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DEVELOPMENT OF HIGH YIELDING AND CLCuV RESISTANT ULPAND COTTON VARIETY "CIM-608"

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A B S T R A C T

The new variety CIM-608 has been developed through interspecific hybridization i.e. 2 (*Gossypium hirsutum* × *G. anomalum*) × [3]*G. hirsutum*. at Central Cotton Research Institute, Multan. The variety produced significantly higher yield in varietal trials compared with standard variety i.e. MNH-786. CIM-608 was also evaluated in varietal and Zonal Varietal Trials at farmers' fields and Govt. Farms. In varietal trials CIM-608 gave 33.7%, and 8.97% more yield over commercial varieties MNH-786 and CIM-554, respectively for seed cotton yield. While in Zonal varietal trial during 2010-11, CIM-608 gave 2828 Kg ha^{-1} yield of seed cotton as compared to standard variety CIM-554 (2600 Kg ha^{-1}). In National Co-ordinated Varietal Trial (NCVT), CIM-608 dominated over most existing varieties/strains in two consecutive years i.e. 2010-11and 2011-12 for seed cotton yield. This variety showed tolerance to Burewala Strain of cotton leaf curl virus (BSCuV). CIM-608 has combination of characters including CLCuV tolerance, earliness, and heat tolerance with good fibre characteristics. The presented variety of *G. hirsutum* L. will significantly contribute in the cotton industry of Pakistan.

Keywords: Introgression, CLCuV resistant, wide hybridization, fiber traits, early maturity.

INTRODUCTION

The importance of cotton (*Gossypium hirsutum* L.) is obvious from the fact that it is the world's leading fibre producing specie (Fryxell, 1992, Dutt *et al*., 2004). It contributes about 60% in the total foreign exchange through the exports of value added products (Iqbal *et al*., 2005). It contributes for 8.6% of the value added in agriculture and about 1.8 % to GDP of Pakistan (Anonymous, 2007). There are several reasons for low yield of seed cotton but occurrence of Cotton Leaf Curl Virus is one of the major reason in Pakistan. Several varieties of cotton namely, CIM-448, CIM-1100, CIM-446, MNH-552, CIM-443 and MNH-554 were developed by various cotton breeding centers that showed tolerance against CLCuV. Although these varieties of cotton exhibited tolerance but later on showed susceptibility due to the presence of high inoculums pressure in the environment (Shah *et al*., 2004). The long-term approach to manage with this problem and to save this crop from the ravages of CLCuV is the development of Cotton Leaf Curl resistant varieties (Akhtar *et al*., 2002), as previously practiced in Sudan and Egypt (Kirkpatrick, 1931). The first step of this study was also introgression of CLCuV resistance from wild species to upland cotton.

The new variety CIM-608 possesses higher yield potential, better lint percentage and good fibre characteristics compared with the existing commercial varieties in addition to tolerance against leaf curl virus and thermal stress. Its fibre is capable of spinning on higher counts of yarn for making quality fabrics. It is hoped that the approval and release of this variety for commercial cultivation will significantly add to cotton production.

Significant differences were observed in yield and yield contributing traits with the development of new varieties of Upland cotton (Singh *et al*., 1973). Ahmad *et al*. (1982) reported highly significant differences in various varieties of *G. hirsutum* L. yield of seed cotton. Soomro *et al*. (1986) reported significant differences in yield, ginning out turn %age and staple length for varieties. Khan *et al*. (1989) also observed significant

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differences in yield, ginning turn out percentage, number of bolls per plant and boll weight in different genotypes. Afzal *et al*. (2001) studied that there were highly significant variations among years, genotypes (varieties) and year × genotypes interaction for number of bolls per plant, boll weight and seed cotton yield. Afzal *et al*. (2002) reported significant differences in yield, boll weight, number of bolls per plant and plant height due to difference in genotypes (varieties). Hanif *et al*. (2001) also reported significant variations in seed cotton yield due to varieties. Khan *et al*. (2002) found that varietal variation affect plant characters up to high extent in upland cotton. Arshad *et al*. (2003a) search out significant variation for various traits like seed cotton yield, number of bolls, boll weight etc due to the use of various genotypes. Arshad *et al*. (2003b,c) found significant variation for various characters like Ginning out percentage, staple length, number of bolls and boll weight due to the use different genotypes. Arshad *et al*. (2003d) studied that varieties affect the yield of the plant significantly and also reported significant variation in cotton crop due to the use of different varieties. The damage of cotton leaf curl virus has been minimized as a result of the evolution of CLCuV resistant varieties i.e. CIM-1100, CIM-448, CIM-443, CIM-446, CIM-482, CIM-473, CIM-499, CIM-496, CIM-707 and CIM-506 for the first time in the history of the country by the scientists of Central Cotton Research Institute Multan. Later on, Cotton Research Institutes/Stations of Punjab and Federal Government respectively, evolved CLCuV resistant varieties i.e. FH-634, FVH-53, FH-900, FH-901 FH-1000, and NIAB-999 up to 2005. With the introduction of this new CLCuV resistance, early maturing variety CIM-608 above mentioned problems would be automatically solved.

MATERIALS AND METHODS

Parentage/Pedigree: The new variety CIM-608 has been developed through interspecific hybridization i.e. 2(*G. hirsutum* × *G. anomalum*) × ^{3}*G. hirsutum*. The cross was attempted in 2000-2001 and the strain was bulked during 2008-2009 in F_6 generation of BC_3.

Breeding History

Breeding Methods: The variety has been bred through interspecific hybridization.

Different Stages of Selection:

Year	Generation/Trial	Activity
2000-2001	F_1	Cross attempted & treated with Colchicine to get Hexaploid & back crossed with *G. hirsutum* to convert into pentaploid in greenhouse
2001-2002	BC_1	Selection of CLCuV free plants from Pentaploid through petiole grafting and back crossed with *G. hirsutum* to make tetraploid
2002-2003	BC_2	Selection of CLCuV free plants from tetraploid through petiole grafting and back crossed with *G. hirsutum* to incorporate economic & fibre traits.
2003-2004	F_1 of BC_3	Selection of CLCuV free plants from F_1 of BC_3 through petiole grafting and raised F_2 of BC_3
2004-2009	F_2-F_6	Screening and selection in different segregating generations and finally bulked as strain.
2009-2011	VT, ZVT, NCVT, PCCT, DUS TRIAL and BIGGER BLOCKS	• Trials at Central Cotton Research Institute, Multan and farmers' Fields. DUS trials by National Seed Certification and Registration Department and bigger blocks at Punjab Seed Corporation Farms, Khanewal. • Spot examination by the Expert Sub-Committee of Punjab Seed Council.
2012-2013	Data compilation and preparation of proposal	Submission of proposal for consideration by the Expert Sub-Committee for forwarding it to the Punjab Seed Council for approval and this strain is approved in 2013 for general cultivation.

RESULTS AND DISCUSSIONS

Varietal Trials: The strain (CIM-608) was tested in replicated varietal trials at Central Cotton Research Institute, Multan in comparison to the commercial varieties for two years. Yield data revealed that that CIM-608 produced significantly higher yield than the commercial varieties. The yield produced by CIM-608 was 33.7% and 8.97 % higher than MNH-786 and CIM-554, respectively (Table 1).

Zonal Varietal Trials: During 2010-2011 and 2011-12, CIM-608 was tested in Zonal Varietal Trials at government as well as at private farms of the progressive growers in different ecological zones. Averaged yield data of 20 locations, for the year 2010-11, indicated that CIM-608 produced 2828 kg ha^{-1}

compared to 2600 kg ha^{-1} seed cotton yield of standard variety CIM-554 (Table 2). During 2011-12, CIM-608 was further tested in Zonal Varietal Trials at 19 different ecological zones. The averaged data of 19 locations presented in Table-3 showed that CIM-608 produced seed cotton yield of 2859 kg ha^{-1} whereas the yield produced by CIM-554 was 2586 kg ha^{-1}. Performance of cotton crop varies under varying environments due to genetic variability (Khan *et al*., 2008).

Table 1. Performance of CIM-608 in varietal trials at Central Cotton Research Institute, Multan during 2010-11 and 2011-12.

Year	Name of Trial	Location	Varieties / seed cotton (kg ha^{-1})			CD (5%)
			CIM-608	MNH-786	CIM-554	
2010-11	VT-2	Multan	3317	2163	2654	215.2
2011-12	VT-1	Multan	2920	-	2621	50.6
	Average		2891	2163	2653	
	Percent increase over		-	33.7	8.97	

Table 2. Yield performance (kg ha-1) in Zonal Varietal Trial at farmers' fields during 2010-11.

Sr. No.	Name of grower and location	CIM-608	CIM-554
1	Mr. Muhammad Saleem, Lodhran	2905	2600
2	Haji Tariq Mahmood Bhutta, 6-Faiz, Multan	2863	2585
3	Ch. Ghohar Ali, Makhdum Rasheed	2910	2600
4	Ch. Muhammad Hanif 108/7R, Sahiwal	2818	2683
5	Ch. Muhammad Saddiq, 17/11R, Sahiwal	2913	2486
6	Ch. Muhammad Akbar 70/5L, Sahiwal	2714	2593
7	Mr. Khuda Bux, 19 Kasi, Multan	2834	2682
8	Iftikhar Shah D. G. Khan	2735	2676
9	Mr. Shahid Manzoor, Khanpur	2943	2563
10	Ch. Rehmat Ali, 88/10-R, KWL	2786	2498
11	Mr. Aleem Ahmad Khan, Tounsa	2817	2600
12	Sh. Abdul Rasheed, 88/WB Vehari	2900	2698
13	Haji Allah Ditta, Kukar Hatta	2843	2691
14	Ch. Ramzan Ahmad, Hasilpur	2731	2570
15	Mr. Ghulam Mustafa Chatta, Uch Sharif	2900	2594
16	Ch. Zia-ur-Rehman, Liaquat Pur	2731	2499
17	Ch. Hafeez, Rajanpur	2865	2531
18	Haji Zulfiqar Ali Haroonabad	2781	2636
19	Mian Mukhtair Mailsi	2801	2613
20	Mr. Dawood Sarwar,Chak 14/8AR, Mian Channu	2765	2599
	Average	2828	2600

Table 3. Yield performance (kg ha-1) in Zonal Varietal Trial at farmers' fields during 2011-12.

Sr. No	Name of grower and location	Strain/variety	
		CIM-608	CIM-554
1	Mr. Muhammad Tahir, Ali pur	2743	2575
2	Mr. Muhammad Saleem, Lodhran	2914	2479
3	Haji Tariq Mahmood Bhutta, 6-Faiz, Multan	2879	2523
4	Ch. Ghohar Ali, Makhdum Rasheed	2786	2613
5	Ch. Muhammad Hanif 108/7R, Sahiwal	3014	2365
6	Ch. Muhammad Saddiq, 17/11R, Sahiwal	2778	2579
7	Ch. Muhammad Akbar 70/5L, Sahiwal	2789	2713
8	Mr. Khuda Bux, 19 Kasi, Multan	2956	2589

Continue…

9	Mian Mehboob Qureshi, Kot Addu	2814	2615
10	Iftikhar Shah D. G. Khan	2920	2483
11	Mr. Shahid Manzoor, Khanpur	2863	2594
12	Ch. Rehmat Ali, 88/10-R, KWL	2953	2753
13	Mr. Aleem Ahmad Khan, Tounsa	2746	2497
14	Sh. Abdul Rasheed, 88/WB Vehari	2895	2596
15	Haji Allah Ditta, Kukar Hatta	2942	2648
16	Ch. Ramzan Ahmad, Hasilpur	2776	2676
17	Mr. Ghulam Mustafa Chatta, Uch Sharif	2838	2483
18	Ch. Zia-ur-Rehman, Liaquat Pur	2784	2564
19	Ch. Hafeez, Rajanpur	2937	2786
	Average	2859	2586

Regional Adaptability Trials

National Coordinated Varietal Trials: CIM-608 was included in National Co-ordinated Varietal Trials for two years i.e. 2010-11 and 2011-12. Seed cotton yield data for the year 2010-11 indicated that, in Faisalabad Region, CIM-608 produced higher yield of 2457 kg ha^{-1} compared with the standard variety MNH-786 which produced 2290 kg ha^{-1} (Table 4)**.** CIM-608 also produced higher yield of 1959 kg ha^{-1} in Multan Zone as compared with the standard variety MNH-786 which produced 1400 kg ha^{-1} (Table-5)**.** Average yield data of all the locations in Punjab, for 2010-11, show that CIM-608 again produced higher yield of 2158 kg ha^{-1} in comparison to the MNH-786 which gave 1756 kg ha^{-1} (Table-5)**.**

Table 4. National Coordinated Varietal Trial 2010-11 (Faisalabad Zone).

Varieties	Faisalabad Zone				
	CRS SWL	AARI FSD	NIAB FSD	NIBGE FSD	Avg.
FH-2015	1120	2279	2473	2869	2185
VH-289	2090	1746	2842	3070	2437
CIM-608	1873	2485	2398	3070	2457
GH-114	997	3045	1575	2640	2064
BH-175	1660	2816	3022	2955	2613
NIAB-9811	2643	2466	3087	3013	2802
CRIS-486	2195	1462	2312	3156	2281
SLH-334	1660	1394	1828	3271	2038
FH-4243	1570	2148	2713	2697	2282
CIM-573	1965	3060	2597	2883	2626
GS-321	827	2721	2875	2869	2323
GS-378	942	2580	3230	2683	2359
NIAB-2009	3005	1922	2780	3328	2759
NIBGE-314	2205	2441	3087	2769	2626
MNH-814	2510	2119	2829	2883	2585
RH-625	2240	2537	3084	2439	2575
MNH-786	1642	1056	3297	2267	2290
CRIS-494	1883	2403	2503	3271	2515
NIAB-2008	1972	2617	3248	2310	2536
NIAB-2010	1300	3062	3619	2424	2601
CD 5%	135.87	631.37	476.47	174.81	

During 2011-12, in Multan Zone, CIM-608 also produced 2542 kg ha^{-1} as compared to standard MNH-786 having seed cotton yield of 2011 kg ha^{-1}. Similarly averaged yield data on Punjab basis, show that the candidate variety CIM-608 produced seed cotton yield of 2158 kg ha^{-1} whereas the standard variety MNH-786 yielded 1762 kg ha^{-1} (Table 6).

Table 5. National Coordinated Varietal Trial 2010-11 (Multan Zone).

Varieties	Multan Zone								KPK	Punjab & KPK Avg.
	CCRI MUL	PSC KW	CRS MUL	CRS VEH	CRS BWP	CRS RYK	Mul Zone	Punj. Avg.	DI Khan	
FH-2015	1103	1345	957	1891	1650	2010	1493	1770	560	1660
VH-289	1937	1838	1710	2539	2207	2642	2145	2262	851	2134
CIM-608	1785	1686	1650	2502	2287	1846	1959	2158	668	2023
GH-114	762	1058	634	1812	1615	1421	1217	1556	472	1457
BH-175	1273	1381	1507	1839	1821	2460	1713	2073	945	1971
NIAB-9811	2251	2475	1973	3579	2781	3174	2705	2744	915	2578
CRIS-486	1928	825	1328	2198	1740	1895	1652	1904	695	1754
SLH-334	1829	1175	1399	2269	2754	2427	1976	2001	1242	1932
FH-4243	1722	1067	1124	1839	2772	2134	1776	1979	927	1883
CIM-573	2000	2152	1124	3229	2233	2187	2154	2343	669	2191
GS-321	888	1013	825	1238	1758	1530	1209	1654	371	1538
GS-378	942	879	981	1041	1785	1505	1189	1657	259	1530
NIAB-2009	2466	1139	1627	3373	1928	2267	2133	2383	1153	2272
NIBGE-314	1982	1121	1316	2009	1964	2188	1763	2108	1220	2027
MNH-814	1470	1605	1423	2431	1831	1974	1789	2108	1031	2010
RH-625	2161	1820	1459	2772	1991	2707	2152	2321	878	2190
MNH-786	404	1677	658	1893	1749	2017	1400	1756	599	1651
CRIS-494	1946	834	1100	2754	1731	2054	1737	2048	772	1963
NIAB-2008	1166	1300	993	1722	1713	1610	1417	1865	673	1757
NIAB-2010	1417	995	897	2323	1641	1942	1536	1962	783	1855
CD 5%	619.40	575.33	437.47	782.3	101.1	500.2			94.58	

Table 6. National Coordinated Varietal Trial 2011-12 (Multan Zone).

Varieties	Multan Zone						KPK	Punj. & KPK Avg.
	CCRI MUL	PSC KWL	CRS MUL	CRS RYK	Mul Zone	Punjab Avg.	D.I. Khan	
NIAB-9811	3143	1883	2072	2870	2492	2247	1946	2197
PB-38	2674	2331	2564	2411	2495	2178	2404	2215
NIAB-2010	2618	1614	1594	1435	1815	1648	2045	1714
SLH-334	3293	2797	2644	1880	2654	2281	2332	2289
NIAB-2009	3180	1479	2404	1622	2172	1952	2224	1998
GH-114	2663	2914	1753	3229	2640	2361	1794	2266
NIAB-112	2684	1569	1806	1808	1967	1746	1435	1694
NIA-80	2984	2869	2590	2612	2764	2460	2619	2486
JS-212	2670	2735	1687	2555	2412	2097	1587	2012
IUB-11	3326	2107	1993	1880	2327	2033	1623	1965
MPS-II	2711	2286	1820	2583	2350	2138	2359	2175
GS-378	2092	1390	1315	1277	1518	1483	1211	1437
GS-444	2007	1614	1421	1392	1609	1478	664	1342
BH-175	2752	1964	1620	1923	2065	1838	2234	1904
BH-176	3043	2511	2962	2770	2821	2458	2305	2432
FH-2015	2938	3138	1913	2339	2582	2266	1516	2141
CRIS-494	2788	2511	2006	2425	2432	2238	1794	2164
CRIS-510	3021	3183	2272	2612	2772	2442	1534	2291
MNH-786* CRIS-342**	2582	1892	1448	2124	2011	1762	1453	1711
CIM-608	3414	2511	2391	1851	2542	2158	2287	2179
CIM-591	3400	2376	1793	2024	2398	2139	2395	2181
VH-300	3873	2645	2683	2311	2878	2522	1892	2417
NIBGE-314	2957	1219	1793	2483	2113	1815	2628	1950
CD (5%)	602.13	547.07	802.31	518.12			488.96	
CD (1%)	804.37	730.81	1071.78	692.14			653.19	

Table 7. Comparison of CIM-608 for yield (kg ha-1) with other varieties of *G. hirsutum* included in Provincial Coordinated Cotton Trials.

Seed cotton Yield kg ha^{-1}																		
Code	Varieties	CRI, FSD	CRI, R.Y.K	NIAB FSD	CCRI, MUL	CRS, MUL	CRS, VEH	CRS, BWP	CRS, SWL	CRSS, R. wind	CRSS, SGD	ARS, Karor	PSC, KWL	ARS FSD	ARSK WL	ARS, BWP	CRS JHG	Avg.
V-5	VH-300	1812	2799	1411	3513	2811	2272	3061	1760	573	4629	1645	2510	640	1966	2940	2550	2306
V-3	SLH-334	2129	2402	1578	3808	2393	2392	2942	1835	645	3912	955	2151	596	1832	2367	2077	2126
V-9	RH-624	1819	2462	1363	3330	2436	1316	2703	1910	573	3586	1310	2391	1280	2209	2893	2170	2109
V-10	CIM-591	1366	2946	1901	4019	2122	1555	2488	2145	1542	3032	959	2272	1053	1565	2415	2049	2089
V-2	CIM-608	1479	2399	1602	3973	3099	2033	2583	1860	932	3260	1019	2510	870	1916	1769	2027	2083
V-6	NIAB-9811	1625	3007	1901	4032	2410	1555	2057	2180	609	2673	839	2151	1053	1611	2271	2149	2008
V-12	CIM-496	1809	2818	1889	2728	1704	1794	2727	2045	681	3032	719	2510	1282	1893	2391	1146	1948
V-8	NIAB-2009	1942	2276	1470	3068	2509	1635	2631	2015	860	3064	1137	1314	1097	1688	2558	1619	1930
V-1	BH-176	928	2721	1207	3571	2423	1076	2715	2065	1362	2738	957	2272	549	1747	2302	2049	1918
V-11	NIAB-112	1088	2857	1184	3321	2049	1435	1818	1795	932	2478	778	2631	1282	1521	2367	1547	1818
V-7	BH-175	886	2592	1172	3082	2135	1435	1913	1845	753	2152	1073	1675	870	1672	2391	2407	1753
V-4	NIAB-2010	1439	1672	1303	2274	1894	1196	2320	1645	860	3227	840	1793	618	1498	2725	1332	1665
	Average	1527	2579	1498	3393	2332	1641	2497	1925	860	3149	1019	2182	932	1760	2449	1927	853

The new variety was compared with a commercial variety MNH-786 as well as different other candidate varieties as checks under national coordinated varietal trials (NCVT) throughout Pakistan during 2010 to 2011 because two years studies are compulsory for the approval of any variety. Hanif *et al*. (2001) and Afzal *et al*. (2002) reported similar findings among varieties for seed cotton yield.

Provincial Coordinated Cotton Trials: During the 2011-12, CIM-608 was evaluated in PCCT Trials. The seed cotton yield data for year 2011-12 presented in Table-7 revealed that on average basis of 16 locations, CIM-608 produced seed cotton yield of 2083 kg ha^{-1} compared to the yield of 1948 kg ha^{-1} produced by CIM-496.

Ginning out turn and fibre characters: CIM-608 had 41.1% ginning out turn 29.7mm staple length and desirable micronaire value of 4.6 ug inch^{-1} (Table 8). CIM-496 had 93.5 tppsi fibre strength, 0.98 maturity ratio and 48.6% uniformity ratio. CIM-496 had 2208 counts lea strength product (CLSP) value at 50 counts and falling in A grade. Fiber quality of CIM-608 is better than that of approved varieties. Ali *et al*. (2008) reported that these traits are important for textile industry.

Yield related traits: Two years average data of plant characters viz, plant height (cm), number of monopodial and sympodial branches and boll weight (g) indicated that CIM-608 had 158 cm plant height, 2.6 and 27 monopodial and sympodial branches per plant, respectively. It produced 2.8g averaged boll weight (Table 9).

Entomological studies: Entomological studies on CIM-608 were conducted by the Entomology Section of Central Cotton Research Institute, Multan in "Host Plant Resistance Trial" to assess its tolerance level against jassid, whitefly, thrips

and bollworm damage as compared with the commercial variety CIM-496. Data on pest population under un-sprayed conditions presented in Table-10 indicated that CIM-608 showed better tolerance against sucking pests and was at par with CIM-496 against bollworm.

Table 8. Summary of salient characteristics of CIM-608.

Fiber Characteristics	Varieties/lines		
	CIM-608	MNH-786	CIM-554
Ginning out turn (%)	41.1	38.5	41.0
Staple length (mm)	28.5	27.5	28.1
Micronaire value (μg inch^{-1})	4.6	5.4	4.7
Fibre strength (tppsi)	93.9	102.5	101.0
Maturity ratio	1.03	1.02	1.04
Uniformity ratio (%)	84.4	81.7	81.6

Table 9. Plant characters of CIM-608 recorded during 2010-11.

Year	Trial	CIM-608	MNH-786	CIM-554
		Plant height (cms)		
2010-11	VT-2	175	128	169
2011-12	VT-1	140	-	167
Average		158	128	168.0
		No. of monopodial branches plant^{-1}.		
2010-11	VT-2	2.2	1.9	2.3
2011-12	VT-1	2.9	-	2.1
Average		2.6	1.9	2.2
		No. of sympodial branches plant^{-1}.		
2010-11	VT-2	29	17	33
2011-12	VT-1	25	-	32
Average		27	17	32
		Average boll weight (g).		
2010-11	VT-2	2.9	3.5	3.0
2011-12	VT-1	2.6	-	3.2

Table 10. Response of CIM-608 against sucking pests and bollworms at Central Cotton Research Institute, Multan during 2010-11.

Varieties	No. of insects/leaf			% bollworm damage	
	Jassid	Whitefly	Thrips	Spotted	Pink
CIM-608	1.62	3.19	0.40	13.78	5.05
CIM-496	1.63	2.76	0.41	13.40	4.30

Pathological studies: Twenty three strains of National Coordinated Varietal Trial were tested against stunting, boll rot and Cotton Leaf Curl Disease under field conditions during 2011-12. All the NCVT strains showed high susceptibility to cotton leaf curl disease. Maximum CLCuD severity was recorded in GS-444 and minimum in CIM-608. Maximum disease index was observed in GS-444 followed by JS-212. Maximum boll rot was recorded in BH-175 followed by FH-2015. Stunting disease was observed in traces (Table 11). Weiss (2000) reported that agricultural practices would be of no value unless these are accompanied by research into method of disease tolerance/resistance.

Agronomic studies

Fertilizer trial: The performance of CIM-608 was tested against CIM-591 and CIM-554 at four nitrogen levels i.e. 50, 100, 150 and 200 kg ha^{-1}. Data indicated that CIM-608 surpassed the other varieties in terms of yield performance at all levels of nitrogen. Maximum seed cotton yield of 2577 kg ha^{-1} was observed at the highest dose of 200 kg N ha^{-1} (Fig. 1). Nitrogen increases cotton plant growth, fastens number of bolls which ultimately leads increase in seed cotton yield (Saleem *et al*., 2010).

Table 11. Reaction of various strains to different cotton diseases.

NCVT	Disease incidence (%age)			*Severity	Φ Disease
Strain	Stunting	Boll Rot	CLCuD	(0-6)	Index (%age)
NIAB-9811	0.0	1.2	100	2.56	28.57
PB-38	0.0	2.0	100	3.17	41.28
NIAB-2010	0.3	1.6	100	2.92	34.35
SLH-334	0.0	1.6	100	2.11	18.88
NIAB-2009	0.0	0.7	100	3.22	42.41
GH-114	0.4	1.5	100	4.03	60.13
NIAB-112	1.0	1.5	100	2.89	34.47
NIA-80	0.0	2.5	100	3.72	53.17
JS-212	0.0	1.1	100	4.12	65.23
IUB-11	0.8	1.3	100	3.44	47.39
MPS-II	0.0	1.2	100	4.16	64.98
GS-378	0.2	1.8	100	4.08	63.62
GS-444	0.0	2.4	100	4.47	70.46
BH-175	0.0	3.3	100	2.75	32.88
BH-176	0.0	1.6	100	2.75	32.31
FH-2015	1.4	2.7	100	3.58	51.16
CRIS-494	0.0	1.4	100	3.78	56.13
CRIS-510	0.0	1.7	100	3.88	58.68
MNH-786	0.0	2.5	100	3.91	58.65
CIM-608	0.2	1.7	100	1.02	5.04
CIM-591	0.0	1.2	100	3.57	49.95
VH-300	0.6	0.7	100	2.59	29.23
NIBGE-314	0.4	1.4	100	3.17	40.64

*0 = Complete absence of symptoms, 1= Few small scattered vein thickening, 2 = Small scattered vein thickening, 3 = Vein thickening involving small groups of veins, 4 = Large groups of veins involved, 5 = All veins involved, 6 = All veins involved and severe curling. Φ= Disease incidence x Severity/ maximum severity value (6).

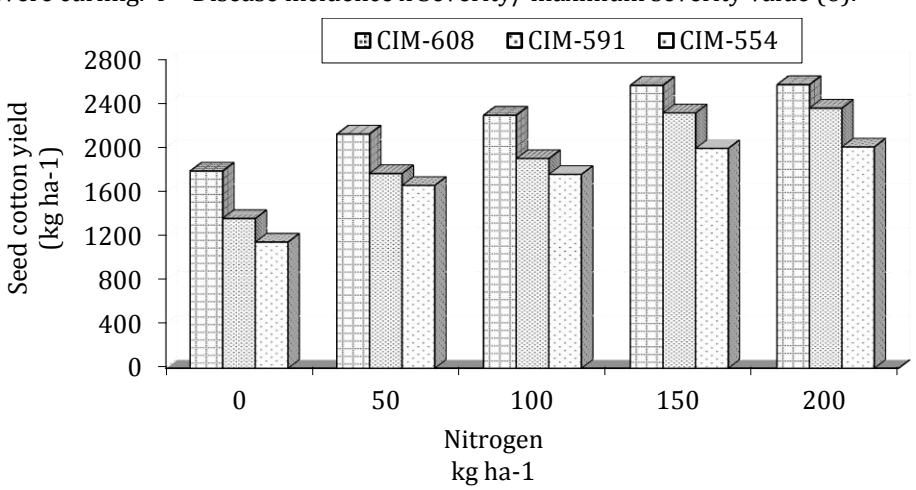

Figure 1. Yield performance of CIM-608 at different doses of nitrogen.

Sowing date trial: Data in Fig. 2 revealed that CIM-608 produced the better yield than CIM-554 at all sowing dates. The highest seed cotton yield of 2297 kg ha^{-1} was observed on April 15th sowing followed by the yield of 2160 kg ha^{-1} on May 1st sowing. The yield successively declined as the sowing was delayed from May 15th to June 15th. Delaney *et al*. (1999) reported similar results that seed cotton yield has been reduced significantly when cotton sown later than 30th May in Alabama, USA.

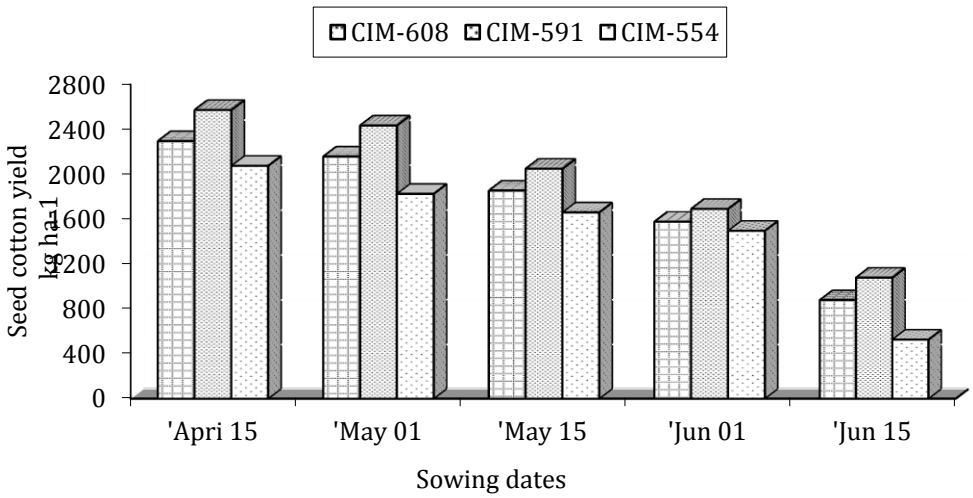

Figure 2. Yield performance of CIM-608 under different sowing dates.

Cross between *G. anomalum* and *G. hirsutum* were found resistant to CLCuV indicating the possibility of transferring Leaf Curl Virus resistant genes from *G. anomalum*. to *G. hirsutum* L. through hybridization and backcrossing. These findings further confirm the method of using autotetraploid to introgress desirable traits from diploid specie into tetraploid upland cotton and it is hoped that using conventional breeding methods, cotton breeders can set out resilient resistance against Cotton Leaf Curl Virus in elite genetic material.

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