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Correlation and Path Coefficient Analysis for Some Quantitative Traits of Cotton (*Gossypium hirsutum* L.) Genotypes under Irrigated Conditions

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Abstract

Comprehensive understanding about the crop nature, performance level and association of numerous agronomic attributes with yield is necessary for plant researchers to tackle the cotton yield limiting constraints. However, there is a lack of sufficient information on cotton yield, yield related and fiber quality traits correlation and path coefficient analysis in Ethiopia. Knowledge of correlation between different traits and the further partitioning of correlation coefficients into direct and indirect effects is a prerequisite for any underutilized crop improvements of sustainable genetic enhancement. The experiment was conducted on twelve genotypes with three checks in order to assess the association, direct and indirect effects of different characters on lint yield. The experiment was planted at Werer Agricultural Research Center and Nasa/Birale Farm under irrigated condition in a Randomized Complete Block Design with three replications during the 2016 to 2018 cropping seasons. Data were collected on yield, yield related and fiber quality traits. Correlation studies revealed that lint yield was significantly and positively correlated with the number of bolls per plant, seed cotton yield, ginning outturn and micronaire, whereas it was significantly and negatively correlated with fiber length at both phenotypic and genotypic levels. Path coefficient analysis, both at phenotypic and genotypic levels, revealed that seed cotton had the greatest direct effect on lint yield followed by ginning outturn and number of bolls per plant. Both correlation and path analysis indicated that seed cotton yield, ginning outturn and the number of bolls per plant were the major direct contributors to lint yield. Hence, the present study suggests that more seed cotton yield, ginning outturn and number of bolls per plant are major yield factors in selecting high lint yielding cotton genotypes.

Key words: Cotton, correlation, path analysis, lint yield.

Introduction

In plant breeding, genetic variation and diversity among plant traits is a pre-requisite for selecting desirable types as an end product. Independent variables affect yield either directly or indirectly and they are interrelated in a complex way (Singh *et al*. 1995). The correlation coefficient is the measure of the degree of the linear association between two variables (Gomez and Gomez, 1984). A knowledge of the correlations that exists between important characters may facilitate the interpretation of results obtained and provide the basis for planning a more efficient program for the future (Johnson *et al.* 1955b). Studies on genotypic and phenotypic correlations among characters of crop plants are useful in planning, evaluating and setting selection criteria for desired characters for selection in breeding programs (Johanson *et al*. 1955a; Amsal, 2001). The association between traits could be due to genotypic correlation, which is attributed to linkage between genes or a pleiotropic gene effect, or due to an environmental effect, or both (Falconer and Mackey, 1996; Shafique *et al*. 2016). Phenotypic correlations measure the extent to which the two observed characters are linearly related and determined from measurements of the two characters in a number of individuals of the populations. The various characteristics of crop plants are generally interrelated or correlated. Such correlations can be either negative or positive.

Path analysis is an important statistical tool that has been used by plant breeders to identify traits that serve as selection criteria to improve crop yield (Dewey and Lu, 1959, Samonte et *al*. 1998) and is a tool developed by Wright (1921). It is a useful technique designed to ascertain the path along which relationships among variables are oriented and to facilitate the understanding of the causal relationship between the interrelated variables. Path coefficient analysis provides an effective means of finding the direct and indirect causes of association (Kale *et al*. 2007). It measures the direct influence of one variable upon the other and permits separation of correlation coefficients into components of direct and indirect effects. Partitioning of total correlation into direct and indirect effects provides actual information on contribution of characters and thus forms the basis for selection to improve the yield (Khan and Dar, 2009).

Many of the studies on correlation and path analyses have been conducted in cotton. Seed cotton yield, its components and fiber quality characters of a plant are heritable in nature (Poehlman and Sleper, 1995) and thus genetic improvement in all these characters through selection and breeding is possible. The average boll weight and number of bolls per plant were significantly and positively correlated with seed cotton yield per plant (Iqbal *et al*. 2006). DeGui *et al.* (2003) also found that the higher yield in cotton cultivars was mainly due to a greater number of bolls per plant. Ashokkumar and Ravikesavan (2010) revealed that correlation and path coefficient studies disclosed the significant positive association of seed cotton yield with number of bolls per plant, boll weight, ginning outturn and lint index.

Being a valuable resource for cotton breeders, establishing a correlation between yield and its contributing attributes is the primary goal of examining the connection between traits and which plant parameters should be selected first to enhance cotton seed and lint yields (Khakwani *et al*. 2012). The objective of the present study was to investigate the association among various quantitative traits and their direct or indirect contribution to seed cotton yield with path coefficient analysis in upland cotton.

Materials and Methods

The experiment was carried out at two locations for three consecutive seasons (2016, 2017 and 2018). Werer Agricultural Research Center is one of the experimental sites located in Afar region at latitude of 9^0 34’12” N latitude, 40^0 17’22”E and 740 meters above sea level while the second experimental site was at Nasa/Birale Farm located in South Ethiopia Regional State situated at 5°22’22’’ N latitude, 36°59'36" E longitude and 570 meters above sea level. Fifteen genotypes of upland cotton were grown in randomized complete block design with three replications (Table 1). Each plot consisted of five rows of 5 m length with a spacing of 90 and 20 cm of inter and intra row, respectively. Optimum crop management techniques were applied to help the genotypes express their potential. Data for nine (9) quantitative agronomic and fiber qualities characters were recorded on plot and individual plant basis. Data recorded included plant height, number of boll per plant, average boll weight, seed cotton yield, ginning outturn, lint yield, micronaire, fiber length and fiber strength. The genotypic and phenotypic correlation coefficient estimates were carried out using the formula given by Kwon and Torrie (1964). Genotypic correlations were computed using variance and co-variances as suggested by Johnson *et al.* (1955). Statistical significance of phenotypic correlations was determined by T-test as described by Steel and Torrie (1984). Path coefficient analysis was performed as suggested by Deway and Lu (1959).

Table 1. List of Cotton Genotypes used in the Experiment

S.No.	Name of the Genotype
1	Delcero x Deltapine-90 #F5-5-2-2-1
2	Delcero x Deltapine-90 #F5-5-4-2-2
3	Delcero x Deltapine-90 #F5-5-4-2-3
4	Delcero x Deltapine-90 #F5-5-4-3-2
5	Delcero x Krishna 16-2
6	Delcero x Coker 315-3
7	Stam 59A x Gedera – 236-1
8	Delcero x Ionia-4
9	Urania x Krishina 16-25
10	HSC-99
11	Europa x Stam 59A – 04-5
12	Arbaminch Farm no 3-2 DP-90 F1#288
13	Deltapine-90
14	Stam-59A
15	Ionia

Results and Discussion

Genotypic and Phenotypic Correlation Coefficients

The estimates of genotypic and phenotypic correlation coefficients between yield, yield related and fiber qualities are presented in Table 2. Correlation of lint yield and its components alone are not adequate in any selection programme in which inter relationship among the individual character may ultimately influence the lint yield. In the present result, the correlation of lint yield with number of bolls per plant (r_g = 0.61 and r_p = 0.44) and with micronaire (r_g = 0.56 and r_p = 0.48) was positive and significant at both genotypic and phenotypic levels. Likewise, the correlation of lint yield with seed cotton yield (r_g = 0.89 and r_p = 0.89) and ginning outturn (r_p = 0.57 and r_g = 0.63) was positive and significant. Similarly, Alehegn (2020) reported that lint yield had positive genotypic and phenotypic correlations with the number of bolls per plant, seed cotton yield, ginning outturn and micronaire. On the other hand, the correlation of lint yield with fiber length was negative and significant at both phenotypic and genotypic levels. The correlation of lint yield with fiber strength was negative and significant at the phenotypic level. The negative associations of lint yield with fiber length and fiber strength also reported by Merdasa *et al*. (2020) and Alehegn (2020).

The fiber strength showed a positive and significant phenotypic correlation with average bolls weight, while it had a positive and significant association with fiber length at both phenotypic and genotypic levels. The number of bolls per plant exhibited a positive and significant association with ginning outturn and lint yield at both phenotypic and genotypic levels, while it showed a positive and significant association with seed cotton yield only at the phenotypic level. Similarly, Erande *et al.* (2014) and Srinivas *et al.* (2014) reported a positive and significant association of seed cotton yield with number of bolls per plant. This indicates that the selection for the number of bolls per plant can be effective in the search for high yielding cotton genotypes.

Table 2. Genotypic and Phenotypic Correlation Coefficients of various Traits in Cotton

Traits		PH	NBPP	ABW	SCY	GOT	LY	M	FL	FS
PH	r_g	1	-0.44	0.02	-0.23	0.33	-0.03	0.13	-0.04	0.18
	r_p		-0.29	-0.01	-0.07	0.21	0.05	0.01	-0.01	0.15
NBPP	r_g		1	-0.64*	0.43	0.52*	0.60*	0.18	-0.43	-0.69*
	r_p			-0.41*	0.31*	0.39*	0.44*	0.15	-0.34*	-0.51**
ABW	r_g			1	0.25	-0.45	-0.03	0.19	-0.03	0.51
	r_p				0.19	-0.41*	-0.03	0.21	-0.03	0.49**
SCY	r_g				1	0.21	0.89**	0.58*	-0.51	-0.14
	r_p					0.16	0.89**	0.48**	-0.45*	-0.12
GOT	r_g					1	0.63*	0.26	-0.49	-0.48
	r_p						0.57**	0.25	-0.47*	-0.45*
LY	r_g						1	0.56*	-0.63*	-0.34
	r_p							0.48**	-0.58**	-0.29*
M	r_g							1	-0.38	0.09
	r_p								-0.33*	0.06
FL	r_g								1	0.61*
	r_p									0.59**
FS	r_g									1
	r_p									1

*, ** significant at 5 % and 1 % probability level, respectively. PH = plant height, NBPP = number of bolls per plant, ABW = average boll weight (gm), SCY = seed cotton yield (t ha^{-1}), GOT = Ginning outturn, LY = lint yield (t ha^{-1}), M = Micronaire, FL = fiber length (mm) and FS = fiber strength (g/tex).

The number of bolls per plant, however, showed a negative and significant association with fiber strength at both phenotypic and genotypic levels, while it exhibited a negative and significant relationship with fiber length only at the phenotypic level. The average bolls weight showed a negative and significant phenotypic correlation with ginning outturn. Seed cotton yield showed a positive and significant correlation with micronaire at both phenotypic and genotypic levels, but it showed a negative and significant association with fiber length at the phenotypic level. Similarly, Vinodhana *et al. (*2013) reported that seed cotton yield was negatively associated with fiber length. Ginning outturn revealed a negative and significant correlation with fiber length and fiber strength. Vinodhana *et al. (*2013) also reported that among the fiber quality traits, the ginning outturn had a negative and significant association with fiber length and fiber strength. A negative and significant association was noted between micronaire and fiber length at both phenotypic and genotypic levels. A positive and significant and association has been reported between fiber length and fiber strength (Vinodhana *et al.* 2013). In the present study, the genotypic correlation was larger than their corresponding phenotypic correlation in most of the traits examined. This suggests that there is a strong association between characters that are largely governed by genetic factors and are less affected by environmental factors (Zerihun *et al.* 2009).

Path Coefficient Analysis

Path analysis helps to know the exact forces involved in the consolidation of the total correlation. In the present study, the lint yield was considered to be the dependent variable, and other traits were considered to be independent variables (casual factors). The genotypic path coefficients that were partitioned into direct and indirect effects based on various lint yield contributing characters are presented in Table 3. The residual effect (0.0601) indicates that the traits included in the genotypic path analysis explained 93.9% of the total variation in lint yield. All agronomic traits, including the number of bolls per plant (0.0251), seed cotton yield (0.8002) and ginning outturn (0.4576), had positive direct effects. However, fiber quality traits such as micronaire (-0.0355) and fiber length (-0.0008) had negative direct effects on lint yield. The highest direct effect was exhibited by seed cotton yield (0.8002), followed by ginning outturn (0.4576). The direct effect of number of bolls per plant on lint yield was low. Seed cotton yield and ginning outturn showed a high and positive indirect effect on lint yield via the number of bolls per plant and the micronaire. However, seed cotton yield, ginning outturn and the number of bolls per plant exerted a negative indirect effect on lint yield through fiber length.

Table 3. Direct (bold, underlined and diagonal) and indirect genotypic effects of five traits on lint yield of 15 cotton genotypes

Traits	Number of bolls per plant	Seed cotton yield(t/ha)	Ginning outturn (%)	Micronaire	Fiber length(mm)
Number of bolls per plant	**<u>0.0251</u>**	0.3474	0.2361	-0.0064	0.0003
Seed cotton yield(t/ha)	0.0109	**<u>0.8002</u>**	0.0979	-0.0207	0.0004
Ginning outturn (%)	0.0129	0.1711	**<u>0.4576</u>**	-0.0094	0.0004
Micronaire	0.0045	0.4675	0.1211	**<u>-0.0355</u>**	0.0003
Fiber length(mm)	-0.0108	-0.4071	-0.2265	0.0135	**<u>-0.0008</u>**

Residual effect: 0.0601

As depicted in Table 4, the estimated residual effect of phenotypic path analysis was low (0.1261), indicating that about 87.4 % of the variability in lint yield was attributed to the five traits included in the path analysis. This residual effect on lint yield might be caused by other characters or environmental factors or sampling errors. According to the phenotypic path coefficient analysis, the number of bolls per plant (0.0313), seed cotton yield (0.8224), ginning outturn (0.4457) and fiber strength (0.0324) had a positive direct effect on lint yield, indicating the importance of these traits in improving lint yield (Table 4).

Table 4. Direct (bold, underlined and diagonal) and indirect Phenotypic effects of six traits on lint yield of 15 cotton genotypes

Traits	NBPP	SCY	GOT	M	FL	FS
Number of bolls per plant [NBPP]	**0.0313**	0.2501	0.1739	-0.0065	0.0081	-0.0166
Seed cotton yield(t/ha) [SCY]	0.0095	**0.8224**	0.0701	-0.0204	0.0107	-0.0039
Ginning outturn (%) [GOT]	0.0122	0.1294	**0.4457**	-0.0105	0.0112	-0.0145
Micronaire [M]	0.0048	0.3942	0.1105	**-0.0426**	0.0079	0.002
Fiber length(mm) [FL]	-0.0106	-0.3672	-0.2076	0.0140	**-0.024**	0.019
Fiber strength(g/tex) [FS]	-0.016	-0.0982	-0.1989	-0.0026	-0.0141	**0.0324**

Residual effect: 0.1261

On the other hand, other traits such as micronaire (-0.0426) and fiber length (-0.024) had negative direct effects on lint yield. The negative effect of the number of bolls per plant and seed cotton yield through micronaire and fiber strength cannot be ignored while selecting for desirable genotypes. The seed cotton yield had a strong phenotypic direct effect on lint yield, and it had also the highest indirect positive effect via the micronaire. Therefore, a compromise between micronaire and seed cotton yield is an important consideration for selection. On the other hand, fiber length and fiber strength had the highest negative indirect effect on lint yield through seed cotton yield (-0.3672) and ginning outturn (-0.1989), respectively.

Conclusion

The present study revealed that the genotypic correlations were higher than phenotypic correlation in most traits studied, which indicates that traits are strongly associated due to genetic control. The correlation of lint yield with the number of bolls per plant, seed cotton yield, ginning outturn and micronaire was positive and significant both at genotypic and phenotypic levels. Hence, improving one or more of these traits could result in a higher cotton lint yield. However, technological traits, such as fiber length and strength had negative phenotypic and genotypic correlations with lint yield. The path coefficient analysis revealed that micronaire and fiber length had a negative direct effect on seed cotton yield at both the genotypic and the phenotypic levels. This analysis also indicated that among the five causal traits, number of bolls per plant, seed cotton yield, and ginning outturn, there were positive direct effects on lint yield. Thus, these traits may be used as effective selection criteria for obtaining high lint yield in cotton breeding programme.

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