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Evaluation of Cotton Germplasm for Source of Resistance against Cotton Leaf Curl Disease

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Cotton leaf curl disease (CLCuD) is main constraint to American cotton (*Gossypium hirsutum*) cultivation which is one of the most important cash crops in northwestern India. At this time no single variety/hybrids have available that's having resistant reaction towards cotton leaf curl disease. Screening of germplasms is a basic step to explore resistant source. With this objective, the germplasm comprising three hundred seventy seven genotypes were evaluated against cotton leaf curl disease at CCS HAU Cotton Research Station, Sirsa during *kharif* 2013 to 2015. None was found immune/ disease free or highly resistant. However, thirty four genotypes were found resistant, one hundred thirty four expressed moderately resistant reaction and one hundred forty four were found moderately susceptible. Forty nine genotypes were observed susceptible and sixteen were found highly susceptible to CLCuD. The resistant genotypes may be used for variety/ hybrid development or as a donor of resistant genes.

Keywords: Cotton leaf curl disease, Germplasm, *Gossypium hirsutum*, Resistance.

Cotton is an important commercial cash crop of global importance. India occupies largest area in the world (12.6 million ha.). However, India ranked second in production (37.4 million bales) with a very low productivity of 537 kg/ha as compared to world average of 760 kg/ha[4]. Among the many limiting factors of low productivity, cotton leaf curl disease (CLCuD) is most crucial in northwestern India. The appearance of the disease at seedling stage seriously retards the flowering, boll formation and seed cotton yield.

Among the recommended practices to control cotton leaf curl disease (CLCuD), cultivation of resistant cultivars and management of causal agent are the most promising. Development of resistant varieties along with agronomic, fertilizer, insecticidal control and biotechnological methods can be used alone and in combination to control this severe disease[5]. Among these, development of cotton leaf curl resistant varieties is long-term approach to cope with this problem and to save this crop from the ravages of CLCuV. Resistance breaking cotton leaf curl Burevala virus (CLCuBuV) is now the dominant virus strain in many fields of northwestern India[9]. Thus the main objective of present study was to find out resistant genotypes, possessing desirable characteristics that can directly be used for commercial cultivation, or it can be used in hybridization programme for the development new resistant cultivars.

MATERIALS AND METHODS

The present investigation of evaluation of cotton gemplasm for source of resistance against cotton leaf curl disease (CLCuD) was carried

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out to identify the sources of resistance under field condition. The germplasm comprising three hundred seventy seven genotypes were sown in two replications with plant to plant and row to row spacing of 30 cm and 67.5cm, respectively during *kharif* 2013 to 2015at CCS HAU Cotton Research Station Sirsa under natural field condition where virus source and vector were abundantly present. Recommended agronomical practices were carried out to raise good crop. CLCuD Susceptible check HS 6 was sown after every fourth row and also as border of two rows around the experiment to ensure the enough inoculum. All the plants of a genotype were thoroughly observed for appearance of cotton leaf curl virus symptoms and observation on the disease intensity was recorded according to revised rating scale describe by AICCIP (Table 01).

Calculation of PDI

Per cent disease Intensity (PDI) was calculated for each entry by using the following formula given below:

$$PDI = \frac{\text{Sum of all the numerical ratings of plants observed}}{\text{Total no. of plants observed x Maximum grade}} \text{ x100}$$

RESULTS AND DISCUSSION

The average of three years percent diseases intensity (PDI) was calculated for genotypes of germplasm collection at CRS, Sirsa (Table 02). Average Per cent diseases intensity ranged from 11.1 to 57.2 among all the genotypes. The result of pooled data over the years of three hundred seventy seven genotypes evaluated, none was found immune/diseases free and/or highly resistant However, thirty four genotypes were recorded as resistant; one hundred thirty four expressed as moderately resistant reaction, while one hundred forty four were found moderately

Table 1. Rating scale of PDI given by AICCIP.

Symptoms	Disease Severity (grade)	Per cent Disease intensity	Disease reaction
Complete absence of symptoms	0	0	Immune /disease free
Thickening of few small scattered veins on one or few leaves of a plant observed after careful observation	1	0.1-10	Highly Resistant
Thickening of small group of veins, no leaf curling, no reduction in leaf size and boll setting	2	10.1-20	Resistant
Thickening of all veins, minor leaf curling, leaf enations, deformity of internodes with minor reduction in leaf size but no reduction in boll setting.	3	20.1-30	Moderately Resistant
Severe vein thickening, moderate leaf curling, leafy enations, minor deformity of internodes and minor reduction in leaf size and boll setting.	4	30.1-40	Moderately Susceptible
Severe vein thickening, moderate leaf curling, leaf enations and deformity of internodes with moderate reduction in leaf size and boll setting followed by moderate stunting.	5	40.1-50	Susceptible
Severe vein thickening, leaf curling, reduction in leaf size, leafy enations, deformed internodes and severe stunting of plant with no or few boll setting	6	> 50	Highly Susceptible

Table 2. Reaction of Cotton Leaf Curl Disease on genotypes of American Cotton

Sr. No.	Name of Genetic Collection	PDI (Percent Disease Intensity) 2013	2014	2015	Average	Sr. No	Name of Genetic Collection	PDI (Percent Disease Intensity) 2013	2014	2015	Average
1	101-102B	16.2	14.4	24.2	18.3	28	A O2N 75	30.3	31.7	41.7	34.5
2	101-102-B 2	22.4	26.6	30.0	26.3	29	A02 N 149	36.4	33.3	40.0	36.6
3	1412-A 1	28.3	25.5	34.2	29.3	30	A02 N 106	30.6	30.6	38.3	33.2
4	150-3-1-1	35.4	44.4	41.7	40.5	31	A02 N 52	26.6	28.6	33.3	29.5
5	1556F	20.6	14.4	27.2	20.7	32	A02 N 84	33.0	33.3	43.3	36.5
6	1695-175 J	20.2	20.2	26.7	22.4	33	A02N 85	56.2	50.0	50.0	52.1
7	16-SH-1274	34.2	22.2	40.0	32.1	34	A03 N 139	24.9	20.2	26.1	23.7
8	320-F	52.4	51.5	51.9	51.9	35	A03 N 144	26.8	29.1	38.3	31.4
9	33-STONE VILLE 213	46.2	40.2	55.0	47.1	36	A03 N 148	30.2	31.1	36.7	32.7
10	36B	26.6	25.6	30.0	27.4	37	A03 N 150	19.9	22.2	26.3	22.8
11	42- STONEVILLE 62	20.5	12.2	27.4	20.0	38	A03 N132	46.5	43.3	55.6	48.5
12	43-P 12	41.6	40.2	45.0	42.3	39	A-72-62	23.2	23.3	33.4	26.7
13	49-CSH 875	32.6	32.2	40.7	35.2	40	ABH 6	33.2	18.8	38.3	30.1
14	4-SAMARU 26	18.2	21.1	32.8	24.0	41	ABOHAR 3	23.2	29.6	33.3	28.7
15	59-SV-7A	45.2	42.2	43.3	43.6	42	ACOLA SJ-1	16.6	23.3	38.3	26.1
16	7203-14-104	8.5	11.1	19.7	13.1	43	AET 55	48.1	33.3	45.0	42.1
17	76-IH 23	29.6	30.4	33.3	31.1	44	AK-182/Gland 361-3462	20.6	31.7	46.7	33.0
18	78-CAT 131	50.6	56.6	51.7	53.0	45	AKG -2/54	25.6	34.4	31.7	30.6
19	9-1487	20.4	25.5	31.7	25.9	46	AKG 2	40.5	38.6	46.7	41.9
20	9-3X13L1 CO2-1-3	16.6	10.0	29.6	18.7	47	AKG-3/62	20.5	31.7	35.6	29.3
21	98-NH-BBR 44	32.2	31.1	44.2	35.8	48	AKH 2910	24.6	10.6	30.0	21.7
22	A 02 N 89	18.6	22.2	30.7	23.8	49	AKH 9913	33.6	22.2	37.6	31.1
23	A 02N 65	18.4	22.2	26.7	22.4	50	AKH 8931	27.5	29.3	32.1	29.6
24	A 03 N 121	35.4	33.3	36.7	35.1	51	ALBAR 629	42.1	43.3	40.0	41.8
25	A 03 N 153	18.9	31.1	33.7	27.9	52	ALBAR-7-MB	15.4	22.2	26.3	21.3
26	A 03 N124	28.3	31.1	40.0	33.1	53	AMBASSADOR	28.4	26.6	32.4	29.1
27	A O2N 40	48.1	31.7	35.2	38.3	54	AMERICANNECTARILESS	30.2	30.2	31.1	30.5
55	ANMOL	50.0	51.6	53.3	51.6	88	C 100A	25.4	20.6	30.0	25.3
56	AO3 N103	51.6	50.0	51.7	51.1	89	C 1412-A	44.4	41.2	46.7	44.1
57	AO3 N146	25.6	30.2	38.3	31.4	90	CA 99541	46.2	43.6	48.3	46.0

58	ARB 757	35.0	33.8	38.3	35.7	91	CAK PH-93	32.4	31.1	35.2	32.9
59	ARKANSAS GREEN	20.6	25.5	36.7	27.6	92	CCH 510-4	30.2	31.6	38.3	33.4
60	ATHENS I	26.4	33.3	45.6	35.1	93	CIRPAN 2362	15.6	22.4	26.7	21.6
61	AUBURN	25.8	33.3	42.4	33.8	94	CNH 120	32.0	30.8	33.3	32.0
62	AV 3649	25.6	29.8	36.7	30.7	95	CNH 13	32.4	31.4	39.6	34.5
63	AVB NE 165	30.5	33.3	35.0	32.9	96	CNH 151	30.4	29.3	32.6	30.8
64	AVB SM 213	50.2	52.2	51.7	51.4	97	CNH 154	31.6	31.1	40.0	34.2
65	AVB SM 277	16.4	20.0	30.6	22.3	98	CNH-36	48.2	45.5	48.1	47.3
66	B 143	16.8	19.3	28.9	21.7	99	COKER 310	46.2	41.8	53.7	47.2
67	B 56-181	18.5	28.8	34.4	27.2	100	COKER 413	30.5	35.5	43.6	36.5
68	B 57-876	32.4	33.3	35.3	33.7	101	COKER 100	20.2	26.6	33.3	26.7
69	B 68-1146	32.4	30.0	30.8	31.1	102	COKER 210	30.6	21.1	31.7	27.8
70	B 72-2889	32.6	42.2	41.5	38.8	103	COTTON 14	46.4	41.1	51.7	46.4
71	BADNAWARI	18.6	21.7	25.0	21.8	104	COTTON 35	19.8	21.1	25.2	22.0
72	BAN 9561	24.4	24.4	26.7	25.2	105	COTTON 4	36.3	32.2	38.3	35.6
73	BATIN ROUGH	26.4	29.1	32.7	29.4	106	COTTON 5	20.8	22.1	30.2	24.4
74	BC 68-2	36.8	40.8	47.7	41.8	107	CPD 03-2	20.8	24.4	31.1	25.4
75	BHAGYA	36.4	40.0	43.3	39.9	108	CPD 8-1	45.7	46.6	45.0	45.8
76	BHATINDA No. 1	46.2	44.4	38.3	43.0	109	CSH 36	15.6	29.2	35.4	26.7
77	BJR 592	27.6	30.8	48.3	35.6	110	CSH 3050	14.8	29.3	30.6	24.9
78	BJR-JK 97-16-4	30.6	36.6	41.7	36.3	111	CSH 911	10.2	10.2	23.6	14.7
79	BLIGHT MASTER	15.2	15.5	21.7	17.5	112	CVT 5	9.6	19.3	26.7	18.5
80	BM COT 95 - BLL	10.2	12.2	25.2	15.9	113	CVT 6	16.4	21.7	28.1	22.1
81	BN FREGOBRACT	20.6	24.4	28.9	24.6	114	DC 1-20	30.4	33.5	48.3	37.4
82	BR01-200/85	29.5	31.7	33.3	31.5	115	DC I-116	32.4	35.5	46.7	38.2
83	BS 101	20.3	23.3	28.3	24.0	116	DELCERO	20.1	10.6	20.4	17.0
84	BURI O349 (1075)	20.8	28.8	39.3	29.6	117	DELCOT377	22.2	21.8	31.7	25.2
85	BURI 0394(1075)V	19.6	29.9	28.9	26.1	118	DELFOS	26.4	19.3	30.0	25.2
86	BWR 28	29.4	31.8	35.7	32.3	119	DELTA SL	10.7	13.3	21.7	15.2
87	BWR 38562	20.6	23.3	37.0	27.0	120	DELTAPINE (C5)	28.4	32.3	43.3	34.7
121	DH 21	30.2	29.1	28.3	29.2	154	G COT12	20.2	13.3	26.7	20.1
122	DHLYY	16.8	14.4	25.8	19.0	155	G COT8M	20.6	27.7	22.6	23.6
123	DHY 286	52.1	56.6	54.2	54.3	156	G17	30.4	22.6	30.0	27.7
124	DP 16	30.3	34.4	53.9	39.5	157	G205- SA	34.5	35.5	36.7	35.6
125	DSU 28	20.4	22.2	36.7	26.4	158	G245-10-2	35.2	30.2	40.0	35.1
126	DUNN	28.2	28.8	31.4	29.5	159	G67	40.5	20.3	43.7	34.8

127	DUNN 56-C-B	36.4	33.3	46.7	38.8	160	GANGA	33.4	32.2	35.2	33.6
128	EC 141679	20.6	22.2	23.3	22.0	161	GANGA NAGER AGETI	30.2	29.3	36.7	32.1
129	EC 141712	30.5	31.1	30.0	30.5	162	GBHV 148	36.4	22.2	30.0	29.5
130	EC 76765	40.9	51.1	36.7	42.9	163	GICS15	28.6	29.8	33.7	30.7
131	EC124096	20.0	35.5	45.0	33.5	164	GISV12	24.5	29.3	28.3	27.4
132	EC132033	26.3	25.5	35.8	29.2	165	GISV86/58	36.4	34.4	33.3	34.7
133	EC 356587	26.2	33.3	33.3	30.9	166	GJHS16	30.5	29.4	31.7	30.5
134	EC 52-SN	28.4	38.5	36.7	34.5	167	GJHS270	30.6	33.3	30.0	31.3
135	EMPIRE 61	34.5	44.3	41.7	40.2	168	GJHS53	20.8	21.1	23.3	21.7
136	EPRT 6	20.6	22.4	35.0	26.0	169	GL-CO2-4 -4	30.9	33.3	44.4	36.2
137	F 1980	20.6	19.8	23.8	21.4	170	GN67-1 DWARF	30.4	26.6	26.7	27.9
138	F 1378	24.6	26.6	28.3	26.5	171	G-OKRA	30.1	39.5	31.7	33.8
139	F 1794	33.4	32.4	48.3	38.0	172	GREGG35	29.6	30.0	36.3	32.0
140	F 1861	20.6	20.4	25.0	22.0	173	GREGG45	24.7	22.2	25.8	24.2
141	F 1875	24.6	33.3	26.7	28.2	174	GRS6015	49.7	50.2	40.0	46.6
142	F 1914	40.5	39.6	45.0	41.7	175	GRS60-GIL3-4	20.4	16.6	28.3	21.8
143	F 1980	30.6	20.1	38.3	29.7	176	GS10	34.9	30.1	45.0	36.7
144	F 2035	25.4	29.6	36.7	30.6	177	GS10N	24.6	31.7	32.5	29.6
145	F 414	20.6	21.7	26.3	22.9	178	GS23	21.6	33.3	35.0	30.0
146	F 846	50.0	54.4	41.7	48.7	179	GTSV-337	45.6	43.3	45.6	44.8
147	FD 89	35.4	40.0	46.7	40.7	180	GUMBO	30.2	31.1	31.7	31.0
148	FFS103	36.4	33.3	38.3	36.0	181	H 655 C	18.4	20.0	25.0	21.1
149	FM 531 B LINE-7	29.0	29.1	30.0	29.4	182	H103	16.3	19.3	21.7	19.1
150	FREGOBRACT	32.4	36.6	37.9	35.6	183	H1117	10.1	11.1	18.3	13.2
151	FS 128	40.6	31.6	41.7	38.0	184	H1150	46.2	41.1	41.7	43.0
152	G COT 8- F	45.2	53.4	51.7	50.1	185	H1180	19.7	23.3	28.3	23.8
153	G COT100	37.4	40.0	41.7	39.7	186	H1226	32.9	30.1	28.3	30.4
187	H1236	33.0	33.3	31.6	32.6	220	L 759	20.9	16.6	21.7	19.7
188	H14	15.9	18.3	21.6	18.6	221	L11	35.2	34.4	40.0	36.5
189	H655C	20.6	26.6	25.6	24.3	222	L147	32.1	33.3	34.6	33.3
190	H974	23.4	33.3	33.7	30.1	223	L604	27.6	29.3	21.7	26.2
191	HS 251	50.0	43.3	53.3	48.9	224	L740-1	20.4	23.3	25.0	22.9
192	HS100	22.1	21.1	38.3	27.2	225	L762	37.2	35.5	40.0	37.6
193	HS182	33.6	33.3	40.0	35.6	226	LA FRGO BRACT	19.2	27.7	23.3	23.4
194	HS2	45.6	50.4	45.0	47.0	227	LAM GUNTURE	46.7	42.6	53.3	47.5
195	HS6	51.9	58.8	58.3	56.3	228	LAM787	34.2	33.3	41.7	36.4
196	I -81	20.3	21.6	27.0	23.0	229	LANKBURN	36.0	33.3	38.3	35.9

197	IAN1327 F	27.7	29.1	36.7	31.2	230	LAS 45 RED AK	27.4	26.6	30.0	28.0
198	IC1832	38.0	36.6	37.0	37.2	231	LASSANI 11	25.6	30.0	33.3	29.6
199	IRMA323	28.4	33.3	37.9	33.2	232	LCH10	50.0	51.1	56.7	52.6
200	JK 344	20.6	22.2	23.3	22.0	233	LCMS6B	36.4	28.8	40.0	35.1
201	JK105	20.6	31.7	30.0	27.4	234	LH 2001	32.8	40.0	51.2	41.3
202	JK255	41.6	40.4	33.3	38.4	235	LH1802	25.6	23.7	31.7	27.0
203	JK345	35.4	30.2	36.7	34.1	236	LH1911	24.6	24.4	38.3	29.1
204	JK97-621	34.2	31.5	33.3	33.0	237	LH1953	28.0	20.6	35.0	27.9
205	JK97-MB	26.3	23.3	35.0	28.2	238	LH1960	19.8	28.8	27.8	25.5
206	JKCL702	46.7	40.2	46.7	44.5	239	LH1995	20.4	22.2	34.4	25.7
207	JP No.9	40.0	39.6	47.9	42.5	240	LH2002	46.7	40.0	55.0	47.2
208	JP17	29.4	39.6	45.0	38.0	241	LOCKET-4487	50.1	53.3	55.2	52.9
209	JP-No-8	56.8	56.6	58.3	57.2	242	LOCKET4789	46.7	42.7	52.4	47.3
210	K 4005	24.6	33.3	33.3	30.4	243	LRK516	29.8	21.8	41.7	31.1
211	KDGH178	52.2	50.0	56.7	53.0	244	LSS	26.4	19.1	42.9	29.5
212	KDGH50	12.4	12.2	18.2	14.3	245	LSV24	26.4	33.3	40.0	33.2
213	KDGH50-4	30.6	22.2	32.5	28.4	246	LUXMI	10.2	14.4	16.7	13.8
214	KH 155	25.4	29.3	25.6	26.8	247	M11	20.1	35.5	34.8	30.1
215	KH113	30.8	31.6	30.0	30.8	248	M8	20.8	35.5	31.1	29.1
216	KH138	15.4	22.2	28.9	22.2	249	MAHALUXMI	16.4	20.4	13.3	16.7
217	KHD2	16.8	24.4	28.9	23.4	250	MC130	10.1	11.1	16.7	12.6
218	KKS	29.1	33.3	30.2	30.9	251	MC82	8.4	10.7	20.0	13.0
219	KKS4F	20.3	21.1	24.4	21.9	252	MC86	10.8	22.2	23.3	18.8
253	MCU7	12.6	22.2	22.9	19.2	286	PIL9	21.5	31.1	40.0	30.9
254	MDU5	25.4	28.8	35.0	29.7	287	PK54	21.6	33.6	35.0	30.1
255	MESR17	25.4	29.8	36.7	30.6	288	PKV0804	22.1	22.2	35.4	26.6
256	MZ561-3	30.2	30.3	34.7	31.7	289	PKV081	16.6	26.6	30.0	24.4
257	N3	20.6	24.4	30.0	25.0	290	PKY RAJAT	29.5	31.8	37.5	32.9
258	N34	25.9	30.2	31.7	29.3	291	PRS72	19.7	26.6	28.3	24.9
259	N72	42.5	40.4	40.5	41.1	292	PUSA 1803	26.4	32.5	39.6	32.8
260	N86	30.8	30.0	35.0	31.9	293	PUSA 3216	13.9	23.3	38.3	25.2
261	NA 1375	30.7	30.5	45.2	35.5	294	PUSA 95	13.2	21.1	28.9	21.1
262	NA920	45.7	30.4	53.3	43.1	295	PUSA180	29.4	30.4	32.4	30.7
263	NCAC11	35.2	35.3	44.4	38.3	296	PUSA31	19.4	20.2	38.8	26.1
264	NCAC15	17.7	22.2	31.7	23.9	297	PUSA317	47.5	51.5	56.7	51.9
265	NHBBR-38	28.7	32.2	26.7	29.2	298	PUSA864	25.6	28.3	33.3	29.1
266	NM 755404	26.4	20.2	36.7	27.8	299	R-40	32.4	41.1	55.0	42.8

267	OKRA RED FREGO	38.4	31.8	48.3	39.5	300	RAH 3	26.6	24.4	31.7	27.6
268	P 367	9.5	12.2	30.0	17.2	301	RAH53	26.4	28.6	33.3	29.4
269	P 729-37	12.4	11.1	15.7	13.1	302	RCMS2B	20.3	19.4	26.7	22.1
270	P15	26.6	20.8	26.7	24.7	303	REBA B50	32.5	52.8	40.5	41.9
271	P216-F	8.4	12.2	23.3	14.6	304	REBA PVT9	6.4	10.1	16.7	11.1
272	PARAS	36.4	31.1	38.1	35.2	305	RED	21.2	23.3	35.0	26.5
273	PAYMASTERIII	28.6	31.1	45.1	34.9	306	REX66	25.3	33.3	44.2	34.3
274	PB-557	29.4	31.1	38.0	32.8	307	RH1	26.7	29.8	46.7	34.4
275	PB84-RV 4	36.2	39.5	48.3	41.3	308	RHC1179	22.2	31.1	46.7	33.3
276	PD380	37.8	33.3	53.3	41.5	309	RHC2022	35.4	40.0	58.3	44.6
277	PH-348	26.6	23.3	25.0	25.0	310	RHC9740	20.2	17.7	25.6	21.2
278	PIL-60	26.4	33.3	43.3	34.3	311	RS2098	30.5	40.0	42.8	37.8
279	PIL104	9.6	11.1	30.0	16.9	312	RS 2351	25.4	14.4	48.3	29.4
280	PIL18	24.3	28.8	33.7	28.9	313	RS 2390	30.6	20.4	40.7	30.6
281	PIL20	24.8	33.3	43.3	33.8	314	RS2013	28.4	18.8	30.0	25.7
282	PIL27	20.6	19.3	25.6	21.8	315	RS2097	24.5	20.6	26.7	23.9
283	PIL8	9.9	10.4	17.0	12.4	316	RS810	30.4	29.1	36.1	31.9
284	PIL8-5	25.4	30.2	40.0	31.9	317	RS875	30.6	35.6	35.2	33.8
285	PIL8-7	12.2	15.5	18.3	15.3	318	RS89	30.5	21.1	41.7	31.1
319	RST9	24.6	44.4	40.0	36.3	351	T167	42.0	42.8	55.0	46.6
320	RUU/U	31.6	35.8	37.0	34.8	352	TAMCOT CAMPE	14.6	18.8	25.6	19.7
321	S44	18.2	22.2	25.0	21.8	353	TAMCOT SP-37	32.8	31.8	33.3	32.6
322	S4727	18.9	22.2	30.0	23.7	354	TAMXOT SP23	13.4	23.3	26.8	21.2
323	S 69-993	32.5	30.8	38.3	33.9	355	TCH 1002	30.1	29.4	36.6	32.0
324	S344	28.4	28.8	38.1	31.8	356	TCH1599	26.6	25.5	26.7	26.3
325	SA 966	42.6	42.8	50.0	45.1	357	TEXAS31	40.2	38.8	51.3	43.4
326	SA1197	35.2	45.8	51.7	44.2	358	TEXAS34	25.4	19.4	43.7	29.5
327	SA1243	30.2	40.0	53.3	41.2	359	TEXAS44	26.6	25.5	41.7	31.3
328	SA1246	32.4	31.6	51.7	38.6	360	TEXAS709	32.4	31.8	45.6	36.6
329	SA201	36.4	20.5	42.9	33.3	361	TEXAS79	24.6	21.2	33.3	26.4
330	SA305A	10.6	21.1	43.8	25.2	362	TEXAS937	40.8	40.0	38.4	39.7
331	SA497	12.8	16.6	35.0	21.5	363	TH46	51.6	53.3	50.0	51.6
332	SA72	29.4	23.2	34.8	29.1	364	THAUNWAS	25.4	13.3	16.2	18.3
333	SA7A	20.6	18.3	53.3	30.7	365	32 IC 333984	36.1	29.3	35.0	33.5
334	SAHANE	23.7	29.1	35.2	29.3	366	TSH1608	10.5	10.0	22.6	14.4
335	SCS52-3	23.4	23.3	31.7	26.1	367	TX ORSZ78	36.4	33.3	37.0	35.6
336	SHARDA	20.4	16.6	34.4	23.8	368	UPA (57) 17	35.8	33.3	33.3	34.1

337	SIMA1	18.9	26.6	36.7	27.4	369	UPA(62)31-65	50.6	52.8	56.7	53.4
338	SIN8	30.5	31.6	40.0	34.0	370	VCA2	28.2	39.3	48.3	38.6
339	SK663	20.7	23.3	36.7	26.9	371	VC-3	24.6	34.4	46.3	35.1
340	SLM8	15.6	14.4	28.3	19.4	372	VCA6	44.2	44.4	53.3	47.3
341	SP84-213	32.0	32.7	43.7	36.1	373	VCA9	45.0	46.1	45.0	45.4
342	SR38	10.8	12.2	32.7	18.6	374	VCC22	42.6	40.6	48.3	43.8
343	SR5	25.4	29.8	36.1	30.4	375	VCC24	29.8	23.3	37.1	30.1
344	SS113	40.6	45.5	37.0	41.0	376	VCC3	36.6	35.5	44.4	38.8
345	STONEVILLE 7A	26.4	30.2	45.8	34.1	377	VVCH1501	29.5	34.4	43.3	35.7
346	STONEVILLE20	44.4	42.2	46.7	44.4						
347	STONEVILLE62	32.6	31.8	38.1	34.2						
348	SUDAN ARBAN COTTON	18.4	20.0	25.0	21.1						
349	SUMAN	28.2	31.1	43.3	34.2						
350	SV213	34.1	32.2	40.0	35.4						

susceptible. Further, forty nine were observed susceptible and sixteen were found highly susceptible to cotton leaf curl disease (Table 03).

Screening of germplasm to explore resistant source is a basic step towards the solution of this hazardous problem. With this objective genetic material were graded for degree of tolerance to the cotton leaf curl virus after screening on a natural hot spot by various workers. Ahuja *et al.* (2007) screened one hundred and forty two cotton germplasm lines for cotton leaf curl virus symptoms in field evaluation during 2003 to 2005 and observed dominant expression of the disease resistance and there were no maternal or cytoplasmic effects detected from reciprocal hybridization. As the same way 1799 cotton germplasm lines evaluated against CLCuD during 1997-2006 under natural conditions and only seven lines were recorded resistant to cotton leaf curl virus disease[7]. *G. stockii* is a resistant species to cotton leaf curl virus disease and speculated on the possibility of the usefulness of this species in producing disease-resistant cultivated cotton by hybridization[2]. Nazeer *et al.*, (2014) also indicated the possibility of transferring CLCuD resistant genes from *G. arboreum* to *G. hirsutum* through conventional hybridization and back crossing. 11600 genotypes were tested at Cotton Research Station, Vehari and demonstrated that it is possible to explore resistant material from germplasm through screening on the basis of incidence and intensity and the same can be utilized in the programme for evolving CLCuV tolerant/ resistant varieties of cotton[1]. Similarly in the present study, identified resistant genotypes may be utilized by the plant breeders for exploitation and providing leaf curl disease resistance in cotton as breeding for resistance essentially depends upon a constant supply of new source of resistance.

CONCLUSION

Cotton leaf curl has a very severe impact on cotton production and productivity. However, there is no resistance germplasm available against CLCuD. Evaluation of germplasm is the best way to overcome the effect of CLCuD and leads to the sustainable cotton production. Screening of germplasm is also a way of exploring natural variability present in an area leading to the selection

Table 3. Grouping of different genotypes based on their reaction to CLCuD

PDI	Disease reaction	Total entries	Genetic collection Name
0	Immune/Disease Free (0)*	0	-
1	Highly Resistant (0.1-10.0%)	0	-
2	Resistant (10.1-20.0%)	34	REBA PVT9 , PIL8, MC130, MC 82, 7203-14-104, P 729-37, H 1117, LUXMI, KDGH 50, TSH 1608, P 216-F, CSH 911, DELTA SL, PIL 8-7, BM COT 95–BLL, MAHALUXMI, PIL104, DELCERO, P367, BLIGHT MASTER, 101-102 B, THAUNWAS, CVT5, H14, SR38, 9-3X13L1CO2-1-3, MC 86, DHLYY, H 103, MCU 7, SLM 8, L759, TAMCOT CAMPE, 42- STONEVILLE 62
3	Moderately Resistant (20.1-30.0%)	134	GCOT12, 1556F, H655C, PUSA95, SUDANARBANCOTTON, RHC9740, TAMXOTSP23, ALBAR-7-MB, F1980, SA497, CIRPAN2362, AKH 2910, B143, GJHS53, BADNAWARI, GRS60-GIL3-4, PIL27, S44, KKS 4F, COTTON35, EC141679, F 1861, JK 344,CVT 6, RCMS 2B,KH138,AVB SM 277,1695-175 J, A02N 65, A03 N 150, F 414, L740-1, I81, KHD2, LAFRGOBRACT, GCOT8M, A03N139, S4727, A02N89, H1180, SHARDA, NCAC15, RS2097, 4SAMARU26, S101, GREGG45, H655C, COTTON5, PKV081, BNFREGOBRACT, P15CSH3050, PRS72, N3, PH348, BAN9561, DELCOT377, DELFOS, PUSA3216, SA305A, C100A, CPD032, LH1960, LH1995, RS2013, 91487, EPRT6, ACOLASJ1, BURI0394(1075)V, PUSA31, SCS523, L604, 101102B2, TCH1599, DSU28, TEXAS79, F1378, RED, PKV0804, A7262, COKER100, CSH36, KH155, SK663, BWR38562, LH1802, B56-181, HS100, 36B, GISV-12, JK105, SIMA1, ARKANSASGREEN, RAH3,G17, COKER210, NM755404, A03N153, GN671DWARF,LH1953, LAS45REDAK, F1875 , JK97MB, KDGH504, ABOHAR3, PIL18, AMBASSADOR, LH1911, M8, PUSA864, SA72, DH21, EC132033, NHBBR38, 1412-A1, AKG3/62, N34, SAHANE, BATINROUGH, FM531BLINE-7, RAH53, RS2351, A0252, DUNN, GBHV148, LSS, TEXAS34, AKH8931, BURIO349(1075), GS10N, LASSANI 11, F1980, MDU5, GS23,
4	Moderately Susceptible (30.1-40.0%)	144	ABH6,H974,M11,PK54,VCC24,H1226,K4005,SR5, AMERICANNECTARILESS,EC141712, GJHS16, AKG2/54, F2035, MESR17, RS2390, AV3649, GICS15, PUSA180,SA7A, CNH151, KH113,EC356587,KKS,PIL9,GUMBO,76IH23, AKH9913,B68-1146, LRK516, RS89, IAN1327F, GJHS270, TEXAS44, A03N144,AO3N146,BR01-200/85, MZ561-3, S344, N86, PIL8-5, RS810, CNH120,GREGG35,TCH1002, 16-SH-1274,GANGANAGERAGETI,BWR28, H1236, TAMCOTSP37,A03N148, PB557,PUSA1803, AVBNE165, CAK-PH93, PKY-RAJAT,AK-182/Gland361-3462,JK97-621, A03N124,A02N 106,IRMA-323,LSV24,L147, RHC1179, SA201,CCH510-4,EC124096,32-IC333984, GANGA,B57-876, AUBURN, G-OKRA, PIL20, RS875,S69-993, SIN8, JK345, STONEVILLE7A,UPA(57)17, CNH154, STONEVILLE62, SUMAN, PIL60, REX66,RH 1,AO2N75,CNH13,EC52SN, DELTAPINE(C5), GISV-86/58,G 67, RUU/U, PAYMASTER-III,

5	Susceptible (40.1-50.0%)	49	A03N121, ATHENS1, G-245-10-2, LCMS6B, VCA3,49-CSH875, PARAS, SV213, NA1375 ,BJR592, COTTON4, FREGOBRACT, G205SA, HS182, TXORSZ78, ARB757, VVCH1501, 98-NHBBR44, LANKBURN, FFS103, SP84-213, GLCO2-4-4, BJR-JK97-164, RST9, LAM787, A02N84, COKER413, L11, A02N149, TEXAS709, GS10, IC1832, DC1-20, L762, RS2098, F1794, FS128, JP17, DCI116, AO2N40, NCAC11, JK255, SA1246, VCA2, B72-2889, DUNN56-C-B, VCC3, DP16, OKRAREDFREGO, GCOT100, TEXAS937, BHAGYA, EMPIRE61,150-3-1-1, FD89, SS113, N72, SA1243, LH2001, PB84-RV4, PD380,F1914, ALBAR629,BC68-2, AKG2, REBA-B-50,AET55,43-P12, JPNo.9, R40,EC76765, BHATINDANo.1, H1150,NA920,TEXAS31,59- SV7A, VCC22, C1412-A,SA1197, STONEVILLE20, KCL702, RHC2022, GTSV337, SA966, VCA9,CPD8-1, CA99541, COTTON14, GRS6015, T167, HS2, 33-STONEVILLE213,COKER310, LH2002,CNH36,LOCKET4789,VCA6,LAMGUNTURE, A03N132,F846,HS 251
6	Highly Susceptible (>50.0%)	16	G COT 8- F, AO3 N103, AVB SM 213, ANMOL, TH46,320-F, PUSA317, A02N 85, LCH-10, LOCKET4487, 78-CAT131, KDGH178, UPA(62)31-65, DHY286, HS6, JP-No8

of best genotype against CLCuD. Best resistant and moderate resistant genotypes may be recommended as variety at field level directly or also may be utilized as source of resistance in various breeding programms.

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