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Annals of Biological Research, 2012, 3 (8):3910-3915
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Scholars Research Library
ISSN 0976-1233
CODEN (USA): ABRNBW

Yield and fibre quality components analysis in upland cotton (*Gossypium hirsutum* L.) under salinity

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ABSTRACT

Cotton being an important cash crop of India plays a distinguished role in energizing the economy of the country by fetching appreciable amount of foreign exchange annually. The cotton production of country is improving significantly but the yield per unit area is still lower than that of the other countries due to some biotic and abiotic factors. Amongst the abiotic stresses, salinity is a serious threat next to drought. Keeping in view, the present study was conducted to assess the salt tolerance of 32 popular upland varieties released for general cultivation between 1980 and 2001 in India. The study was carried out in normal as well as saline-alkaline condition; in which salinity were created using bore well water irrigation and the average electrical conductivity level of bore well water is 3.10 ds/m. The 32 upland cotton genotypes under both salinity and normal conditions revealed high GCV and genetic gain for number of bolls per plant, boll weight, lint yield per plant, 2.5 per cent span length, leaf area index, Na-K ratio and seed cotton yield and these traits could be improved by simple selection. Correlation and path analysis studies revealed that the seed cotton yield was highly influenced by lint yield per plant in both normal and saline-alkaline condition. Significant positive correlations exists between Bartlett's rate index with uniformity ratio, 2.5 per cent span length with bundle strength, uniformity ratio with micronaire and elongation percent, specific leaf area with leaf area index. These results clearly indicated that selection for any one of these traits might lead to concurrent improvement of other traits as well as seed cotton yield. The characters boll weight (-0.347), ginning out turn (-0.528), 2.5% span length (-0.312) and uniformity ratio (-0.440) registered high order negative direct effect on seed cotton yield. This result further confirms the negative association between the quality and yield.

Key words: Cotton, Salinity, Variability, Correlation, Path analysis

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INTRODUCTION

Cotton, popularly referred as "**White Gold**", is an important fibre crop of global importance, cultivated in tropical and sub-tropical regions of more than seventy countries. Its importance in our economy is reflected in terms of generating employment, and foreign exchange earnings. Cotton is the lifeline for about 60 million people which includes farmers and workers involved in the cotton industry from processing to trading [11]. Even though India has largest area planted to cotton (9.58 m. ha) and second in production (310 lakh bales) productivity is very low (555 kg lint/ha) *i.e.*, far below the world average [2]. This is due to the fact that, cotton growing areas are largely rainfed. To achieve higher production, various biotic and abiotic stresses that limit cotton productivity have to be carefully analysed. Among various abiotic stresses, salinity is a serious threat, next to drought. In India, out of 8.6 m. ha of salt affected soils, 2.19 m ha are coastal saline. In some areas of Gujarat, Karnataka, Andhra Pradesh and Haryana, the cotton crop is adversely affected by soil and water salinity. Salinity affects extensive arid and semiarid areas all over the world, producing diminished yields of many crops.

The problem of saline soil is increasing owing to the use of poor quality water for irrigation, improper drainage in canal-irrigated wet land agro ecosystems, entry of sea water during cyclones in coastal areas and salt accumulation in the root zone in arid and semi arid regions due to high evaporation demand and insufficient leaching of ions due to inadequate rainfall [6]. Karaikal, one of the four regions of Union Territory of Puducherry situated in coramandal coast, is in the tail end of Cauvery delta zone. Upland cotton is cultivated as rice fallow crop wherever potential irrigation source is available, mainly from bore wells. However due to uncertainty or less quantum of canal water received, recharging of ground water is drastically affected. This has resulted in seawater intrusion into the lower aquifers and hence deep bore wells pump only poor quality water [16]. The Central Ground Water Board Report (1993) indicates the quality of majority of bore wells in this region as highly saline sodic.

Since upland cotton is known for salt tolerance, there is ample scope to sustain cotton productivity in the existing cropping pattern. Against this back drop, the present investigation, involving *Gossypium hirsutum* genotypes released for general cultivation between 1998 and 2001 in India, was undertaken herein to assess and screen for salt tolerance, to understand the degree and direction of association of various traits with seed cotton yield among themselves, to study the direct and indirect contribution of different traits to seed cotton yield and to identify the superior genotypes from diverse genetic stocks for further use in hybridization programme.

MATERIALS AND METHODS

The experimental material included 32 varieties of upland cotton (*Gossypium hirsutum* L.) collected from different cotton growing regions of India. The experiment was conducted in randomized complete block design with three replications under normal and saline-alkaline conditions during summer 2007 at Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The characteristics of soil and irrigation water are presented in Table I. Recommended package of practices and plant protection measures were adopted to raise a good crop and the spacing followed was 60 cm between rows and 30 cm between plants with a row length of three meter. Water samples were collected at each irrigation. The characteristics of water samples collected are presented in the Table II. Observations were recorded in five randomly selected plants of each genotype in each replication under both saline alkaline and normal conditions for number of bolls per plant, boll weight (g), lint yield per plant (g), ginning out turn (%), bartlett's rate index, seed cotton yield per plant (g), 2.5 per cent span length (mm), uniformity ratio, micronaire value (µg/inch), bundle strength (g/tex), specific leaf area, leaf area index and Na-K ratio. A sample of 50 g lint in each genotype was taken for the fibre quality analysis using "High Volume Instrument" at Cotton Breeding Station, Tamil Nadu Agricultural University, Coimbatore. The mean values of the genotypes were compared based on the classification of fibre characteristics for each of the characters as advocated by Central Institute for Research on Cotton Technology (CIRCOT), Mumbai.

Statistical analysis

The mean values of all the biometric traits in both normal and saline-alkaline condition were taken separately for statistical analysis. The statistical parameters like mean, variance, standard error and critical difference were estimated and the analysis of variance was done as per the method [14]. From mean values of each character, genotypic and phenotypic coefficients of variation, heritability (broad sense) and genetic advance were computed using standard statistical procedures [10]. The phenotypic and genotypic variances were calculated by utilizing the respective mean sum of square from variance table [12]. The association between yield and component traits and among themselves were computed based on the *per se* performance of the genotypes as genotypic and phenotypic correlation coefficients [8]. The variance and covariance components were utilised to calculate phenotypic and genotypic correlation coefficients [1]. Path coefficient analysis [7] was used to partition the correlation coefficients into direct and indirect effects.

Table I. Characteristics of soil and irrigation water

Sample	Condition	Ec (ds/m)*	pH*	SAR*	RSC (meq/l)*
Soil	Normal	2.16	8.26	-	-
	Saline	5.50	9.20	-	-
Irrigation water	Normal (Pond water)	0.86	8.20	9.01	2.28
	Saline (Bore well)	3.10	8.60	18.83	10.83

Table II. Characteristics of irrigation water taken at every irrigation

Stage	Ec (ds/m)*	pH*	SAR*	RSC (meq/l)*
16^{th} day	4.72	9.00	28.10	18.50
26^{th} day	4.84	9.50	27.40	16.55
44^{th} day	2.85	8.95	23.10	14.79
57^{th} day	3.40	8.88	22.44	12.26
72^{nd} day	3.10	9.30	26.31	12.54
154^{th} day	2.74	9.15	24.15	14.12

**Ec - Electrical conductivity*
**pH - Measure of acidity or basicity of an aqueous solution*
**SAR - Sodium absorption ratio*
**RSC - Residual sodium carbonate*

RESULTS AND DISCUSSION

Cotton is known for salt tolerance [4, 9], but salinity reduces net photosynthetic rate, transpiration rate, and stomatal conductance in upland cotton [15]. Therefore, a satisfactory stand of cotton crop on saline soils and or under saline water irrigation is a serious problem of common occurrence. The present attempts to study degree and direction of association of various traits with seed cotton yield among themselves, to study the direct and indirect contribution of different traits to seed cotton yield and to identify the superior genotypes from diverse genetic stocks for further use in hybridization programme.

Genetic variability

The variability available in breeding material is the prime requirement for the improvement and selection of elite cotton genotypes. High estimates of phenotypic and genotypic coefficient of variation was observed for number of bolls per plant, boll weight, lint yield per plant, leaf area index, Na-K ratio and seed cotton yield (Table III). Varieties of upland cotton responded differently to salinity, and the character was heritable in nature [3, 5]. The same inference was drawn earlier in *Gossypium herbaceum* genotypes under saline condition for number of bolls per plant and seed cotton yield [13]. The traits *viz.*, ginning out turn, 2.5 per cent span length and specific leaf area recorded moderate phenotypic and genotypic coefficient of variation. However, earlier report indicated low phenotypic and genotypic coefficient of variation for ginning out turn and 2.5 per cent span length [13]. Low phenotypic and genotypic coefficient of variation was expressed for Bartlett's rate index, uniformity ratio, micronaire value, bundle strength and elongation percent and these characters might be a poor index for selection of genotypes. Similar findings were reported for the characters like uniformity ratio and bundle strength [13].

High heritability and genetic advance were observed for the traits *viz.*, number of bolls per plant, boll weight, lint yield per plant, 2.5 per cent span length, specific leaf area, leaf area index, Na-K ratio and seed cotton yield. This observation differed from the findings [13] in *Gossypium herbaceum* genotypes who reported moderate heritability and genetic advance for number of bolls per plant and seed cotton yield under saline condition. The high estimates of heritability and genetic advances observed for these traits indicated predominance of additive gene action indicating scope of selection for the improvement through these characters. High heritability with moderate genetic advance was observed for Bartlett's rate index, micronaire value, bundle strength and elongation percent indicating the action of both additive and non-additive genes. A high heritability with low genetic advance was observed for uniformity ratio. These results indicated little scope of improvement through selection for these traits.

While comparing genetic variability for different characters of upland cotton genotypes under normal and salt affected conditions, it could be observed that phenotypic and genotypic coefficient of variation were high for number of bolls per plant, boll weight, lint yield per plant, Na-K ratio and seed cotton yield in both conditions. High heritability and genetic advance was observed for the characters number of bolls per plant, boll weight, lint yield per plant, ginning out turn, specific leaf area, leaf area index, Na-K ratio and seed cotton yield in both the conditions, indicating that these traits are under the control of additive gene action and are not much influenced by environment. Exercise of selection on these characters could capitulate improvement of genotypes. The traits *viz.*, micronaire value, bundle strength and elongation percent expressed high heritability and moderate genetic advance in both the conditions indicating involvement of both additive and non-additive gene action.

Correlation studies

Studies on correlation under saline condition (Table IV) revealed significant positive association of lint yield per plant and leaf area index with seed cotton yield. Maximum correlation coefficients were exhibited by lint yield (r= 0.827) followed by leaf area index (r= 0.372). Positive and significant inter correlation existed between number of bolls per plant with boll weight and lint yield per plant with ginning out turn. Such association between these two traits was reported earlier also [13]. Significant positive correlations exists between Bartlett's rate index with uniformity ratio, 2.5 per cent span length with bundle strength, uniformity ratio with micronaire and elongation percent, specific leaf area with leaf area index. These results clearly indicated that selection for any one of these traits might lead to concurrent improvement of other traits as well as seed cotton yield. Simultaneous selection for plant height, maturity coefficient, number of sympodia, number of bolls per plant, seed index and 2.5 per cent span length were important for improvement for *Gossypium herbaceum* genotypes under saline condition [13]. In the present investigation, based on direct and indirect effects, the characters *viz.*, number of bolls per plant, boll weight, lint yield per plant, specific leaf area, leaf area index, Na-K ratio, 2.5 per cent span length, bundle strength, uniformity ratio and micronaire value could be considered as reliable indicators in selection of high yielding genotypes for improvement of seed cotton yield. While, comparing the correlation analysis under both the situation it is construed that the lint yield per plant could be given due weightage while selection since it recorded desirable correlation with seed cotton yield. However under saline alkaline condition, leaf area index may also be given importance while selection.

Table III. Estimates of variability parameters for different characters of *Gossypium hirsutum* genotypes under saline-alkaline condition

Characters	Variance		Coefficient of variation		Heritability (Broad sense)	Genetic advance (% of mean)
	PV*	GV*	PCV*	GCV*		
Number of bolls per plant	42.22	41.85	35.35	37.19	99.14	76.28
Boll weight (g)	0.81	0.70	29.26	27.21	86.53	52.16
Lint yield per plant (g)	15.42	15.31	22.61	22.53	99.29	46.25
Ginning out turn (%)	19.00	18.30	13.65	13.39	96.34	27.09
Bartlett's rate index	0.01	0.01	9.72	9.64	98.21	19.68
2.5% span length (mm)	7.03	6.38	10.80	10.29	90.70	20.19
Uniformity ratio	4.69	4.04	4.48	4.16	86.18	7.96
Micronaire value	0.20	0.19	9.58	9.35	95.17	18.79
Bundle strength	3.81	3.42	9.95	9.44	89.89	18.44
Elongation ratio	0.15	0.14	8.51	8.22	93.38	16.37
Specific leaf area	201.81	193.00	11.98	11.71	95.63	23.60
Leaf area index	0.18	0.14	22.99	20.33	78.18	37.03
Na-K ratio	3.28	3.22	77.68	77.00	98.24	89.50
Seed cotton yield plant^{-1} (g)	139.48	139.05	26.49	26.45	99.69	54.41

***PV** *- Phenotypic variance*
***GV** *- Genotypic variance*
***PCV** *- Phenotypic co-efficient of variation*
***GCV** *- Genotypic co-efficient of variation*

Path analysis

As simple correlation does not provide the true contribution of the characters towards the yield, these genotypic correlations were partitioned into direct and indirect effects through path coefficient analysis. Lint yield recorded very high order positive direct effect on seed cotton yield (1.061) followed by leaf area index (0.355) and number of bolls per plant (0.318). Moderate positive effect on seed cotton yield was expressed by micronaire value (0.224). A low order positive direct effect on seed cotton yield was registered by Bartlett's rate index (0.151). The characters boll weight (-0.347), ginning out turn (-0.528), 2.5% span length (-0.312) and uniformity ratio (-0.440) registered high order negative direct effect on seed cotton yield. A moderate but negative direct effect on seed cotton yield was registered by specific leaf area (-0.255), while all other characters registered negligible effects on seed cotton yield (Table V). Path analysis under salinity indicated that the traits *viz.*, number of bolls per plant, lint yield per plant, leaf area index, Bartlett's rate index and micronaire value exhibited positive direct effect on seed cotton yield.

Maximum direct effect on seed cotton yield was contributed by lint yield per plant. Similar results for number of bolls per plant on seed cotton yield in *Gossypium herbaceum* genotypes under saline condition [13]. Comparing path analysis on both the normal and salinity conditions, it could be inferred that selection based on lint yield per plant alone would result in improvement of seed cotton yield.

Table IV. Genotypic correlation coefficient for different character pairs of *Gossypium hirsutum* genotypes under saline condition

	BW	LYPP	GOT	BRI	SL	UR	MIC	BS	EP	SLA	LAI	Na-K	SCY
NBPP	-0.84**	0.21	0.06	-0.16	0.18	-0.16	0.17	0.23	-0.04	-0.20	-0.07	-0.02	0.24
BW		0.16	-0.01	0.05	0.00	0.01	-0.06	-0.12	-0.07	0.14	0.09	0.00	0.07
LYPP			0.43*	-0.09	0.14	0.02	0.20	0.15	-0.17	-0.25	0.15	-0.26	0.83**
GOT				0.34	-0.10	0.25	0.14	-0.11	0.07	-0.41	-0.17	-0.17	-0.04
BRI					-0.30	0.36*	0.07	-0.45*	0.12	0.12	-0.04	0.01	-0.21
SL						-0.86**	-0.64**	0.70**	-0.71**	-0.01	0.12	-0.15	0.13
UR							0.70**	-0.42*	0.53**	-0.03	-0.07	-0.08	-0.07
MIC								-0.28	0.32	-0.17	-0.20	-0.05	0.18
BS									-0.49**	-0.04	0.05	-0.37	0.13
EP										0.07	-0.09	0.17	-0.16
SLA											0.73**	-0.27	-0.02
LAI												-0.27	0.37*
Na-K													-0.19

**Significant at 5% level; **Significant at 1% level*

***NBPP**- Number of bolls per plant; **BW**- Boll weight; **LYPP**- Lint yield per plant; **GOT**- Ginning out turn; **BRI**- Bartlett's rate index; **SL**- 2.4% span length; **UR**- Uniformity ratio; **MIC**- Micronaire value; **BS**- Bundle strength; **EP**- Elongation per cent; **SLA**- Specific leaf area; **LAI**- Leaf area index; **Na-K**- Na-K ratio; **SCY**- Seed cotton yield.*

Table V. Direct and indirect effects of different characters on Seed cotton yield under saline condition

	LYPP	BW	LYPP	GOT	BRI	SL	UR	MIC	BS	EP	SLA	LAI	Na-K	rg with SCY
NBPP	**-0.318**	0.291	0.224	-0.032	-0.023	-0.055	0.071	0.039	0.014	0.000	0.052	-0.026	0.001	0.237
BW	0.267	**-0.347**	0.169	0.004	0.008	0.001	-0.004	-0.012	-0.007	0.001	-0.035	0.030	0.000	0.073
LYPP	-0.067	-0.055	**1.061**	-0.227	-0.013	-0.045	-0.009	0.044	0.009	0.001	0.064	0.055	0.010	0.827**
GOT	-0.019	0.003	0.456	**-0.529**	0.052	0.032	-0.111	0.031	-0.007	0.000	0.102	-0.061	0.007	-0.042
BRI	0.049	-0.018	-0.094	-0.180	**0.151**	0.093	-0.157	0.016	-0.027	-0.001	-0.029	-0.014	-0.001	-0.210
SL	-0.056	0.001	0.152	0.054	-0.0451	**-0.312**	0.379	-0.143	0.043	0.005	0.002	0.043	0.006	0.128
UR	0.051	-0.003	0.021	-0.133	0.054	0.269	**-0.440**	0.157	-0.026	-0.004	0.008	-0.024	0.003	-0.068
MIC	-0.055	0.019	0.207	-0.074	0.011	0.199	-0.309	**0.224**	-0.017	-0.002	0.044	-0.071	0.002	0.179
BS	-0.072	0.042	0.158	0.060	-0.067	-0.219	0.185	-0.062	**0.061**	0.004	0.010	0.017	0.014	0.130
EP	0.013	0.024	-0.178	-0.004	0.018	0.222	-0.233	0.072	-0.030	**-0.008**	-0.018	-0.031	-0.007	-0.159
SLA	0.064	-0.048	-0.265	0.216	0.017	0.003	0.014	-0.039	-0.002	-0.001	**-0.255**	0.261	0.010	-0.024
LAI	0.024	-0.030	0.163	0.091	-0.006	-0.037	0.030	-0.044	0.003	0.001	-0.187	**0.355**	0.010	0.372*
Na-K	0.006	-0.001	-0.272	0.092	0.002	0.046	0.035	-0.011	-0.023	-0.001	0.069	-0.095	**-0.038**	-0.191

*Residual effect= 0.2185; rg= genotypic correlation coefficient; **Significant at 1 per cent level; *Significant at 5 per cent level*

***NBPP**- Number of bolls per plant; **BW**- Boll weight; **LYPP**- Lint yield per plant; **GOT**- Ginning out turn; **BRI**- Bartlett's rate index;**SL**- 2.4% span length; **UR**- Uniformity ratio; **MIC**- Micronaire value; **BS**- Bundle strength; **EP**- Elongation per cent; **SLA**- Specific leaf area; **LAI**- Leaf area index; **Na-K**- Na-K ratio; **SCY**- Seed cotton yield.*

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