



Harnessing the association between morphological, biochemical and fibre quality traits in *desi* cotton (*Gossypium arboreum*) genotypes

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ABSTRACT

An experiment was conducted during the rainy (*kharif*) seasons of 2019 and 2020 at the research farm of Chaudhary Charan Singh Haryana Agriculture University, Hisar, Haryana to study the relationship between morphological, biochemical and fibre quality parameters in 150 *desi* cotton [*Gossypium arboreum* (L.)] genotypes in augmented design. Findings of the experiment indicated that the seed cotton yield per plant was significantly and positively correlated with all the traits except days to first flower (-0.226) and plant height (-0.521), while, negatively correlated with biochemical and fibre quality traits. Thus, while improving other traits, seed cotton yield per plant will also increase. Fibre quality traits like fibre length was significant and positively (0.754) correlated with fibre strength but negatively correlated with seed cotton, suggesting quality and quantity can not be improved simultaneously. Hence selection should be done very precisely that as one can not be compromised. Path analysis also revealed that the maximum contribution towards yield was by the number of bolls per plant (0.57), boll weight (0.33), GOT (0.11) and the number of monopods (0.10). Fibre quality parameters did not show any significant contribution directly or indirectly to seed cotton yield. The five traits, viz. number of bolls per plant, number of monopods, ginning outturn (%), seed index (g) and number of seed per boll can contribute to the improvement in cotton. Overall, the significance of this study lies in its potential to yield improvement in *desi* cotton.

Keywords: Association, *Desi* cotton, Fibre quality, Path analysis, Seed cotton yield

Cotton genus *Gossypium* (L.) contains 50 species, with *Gossypium arboreum* (L.) being a diploid variation from the Indian subcontinent (Li *et al.* 2014). Diploid cotton thrives in marginal settings under rainfed circumstances, demonstrating tolerance to climate change and resistance to numerous pest and diseases (Ankanaranayanan *et al.* 2021). Despite these advantages, diploid cotton has hurdles because of its short, fragile, coarse fibres and inability to spin. When compared to tetraploid cotton, these qualities make diploid cotton less often used in textiles (Romeu-Dalmau *et al.* 2015). *Desi* cotton gained prominence following the *Bt* cotton era because of its resistance to climatic fluctuations (Blaise *et al.* 2022). As a result, improving the fibre characteristics of *desi* cotton has become critical in order to meet the expanding demands of the textile industry

(Chandra and Sreenivasan 2011). Given the strong negative association between quality and yield (Yu *et al.* 2013), the issue is in breeding high-yield cotton with exceptional fibre quality. Cotton breeding programmes face a significant difficulty in simultaneously boosting yield and quality (Wang *et al.* 2016).

Correlation studies offer a greater understanding of the relationship that exists between highly heritable characteristics and most economic characters, as well as a better comprehension of the contribution of each variable to the genetic makeup of the crop (Rani *et al.* 2023). Because seed cotton yield and fibre quality attributes are complex quantitative traits impacted by environmental conditions, direct selection may not be a reliable strategy (Jangid *et al.* 2022). Breeders need to be aware of both the direct and indirect effects of the different features while making selections. Path coefficient analysis breaks down the correlation into direct and indirect components, making it a helpful tool for selection. More understanding of the traits that affect yield and their direct and indirect relationships is required in order to design an efficient breeding programme (Kumar *et al.* 2023). In this study, we tested 150 genotypes of *desi* cotton for several morpho-biochemical and fibre quality parameters.

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MATERIALS AND METHODS

A total of 150 germplasm lines of Asiatic cotton were grown during the rainy (*kharif*) seasons of 2019 and 2020 at the research farm of Chaudhary Charan Singh Haryana Agriculture University, Hisar, Haryana. The experiment material was grown in augmented design with 3 control varieties, HD 432; HD 324 and HD 123, sowed after every 15 genotypes in a single row of 6 m length, with the spacing between rows and plants being 1.35 m and 30 cm, respectively. From sowing until harvesting, the entire recommended cultural package of practices were followed. The correlation coefficients were computed using the equations suggested by Al-Jibouri *et al.* (1958). Path coefficient analysis was conducted based on the method introduced by Wright (1921) and subsequently endorsed by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation coefficient: Seed cotton yield is a complex trait i.e. highly influenced by genotype-environment interaction. Thus, simple direct selection based on yield *per se* will not be effective. Under such conditions, selection may be based on simple traits which show a positive association with yield. Results (Table 1) shows the relationship of different traits and their level of significance and correlogram (Fig. 1) represents the intensity of the association among different studied traits. The current study revealed that days to first flower were significant positively correlated with protein content (0.171), fibre strength (0.195) and fibre maturity (0.199), but significant negatively correlated with seed cotton yield (-0.226), ginning out turn (-0.221) and boll weight (-0.198) (Table 1). Plant height was considerably and positively correlated with oil content (0.309), protein content (0.403), and fibre uniformity (0.223), but significant negatively correlated with seed cotton yield (-0.521). Though the days to the first flowering and the height of the plant had negative values, this demonstrates the nature of the relationship with seed cotton yield. Kumar and Ravikesvan (2010) and Chaudhari *et al.* (2017) similarly found a negative and significant relationship between days to first flowering and the seed cotton yield (g).

The seed index was correlated with the number of bolls per plant (0.268), the number of seeds per boll (0.171), the number of monopods per plant (0.229), and the seed cotton

yield (0.353). The number of monopods per plant (0.248), fibre uniformity (0.171) and seed cotton yield (0.288) all had an intensely positive correlation with boll weight (g). The number of bolls per plant correlated significantly with ginning out turn (0.361), number of locules per plant (0.205), number of monopods per plant (0.462), and seed cotton yield (0.714), but negatively correlated with oil content (-0.259), protein content (-0.201), and gossypol content (-0.248). The number of seeds per boll (0.350), number of locules per plant (0.214), number of monopods per plant (0.447) and seed cotton yield (0.576) all indicated a significant and positive association with ginning out turn (g). Similar results were discovered by Vinodhana *et al.* (2013). The number of seeds per bolls had a significant and positive correlation with seed index (0.171), the number of bolls per plant (0.350), the number of locules per plant (0.436), the number of monopods per plant (0.374), and the seed cotton yield (0.448), whereas the number of locules per bolls had a significant and positive correlation with the number of bolls per plant (0.205) and ginning out turn (0.214). Mahesh *et al.* (2021) and Jangid *et al.* (2022) revealed similar results of a positive correlation with seed cotton production per plant. These findings revealed that selecting the number of bolls per plant, ginning out turn (%), number of seeds per

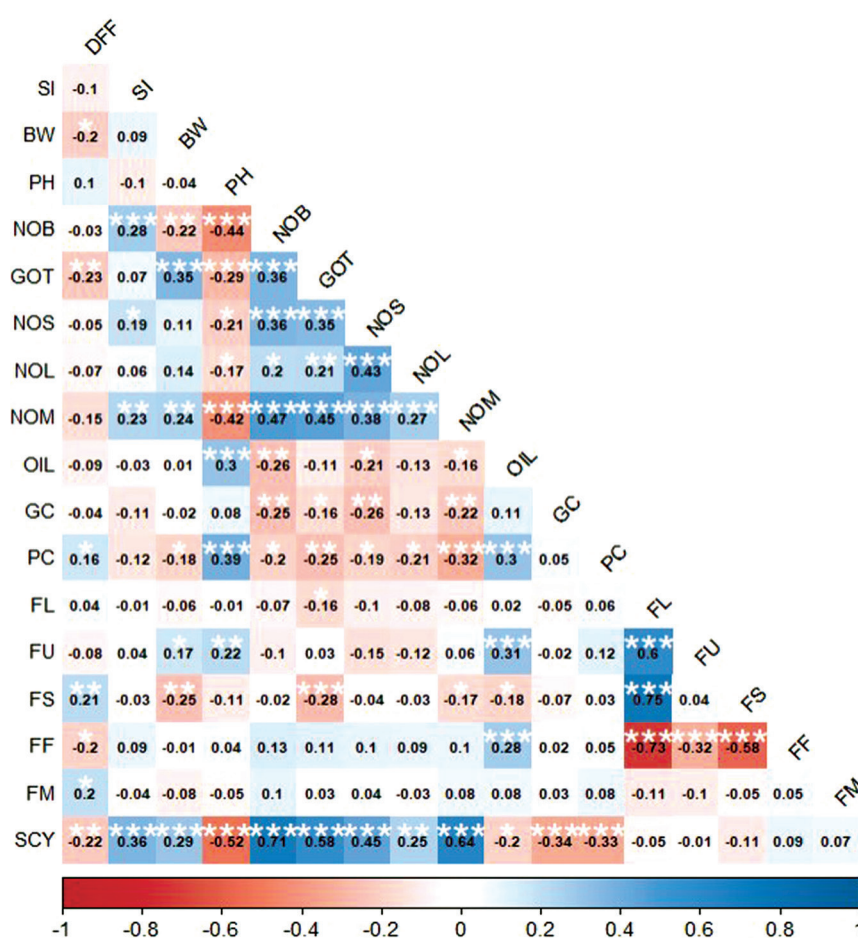


Fig. 1 Correlogram showing the intensity of correlation among various characters of *desi* cotton.

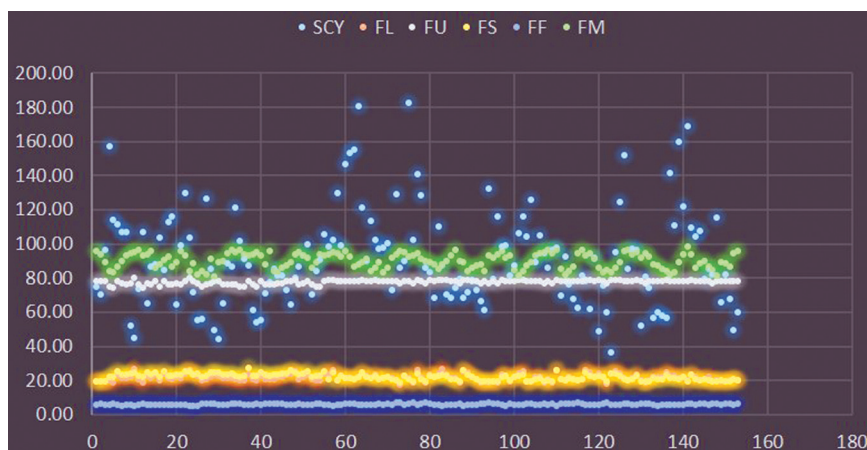


Fig. 2 Showing mean performance for the traits, viz. seed cotton yield (g); FL, Fibre (mm); FU, Fibre uniformity (%); FS, Fibre strength (g/tax); FF, Fibre fineness (μ /inch); FU, Fibre uniformity (%); and FM, Fibre maturity (%).

boll, and number of monopods per plant boosted seed cotton yield in *desi* cotton. Based on the investigation's findings, it is possible that the increase in seed cotton yield will occur concurrently due to coinheritance.

The number of bolls per plant, ginning out turn (%), number of seeds per boll, number of monopods and seed cotton yield (g) were significantly correlated with biochemical parameters, viz. oil content (%), protein content (%) and gossypol content (%). The significance of protein content (%), from its role as a key source of protein for vegetarians. However, there is a negative correlation between seed cotton yield (g), protein, oil and gossypol concentration. As a result, direct selection for these traits using seed cotton yield (%) is not practicable. Selection for a genotype with a moderate seed cotton yield, a low gossypol concentration and a high oil (%) and protein content (%). Rai and Sangwan (2020) and Jangid *et al.* (2022) reported similar findings. Considering the fibre quality parameters, fibre length, uniformity and fibre strength exhibited non-significant negative association with seed cotton yield (g), whereas fibre maturity (0.067) and fibre fineness (0.087) established a positive but non-significant relationship with it.

The negative association between quality and yield implies that selection must be done extremely precisely, as focusing only on one attribute will worsen the other. The relationship between the loci of fibre quality traits and seed cotton yield could explain the negative association. To break this association, Clement *et al.* (2012) propose selecting outliers with greater fibre length, strength, fineness and seed cotton yield and then employing these outlier lines in a recurrent selection program. Satish *et al.* (2020) discovered that fibre quality parameters did not substantially correlate with seed cotton yield. The interrelationships between the features were also investigated and it was discovered that the number of bolls per plant correlated positively with the number of seeds per boll, ginning out turn (%) and number of monopods per plant, but negatively with fibre quality measures. Quality parameters have a positive relationship with one another. This means that by enhancing one quality

attribute, other traits may improve automatically and simultaneously. Nandhini *et al.* (2019) also discovered a association between fibre strength, fibre length, and uniformity ratio. Fig. 2 depicts the mean performance of all genotypes for seed cotton yield (g) and different fibre quality characteristics.

Path coefficient analysis:

Correlation gives the association between the traits while the path analysis was used to evaluate the direct and indirect effects of different components traits on seed cotton yield.

In the present study the maximum positive direct effect on seed cotton yield was observed in the number of bolls per plant (0.57), succeeded

by boll weight (0.334), ginning outturn (0.114), and the number of monopods (0.107). While the highest negative direct effect was demonstrated by plant weight (-0.114), followed by gossypol content (-0.122), days to first flower (-0.088), number of locules per bolls (-0.055), and protein content (-0.090) (Table 2). Seed index displayed a positive indirect effect through the number of bolls per plant (0.154), boll weight (0.027), and number of seeds per boll (0.017). Conversely, it exhibited negative indirect effects through the number of locules per boll, oil content (%), fibre uniformity, fibre fineness, and fibre maturity, although these effects were minimal. Similar findings were reported by Hasan and Latha (2017), Chaudhari *et al.* (2017). Mahdy *et al.* (2021), highlighting positive direct and indirect impacts of the number of bolls and boll weight on seed cotton yield (g).

Through the number of bolls per plant, boll weight, seed index, plant height and number of seeds per boll, ginning out turn, the number of locules per boll and the number of monopods had a postive indirect effect on seed cotton yield, however, the number of locules per boll showed a negligible positive indirect effect (Table 2). Babu *et al.* (2017) also emphasize the number of bolls and boll weight for improving yield per plant. This study has brought clarity to the importance of traits like the number of bolls per plant, number of monopods and ginning outturn (%). These traits had a highly significant positive association with seed cotton yield, featuring direct positive effects and positive effects association with seed yield, featuring direct positive indirect effects on various other traits related to seed cotton yield. Prioritizing number of bolls per plant, number of monopods and ginning outturn (%) in the selection process, alongside other like seed index (g) and number of seed per boll, can contribute to the improvement in cotton. The focused approach in the selection process aims to develop high-yielding varieties that would ultimately benefit cotton farmers.

The number of bolls per plant, ginning out turn, number of seeds per boll, number of monopods per plant, and oil content all showed a positive indirect effect of fibre fineness

Table 1 Phenotypic correlation studies of various characters with seed cotton yield

Trait	DFF	SI	BW	PH	NOB	GOT	NOS	NOL	NOM	OIL	GC	PC	FL	FU	FS	FF	FM	SCY
DFF	1																	
SI	-0.091	1																
BW	-0.198*	0.098	1															
PH	0.111	-0.109	-0.031	1														
NOB	-0.036	0.268**	-0.225**	-0.441**	1													
GOT	-0.221**	0.065	0.351**	-0.272**	0.361**	1												
NOS	-0.052	0.171*	0.103	-0.201*	0.365**	0.350**	1											
NOL	-0.069	0.038	0.127	-0.165*	0.205*	0.214**	0.436**	1										
NOM	-0.151	0.229**	0.248**	-0.406**	0.462**	0.447**	0.374**	0.252**	1									
OIL	-0.084	-0.039	0.008	0.309**	-0.259**	-0.104	-0.203*	-0.131	-0.155	1								
GC	-0.039	-0.097	-0.019	0.069	-0.248**	-0.164*	-0.260**	-0.128	-0.223**	0.102	1							
PC	0.171*	-0.129	-0.175*	0.403**	-0.201*	-0.241**	-0.185*	-0.202*	-0.311**	0.306**	0.043	1						
FL	0.029	-0.001	-0.071	-0.033	-0.06	-0.165*	-0.096	-0.069	-0.075	0.008	-0.041	0.035	1					
FU	-0.075	0.037	0.171*	0.223**	-0.098	0.029	-0.148	-0.123	0.059	0.309**	-0.02	0.123	0.580**	1				
FS	0.195*	-0.022	-0.258**	-0.131	-0.007	-0.279**	-0.038	-0.017	-0.175*	-0.188*	-0.054	0.013	0.754**	0.034	1			
FF	-0.195*	0.086	-0.004	0.055	0.128	0.116	0.103	0.087	0.105	0.285**	0.011	0.056	-0.730**	-0.314**	-0.581**	1		
FM	0.199*	-0.026	-0.072	-0.043	0.093	0.028	0.03	-0.045	0.087	0.08	0.031	0.089	-0.128	-0.097	-0.064	0.057	1	
SCY	-0.226**	0.353**	0.288**	-0.521**	0.714**	0.576**	0.448**	0.250**	0.631**	-0.200*	-0.334**	-0.333**	-0.046	-0.013	-0.102	0.087	0.067	1

**Significant at 1% and *Significant at 5%. DFF, Days to first flower; BW, Boll weight (g); PH, Plant height (cm); NOS, Number of seed per boll; GOT, Ginning out turn (%); SI, Seed index (g); NOB, Number of bolls per plant; NOL, Number of locules per boll; NOM, Number of monpods per plant; OIL, Oil content (%); GC, Gossypol content (mg/g); PC, Protein content (%); SCY, Seed cotton yield, FF, Fibre fineness (μ /inch); FS, Fibre strength (g/tax); FL, Fibre length (mm); FU, Fibre uniformity (%) and FM, Fibre maturity (%).

Table 2 Pooled direct (diagonally) or indirect (off the diagonal) effects of various traits contributing to seed cotton yield

Trait	DFF	SI	BW	PH	NOB	GOT	NOS	NOL	NOM	OIL	GC	PC	FL	FU	FS	FF	FM	SCY
DFF	-0.088	-0.011	-0.063	-0.014	-0.006	-0.028	-0.005	0.004	-0.017	-0.007	0.006	-0.005	0.001	0.004	0.003	0.009	0.008	-0.226
SI	0.011	0.091	0.027	0.016	0.154	0.009	0.016	-0.004	0.027	-0.003	0.013	0.003	0.000	-0.002	0.000	-0.005	-0.002	0.353
BW	0.017	0.007	0.334	0.003	-0.131	0.040	0.010	-0.008	0.026	0.001	0.001	0.005	-0.001	-0.008	-0.003	0.000	-0.002	0.288
PH	-0.009	-0.010	-0.007	-0.144	-0.256	-0.031	-0.017	0.009	-0.044	0.025	-0.010	-0.011	-0.001	-0.009	-0.002	-0.003	-0.002	-0.521
NOB	0.001	0.025	-0.077	0.065	0.570	0.040	0.031	-0.011	0.049	-0.021	0.032	0.005	-0.001	0.004	0.000	-0.005	0.004	0.714
GOT	0.022	0.007	0.117	0.039	0.199	0.114	0.031	-0.011	0.048	-0.009	0.018	0.007	-0.003	-0.001	-0.003	-0.006	0.001	0.576
NOS	0.005	0.016	0.037	0.027	0.199	0.040	0.089	-0.024	0.041	-0.016	0.030	0.005	-0.002	0.007	-0.001	-0.005	0.001	0.448
NOL	0.007	0.006	0.047	0.024	0.114	0.023	0.038	-0.055	0.027	-0.011	0.015	0.006	-0.001	0.005	0.000	-0.004	-0.001	0.25
NOM	0.014	0.023	0.080	0.059	0.262	0.051	0.034	-0.014	0.107	-0.012	0.026	0.009	-0.002	-0.002	-0.002	-0.005	0.003	0.631
OIL	0.007	-0.004	0.003	-0.045	-0.148	-0.012	-0.018	0.007	-0.016	0.082	-0.012	-0.009	0.000	-0.014	-0.002	-0.013	0.003	-0.2
GC	0.004	-0.010	-0.003	-0.012	-0.148	-0.017	-0.022	0.007	-0.022	0.008	-0.122	-0.001	-0.001	0.001	-0.001	-0.001	0.001	-0.334
PC	-0.015	-0.011	-0.060	-0.056	-0.108	-0.030	-0.017	0.012	-0.033	0.025	-0.006	-0.029	0.001	-0.005	0.000	-0.002	0.003	-0.333
FL	-0.005	-0.002	-0.020	0.004	-0.034	-0.019	-0.009	0.003	-0.009	0.002	0.007	-0.001	0.019	-0.027	0.009	0.034	-0.003	-0.046
FU	0.007	0.004	0.057	-0.030	-0.051	0.002	-0.013	0.006	0.005	0.025	0.002	-0.003	0.012	-0.045	0.001	0.015	-0.004	-0.013
FS	-0.020	-0.004	-0.083	0.019	0.000	-0.032	-0.004	0.001	-0.019	-0.015	0.009	-0.001	0.015	-0.003	0.012	0.027	-0.001	-0.102
MIC	0.018	0.009	0.000	-0.010	0.063	0.015	0.011	-0.004	0.012	0.023	-0.002	-0.001	-0.015	0.015	-0.007	-0.046	0.001	0.087
FM	-0.019	-0.005	-0.020	0.007	0.063	0.002	0.004	0.002	0.009	0.006	-0.002	-0.003	-0.002	0.004	0.000	-0.002	0.037	0.067

R= 0.18. DFF, Days to first flower; SI, Seed index (g); BW, Boll weight (g); PH, Plant height (cm) (%); NOB, Number of bolls per plant; GOT, Ginning out turn (%); NOS, Number of seed per boll; NOL, Number of locules per boll; NOM, Number of monopods per plant; OIL, Oil content (%); GC, Gossypol content (mg/g); PC, Protein content (%); FL, Fibre length (2.5% span length) (mm); FU, Fibre uniformity (%); FS, Fibre strength (g/tax); FF, Fibre fineness (μ /inch); FM, Fibre maturity (%) and SCY, Seed cotton yield.

and fibre maturity on seed cotton yield; however, the fibre length, gossypol content, and protein content showed a negative indirect effect on seed cotton yield (Table 2). Similar results were obtained by Chaudhari *et al.* (2017), who found that variables related to fibre quality show a negative correlation, either directly or indirectly, with seed cotton yield. The residual effect was found to be 0.18, indicating that variables that were considered reliable were being impacted by traits or factors other than those under study, specifically seed cotton yield per plant. Based on the data, it was shown that the seed cotton yield per plant had a negative correlation with biochemical and fibre quality parameters and significantly and favourably correlated with all other traits, with the exception of days to first flower and plant height. Hence, by enhancing number of bolls per plant, boll weight (g), GOT (%) and number of monopods per plant, seed cotton yield per plant will increase. Fibre quality characteristics, such as fibre length, showed a strong positive correlation with fibre strength but a negative correlation with seed cotton yield, indicating that one must compromise on quality in order to improve quantity.

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