Environment Conservation Journal 24 (2):70-76, 2023

Journal homepage:https://www.environcj.in/

Environment Conservation Journal

ISSN 0972-3099 (Print) 2278-5124 (Online)

Association and path analysis studies for yield contributing and fibre quality traits in the F_1 population of *Gossypium hirsutum* L.

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ARTICLE INFO

Received : 13 July 2022
Revised : 27 October 2022
Accepted : 28 October 2022

Available online: 09 March 2023

Key Words:
Association studies
path analysis
correlation in cotton hybrids

ABSTRACT

The present investigation on correlation and path analysis studies helps to study the relationship among the yield and yield contributing traits along with the quality parameters. The observations were taken in the F_1 population of 35 hybrids along with lines (7 lines) and testers (5 testers) for the traits *viz.* plant height (cm), number of sympodial branches per plant, the number of bolls per plant, boll weight (g), lint index (g), single cotton yield per plant (g), ginning outturn (%), upper half mean length (cm), elongation percent (%) and micronaire value (µg per inch). The results revealed that seed cotton yield per plant had strong and positive association with the traits namely number of sympodial branches per plant (0.646), number of bolls (0.633) and boll weight (0.652). Path analysis study revealed that number of sympodial branches per plant (1.5396), boll weight (0.6285), lint index (1.3526) and upper half mean length (0.3392) had high direct positive effects on single plant yield and indirect very high positive effects through the traits *viz.*, number of sympodial branches per plant *via.*, number of bolls per plant (1.5125) and boll weight (1.0121). Hence selection based on these traits that are positively associated and direct positive effect with the yield would produce the best outcome in the genotypes in further breeding programmes.

Introduction

Cotton (*Gossypium hirsutum* L.), often known as "White Gold" belong to Malvaceae family which is mostly farmed in the tropics and subtropics as a fibre crop. Cotton enhancement programmes all around the world have always adapted to the demands of the market as suggested by Faylet *et al.* (2014). Farmers and industries worked together to achieve a high output while maintaining decent fibre quality. India is a country where a major goal is to create high-yielding cotton types with improved fibre quality. Many cotton improvement programmes have this as their goal. Among the species of cotton, *G. hirsutum* was estimated to account 90% of world commerce from its highly improved modern cultivars. The current study also aims to investigate the relationship between various yield and fibre quality factors in order to strengthen the cotton breeding research.

Correlation studies in plant breeding open the path for a deeper understanding of the relationship. Association studies between highly heritable traits and the most economic ones such as fibre quality provide superior results comprehending the role of

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each attribute in the development of the crop's genetic make-up. When selecting plants for breeding, there is an indirect association between the different characters under study. Path coefficient analysis is a useful tool for selection since it divides the correlation into segments of both direct and indirect components.

Material and Methods

The present study was carried out at Department of Cotton, Tamilnadu Agricultural University, Coimbatore - 03 during 2021. The F_1 hybrids were obtained by the crosses made between lines (BSH 18, MCU 5, CO 14, CO 17, TCH 1828, TCH 1199 and Suraj) and testers (KC2, KC 3, GTHV 15-32, GISV 323 and RHC 1409). Spacing of 120x 60 cm was followed and one plant per hill was maintained. All agronomic and cultural operations were completed on schedule. The data was collected in the F_1 hybrids for the following characters namely, days to first flowering (days), plant height (cm), number of monopodial branches per plant, number of sympodial branches per plant, the number of bolls per plant , boll weight (g), number of locules per boll, seed index (g), lint index (g), 100 seed weight (g), seed cotton yield per plant (g), ginning outturn (%), upper half mean length (mm), uniformity index (%), bundle strength (g/tex), elongation percent (%) and micronaire value (µg per inch). Correlation studies were done using the SPSS software 16.0 and the path analysis was carried out in the TNAU STAT developed by Manivannan (2014).

Results and Discussion

Correlation

Correlation helps to identify the linear association between different traits statistically hence the selection could be made effective through direct selection of the trait. Correlation identifies the relationship between yield and its attributing traits and paves way for indirect selection of best genotype. In this study, days to first flowering showed negative significant correlation with boll weight (-0.468) and seed cotton yield per plant (-0.436). The character, number of sympodial branches per plant (0.547) was found to be positively and highly significantly associated with the plant height as reported by Gauswami Jyoti *et al*. (2021), Attiq Ur Rehman Gohar, M. (2020) and Rai *et al*. (2020) . The trait plant height exhibited positive highly significant value with the traits *viz*, number of bolls per plant (0.541) and boll weight (0.628) as reported by Mudhalvan *et al.,*(2021) and number of locules per boll (0.550). The trait number of sympodial branches increases with the increase in height of the plant, thereby indirectly contributing to the yield of cotton. Hence farmers would fetch more income with the increase in number of bolls per plant and boll weight with the increase in number of sympodial branches. Number of monopodial branches per plant had negative and highly significant correlation with various traits *viz.,* boll weight (-0.325), ginning outturn (-0.398), upper half mean length (-0.427) and uniformity index (-0.462). The same trait contributed negative correlation with bundle strength (-0.297) and positive correlation with seed index (0.380). Number of sympodial branches per plant showed positive highly significant correlation with number of bolls per plant (0.982) as reported by Monisha *et al*., (2018) and Baloch *et al.* (2020). Number of bolls would channelize to the increased fibre yield of cotton hence favouring the textile industries with higher outcomes of yarn. Same trait also had positive significant correlation with the traits *viz.,* boll weight (0.657) and number of locules per bolls (0.526). The trait number of bolls per plant had positive and highly significant value with boll weight (0.670) and number of locules per boll (0.534). The boll weight per plant showed positive correlation value with the traits namely, number of locules per boll (0.683) and uniformity index (0.314). The trait number of locules per boll revealed positive correlation value for the traits *viz.,* upper half mean length (0.288), uniformity index (0.391) and seed yield of cotton (0.559). The trait seed index reported negative highly significant correlation with two traits, ginning outturn (-0.672) and elongation percent (-0.372). The same trait was found to have positive correlation value with lint index (0.448) and micronaire value (0.301). The traits ginning outturn (0.358) and upper half mean length (0.326) have positive significant correlation with lint index. The trait upper half mean length showed positive and significant correlation with bundle strength (0.456) and negative significant correlation with micronaire value (-0.370).The bundle strength exhibited highly significant positive

Table 1: Phenotypic correlation of 35 F_1 hybrids for yield , yield attributing and fibre quality characters in cotton (*Gossypium hirsutum* L.)

	DFF	PH	M	S	NB	BW	NLB	SI	LI	GOT	UHML	UI	STR	EL	MIC	Y
DFF	1															
PH	-0.068	1														
M	0.234	0.063	1													
S	-0.268	.547**	-0.248	1												
NB	-0.26	.541**	-0.202	.982**	1											
BW	-.468**	.628**	-.325*	.657**	.670**	1										
NLB	-0.274	.550**	-0.151	.526**	.534**	.683**	1									
SI	-0.11	.318*	.380**	0.032	0.025	0.039	0.136	1								
LI	-0.042	0.268	0.003	0.037	0.012	-0.013	0.012	.448**	1							
GOT	0.071	-0.104	-.398**	-0.004	-0.016	-0.046	-0.123	-.672**	.358*	1						
UHML	-0.229	-0.039	-.427**	0.123	0.108	0.212	.288*	-0.009	.326*	0.28	1					
UI	-0.149	0.15	-.462**	0.147	0.14	.314*	.391**	-0.104	-0.033	0.092	0.095	1				
STR	-0.131	-0.101	-.297*	0.087	0.068	0.218	0.236	-0.134	-0.132	0.033	.456**	0.242	1			
EL	-0.16	-0.133	-0.274	0.239	0.267	0.171	0.135	-.372**	-0.139	0.283	0.234	0.237	.444**	1		
MIC	-0.12	0.09	.377**	-0.135	-0.1	-0.123	-0.179	.301*	0.065	-0.261	-.370**	-0.095	-.434**	-0.242	1	
Y	-.436**	0.214	-0.24	.646**	.633**	.652**	.559**	-0.014	-0.018	-0.007	.414**	0.217	.321*	.402**	-0.048	1

****. Correlation is significant at the 0.01 level (2-tailed).**
***. Correlation is significant at the 0.05 level (2-tailed).**

DFF: Days to first flowering
M: Number of monopodial branches (nos.)
PH: Plant height (cm)
S: Number of sympodial branches (nos.)
GOT: Ginning outturn (%)
SI: Seed index (g)
LI: Lint Index (g)
EL: Elongation percent (%)
NBPP: Number of bolls per plant (Nos.)
NLB: Number of locules per boll (nos.)
Y: Seed Cotton yield per plant (g)
BW: Boll Weight (g)
UHML: Upper Half Mean Length (mm
MIC: Micronaire value (µg/inch)
UI: Uniformity index (%)
STR: Bundle strength (g/tex)

correlation with elongation percent (0.444) and negative correlation with micronaire value (-0.434). The seed cotton yield per plant showed positive significant values with the quality parameters *viz.,* upper half mean length (0.414), bundle strength (0.321) and elongation percent (0.402). The single plant yield showed highly positive significance for the trait number of sympodial branches per plant (0.646) as reported by Kakar *et al.* (2021) and Rehman *et al.* (2020). Number of bolls per plant (0.633), boll weight (0.652) as reported by Nikhil *et al*. (2018) and Baloch (2015) showed highly positive significance correlation for single plant yield. Similarly the same traits *viz.,* number of bolls per plant, boll weight and number of sympodial branches per plant exhibited a significant positive correlation with seed cotton yield per plant as reported by Mudasir *et al*. (2021), Hampannavar et al. (2020), Saritha *et al*. (2019) and Handi (2017). Hence it was evident that breeding of a particular trait would increase the related traits that contributes to the increased seed cotton yield per plant.

Path analysis

Path analysis was used to assess the partitioning of the correlation coefficient of different components with different yield and quality traits into direct and indirect effects. Trait analysis on a path which has a direct influence on single plant yield output may be deemed the best selection criteria for increasing the population's yield output.Direct effect refers to the influence of an independent character on the dependent character, whereas indirect effect refers to the effect of an independent character on the dependent character via other independent traits.

Direct effects

From the table 2, among the characters, number of sympodial branches per plant (1.5396) had very high direct positive effect on yield per plant followed by lint index (1.3526), this was in accordance with the findings of Monicashree *et al*. (2018). Similar result of high direct effect of number of sympodial branches per plant was reported by Arunkumar *et al.* (2020) and Manonmani *et al*. (2019). Direct effect relates to the trait that directly contributes to the dependent trait *i.e.,* yield of the crop. Hence by selection of higher number of sympodial branches per plant, seed cotton yield per plant could be maximized. High direct effect for seed cotton yield was also recorded through the traits namely boll weight (0.6285) and upper half mean length (0.3392). Increasing the boll weight and upper half mean length the increased seed cotton yield could be obtained.The traits *viz.,* number of monopodial branches per plant (0.2828), elongation percent (0.2096) and micronaire value (0.2835) exhibited moderate positive direct effect on yield. High negative direct effect on single plant yield was contributed by plant height (-0.5029) as reported by Arunkumar *et al.* (2020) and Jangid, K. (2019). Increased plant height do not favour to the yield of the crop, hence it had high negative direct effect. Hence selection should not be performed for higher plant height. The traits seed index (-1.7377), number of bolls per plant (-1.1177) and ginning outturn (-1.6504) revealed negative high direct effect with seed cotton yield per plant The remaining characters exhibited only low and negligible direct effects on the single plant yield. The path analysis of 35 F_1 hybrids has the residual effect of 0.4225.

Indirect effects

Positive very high indirect effect for number of sympodial branches per plant with single plant yield *via* the trait boll weight (1.0121) was high through the traits number of bolls per plant (1.5125) which was similar as reported by Satish *et al*. (2020). The same trait reported positive high indirect effect with single plant yield through the traits *viz.,* plant height (0.8424) as reported by Farooq *et al.* 2018, Gulhane and Wadikar *et al.* 2017 and further also with the traits, number of locules per boll (0.8099) and elongation percent (0.3686). High indirect positive effect suggested that selection made for the aforementioned traits would contribute indirectly to seed cotton yield through other traits. The number of bolls per plant exhibited negative very high indirect effect through the trait sympodial branches per plant (-1.0979) and high indirect negative effect through the trait boll weight (-0.7492) and number of locules per boll (-0.5963). Boll weight contributed high indirect positive effect linking through the traits *viz*., plant height (0.3946), number of sympodial branches per plant (0.4132), number of bolls per plant (0.4213) and number of locules per boll (0.4296). Very high positive indirect effect of seed index with single plant yield was high through the trait ginning out turn (1.1672) and high positive

Table 2: Phenotypic path analysis of 35 F_1 hybrids for yield, yield attributing and fibre quality characters in cotton (*Gossypium hirsutum* L.)

	DFF	PH	M	S	NB	BW	NLB	SI	LI	GOT	UHML	UI	STR	EL	MIC	Y
DFF	**0.0614**	0.0342	0.0662	-0.412	0.2909	-0.2941	-0.047	0.1917	-0.0568	-0.1178	-0.0775	-0.0091	0.0016	-0.0336	-0.034	-0.436
PH	-0.0042	**-0.5029**	0.0178	0.8424	-0.605	0.3946	0.0944	-0.5528	0.3629	0.1721	-0.0134	0.0092	0.0012	-0.0279	0.0256	0.2138
M	0.0144	-0.0316	**0.2828**	-0.382	0.2254	-0.2041	-0.026	-0.6604	0.0045	0.6573	-0.1448	-0.0284	0.0036	-0.0574	0.107	-0.2398
S	-0.0164	-0.2751	-0.0702	**1.5396**	-1.0979	0.4132	0.0903	-0.055	0.0497	0.0064	0.0416	0.009	-0.0011	0.0502	-0.0384	0.6459
NB	-0.016	-0.2722	-0.057	1.5125	**-1.1177**	0.4213	0.0915	-0.0438	0.0162	0.0261	0.0365	0.0086	-0.0008	0.056	-0.0283	0.633
BW	-0.0287	-0.3157	-0.0918	1.0121	-0.7492	**0.6285**	0.1173	-0.0685	-0.0173	0.0755	0.0721	0.0193	-0.0026	0.0358	-0.0348	0.6517
NLB	-0.0168	-0.2766	-0.0428	0.8099	-0.5963	0.4296	**0.1716**	-0.2356	0.0162	0.2035	0.0976	0.0241	-0.0029	0.0282	-0.0508	0.5588
SI	-0.0068	-0.16	0.1075	0.0488	-0.0282	0.0248	0.0233	**-1.7377**	0.6064	1.1086	-0.0029	-0.0064	0.0016	-0.0781	0.0854	-0.0137
LI	-0.0026	-0.1349	0.0009	0.0566	-0.0134	-0.008	0.0021	-0.7791	**1.3526**	-0.5916	0.1105	-0.002	0.0016	-0.0291	0.0185	-0.018
GOT	0.0044	0.0524	-0.1126	-0.006	0.0177	-0.0287	-0.0212	1.1672	0.4849	**-1.6504**	0.095	0.0056	-0.0004	0.0593	-0.0741	-0.0069
UHML	-0.014	0.0199	-0.1207	0.1888	-0.1204	0.1335	0.0494	0.0149	0.4408	-0.4622	**0.3392**	0.0059	-0.0055	0.0489	-0.1049	0.4136
UI	-0.0091	-0.0752	-0.1306	0.2264	-0.1566	0.1971	0.0672	0.1807	-0.0451	-0.1514	0.0323	**0.0614**	-0.0029	0.0497	-0.0268	0.2171
STR	-0.008	0.0509	-0.084	0.1341	-0.0765	0.1373	0.0405	0.2331	-0.1788	-0.0546	0.1547	0.0149	**-0.0121**	0.0931	-0.1231	0.3212
EL	-0.0099	0.067	-0.0775	0.3686	-0.2988	0.1073	0.0231	0.6472	-0.1879	-0.4669	0.0792	0.0146	-0.0054	**0.2096**	-0.0685	0.4019
MIC	-0.0074	-0.0454	0.1067	-0.2084	0.1115	-0.0772	-0.0307	-0.5233	0.0881	0.4314	-0.1255	-0.0058	0.0053	-0.0506	**0.2835**	-0.0479

Residual effect = 0.4225

DFF: Days to first flowering
M: Number of monopodial branches (nos.)
PH: Plant height (cm)
S: Number of sympodial branches (nos.)
GOT: Ginning outturn (%)
SI: Seed index (g)
LI: Lint Index (g)
EL: Elongation percent (%)
NBPP: Number of bolls per plant (Nos.)
NLB: Number of locules per boll (nos.)
Y: Seed Cotton yield per plant (g)
BW: Boll Weight (g)
UHML: Upper Half Mean Length (mm
MIC: Micronaire value (µg/inch)
UI: Uniformity index (%)
STR: Bundle strength (g/tex)

Indirect effect through the trait elongation percentage (0.6472). The same trait had negative high indirect effect via the traits *viz*., plant height (-0.5528), number of monopodial branches per plant (-0.6604), lint index (-0.7791) and micronaire value (-0.5233). Positive high indirect effect of lint index was contributed via the traits *viz*., plant height (0.0629), ginning outturn (0.4849) and upper half mean length (0.4408). Very high positive indirect effect of ginning outturn was high channelizing through the trait seed index (1.1086) and high positive indirect effect *via.,* number of monopodial branches per plant (0.6573) and micronaire value (0.4314) for the seed cotton yield of the plant. The same trait contributed negative high indirect effect to the traits namely, lint index (-0.5916), upper half mean length (-0.4622) and elongation percent (-0.4669). High indirect negative effect for seed cotton yield per plant was contributed by the trait boll weight through plant height (-0.3157). Moderate indirect negative effect for single plant yield was contributed through the trait plant height *via.,* the trait sympodial branches (-0.2751) and also for the traits *viz*., number of bolls per plant (-0.2722) and number of locules per boll (-0.2766).

Hence from the studies of correlation and path analysis, the most promising traits that enhances the yield could be identified and the selection criteria based on those traits would confer desirable genotypes. The traits namely, number of sympodial branches per plant, number of bolls per plant and boll weight had greatest impact on the yield of the cotton which had positive correlation with direct and indirect effects on increasing the yield of cotton. Hence, correlations and direct and indirect effects estimation would provide useful information for planning a successful breeding programme for simultaneously enhancing both yield and fibre quality traits through selection of these traits.

Conclusion

As a concluding remark, seed cotton yield per plant showed strong and positive association with the traits namely number of sympodial branches per plant, number of bolls per plant and boll weight. Path analysis study revealed that number of sympodia, lint index, boll weight and upperhalf mean length had direct high positive effects on single plant yield and indirect high positive effects through the traits *viz.,* plant height *via.,* number of sympodial branches per plant and boll weight) and number of sympodial branches per plant *via.,* the traits namely, number of bolls per plant, boll weight, number of locules per boll and elongation percent. High indirect positive effect on seed cotton yield per plant for number of bolls per plant was directed *via* the traits *viz.,* boll weight and number of locules per boll and also ginning outturn *via* seed index. Hence these characters can be accounted as the best criterion for selection of yield enhancing traits in further breeding programmes. As a result, the current study, which was based on correlation and path co-efficient analysis, confined that simultaneous selection based on important yield traits in terms of yield and quality attributes may be promising.

Acknowledgement

I sincerely thank my friends and professors in my department who helped and guided me through the research.

Conflict of interest

The authors declare that they have no conflict of interest.

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