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Full Length Research Article

Evolution of Cotton (*Gossypium hirsutum* L.) Variety *Bt*.CIM-598 Equipped with Wider Adaptability Traits, CLCuV Tolerant and Desirable Fibre Traits

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Abstract

The new variety *Bt*.CIM-598 has been developed through intra-specific hybridization between CIM-446 and IR-CIM-448 at Central Cotton Research Institute, (CCRI) Multan. This variety gave significantly higher yield in varietal trials compared with the commercial varieties. *Bt*.CIM-598 was also evaluated in Zonal Varietal Trials at farmers' fields and Government Farms. In these trials, *Bt*.CIM-598 gave 16.8% increase over commercial varieties IR-3701 for seed cotton yield. *Bt*.CIM-598 possesses higher ginning out turn percentage, better fibre qualities and spinning performance compared with all the existing commercial *Bt*. varieties. The entomological study showed the there in no boll worm damage through out the season and no bollworm larvae were found. This variety has also shown high tolerance to cotton leaf curl virus and sucking insect pests due to their profuse hairiness. The commercial cultivation of this virus tolerant and Genetically Modified (GM) cotton variety will significantly contribute to the overall cotton production.

Key Words: Bt. cotton, CIM-598, CLCuV tolerant, high yielding, *Gossypium hirsutum*.

Introduction

Cotton which is called as 6F (food, feed, fiber, fuel, fertilizer and forage) plant plays an imperative role in the economic system of Pakistan. It is the most significant cash crop, providing employment opportunity, raw material for industry and a source of foreign exchange. The development of new cotton varieties is one of most important factors for increasing cotton yield, early maturing with improved fibre characteristics, resistant/tolerant to pests, diseases and more suited to the local climatic conditions.

The research on cotton is mainly subjected to developing high yielding, early maturing varieties with better fibre characteristics, resistant to prevailing insect pests, diseases and most adapted to local agro-climatic conditions. A number of varieties have been released since long but with the passage of time varieties become susceptible to those diseases for which those varieties are evolved. So it is need of the day to evolve varieties which could face the problems of present scenario.

Singh *et al.*, (1973) reported that significant differences in raw cotton yield of upland cottons were due to varieties. Ahmad *et al.*, (1982) also obtained significant differences in yield of upland cotton due to varieties. Soomro *et al* (1986) reported significant differences in yield, ginning out turn and staple length for varieties. Khan *et al* (1989) also observed significant differences in yield, ginning out turn and staple length for varieties. Afzal *et al* (2001) studied that there were highly significant variations among year, genotypes (varieties) and year x 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 planting of various genotypes (varieties). Hanif *et al* (2001) also fond significant variations in seed cotton yield due to varieties.

The varieties have their role for increasing number of bolls per plant and lint percentage (Wang *et al*., 2004 and Khan *et al*., 1989) and seed cotton yield (Ali *et al*., 2005 and Rahman *et al*. 1993). Sezener *et al*. (2006) also found significant variation in seed cotton yield due to genotypes. Efforts have been directed towards producing high yielding and early maturing *Bt*. varieties without loss of quality fibre traits. The present research was conducted with the objective to develop a variety having resistance against bollworms along with desirable fiber traits. Fibre traits of all the prevailing Bt. varieties were not up to standard.

Materials and Methods

The new variety, *Bt*.CIM-598 has been developed through the hybridization of CIM-446 and IR-CIM-448 at Central Cotton Research Institute, Multan. The cross was attempted during 2001-02 and F_1 population was planted in glass house during the same cropping season. Pedigree selection procedure was used to sort desirable genotypes from segregating population. During 2005-06 in F_5, generation, lines with uniform morphology, fibre and seed characters were bulked

as *Bt*.CIM-598 (Fig. 1). *Bt*.CIM-598 passed through a series of yield trials viz

- Micro-Varietal Trial 2009-10
- Multi-Location Varietal Trials 2010-11
- Zonal Varietal Trials 2010-11
- National Coordinated Varietal Trials 2010-11 and 2011-12

The Cry1Ab/Ac Immuno Strip is used to quickly determine the presence or absence of the *Bt*-Cry1Ac proteins in segregating population. Kanamycin *Bt*. detection procedure is used for screening of *Bt* plant in field condition.

Results and Discussions

MICRO-VARIETAL / VARIETAL TRIALS

The new strain *Bt*.CIM-598 was tested in replicated Varietal Trials at Central Cotton Research Institute, Multan and its testing centers in comparison with the commercial varieties for two years. The data presented in Table-1 showed that *Bt*.CIM-598 gave significantly higher yield than the commercial varieties. Variety *Bt*.CIM-598 gave 72.7%, 18.0% and 32.7%, increase over CIM-496, Ali Akbar-802 and Neelum-121 respectively. The differences among the varieties for yield were statistically significant.

ZONAL VARIETAL TRIALS

Variety *Bt*.CIM-598 was tested in Zonal Varietal Trials at Government Farms as well as with the progressive growers in different ecological zones during 2010-2011. The data presented in Table-2 revealed that averaged cross locations, seed cotton yield of *Bt*.CIM-598 was 3309 kg ha^{-1} compared with 2833 kg ha^{-1} of IR-3701 during 2010-11.

REGIONAL ADAPTABILITY TRIALS

National Coordinated Varietal Trials

Bt.CIM-598 was included in National Coordinated Varietal Trials for two years i.e. 2010-11 and 2011-12. The yield data of Punjab, Sindh, are presented in Table-3. It is revealed from the data that during first year *Bt*.CIM-598 gave highest yield at CRS Bahawalpur and NIAB, Faisalabad during 2010-11.

During 2011-12 *Bt*.CIM-598 again out yielded the standard variety A.A.802 and IR-3701 in all the provinces. The data in Table-3 revealed that seed cotton production of *Bt*.CIM-598 in NCVT trial in 2011-12 out yielded (2998 kg ha^{-1}) all the twenty-five genotypes in Punjab and was at 2nd position in the overall Pakistan average.

Trials at Punjab Seed Corporation (PSC) Farm, Khanewal

YIELD PERFORMANCE IN 1-1/4 ACRE BLOCK AT PSC FARM

Bt.CIM-598 was evaluated in 1-1/4 acre block at PSC Farm Khanewal during 2010-11. The data presented in Table-4 revealed that *Bt*.CIM-598 gave the yield 24.23 maunds $acre^{-1}$.

GINNING OUT-TURN (%)

Varietal Trials

The data for ginning out turn (%) of *Bt*.CIM-598 given in Table-5 showed that on the basis of two-year average *Bt*.CIM-598 had 40.1% ginning out-turn compared with 43.0%, 38.6% and 41.0% of CIM-496, Ali Akbar-802 and Neelum-121 respectively.

Zonal Varietal Trials

The data of ginning out turn of Zonal Varietal Trials presented in Table-6 indicated that on the basis of average of 10 locations *Bt*.CIM-598 had 40.2% ginning out-turn compared with 40.9% of *Bt*.CIM-595 and 43.2% of IR-3701 during 2010-11.

STAPLE LENGTH

Varietal Trials

The data of staple length of Varietal Trials conducted during 2009-10 and 2010-11 presented in Table-7 indicated that *Bt*.CIM-598 had 28.3 (mm) staple length compared with 27.8, 28.1 and 26.5 (mm) of CIM-496, Ali Akbar-802 and Neelum-121 respectively.

Zonal Varietal Trials

Data of staple length at ten locations of Zonal Varietal Trial conducted during 2010-11 presented in Table-8 indicated that on the basis of average of ten locations *Bt*.CIM-598 had 28.2 mm staple length. Whereas, *Bt*.CIM-595 and IR-3701 had 29.0mm and 25.4 mm staple length respectively.

OTHER FIBRE CHARACTERISTICS

In addition to staple length, other fibre characteristics i.e. micronaire value, uniformity ratio, fibre strength as well as spinning values of *Bt*.CIM-598 were also determined from the composite samples of replicated varietal trials conducted at Central Cotton Research Institute, Multan and PSC Farm Khanewal. The details of these characteristics are given below.

Micronaire Value

The data of micronaire value presented in Table-9 showed that on the basis of an average of two years *Bt*.CIM-598 had micronaire value 4.2µg $inch^{-1}$ compared with 5.0 µg $inch^{-1}$ of CIM-496, 5.3 µg $inch^{-1}$ of AA-802 and 5.1µg $inch^{-1}$of Neelum-121.

Uniformity Ratio (%)

As seen from the data in Table-10 on an average of two years variety *Bt*.CIM-598 had 48.9% uniformity ratio compared with 47.7%, 48.4% and 48.2% of CIM-496, AA-802 and N-121 respectively.

Fibre Strength

A look at data presented in Table-11 show that on the basis of two years average, *Bt*.CIM-598 had 96.8 thousand pounds per square inch (tppsi) fibre strength compared with 92.0 tppsi of CIM-496, 101.9 tppsi of AA-802 and 104.8 tppsi of N-121.

Spinning Value

Spinning performance of *Bt.*CIM-598 is presented in Table-13 which indicates that this variety has the spin ability at 40 counts as it has A grade with 2210 CLSP value.

Plant Characters

The data of plant characters via, plant height, number of monopodial and sympodial branches, average boll weight and number of bolls per plant presented in Table-14 showed that on an average of two years, *Bt.*CIM-598 had 125cm plant height, 1.8 and 25.6 monopodial and sympodial branches per plant respectively. It possessed 2.9g average boll weight and 36.0 bolls plant^{-1}.

ENTOMOLOGICAL STUDIES

Entomological studies were conducted on NC*Bt* Trial by the Entomology Section of Central Cotton Research Institute, Multan to assess the tolerance level against jassid, whitefly, thrips and bollworm damage of different strains compared with commercial varieties IR-3701. Data on pest population shown in Table-15 indicated that the new variety *Bt.*CIM-598 has greater level of tolerance against bollworm as that of commercial varieties IR-3701.

AGRONOMIC STUDIES

Fertilizer trial

The yield performance of *Bt.*CIM-598 was tested under five nitrogen levels i.e. 50, 100, 150, 200 and 250 kg N.ha^{-1}. Data given in Fig. 2 indicated that *Bt.*CIM-598 gave 3860 kg ha^{-1} seed cotton yield with application of 200 kg Nha^{-1} while at 250 kg N.ha^{-1} produced 3900 kg ha^{-1} but it is non significant. The yield was lowest in case of 50 kg N/ha. (2340 kg ha^{-1}).

Sowing Date Trial

The data in Fig. 3 showed that variety *Bt.*CIM-598 gave the highest yield of seed cotton (4580 kg ha^{-1}) in the sowing of 1st April followed by 4310 kg ha^{-1} of sowing date April 15th. The yield successively declined in sowing done from 1st June and onward.

Hundreds of crosses attempted for this purpose has yielded a new variety *Bt.*CIM-598, which is early maturing and virus tolerant *Bt* variety which possesses higher yield potential, better Ginning-out turn and excellent fibre characteristics compared with the existing commercial varieties. It is capable of spinning on higher counts of yarn for producing quality fabrics. It is hoped that the approval and release of *Bt.* CIM-598 for commercial cultivation will significantly contribute to the overall cotton production as well as saving of foreign exchange through less export of pesticides.

Conclusion

The case of variety Bt.CIM-598 was presented in expert subcommittee of variety approval and the committee recommended the variety for approval to Punjab Seed Council, Punjab, Pakistan by keeping in view its performance in different trials and fibre traits. The variety got approval for general cultivation from Punjab seed council in 42nd meeting during 2012.

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Table-1: Yield performance of *Bt.*CIM-598 in Micro Varietal and Varietal Trials from 2010 to 2011.

Year	Trial	Location	Seed cotton yield (kg ha^{-1})				CD (5%)
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**	
2009-10	MVT-4	Multan	4085	2365	-	-	216.04
2010-11	VT-1	Multan	3393	-	2840	2648	144.72
		Khanewal	3052	-	2621	2209	
		Average	**3223**		**2731**	**2429**	**-**
Grand Average			**3654**	**2365**	**2731**	**2429**	**-**
Increase %age				**72.7**	**18.0**	**32.7**	**-**

Table-2: Two years average of seed cotton yield of *Bt.*CIM-598 in Zonal Varietal Trials during 2010-11

Sr. No.	Name of grower and location	Seed cotton yield (kg ha^{-1})		
		***Bt.*CIM-595**	***Bt.*CIM-598**	**IR-3701**
1	Haji Zulfiqar Ali Haroonabad	3256	3256	2846
2	Mr. Muhammad Saleem, Lodhran	3456	3359	2846
3	Ch. Ghohar Ali, Makhdum Rasheed	3158	3176	2804
4	Ch. Muhammad Hanif 108/7R, Sahiwal	3167	3592	2900
5	Ch. Muhammad Akbar 70/5L, Sahiwal	3086	2934	2831
6	Iftikhar Shah D. G. Khan	2999	3176	2855
7	Ch. Rehmat Ali, 88/10-R, KWL	3176	3159	2799
8	Haji Allah Ditta, Kukar Hatta	3089	3368	2843
9	Ch. Ramzan Ahmad, Hasilpur	2953	3579	2809
10	Ch. Zia-ur-Rehman, Liaquat Pur	3249	3495	2798
	Average	**3159**	**3309**	**2833**

Table-3: Yield performance of *Bt.*CIM-598 in National Coordinated Varietal Trials during 2010-11- and 2011-12

Location	Seed Cotton Yield (kg ha^{-1})	
	2010-11	**2011-12**
CCRI, Multan (Punjab)	2538	3564
NIAB, Faisalabad (Punjab)	3150	-
AARI, Faisalabad (Punjab)	1678	2070
CRS, Bahawalpur (Punjab)	3164	-
CRS, Vehari(Punjab)	1202	-
CRS Sahiwal	-	3215
PSC Khanewal	-	3228
CRS R Y Khan	-	2915
Punjab Average	**2346**	**2998**
CCRI Sakrand	2272	1435
NIA/ARI Tandojam	1256	714
CRS Mirpurkhas	-	135
CRS Ghotki	-	1515
Pakistan Average	**2180**	**2088**

Table-4: Yield performance of new strains in 1-1/4 acre block at PSC Farm during 2010-11

Sr. No.	Variety	Yield (mds acre^{-1})
1.	KZ-191	24.82
2.	SB-149	21.86
3.	4B-502	32.10
4.	4B-601	40.28
5.	FH-114	22.60
6.	FH-113	21.18
7.	NIAB-824	12.28
8.	*Bt.*CIM-595	19.08
9.	*Bt.*CIM-598	24.23
10.	CIM-599	21.16
11.	BZUM-A	19.05
12.	BZUM-C	18.13
13.	BZUM-D	14.70
14.	BZUM-H	17.29
15.	BZUM-J	22.31
16.	VH-259	15.54
17.	IR-901	19.11
18.	IR-902	21.14
19.	IUB-2009	36.26
20.	MNH-886	38.63
21	MNH-888	30.88
22	SITARA-008	25.34
23	*Bt*-121	29.44
24	*Bt*-131	30.44
25	*Bt*-141	30.00
26	SITARA-009	24.03
27	ASR-905	25.44
28	CEMB-2	11.58

Table-5 : Ginning out turn (%) of variety *Bt.*CIM-598 in varietal trials

Year	Trial	Location	Ginning out turn (%)			
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
2009-10	MVT-4	Multan	40.1	43.0		
2010-11	VT-1	Multan	40.2		38.8	41.3
		Khanewal	39.8		38.4	40.7
		Average	**40.0**		**38.6**	**41.0**
Grand Average			**40.1**	**43.0**	**38.6**	**41.0**

Table-6: Ginning out turn (%) of variety *Bt.*CIM-598 in Zonal Varietal Trial at farmers' fields

Sr. No.	Name of grower and location	Ginning out turn (%)		
		***Bt.*CIM-595**	***Bt.*CIM-598**	**IR-3701**
1	Haji Zulfiqar Ali Haroonabad	41.1	40.2	44.1
2	Mr. Muhammad Saleem, Lodhran	41.1	40.6	43.2
3	Ch. Ghohar Ali, Makhdum Rasheed	39.9	40.1	43.5
4	Ch. Muhammad Hanif 108/7R, Sahiwal	41.2	39.8	42.6
5	Ch. Muhammad Akbar 70/5L, Sahiwal	41.3	40.8	43.5
6	Iftikhar Shah D. G. Khan	41.2	39.8	42.8
7	Ch. Rehmat Ali, 88/10-R, KWL	40.6	40.1	44.2
8	Haji Allah Ditta, Kukar Hatta	41.0	40.0	43.7
9	Ch. Ramzan Ahmad, Hasilpur	40.2	39.9	42.6
10	Ch. Zia-ur-Rehman, Liaquat Pur	40.9	40.6	42.0
	Average	**40.9**	**40.2**	**43.2**

Table-7: Staple length (mm) of *Bt.*CIM-598 in Varietal Trials from 2009-10 to 2010-11

Year	Trial	Location	Staple Length (mm)			
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
2009-10	MVT-4	Multan	28.2	27.8		
2010-11	VT-1	Multan	28.0		27.9	25.9
		Khanewal	28.5		28.3	27.0
		Average	**28.3**		**28.1**	**26.5**
Grand Average			**28.3**	**27.8**	**28.1**	**26.5**

Table-8: Staple length (mm) of *Bt.*CIM-598 in Zonal Varietal Trial at farmers' Fields during 2010-2011

Sr. No.	Name of grower and location	Staple length (mm)		
		***Bt.* CIM-595**	***Bt.* CIM-598**	**IR-3701**
1	Haji Zulfiqar Ali Haroonabad	28.4	28.2	26.0
2	Mr. Muhammad Saleem, Lodhran	29.7	27.9	25.1
3	Ch. Ghohar Ali, Makhdum Rasheed	28.4	28.1	25.1
4	Ch. Muhammad Hanif 108/7R, Sahiwal	29.1	27.9	26.1
5	Ch. Muhammad Akbar 70/5L, Sahiwal	28.8	28.6	25.3
6	Iftikhar Shah D. G. Khan	29.1	28.1	25.4
7	Ch. Rehmat Ali, 88/10-R, KWL	28.6	28.1	25.0
8	Haji Allah Ditta, Kukar Hatta	29.1	27.9	25.0
9	Ch. Ramzan Ahmad, Hasilpur	28.6	28.4	26.0
10	Ch. Zia-ur-Rehman, Liaquat Pur	29.7	28.8	25.1
	Average	**29.0**	**28.2**	**25.4**

Table-9 Micronaire value of *Bt.*CIM-598 in varietal trials during 2009-10 to 2010-11

Year	Trial	Location	Micronaire value (μg inch^{-1})			
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
2009-10	MVT-4	Multan	4.2	5.0		
2010-11	VT-1	Multan	4.4		5.1	4.9
		Khanewal	4.0		5.4	5.2
		Average	**4.2**		**5.3**	**5.1**
Grand Average			**4.2**	**5.0**	**5.3**	**5.1**

Table-10: Uniformity ratio of *Bt.*CIM-598 in varietal trials from 2009-10 to 2010-11

Year	Name of Trial	Location	Uniformity ratio			
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
2009-10	MVT-4	Multan	48.8	47.7		
2010-11	VT-1	Multan	48.7		48.2	48.1
		Khanewal	49.0		48.6	48.3
		Average	**48.9**		**48.4**	**48.2**
Grand Average			**48.9**	**47.7**	**48.4**	**48.2**

Table-11: Fibre strength (tppsi) of *Bt.*CIM-598 in varietal trials from 2009-10 to 2010-11

Year	Trial	Location	Fibre strength (tppsi)			
			***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
2009-10	MVT-4	Multan	95.7	92.0		
2010-11	VT-1	Multan	100.4		103.5	106.2
		Khanewal	95.3		100.2	103.3
		Average	**97.9**		**101.9**	**104.8**
Grand Average			**96.8**	**92.0**	**101.9**	**104.8**

Table-13: Spinning test reports of *Bt.*CIM-598 for the years 2010-11

Varieties	Nominal Count	Actual Count	T.M.	Lea strength		CLSP	Grade
				Lbs	Kgs		
*Bt.*CIM-598	40.0	39.9	4.0	55.38	25.12	2210	A

Table-14: Plant characters of *Bt.*CIM-598 recorded during 2009-10 & 2010-11

Year	Trial	***Bt.*CIM-598**	**CIM-496**	**AA-802**	**N-121**
		Plant height (cms)			
2009-10	MVT-4	120	110		
2010-11	VT-1	130		170	110
Average		**125**	**110**	**170**	**110**
		No. of monopodial branches plant^{-1}.			
2009-10	MVT-4	1.6	1.0		
2010-11	VT-1	1.9		2.0	1.9
Average		**1.8**	**1.0**	**2.0**	**1.9**
		No. of sympodial branches plant^{-1}.			
2009-10	MVT-4	27.6	20.1		
2010-11	VT-1	23.5		16.5	15.0
Average		**25.6**	**20.1**	**16.5**	**15.0**
		Average Boll Weight			
2009-10	MVT-4	2.9	2.9		
2010-11	VT-1	2.9		2.8	3.1
Average		**2.9**	**2.9**	**2.8**	**3.1**
No. of bolls plant^{-1}					
2009-10	MVT-4	32.0	21.0		
2010-11	VT-1	40.0		28.0	24.0
Average		**36.0**	**21.0**	**28.0**	**24.0**

Table-15: Reaction of *Bt.*CIM-598 to sucking pests and bollworm damage at Central Cotton Research Institute, Multan during 2010-11

Varieties	No. of insects/leaf (Seasonal Mean)			Seasonal total of live larvae		% bollworm damage	
	Jassid	Whitefly	Thrips	Spotted	Pink	Spotted	Pink
*Bt.*CIM-598	0.4	2.6	1.2	0.0	0.0	0.0	0.0
IR-3701	0.2	1.2	0.5	0.4	0.2	0.1	0.3

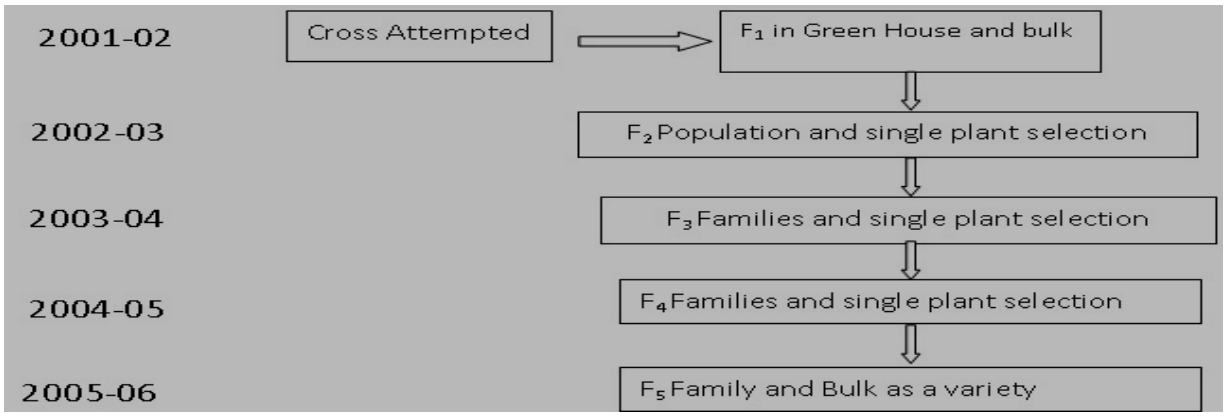

Fig. 1 Flow Diagram of development phases of *Bt.*CIM-598

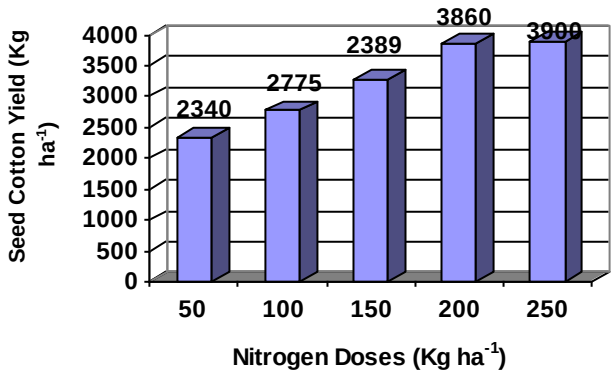

Fig. 2 Yield performance of *Bt.*CIM-598 under different doses of nitrogen

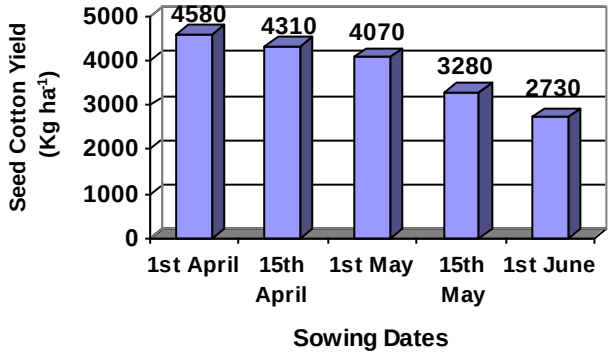

Fig. 3 Yield performance of *Bt*CIM-598 under different sowing dates