

Original Research Article

Unravelling the genetic divergence and trait association for yield and its component traits among germplasm lines in cotton (*Gossypium hirsutum* L.)

ABSTRACT

The current study was focused on unravelling the genetic basis for seed cotton yield and yield attributing traits with an emphasis on isolating most potential germplasm accessions. A set of 192 cotton germplasm accessions were evaluated for two seasons and two environments. The results of correlation analysis indicated the presence of significant and positive correlation between seed cotton yield with number of sympodia per plant, number of bolls per plant, lint yield, boll weight and lint index, indicating selection for these traits indirectly enhance the seed cotton yield. While diversity analysis categorized germplasm accessions into eight different clusters. These results indicated the existence of adequate genetic diversity among the germplasm lines which can be exploited to manifest higher magnitude of heterosis through hybridization of genotypes belonging to different clusters.

Keywords: Germplasm, Correlation, Genetic diversity, K means clustering and R software

INTRODUCTION

Cotton, the foremost non-food agricultural commodity globally, stands as one of the earliest plant fibers utilized for textiles. Even in contemporary times, cotton remains an undisputed natural textile fiber seamlessly integrated into our daily lives in diverse manners, esteemed above hundreds of other fiber-yielding plants known to humanity. The volume of cotton production surpasses that of all other fibers combined. Being the precious gift of nature to mankind contributed by genus *Gossypium* to the people all over the world, cotton remains the most miraculous fiber, even after 8000 years of its first use. No agricultural commodity in the world exercised such a profound influence on men and matter as cotton has done from time immemorial Anon [1]. India has been the traditional home for cotton and cotton textiles. A comprehensive knowledge of genetic basis of quantitative traits is of prime importance in understanding the genetic potential of germplasm accessions and its use in crop improvement. Most of the yield and fibre traits known to be controlled by polygenes or quantitative trait loci (QTLs) Ulloa [2].

The correlation reveals the nature of relationship between yield and its component traits. If the correlation between two traits is positive and significant, improvement in one trait will exert a significant impact on the other, which helps the breeder to exhibit his skills in designing selection strategies in plant breeding. Comprehending correlation enables the concurrent enhancement of multiple traits, aiming to achieve the desirable blend of various yield components. The appraisal of genetic diversity is important to understand the pattern and evolutionary relationship among germplasm or genotypes, which will aid in sampling the genetic resources in a more systematic manner for conservation and crop improvement. Hence, this study was conducted to get insights into the genetic divergence and traits association among germplasm lines for yield and its component traits in cotton Wakelyn and Chaudhry, [3].

MATERIAL AND METHODS

A set of 192 cotton germplasm accessions maintained at All India Co-ordinated Research Project (AICRP) on Cotton in University of Agricultural Sciences (UAS) Raichur were used in the current investigation. The phenotyping was done by raising the germplasm lines in two locations *i.e.*, MARS, Raichur and College of Agriculture, Bheemaranagudi for two successive years in *kharif* of 2021 and 2022. Augmented design was used for evaluation along with five checks (BGDS-1033, BGDS-1063, SCS-1061, SCS-1062 and SCS-793) and observations on different quantitative traits such as Plant height (PH), Number of monopodia per plant (NM), Number of sympodia per plant (NS), Number of bolls per plant (NB), Boll weight (BW), Seed cotton yield per plant (SCY), Lint yield (LY), Ginning out turn (GOT), Lint index (LI) and Seed index (SI) were recorded. Seed cotton yield being a complex trait is affected by many genetic and non-genetic factors. In order to identify the independent variables like yield attributes, association studies serve as an effective tool. The correlation based on Pearson method and diversity analysis using K Means clustering were performed in R software using *metan* and *factoextra* packages, respectively.

RESULTS AND DISCUSSION

The results on correlation studies of seed cotton yield with yield attributing traits revealed that seed cotton yield was positively significantly correlated with number of sympodia per plant (0.40), number of bolls per plant (0.91), lint yield (0.94) at 1% level of significance, whereas boll weight (0.28) and lint index (0.32) were found to be significant at 5% level of significance (Table 1). Other traits were also found to be associated with seed

cotton yield but not in a significant amount. It indicated that the yield could be enhanced in a significant manner by improving these strongly associated traits, mainly formerly mentioned three traits (Fig.1 and 2). Similarly, LY was significantly positive correlated with other traits such as LI (0.41) and GOT (0.40). Seed Index was also found to be associated with BW (0.62). NB was associated with NS (0.41). However, PH was positively correlated with NS (0.67) and SI (0.28) in a significant manner. It was observed that non-existence of significant

Table1. Estimates of correlation between yield and its component traits among germplasm accessions

	PH	NM	NS	NB	LY	SI	BW	GOT	LI	SCY
PH	1.00									
NM	0.20	1.00								
NS	0.67**	0.19	1.00							
NB	0.20	0.20	0.41**	1.00						
LY	0.15	0.19	0.35**	0.91**	1.00					
SI	0.28*	0.07	0.17	0.02	0.09	1.00				
BW	0.09	-0.05	0.03	-0.03	0.21	0.62**	1.00			
GOT	-0.22	-0.01	-0.05	0.22	0.40**	-0.43	-0.13	1.00		
LI	0.08	0.06	0.12	0.18	0.41**	0.66**	0.53**	0.39**	1.00	
SCY	0.25	0.20	0.40**	0.91**	0.94**	0.26	0.28*	0.07	0.32*	1.00

association of NM with any of the traits.

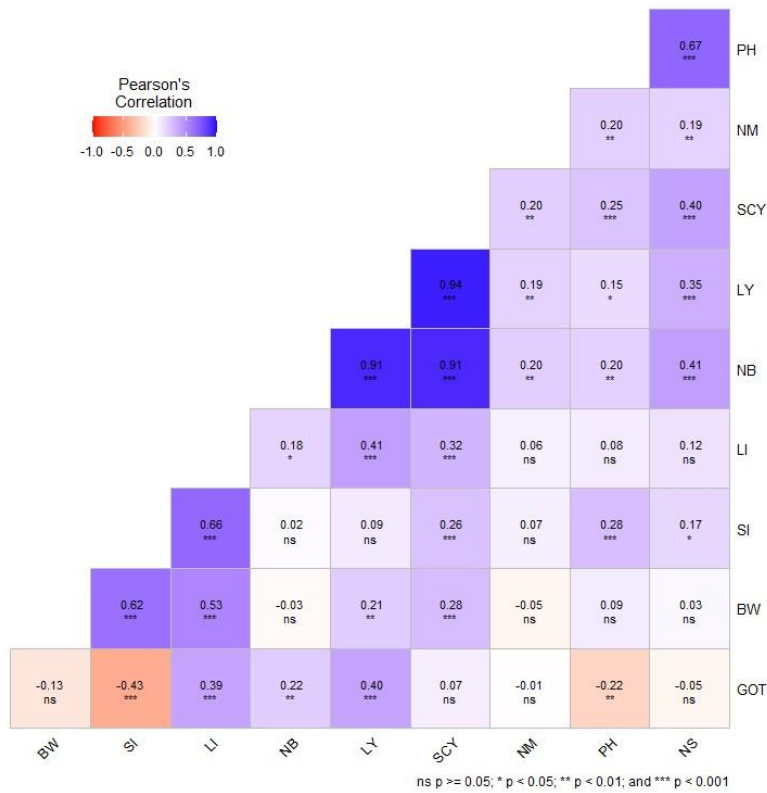


Fig 1. Heatmap depicting estimates of correlation coefficients between yield and its component traits among germplasm accessions

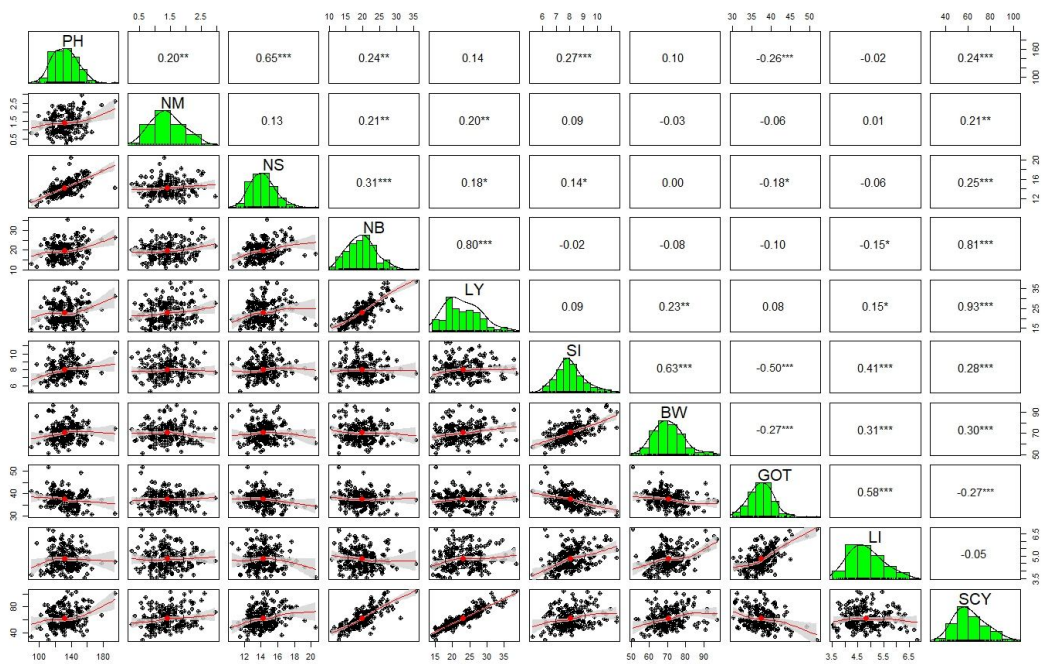


Fig 2. Corrplot depicting estimates of correlation coefficients between yield and its component traits among germplasm accessions

Genetic diversity is referred to as any variation at the phenotypic, DNA or genomic level of an individual, population or species. The appraisal of diversity is important to understand its pattern and evolutionary relationships between germplasm or genotypes, which will aid in sampling the genetic resources in a more systematic manner for conservation and crop improvement Revanasiddayya [4]. The diversity analysis based on K Means clustering classified the complete set of 192 germplasm lines into eight different clusters (Fig. 3) viz., cluster I, cluster II, cluster III, cluster IV, cluster V, cluster VI, cluster VII, cluster VIII with a cluster size of 13, 47, 21, 26, 31, 19, 27 and 8 respectively. First two clusters share similarity more than the next six clusters, which share quite common similarity. Cluster I have germplasm lines which are distant from the germplasm lines of cluster VIII. These results indicated the existence of adequate genetic diversity among the germplasm lines (Fig.4), that could be exploited for further development of hybrids or varieties by selecting individuals in segregating generations of a cross between distant germplasm lines. The better hybrids can be expected when the germplasm lines of cluster I are crossed with the germplasm lines of cluster VIII. High yielding varieties can also be produced from the selections in segregating generations of the cross between the distant lines belong to cluster I and cluster VIII.

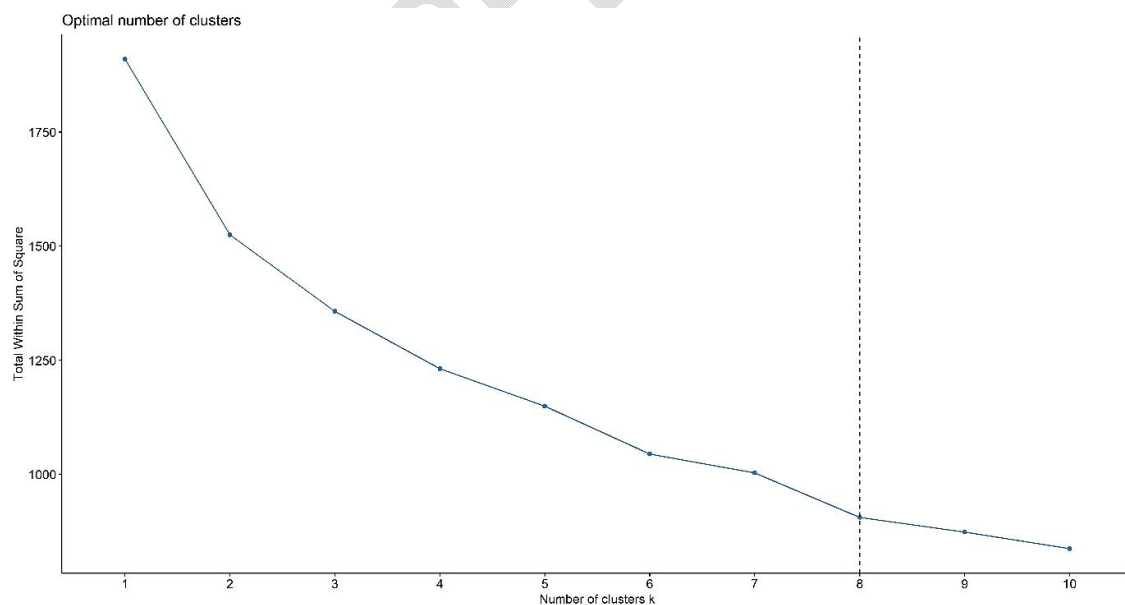


Fig 3. Optimum number of clusters defined using K Means clustering

The information about the contribution of these characters to genetic divergence is essential for understanding which traits are driving the differences among the cotton germplasm. This knowledge can guide breeding programs and help prioritize specific traits for improvement or selection of diverse germplasm for hybridization. Meanwhile, Similar results were obtained by Bhimate[5], Santos [6], Rajendrakumar [7], Gururajan and Manickam [8], Kiran [9] and Karunakar [10].

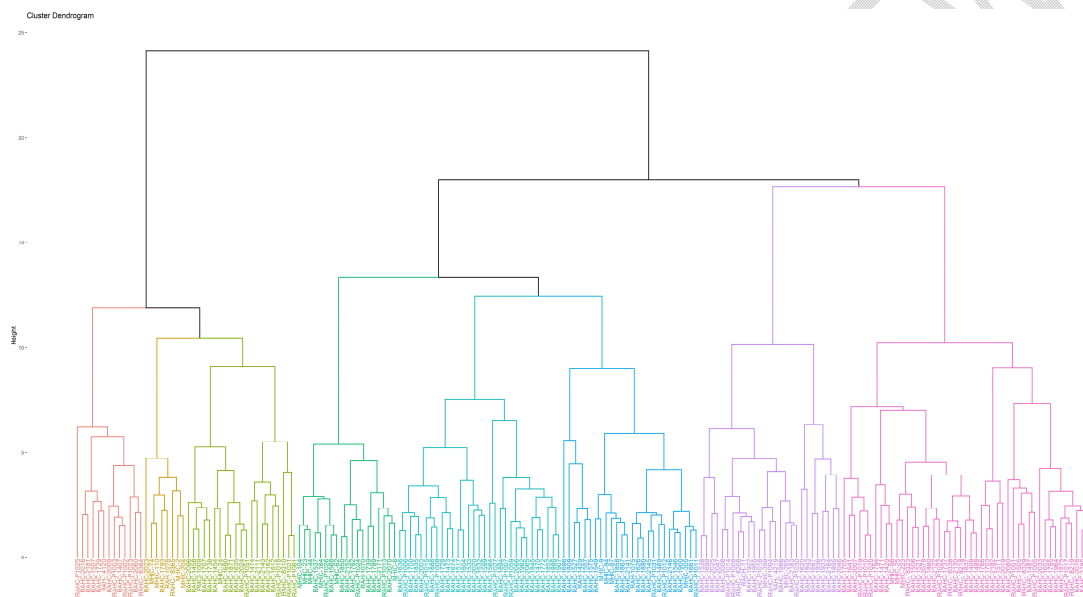


Fig4. Dendrogram deciphering different clusters of cotton germplasm accessions

The correlation analysis indicates that several traits are significantly and positively associated with seed cotton yield (SCY), suggesting that indirect selection for these yield-related traits could be effective for genetic improvement in cotton. In this investigation, SCY was found to be significantly associated with lint yield (LY), number of bolls per plant (NB), number of sympodia per plant (NS), boll weight (BW), and lint index (LI). This means that enhancing SCY could be achieved by selecting for any of these traits. Similar trends were observed in previous studies by Deshmukh [11], Selvaraj [12], Hampannavar[13], Chapepa[14] and Jangid [15] which also reported significant associations between SCY and these traits.

Additionally, the significant genetic diversity exhibited by the germplasm lines can be harnessed to achieve a higher magnitude of heterosis through the hybridization of genotypes from distant clusters. The diversity analysis categorized the germplasm lines into distinct clusters, suggesting that crossing lines from genetically diverse clusters could result in superior hybrids with enhanced yield potential. This finding aligns with the results of previous studies by Nishanth [16], Nikhil [17], Vinodhana and Gunasekaran [18] and Sarwar [19] who also highlighted the importance of genetic diversity in breeding programs.

CONCLUSION

This study provides valuable insights into the nature of the association between yield and its component traits, emphasizing the potential of indirect selection for yield improvement in cotton. By leveraging both the significant trait associations and the genetic diversity within the germplasm, breeders can develop high-yielding, resilient cotton varieties. The findings underscore the importance of comprehensive genetic analyses in guiding effective cotton breeding strategies aimed at enhancing productivity and sustainability in cotton cultivation.

REFERENCES

- Anonymous., 2023, Ancient history of Cotton. (<https://indianculture.gov.in>)
- Ulloa M, Saha S, Jenkins JN, Meredith Jr WR, McCarty Jr JC, Stelly DM. Chromosomal assignment of RFLP linkage groups harboring important QTLs on an intraspecific cotton (*Gossypium hirsutum* L.) joinmap. *Journal of Heredity*. 2005;96(2):132-44.
- Wakelyn, P. J. and Chaudhry, M. R., 2010, Cotton: technology for the 21st century. ICAC.
- Revanasiddayya JM, Fakrudin B, Kuchanur P, Yogeesh LN, Hanchinal S, Suma TC, Sunkad G, Muralidhara B, Maheshkumar D, Channabasava SP, Rashmi S. Genetic diversity among coloured cotton genotypes in relation to their fibrecolour and ploidy level based on SSR markers. *Czech J. Genet. Plant Breed*. 2024;60:12-24.
- Bhimate M, Deshmukh S, Rathod D, Jadhav P, Ujjainkar V. Assessment of genetic diversity in cotton (*Gossypium hirsutum* L.) genotypes using morphological traits. *Multilogic in science*. 2019; 8:142-7.

- Santos IG, Teodoro PE, Farias FC, Farias FJ, de CARVALHO LP, Rodrigues JI, Cruz CD. Genetic diversity among cotton cultivars in two environments in the State of Mato Grosso. 2017.
- Rajendrakumar P, Raveendran TS, Venkatakrishnan S. Genetic diversity and association studies for fibre characters in cotton (*Gossypium hirsutum* L.). J. Indian Soc. Cotton Improv. 2000;25(3):89-93.
- Gururajan KN, Manickam S. Genetic divergence in Egyptian cotton (*G. barbadense* L.). J. Indian Soc. Cotton Improv. 2002;27(2):77-83.
- Kiran LS, Reddy NA, Neelima S, 2004, Studies on genetic divergence in American cotton (*Gossypium hirsutum*L.). Nation. Symp. on changing world order – cotton research, development and policy in contex. Professor Jayashankar Telangana State Agric. Univ., Rajendranagar, Hyderabad.
- Karunakar RGB, Reddy CV, Panduranga RC., Multivariate analysis of genetic diversity in upland cotton. The Andhra Agri. J.,2005;52(1): 66-74.
- Deshmukh MR, Deosarkar DB, Deshmukh JD, Chinchane VN. Correlation and path coefficient analysis of yield contributing and fiber quality traits in Desi cotton (*Gossypium arboretum* L.). International Journal of Chemical Studies. 2019;7(3):585-589.
- Selvaraj S, Rajeswari S, Premalatha N, Kalaimagal T, Muthuswami M, Jeyakumar P, Keerthivarmaan K. Association and path analysis studies for yield contributing and fibre quality traits in the F1 population of *Gossypium hirsutum* L. Environment Conservation Journal. 2023 ;24(2):70-6.
- Hampannavar MR, Patil BR, Katageri IS, Kumar BA, Janagoudar BS. Genetic variability and correlation analysis for agronomic and fibre quality traits in intra-specific cotton (*G. hirsutum*× *G. hirsutum*) recombinant inbred lines (RILs). Int. J. Curr. Microbiol. Appl. Sci. 2020;9:493-503.
- Chapepa B, Mubvekeri W, Mare M, Kutuywayo D. Correlation and path coefficient analysis of polygenic traits of upland cotton genotypes grown in Zimbabwe. Cogent Food & Agriculture. 2020;6(1):1823594.
- Jangid K, Sangwan O, CHAUDHARY M, KUMAR P. Correlation and path analysis for seed cotton yield and its contributing traits under irrigated conditions of Sirsa in desi

cotton: Correlation and path analysis for seed cotton yield. *Journal of AgriSearch*. 2022;9(2):129-132..

Nishanth GK, Harijan YA, Katageri IS. Genetic diversity and variability studies for yield and fiber traits in cotton (*Gossypium hirsutum* L.). *Green Farming*. 2015;6:1174-1179.

Nikhil PG, Nidagundi JM, Hugar A. Genetic variability and heritability studies for seed cotton yield, yield attributing and fibre quality traits in upland cotton (*Gossypium hirsutum* L.). *Journal of Pharmacognosy and Phytochemistry*. 2018;7(5):1639-1642.

Vinodhana NK, Gunasekaran P. Evaluation of genetic diversity in cotton (*Gossypium barbadense* L.) germplasm for yield and fibre attributes by principle component analysis. *International Journal Current Microbiology Applied Science*. 2019;8(4):2614-2621.

Sarwar G, Nazir A, Rizwan M, Shahzadi E, Mahmood A. Genetic diversity among cotton genotypes for earliness, yield and fiber quality traits using correlation, principal component and cluster analyses. *Sarhad Journal of Agriculture*. 2021;37(1):307-14.

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