to 3.5 cm). Only 20 per cent of such initials cells showing elongation by 2 DPA are known to elongate into fibres (Arpat *et al.*, 2004; Wilkins *et al.*, 2005; Hee *et al.*, 2001; Stewart, 1975). In figure 1 fibre initials were observed in both linted (FL) and lintless (FI) cotton at 2 DPA but fibres were observed only in linted (FL) (Fig. 2).

Genetics of fibre elongation

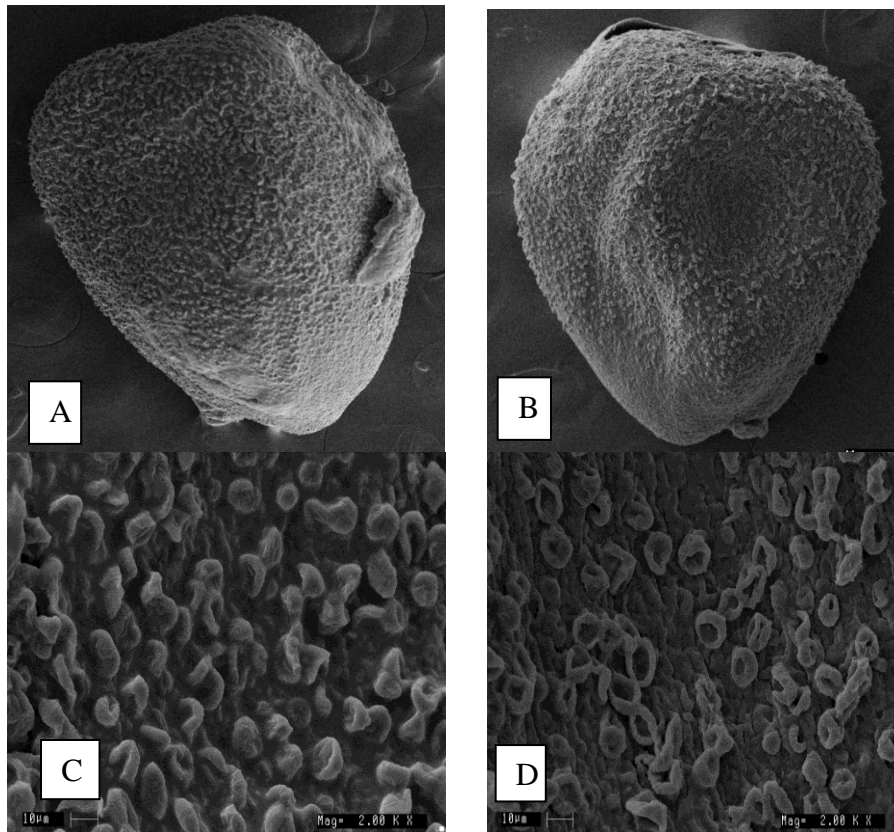
The *G. herbaceum* (A genome) diploid cotton is normal fibred cotton which was crossed with *G. anomolum* (B genome), and the F₁ was partially fertile, the partial fertile F₁ was used as male and *G. herbaceum* was used as female to obtain BC₁F₁ plants. BC₁F₁ plants were fertile, they were further continued to derive recombinant inbred lines (Choudki *et al.*, 2013). Two lines of BC₁F₉, one being normal Fuzzy-linted (FL) and another Fuzzy-

lintless (Fl) were used to study the genetics of fibre elongation in present study.

Morphologically both fuzzy-linted (FL) and Fuzzy-lintless (Fl) lines were similar for traits like plant height, leaf size, leaf hairiness, stem pigmentation, stem hairiness, boll shape, boll colour, petal colour, pollen colour, anther colour and anther filament colour. So far no

studies on genetics of fibre elongation were conducted from such Fuzzy-linted (FL) and Fuzzy-lintless (Fl) diploid cotton. In present study based on observation on 309 F₂ plants for normal fibred (linted), versus fibreless (lintless), the presence of two gene interaction was evident from Chi-square test to indicate double recessive nature of gene interaction is responsible for lintless trait (Table 1).

Fig.1 SEM micrograph of 2 DPA ovule



A: Fuzzy linted (FL), B: Fuzzy lintless (Fl), C: FL ovule surface (100 μm^2) and D: Fl ovule surface (100 μm^2).

Fig.2 A: Opened boll of FL, B: Opened boll of Fl

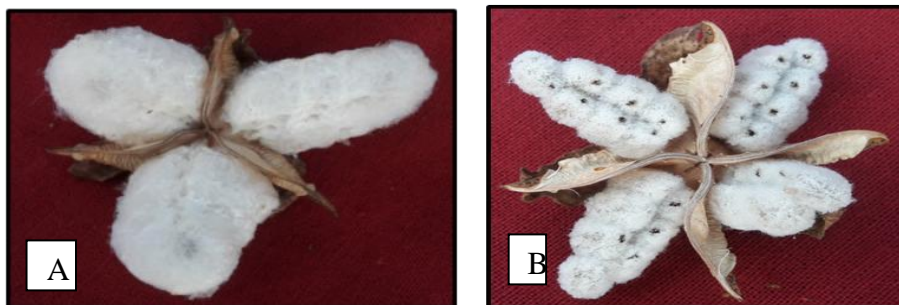


Table.1 Chi-square table

Cross	Linted		Lintless		Total number of plants	χ^2 Value	Table χ^2 Value
	Observed	Expected	Observed	Expected			
Fuzzy-linted× Fuzzy-lintless	287	290	22	19	309	0.477	3.84

Table.2 Number of fibre initials per 100 μm^2 area of 2 DPA ovules

Sl. No	Genotype	Fibre initials per 100 μm^2
1	Fuzzy-linted (FL)	68
2	Fuzzy-lintless (Fl)	53

Table.3 Mean and range for ginning outturn in segregating population

Character	Population (F ₂)	Mean	Range
GOT (%)	Fuzzy-linted (FL) × Fuzzy-lintless (Fl)	36.70	0.0-38.08

GOT: Ginning outturn

Variability for ginning out turn in diploid cotton

Ginning outturn, the proportion of lint in total kapas is mainly depending on number of fibres elongated from the surface of the epidermal layer, rather than fibre length. It is very clear from the difference in ginning outturn between different cultivated species. For example genotype belongs to *G. barbadense* are considered as extra-long staple cotton as their fibre length is more than 32 mm, however the ginning out turn or lint yielding ability of these extra-long staple cotton is always between 32 to 34 %.

Whereas in case of *G. hirsutum* the fibre length varies from 24 to 30 mm, and ginning out turn also varies between 35 to 40 %. The higher ginning out turn in *G. hirsutum* cotton may be due to the more number of fibres per unit area than the fibre length. Therefore the present study has been validation to find out genetic variability for number of fibre initials and elongating fibres in segregating population (F₂) obtained from the cross

between Fuzzy-linted (FL) and Fuzzy-lintless (Fl) cotton.

In diploid cotton to measure number of fibres elongated, the main trait considered for recording observation was ginning outturn. There were only two classes in F₂, one was lintless and other was linted. Ginning outturn of all lintless F₂ plant was however 0 %, whereas among the linted F₂ plant ginning out turn varied from 29.31 to 38.08 % (Table 3). So the observed variation for ginning outturn is due the increase in number of fibres per unit area. To increase ginning outturn in normal fibred cotton genotype is therefore possible by increasing number of elongating fibres. The genetic material evaluated under present study would be the valuable material for understanding molecular basis of fibre cell elongation in future.

Abbreviations

DPA: Days Post Anthesis, FL: Fuzzy linted, Fl: Fuzzy lintless, SEM: Scanning Electron Microscope

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