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Association and path analysis of earliness, yield and fiber related traits under cotton leaf curl virus (CLCuV) intensive conditions in *Gossypium hirsutum* L.

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Abstract

The present experiment was aimed to find out genotypic, phenotypic correlation coefficients and path analysis at the genotypic level between seed cotton yield, earliness, fiber and yield contributing traits in 31 cotton cultivars under CLCuV intensive conditions. The material was sown on 15th of June to observe their tolerance ability against Cotton leaf curl virus and influence of late sown conditions on association among fiber, earliness and yield related traits. Heritability was estimated to determine the selection criteria under virus intensive conditions for the studied traits. Phenotypic coefficient of variation (PCV%) was higher in magnitude than the genotypic coefficient of variation (GCV%) for all the traits. Heritability (broad sense) revealed higher estimates of fiber strength (97%), CLCuV% (97%), fiber fineness (91%), yield kg/ha (91%), boll weight (90%), plant height (87%), bolls per plant (86%), days taken to 1st flower (84%), Days taken to 1st bud (82%) while for nodes to 1st fruiting branch (56%), staple length (46%), monopodia per plant (42%) moderate but for GOT% (32%) and sympodia per plant (28%) low estimates were found. Regarding correlation studies seed cotton yield had only positive genotypic association with bolls per plant, plant height and sympodia per plant. Path coefficient analysis results revealed that all the traits indirectly influenced seed cotton yield. The traits like plant height, bolls per plant and sympodia per plant may be considered for selection in virus intensive conditions as they showed higher estimates of broad sense heritability along with positive and significant genotypic correlation with seed cotton yield.

Keywords: Broad sense heritability, Seed cotton yield, Cotton, genotypic correlations, CLCuV%.

Introduction

Cotton (*Gossypium hirsutum* L.) as a fiber crop occupies a pivotal position in the world in general and particularly in Pakistan (Amjad et al., 2009). The adequate production of cotton to meet the needs of ever-increasing world's population is now generally realized. More productive genotypes possessing good fiber quality, CLCuV tolerance and better yield are equally important for textile industry and farmers. Keeping in view these needs cotton research needs to be more versatile and accelerated to develop more productive cotton genotypes for various agro–ecological zones of Pakistan. Because of the importance of the cotton crop in the economy of the country efforts have been made to boost cotton production (Amjad et al., 2009). For improvement in aforementioned traits plant breeder must know the relationship between yield and its components which enable him to select desirable plant types. As seed cotton yield is influenced by genetic and environmental factors which make it difficult for the breeders to select desirable plants with increased yield. If the magnitude of genetic association among traits is very high, then selection for one trait will concurrently result in changes in the other trait. This correlation may be either beneficial or harmful, depending upon the direction of the genetic association and the objectives of the breeder (Desalegn et al., 2009). For a simultaneous selection of both yield and fiber quality traits, knowledge about the association of yield and fiber quality traits is a prerequisite. The correlation analysis provides a good index to predict the corresponding change which occurs in one trait at the expanse of the proportionate change in the other (Khan et al., 2007; Ahmad et al., 2008). Genetic variation and positive correlation in cotton between yield and its components was reported by (Iqbal et al., 2003; Wang et al., 2004). DeGui et al. (2003) studied yield and yield contributing traits and observed that more number of bolls will result in higher seed cotton yield. According to the studies of Iqbal et al., 2006 sympodia per plant, boll weight and bolls per plant are significantly and positively correlated with seed cotton yield. Likewise path analysis provides an efficient mean of finding the direct and indirect causes of correlation (Kale et al., 2007).The present studies aimed to explore the genetic potential of different cotton cultivars and relationship of seed cotton yield with different earliness, fiber and yield related traits under CLCuV intensive conditions.

Results

Genotypic and phenotypic correlations

The list of genotypes along with their source is given in table-2 and the mean performance of 31 genotypes is given in table-3. The data of all the traits showed significant genotypic mean square values. PCV % was higher in magnitude than GCV% for all the traits table-4. Heritability (broad sense) revealed high estimates for the traits like fiber strength (97%), CLCuV% (97%), fiber fineness (91%), yield kg/ha (91%), boll weight (90%), plant height (87%), bolls per plant

Table 1. Rating scale for cotton leaf curl virus (CLCuV) symptoms (Akhtar et al., 2010).

Symptoms	Disease rating	Disease index (%)	Disease reaction
Absence of symptoms.	0	0	Immune
Thickening of a few small veins or the presence of leaf enations on 10 or fewer leaves of a plant.	1	0.1- 1	Highly resistant
Thickening of a small group of veins.	2	1.1- 5	Resistant
Thickening of all veins but no leaf curling.	3	5.1-10	Moderately resistant
Severe vein thickening and leaf curling on the top third of the plant.	4	10.1 – 15	Moderately susceptible
Severe vein thickening and leaf curling on the half of the plant.	5	15.1 – 20	Susceptible
Severe vein thickening, leaf curling, and stunting of the plant with reduced fruit production.	6	>20	Highly susceptible

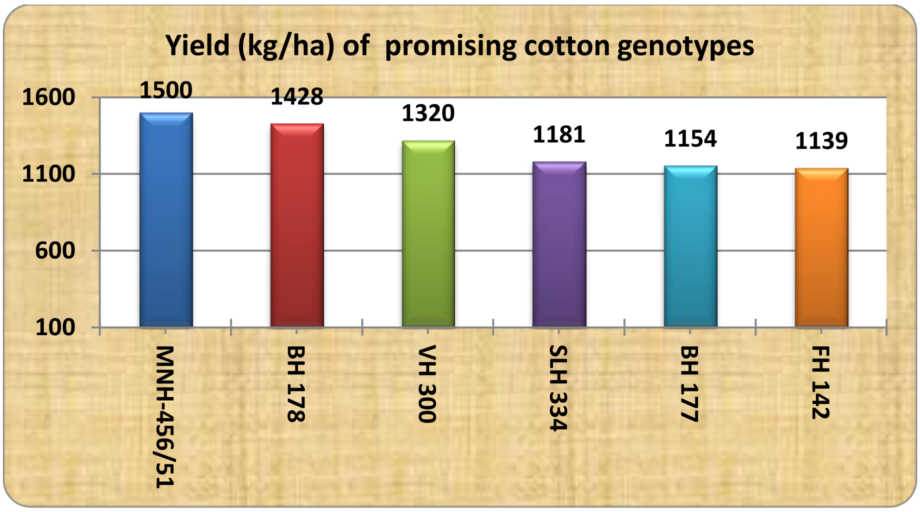

Fig1. Yield (kg/ha) performance of some promising cotton genotypes under virus intensive conditions.

(86%), days taken to 1st flower (84%) Days taken to 1st bud (82%) while for nodes to 1st fruiting branch (56%),staple length (46%), monopodia per plant (42%) moderate but for GOT% (32%) and sympodia per plant (28%) low estimates were found. Analysis of variance revealed highly significant differences among the strains/genotypes for all the traits studied. The results of genotypic and phenotypic correlations are given in table-5and6. The promising results of genotypes in terms of CLCuV% tolerance ability and yield kg/ha is given in Fig-1 and 2 respectively. The results of correlation coefficients indicated that days taken to 1st square had positive and significant correlation with days to 1st flower and monopodia per plant at the genotypic level but at the phenotypic level no significant correlation was found with any of the traits. Days to 1st flower had a positive association with monopodia at both levels but with sympodia per plant it showed correlation only at the genotypic level. Nodes to 1st fruiting branch had only positive association with fiber strength at the genotypic level but at the phenotypic level no significant positive association was found. Monopodia per plant did not show any significant positive correlation with any of the traits both at genotypic and phenotypic level but sympodia per plant and bolls per plant showed positive association with plant height and seed cotton yield at both levels. However, at phenotypic level sympodia per plant had no association with any of the traits. Plant height showed significant genotypic and phenotypic correlation with fiber strength and with a yield at the genotypic level only. CLCuV % showed negative significant correlation with fiber strength and yield kg/ha at both levels and with GOT% at the genotypic level. Boll weight showed positive genotypic and phenotypic correlation with fiber fineness and GOT% showed its association with staple length only at the genotypic level. The traits like fiber length, strength and fineness did not show any positive significant genotypic or phenotypic association with yield kg/ha.

Direct and indirect effects

The results of the Path coefficient analysis are given in table-7. Path coefficient analysis results revealed that none of the traits showed any direct effect on yield. Days taken to 1st square showed a positive indirect effect on yield via days taken to 1st square and GOT%. Days taken to 1st flower positively and indirectly influenced yield through, days taken to 1st flower, nodes to 1st fruiting branch, plant height, CLCuV%, GOT%, fiber fineness and strength but for all other traits it showed negative indirect impact. For nodes to 1st fruiting branch the traits like days taken to 1st square, monopodia per plant, plant height, CLCuV% and GOT% indirectly influenced yield while all other traits indirectly showed the negative influence on yield. For monopodia per plant the traits like days taken to 1st square and flower, Nodes to 1st fruiting branch, bolls per plant, plant height, GOT%, fiber fineness and strength indirectly and positively exerted influence on seed cotton yield but remaining traits showed a negative indirect effect on yield. The symposia per plant influenced seed cotton yield via days taken to 1st square and

Table 2. List of genotypes used in this study along with their source.

Genotypes	No. of Genotypes	Source
FH 114, FH 118, FH 142 , FH-172, FH-163, FH-168, FH 2015, FH-4243	8	Cotton Research Institute, Faisalabad, Pakistan
MNH-456/51, MNH 886, CRSM 38, MNH 909, MNH 814	5	Cotton Research Station, Multan, Pakistan
VH 281, VH 282, VH 300	3	Cotton Research Station, Vehari, Pakistan
BH 172, BH 175, BH 176, BH 177, BH 178, BH 179	6	Cotton Research Station, Bhawalpur, Pakistan
SLH 317, SLH 334	2	Cotton Research Station, Sahiwal, Pakistan
NIAB 2008, NIAB 2010, NIAB 852, NIAB 9811, IR-NIAB 824, NIAB 2009, NIAB 112	7	Nuclear Institute for Agriculture and Biology, Faisalabad, Pakistan
Total	31	

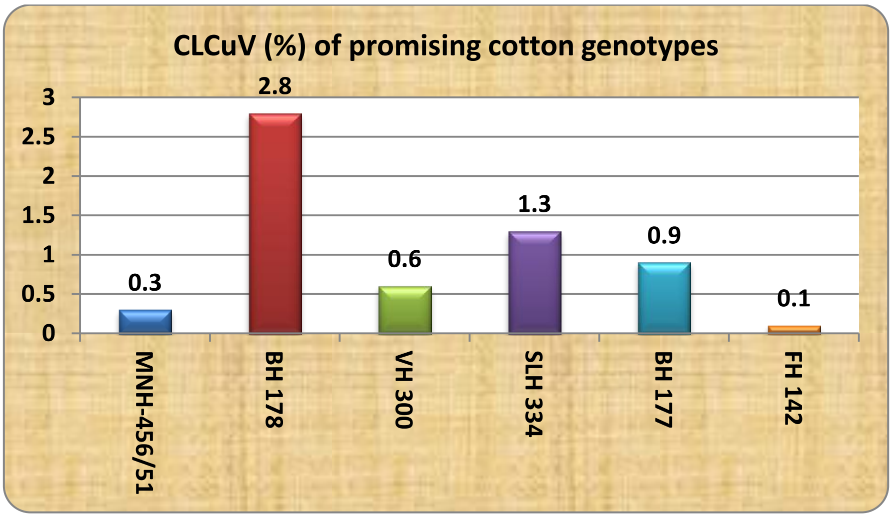

Fig 2. CLCuV(%) of some promising cotton genotypes.

flower, bolls per plant, plant height, CLCuV%, boll weight, GOT%, staple length and fiber fineness while other traits showed negative influence. Bolls per plant indirectly and positively exerts influence through nodes to 1st fruiting branch, plant height, CLCuV%, boll weight and staple length. For plant height maximum positive indirect effect was shown by bolls per plant followed by CLCuV% and days taken to 1st flower. Staple length and boll weight also influenced seed cotton yield positively but its impact was not much pronounced. Remaining traits showed negative indirect effects. Indirect effects of CLCuV% influenced the seed cotton yield positively through days taken to 1st square, nodes to 1st fruiting branch, sympodia per plant, boll weight and with all fiber related traits. The traits like Days taken to 1st flower, nodes to 1st fruiting branch, bolls per plant and plant height indirectly and negatively affected the seed cotton yield. Boll weight influenced seed cotton yield indirectly and positively through nodes to 1st fruiting branch, monopodia per plant, bolls per plant, plant height, fiber length and fineness. Fiber length and GOT% exerted positive indirect effects on yield through nodes to 1st fruiting branch, monopodia per plant, bolls per plant, plant height and boll weight. Other positive indirect effects of GOT% on seed cotton yield were through sympodia per plant, CLCuV%, boll weight and staple length. Fiber fineness indirectly affected seed cotton yield through days taken to 1st flower, nodes to 1st fruiting branch, boll weight, GOT% and fiber strength. Fiber strength influenced negatively and indirectly through days taken to 1st flower, nodes to 1st fruiting branch, sympodia per plant, GOT% and fiber fineness and for all other traits it showed a positive indirect effect on seed cotton yield.

Discussion

To launch an effective plant breeding program presence of sufficient amount of genetic variation in plant material is a prerequisite to find out the nature and extent of association among various yield, earliness and fiber related traits. In the present set of germplasm sufficient amount of variability is evident from the study of analysis of variance for all the traits. In the current studies magnitude of the PCV was higher than GCV which indicated that the environment played a vital role for all the traits. Heritability is the measure of phenotypic variance attributable to genetic variance (Songsri et al., 2008). High to moderate estimates of heritability was found in almost all the traits except GOT% and sympodia perplant in the current findings. Basbeg and Gencer (2004) reported higher estimates of heritability for fiber fineness and strength which are in agreement with the current estimates but for bolls per plant and seed cotton yield low estimates which are in contradiction to the present research. Similarly Mendez-Natera et al., 2012 found higher estimates for fiber fineness and moderate values for fiber length which supports the present work but moderate estimates for plant height, and fiber strength and low values for bolls per plant, boll weight and seed cotton yield contradict the results. Naveed et al., 2004 reported low values for lint percentage which are in agreement with the present findings but for boll weight the results were opposite.

Table 3. Mean performance of 31 genotypes/ strains in terms of earliness, fiber quality, CLCuV% and yield contributing traits in cotton.

Genotypes	DFS	DFF	NFFB	MPP	SPP	BPP	PH (cm)	CLCuV (%)	BW (g)	GOT (%)	SL (mm)	FF (µg/inch)	FS (tppsi)	Yield (kg/ha)
MNH-456/51	29	51	6	1	16	29	135	0.3	4.0	40	26.7	4.7	99	1500
BH 178	31	53	8	3	14	18	107	2.8	4.7	39	26.5	5.0	100	1428
BH 179	32	53	8	1	16	14	85	1.5	4.0	38	26.0	5.1	91	1410
FH 118	32	51	7	2	15	13	75	7.2	4.7	40	27.3	5.3	95	1327
VH 300	33	52	9	2	15	23	123	0.6	3.4	39	26.2	4.4	101	1320
FH-172	32	52	9	2	15	22	98	7.1	3.3	38	26.2	4.9	99	1209
SLH 334	33	51	10	2	15	17	100	1.3	3.1	39	27.5	4.7	97	1181
BH 177	32	53	8	2	16	15	104	0.9	3.4	39	25.4	5.0	95	1154
SLH 317	32	53	8	2	17	21	127	3.5	3.5	38	26.7	4.7	96	1143
FH-168	30	53	9	2	17	24	118	2.1	4.0	36	26.6	4.7	95	1141
FH 142	30	49	8	0	14	26	85	0.1	4.3	41	26.7	4.6	102	1139
FH-163	32	53	9	1	16	16	104	3.5	3.0	39	27.3	4.9	100	1128
CRSM 38	31	52	8	2	17	24	123	3.5	3.8	39	27.5	4.3	100	1120
NIAB 9811	32	52	8	2	16	20	105	2.2	3.9	39	26.7	5.0	97	933
VH 282	32	51	9	0	15	13	86	1.7	3.9	39	27.5	4.2	100	904
NIAB 852	32	52	9	3	12	16	95	3.9	2.6	38	26.5	4.1	93	900
BH 172	30	51	9	1	13	13	98	2.3	3.6	39	25.3	4.7	98	886
MNH 909	30	52	9	2	14	23	125	0.6	3.5	40	27.5	4.9	98	877
FH 2015	31	51	9	2	16	23	121	4.3	4.0	38	27.3	4.5	102	798
NIAB 2010	32	53	8	2	17	22	101	3.2	3.4	38	26.8	4.7	94	759
NIAB 2008	32	53	8	2	18	18	83	2.7	3.3	38	27.0	5.0	100	740
MNH 886	30	52	8	1	16	16	109	0.4	4.8	40	27.5	5.1	92	738
BH 175	31	54	8	1	15	15	106	3.3	3.2	41	27.3	4.2	95	724
BH 176	32	53	8	1	16	13	90	3.9	3.1	38	26.3	5.0	95	695
VH 281	31	50	9	1	16	16	100	1.2	3.5	39	27.7	5.1	101	643
IR-NIAB 824	32	52	7	2	14	12	82	11.4	4.1	38	26.7	4.9	92	635
FH 114	29	49	9	1	14	13	81	3.4	2.8	38	26.2	4.6	94	603
NIAB 2009	31	54	7	1	14	16	93	1.8	3.6	38	26.5	5.4	97	503
NIAB 112	31	52	8	1	14	19	89	2.5	3.3	39	27.0	4.4	94	479
MNH 814	33	51	9	1	14	16	110	4.8	3.5	39	27.2	4.1	98	471
FH 4243	31	50	7	1	13	14	81	12.3	3.8	38	27.0	5.1	92	178

NTFFB= Nodes to 1st fruiting branch, MPP= Monopodia per plant, SPP= sympodial per plant, PH= Plant height, BWT= boll weight, SL= Staple length,FF= fiber fineness, FS= Fiber strength, GOT= Ginning out turn, DFS= days to 1st square, DFF= days to 1st flower, CLCuV= Cotton leaf curl virus, GCV= genotypic coefficient of variation, PCV= phenotypic coefficient of variation

Table 4. Mean squares, genotypic and phenotypic coefficients of variation and heritability for various traits of 31 genotypes/strains of cotton.

Characters	Mean squares	GCV%	PCV%	Heritability (bs%)
NTFFB	2.08**	8.96	12.02	0.56
MPP	1.28**	33.88	52.61	0.42
SPP	5.48**	6.49	12.32	0.28
BPP	60.22**	24.15	26.00	0.86
PH(cm)	764.45**	15.37	16.50	0.87
BW(g)	0.82**	14.09	14.86	0.90
SL(mm)	1.12**	1.93	2.85	0.46
FF(µg/inch)	0.35**	7.08	7.42	0.91
FS (tppsi)	30.88**	3.30	3.36	0.97
GOT (%)	2.73**	1.87	3.34	0.32
DFB	3.15**	3.16	3.49	0.82
DFF	4.34**	2.24	2.45	0.84
CLCuV%	24.88**	88.81	90.29	0.97
Yield (kg/ha)	313740**	34.63	36.22	0.91

Mass or early generation selection could be practiced in traits showing higher and moderate estimates of broad sense heritability in current studies. The higher magnitude of heritability is indicative of additive genetic effects so adoption of the selection procedure for traits possessing higher estimates is much easier (Khan et al., 2008; Soomro et al., 2010). Environmental factors play a vital role in the development of phenotypic correlations (Ali et al., 2009). In some instances environment influence the two traits under study in the same direction and in some cases in different directions. Phenotypic correlation arises due to the net result of genotypic and environmental correlations. The magnitude of genotypic correlations cannot be determined from phenotypic correlations due to the dual nature of phenotypic correlations. Seed cotton yield in the present findings has positive and significant genotypic association with sympodia per plant, bolls per plant and plant height but with CLCuV% it showed negative correlation. These results are in agreement with the findings of Ashokkumar and Ravikesavan (2010) and Iqbal et al. (2006). Early generation selection could be practiced for the traits showing significant genotypic correlations. The important role of significant genotypic correlations was observed in the present studies which are in conformity with the findings of Desalegn et al. 2009 and Qayyum et al. 2010 which reported the chief role of genetic effects. Positive correlation of sympodia per plant with plant height and seed cotton yield was reported by Ashokkumar and Ravikesavan (2010) and Ahuja et al. (2006) which are in accordance with the present findings but regarding fiber traits contradictory results were reported by these scientists. Negative correlation of fiber traits with yield contributing traits has been reported by Desalegn et al 2009**.** In the present studies undesirable results were found for some of the traits as the experiment was laid out in CLCuV intensive conditions. Onset of disease affected most of the traits. Only few genotypes performed better in these intensive conditions. In the present studies, though none of the traits showed positive direct effects on seed cotton yield. Negative direct effects for sympodial branches on seed cotton yield have been earlier reported by Ahuja et al 2006 and Rauf et al 2004. For days taken to 1st flower, monopodia per plant and fiber fineness negative direct effects has been found in the findings of Ashokkumar and Ravikesavan (2010).The traits like days taken to 1st flower, nodes to 1st fruiting branch sympodia per plant and bolls per plant indirectly influenced seed cotton yield through most of the yield contributing traits. Similar indirect effects were found in the studies of Ashokkumar and Ravikesavan (2010). For evolving genotypes possessing three required traits i.e., earliness, yield and fiber quality the breeder should use reciprocal recurrent selection, modified back cross, or three way crosses within the genetic material under study.

Materials and methods

Plant material and site characteristics

A total of 31 diverse genotypes was evaluated in the experimental area of Cotton Research Institute, Faisalabad during the year 2010-11. The material was sown on 15th of June to observe their tolerance ability regarding CLCuV and influence of late sown conditions on association among fiber, earliness and yield related traits.

Experimental design, plot size and cultural practices

Layout of the experiments was randomized complete block design (RCBD) with three replications. For each entry, plot size measured 4.572 m × 6.096 m, comprising six rows set 75 cm apart. Distance between plants within rows was 30 cm. Normal agronomic and cultural practices (irrigation, weeding, hoeing, and fertilizer applications) were adopted as and when required.

Measurement of various traits studied

For measuring the traits 10 representative, undamaged plants were selected in each line and marked for identification. Nodes to 1st fruiting branch counted from zero node (cotyledonary node) to the node at which first flower was appeared. The data regarding appearance of 1st square and flower were taken by counting number of days from planting to the appearance of 1st square and 1st flower respectively. Data on plant height in centimeters were recorded from the base of the plant to the tip of the plant. Data on monopodia and sympodia were taken by counting the number of vegetative and fruiting branches. Number of bolls counted from the guarded plants upto final picking. The bolls were picked and seed cotton yield was calculated in grams (g). Average boll weight in grams (g) was calculated by dividing the total seed cotton yield per plant with the total number of bolls of that plant. Mean boll weight of each plant was taken in grams (g) and then overall averaged. Seed cotton was picked when the crop was mature and recorded as Kg / plot and extrapolated in Kg / hectare. The harvest was weighed with the help of electrical balance and final averages were made from each tagged plant. Cleaned and dry samples of

Table 5. Genotypic Correlation coefficient of various plant traits in cotton.

VARIABLES	DFS	DFF	NFFB	MPP	SPP	BPP	PH(cm)	CLCuV(%)	BW(g)	GOT(%)	SL(mm)	FF(µg/inch)	FS(tppsi)	Yield kg/ha
DFS	1													
DFF	.4122 *	1												
NFFB	0.2236	-0.2906	1											
MPP	.4814 **	.5823 **	-0.0534	1										
SPP	0.1885	.5355 **	0.01	0.1465	1									
BPP	-0.2726	-0.0205	-0.0039	0.1936	.3778 *	1								
PH (cm)	-0.135	0.2515	0.0511	0.3383	.3592 *	.7065 **	1							
CLCuV(%)	0.1876	-0.0978	-.3666 *	0.2338	-.4339 *	-.3833 *	-.4168 *	1						
BW (g)	-0.3291	-0.0823	-0.3394	-0.0093	0.146	0.1254	0.017	0.0419	1					
GOT (%)	-0.3156	-0.2623	-0.0957	-.4185 *	-0.185	0.2006	0.2229	-.4563 **	0.2807	1				
SL(mm)	-0.0449	-0.1804	-0.014	-0.0479	0.1643	0.1168	0.1556	0.0484	0.1944	.4698 **	1			
FF(µg/inch)	-0.1315	0.1534	-.4169 *	0.019	0.1621	-0.2232	-0.286	0.1259	.3892 *	-0.1861	-0.1598	1		
FS (tppsi)	0.0265	-0.1961	.3609 *	-0.0551	0.2534	.5349 **	.4056 *	-.3795 *	0.0503	0.3048	0.2363	-0.199	1	
Yield (kg/ha)	0.0628	0.1686	0.1549	0.3412	.4344 *	.428 *	.3627 *	-.3923 *	0.2802	0.2438	-0.2557	0.0256	0.3197	1

Table 6. Phenotypic Correlation coefficient of various plant traits in cotton.

VARIABLES	DFS	DFF	NFFB	MPP	SPP	BPP	PH(cm)	CLCuV (%)	BW(g)	GOT%	SL(mm)	FF(µg/inch)	FS (tppsi)	Yield(kg/ha)
DFS	1													
DFF	.3101	1												
NFFB	.1644	-0.2276	1											
MPP	.2952	.3763 *	-0.05	1										
SPP	.1096	0.2811	0.0528	0.1492	1									
BPP	-.226	-0.0115	-0.0098	0.1173	0.1938	1								
PH (cm)	-.1098	0.2235	0.0185	0.2037	0.2808	.6151 **	1							
CLCuV(%)	.1746	-0.1055	-0.2275	0.1205	-0.2429	-.3616 *	-.3957 *	1						
BW (g)	-.266	-0.0669	-0.2489	-0.0084	0.0565	0.1194	0.0436	0.0396	1					
GOT (%)	-. 2137	-0.1849	-0.0091	-0.1008	-0.1332	0.0976	0.0983	-0.2548	0.1186	1				
SL(mm)	.0185	-0.0865	0.0429	-0.0683	0.2051	0.0724	0.11	0.0209	0.1025	0.1914	1			
FF(µg/inch)	-.0778	0.1309	-0.2718	0.0566	0.1418	-0.1887	-0.2609	0.1259	.3517 *	-0.1725	-0.0799	1		
FS (tppsi)	.0236	-0.1808	0.2492	-0.0299	0.1204	.4856 **	.3744 *	-.3715 *	0.0493	0.1999	0.1822	-0.2	1	
Yield(kg/ha)	.059	0.1602	0.0821	0.2256	0.1994	.3768 *	0.3405	-.3684 *	0.2401	0.1173	-0.1768	0.0248	0.2992	1

Table 7. Direct (diagonal) and Indirect (off-diagonal) effects of various plant traits in cotton.

VARIABLES	DFS	DFF	NFFB	MPP	SPP	BPP	PH(cm)	CLCuV (%)	BW(g)	GOT%	SL(mm)	FF(µg/inch)	FS (tppsi)	Yield (kg/ha)
DFS	(-1.8683)	0.7863	-0.0393	-1.1042	-0.6885	-0.5209	-0.0565	-0.4475	-0.5737	0.9667	-0.0746	-0.0516	-0.0016	0.0628
DFF	0.7702	(-1.9074)	0.0511	-1.3357	-1.9555	-0.0392	0.1051	0.2333	-0.1434	0.8035	-0.3	0.0603	0.0116	0.1686
NFFB	0.4177	-0.5542	(-.1758)	0.1226	-0.0366	-0.0075	0.0214	0.8744	-0.5918	0.2932	-0.0233	-0.1638	-0.0214	0.1549
MPP	0.8993	1.1107	0.0094	(-2.2939)	-0.5349	0.37	0.1414	-0.5576	-0.0162	1.282	-0.0797	0.0075	0.0033	0.3412
SPP	0.3523	1.0215	-0.0018	-0.336	(-3.6515)	0.722	0.1502	1.0347	0.2545	0.5667	0.2732	0.0637	-0.015	0.4344
BPP	-0.5093	-0.0391	0.0007	-0.4442	-1.3797	(-1.9109)	0.2954	0.9142	0.2186	-0.6144	0.1943	-0.0877	-0.0317	0.428
PH (cm)	-0.2522	0.4796	-0.009	-0.7759	-1.3115	1.3499	(-0.4181)	0.9942	0.0297	-0.6828	0.2589	-0.1123	-0.0241	0.3627
CLCuV%	0.3505	-0.1866	0.0645	-0.5363	1.5842	-0.7324	-0.1743	(-2.385)	0.0731	1.3977	0.0804	0.0495	0.0225	-0.3923
BW (g)	-0.6148	-0.1569	0.0597	0.0214	-0.533	0.2396	0.0071	-0.1	(-1.7435)	-0.8597	0.3234	0.1529	-0.003	0.2802
GOT (%)	-0.5896	-0.5003	0.0168	0.9601	0.6756	0.3833	0.0932	1.0883	0.4893	(-3.0631)	0.7814	-0.0731	-0.0181	0.2438
SL(mm)	-0.0838	-0.344	0.0025	0.1099	-0.5998	0.2232	0.0651	-0.1153	0.339	-1.439	(-1.6634)	-0.0628	-0.014	-0.2557
FF(µg/inch)	-0.2456	0.2925	0.0733	-0.0437	-0.5921	-0.4266	-0.1196	-0.3004	0.6787	0.5701	-0.2658	(-0.3929)	0.0118	0.0256
FS (tppsi)	0.0496	-0.374	-0.0635	0.1264	-0.9252	1.0221	0.1696	0.9051	0.0877	-0.9336	0.3931	-0.0782	(-.0593)	0.3197

seed cotton were weighed and then ginned separately with single roller electric ginning machine. The lint obtained from each sample was weighed and ginning out turn % was calculated by the following formula

Ginning outturn (%) = Weight of lint / Weight of seed cotton × 100

Fiber characteristics such as staple length, fiber fineness and fiber strength of each guarded plant were measured by using spin lab HVI-900. This computerized instrument provides us a true profile of raw fiber. It measures the most important characters such as staple length (mm), fiber fineness (µg/inch) and fiber strength (tppsi) within a quick period of time according to international trading standards.

CLCuV disease incidence (%) methodology

CLCuV disease incidence (%) and the reaction of the cultivars was determined using the disease scale (Table 1) described by Akhtar et al. 2010 and Farooq et al. 2011. Then %age of CLCuV disease incidence was calculated by using the following formula;

CLCuV disease incidence (%) = Sum of all disease ratings/total number of plants ×16.16

Seed cotton was picked when the crop was mature and recorded as Kg / plot and extrapolated in Kg / hectare.

Statistical analysis

The data of various morphological, earliness, CLCuV and fiber quality traits of 31 cotton genotypes were subjected to analysis of variance (ANOVA) using the Mstatc package (Russell, D. Freed, Michigan State University, USA). Where the "F" statistics indicated significance, the means were separated using Fisher's protected least significance difference test (LSD) at P = 0.05. Heritability in broad sense was estimated according to the technique of Burton and De Vane (1953). All correlations (phenotypic and genotypic) were computed following the statistical technique prescribed by Kowon and Torrie (1964). Genotypic correlations were tested against the double value of the standard error of genotypic correlations following the method of Lotherop et al. 1985. The statistical significance of phenotypic correlations was determined by T-test as described by Steel and Torrie (1984). Path coefficient analysis was followed to the method suggested by Dewey and Lu (1959).

Conclusion

Positive correlation, high heritability and positive indirect effects of sympodia per plant, bolls per plant and plant height with seed cotton yield is indicative that selection for these traits may be practiced to enhance seed cotton yield under CLCuV intensive conditions.

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