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Genetic Variability and Association Analysis in Three Different Morphological Groups of Cotton (*Gossypium hirsutum* L.)

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Abstract: Genetic variability, correlations and path coefficients were studied in three different morphological groups viz., robust, semi-compact and compact types of *Gossypium hirsutum.* A combination of high heritability and genetic advance was noticed for characters plant height, internode length, number of sympodia, length of sympodia, number of flower bearing nodes, number of bolls, boll weight, seed cotton yield, micronaire, elongation percentage, specific leaf area, specific leaf weight, leaf area index and root length showing that they will respond to selection. Correlation and path analysis revealed that number of bolls per plant and boll weight were the important yield components in all the three groups while pre-flowering duration and internode length in semicompact types and specific leaf area in compact accessions also contributed to yield and formed the critical characters for cotton improvement.

Key words: Genetic variability, correlation, path, three morphological groups, cotton

INTRODUCTION

India ranks first in the world in respect of cotton area, but it is relegated to third place in total production and to seventeenth place in productivity, the low productivity being attributable to the predominance of rainfed cultivation. Water becoming increasingly scarce commodity every year in our country, a change in the approach is needed for development and identification of high yielding genotypes possessing the set of traits controlling productivity coupled with sufficient plasticity hardiness for cultivation in rainfed areas. In this context, the plant ideotype concept assumes greater importance as the set of morphological, physiological and productivity character is likely to vary according to the environment in which the genotype is being cultivated. It would therefore, be worthwhile to identify the attributes controlling productivity and plasticity. This information on yield related metric traits, physiological and biochemical characters would make it possible to plan crosses and to fix up a selection criteria based on the above characters not only to improve the yield but also the plasticity and thus finally a model plant type can be constructed for each situation. Importance of morphological, physiological, biochemical, anatomical and phenological traits in developing an ideal plant type has been reported by Rasmusson (1987).

Having a model plant in breeders mind, it is important to visually evaluate genetic material and identify a set of characters and study their nature of relationship and inheritance during germplasm screening (Rasmusson, 1991). In the present investigation, efforts were made to study nature of inheritance of yield, quality, physiological and biochemical traits. Further their interrelationships have also been studied.

MATERIALS AND METHODS

The experiment was conducted at Department of Cotton, Tamilnadu Agricultural University, Coimbatore. A set of one fifty accessions of *Gossypium hirsutum* were raised in randomized block design replicated twice with a spacing of 75 cm between ridges and 30 cm between plants. The genotypes were visually evaluated based on their stature, branching habit, leaf size, internode length and grouped into three distinct morphological groups viz. robust, semicompact and compact. In each replication, 5% plants were randomly selected per genotype for recording observations on yield and quality traits viz., plant height-PH (cm), petiole length-PL (cm) internode length-IL (cm), number of sympodia per plant-NOS, length of sympodia-LS (cm), number of flower bearing nodes in sympodia-NFBN, days to first flowering-FF, number of bolls per plant-NOB, boll weight-BW(g boll^{-1}), days to first boll

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bursting-FBB, days to fifty percent boll bursting-FIFBB, seed cotton yield-SCYLD (g plant^{-1}), seed index-SI, lint Index-LI, ginning out turn-GOT, 2.5 percent span length-SL (mm), bundle strength-BS (g tex^{-1}), uniformity ratio-UR, micronaire-MIC and elongation per cent-EL (percent). Apart from this, four physiological parameters namely leaf area index-LAI, specific leaf area-SLA (cm^2 g^{-1}), specific leaf weight-SLW (mg cm^{-2}) and root length-RL (cm) were recorded. The data recorded for robust, semi-compact and compact types were individually subjected to statistical analysis. Genotypic correlation was computed as per method suggested by Robinson *et al.* (1951). The path analysis was carried out as per the method suggested by Wright (1921) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

Germplasm has served as a major resource in conjugation with suitable breeding strategies for continuous improvement of yield in cotton, particularly in the last 50 years. The first and foremost criterion to be considered in any breeding programme is the magnitude of genetic variability present in base population which is the prime requirement for starting a judious breeding programme for combining desirable genes from diverse sources.

In present investigation, where 150 genotypes were grouped and studied for 28 characters, the group wise analysis indicated significant differences among the 67 robust genotypes for all the traits except number of flower bearing nodes, boll weight, seed index, lint index and micronaire. In semicompact genotypes variability among the genotypes were recorded for all the traits except number of flower bearing nodes, lint index, leaf area index and micronaire. Compact genotypes showed wide range of variation for all traits excluding number of flower bearing nodes, seed index, lint index, leaf area index, micronaire and elongation percentage. Thus the genotypes satisfied the preliminary requirements of sufficient variability qualifying them for further investigation.

Since the variances are influenced by magnitude of the units of measurement of different traits, a measure co-efficient of variation, which is independent of the unit of the measurement was used for comparison between different populations. The coefficient of phenotypic variation (PCV) was found to be greater than genotypic coefficient of variation (GCV) for all the characters studied indicating some degree of environmental influence (Table 1). Also estimates of GCV were closer to the estimates of PCV for all traits excluding number of flower bearing nodes in all the three groups and indicated the low effect of the non genetic factors. The semi-compact and compact types displayed high influence of environment as seen from wide differences between PCV and GCV estimates for specific leaf weight. Wide differences between PCV and GCV estimates for specific leaf weight have been reported by Raja (1996). Further

Table 1: Estimation of genetic parameters for different traits in robust, semicompact and compact genotypes

	Robust				Semi compact				Compact			
Characters	PCV (%)	GCV (%)	H^2 (%)	GA as % mean	PCV (%)	GCV (%)	H^2 (%)	GA as % mean	PCV (%)	GCV (%)	H^2 (%)	GA as % mean
PH	12.96	12.85	98.36	26.26	17.03	16.91	98.60	34.60	11.46	11.24	96.29	22.74
IL	17.20	16.59	93.04	32.96	19.65	19.10	94.57	38.27	25.23	24.61	95.17	49.46
PL	10.35	9.48	84.00	17.91	15.92	15.53	95.16	31.22	17.25	16.59	92.52	32.88
NOS	18.25	17.23	89.08	33.49	22.22	21.42	92.92	42.53	23.20	22.10	90.70	43.35
LS	16.75	16.45	96.45	33.27	13.24	12.51	89.25	24.35	15.53	14.82	91.06	29.13
FBN	26.40	21.36	65.45	35.60	30.00	27.32	82.90	51.24	31.60	27.89	77.86	50.69
FF	4.42	4.28	93.41	8.51	3.56	3.31	86.13	6.32	3.73	3.42	84.33	6.47
NOB	21.63	20.52	89.95	40.08	24.18	23.16	91.74	45.70	26.96	25.79	91.50	50.83
BW	22.71	21.81	92.26	43.16	23.31	22.63	94.26	45.26	23.31	21.46	84.75	40.69
FBB	8.35	8.33	99.58	17.13	8.31	8.29	99.41	17.03	8.29	8.28	99.76	17.04
FIFBB	7.83	7.82	99.73	16.08	7.70	7.68	99.60	15.79	7.54	7.53	99.80	15.50
SCYLD	23.94	23.75	98.40	48.53	26.72	26.55	98.69	54.33	33.64	33.44	98.81	68.48
SI	10.35	9.20	78.80	16.80	12.00	10.85	81.71	20.19	9.11	7.26	63.40	11.90
LI	12.44	10.97	77.71	19.92	13.42	11.97	79.52	21.99	11.10	9.49	73.06	16.71
GOT	6.06	5.75	90.13	11.25	7.42	7.21	94.30	14.42	5.68	5.26	85.36	10.03
SLW	11.04	9.05	67.22	15.29	15.87	12.13	58.49	19.12	16.54	13.29	64.56	21.99
SLA	10.75	10.12	88.72	19.65	12.99	12.48	92.24	24.68	14.21	13.91	95.80	28.05
LAI	28.43	28.41	99.85	58.49	31.86	31.85	99.94	65.60	36.39	36.28	99.37	74.50
RL	22.60	21.90	93.84	43.68	19.84	18.92	90.93	37.17	20.53	18.91	84.80	35.86
SL	6.22	5.70	84.19	10.78	7.23	6.85	89.81	13.38	5.16	4.57	78.39	8.33
UR	3.94	3.10	61.86	5.02	4.53	3.78	69.63	6.49	4.25	3.48	66.71	5.85
MIC	11.71	11.45	95.53	23.05	11.72	11.42	94.87	22.90	11.94	11.69	95.87	23.57
BS	6.28	5.79	84.74	10.97	7.87	7.42	88.92	14.42	8.88	8.53	92.42	16.90
EL	14.42	14.23	97.35	28.93	14.64	14.46	97.51	29.41	12.98	12.73	96.17	25.72

correspondence of GCV and PCV estimates for all other characters indicates that there is ample scope for improvement in these traits through selection. Similar results were obtained by Bharad *et al*. (1999), Gururajan (2000) and Girase and Mehetre (2002). In case of semicompact group the characters amenable for selection are number of sympodia, number of bolls, boll weight, seed cotton yield and leaf area index. In addition to these characters internode length was found to exhibit wide genetic variability in compact genotypes. Earliness indicated by days to first flowering, days to first boll bursting and days to 50% boll bursting and the important quality characters viz., 25% span length, uniformity ratio and bundle strength showed low GCV estimates in all the three groups indicating the limited scope of the genotypes for improvement.

Genotypic co-efficient of variation does not give an exact idea on total variation that is heritable. A perusal of heritability (H^2) estimates indicated that all the characters under study showed high heritability in all the three groups. The only exception was the specific leaf weight, which showed moderate heritability values in semicompact group.

High heritability coupled with high genetic advance (GA) was noticed for plant height, internode length, number of sympodia, length of sympodia, number of flower bearing nodes, number of bolls, boll weight, seed cotton yield, leaf area index, root length, micronaire and elongation percentage in all the three groups (Table 1). Apart from these traits, high heritability and high genetic advance for petiole length, seed index and lint index and specific leaf area was recorded in semicompact genotypes. In robust type's petiole length, specific leaf weight and specific leaf area recorded high estimates of heritability and genetic advance together. All these traits can be improved through selection as they are controlled by additive genes. Days to first flowering and the fibre uniformity ratio recorded high heritability estimates combining low genetic advance in all the three groups suggesting the involvement of non-additive gene action in their inheritance. The high degree of environmental influence to which these characters respond might have resulted in such situation. High heritability coupled with high genetic advance was reported by Valarmathi and Jehangir (1998) and Girase and Mehetre (2002) for some of the characters included in the study.

Seed cotton yield is the resultant product of component characters which is not under the direct control of any gene. Thus, an improvement of component characters leads to a consequent improvement of yield. Therefore, for achieving rational improvement of yield and its components, knowledge of mechanism of association, cause and effect relationship provide a basis for formulating suitable selection methods on the basis of yield components. In the present investigation correlation and path analyses were carried out separately for each group (robust, semicompact and compact) to formulate selection indices for yield improvement. This further gives an idea on the characters to be considered for developing suitable plant type in each group. A perusal of the genotypic correlation co-efficients of robust types (Table 2) revealed that number of bolls, boll weight, days to first boll bursting and leaf area index were positively associated with seed cotton yield. Reports are already available on the positive association of yield with number of bolls (Rao *et al*., 2001; Iqbal *et al*., 2003, 2006), with boll

Table 2: Genotypic correlation co-efficient between different traits in robust genotypes

Characters	IL	PL	NOS	LS	FBN	FF	NOB	BW	FBB	FIFBB	SI
PH	0.35**	-0.03	0.52**	0.23**	0.22**	0.15	0.28**	-0.25**	-0.06	-0.09	0.07
IL		0.30**	0.11	-0.02	-0.08	0.14	0.05	-0.12	0.01	0.01	0.06
PL			-0.05	0.09	-0.11	0.03	0.04	-0.21*	0.35**	0.36**	-0.16
NOS				0.27**	-0.19*	0.09	0.17	0.10	-0.14	-0.13	0.11
LS					0.24**	0.16	0.27**	-0.35**	0.06	0.08	0.10
FBN						0.04	0.15	-0.13	0.24**	0.24**	0.22**
FF							0.12	-0.10	0.06	0.08	0.16
NOB								-0.54**	0.36**	0.35**	0.23**
BW									-0.21*	-0.24**	0.01
FBB										0.99**	-0.08
FIFBB											-0.06
SI											
LI											
GOT											
SLW											
SLA											
LAI											
RL											
SL											
UR											
MIC											
BS											
EL											

Table 2: Continued

Characters	LI	GOT	SLW	SLA	LAI	RL	SL	UR	MIC	BS	EL	SCYLD
PH	0.06	0.02	-0.20*	0.11	0.38**	0.14	0.10	-0.19*	-0.29**	0.12	0.09	-0.08
IL	-0.19*	-0.06	-0.27**	0.12	0.15	-0.01	-0.05	0.03	-0.11	0.17*	0.23**	0.05
PL	-0.08	-0.01	-0.13	0.07	0.06	0.18*	-0.29**	0.12	0.24	0.15	0.01	-0.03
NOS	-0.09	-0.04	0.04	-0.24**	0.46**	-0.06	0.03	-0.17*	-0.01	-0.14	0.02	0.12
LS	-0.11	-0.16	0.25**	-0.06	0.22*	-0.03	-0.09	-0.14	-0.08	-0.08	0.02	-0.10
FBN	0.29*8	0.06	-0.15	0.18	0.00	0.08	-0.14	0.01	-0.26**	-0.06	0.04	-0.06
FF	0.10	0.02	0.36**	-0.31**	-0.18*	-0.15	0.14	-0.37**	-0.17*	0.08	-0.10	0.06
NOB	0.29**	-0.05	-0.15	0.13	0.17*	-0.03	0.19**	0.01	-0.12	0.22*	0.02	0.39**
BW	-0.17	0.04	-0.15	-0.05	0.12	0.06	-0.08	0.06	0.14	-0.23**	-0.15	0.50**
FBB	0.14	0.23**	0.00	-0.03	-0.07	0.05	-0.16	0.02	0.01	0.01	-0.01	0.14
SI	0.46**	-0.28**	-0.06	0.08	-0.13	-0.08	0.67**	-0.08	-0.09	0.43**	-0.26**	0.17
LI		0.52**	-0.06	0.16	-0.16	0.11	0.38**	0.03	0.19*	0.28**	-0.16	0.04
GOT			-0.07	0.05	0.09	0.27**	-0.21*	0.13	0.17*	-0.17	0.27**	-0.04
SLW				-1.00	-0.16	-0.12	0.03	-0.14	-0.01	0.21**	-0.03	-0.19*
SLA					-0.01	0.06	-0.08	0.23**	0.07	-0.18**	0.04	0.02
LAI						0.25**	-0.03	-0.04	-0.17*	0.01	-0.07	0.19*
RL							-0.06	-0.04	0.11	-0.14	0.01	0.01
SL								-0.97**	-0.33**	0.47**	-0.62**	-0.03
UR									0.25**	-0.35**	0.43**	0.11
MIC										-0.29**	0.01	0.09
BS											-0.27**	-0.03
EL												-0.05

**Significance at 1 % level,*Significance at 5% level

Table 3: Direct and indirect effects of different traits in robust genotypes (based on genotypic correlation)

Characters	NOB	BW	FBB	SLW	LAI	SCYLD
NOB	**1.126**	-0.607	0.402	-0.173	0.195	0.389**
BW	-0.973	**1.805**	-0.379	-0.273	0.219	0.504**
FBB	-1.543	0.908	**-4.322**	0.059	0.189	0.174*
SLW	-0.019	-0.019	-0.002	**0.122**	-0.019	-0.19*
LAI	-0.018	0.013	-0.004	-0.016	**0.103**	0.194*

**Significance at 1% level,*Significance at 5% level (Note: Only those characters which showed significant association with SCYLD were used for path coefficient analysis)

weight (Manimaran, 1999; Iqbal *et al*., 2003, 2006), with leaf area index (Ashley *et al*., 1963). The intercorrelation of number of bolls with days to first and 50% boll bursting, seed index, lint index, leaf area index, 2.5% span length and bundle strength were positive. Due weightage should therefore, be given for the above characters also. Further partitioning of correlation through path analysis indicated the importance of the characters boll number and boll weight which exerted high positive direct influence on seed cotton yield (Table 3) which was in accordance with the reports of many authors in general for the *Hirsutum* varieties. The positive direct effects exerted by specific leaf weight and leaf area index indicate the importance of these physiological traits in improving the yield.

In respect of semicompact genotypes (Table 4), internode length, length of sympodia, number of flower bearing nodes, days to first flowering, number of bolls, boll weight and leaf area index had shown significant positive correlation with seed cotton yield. In this group in addition to yield components the morphological characters like internode length and length of sympodia had also exerted their importance. There was negative correlation of bundle strength with seed cotton yield. The high direct effects exerted by days to first flowering, boll weight, number of bolls and internode length (Table 5) suggest that these characters should be assigned high priority while making selection of elite semicompact genotypes. Nevertheless, lateness of crop duration should be critically considered to arrive at optimum combination of duration and yield.

In compact genotypes, positive correlation of seed cotton yield with internode length, days to first flowering, number of bolls, boll weight, lint index, specific leaf area, leaf area index, uniformity ratio and micronaire was observed (Table 6). However among these traits, high positive direct effect was exerted by boll weight, number of bolls and specific leaf area (Table 7). So these traits must be given importance while exercising selection on compact genotypes.

The comparison of the results of path analysis of each of the three groups has revealed two interesting points for exploitation. The two important characters to be considered in common for all the three groups are the boll weight and boll number. Besides, in semicompact group, pre-flowering duration and internode length and in compact type, specific leaf area also have to be considered. The specific leaf area is an indication of the total leaf area of the plant as well as the entire photosynthetic activity, which is lesser than the other two groups and becomes the limiting factor in compact genotypes. In robust group however in view of large leaf area, there is abundant photosynthetic activity. In

Table 4: Genotypic correlation co-efficient between different traits in semicompact genotypes

Characters	IL	PL	NOS	LS	FBN	FF	NOB	BW	FBB	FIFBB	SI
PH	0.30**	0.19*	0.62**	0.03	-0.04	-0.02	0.24**	0.13	0.09	-0.14	0.15
IL		0.23**	0.00	0.19*	0.24**	0.12	0.24**	0.28**	0.22*	-0.02	0.17*
PL			0.19*	0.29**	0.25**	-0.02	0.28**	0.30**	0.26**	-0.18*	0.03
NOS				0.06	0.02	-0.16	-0.07	0.04	0.14	0.29**	-0.21*
LS					0.30**	0.07	0.09	0.05	0.10	0.35**	0.02
FBN						0.10	0.18*	0.02	-0.01	0.05	-0.09
FF							0.41**	0.16	0.15	-0.16	0.02
NOB								0.03	0.00	-0.41**	0.25**
BW									0.88**	0.03	-0.02
FBB										0.13	-0.10
FIFBB											-0.22*
SI											
LI											
GOT											
SLW											
SLA											
LAI											
RL											
SL											
UR											
MIC											
BS											
EL											

Table 4: Continued

Characters	LI	GOT	SLW	SLA	LAI	RL	SL	UR	MIC	BS	EL	SCYLD
PH	0.14	0.01	0.22*	-0.27**	0.25**	0.02	0.11	-0.12	-0.15	0.13	0.20*	0.03
IL	0.23**	-0.02	0.24**	-0.25**	0.41**	0.24**	0.16	-0.33**	-0.31**	0.09	-0.03	0.22**
PL	0.07	-0.10	0.22*	-0.18*	0.22*	0.12	0.01	-0.01	0.17	0.16	0.12	0.03
NOS	-0.19*	0.05	0.18*	-0.19*	0.18*	-0.22	-0.17*	0.06	-0.02	-0.03	0.28**	0.12
LS	0.12	0.11	0.18*	-0.23**	0.05	-0.15	-0.09	0.11	0.37**	-0.05	0.11	0.47**
FBN	-0.07	0.01	0.22*	-0.10	0.11	0.02	-0.16	0.01	0.01	-0.03	-0.16	0.20*
FF	0.05	-0.08	-0.09	0.04	0.18*	0.06	0.14	-0.18*	-0.07	0.17*	-0.24**	0.27**
NOB	0.24**	-0.08	0.20*	-0.13	0.33**	0.30**	0.09	0.01	-0.03	0.14	-0.01	0.45**
BW	0.18*	0.11	0.44**	-0.34**	0.30**	0.26**	-0.14	-0.11	-0.14	-0.06	0.10	0.06
FBB	0.13	0.13	0.40**	-0.34**	0.28**	0.16	-0.21*	-0.02	-0.08	-0.04	0.10	0.13
FIFBB	-0.05	0.23**	-0.17	-0.04	0.01	-0.12	-0.12	0.16	0.09	-0.36**	0.18*	0.57**
SI	0.46**	-0.27**	0.00	0.05	-0.11	0.06	0.46**	-0.42**	0.06	0.36**	-0.19*	0.15
LI		0.61**	-0.15	0.00	0.07	0.25**	0.09	0.07	0.20*	-0.04	0.07	0.14
GOT			-0.07	-0.05	0.01	0.30**	-0.22*	0.42**	0.33**	-0.32**	0.21**	0.01
SLW				-0.98**	0.42**	0.01	0.06	-0.16	-0.07	0.46**	0.07	-0.01
SLA					-0.40**	-0.12	-0.05	-0.06	0.02	-0.26**	-0.24**	-0.16
LAI						0.18*	0.19*	-0.24**	-0.22**	-0.02	-0.04	0.25**
RL							-0.03	0.04	0.05	-0.10	0.01	0.09
SL								-0.99**	-0.27**	0.41**	-0.33**	0.03
UR									0.32**	-0.33**	0.26**	-0.04
MIC										-0.19*	-0.01	0.09
BS											-0.43**	-0.23**
EL												0.15

**Significance at 1 % level,*Significance at 5% level

Table 5: Direct and indirect effects of different traits in semi compact genotypes (based on genotypic correlation)

Characters	IL	LS	NFBN	FF	NOB	BW	LAI	BS	SCYLD
IL	**0.675**	0.013	0.016	0.008	0.016	-0.002	0.028	0.006	0.221*
LS	0.013	**0.070**	0.021	0.005	0.006	0.025	0.004	-0.004	0.469**
NFBN	0.018	0.023	**0.076**	0.007	0.014	0.004	0.008	-0.002	0.197*
FF	0.010	0.006	0.008	**0.876**	0.036	-0.014	0.015	0.015	0.267**
NOB	0.168	0.065	0.127	0.291	**0.713**	-0.290	0.236	0.101	0.451**
BW	-0.020	0.290	0.038	-0.133	-0.332	**0.817**	0.000	-0.294	0.569**
LAI	-0.035	-0.005	-0.009	-0.015	-0.028	-0.00	**-0.086**	0.001	0.245**
BS	-0.012	0.007	0.004	-0.023	-0.019	0.048	0.002	**-0.133**	-0.233**

**Significance at 1% level,*Significance at 5% level (Note: Only those characters which showed significant association with SCYLD were used for path coefficient analysis)

Table 6: Genotypic correlation co-efficient between different traits in compact genotypes

Characters	IL	PL	NOS	LS	FBN	FF	NOB	BW	FBB	FIFBB	SI
PH	0.38*	0.36*	0.17	0.33	0.48**	0.38*	0.25	0.21	0.23	-0.39*	-0.28
IL		0.34*	-0.26	0.20	0.04	0.14	0.32	0.12	0.08	-0.08	0.09
PL			0.06	0.36*	-0.12	0.00	-0.08	0.15	0.16	-0.17	0.08
NOS				0.32	0.18	-0.01	-0.03	-0.56**	-0.50**	0.28	0.09
LS					0.03	-0.09	0.35*	0.06	0.11	0.00	0.05
FBN						0.34*	-0.24	0.12	0.12	-0.40*	-0.32
FF							0.36*	0.18	0.16	-0.01	-0.95**
NOB								-0.03	-0.09	-0.20	-0.25
BW									0.99**	-0.33	-0.06
FBB										-0.29	-0.05
FIFBB											0.53**
SI											
LI											
GOT											
SLW											
SLA											
LAI											
RL											
SL											
UR											
MIC											
BS											
EL											

Table 6: Continued

Characters	LI	GOT	SLW	SLA	LAI	RL	SL	UR	MIC	BS	EL	SCYLD
PH	0.23	0.41**	0.01	-0.13	0.31	0.53**	-0.39*	0.20	0.06	-0.18	0.15	0.01
IL	0.32	0.37*	0.35*	-0.23	0.03	0.47**	-0.12	0.27	0.01	0.13	-0.04	0.41*
PL	0.08	0.03	-0.15	-0.02	-0.22	0.27	0.21	-0.11	-0.15	0.32	0.07	-0.09
NOS	0.27	0.03	-0.78**	0.50**	0.46**	-0.34	-0.47**	-0.03	0.46**	-0.57**	0.40*	0.09
LS	-0.11	-0.37*	-0.56**	0.41**	-0.31	0.33	-0.63**	-0.09	0.05	-0.27	0.35	0.24
FBN	-0.60**	-0.23	-0.27	0.07	0.31	0.08	-0.45**	-0.30	-0.24	-0.12	0.29	-0.41*
FF	0.04	0.59**	-0.19	0.39*	0.70**	0.14	-0.46**	0.47**	0.14	-0.41*	0.32	0.42*
NOB	0.27	0.06	-0.06	-0.16	0.24	0.43*	-0.50**	0.33	-0.05	-0.45**	-0.21	0.58**
BW	-0.05	0.18	0.12	-0.16	-0.24	0.52**	0.16	-0.12	-0.41**	0.02	-0.12	-0.25
FBB	-0.04	0.20	0.06	-0.10	-0.22	0.45**	0.08	-0.05	-0.40*	0.01	-0.01	-0.28
FIFBB	0.44	0.03	-0.37*	0.68**	0.27	-0.44**	0.07	0.26	0.74**	-0.09	0.39*	0.62**
SI	0.47**	-0.33	0.35	-0.07	-0.26	0.07	0.44**	-0.52**	0.37*	0.02	-0.21	0.17
LI		0.47**	0.23	-0.15	0.40**	-0.08	-0.10	-0.02	0.42*	-0.46**	-0.14	0.52**
GOT			0.40*	-0.30	0.48**	-0.07	-0.29	0.41*	-0.17	-0.37*	-0.09	0.08
SLW				-1.02	-0.28	0.09	0.40*	-0.18	-0.48**	0.58**	-0.61**	-0.37*
SLA					0.34*	-0.39*	-0.34*	0.45**	0.54**	-0.18	0.79**	0.45**
LAI						-0.20	-0.56**	0.33	0.42*	-0.55**	0.39*	0.39*
RL							0.29	-0.38*	0.05	-0.06	-0.53**	0.09
SL								-1.17	-0.01	0.46**	-0.81**	-0.29
UR									-0.19	-0.15	0.58**	0.50**
MIC										-0.19	0.14	0.60**
BS											-0.03	-0.23
EL												0.20

**Significance at 1% level,*Significance at 5% level

Table 7: Direct and indirect effects of different traits in compact (based on genotypic correlation)

Characters	IL	NFBN	FF	NOB	BW	LI	SLW	SLA	LAI	UR	MIC	SCYLD
IL	0.294	0.013	0.043	0.095	-0.025	0.095	0.110	-0.069	0.009	0.078	0.002	0.414*
NFBN	0.002	0.058	0.020	-0.014	-0.024	-0.035	-0.016	0.004	0.018	-0.017	-0.014	-0.414
FF	-0.004	-0.009	-0.026	-0.009	0.001	-0.001	0.005	-0.010	-0.018	-0.012	-0.004	0.420*
NOB	0.131	-0.100	0.147	0.409	-0.084	0.111	-0.023	-0.064	0.099	0.136	-0.020	0.576**
BW	-0.044	-0.212	-0.005	-0.107	0.523	0.230	-0.194	0.353	0.143	0.138	0.388	0.624**
LI	0.051	-0.094	0.006	0.043	0.070	0.158	0.037	-0.024	0.063	-0.004	0.066	0.522**
SLW	0.039	-0.030	-0.022	-0.006	-0.042	0.026	0.112	-0.114	-0.031	-0.020	-0.054	-0.367*
SLA	-0.116	-0.035	0.197	-0.078	0.338	-0.077	-0.511	0.500	0.171	0.223	0.272	0.450**
LAI	-0.001	-0.005	0.012	-0.004	-0.005	-0.007	0.005	-0.006	-0.016	-0.005	-0.007	0.386*
UR	0.055	-0.061	0.096	0.068	0.054	-0.005	-0.036	0.091	0.068	0.205	-0.039	0.495**
MIC	0.002	-0.045	0.026	-0.009	0.137	0.077	-0.0890	0.101	0.078	-0.035	0.185	0.602**

**Significance at 1% level,*Significance at 5% level (Note: Only those characters which showed significant association with SCYLD were used for path coefficient analysis) semicompact group late flowering types and plants with greater internode length which favour more light interception and more duration of exposure to sunlight tend to influence the yield.

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