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INHERITANCE PATTERN OF FUZZ AND LINT TRAITS IN UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.)

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ABSTRACT

This study investigated the inheritance patterns of fuzzlessness and lintlessness in cotton using four F_2 segregants of the crosses namely CO14 x AKH98-81, CO17 x AKH98-81, CO14 x TCH1646 and CO17 x TCH1646. The observed segregation ratios for fuzzlessness in AKH98-81 involved combinations were in agreement with the expected 12:3:1 ratio, confirming the involvement of two genes exhibiting a dominant epistastic pattern. In the study of fuzzlessness in CO14 x TCH1646 and CO17 x TCH1646 F_2 populations, the results showed a 3:1 segregation ratio suggesting the involvement of a single recessive gene controlling the trait. For lintlessness, CO14 x TCH1646 and CO17 x TCH1646 crosses displayed a duplicate dominant epistasis pattern with a 15:1 ratio indicating the contribution of two genes with duplicate dominant effects. These results provide valuable insights into the genetic control of fuzz and lint traits in cotton, enabling future breeding efforts to develop cotton varieties with desired fibre characteristics. Understanding the genetic basis of fuzz and lint traits can enhance the economic viability of cotton production by developing improved cotton varieties that are easier and more cost-effective to process. This study has implications for cotton breeding and the textile industry have the potential to contribute to sustainable agricultural practices and boost economic growth in the cotton industry.

Key words : Cotton, Chi-square, Epistasis, Fuzzlessness and Lintlessness.

Introduction

Upland cotton, scientifically known as *Gossypium hirsutum* L., is a vital cash crop in India and also called as “silver fibre”. Its significance extends to both the country’s agricultural and industrial sectors, with 65 to 70 per cent of raw materials for the textile industry. The main economic product derived from cotton is lint, a long and fine fibre measuring about 25 mm in length. Conversely, shorter fibres less than 5 mm are referred to as linter or fuzz. Notably, many wild cotton species lack both lint and fuzz on their seed coats. However, some cotton varieties possess a unique genetic trait - fuzzlessness, which holds significant importance in the textile and agricultural industries. This trait eliminates the labour-intensive process of separating cotton fibres from seeds, reducing production costs, and improving processing efficiency. Moreover, fuzzless cotton has the potential to yield higher-quality fibres with improved properties, making it a highly appealing choice for textile production. Fuzzlessness in cotton presents a numerous advantage as a critical contributor to the textile industry, fuzzless cotton varieties offer cost savings due to the elimination of the labour-intensive process of separating fibres from seeds. Furthermore, the absence of short fibres contributes to smoother, more uniform yarn and fabric, thereby boosting the overall quality of cotton products. The focus on lint production in fuzzless cotton plants also increases yield potential, making it a promising option for sustainable and economically viable cotton farming practices.

Fuzzless cotton seeds exhibit a unique characteristic as they lack a seed covering, leaving the deep brown hull exposed. In these seeds, the percentage of lint, which refers to the long fibres used for textile production, is usually negligible. Delving into the origins of fuzz and lint fibres is essential to comprehending the fundamental differences in their characteristics. Both lint and fuzz fibres in cotton originate from epidermal cells (Farr *et al*., 1931). However, there are distinctions in their development timelines and physical attributes. Lint fibres start growing from the day of anthesis while fuzz fibres develop approximately four days after anthesis (Joshi *et al*., 1967). Additionally, linters, the shorter fibres growing less than 5 mm, exhibit coarseness and possess a thick secondary cell wall (Smith and Cothren, 1999). Unlike lint fibres, which form twisted ribbons of cellulose as the central vacuole collapses, linters maintain their circular cross-sections at maturity, making them suitable for being spun into yarn. The proportion of linters to lint fibres per seed varies and depends greatly on the specific cultivar and the environmental conditions in which cotton is grown (Hutchinson, 1935; Hebert and Thibodeaux, 1988; Turley 2009).

Understanding the distinct characteristics and development processes of fuzz and lint fibres is crucial for cotton researchers and producers. This knowledge can potentially lead to the development of cotton varieties with optimized fibre qualities for various applications in the textile industry. By further studying the origin and behaviour of fuzz and lint fibres, can gain insights into the underlying genetics and mechanisms that govern these processes. A dominant inheritance character of fuzzlessness (Musaev and Abzalov, 1972; Nadarajan and Rangasamy, 1988; Zang and Pan, 1991; Du *et al*., 2001). Ultimately, this understanding may contribute to improved breeding techniques, cultivation practices and cotton fibre quality, leading to advancements in cotton production and its economic significance in regions like India, where cotton plays a pivotal role in both agriculture and industry.

In the context of cotton, “naked seed” refers to seed types that lack a traditional seed covering, exposing the inner seed structure. Within the category of naked seed cotton, there are distinct genotypes with varying fibre characteristics. Some genotypes possess no fuzz at all, but may have a negligible amount of lint at the chalazal end of the seed. On the other hand, there are other naked seed types that have fuzz present at the micropylar end of the seed, forming what is known as “tufted naked seed.” In a recent study, both these types of naked seed were used in hybridization experiments with fuzzy linted cultivars to investigate the inheritance patterns of lint and fuzz traits. The primary objective was to understand how these fibre traits are passed down from the parent plants to their hybrid offspring. To analyse the inheritance patterns, phenotypic data was collected on the presence or absence of lint and fuzz in the resulting hybrids.

To determine the statistical significance of their findings, the phenotypic data to a chi-square test for goodness of fit. The chi-square test is a statistical tool commonly used to assess whether observed data significantly deviate from the expected data under a specific hypothesis. Test to evaluate whether the observed distribution of lint and fuzz traits in the hybrid offspring follows a specific inheritance pattern that can be explained by experimental hypotheses. By using the chi-square test, the study aimed to gain insights into the genetic mechanisms underlying the inheritance of lint and fuzz traits in the hybrid cotton plants. The results of this study may contribute to a better understanding of cotton fibre development and genetics, ultimately assisting cotton breeders in developing new varieties with desirable fibre characteristics for the textile industry.

Materials and Methods

Parental genotypes and generation of segregating population

In this study, two distinct types of naked seed genotypes were used to investigate the inheritance of lint and fuzz traits in cotton. Genotype TCH1646 was characterized as fuzzless and lintless, with only a negligible amount of lint present at the chalazal end of the seed. This specific genotype was sourced from the Department of Cotton, Tamil Nadu Agricultural University, Coimbatore, India. Another genotype AKH98-81 was identified as tufted fuzzless but linted, meaning it had fuzz present at the micropylar end of the seed, while also contains lint fibres and was obtained from ICAR-CICR, Coimbatore.

To study the inheritance of lint and fuzz traits, these two naked seed genotypes were subjected to hybridization experiments with elite cultivars known for their fuzzy linted fibres, CO14 and CO17, which are well-known cultivars with fuzzy linted characteristics. By analysing the resulting hybrids, the genetic mechanisms underlying the inheritance of lint and fuzz traits in cotton can be understood.

Field evaluation of segregating population

Four F_1 populations were produced by crossing the two naked seed genotypes (TCH1646 and AKH98-81) with the elite fuzzy-linted cultivars CO14 and CO17. These F_1 populations, along with their parent plants were raised in a randomized block design with two replications during the *kharif* 2022. Subsequently, the four F_2 populations, each consisting of 150 plants, were raised during the *summer* of 2023. Individual plants in the F_2 populations were carefully observed and classified based on their fuzz and lint phenotypes.

To analyze the F_2 ratings and assess the segregation of fuzzless and fuzzy genotypes, chi-square tests for Goodness of Fit separately for lint and fuzz traits were performed. These statistical tests aimed to determine whether the observed distribution of fuzzless and fuzzy genotypes among the F_2 plants followed a specific expected pattern based on Mendelian inheritance principles. The chi-square values were calculated manually and assigned probability values to each test. The chi-square values with the highest probability values were considered the best explanation for the observed segregation patterns.

Plate 1 : F_2 Segregants of CO14 x AKH98-81 a) Linted fuzzy, b) Linted semi fuzzy, c) Linted slightly fuzzy seeds, d) Linted tufted seeds.

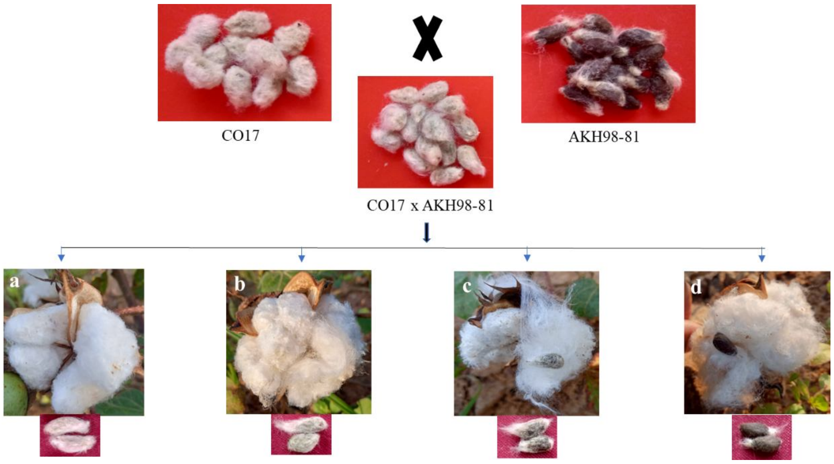

Plate 2 : F_2 Segregants of CO17 x AKH98-81 a) Linted fuzzy, b) Linted semi fuzzy, c) Linted slightly fuzzy seeds, d) Linted tufted seeds.

Results

Inheritance study was conducted using four F_2 population employing fuzzlessness and lintlessness parents. The F_2 population exhibited many grades of fuzz and lint in seed coat of segregants. The segregants were classified into different categories based on the amount of fuzz and lint on seed coat (Table 1).

The inheritance pattern of fuzzlessness was studied using two F_2 populations developed from AKH98-81 (linted fuzzless tufted seeded). Considering the F_2 segregants of CO14 x AKH98-81, four different segregating categories were observed (Plates 1 and 2), namely linted fuzzy, linted semi fuzzy, linted slightly fuzzy and linted fuzzless tufted seeds. Among the 144 F_2 segregants, 105 plants were scored as linted fuzzy (which includes linted fuzzy and linted semi fuzzy), 27 plants were scored as linted partially fuzzy (which includes linted slightly fuzzy segregants) and 12 were scored as linted fuzzless. Data was subjected to goodness of fit using chi square analysis. The test revealed that F_2 segregation for fuzzlessness agrees with dominant epistasis ratio of 12:3:1 (Table 2). The chi square value obtained was 1.083 which was less than the table chi square value and hence found non-significant. The F_2 segregants of CO17 x AKH98-81 also followed the similar trend. Among the 146 F_2 segregants, 111 were scored as linted fuzzy, 25 were found to be linted partially fuzzy and 10 plants which fell under the category of linted fuzzless. The chi square analysis revealed that the F_2 segregants fall under the epistatic ratio of 12:3:1 for the trait seed fuzz lessness. The chi square value (0.26) obtained was less than the table chi square value thus reporting as non-significant.

The inheritance pattern of fuzzlessness and lintlesssness was separately evaluated using two F_2 populations generated from lintless fuzzless genotype TCH1646 as donor parent. Six different types of segregants were obtained (Plates 3 and 4) namely linted fuzzy, linted semi fuzzy, linted tufted fuzzless, linted fuzzless, partially linted fuzzless and lintless fuzzless.

For the trait fuzz lessness, 157 and 153

F_2 segregants of CO14 x TCH1646 and CO17 x TCH1646 respectively were scored. In the F_2 segregants of CO14 x TCH1646, 121 plants were found fuzzy (which includes linted fuzzy and linted semi fuzzy segregants) and 36 plants were scored fuzzless (includes linted tufted fuzzless, linted fuzzless, partially linted fuzzless and lintless fuzzless). Chi square test was performed for evaluation of goodness of fit. The results obtained were in agreement with 3:1 ratio, with a chi squre value (0.367) lower than the table chi squre value. The F_2 segregants of CO17 x TCH1646 also followed similar trend, 113 plants were found fuzzy and 40 plants were grouped as fuzzless. The chisquare value obtained was 0.140 and the segregants fits into the ratio 3:1 and the deviations were found non-significant.

The F_2 segregants of CO14 x TCH1646 and CO17 x TCH1646 were also evaluated to understand the inheritance of lintlessness. Among the 157 F_2 population, 149 were identified as linted (which includes linted fuzzy, linted semi fuzzy, linted tufted fuzzless, linted fuzzless and partially linted fuzzless) and eight plants were observed as lintless. When tested for goodness of fit using chi square test, the result obtained was in agreement with duplicate dominant (duplicate) epistatic ratio 15:1 (Table 3). The chi square value (0.427) obtained was found lesser than table chi square value. Occurrence of lint in CO17 x TCH1646 was categorized into linted and lintless. A total of 145 plants (including linted fuzzy, linted semi fuzzy, linted tufted fuzzless, linted fuzzless and partially linted fuzzless) were found linted and eight plants were obtained lintless in the entire population of 153 F_2 segregants. Chi square test was performed for evaluation of goodness of fit. The results obtained were in agreement with the duplicate dominant epistatic ratio of 15:1. On comparing the calculated chi square value (0.459) with table value, the deviations were found non-

Plate 3 : F_2 Segregants of CO14 x TCH1646 a) Linted fuzzy, b) Linted semi fuzzy c) Linted tufted seeds, d) Linted fuzzless, e) Partially linted fuzzless, f) Lintless fuzzless.

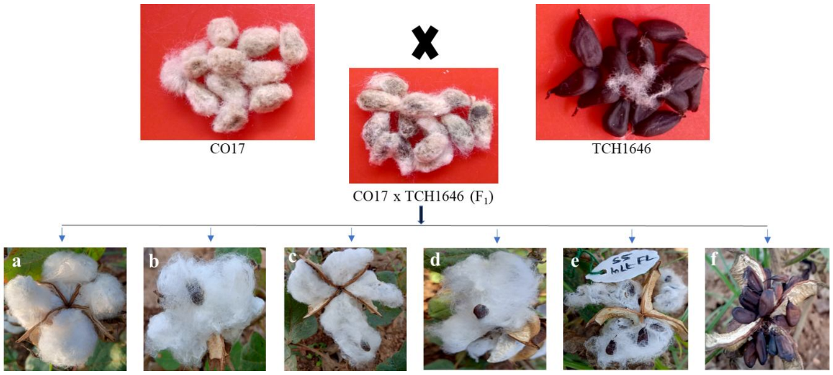

Plate 4 : F_2 Segregants of CO17 x TCH1646 a) Linted fuzzy, b) Linted semi fuzzy, c) Linted tufted seeds, d) Linted fuzzless, e) Partially linted fuzzless, f) Lintless fuzzless.

Table 1 : Different categories of segregants based on the amount of fuzz and lint on seed coat.

S. no.	Segregant type	Representation
AKH98-81 involved crosses		
1.	Linted semi fuzzy	S1
2.	Linted slightly fuzzless	S2
3.	Linted fuzzy	S3
4.	Linted fuzzless	S4
TCH1646 involved crosses		
5.	Linted semi fuzzy	S1
6.	Linted tufted fuzzless	S2
7.	Linted fuzzless	S3
8.	Linted fuzzy	S4
9.	Partially linted fuzzless	S5
10.	Lintless fuzzless	S6

Table 2 : Chi square test for the inheritance of seed coat fuzz trait in AKH98-81 involved crosses.

Crosses	Observed value			Expected ratio	Chi square value	Remark
	Linted fuzzy	Linted partially fuzzy	Linted fuzzless			
CO14 / AKH98-81	105	27	12	12:3:1	1.083	Non- Significant
CO17 / AKH98-81	111	25	10	12:3:1	0.26	Non - Significant

Table 3 : Chi square test for the inheritance of seed coat fuzz trait in TCH1646 involved crosses.

Crosses	Observed value		Expected ratio	Chi square value	Remark
	Fuzzy	**Fuzzless**			
CO14 / TCH1646	121	36	3:1	0.367	Non- Significant
CO17 / TCH1646	113	40	3:1	0.140	Non – Significant
Crosses	**Observed value**		**Expected ratio**	**Chi square value**	**Remark**
	Linted	**Lintless**			
CO14 / TCH1646	149	8	15:1	0.427	Non- Significant
CO17 / TCH1646	145	8	15:1	0.459	Non – Significant

significant.

Discussion

The results of inheritance pattern of fuzzlessness in F_2 segregants of CO14 x AKH98-81 and CO17 x AKH98-81 revealed that the observed segregation ratio was in agreement with the expected ratio of 12:3:1 which was confirmed by chi square analysis. The chi square test revealed that the F_2 segregation for fuzzlessness followed a dominant epistasis ratio in both the crosses implying the involvement of two genes. This type of inheritance pattern is commonly exhibited when multiple genes interact to determine the trait. The dominant gene at one locus masks the expression of recessive gene at another locus, resulting in the observed segregation ratios. The non significance of chi square test indicated the inheritance of fuzzlessness in these populations which is in agreement with the expected pattern and does not deviate significantly. The inheritance of this trait in 12:3:1 ratio was found in accordance with the earlier findings of Manimaran (2003).

Inheritance of fuzzlessness was studied in two F_2 populations of CO14 x TCH1646 and CO17 x TCH1646. The results of chi square analysis revealed that the inheritance of fuzzlessness in both the crosses followed a 3:1 segregation ratio indicating the involvement of a single recessive gene controlling the trait. The non significance of chi square test highlights that the observed ratio fits to the expected ratio and does not deviate significantly. Similar inheritance pattern for fuzzlessness was reported by Du *et al.* (2001), Turley and Kloth (2002), Bechere *et al.* (2012), Bardak and Bolek (2016) and Hendon *et al.* (2019). These results are also contradictory to the findings of Turley *et al.* (2007), who proposed 1:3 segregation ratio for fuzzy and fuzzlessness.

For lintlessness, both crosses depicted a duplicate dominant epistasis with a ratio of 15:1 indicating the contribution of two genes with duplicate dominant effects. Duplicate dominant epistasis occurs, when two different dominant alleles at two different gene loci interact to produce a lint phenotype that masks the expression of both recessive alleles expressing lintlessness. In this pattern, the presence of either dominant allele at either gene locus is sufficient to produce the dominant phenotype (linted), while the presence of two recessive alleles at both loci is required to produce the recessive phenotype (lintlessness). The inheritance pattern observed is in accordance with the results of Nadarajan *et al.* (1999), Du *et al.* (2001), Bardak and Bolek (2016), Kumar *et al.* (2019).

Conclusion

This study investigated the inheritance patterns of fuzzlessness and lintlessness in cotton using F_2 segregants from different crosses. For fuzzlessness, the results revealed the presence of dominant epistasis and a 12:3:1 segregation ratio suggesting the involvement of two genes. For lintlessness, a duplicate dominant epistasis pattern with a 15:1 ratio was observed indicating the contribution of two genes with duplicate dominant effects. These findings provide valuable insights into cotton genetics and inheritance mechanisms, enabling future breeding efforts to develop cotton varieties with desired fibre characteristics. Understanding the genetic control of fuzz and lint traits can lead to the development of improved cotton varieties that are easier and more cost-effective to process, enhancing the economic viability of cotton production. The study's implications for cotton breeding and textile industry have the potential to enhance cotton cultivation practices, contribute to sustainable agricultural practices, and boost the cotton industry's economic growth.

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