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Research Article

Correlation Analysis for Agronomic and Fiber Quality Traits of Upland Cotton (*Gossypium hirsutum* L.) Genotypes under Irrigated Condition of Ethiopia

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ABSTRACT

Cotton breeders have faced the challenge of simultaneously improving yield and fiber quality traits. However, seed cotton yield must at least be maintained when improving fiber quality for a cultivar to remain competitive. The research work pertaining to the study of mean performance and correlation for agronomic and fiber quality traits during 2016 to 2018 at Werer Agricultural Research Center and Nasa-farm using RCBD with three replication among 12 cotton genotypes and 3 cotton checks variety. Analysis of variance manifested highly significant differences among the genotypes for all agronomic and fiber quality traits except average bolls weight and plant height. Genetic potential of fifteen cotton genotypes for different agronomic and quality traits were recorded. Highest mean value for seed cotton yield were registered for genotypes Chamo Farm no 1A1-1DP-90 F_1#307(5.28 t ha^{-1}) followed by genotypes Farm no Ago1 DP-90 F_1#337(5.22 t ha^{-1}) and Weyto Farm no M1 DP-90 F_1#376(5.05 t ha^{-1}) with good ginning outturn, fiber length and fiber strength. Phenotypic correlation of seed cotton yield and lint yield with other traits was found positive for majority of traits except fiber strength and fiber length that negatively correlated. Yield traits showed positive and significant genotypic correlations to ginning outturn and micronaire. It was also evident that the higher magnitude of genotypic correlation coefficients over phenotypic correlation coefficients of seed cotton yield with ginning outturn and micronaire as the result suggested that indirect selection of agronomic traits may be used to increase seed cotton yield.

Keywords: Correlation; Cotton; Fiber-quality; Lint-yield

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) called as 'White gold' is a premier cash and world leading fiber crop. It is major contributor towards financial stability of many countries with abundance annual production [1]. Ethiopia has a long history of cotton farming, however, the existing level of cotton production remains well short of potential. At present, only around 6% of the land designated by the government for cotton farming is used to grow cotton for downstream use in the textile industry with the balance remaining uncultivated [2]. Effective breeding program depends upon the variation present in the gene pool for the yield enhancing traits and selection is effective when magnitude of variability in the breeding population is enough [3].

Knowledge about the mean performance and correlation of yield with various agronomic characters is indispensable for breeder to tackle the problem of yield increase successfully. The correlation analysis also reflects the correlated response of a particular character with it counterpart and also provides a good index to predict the corresponding change which occurs in one character at the expense of the proportionate change in the other [4]. Correlation coefficient measures the association between two variables which measures the rate of change in dependent variable per unit rate of change of independent variable and varies between +1 and -1 but tells us nothing about the causal relation of variables. Three types of correlations discussed in quantitative genetics and these are phenotypic, genotypic and environmental correlations. Genotypic correlation between two

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more characters may results from pleiotropic effects of genes or linkage of genes governing inheritance of two or more characters. While phenotypic correlation is association between two characters that observe and measure which the value is determined by genotypic value and environment deviation in which environmental correlation is a two variables comprises of correlation due to environmental traits and non-additive genetics causes [5]. Tallyta et al. also revealed that the estimates of genotypic, phenotypic and environmental correlations are indispensable for estimate the magnitude of the genetic variability of a population and the selection gains [6].

Correlation study is crucial asset to cotton breeders and determine the relationship between yield and quality characters or between the various factors contributing to seed cotton yield and lint yield. Khakwani et al. also reported that correlation is principal endeavor for cotton breeder to explore the relationship between yield and yield contributing attributes to boost up cotton seed and lint yield [7]. It also happens that due to character association, improvement in respect of one character may have been obtained at the expense of other in which increase in ginning outturn may result in the reduction of staple length and vice versa [8]. Early cotton research has revealed that seed cotton yield and fiber quality properties have strong negative associations due to genetic linkage, pleiotropy and various physiological reasons [9]. Baloch et al. also reported that for superiority of cotton varieties the associations of seed cotton yield with fiber quality and yield traits are indispensable [10]. Werer Agricultural Research Center under Ethiopian Institute of Agricultural Research has been making a maximum effort to develop high yielding varieties with better fiber qualities through the utilization of hybridization methods and selection technique [11]. Hence, the aim of the present study was to estimate the mean performance and correlation for promising cotton genotypes and to evaluate suitable selection criteria for further cotton breeding program.

MATERIALS AND METHODS

Experimental site, design and materials

Twelve cotton genotypes comprised from breeding achievement under Werer agricultural Research Center and three checks cotton variety were used for this study (Table 1). The experiments were conducted under irrigated conditions during the main season at two locations, Werer Agricultural Research Center (Werer) and Nasa-farm in Ethiopia for Consecutive three years from 2016 to 2018. Werer is situated at 9°20’31” N latitude, 40°10’11”E longitude with an altitude of 740 m above sea level (asl) at Afar Region and Nasa-farm at 5°22’22’’ N latitude, 36°59'36" E longitude and 570 m above sea level (asl) at Southern Nations, Nationalities, and People's Region. The genotypes were planted in a ‘Randomized Complete Block Design’ (RCBD) with three replications at each location. All entries were sown and thinned to one plant per hill. Each entry was planted in five rows with each 5 m long with spacing of 90 cm and 20 cm between rows. All agronomic practices were adopted for all the entries from sowing till picking.

Data collection

Agronomic traits: Plant height (PH) was measured from the base of the plant to the top of the plant using meter tape from pre-tagged of 15 plants. Number of bolls per plant (NBPP) was counted average number of both opened and unopened bolls from the 15 pre-tagged plants before first picking. Average bolls weight (ABW) was recorded during prior to harvest from 30 bolls of pre-tagged plants. Seed cotton yield (SCY) were obtained in grams from net plot area of three rows at first and second picking including sample of average bolls weight and converted to t ha^{-1}. Ginning outturn (GOT) was recorded from proportion of lint weight from total seed cotton yield and expressed in percentage. Lint yield(LY) was obtained from product of total weight of seed cotton yield per plot multiplied by ginning percentage value for each plot.

Fiber quality traits: Fiber Length (FL) is basically a genetic character of the variety and recorded the average length of the longer one half of the fibers. Fiber strength (FS) was recorded the amount of force required to break a bundle of cotton fibers in one tex unit in size and cotton fiber strength is measured in grams per tex (g/tex). Micronaire (M) was measure of reflect fiber fineness, maturity and addition surface properties. All fiber quality were tested by high volume instrument (HVI) at Ethiopian Textile Industry Development Institute.

Table 1: Genotypes used for the study.

S.N	Genotypes
1	Etna F4# 1-11
2	Europa X Gedera 236-02-4
3	Europa X Gedera 236-02-5
4	Stam 59A X Europa-01-33
5	Stam 59A X Europa-5-2-1
6	Melkawerer Farm 2 Farm no 51 DP-90 F1#111
7	Arbaminch Farm no 3-2 DP-90 F1#286
8	Chamo Farm no 1A1-1 DP-90 F1#307
9	Farm no Ago1 DP-90 F1#334
10	Farm no Ago1 DP-90 F1#337
11	Weyto Farm no M1 DP-90 F1#375
12	Weyto Farm no M1 DP-90 F1#376
Checks	
13	Deltapine-90
14	Stam-59A
15	Ionia

Data analysis

Data Analysis of variance was computed for all traits considering Randomized Complete Block Design (RCBD) as per Montgomery [12]. Phenotypic and genotypic correlation coefficients were computed using the method described by Miller et al. [13]. Analysis of variance, phenotypic and genotypic correlation was computed with SAS statistical software (9.3) [14]. The significance of mean differences was tested by least significant difference test p ≤ 0.05 [LSD] as stated in Gomez and Gomez.

RESULTS

Analysis of variance

Results of analysis of variance of nine agronomic and quality traits are presented in Table 2. Mean squares for genotypes showed highly significant differences for all the traits except plant height and average bolls weight. This indicates that there is sufficient variability for the traits in the genotypes studied. On the hand, Genotypes x year interaction mean squares significantly different (p ≤ 0.01) for ginning outturn, micronaire, fiber length and fiber strength while genotypes x location mean squares was significant for most important agronomic traits viz. seed cotton yield, lint yield and ginning outturn. The highly significant interaction term (p ≤ 0.01), genotypes x environment (location and year) for the traits of seed cotton yield, ginning outturn and lint yield, and significant different for fiber length.

Table 2: Mean squares from combined analysis of variance for 9 phenotypic traits.

Traits	Genotypes (df=14)	Genotypes × year (df=28)	Genotypes × Location (df=14)	G × E Interaction (df=14)	Error (df=168)	CV (%)	R^2 (%)
Plant height(cm)	1681.48^{ns}	165.69^{ns}	157.01^{ns}	351.45^{ns}	198.1	12.76	73.74
Number of bolls per plant	1.73**	0.36^{ns}	0.18^{ns}	0.37^{ns}	0.38	11.98	47.43
Average bolls weight(gm)	19.97^{ns}	15.89^{ns}	12.03^{ns}	16.37 ^{ns}	14.36	19.55	78.8
Seed Cotton Yield(t/ha)	2.65**	0.87^{ns}	2.01**	1.25**	0.61	16.44	74.59
Ginning out turn (%)	56.56**	3.04**	2.35*	2.57**	1.24	2.94	88.33
Lint Yield(t/ha)	0.8**	0.11 ^{ns}	0.31**	0.17**	0.09	16.58	77.16
Micronaire	0.4**	0.16**	0.06 ^{ns}	0.09^{ns}	0.07	5.96	78.11
Fiber length(mm)	20.46**	2.26**	1.05^{ns}	0.99*	0.64	2.73	82.22
Fiber strength(g/tex)	23.7**	4.88**	3.22^{ns}	2.59^{ns}	2.33	5.29	87.01

Note: ns, * and **, non-significant, significant at P<0.05 and P<0.01, respectively, CV (%)=coefficient of variation in percent, df=Degree of freedom.

Table 3: Mean performance of agronomic and quality traits in cotton genotypes at Werer and Nasa-farm during 2016-2018.

Genotypes	PH	NBPP	ABW	SCY	GOT	LY	M	FL	FS
G1	117.52^{bc}	19.26^{ab}	4.79^{ef}	4.46^{cdfe}	37.13^{e}	1.66^{e}	4.31d^{e}	29.89^{d}	29.67^{abc}
G2	92.67^{e}	20.27^{ab}	4.51^{f}	3.94^{f}	36.39^{f}	1.43^{f}	4.23^{e}	28.46^{gh}	26.88^{e}
G3	99.06^{de}	19.33^{ab}	4.93de^{f}	4.41^{def}	35.61^{g}	1.57^{ef}	4.24^{e}	28.99^{efg}	26.77^{e}

G4	97.03^{e}	18.65^{ab}	5.23^{bcde}	4.76^{a-e}	34.43^{h}	1.64^{ef}	4.37^{bcde}	27.63^{i}	27.23^{e}
G5	124.59^{ab}	17.92^{b}	5.42^{abc}	4.32^{f}	35.65^{g}	1.54^{ef}	4.27^{e}	30.52^{bc}	30.44^{a}
G6	107.26^{cd}	20.04^{ab}	5.29^{abcd}	5.02^{abc}	40.18^{a}	2.01^{ab}	4.61^{a}	28.89^{efg}	29.32^{abcd}
G7	108.82^{cd}	19.68^{ab}	5.16^{bcde}	4.88^{a-e}	38.71^{c}	1.9^{bc}	4.5^{abcd}	29.46^{de}	29.12^{bcd}
G8	109.81^{c}	21.38^{a}	5.16^{bcde}	5.28^{a}	40.16^{a}	2.13^{a}	4.65^{a}	28.15^{hi}	28.91^{bcd}
G9	108.07^{cd}	19.56^{ab}	4.9^{def}	4.92^{abcd}	39.58^{ab}	1.96^{abc}	4.37^{bcde}	29.27^{ef}	29.41^{abcd}
G10	108.54^{cd}	19.99^{ab}	5.27^{bcd}	5.22^{ab}	39.05^{bc}	2.03^{ab}	4.55^{ab}	28.76^{fg}	28.83^{cd}
G11	113.02^{c}	20.22^{ab}	5.35^{abcd}	5.04^{abc}	39.09^{bc}	1.97^{abc}	4.63^{a}	27.83^{i}	28.61^{cd}
G12	114.32^{c}	20.14^{ab}	4.99^{cde}	5.05^{abc}	38.81^{bc}	1.96^{abc}	4.59^{a}	29.09^{ef}	28.34^{d}
G13	109.63^{c}	18.79^{ab}	5.32^{abcd}	4.66^{bcd}	37.72^{de}	1.76^{cde}	4.2^{abc}	29.99^{cd}	28.64^{cd}
G14	129.58^{a}	17.44^{b}	5.53^{ab}	4.32^{f}	39.01^{bc}	1.68^{de}	4.33^{cde}	31.13^{a}	30^{ab}
G15	115.06^{bc}	18.07^{b}	5.75^{a}	4.93^{abcd}	38.33^{cd}	1.88^{bcd}	4.39^{bcde}	30.94^{ab}	30.29^{a}
Mean	110.33	19.38	5.18	4.75	37.99	18.08	4.44	29.27	28.83
LSD	9.26	2.49	0.41	0.51	0.73	0.19	0.17	0.53	1.01

Note: Mean values followed by similar letter(s) in each column are not significant different each other. LSD (5%)=least significant difference at $P<0.05$, PH=plant height, NBPP=number of bolls per plant, ABW=average bolls weight, SCY (t ha^{-1})=seed cotton yield, GOT(%)=ginning outturn, LY(t ha^{-1})=lint yield, M=micronaire, FL(mm)=fiber length and FS(g/tex)=fiber strength

Mean performance of genotypes

The mean values of 15 cotton genotypes for 6 and 3 agronomic traits and quality traits are given in Table 2, respectively. The overall mean values of some candidate's genotypes were greater than the checks genotypes for all most important agronomic traits of seed cotton yield, ginning outturn and lint yield. Ten, 5, 5, 7 and 6 genotypes had maximum mean value than best performed checks variety for number of bolls per plant, seed cotton yield, ginning outturn, lint yield and Micronaire, respectively. The largest mean plant height (129.58 cm) and fiber length (31.13 cm) were measured for check (Stam-59A) genotype while, Chamo Farm no 1A1-1 DP-90 F1#307(G8) were recorded high mean performance for number bolls per plant (21.38), seed cotton yield (5.28 t ha^{-1}), lint yield (2.13 t ha^{-1}) and micronaire (4.65). High mean values of ginning outturn were obtained from Melkawerer Farm 2 Farm no 51 DP-90 F1#111(G6).

Candidate genotypes registered higher overall mean values for 6 out of 9 agronomic and fiber quality traits namely, number of bolls per plant, seed cotton yield, lint yield, ginning outturn, micronaire and fiber strength while check varieties exhibited higher overall mean values for plant height, average bolls weight and fiber length. Farm no Ago1 DP-90 F_1#337(G10), Melkawerer Farm 2 Farm no 51 DP-90 F_1#111(G6), Weyto Farm no M1 DP-90 F_1#375(G11) and Weyto Farm no M1 DP-90 F_1#376(G12) registered successor highest mean value for seed cotton yield and lint yield. However, when individual genotypes mean values were considered, only one Chamo Farm no 1A1-1 DP-90 F_1#307(G8) recorded highest mean values for four traits namely number of bolls per plant, seed cotton yield, lint yield and micronaire but high values of micronaire as undesirable traits in cotton breeding. In addition, among genotypes, Chamo Farm no 1A1-1 DP-90 F_1#307(G8) had 6.61% and 11.82% yield advantage for over best check variety for seed cotton yield and lint yield respectively, in which the genotype had good ginning outturn, fiber length and fiber strength (Table 3).

Phenotypic and genotypic correlations

All possible pairs-wise of phenotypic and genotypic correlation coefficients were computed for nine agronomic and fiber quality traits were presented in Table 4. Seed cotton yield had high significant Positive phenotypic correlation with yield contributor of agronomic traits namely, average bolls weight, number of bolls per plant and ginning outturn while lint yield had high significant and positive phenotypic correlation viz. number of bolls per plant and ginning outturn but positive and non-significant to average bolls weight. On other hand, lint yield and seed cotton yield showed negative and significant phenotypic association for quality traits namely, fiber length and fiber strength but positive and highly significant to micronaire. Plant height had positive and significant phenotypic correlation to average bolls weight, fiber length and fiber strength, but negative correlation with micronaire while non-significant to number of bolls per plant. However, plant height had negative and non-significant phenotypic correlation to seed cotton yield, ginning outturn and lint yield. Average bolls weight showed positive and significant phenotypic association with fiber strength and seed cotton yield, while negatively and significant to ginning outturn and micronaire. Similarly, number of bolls per plant exhibited positive and significant phenotypic associations to all quality test traits namely, micronaire, fiber length and fiber strength. It has been observed negative and highly significant phenotypic associations in considerable pairs of fiber strength and ginning outturn. On other hand, the correlation between fiber length and fiber strength was positive and significant.

Table 4: Pair-wise genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among 9 traits of 15 cotton genotypes evaluated at Werer and Nasa-farm, 2016-2018.

Traits	PH	ABW	NBPP	SCY	GOT	LY	M	FL	FS
PH	1	0.03ns	0.57*	0.03 ns	0.32 ns	0.14 ns	0.08 ns	0.71**	0.85**
ABW	0.31**	1	-0.52*	0.47 ns	0.42 ns	0.52*	0.56 *	-0.75**	-0.41 ns
NBPP	0.03 ns	-0.02 ns	1	0.35 ns	0.21 ns	0.30 ns	0.30 ns	0.43 ns	0.59*
SCY	-0.04 ns	0.20**	0.17**	1	0.65**	0.95**	0.87**	-0.34 ns	0.20 ns
GOT	-0.06 ns	-0.29**	-0.05 ns	0.16**	1	0.84**	0.72**	0.05 ns	0.45 ns
LY	-0.05 ns	0.12 ns	0.15*	0.97**	0.38**	1	0.89**	-0.23 ns	0.30 ns
M	-0.5**	-0.27**	0.21**	0.28**	0.25**	0.33**	1	-0.36 ns	0.14 ns
FL	0.4**	-0.1 ns	0.16**	-0.13*	-0.11 ns	-0.15*	-0.16**	1	0.7**
FS	0.3**	0.22**	0.14*	-0.27**	-0.27**	-0.30**	-0.01 ns	0.51**	1

Note: ns, *and**, non-significant, significant at $p<0.05$ and $p<0.01$, respectively. PH=plant height, NBPP=number of bolls per plant, ABW=average bolls weight, SCY(t ha^{-1})=seed cotton yield, GOT(%)=Ginning Outturn and LY(t ha^{-1})=Lint Yield, M=Micronaire, FL(mm)=Fiber Length and FS(g/tex)=Fiber Strength

Genotypic correlation of seed cotton yield and ginning outturn was positive but non-significant correlated with yield contributor namely, average bolls weight, plant height and number bolls per plant. The genotypic correlations among seed cotton yield, ginning outturn and micronaire were positive and highly significant. The genotypic correlation of lint yield has a positive and significant association with average bolls weight, seed cotton yield and ginning outturn but positively and non-significant correlated with plant height and number of bolls per plant. It is result from the result (Table 4) that the genotypic correlation coefficients of micronaire with average bolls weight, seed cotton yield, ginning outturn and lint yield but negative correlation with fiber length, while exhibited positive but non-significant correlation to plant height and number of bolls per plant. Fiber length showed highly significant and positive genotypic correlations with plant height but negatively correlated with average bolls weight. However, fiber length has positively and non-significant genotypic associations number of bolls per plant and ginning outturn while negatively non-significant genotypic correlated with seed cotton yield, lint yield and micronaire. Fiber strength exhibited positive and significant genotypic correlations with plant height, number bolls per plants and fiber length while it showed positively and non-significant associations with seed cotton yield, ginning outturn, lint yield and micronaire but negatively and non-significant correlated average bolls weight.

DISCUSSION

The end product of yield components is the seed cotton yield with good ginning out turn and fiber quality traits. Therefore, mean performance and developmental association of plant traits can play a key role in the selection of desirable traits. The analysis of variance revealed significant differences among the genotypes for all most all the traits. In addition, mean performance and estimates of phenotypic and genotypic coefficients indicating the presence of variation and genotypes were diverse materials. Analysis variance of fifteen cotton genotypes high significant different for all agronomic and fiber quality traits except plant height as Kedir et al. reported analysis of variance were significant for most agronomic traits of plant height, number of bolls per plant, average bolls weight, seed cotton yield and lint yield [15]. The overall mean values of the candidate genotypes were higher than the checks variety for seed cotton and lint yield. Chamo Farm no 1A1-1 DP-90 F_1#307 (5.28 t ha^{-1}) had revealed highest mean performance followed by Farm no Ago1 DP-90 F_1#337 (5.22 t ha^{-1}) and Weyto Farm no M1 DP-90 F_1#376(5.05 t ha^{-1}) with good ginning outturn and quality traits as the presence of variations within upland cotton genotypes was reported. Kaleri et al. revealed that there is presence of variation among the genotypes with range of 82.46 to 153.65g per plant for seed cotton yield of upland genotypes [16]. Mean performance of the genotypes of cotton upland had the highest seed cotton yield (5170.3 $kgha^{-1}$) and lint yield (2091.8 $kgha^{-1}$), respectively as Alehegn et al. revealed [17].

Significant and positive phenotypic correlation was observed between seed cotton yield and yield contributor agronomic traits like average bolls weight and number of bolls per plant while negatively correlated fiber length and fiber strength in which Zeng and Meredith studied for having found negative association between fiber length and seed cotton yield within intraspecific G. *hirsutum* populations [18]. Ganapathy et al. and Meena and Meena also stated that number of plant bolls per plant were positively associated with seed cotton yield per plant in simultaneous selection of number of bolls per plant will increase the seed-cotton yield automatically [19,20]. On the hand, lint yield positively correlated with number of bolls per plant and ginning outturn. Yield traits namely seed cotton yield and lint yield positive and significant genotypic correlations to ginning outturn and micronaire. Muhammad et al. revealed that the characters like plant height, number of bolls per plant, ginning outturn and fiber fineness had positive phenotypic association with agronomic and quality traits [21]. Similarly, significant positive association of seed cotton yield was observed by Erande et al. and Farooq et al. for number of bolls and average bolls weight [22,23]. Afiah and Ghoneim revealed that average bolls weight is major contributor to yield for phenotypic correlation [24]. It was also evident that the higher magnitude of genotypic correlation coefficients over phenotypic correlation coefficients between seed cotton yield and ginning outturn and micronaire [25]. The result suggested that indirect selection of agronomic traits may be used to increase seed cotton yield.

CONCLUSION AND RECOMMENDATION

This study showed that the presence of considerable significant different among genotypes. High performing candidate genotypes for most of the traits as compared to checks variety in which genotypes chamo. Farm no.1A1-1 DP-90 F_1#307 and Farm no Ago1 DP-90 F_1#337 were among the genotypes with high mean performance for seed cotton yield and yield lint with other yield related traits and fiber quality traits. Furthermore, positive and significant genotypic correlation higher than phenotypic correlation was evident between seed cotton yield and yield component and fiber quality traits. This suggested that the higher the chance of improving seed cotton yield and lint yield through selection genotypes for yield components and fiber quality traits as correlation analysis suggested that selection based on the positive association of these characters with each other would be quite effective to improve the yield and fiber quality in upland cotton. The generated information showed that conventional breeding procedure is appropriate breeding method for achievement of variety development to improve yield and other desirable traits in target region in particular and in the country.

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