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Path Coefficient Analysis Studies for Yield and Yield Contributing and Fibre Quality Traits in Cotton (*Gossypium hirsutum* L.)

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A B S T R A C T

Seed cotton yield and fibre quality traits are governed by polygenes and these traits are highly influenced by the environment. Hence, selection merely based on yield is not effective. In order to enhance the yield potential of the cotton varieties, knowledge on the direct contribution of different characters to yield would be highly important for formulating a selection programme. The path analysis study indicated that the selection based on plant height, number of sympodia per plant, days to 50% boll bursting, number of bolls per plant, lint yield per plant will improve the seed cotton yield per plant as high direct effect were reported by these traits. The fibre quality traits micronaire, fibre strength and elongation % were also had high direct effect on seed cotton yield per plant. Therefore these characters may be considered as the most important yield contributing characters and due emphasis should be placed on these characters while breeding for high seed cotton yield in cotton.

Introduction

Cotton (*Gossypium spp.* 2n = 4x = 52) is grown in largest quantity in the world more concentrated in countries like China, United States, India, Pakistan and Brazil in the tropical and sub-tropical regions of more than 80 countries, and other are depend heavily on cotton for earning foreign exchange. Cotton is one of the top most cash crops and it is considered as a main pillar of textile industry. It is world's most utilized natural textile fibre crop. No agricultural commodities in the world have exercised such a profound influence on men and matters as cotton has done from times immemorial. India has a pride place in the global cotton scenario, it has the distinction of having the largest cotton area of 120.64 lakh hectares, production of 358.70 lakh bales (1 bale= 170 kg lint) (Anonymous, 2018).

The path coefficient analysis, a statistical device developed by Wright (1921), which takes into account the cause and effect relation between the variables is unique in partitioning the association into direct and indirect effect through other independent variables. The path coefficient analysis also measures the relative importance of causal

factors involved. This is simply a standard partial regression analysis, wherein total correlation value is sub-divided into causal scheme. Path diagram facilitates the understanding of the nature of cause and effect system. Path coefficient analysis helps in giving the weightage to particular character during the selection.

The primary objective of this study was to measure the direct and indirect effects of various traits on seed cotton yield. Such information can be useful in articulating efficient selection program for development of new promising cotton varieties with improved yield.

Materials and Methods

The present investigation was undertaken during *kharif* 2018. Field work was carried out at the experimental farm of Cotton Research Station, Nanded. The experimental material included in the present study comprised of eight parents *viz*., NDLH-2028, AKH-09-05, ARBC-1551, LHDP-1, SCS-1061, AC-738, NH-615 and GSHV-180 having wide diversity, are mated in diallel fashion to obtain fifty six crosses. These hybrids along with their Parents and Standard checks were grown in randomized block design in *kharif* 2018.

The observation were recorded on various morphological characters like plant height (cm), number of monopodia per plant, number of sympodia per plant, days to 50% flowering, days to 50 boll bursting, days to maturity. In addition to this yield and yield contributing and economic character like seed cotton yield per plant (g), lint yield/plant (g), number of bolls per plant, average boll weight (g), bartlett's index, ginning outturn (%), lint index, seed index, harvest index and fibre quality parameters *viz.*, upper half mean length (mm), fibre strength (g/taex^{-1}), micronaire value (µg/inch), uniformity ratio (%) and elongation % were also studied.

The correlation coefficient measures the relationship existing between pairs of character. But, a dependent character is an interaction production of many mutually, associated component characters and change in any one component will disturb whole network of cause and effect system.

In order to study the cause and effect, the genotypic correlation coefficients between yield and its components were further partitioned into direct and indirect effects with the help of path coefficient analysis originally suggested by Wright (1921) and further outlined by Dewey and Lu (1959).

Results and Discussion

The nature and extent of direct and indirect contributions of different traits to seed cotton yield per plant are presented in Table 1, and the same have been described in the following paragraphs.

From the results on path coefficient analysis, the residual effect of (0.4367 for genotypic path and 0.7694 for phenotypic path) indicates that most of characters contributing to the improvement of seed cotton yield per plant have been accounted for making the results more reliable and realistic.

The character plant height (G=0.4489, P=0.2803), days to 50% boll bursting (G=0.1573), P=0.0143), GOT% (G=0.0560, P=0.0663), lint yield per plant (G=0.5542, P=0.3223), number of bolls per plant (G=0.0888, P=0.1742), micronaire (G=0.9955, P=0.1497) and GOT% had exerted positive and direct effect on seed cotton yield per plant at both genotypic and phenotypic level.

Table.1 Direct and indirect (Genotypic and Phenotypic) effect of twenty characters with seed cotton yield per plant

Character		Plant height (cm)	Monopodia/ Plant	Sympodia/ Plant	Days to 50% flowering	Days to 50% boll bursting	Days to Maturity	Bartlett's index	GOT%	Lint Index	Seed index	**SC Yield/ Plant (g)**
Plant height (cm)	G	**0.4489**	0.0765	0.2608	0.0538	0.1326	0.1361	0.0150	0.0106	0.1360	0.2333	**0.4217**
	P	**0.2803**	0.0295	0.1167	0.0327	0.0247	0.0177	-0.0068	-0.0125	0.0496	0.1058	**0.2350**
No. of Monopodia/ Plant	G	-0.0323	**-0.1892**	-0.1146	-0.0072	-0.0053	-0.1106	-0.0022	-0.0898	-0.0487	-0.0258	**0.2655**
	P	0.0087	**0.0828**	0.0365	0.0043	0.0033	0.0271	0.0002	0.0246	0.0066	0.0015	**0.1823**
No. of Sympodia/ Plant	G	0.1292	0.1347	**0.2224**	0.0591	-0.0445	0.1115	-0.0532	0.0239	0.0743	0.0504	**0.2320**
	P	-0.0372	-0.0393	**-0.0892**	-0.0161	0.0084	-0.0185	0.0116	-0.0074	-0.0112	-0.0073	**0.1342**
Days to 50% flowering	G	-0.0572	-0.0183	-0.1269	**-0.4775**	-0.1747	-0.1735	0.3754	0.1803	0.1765	0.1090	**-0.3360**
	P	-0.0387	-0.0173	-0.0598	**-0.3319**	-0.0610	-0.0517	0.2104	0.0672	0.0937	0.0457	**-0.3002**
Days to 50% boll bursting	G	0.0464	0.0044	-0.0315	0.0575	**0.1573**	0.0518	-0.0066	-0.0071	-0.0384	0.0180	**-0.0736**
	P	0.0013	0.0006	-0.0013	0.0026	**0.0143**	0.0040	-0.0002	0.0004	-0.0026	-0.0015	**-0.0453**
Days to Maturity	G	0.0085	0.0165	0.0141	0.0102	0.0093	**0.0282**	-0.0058	-0.0214	-0.0023	0.0020	**0.0053**
	P	-0.0007	-0.0036	-0.0023	-0.0017	-0.0030	**-0.0109**	0.0011	0.0011	0.0004	-0.0002	**-0.0511**
Bartlett's index	G	-0.0084	-0.0030	0.0599	0.1968	0.0105	0.0515	**-0.2504**	-0.0962	-0.0737	-0.0454	**0.3184**
	P	0.0036	-0.0003	0.0192	0.0937	0.0017	0.0149	**-0.1477**	-0.0417	-0.0291	-0.0156	**0.1997**
GOT%	G	0.0013	0.0266	0.0060	-0.0211	-0.0025	-0.0425	0.0215	**0.0560**	0.0173	0.0070	**0.3691**
	P	-0.0030	0.0197	0.0055	-0.0134	0.0019	-0.0067	0.0187	**0.0663**	0.0005	-0.0081	**0.2651**
Lint Index	G	-0.0471	-0.0401	-0.0520	0.0575	0.0380	0.0125	-0.0458	-0.0481	**-0.1556**	-0.1334	**0.1000**
	P	-0.0017	-0.0008	-0.0012	0.0027	0.0018	0.0003	-0.0019	-0.0001	**-0.0097**	-0.0066	**0.0075**
Seed index	G	-0.2188	-0.0574	-0.0954	0.0961	-0.0482	-0.0297	-0.0764	-0.0525	-0.3609	**-0.4210**	**0.0594**
	P	-0.0635	-0.0030	-0.0138	0.0232	0.0173	-0.0030	-0.0178	0.0207	-0.1149	**-0.1682**	**-0.0158**
Harvest Index	G	0.0230	0.0327	0.0473	0.0301	0.0194	0.0720	-0.0334	-0.0597	0.0041	-0.0020	**0.2216**
	P	-0.0009	-0.0017	-0.0027	-0.0013	-0.0002	-0.0035	0.0020	0.0030	-0.0008	-0.0005	**0.0728**
Lint yield/ plant (g)	G	0.1622	0.1027	0.1066	-0.2394	-0.0993	-0.1289	0.2508	0.3012	0.1286	0.1437	**0.5549**
	P	0.0651	0.0460	0.0675	-0.1042	-0.0267	-0.0250	0.1190	0.1025	0.0409	0.0437	**0.4676**
No. of Bolls/plant	G	0.0281	0.0287	0.0331	-0.0207	-0.0322	-0.0071	0.0199	0.0401	-0.0038	-0.0303	**0.6625**
	P	0.0368	0.0449	0.0476	-0.0227	-0.0225	-0.0076	0.0246	0.0171	0.0025	-0.0060	**0.3905**
Boll weight (g)	G	-0.0411	-0.1730	-0.0508	0.0462	-0.0942	0.0922	-0.1112	-0.3061	-0.0173	0.0124	**0.3647**
	P	-0.0018	-0.0013	-0.0008	0.0005	-0.0009	-0.0006	-0.0011	-0.0023	-0.0007	-0.0006	**0.2084**
UHML (mm)	G	-0.2199	-0.0011	-0.1601	-0.0136	-0.0198	-0.0830	-0.0115	0.0173	-0.0636	-0.2485	**-0.0289**
	P	0.0168	0.0005	0.0047	0.0050	-0.0056	0.0148	-0.0033	-0.0095	0.0095	0.0179	**0.0779**
Micronaire (µg/inch)	G	-0.0882	0.2274	0.0332	0.1156	-0.0387	-0.0927	-0.0180	0.4740	0.0800	0.1064	**0.1830**
	P	-0.0092	0.0253	0.0048	0.0092	-0.0085	-0.0117	0.0033	0.0448	0.0020	0.0131	**0.1247**
Fibre strength (g/tex^{-1})	G	0.1174	0.0816	0.1229	-0.2986	-0.0995	-0.0388	0.2028	0.2190	0.3392	0.3397	**0.3660**
	P	-0.0104	-0.0127	0.0019	0.0263	0.0115	0.0160	-0.0209	-0.0104	-0.0263	-0.0256	**0.0665**
Uniformity Ratio (%)	G	-0.0328	0.0269	-0.0171	-0.0316	-0.0093	0.0049	0.0228	0.0379	-0.0058	-0.0113	**-0.1779**
	P	-0.0099	0.0130	0.0010	-0.0093	-0.0013	-0.0062	0.0085	0.0012	-0.0027	-0.0030	**-0.1405**
Elongation (%)	G	0.2024	-0.0113	-0.0260	0.0506	0.2275	0.1513	0.0247	-0.3104	-0.0860	-0.0445	**-0.0053**
	P	-0.0006	0.0000	-0.0001	0.0001	-0.0006	-0.0006	0.0000	0.0002	-0.0003	-0.0002	**-0.022**

R square = 0.8093, Residual effect =0.4367 for Genotypic and R square = 0.4080, Residual effect =0.7694 for Phenotypic. *P=0.05%, **P=0.01%

Contd… Table 1: Direct and indirect (Genotypic and Phenotypic) effect of twenty characters with seed cotton yield per plant.

Character		Harvest Index	Lint yield/ plant (gm)	No. of Bolls/plant	Boll weight (g)	UHML (mm)	Micronaire (µg/inch)	Fibre strength (g/tex^{-1})	Uniformity Ratio (%)	Elongation (%)	SC Yield/ Plant
Plant height (cm)	G	-0.0958	0.1314	0.1418	0.0503	0.2128	-0.0398	0.1309	0.1255	0.1517	0.4217
	P	-0.0230	0.0566	0.0592	0.0824	0.0418	-0.0172	0.0280	0.0388	0.0609	0.2350
No. of Monopodia/ Plant	G	0.0572	-0.0351	-0.0611	-0.0891	-0.0004	-0.0432	-0.0384	0.0434	0.0036	0.2655
	P	-0.0126	0.0118	0.0213	0.0172	0.0004	0.0140	0.0101	-0.0151	-0.0013	0.1823
No. of Sympodia/ Plant	G	-0.0974	0.0428	0.0829	0.0308	0.0767	0.0074	0.0679	0.0324	-0.0096	0.2320
	P	0.0220	-0.0187	-0.0244	-0.0112	-0.0037	-0.0028	0.0017	0.0013	-0.0027	0.1342
Days to 50% flowering	G	0.1333	0.2063	0.1115	0.0601	-0.0140	-0.0554	0.3544	-0.1287	-0.0403	-0.3360
	P	0.0391	0.1073	0.0432	0.0241	-0.0148	-0.0204	0.0838	-0.0432	0.0069	-0.3002
Days to 50% boll bursting	G	-0.0282	-0.0282	-0.0570	0.0403	0.0067	-0.0061	-0.0389	0.0124	0.0597	-0.0736
	P	-0.0002	-0.0012	-0.0018	0.0020	-0.0007	-0.0008	-0.0016	0.0003	0.0030	-0.0453
Days to Maturity	G	-0.0188	-0.0066	-0.0023	-0.0071	0.0050	-0.0026	-0.0027	-0.0012	0.0071	0.0053
	P	0.0035	0.0008	0.0005	-0.0011	-0.0014	0.0008	0.0017	-0.0009	-0.0021	-0.0511
Bartlett's index	G	-0.0774	-0.1133	-0.0560	-0.0758	-0.0062	0.0045	-0.1262	0.0487	-0.0103	0.3184
	P	-0.0276	-0.0545	-0.0208	-0.0256	0.0043	-0.0032	-0.0296	0.0175	0.0014	0.1997
GOT%	G	0.0309	0.0304	0.0253	0.0466	-0.0021	0.0266	0.0305	-0.0181	-0.0290	0.3691
	P	0.0182	0.0211	0.0065	0.0247	-0.0056	0.0198	0.0066	-0.0011	-0.0052	0.2651
Lint Index	G	0.0059	-0.0361	0.0066	-0.0073	-0.0213	-0.0125	-0.1312	-0.0076	0.0223	0.1000
	P	0.0007	-0.0012	-0.0001	-0.0011	-0.0008	-0.0001	-0.0024	-0.0004	-0.0009	0.0075
Seed index	G	-0.0080	-0.1092	0.1435	0.0142	-0.2255	-0.0450	-0.3554	-0.0404	0.0313	0.0594
	P	0.0080	-0.0228	0.0058	-0.0152	-0.0266	-0.0147	-0.0412	-0.0071	-0.0089	-0.0158
Harvest Index	G	**-0.1080**	-0.0305	-0.0010	-0.0264	0.0198	-0.0118	-0.0362	-0.0037	-0.0063	0.2216
	P	**0.0109**	0.0020	-0.0006	0.0007	-0.0008	0.0004	0.0018	-0.0008	-0.0006	0.0728
Lint yield/ plant (g)	G	0.1565	**0.5542**	0.3261	0.2194	0.1068	-0.0483	0.4712	-0.1316	-0.1406	0.5549
	P	0.0590	**0.3223**	0.1393	0.0696	0.0190	-0.0236	0.1140	-0.0518	0.0053	0.4676
No. of Bolls/plant	G	0.0008	0.0523	**0.0888**	0.0343	-0.0024	0.0077	0.0134	0.0107	-0.0134	0.6625
	P	-0.0093	0.0753	**0.1742**	0.0297	-0.0233	0.0086	0.0061	-0.0017	-0.0075	0.3905
Boll weight (g)	G	-0.0898	-0.1454	-0.1416	**-0.3673**	0.0385	-0.2106	-0.1226	0.1291	0.2166	0.3647
	P	-0.0004	-0.0013	-0.0011	**-0.0062**	0.0002	-0.0013	-0.0008	0.0002	0.0005	0.2084
UHML (mm)	G	0.0852	-0.0894	0.0124	0.0486	**-0.4641**	0.0815	-0.1134	0.0068	-0.2444	-0.0289
	P	-0.0088	0.0067	-0.0151	-0.0028	**0.1130**	-0.0077	0.0097	0.0056	0.0078	0.0779
Micronaire (µg/inch)	G	0.1090	-0.0867	0.0863	0.5709	-0.1749	**0.9955**	-0.2802	-0.2101	-0.6257	0.1830
	P	0.0052	-0.0110	0.0074	0.0312	-0.0102	**0.1497**	-0.0212	-0.0159	-0.0483	0.1247
Fibre strength (g/tex^{-1})	G	0.1350	0.3421	0.0609	0.1344	0.0984	-0.1132	**0.4024**	-0.1462	0.0657	0.3660
	P	-0.0174	-0.0369	-0.0036	-0.0131	-0.0089	0.0148	**-0.1043**	0.0062	-0.0024	0.0665
Uniformity Ratio (%)	G	-0.0040	0.0279	-0.0142	0.0412	0.0017	0.0248	0.0426	**-0.1173**	-0.0427	-0.1779
	P	0.0053	0.0115	0.0007	0.0028	-0.0036	0.0076	0.0042	**-0.0714**	-0.0251	-0.1405
Elongation (%)	G	0.0350	-0.1520	-0.0905	-0.3533	0.3156	-0.3766	0.0978	0.2179	**0.5992**	-0.0053
	P	0.0002	0.0000	0.0001	0.0002	-0.0002	0.0009	-0.0001	-0.0010	**-0.0029**	-0.0222

R square = 0.8093, Residual effect =0.4367 for Genotypic and R square = 0.4080, Residual effect =0.7694 for Phenotypic. *P=0.05%, **P=0.01%

Whereas number of sympodia per plant (G=0.2224), days to maturity (0.0282), fibre strength (G=0.4024) and elongation % (G=0.5992) revealed the positive and direct effect at genotypic level, while number of monopodia per plant (0.0828), harvest index (0.0109) and upper half mean length (0.1130) had revealed direct positive effect on seed cotton yield per plant at phenotypic level.

The direct effect of days to 50% flowering (G=-0.4775, P=-0.3319), bartlett's index (G=-0.2504, P=-0.1477), lint index (G=-0.1556, P=-0.0097), seed index (G=-0.4210, P=-0.1682), average boll weight (G=-0.3673, P=-0.0062) and uniformity ratio (G=-0.1173, P=-0.0714) was negative on seed cotton yield per plant at both genotypic and phenotypic level.

The character monopodia per plant (G=-0.1892), harvest index (G=-0.1080) and upper half mean length (G=-0.4641) exerted negative direct effect at genotypic level, whereas sympodia per plant (P=-0.0892), days to maturity (P=-0.0109), fibre strength (P=-0.1043) and elongation % (P=-0.0029) exerted negative direct effect at phenotypic level on seed cotton yield per plant.

The residual effect of (Genotypic =0.4367 and Phenotypic =0.7694) indicates that nearly 43 per cent of characters affecting seed cotton yield per plant have been accounted for in this study and about 57 per cent of other characters not dealt here, would be affecting the seed cotton yield per plant.

From these results, it is clear that the selection based on plant height, number of sympodia per plant, days to 50% boll bursting, number of bolls per plant, lint yield per plant, micronaire, elongation % and fibre strength will improve the seed cotton yield per plant as high direct effect were reported by these traits.

The path analysis indicated that the direct effect of days to 50% flowering, bartlett's index, lint index, seed index, average boll weight and uniformity ratio was negative on seed cotton yield per plant at both genotypic and phenotypic level. Thus, this indicated that direct selection for these characters will reduce the breeding efficiency for seed cotton yield in cotton.

Through the study of path analysis it was appearing that maximum direct effects were exerted by plant height, number of sympodia per plant, days to 50% boll bursting, number of bolls per plant, lint yield per plant, micronaire, elongation % and fibre strength. All of these traits exhibited positive and significant correlation with seed cotton yield per plant, therefore these characters may be considered as the most important yield contributing characters and due emphasis should be placed on these characters while breeding for high seed cotton yield in cotton.

Similar result were reported by many workers, Chakresh Kumar *et al.,* (1992) reported that ginning out turn had negative direct effect but indirect effect through lint index was positive. Also they showed that halo length had negative direct effect on seed cotton yield. Kowsalya and Raveendran (1996) found that number of sympodia per plant and number of bolls per plant exerted high, direct and positive effect on seed cotton yield. Muthu *et al.,* (2004) reported 2.5 per cent span length, fibre fineness exhibited direct positive contribution towards seed cotton yield. Neelima *et al.,* (2005) positive direct effect found for micronaire, number of sympodia per plant. The negative direct effect on yield was recorded by seed index, ginning out turn and bolls per plant. Bayappu *et al.,* (2015) indicated that the number of bolls plant-1, boll weight (g), seed index, 2.5% span length (mm) and lint yield plant (g) showed direct positive effects and significant

positive correlation with seed cotton yield plant. Ashish and wadikar (2017) revealed positive direct genotypic effect on seed cotton yield per plant through boll weight, number of bolls per plant, seed index, ginning out turn, number of sympodia per plant, 2.5% span length, fibre elongation and number of monopodia per plant while negative direct effect was observed with lint index, plant height, bundle strength and micronaire value except lint index that had positive direct phenotypic effect on seed cotton yield per plant. however, Nikhil (2019) indicated that boll weight and number of bolls per plant had highest direct effect on seed cotton yield per plant, whereas traits like plant height, UHML, fibre strength and lint index had direct negative effect on yield

The results discussed above indicate that correlation and direct and indirect effect estimates vary for different traits with variation in genetic material based on yield contributing trait and fibre properties. Hence, correlations and direct and indirect effect estimation would provide useful information for planning a successful breeding programme if the genetic material is grouped for number of sympodia per plant, number of bolls per plant and GOT%, lint yield per plant, micronaire length and fibre strength.

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