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Genetic parameters, correlation and path analysis of agro-morphological traits in elite genotypes of upland cotton (*Gossypium hirsutum* L.)

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Abstract
The experimental material for the present investigation comprised of 40 elite genotypes of upland cotton with one check (H 1098i). All the genotypes and checks were sown in the experimental area of the Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. Based on the mean performance genotypes *viz.,* H 1480, H 1489, H 1508, H 1530, H 1542, H 1556 and H 1557 had high mean values for different yield and yield contributing traits. Analysis of variance revealed significant differences for all traits studied among the progenies. Moderate estimates of the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. High heritability coupled with high genetic advance as per cent of mean was recorded for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. The correlation studies reveal highly significant positive association of seed cotton yield per plant with all the important yield contributing traits. The path-coefficient analysis suggested the importance of lint yield per plant and seed index as they exhibited high positive direct effects on seed cotton yield per plant. Hence, selections based on the above characters will result in genotypes with high seed cotton yield.

Keywords: Cucumber, boron, yield, quality, Konkan

Introduction

Cotton belongs to *Gossypium* genus which is a large, rich and economically important genus. Cotton is one of the most important fiber and cash crops in India. It plays a major role in Indian economy both in terms of providing raw material for textile manufacturing, mulch and cattle feed, employment directly and indirectly to about 60 million people and earning foreign exchange for the country. On account of its agricultural, as well as industrial importance, it is also called as 'White Gold'. The productivity of cotton has not made headway particularly in *Gossypium hirsutum*. Keeping in view the future needs of the country, there is a need to break plateau of yield potential by developing a high yielding cotton varieties or hybrids. Information on the nature and the extent of genetic variability is an important prerequisite in framing any crop improvement program. Genetic variability of a character indicated the possibility and extent to which improvement was feasible through selection on phenotypic and molecular basis. Genetic diversity is important for the selection of suitable diverse parents to obtain heterotic hybrids, predict progeny performance, conserve and characterize used germplasm. Correlation study is important for cotton breeding programs as correlation analysis determines the relationship between yield and quality characters. It also measures the relationship between various traits and determines the component characters on which selection can be based for genetic improvement in seed cotton and lint yield (Salahuddin *et al*., 2010) [28]. Correlation between yield and contributing traits is a powerful method for selection of superior genotypes from diverse genetic background but it does not give information about direct and indirect effects of independent variables on the dependent one and for this purpose path coefficient analysis is necessary (Erande *et al*., 2014) [11]. Correlation coefficient is divided into direct and indirect effects by path analysis. Path coefficient analysis is done in order to study the direct and indirect effects of individual component characters on the dependent variable i.e., seed cotton yield per plant. Study of path coefficients enable the breeders to concentrate on the variables which show high direct effect on seed cotton yield per plant. Keeping these above points in view, the present study on genetic variability, correlation and path analysis for different traits in promising genotypes of *G. hirsutum* was done to study the pattern of genetic variability and to estimate direct and indirect effects on seed cotton yield.

Materials and methods

The experimental plant materials for the present study comprised of 41 genotypes (Table 1) of upland cotton (*G. hirsutum* L). These genotypes were sown in the experimental area of the Cotton Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar during *Kharif* 2018 in a two rows of 3 meter length adopting a spacing of 67.5 cm between rows and 30 cm between the plants in randomized block design with three replications. All the recommended package of practices were followed to raise healthy crop.

Table 1: List of genotypes

Sr. No.	Genotype	Sr. No.	Genotype	Sr. No.	Genotype	Sr. No.	Genotype	Sr. No.	Genotype
1	H1480	10	H 1525	18	H 1535	26	H 1543	34	H 1552
2	H1488	11	H 1526	19	H 1536	27	H 1544	35	H 1553
3	H 1489	12	H 1527	20	H 1537	28	H 1545	36	H 1554
4	H 1508	13	H 1528	21	H 1538	29	H 1546	37	H 1556
5	H 1518	14	H 1529	22	H 1539	30	H 1548	38	H 1557
6	H 1519	15	H 1530	23	H 1540	31	H 1549	39	H 1558
7	H 1520	16	H 1531	24	H 1541	32	H 1550	40	H 1560
8	H 1521	17	H 1533	25	H 1542	33	H 1551	41	H 1098i (check)
9	H 1523								

In each replication five competitive plants were randomly selected and observations were recorded for seed cotton yield/ plant, lint yield/ plant, ginning % boll weight, seed index (g), lint index (g), plant height (cm), number of bolls/ plant.

Analysis of variance of the observations recorded on different characters was carried out as per the standard procedure suggested by Fisher (1925) [13]. According to Burton and Devane (1953) [6], genotypic and phenotypic coefficients of variation were estimated based on the estimates of genotypic and phenotypic variances. The genotypic and phenotypic coefficients of variation were categorized as per the method suggested by Shiva Subramanian and Menon (1973) [29] i.e. 0-10% = Low, 10-20% = Moderate, >20% = High. Heritability in broad sense was calculated as the ratio of genotypic variance to the phenotypic variance and expressed as percentage. The calculated heritability was classified into three groups as suggested by Johnson *et al.* (1955) [15] i.e. 0-30% = Low, 30-60% = Moderate, >60% = High. Genetic advance was calculated as per the formula given by Johnson *et al.* (1955) [15], and also categorized as 0-10% = Low, 10-20% = Moderate, >20% = High. The correlation coefficients among all possible character combinations at phenotypic 'r (p)' and genotypic 'r (g)' level were estimated by employing the formulae given by Al-Jibouri *et al.* (1958) [1]. The path coefficient analysis was performed as per the formula given by Wright (1921) and adopted by Dewey and Lu (1959) [8]. Standard path coefficients, also referred as the standardized partial regression coefficients, were calculated. These values were obtained by solving the following set of 'p' simultaneous equations using INDOSTAT software.

Results

The analysis of variance for the eight seed cotton yield and contributing traits revealed that the mean sum of squares due to genotypes were highly significant for all the traits studied. Therefore, adequate variability was present for yield and yield contributing traits in the material under study (Table 2).

Table 2: Mean Square values for various characters under study in 41 Genotypes

Source of variation (s. v)	Degree of freedom (d. f)	Mean sum of square							
		Seed cotton yield/ plant (g)	Lint yield /plant (g)	Ginning %	Boll weight (g)	Seed index (g)	Lint index (g)	Plant height (cm)	Number of bolls/ plant
Replication	2	120.291	59.537	17.741	0.122	0.854	1.880	158.747	171.413
Treatment	40	1823.327**	230.763**	29.773**	0.416**	1.232**	1.448**	396.924**	191.927**
Error	80	175.864	23.975	2.535	0.086	0.113	0.137	165.494	29.357

In population improvement, determination of the extent of genetic variability is important for trait improvement. The magnitude of variation is not important, but the extent of heritable variation is important for achieving a gain in selection program. Higher the heritability simpler the selection process, greater the response to selection. The variability was estimated for various yield traits in 41cotton genotypes (Table 3). The low phenotypic co-efficient of variance (PCV) and genotypic co-efficient of variance (GCV) were recorded for ginning out turn %, boll weight, seed index and, plant height. Low PCV and GCV estimates for these traits indicate a narrow range of variability for these characters and limited scope for selection. Moderate PCV and GCV were recorded for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. High heritability provides the evidence that larger proportion of phenotypic variance has been attributed to genotypic variance, and reliable selection could be made for these traits on the basis of phenotypic expression. In the genotypes, all the traits under study recorded high heritability except boll weight (55.8%) and plant height (31.8%) which were moderate. The genetic advance as percent of mean was recorded high for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant while moderate for ginning out turn, boll weight and seed index and low for plant height.

Table 3: Estimates of genotypic and phenotypic coefficient of variation, heritability and genetic advance for different characters in cotton genotypes

Traits	Coefficient of Variation (%)		Heritability% (H^2)	Genetic advance	
	Genotypic	Phenotypic		Standard	% of mean
Seed cotton yield/ plant(g)	12.76	14.66	75.7	42.01	22.88
Lint yield /plant(g)	11.53	13.38	74.2	14.73	20.47
Ginning out turn %	7.67	8.67	78.2	5.45	13.96
Boll weight (g)	8.68	11.61	55.8	0.51	13.35
Seed index (g)	7.92	9.05	76.7	1.10	14.29
Lint index (g)	13.21	15.14	76.1	1.19	23.73
Plant height (cm)	4.41	7.82	31.8	10.20	5.12
Number of bolls/ plant	13.48	16.74	64.9	12.21	22.36

For the effective selection process, it is very essential to find out the nature of association among various traits with the seed cotton yield per plant. For computing the nature of association of various traits with seed yield per plant, correlation coefficient analysis was carried out at both genotypic as well as phenotypic level (Table 4). Seed cotton yield (SCY) per plant exhibited positively and highly significant association with lint yield per plant (0.7649, 0.7763), number of bolls per plant (0.8874, 0.6631), plant height (0.449, 0.3427) and seed index (0.3644, 0.2577) at both genotypic as well as phenotypic level, respectively. SCY per plant exhibited positive and significant association with boll weight (0.1713) at genotypic level and also positive correlation with boll weight (0.0915) at phenotypic level. It also exhibited negative and highly significant association with ginning out turn % (-0.3491, -0.3507) at both genotypic as well as phenotypic level, respectively and exhibited negatively and highly significant association with lint index (-0.2305) at phenotypic level and significant association with lint index (-0.1962) at genotypic level. Direct selection for seed cotton yield is not effective as it is a complex quantitative character and much influenced by environment. The change in one character brings about a series of changes in other characters, since they are interrelated. Therefore, the study of correlation between yield and yield components are of considerable importance in selection programmes. Genotypic correlations in general were higher than phenotypic correlations. This may be due to the relative stability of genotypes as majority of them were subjected to certain amount of selection (Johnson *et.al.*, 1955) [15].

For path coefficient analysis, it was found that diagonal values have direct effect as presented in Table 5, the maximum positive value for direct effect was found for lint yield per plant (0.8925) followed by seed index (0.2372) and number of bolls per plant (0.1206).The highest negative effect was shown by lint index (-0.2795) followed by ginning out turn % (-0.2751) and plant height (-0.0868). Number of bolls per plant (0.588) followed by plant height (0.5487), lint index (0.324, ginning out turn % (0.2931), seed index (0.129) and boll weight (0.088) have indirect effects on seed cotton yield per plant through lint yield per plant. Highest negative indirect effect was shown by ginning out turn % (-0.2254) through lint index, followed by plant height (-0.1398), lint yield per plant (-0.1015) through lint index and lint index (-0.2219) through ginning out turn % for seed cotton yield per plant (Fig 1). Residual effects are coming about (0.072).

Table 4: Correlation coefficients among various traits in cotton genotypes

Traits	Lint yield /plant(g)	Ginning out turn %	Boll weight (g)	Seed index (g)	Lint index (g)	Plant height (cm)	Number of bolls/ plant	Seed cotton yield/ plant(g)
Lint yield /plant(g)	1.0000	0.3071**	0.0075	0.0743	0.3110**	0.3395**	0.5105**	0.7763**
Ginning out turn %	0.3284**	1.0000	-0.1205*	-0.2923**	0.8076**	-0.0512	-0.2291**	-0.3507**
Boll weight (g)	0.0986	-0.1161*	1.0000	0.1879*	-0.0245	0.1625*	-0.0847	0.0915
Seed index (g)	0.1445*	-0.3371**	0.3255**	1.0000	0.3083**	0.2835**	0.0350	0.2577**
Lint index (g)	0.3630**	0.8065**	0.0559	0.2681**	1.0000	0.1244*	-0.2533**	-0.2305**
Plant height (cm)	0.6148**	0.1903*	0.4702**	0.5080**	0.5002**	1.0000	0.2983	0.3427**
Number of bolls/ plant	0.6589**	-0.3364**	-0.0766	0.0956	-0.3418**	0.3328**	1.0000	0.6631**
Seed cotton yield/ plant(g)	0.7649**	-0.3491**	0.1713*	0.3644**	-0.1962*	0.4490**	0.8874**	1.0000

Phenotypic correlation (above diagonal) and genotypic correlation (below diagonal)

Table 5: Path coefficient analysis showing direct (diagonal and bold) and indirect effects of different characters on seed cotton yield/ plant in cotton genotypes

Traits	Lint yield /plant(g)	Ginning out turn %	Boll weight (g)	Seed index (g)	Lint index (g)	Plant height (cm)	Number of bolls/plant
Lint yield /plant(g)	0.8925	0.2931	0.0880	0.1290	0.3240	0.5487	0.5880
Ginning out turn %	- 0.0903	- 0.2751	0.0319	0.0927	- 0.2219	- 0.0524	0.0925
Boll weight (g)	0.0039	- 0.0046	0.0399	0.0130	0.0022	0.0187	-0.0031
Seed index (g)	0.0343	- 0.0800	0.0772	0.2372	0.0636	0.1205	0.0227
Lint index (g)	- 0.1015	- 0.2254	- 0.0156	- 0.0750	-0.2795	- 0.1398	0.0955
Plant height (cm)	- 0.0534	- 0.0165	- 0.0408	- 0.0441	-0.0434	- 0.0868	-0.0289
Number of bolls/ plant	0.0794	- 0.0406	- 0.0092	0.0115	- 0.0412	0.0401	0.1206
Correlation. Seed cotton yield/ plant(g)	0.7649	- 0.3491	0.1713	0.3644	- 0.1962	0.4490	0.8874

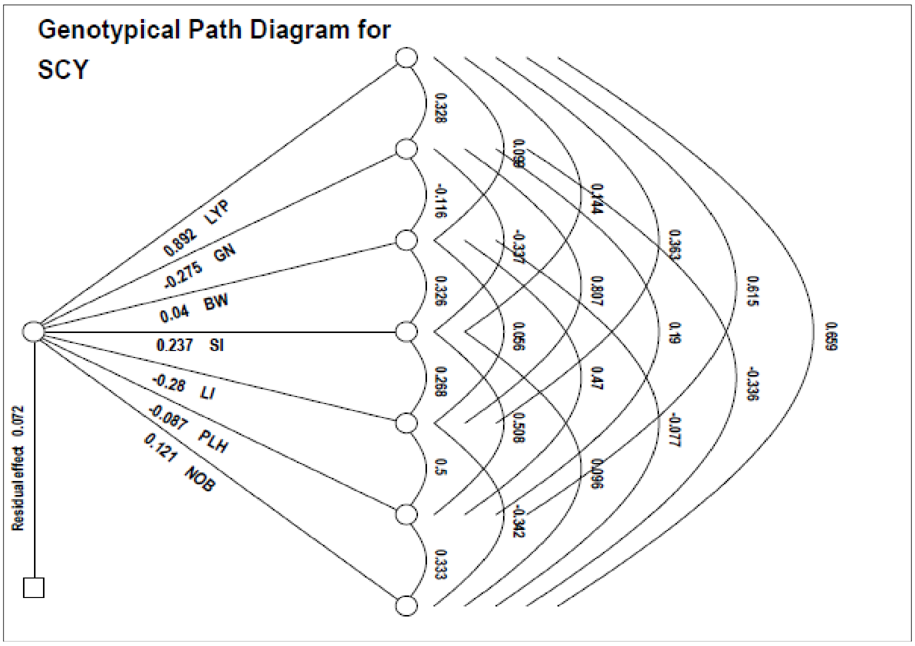

Fig 1: Path diagram showing direct and indirect effects of different traits on seed cotton yield per plant

Discussion

Presence of a wider spectrum of variability will enhance the chance of selecting a desired genotype. In the present study, PCV is greater than GCV for all the characters which were recorded indicating the role of environment in the expression of these traits. The PCV and GCV were low for ginning out turn %, boll weight, seed index and, plant height and moderate for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. Similar results were reported by Soomro *et al*. (2010) [30].

In the genotypes studied, all the traits under study recorded high heritability except boll weight which is moderate whereas genetic advance as percent of mean was recorded highest for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. Thus selection would be more effective for improvement for seed cotton yield per plant, lint yield per plant, lint index and number of bolls per plant. Ginning out turn and seed index recorded high heritability with moderate genetic advance as per cent of mean indicating variations for such characters is due to interaction of both additive and non-additive genetic factors. These findings were in agreement with Elango *et al*. (2012) [10], Hafiz *et al.* (2013) [14], Kulkarni *et al*. (2011) [16], Ranjan *et al*. (2014) [25], Dhivya *et al.* (2014) [9], Muhammad *et al.* (2015) [18] and Rajamani *et al*. (2015) [23].

Computation of correlation between yield and its attributing traits is of considerable importance in plant selection. Seed cotton yield per plant showed positive and highly significant association with lint yield per plant, number of bolls per plant, boll weight, plant height and seed index. It was negatively correlated with ginning out turn and lint index. These results are in conformity with earlier works of Mahantesh *et al.* (2010) and Magadum *et al.* (2012) [17] indicating that as most of the important morphological parameters are showing strong significant positive association with seed cotton yield/ plant, rational improvement in yield is possible through simultaneous selection for these component characters under hybridization programmes in cotton. The number of bolls per plant exhibited significant positive correlation with seed cotton yield per plant, lint yield per plant, plant height and seed index. Tulasi *et al.* (2014) [31] reported that number of bolls per plant showed positive correlation with seed cotton yield per plant, ginning out turn %. Whereas ginning out turn %, lint index and boll weight showed negative association at both genotypic and phenotypic level. The above results were supported by Lakshmi *et al.* (2008) [32]. Plant height exhibited positive and highly significant correlation with seed cotton yield per plant, lint yield per plant, ginning out turn %, boll weight, seed index, number of bolls per plant and lint index. The results were accordance with Vineela *et al.* (2012), Alkuddsi *et al.* (2013) [2], Farooq *et al.* (2014) [12], Patel and Jadan (2014) and Baloch *et al.* (2015) [5]. Seed index and lint index showed positive and significant correlation with lint yield per plant, boll weight and plant height. The results were in agreement with Rao and Gopinath (2013) [22] and Erande *et al*. (2014) [11]. Ginning out turn showed positive and significant correlation with lint index and plant height. Rajanna *et al.* (2011) [24] and Rajamani *et al.* (2013) [22] also obtained the similar results.

Among the characters studied, number of bolls per plant, boll weight, lint yield per plant and seed index showed direct positive effect on seed cotton yield per plant. Hence these traits were considered as important for improvement in the seed cotton yield per plant as they directly contribute towards it. These results were in accordance with Dahiphale and Deshmukh (2018) [7], Asha *et al.* (2015) [3], Padmavathi *et al.* (2015) [19]. Plant height, number of bolls per plant, boll weight, ginning out turn %, seed index and lint index showed positive indirect effect for seed cotton yield per plant through lint yield per plant. Similar results were reported by Reddy *et al.* (2015) [27], Babu *et al.* (2017) [4]. Plant height, ginning out turn and lint index showed direct negative effect on seed cotton yield per plant. Similar results were reported by Pradeep *et al.* (2014) [21], Farooq *et al.* (2013) and Rajanna *et al.* (2011) [24]. Residual effects are coming about (0.072). The lower residual effect indicated that the characters chosen for path analysis were adequate and appropriate.

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