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Correlation studies and path coefficient analysis of yield attributing traits among selected F_2 populations of intra-hirsutum cotton hybrids under rain-fed situation

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Abstract
Genetic potential of the cotton to tolerate rain-fed situation is of utmost importance. In this regard selected F_2 populations i.e. F_3 generation consisting of 90 lines and 5 checks replicated in augmented design were studied for contribution of different componental traits related to yield and other significant traits under rainfed situation. Traits such as number of sympodial branches, inter boll distance, boll weight, number of bolls per plant, number of seeds per boll, ginning out turn, halo length root dry weight, biomass showed significant positive correlation with seed cotton yield. Direct and indirect effects estimated along with correlation studies using Windostat software depicted that halo length (0.758) followed by boll weight (0.332) and ginning out turn (0.229) had high direct effect on seed cotton yield per plant. Highest negative direct effect was on behalf of inter boll distance (-0.108). Traits such as lint index exhibited highest indirect effect through boll weight (0.628) ensuingly halo length through root dry weight (0.492). hence selection of high yielding promising genotypes must be greatly emphasized on genotypes having more halo length, ginning out turn, boll weight and root dry weight and lint index and root dry weight can also be used for indirect improvement of seed cotton yielding genotypes.

Keywords: correlation studies, path coefficient analysis, componental traits and seed cotton yield

Introduction
Cotton is a significant fiber yielding crop belongs to the family *Malvaceae*. Nearly 65% of cotton is grown in rain-fed regions peculiarly in central and southern parts of India (www.nfsm.gov.in). Cotton contributes to agriculture and textile industry in a remarkable manner. It was cultivated in 12.96 million hectares in our country during the year 20-21. Out of the total cropped area around the world, India's cotton occupies 37.5% in terms of area contributing 26% i.e. 6.2 Million metric tonnes out of 23.92 million metric tonnes (cotcorp.org.in). The only country where all the four cultivated types of cotton along with inter specific and intra specific hybrids were grown is India. Cotton being the major source of raw material to textile industry contributes 4% to GDP of India and also promotes foreign exchange. Thus, it plays a significant role in growth and development of Indian economy. Due to the uncertainty of the rainfall and lack of availability of the moisture in the soils, productivity of the cotton is low. The degree and direction of association between the different yield attributing traits and other significant traits related to rain-fed situation mainly depends on environment and genetic constitution of the genotypes. Due to the influential environmental and genetic factors in cotton, degree and direction of association between the different yield attributing traits in relation with seed cotton yield substantially depicts a different association. Hence exploration of correlation and path coefficient analysis assists us to be conscious about the inter-relationship, direct and indirect effects of independent traits on seed cotton yield, there by contributing to the efficiency of selection. Correlation studies in F_3 generation assist in selecting the genotypes that have fabulous quality and promising field performance (Shabbir *et al*., 2016) [11]. Further they can be advanced to higher generation for the development of high performing inbred lines. Correlation studies does not provide information regarding the relative significance of direct and indirect effects of various independent traits on a dependent trait (Lynch & Walsh, 1998) [7]. Correlation coefficients of different independent traits will be partitioned into direct and indirect effects on dependent trait that assists in understanding the trait association with yield. Regression equations are being used to standardize the causal variables which in turn gives the estimates of these effects. Tyagi *et al*., in 1998 and Iqbal *et al*., in 2003 used seed cotton yield as the primary dependent trait in cotton and found

out the direct and indirect effects of different independent traits.

Materials and methods

The experiment was conducted at agricultural research station Hebballi under the University of Agricultural Sciences, Dharwad Karnataka. It is considered to be at north transition zone (zone 8) and lies between 75°2'47"E longitude and 15°27'36"N latitude and is considered to be a rain-fed region respectively. It was considered to be rain-fed region as the rainfall data for the past 5 years recorded annual rainfall less than 760 mm. 90 selected F_2 lines advanced to F_3 generation were sown along with 5 checks replicated in five blocks total accounting for 115 lines. Recommended agronomic practices were applied for the successful raising of the crop. Data was collected on different traits such as plant height (cm), number of monopodia, number of sympodia, sympodial length at 50% plant height(cm), number of nodes, interboll distance (cm), stem diameter(cm) number of bolls per plant, boll weight(g) number of seeds per boll, seed index (g) lint index (g) GOT (%) Halo length(mm) Root dry weight (g) Shoot dry weight (g) Root to shoot dry weight ratio Biomass (g) Seed cotton yield (g/plant). Analysis of variance, correlation and path coefficient analysis was calculated using INDOSTAT 4.1 version.

Results and Discussion

Significant variation among the genotypes was found for all the traits under study at 5% level of significance except for trait stem diameter. This suggested that the traits under the study influenced one another either directly or indirectly in contributing to dependent trait seed cotton yield. Most of the traits under study have high genotypic correlation values that phenotypic correlation portraying that the traits under study were under inherent association. Similar kind of results were observed in sorghum and coriander Wassihun (2006) [13] and Beemnet *et al*., (2013). Seed cotton yield showed highest significant positive genotypic correlation with halo length (0.879*) followed by ginning out turn (0.498*). Other traits that showed significant positive genotypic correlation with seed cotton yield were number of sympodia (0.399*), boll weight (0.353*), inter boll distance (0.328*), root dry weight (0.288*), number of bolls per plant (0.271*) and seed index (0.229*) respectively. Highest negative genotypic correlation was showed by number of nodes (-0.423*) followed by lint index (-0.359*) (Table1), (Figure 1). Among independent traits highest significant genotypic correlation was observed between number of sympodia and number of nodes (0.954*) subsequently between plant height and number of sympodia (0.721*). Seed cotton yield at phenotypic level showed highest significant positive correlation with halo length (0.877*) subsequently ginning out turn (0.488*). Other traits that showed significant positive genotypic correlation with seed cotton yield were number of sympodia (0.379*), boll weight (0.333*), inter boll distance (0.308*), root dry weight (0.278*), number of bolls per plant (0.261*) and seed index (0.219*) respectively. Highest negative genotypic correlation was showed by number of nodes (-0.423*) followed by lint index (-0.359*). Among independent traits highest significant genotypic correlation was observed between number of sympodia and number of nodes (0.954*) subsequently between plant height and number of sympodia (0.721*) (Table 2). Similar reports had been observed by Leelapratap *et al.* (2007) [6], Yashvantha Kumar (2008) [14] and Hanamaraddi (2009) [3]. Certain traits such as stem diameter (0.175), number of seeds per boll (0.187) number of monopodia (-0.009), shoot dry weight (-0.009) Root to shoot dry weight (-0.323) exhibited insignificant association indicating that these traits expressed independently in the current generation of population under study (Hussain *et al*., 2010) [4].

Regression analysis revealed that adjusted R squared has high value (0.934), very low standard error (0.14). This summarized that variability in the response variable was explained by the concerned explanatory variable up to 93 percent (Table 3). P value calculated was less than alpha value (0.05) indicating that the slope of the regression line was differing significantly from zero paving a way for the rejection of null hypothesis. As per Zaiontz (2015) [15] the regression model fits good. Traits like number of bolls per plant, boll weight, seed index, ginning out turn and halo length contributed significantly to the yield as their P value is below 0.05 and remaining traits values are greater than 0.05. Direct and indirect effects of various independent traits on dependent trait seed cotton yield were studied which had put forth a residual effect of 0.319. Among the componental traits, halo length (0.758), boll weight (0.332), ginning out turn (0.229) majorly have direct significant effect on seed cotton yield (Table 4) (Figure 2). Hence can be used for selection of genotypes for the advancement to next generation. Yield attributing traits and other traits studied under rainfed situation does not showed more direct effect when compared to their correlation coefficients. So, study should not be limited to this generation only. Plant height had higher indirect positive effect *via* number of sympodia per plant (0.071), boll weight (0.029) and ginning outturn (0.002). Yashvantha Kumar (2008) observed similar indirect effect of plant height on number of sympodia per plant. The trait ginning outturn had direct and positive effect (0.229) on yield. These results were in agreement with Annapurve (2007) [1] and Salahuddin *et al.* (2010) [10]. Positive direct effect of halo length on seed cotton yield per plant was observed to be 0.758 in this study. Similar direct effects were reported by Patil (1989). Root dry weight has positive direct effect (0.048) on seed cotton yield. Root dry weight to shoot dry weight ratio had negative direct effect (-0.031) on seed cotton yield and also, biomass had negative direct effect (-0.034) on seed cotton yield (Figure 3). The same has been reported by Percival and Sheriff (2002) [9]. Selection should be made for genotypes that are having high halo length, ginning out turn, boll weight, number of bolls per plant, high biomass and high root dry weight respectively. seed cotton yield was affected by high seed index and a greater number of bolls as it has led to decrease in boll weight there by decreasing seed cotton yield. Hence selection should be made for optimum number of bolls and seed index with high boll weight under rainfed situation.

Table 1: Genotypic correlation of different traits with seed cotton yield

Characters	Plant height	Number of monopodia	Number of sympodia	Sympodial length at 50% plant height	Number of nodes	Inter boll distance	Stem diameter	Number of bolls per plant	Boll weight	Number of seeds per boll	Seed index	Lint index	GOT	Halo length	Root dry weight	Shoot dry weight	Root to shoot dry weight ratio	Biomass	Seed cotton yield
Plant height	1	0.211*	0.721**	0.678**	0.682**	*0.055	0.194	-0.056	0.027*	-0.04	-0.271	0.194	0.084	-0.382**	0.008	0.262	0.313	0.294	-0.320*
Number of monopodia		1	0.239	0.116*	0.241	0.153	0.294*	- 0.027	-0.086	-0.123	-0.296*	0.023	0.115	0.010	-0.471 *	-0.155	0.235	-0.129	-0.009
Number of sympodia			1	0.491**	0.954**	-0.350**	0.040	0.044	0.005	-0.167	-0.358**	0.259	0.009	-0.358**	0.171	0.371	0.282	0.477*	0.399*
Sympodial length at 50 per cent plant height				1	0.490*	-0.185	-0.076	-0.051	0.061	0.041	-0.050	0.176	0.009	-0.378**	-0.245	-0.195	0.318	-0.171	-0.325*
Number of nodes					1	-0.330*	0.068	0.005	0.085	-0.089	-0.342**	0.270*	0.057	-0.395**	0.177	0.393	0.256	0.471*	-0.423*
Inter boll distance						1	0.297*	0.039*	-0.105	-0.049	0.153	-0.464**	0.044	0.431**	-0.285	-0.431	-0.050	-0.296	0.328*
Stem diameter							1	-0.114	-0.250	-0.276*	-0.158	-0.199	0.055	0.154	0.463*	-0.258	0.247	-0.143	0.195
Number of bolls per plant								1	-0.210	0.077	-0.042	-0.187	0.180	0.293*	0.371	0.259	0.047	0.099	0.271*
Boll weight									1	0.637**	0.048	0.243	0.341**	0.085	0.121	-0.195	0.065	-0.095	0.353*
Number of seeds per boll										1	0.584*	0.036	0.298*	0.166	0.368	0.227	-0.169	-0.275*	0.197
Seed index											1	-0.294*	-0.048	0.149	0.428*	0.278	-0.335	-0.179	0.229*
Lint index												1	-0.039	-0.299*	-0.011	-0.110	0.227	-0.129	-0.359*
GOT													1	0.384**	0.295	0.276	0.227	-0.298	0.498*
Halo length														1	0.358	0.089	-0.096	-0.258*	0.879*
Root dry weight															1	0.544*	-0.465*	0.296*	0.288*
Shoot dry weight																1	-0.468 *	0.172*	-0.019
Root to shoot dry weight ratio																	1	-0.096	-0.326
Biomass																		1	0.196*
Seed cotton yield																			1

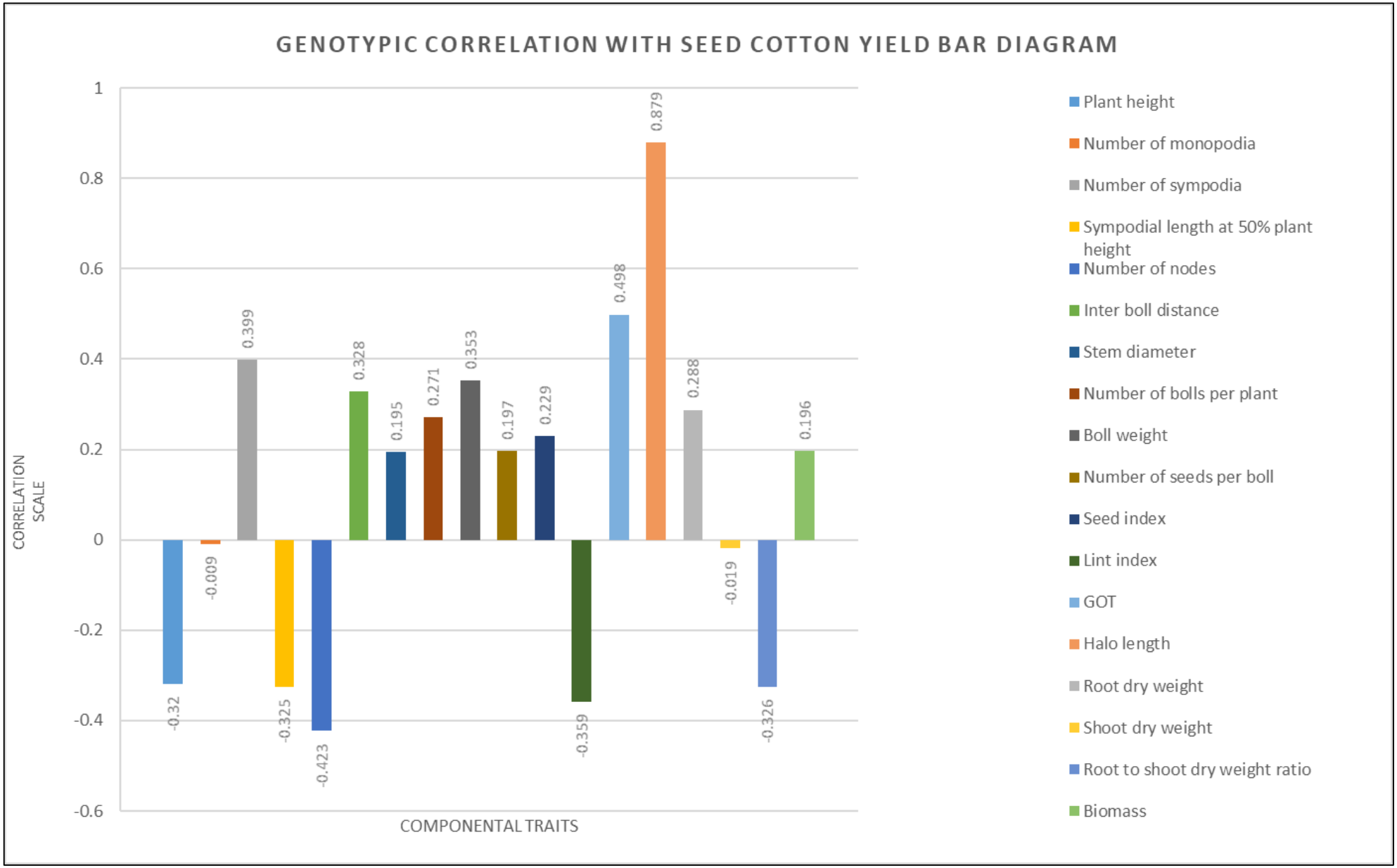

Fig 1: Bar diagram depicting genotypic correlation

Table 2: Phenotypic correlation of different traits with seed cotton yield

Characters	Plant height	Number of monopodia	Number of sympodia	Sympodial length at 50% plant height	Number of nodes	Inter boll distance	Stem diameter	Number of bolls per plant	Boll weight	Number of seeds per boll	Seed index	Lint index	GOT	Halo length	Root dry weight	Shoot dry weight	Root to shoot dry weight ratio	Biomass	Seed cotton yield
Plant height	1	0.191*	0.698**	0.627**	0.669**	*0.045	0.184	-0.066	0.017*	-0.093	-0.241	0.184	0.064	-0.342**	0.006	0.202	0.313	0.294	-0.320*
Number of monopodia		1	0.239	0.116*	0.241	0.153	0.294*	- 0.027	-0.086	-0.123	-0.296*	0.023	0.115	0.010	-0.471 *	-0.155	0.235	-0.129	-0.009
Number of sympodia			1	0.481**	0.924**	-0.330**	0.030	0.024	0.002	-0.147	-0.338**	0.239	0.007	-0.338**	0.151	0.351	0.262	0.457*	0.379*
Sympodial length at 50 per cent plant height				1	0.480*	-0.175	-0.056	-0.041	0.041	0.021	-0.040	0.156	0.009	-0.368**	-0.225	-0.185	0.308	-0.161	-0.315*
Number of nodes					1	-0.320*	0.058	0.003	0.065	-0.069	-0.332**	0.260*	0.037	-0.375**	0.167	0.383	0.246	0.451*	-0.403*
Inter boll distance						1	0.277*	0.038*	-0.095	-0.029	0.113	-0.404**	0.014	0.401**	-0.295	-0.401	-0.010	-0.196	0.308*
Stem diameter							1	-0.104	-0.200	-0.256*	-0.148	-0.189	0.035	0.134	0.433*	-0.238	0.227	-0.123	0.175
Number of bolls per plant								1	-0.200	0.067	-0.012	-0.167	0.150	0.283*	0.361	0.249	0.037	0.089	0.261*
Boll weight									1	0.627**	0.028	0.223	0.331**	0.075	0.111	-0.185	0.060	-0.091	0.333*
Number of seeds per boll										1	0.564*	0.026	0.288*	0.156	0.358	0.217	-0.159	-0.205*	0.187
Seed index											1	-0.284*	-0.028	0.146	0.408*	0.177	-0.332	-0.176	0.219*
Lint index												1	-0.036	-0.289*	-0.010	-0.100	0.207	-0.119	-0.349*
GOT													1	0.364**	0.291	0.216	0.207	-0.294	0.488*
Halo length														1	0.348	0.069	-0.093	-0.238*	0.877*
Root dry weight															1	0.514*	-0.415*	0.186*	0.278*
Shoot dry weight																1	-0.448 *	0.162*	-0.009
Root to shoot dry weight ratio																	1	-0.093	-0.323
Biomass																		1	0.186*
Seed cotton yield																			1

Table 3: Regression analysis of seed cotton yield and associated traits

Regression statistics						
Multiple R			0.96533			
R Square			0.94122			
Adjusted R Square			0.93423			
Standard Error			0.14112			
Observations			115			
Anova	**df**	**ss**	**mss**	**F value**	**significance F**	
Regression	14	324.431	23.1736	421.32	9.22E-284	
Residual	100	5.562	0.0556			
Total	114	114				
Characters	**Coefficients**	**P-value**	**Standard Error**	**t Stat**	**Upper 95%**	**Lower 95%**
plant height	0.0123	0.1884	0.0095	1.3177	0.0309	−0.0066
Number of sympodia	0.0234	0.1224	0.0062	1.4720	0.0452	-0.0453
Sympodial length at 50% plant height	0.0213	0.1412	0.0023	0.4997	0.3412	-0.3214
Number of nodes	0.1421	0.2621	0.0032	0.1631	0.2115	-0.1231
Inter boll distance	0.0919	0.4621	0.0039	0.6214	0.4421	-0.4012
Boll number per plant	0.5984	0.6176	0.0120	0.4981	0.0292	-0.0172
Number of seeds per boll	0.0162	0.2314	0.0154	0.3324	0.0130	-0.0129
Seed Index	0.1321	0.1641	0.0222	1.4210	0.0632	-0.0632
Lint index	0.1543	0.3214	0.0231	1.7431	0.4326	-0.4329
GOT	0.1232	0.1673	0.0821	0.3324	0.4324	-0.3981
Halo length	0.5624	0.3412	0.0163	0.3214	0.6733	0.1414
Boll weight	0.7431	0.5421	0.0821	0.2213	0.7543	0.2431
Root dry weight	0.0451	0.2341	0.0021	0.0610	0.4521	-0.0453
Root to shoot dry weight ratio	0.0154	0.1167	0.0023	0.0430	0.4354	0.1121
Biomass	0.2314	0.6531	0.2213	0.3214	0.3451	0.0121

Table 4: Direct and indirect effects of different traits on seed cotton yield

Characters	**Plant height**	**Number of sympodia**	**Sympodial length at 50% plant height**	**Number of nodes**	**Inter boll distance**	**Boll number per plant**	**Number of seeds per boll**	**Seed Index**	**Lint index**	**GOT**	**Halo length**	**Boll weight**	**Root dry weight**	**Root to shoot dry weight ratio**	**Biomass**	**Correlation with Seed cotton yield**
Plant height	0.035	0.024	0.022	0.023	-0.002	-0.022	-0.002	-0.008	0.006	0.002	-0.012	0.017	-0.002	0.019	0.035	-0.320
Number of sympodia	-0.064	-0.092	-0.044	-0.085	0.030	0.067	-0.002	0.031	-0.022	-0.001	0.031	-0.086	0.163	0.024	0.003	-0.009
Sympodial length at 50% plant height	0.014	0.011	0.022	0.011	-0.004	-0.012	-0.001	-0.001	0.003	0.000	-0.008	0.002	0.106	-0.001	-0.002	-0.315
Number of nodes	-0.044	-0.061	-0.032	-0.066	0.021	-0.167	0.000	0.022	-0.017	-0.003	0.025	0.042	0.099	-0.003	-0.020	-0.403
Inter boll distance	0.005	0.036	0.019	0.035	-0.108	0.150	-0.004	-0.012	0.044	0.002	-0.044	0.066	-0.019	-0.013	-0.021	0.308
Boll number per plant	-0.067	-0.027	0.024	0.003	0.039	0.085	-0.105	-0.012	0.150	0.283	0.150	-0.095	0.085	0.002	0.009	0.261
Number of seeds per boll	-0.001	0.000	-0.001	-0.002	0.001	0.283	0.015	0.000	-0.003	0.002	0.004	-0.201	-0.035	-0.279	-0.284	0.187
Seed Index	-0.015	-0.021	-0.003	-0.020	0.007	0.105	-0.001	0.061	-0.017	-0.002	0.009	-0.201	0.051	0.017	0.042	0.219
Lint index	-0.015	-0.019	-0.013	-0.021	-0.021	0.039	0.032	0.013	-0.080	0.003	0.023	0.628	-0.038	0.002	-0.012	-0.349
GOT	0.015	0.002	0.002	0.009	-0.003	0.003	0.034	-0.006	-0.008	0.229	0.083	0.029	0.187	-0.001	0.031	0.488
Halo length	-0.259	-0.256	-0.279	-0.284	0.304	-0.041	0.215	0.111	-0.219	0.276	0.758	0.224	0.492	0.000	-0.008	0.877
Boll weight	-0.086	0.002	0.017	0.042	0.066	-0.952	0.628	0.029	0.224	0.042	0.066	0.332	0.311	-0.017	-0.003	0.333
Root dry weight	0.036	0.019	0.035	-0.108	0.150	-0.004	-0.012	0.044	0.002	0.024	0.022	0.023	0.048	0.044	0.002	0.278
Root to shoot dry weight ratio	0.283	0.015	0.000	-0.003	0.002	0.004	-0.201	0.261	-0.035	-0.259	-0.256	-0.279	-0.001	-0.031	0.105	-0.323
Biomass	0.105	-0.001	0.061	-0.017	-0.002	0.009	-0.201	0.220	0.051	-0.086	0.002	0.017	0.000	-0.008	**0.039**	0.186

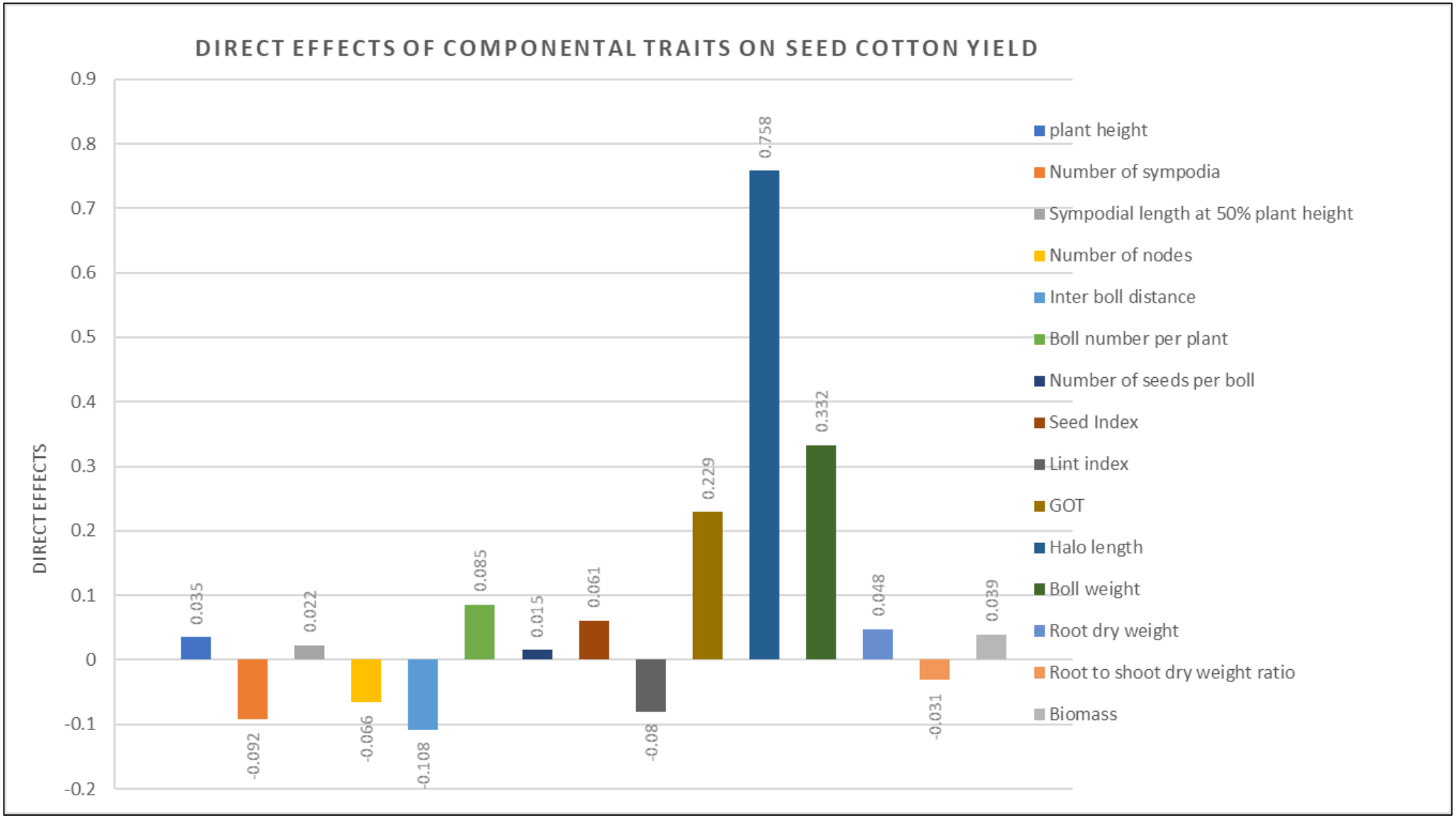

Fig 2: Direct effects of different traits on seed cotton yield.

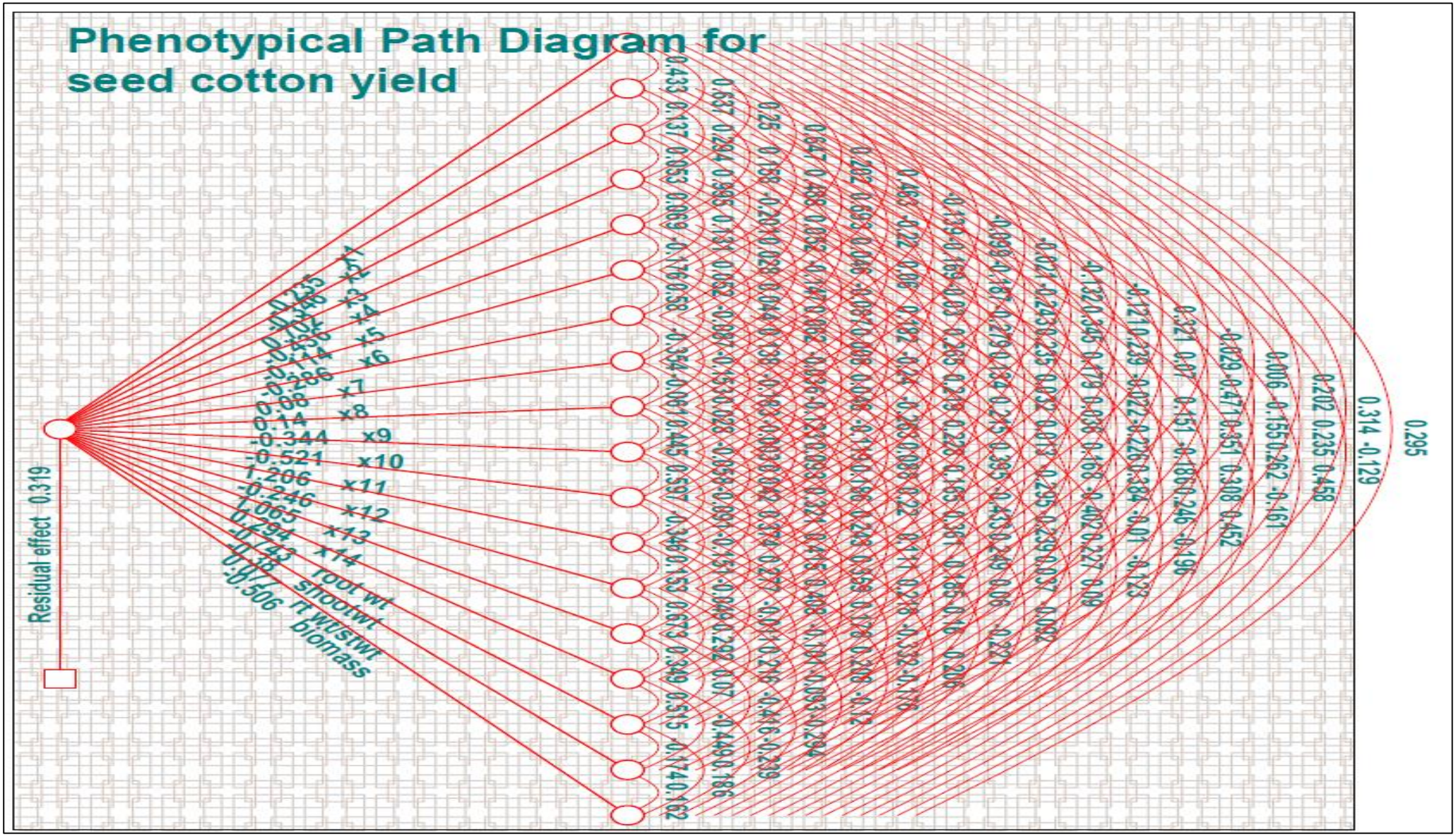

Fig 3: Phenotypic path diagram for seed cotton yield

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