Comparative performance of various advance cotton strains as tested in 2014 - 2015 National Coordinated Varietal Trials (NCVT) of Pakistan Central Cotton Committee (PCCC)

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Abstract

Pakistan Central Cotton Committee (PCCC) has been delegated the authority, by National Seed Council, to conduct National Coordinated Varietal Trials (NCVT)on its behalf every year with the objective to screen high yielding and stress resistant advance strains of cotton meeting national fiber standards tested and trialed at all agro-ecological zones of the national cotton belt. During the crop year 2014-15, fifty-two (52) strains including 12 non-Bt, 40 Bt (38 OPVs and 2 Hybrids) were tested against standard commercial varieties at twelve locations throughout the cotton belt of Pakistan. Total thirty two (32) strains(10 non-Bt and 22 Bt) were developed by public sector breeders and twenty (20) strains (two non-Bt, sixteen Bt and two Bt hybrids) were submitted by private sector breeders for testing. These strains were divided into four sets. Set-A comprised of non-Bt strains, Set-B were of Bt strains from public sector breeders, Set-C Bt strains from private sector breeders and Set-D contained Bt hybrids. From non-Bt strains TH-120 was on top with the national average yield 2795kg per hectare. From public sector Bt Strains FH-Lalazar gave highest seed-cotton yield i.e. 3271kg per hectare. Top performing Bt strain fr om private sector was Crystal-1 with average national production of 2896kg per hectare. Hybrid Al-seemi H-Bt-209 produced 2778 kg per hectare seed cotton yield. All strain almost showed GOT% and other fiber characteristics higher than the recommended standards. Biochemical tests from four reference labs indicated that 49 transgenic lines contained Cry1ac gene (event MON-531)and expressed appropriate toxic protein levels (0.422-2.389ug/g of fresh leaves tested 80 days after planting.Three strains viz. CEMB-66 and CEMB-77 and CA-526 were found to contain two insect-resistant genes (Cry1Ac and Cry2A)that were developed by the Centre of Excellence for Molecular Biology.

Abbreviations:

ARI: Agriculture Research Institute
CCRI: Central Cotton Research Institute
CEMB: Centre of Excellence for Molecular Biology
CRI: Cotton Research Institute
CRS: Cotton Research Station
DAR: Directorate of Agricultural Research
ELISA: Enzyme linked Immunosorbent Assay
HVI: High Volume Instrument
KPK: Khyber Pakhtunkhwah
NCVT: National Coordinated Varietal Trials
NIAB: Nuclear Institute of Agriculture and Biotechnology
NIBGE: National Institute for Biotechnology and Genetic Engineering
NSC: National Seed Council
PCCC: Pakistan Central Cotton Committee
PCR: Polymerase Chain Reaction
PSC: Punjab Seed Corporation

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Introduction

Pakistan is the key player of cotton cultivation, production and processing in the world. Cotton is as a leader fiber, oil and cash crop for resource poor farming community of the Pakistan as well as world (Malik et al 2016; Soomro et al. 2011). The sufficient production of cotton for meeting the fiber requirements of the exploding population of the world is the need of the time so the importance of improving cotton production for cotton growers, textile industry and other members of cotton value chain in Pakistan can hardly be overstated (Channa et al, 2016). Cotton has a pivotal role in the economy of the Pakistan so has a prime position as a cash crop. Many public and private sector institutes are working on cotton research and development throughout the cotton belt of Pakistan. Due to some certain constraints like drought and heat (Raza, 2009), flood, disease attack especially CLCuD, management practices and other problem Pakistan continue to produce per acre yield below than the world average.

It is the matter of great appreciation that the production of cotton is steadily been improved from 3.9 million bales during 1947-48 to 14.95 million bales during 2014-15 based upon several factors including development of high yielding varieties, control of insect pest attack, induction of Bt cotton, improvement in cotton production technologies, etc.

Pakistan Central Cotton Committee (PCCC) of Ministry of Textile Industry, Government of Pakistan is the apex national organization with official mandate of cotton research and development in the country. This research system also has mandate of conducting National coordinated varietal trials (NCVT) on behalf of National Seed Council (NSC). Departmental R&D and testing activities are conducted through the Directorate of Agricultural Research (DAR) of PCCC which serves as National Coordinating Unit of PCCC.

The National Cotton Varietal Trial (NCVT) is a technically and legally sanctioned uniform system of trialing and testing and reporting data regarding yield and other plant and fiber traits of new strains developed by the public and private sector breeders. The trials are conducted annually on selected official locations across the cotton belt of Pakistan. The objective of this trial was to test the newly developed strains by the public and private sector breeders in different agro-ecological zones for adoptability and comparison against standard commercial varieties.

Materials and Methods:

Planting Material:

Overall fifty-two (52) advance strains were submitted by the public and private sector breeders for 2014-15 NCVT as mentioned in Table-1 to Table-5. These strains were divided into four groups viz. Set-A comprised non-Bt strains, Set-B comprised Bt strains from public sector breeders, Set-C Bt strains from private sector breeders and Set-D comprised Hybrid Btstrains. In each set performance of the strains compared with the local adaptive control that already cultivated in the region. The originality of the strains was masked by coding these strains.

Table 1: Public Sector non-Bt strains tested in NCVT during 2014-15.

Sr.	Strain	Breeder/Institute	Sr.	Strain	Breeder/Institute
1	CRIS-533	CCRI Sakrand	6	NIAB-414	NIAB Faisalabad
2	TH-112/05	ARI Tandojam	7	DNH-40	CRS D.I. Khan
3	BH-177	CRS Bahawalpur	8	TH-120	ARI Tandojam
4	MPS-27	CRS MirpurKhas	9	IUB-75	Islamia Uni. Bahawalpur
5	CRIS-585	CCRI Sakrand	10	CIM-620	CCRI Multan

Table 2: Private Sector non-Bt strains tested in NCVT during 2014-15.

Sr.	Strain	Breeder/Institute	Sr.	Strain	Breeder/Institute
1	AA-132	Ali Akbar Seeds Multan	2	GS-433	Gohar Seeds Multan

Table 3: Public Sector Bt strains tested in NCVT during 2014-15.

Sr.	Strain	Breeder/Institute	Sr.	Strain	Breeder/Institute
1	IUB-13	Islamia Uni. Bahawalpur	12	CEMB-77	CEMB Lahore
2	IR-NIBGE-6	NIBGE Faisalabad	13	IR-NIBGE-7	NIBGE Faisalabad
3	FH-Lalazar	CRI Faisalabad	14	Cyto-178	CCRI Multan
4	Cyto-177	CCRI Multan	15	BH-185	CRS Bahawalpur
5	VH-305	CRS Vehari	16	FH-Noor	CRI Faisalabad
6	SLH-8	CRS Sahiwal	17	VH-327	CRS Vehari
7	BH-184	CRS Bahawalpur	18	NIAB-874B	NIAB Faisalabad
8	MNH-988	CRS Multan	19	Baghdadi	CRS Ghotki
9	CIM-616	CCRI Multan	20	RH-647	CRI Rahim Yar Khan
10	CEMB-66	CEMB Lahore	21	TH-21/09	ARI Tandojam
11	CIM-622	CCRI Multan	22	IUB-63	Islamia Uni. Bahawalpur

Table 4: Private Sector Bt strains tested in NCVT during 2014-15.

Sr.	Strains	Breeder/Institute	Sr.	Strains	Breeder/Institute
1	Sahara-120	Patron Seed corporation, Multan	9	JS-733	Jullundar Seeds Pvt. Ltd.
2	Leader-3	Suncrop Pvt. Ltd.	10	BS-70	Bundesha Seeds
3	Eagle-1	Four Brothers Group	11	Crystal-1	Waraich Seed Corp. Khanewal
4	Tarzen-4	Four Brothers Group	12	Tuhafuz-3	SungroPvt Ltd
5	AGC-999	Weal Ag. Corporation, Multan	13	Sahara-150	Patron Seed corporation, Multan
6	Sitara-13	Agri Farm Services, Multan	14	AGC-Nazeer-1	Weal Ag. Corporation, Multan
7	CA-926	Ali Akbar Seeeds, Multan	15	Sitara-14	Agri Farm Services, Multan
8	Leader-5	Suncrop Pvt. Ltd.	16	Auriga-215	Auriga Group of comp.

Table 5: Bt hybrids tested in NCVT during 2014-15.

Sr.	Strains	Breeder/Institute	Sr.	Strains	Breeder/Institute
1	Alseemi H. Bt. 209	Alseemi Seeds Multan	2	Bt. Hybrid-53	Four Brothers Group Multan

Sowing of the Material

Set-A: Non-Bt Strains National Coordinated Varietal Trial was conducted at 13 locationsin Punjab, Sindh, Khyber Pakhtunkhwah and Balochistan. At each location twelve strains from public and private sector breeders were tested against a standard variety (CIM-573 for Punjab and KPK and CRIS-342 for Sindh and Balochistan. Five locations were selected in Punjab (CCRI-Multan, CRS Vehari, CRS-Bahawalpur, CRS-Multanand CRS-Sahiwal), three in Sindh (CCRI-Sakrand, CRS-MirpurKhas and NIA-Tandojam), one in KPK (D.I. Khan) and four in Balochistan (Khuzdar, Loralai, Uthal and Kharan). Entries were coded as A1 – A13.

Set-B: Twenty two Bt Strains from Public Sector Breeders were submitted to conduct National Coordinated Varietal Trial at twelve different locations of cotton growing belt of the country (five locations in Punjab *viz.* CCRI-Multan, CRS-Vehari, CRS-Bahawalpur, CRS-Sahiwal and NIAB-Faisalabad, Four Locations in Sindh viz. CCRI-Sakrand, CRS-MirpurKhas, CRS-Ghotki and NIIA-Tandojam, one location in KPK *viz.* D.I. Khan and two locations in Balochistan *viz.* CRS-Sibbi and ARI-Sariab, Khuzdar). Twenty two candidate
strains of public sector breeders and two standards (CIM-602 and FH-142) were tested for yield and other parameters. The entries were coded as B1 – B24

Set-C: Sixteen candidate strains were submitted by the private sector breeders for possible evaluation in NCVT. National Coordinated Varietal Trial was conducted on twelve locations, five in Punjab (CCRI-Multan, CRS-Sahiwal, PSC Farm Khanewal, CRI-Rahimyar Khan, CRI-Faisalabad), four in Sindh (CCRI-Sakrand, CRS-MirpurKhas, CRS-Ghotki and ARI-Tandojam, one in KPK (D.I. Khan) and two in Balochistan (CRS-Sibbi and ARI-Sariab, Khuzdar). At each location sixteen Bt strains of private sector Breeders were tested against two standards varieties viz. CIM-602 and FH-142. The entries were coded as C1 – C18.

Set-D: For the evaluation of the two Bt Hybrids the National Coordinated Varietal Trial was conducted on eleven locations, seven in Punjab (CCRI-Multan, PSC Farm Khanewal, CRS-Multan, CRI-Rahimyar Khan, NIAB-Faisalabad, NIBGE-Faisalabad and CRI-Faisalabad), two in

Sindh (CCRI-Sakrand and ARI-Tandojam), one in KPK (D.I. Khan) and one in Balochistan (CRS-Sibbi).

Figure 7: Locations of NCVT 2014-15 across the country

Bt Hybrids performance was compared with the two standard varieties viz. CIM-602 and FH-142. The entries were coded as D1 – D4.

All strains along with standard varieties were sown set wise in four replications according to RCBD in a four 30 feet extended rows with plant to plant distance 30cm and row to row distance was 75cm. All agronomic practices were uniformly done in all strains. Yield of this plot was multiplied by the factor (360) to obtain the yield as kg per hectare.

Fiber Trait Analysis

Lint samples of all strains were also tested for GOT (%), staple length (mm), fiber fineness (µg/inch), fiber strength (tppsi or g/tex) and uniformity index (%). The samples were analyzed through HVI (High Volume Instrument) from each station and the data was averaged on national basis.

Bio-Chemical Testing of Transgene

Biochemical testing of transgenic strains was done in four biotechnology labs of *viz*.Agriculture Biotechnology Research Institute (ABRI) Faisalabad, National Institute for Biotechnology and Genetic Engineering (NIBGE) Faisalabad, Center of Excellence of Molecular Biology (CEMB) Lahore and National Institute for Genomics and Advanced Biotechnology (NIGAB, NARC) Islamabad. All strains were tested qualitatively and quantitatively. Purity of Cry1Ac and Cry2AB was tested through immune-strip analysis. Quantification of Cry1Ac protein was done through ELISA test. Confirmation of Cry1Ac event (Mon531) was also done through PCR.

Results and Discussion
Yield Performance:
Non-Bt Strain Trial (Set-A)

In Sindh Province,CRIS-533 and TH-120 were the leading strains among all with the average production of3432kg ha^{-1}(7% higher than the standard CRIS-342 (3214kg ha^{-1})) and 3388kg ha^{-1}(5% higher than the standard CRIS-342) respectively (Figure-1A). In Punjab, the maximum yield was obtained from TH-120 that produced 2633kg ha^{-1}(35% higher than the

standard CIM-573(1955kg ha^{-1})and CIM-602that produced 2608kg ha^{-1}(33% higher than the standard CIM-573)

. In KPK, CIM-620 and TH-120 ranked top among all strains with the average production 1916kg ha^{-1}(38% higher than the standard CIM-573 1391kg ha^{-1}) and 1736kg ha^{-1}(25% higher than the standard CIM-573) respectively. In Balochistan AA-132(2960kg ha^{-1}) and TH-112/05 (2929kg ha^{-1}) produced maximum yield and remained 12% and 11% higher than the standard CRIS-342 respectively that produced 2651kg ha^{-1}. The figure-1Aalso depicted that all strains produced maximum yield in Sindh followed by the Balochistan, Punjab and KPK.

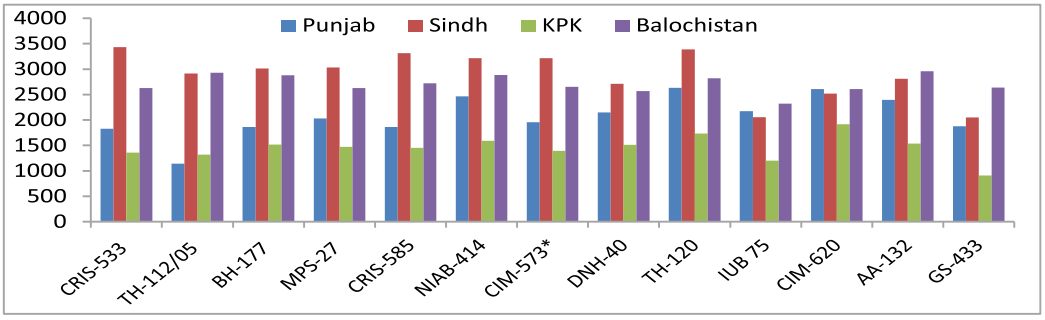

Figure 8A: Performance of Set-A strains in National Coordinated Varietal Trial 2014 -15 in four Provinces.

On National Level TH-120 was leading with the average production 2795kg ha^{-1}(16% higher than the standards) followed by NIAB-414 with the average production 2700kg ha^{-1}(12% higher than the standard) (Figure-2A). The standards (CIM-602 and CRIS-342) gave 2416kg ha^{-1}seed-cotton yield. Five strains produced yield higher than the standard but seven strains remained low than the standards. The lowest yield was obtained from GS-433 i.e.2076kg ha^{-1}.

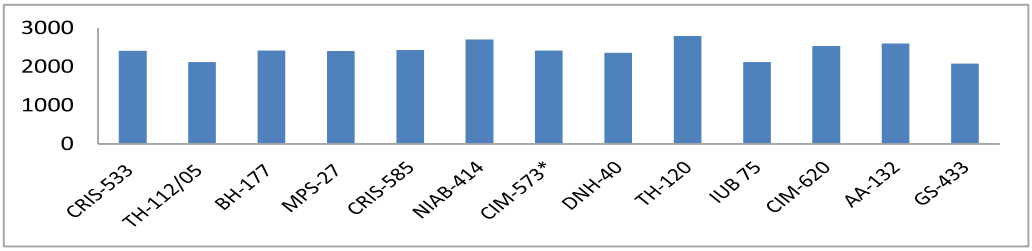

Figure 9A: Performance of Strains in NCVT 2014-15 on National Level.

Among the provinces, Sindh was a leading among all with 2897 kg ha^{-1}average seed cotton yield followed by Balochistan (2710kg ha^{-1}), Punjab (2075kg ha^{-1}) and KPK (1455kg ha^{-1}). Punjab and KPK average was lower than the national average (2413kg ha^{-1}) figure-3A. It showed that climatic conditions were in favor of cotton production in Sindh and Balochistan as compared to Punjab and KPK.In Balochistan only IUB-75 remained lower than the national average and in Sindh IUB-75 and GS-433 remained lower than the national average but in KPK no strain crossed the national yield average (Figure-1A). In Punjab only three strains viz. NIAB-414, TH-120 and CIM-620 passed the national average (2413kg ha^{-1}). In Punjab yield might be lower due to CLCuVD.

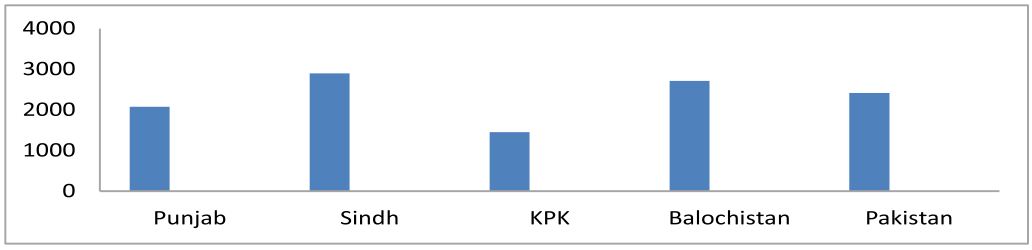

Figure 10A: Average performance of Set-A on Province and National Level.

Public Sector Bt. Strain Trial (Set-B)

Province wise performance of different strains was demonstrated in figure-2B. In Punjab maximum yield was obtained from Baghdadi i.e. 3538kg ha^{-1}(47% higher than the standards-1 (2412kg ha^{-1}) and 16% higher than the standard-2 (3058kg ha^{-1}) followed by the FH-Lalazar i.e. 3500kg ha^{-1}(45% higher than the standards-1 CIM-602 and 14% higher than the standard-2, FH-142). In Sindh FH-Lalazar topped with the average production3579kg ha^{-1}(14% higher than the standard-1 (3135kg ha^{-1}) and 4% higher than the standard-2 (3441kg ha^{-1}). All other strains remained below than the standard-2. Baghdadai ranked third by producing 3357kg ha^{-1}seed cotton yield (9% higher than the standard-1 but 2% lower than the standard-2). In KPK province Bt. strain Baghdadi produced highest seed cotton yield i.e. 2942kg ha^{-1}(15% and 22% higher than the standatd-1 and standard-2 respectively). It was followed by the FH-Lalazar and CEMB-77 with average production 2915kg ha^{-1}and 2816kg ha^{-1}respectively. The production of Standard-1 (CIM-602) was 2548kg ha^{-1}and standard-2 (FH-142) was 2413kg ha^{-1}and remained on 9th and 17th position respectively (Figure-1B). In Balochistan highest seed-cotton yield was obtained from RH-647 i.e. 2703kg ha^{-1}(18% and 11% higher than the standard-1, CIM-602 (2289kg ha^{-1}) and standard-2, FH-142 (2433kg ha^{-1}) respectively). VH-327 was ranked 2nd by producing 2576kg ha^{-1}which is 13% higher than the standard-1 and 6% higher than the standard-2. Standard-1 (CIM-602) was on 15thposition (2289kg ha^{-1}) while standard-2 was on 4th position (2433kg ha^{-1}).

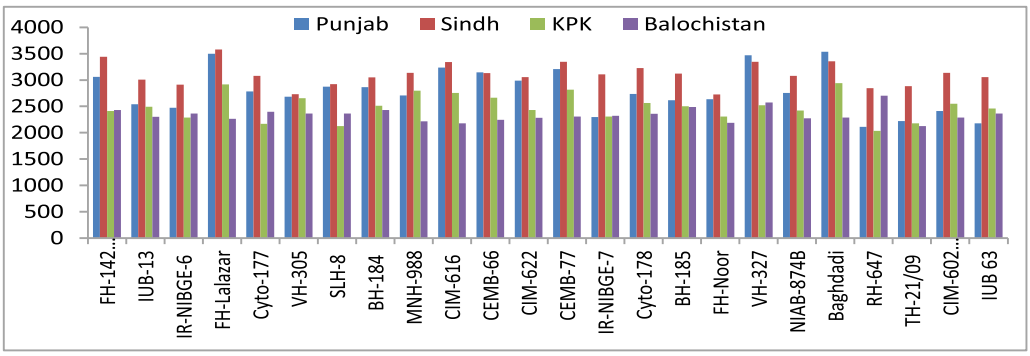

Figure 1B: Performance of Set-B strains in NCVT 2014-15 in four Provinces.

On National Level (Figure-2B) FH-Lalazar gave the highest seed-cotton yield of 3271kg ha^{-1}which was 24% higher than the standard-1 (CIM-602, 2644kg ha^{-1}) and 8% higher than the standard-2 (FH-142, 3028kg ha^{-1}). Baghdadi VH-327 ranked 2nd and 3rd with the average production 3220kg ha^{-1}and 3201kg ha^{-1}respectively. However, on an average basis among all the candidate varieties Baghdadi in Punjab and K P K, FH-Lalazar in Sindh and RH-647 in Balochistan (Figure-1B) super passed all other varieties.

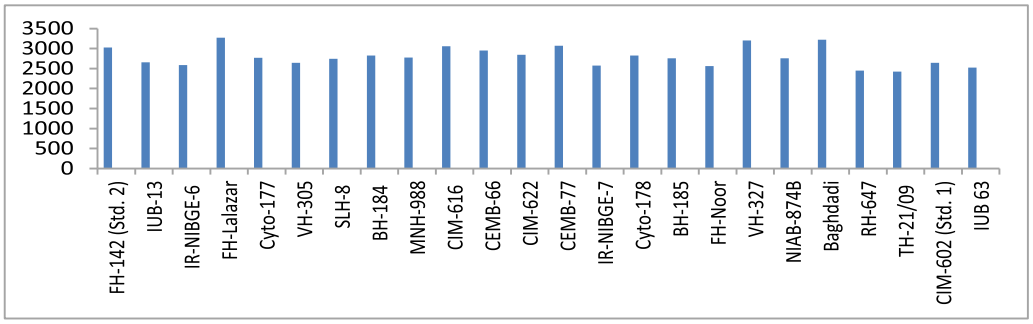

Figure 2B: Performance of Strains in NCVT 2014-15 Set-B on National Level.

All strains performed better in Sindh and Punjab as compared to KPK and Balochistan. Highest seed-cotton yield was obtained from Sindh i.e. 3109 kg ha^{-1}followed by the Punjab 2793 kg ha^{-1}but in KPK yield was 2493 kg $ha^{-1}$and in Balochistan 2338 kg ha^{-1}which was lower than the national average yield i.e. 2683 kg ha^{-1}(Figure-3B).

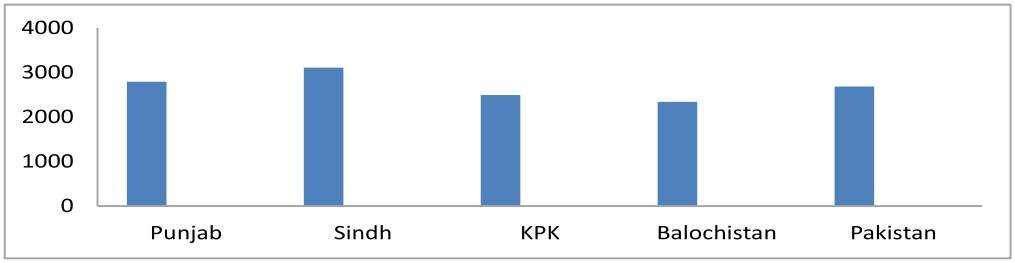

Figure 3B: Average performance of Set-B on Province and National Level.

Private Sector Bt. Strain Trial (Set-C)

In Punjab highest seed cotton yield was obtained from Crystal-1 i.e. 3242kg ha^{-1}followed by the standard-2 FH-142 (3103kg ha^{-1}) which was 10% and 5% higher than the standard-1 CIM-602 that produced 2912kg ha^{-1}. All other strains gave lower yield than standard-2. In Sindh none of the strain gave higher yield than the standard-2 (2927 kg ha^{-1}). Crystal-1, SAHARA-120 and Eagle-1 were on 2nd, 3rd and 4th position by producing 2925 $kgha^{-1}$, 2811 $kgha^{-1}$ and 2752 $kgha^{-1}$seed-cotton yield respectively.Crystal-1 showed 22%, SAHARA-120 showed 18% and Eagle-1 showed 15% higher seed cotton yield than standard-1 (CIM-602, 2389 $kgha^{-1}$). However, the difference in yield between Crystal-1 (2925 $kgha^{-1}$) and Standard-2 (2927 $kgha^{-1}$) was negligible. In KPK Crystal-1 gave the maximum yield of 2916 $kgha^{-1}$(44% and 54% higher yield than standard-1 & 2 respectively) followed by AGC-999 which produced 2719 $kgha^{-1}$. Leader-5 was ranked 3rd by producing2333kg ha^{-1}which is 15% higher than standard-1 and 23% higher than Standard-2. Standard-1 (CIM-602) gave 2028 $kgha^{-1}$and was on 12th position. In Balochistan, strain Tahafuz-3 gave the highest yield of 2411 $kgha^{-1}$(25% and 21% higher yield than standard-1 & 2 respectively) followed by SAHARA-120 (2373 $kgha^{-1}$) and Eagle-1 (2252 $kgha^{-1}$). SAHARA-120 produced 23% and 19% higher yield than standard-1 & 2 respectively whereas, Eagle-1 gave 17% and 13% higher yield than standard-1 & 2 respectively. Over all strains perform much better in Punjab and Sindh as compared to KPK and Balochistan.

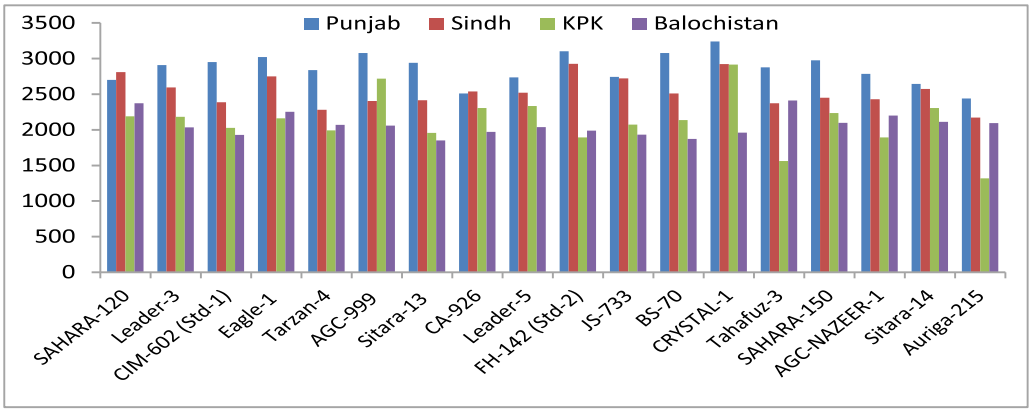

Figure 1C: Performance of Set-C strains in NCVT 2014-15 in four Provinces.

On National basis Crystal-1 produced highest seed-cotton yield i.e. 2896 kgha^{-1}(15% and 5% higher than the standard-1 (CIM-602)and standard-2(FH-142)respectively). All other strains remained lower than the standard-2 (FH-142) which produced 2758kgha^{-1}(10% higher than standard-1). However, on an average basis, Crystal-1 gave highest yield in Punjab, Sindh and KPK, whereas in Balochistan Tahafuz-3 gave the maximum yield among all the candidate strains.

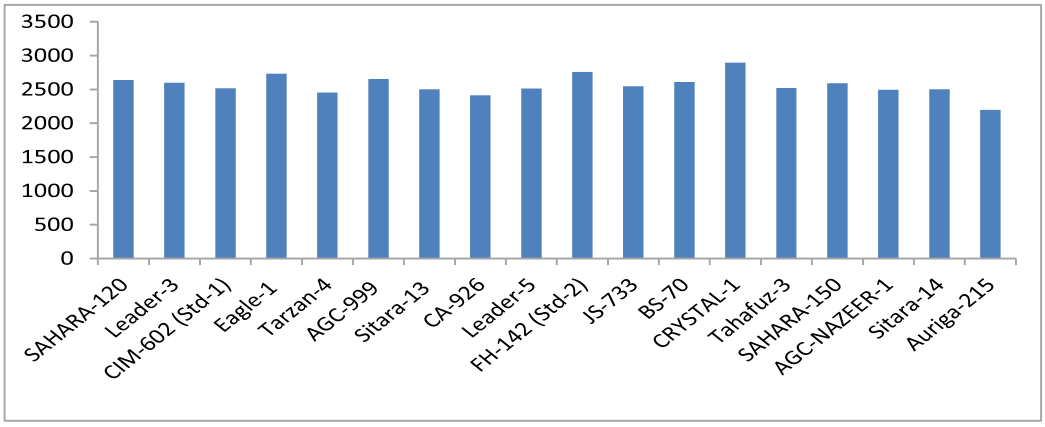

Figure 2C: Performance of Strains in NCVT 2014-15 Set-C on National Level.

If we made comparison of provincial seed cotton yield with the National seed cotton yield in Set-C only in Punjab yield was higher than the national seed-cotton yield average i.e.2564kg ha^{-1}. Punjab average seed-cotton yield was 2866kg ha^{-1}followed by the Sindh 2544kg ha^{-1}, KPK 2122kg ha^{-1}and Balochistan 2069kg ha^{-1}.

Figure-3C: Average performance of Set-C on Province and National Level.

Hybrid Bt. Strain Trial (Set-D)

In Punjab candidate Bt. Hybrid Alseemi HBt-209 produced 3175kg ha^{-1}yield which was 20% and 9% higher than standard-1 (CIM-602) and standard-2 (FH-142) respectively. But Bt Hybrid-53 failed to produce higher yield than the Standards. In Sindh, Bt. hybrid-53 produced maximum yield of 2559kg ha^{-1}which was higher than standard-1 (2440kg ha^{-1}) by 5%.However, there was no difference in yield between the candidate Hybrid and Standard-2 which produced 2552kg ha^{-1}. Alseemi H. Bt. 209 was on 4thposition and produced 3% and 8% lower yield than standard-1 and 2 respectively. In KPK Bt. hybrid-53 and Alseemi H. Bt. 209 produced 1770 and 1619kg ha^{-1}seed cotton yield and was on 2nd and 3rd positions respectively. Standard-2 (FH-142) was on 1st position.Bt hybrid-53 produced 11% higher yield than standard-1 whereas 1% lower than standard-2.Standard-2 (FH-142) produced 1789 kgha^{-1}and 12% higher than standard-1.

In Punjab the yield of hybrids as well as standards was higher than the other provinces. In Balochistan, Bt. hybrid-53 and Alseemi H. Bt.209 produced 2054 and 2000kg ha^{-1}and was on 2ndand 3rdpositions respectively. Standard-1 (CIM-602) was on 1stposition.Bt. hybrid-53 produced 3% higher yield than standard-2 and 3 % lower than standard-1 which produced 2108kg ha^{-1}.Standard-2 produced 2000kg ha^{-1}. However, yield differences in all the varieties were non-significant.

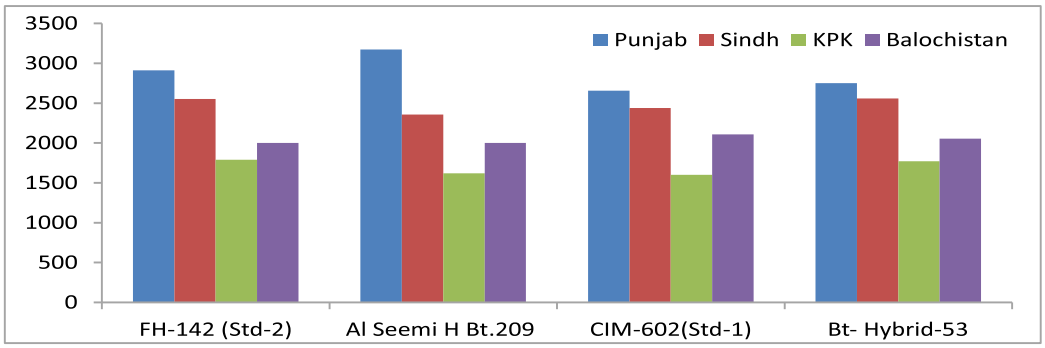

Figure 1D: Performance of Set-D strains in NCVT 2014-15 in four Provinces.

Figure 2D showed that on an average of national basis, (Punjab, Sindh, Khyber Pakhtunkhwah and Balochistan), Alseemi H. Bt.209 produced the highest yield of2778 kg ha^{-1}which was 12% higher than standard-1 (2471kg ha^{-1}) and 4% higher than standard-2 (2662kg ha^{-1}). But Bt. Hybrid-53 failed to produce higher yield than the standards.