



## Original article

## New promising high yielding cotton Bt-Variety RH-647 adapted for specific agro-climatic zone

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## ABSTRACT

The Bt-cotton RH-647 was developed by Cotton Research Institute CRI, Khanpur has been acknowledged for its possesses superior plant characteristics and potential to yield out under harsh agro-climatic conditions of cotton productive district of Rahimyar Khan in Bahawalpur Division and southern Punjab in 2016. RH-647 for its novel plant structure and improved fiber quality heat and drought tolerant to withstand successfully sustain yield out in harsh, highly variable hot and dry climatic conditions of and harsh seasoned. RH-647 was developed through one-way hybridization of elite parental genotypes accompanied by pedigree selection method through gene pyramiding technique for incorporation of excellent combinations of fiber traits and CLCuV disease tolerance with higher yield potential right from F1 population. The superior plant combinations were selected in F2-F6 generations were entirely based on phenotypic plant traits and progeny yield potential in field, plant shape, number of bolls per plant, average boll weight (g) and fiber quality traits over standard varieties. The single plant progenies were selected 56 sister lines were tested for Bt-gene (Cry1 Ac) were evaluated for high yielding performance for this superior cross and finally RH-647 as superior breeding line was bulked in year 2010. The strain was evaluated in Randomized Complete Block Design in preliminary yield trials (PYT) and two years in Advance Yield Trials (AYT) trials and Zonal Varietal trials for two years. The superior line 647/10 was ensued for performance in variety attestation tests as RH-647. RH-647 performed best in two years varietal trials (NCVT and PCCT and DUS) conducted for two successive growing seasons (2014–2015 and 2015–2016). RH-647 yielded out significantly compared with standard varieties MNH-886, FH-142 and CIM 602. After completion of mandatory trials in year 2016, RH-647 was approved as new Bt. cotton variety "RH-647". RH-647 is early in maturity with high yield potential and best suited for wheat-cotton cropping pattern. It has fluffy opening and is easy to pick, strongly tolerant to CLCuV disease, high Ginning out turn GOT% (40.2%) with improved fiber traits; staple length (28.3 mm), fiber strength (4.2ug/inch) is duly capable to fulfill all industrial requisitions.

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## 1. Introduction

Agriculture is the backbone of Pakistan's economy which is important sector of Pakistan economy (Azam and Shafique, 2017). It endows the 45% of total labor employment, poverty reduction and extended cash flow chain from growers to consumers. It is the agriculture sector responsible for providing the

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necessary raw material to industrial sector in Pakistan (Anonymous, 2015). Agriculture accounts for 2.1% contribution in Gross Domestic Production (GDP) in national economic growth and a substantial source of 60% of foreign exchange earnings of country (Anonymous, 2015). The cultivated upland cotton called *Gossypium hirsutum* L. accounts 70% of for major world cotton production. Cotton, being the major cash crop is the mainstay of Pakistan's economy and predominantly governs our agriculture-based socio-economic activity through a cash flow chain in 63% of entire population directly or indirectly employed in agriculture business, as millions of farmers, labor, domestic textile, ginneries, oil spinning and feed units that are highly dependent on cotton farming for their livelihood (Anonymous, 2015) (RAZZAQ et al., 2021). The cotton breeders are continuously putting efforts to identify several morphological, physiological and quantitative yield components and plant such as plant height, plant shape, fruiting type, Boll shape, Days to 1st square, Days to 1st flower, bolls/plant, Boll weight, Sympodia and Monopodia branches/plant, that directly and indirectly contribute to improve seed cotton yield/unit area (Sharma et al., 2021) (Ballester et al., 2021) (Kumar et al., 2000) (RAZZAQ et al., 2021). The excellent combinations of desirable quantitative and qualitative plant characteristics selected through pedigree selection and gene pyramiding techniques of Plant Breeding and Genetics for evolution of new improved cotton varieties to enhance produce/unit area is the prime objective of the Cotton breeders (Zamir, 2001). Hence, being the major cash crop in Pakistan, breeding cotton plant has been the continuous objective of agricultural scientists for development of improved cotton varieties with sustainable production of seed cotton for domestic and export industry.

During couple of years, the productive cotton growing belt of southern Punjab is agro-climatic zone is facing most highly abrupt climate hazards of severe temperature regime from 45 °C to 51 °C an average precipitation of 3.5 per annum and Relative Humidity (%) 40–78% during cotton season not even suitable for normal fertilization and causes shedding of potential flowers bolls sett. To overcome this challenge different irrigation systems to increase the water use efficiency are being used for cotton crop (Ali et al., 2020). Not only this there is need to evolve highly tolerant and strongly adaptive varieties that withstand with adverse climate condition such as high temperature, drought, tolerant to CLCuV, thrive best under water scarcity conditions is a dire need for sustainable production of seed cotton in agro-climatic zone of Bahawalpur Division. RH-647 is a highly tolerant to adverse climatic conditions evaluated for sustainable high yield potential under due attestation NCVT trials and PCCT and DUS trials in Pakistan during 2014–2016 is on the way of commercialization and recommended for cultivation in cotton zone of District Rahim Yar Khan.

## 2. Materials and methods

Based on screening of elite germplasm and breeding lines under Hybridization program of CRI, Khanpur, hybrid plant of RH-647 was originated from parental crosses attempted during 2004–2005. The group of superior F1 plants was raised from single plant progeny in pedigree method in 2005–2006. The F2- segregating populations was raised with the selection of superior and desirable plant characteristics in pedigree selection in 2006–2007. The F3 filial generation was raised from single plant progeny and 256 single plant progenies were selected for novel cross in the field and negative selection was remove undesirable plants. The selected plants progenies were raised in the field and desirable single plants characteristics were identified. 31- elite sister lines were established from 256 plant progenies from F4-F6 were picked and promoted for next generation sowing and finally subjected to selection

pressure. The plant spacing was maintained in order to select single plant from segregating plant population using modified pedigree method. RH-647 is the selected progeny from F5 filial generation as phenotypically superior desirable single plants were tagged in F5 population. The 31 sister lines were separately evaluated and studied for desirable individual plant characteristics and advanced to next successive filial generation F6 during 2009–10. The phenotyping and plant mapping techniques were applied to study each individual line in each filial generation advance lines were further screened based on GOT% and other quality fiber traits. Finally, superior, homogenous and phenotypically homogenous lines with desirable fiber quality traits were bulked together in F6 generation in 2010. The Bulk generations was grown in field conditions 80x100 ft<sup>2</sup> plot size with planting distance of RXR distance 2.5ft and PXP 2.0ft to get homogenous plant population based on botanical characteristics through roughing of off-type plants.


Afterwards, the elite line 647/10 was identified and further attested in Preliminary yield trials for 2010–2012, and Advance yield trials 2012–2014 in plot size of 30x10 ft<sup>2</sup> and 1ft<sup>2</sup> PXP distance organized in Randomized Complete for attestation. Each Varietal yield trial was Block Design using approved standard/check varieties Uniform and recommended agronomic practices were applied during selection and testing procedures. Data of morphological plant traits and fiber quality traits were recorded and statistically studied on the basis of Analysis of Variance ANOVA using for MStat-C software program and significance tests of student *t*-test and Fisher F- test at appropriate probability levels  $p < 0.01$  and  $p < 0.05$  for the comparison with standards checks.

## 3. Results

Newly developed line RH-647 was recommended for general cultivation in Punjab for high yield production in 40th meeting of Punjab Seed Council in 2016. The significant morphological and physiological characters of RH-647 plant are; medium to tall plant are cylindrical in plant shape, with 2–3 Monopodia branches and, 30–40 short and semi erect Sympodial or direct fruit bearing branches having oblong solitary boll bearing (Table 1). Phenology of RH-647(Bt) that takes 35–40 days to first flower and 90–95 days to first boll opening having Av. Boll weight of 3.5 g. The varietal plants of RH-647 endures highly good CLCuV disease, heat and drought tolerance with distinctive fiber quality traits like GOT 40.20%, staple length of 28.3 mm, fiber fineness 4.2ug/inch, fiber strength 31.5 (g/tex) as illustrated in (Table 1).

Although, RH-647 was evolved in high temperature low rainfall regimes of district Rahimyar Khan, CRS, Bahawalpur in Bahawalpur Division, and yielded 2897 Kg/ha cotton seed. Similarly, RH-647 also paved significantly high yield compared to standard varieties in dry and drought climate region of Baluchistan and Sindh in National Coordinated Varietal Trials (NCVT, 2014–2016) as shown in (Table 3) that signify variety potential in present scenario of estimated climate change hazards in country. In Provincial Coordinated Cotton Trials (PCCT, 2014–2016), previously, RH-647 yield out higher than both standard checks at 5 locations and comparatively higher than either standard variety at other locations (Table 2). Similarly, RH-647 performed best in spot examination 2015–2016 at ARS, Khanewal and yield was recorded higher above standard check varieties as shown in (Table 2). In fact, RH-647 is new promising high yielding variety highly adapted to agro-climatic zone of Bahawalpur Division high temperature and low precipitation conditions but RH-647 also yielded high well suited in very dry hot marginal soil in Baluchistan depicted in NCVT 2015–2016 studies (Table 3) showed competitive performance of the RH-647 distinctive features of high range of adaptability in harsh and hot climatic regimes of cotton production (Table 2 and

**Table 1**  
Botanical description of RH-647.

Approved Variety name	RH-647 (Bt)	
Breeding center/institute	Cotton Research Institute, Khanpur	
Area of adaptation	Bahawalpur Dikvision	
Breeders	1. Muhammad Yasin, Principal Scientist, CRI, Khanpur 2. Musarrat Shaheen, Scientific Officer, CRI, Khanpur	
<b>Botanical Characteristics</b>	Progeny Name 647/10 Specie name <i>Gossypium hirsutum</i> L. Parentage RH-500 X FH-113 Breeding method Hybridization Growth habit Medium compact Plant height (cm) 130–140 Plant shape Cylindrical Fruit branch type Short 1st Flower Node 7–8 Monopodia attitude Semi erect Monopodia/plant 0–2 Sympodia attitude Semi erect Sympodia/plant 40 Stem pigmentation Medium Stem tip hair Medium Bud gossypol Normal <b>Flower characteristic</b> Days to flowering (50%) 75–80 Days to opening 90–95 days Flower duration Medium Flower size Medium Sepal pigmentation Present Petal spot Absent Nectaries Present Petal color Cream Anthercolor Cream Stamen density Semi dense Position of stigma Exerted Stigma exertion (mm) 2.0 Stigma height (mm) 22–24 Calyx size Intermediate <b>Seed Characteristics</b> Seed size Medium Seed shape Oblong Seed length (mm) 8.0 Seed width (mm) 4.5 Seed coat color Brown Seed index (g) 8.6 Oil content (%) 19 Seed fuzz Fuzzy Fuzz color White <b>Resistance</b> Lodging Medium Resistant Sucking pests Medium Resistant Boll worms Medium Resistant	
		
	<b>Phenology of RH-647(Bt)</b>	
	<b>Phenology of RH-647(Bt)</b> <b>Seedling characteristics</b> Seedling length (cm) 6.9 Seedling color Green Foliage spot Absent <b>Leaf characteristics</b> Foliage density Intermediate Leaf color Green Leaf type Normal Leaf appearance Flat Leaf attitude Semi Erect Leaf nectaries Present Leaf length(cm) 13–15 Leaf width(cm) 10–12 Petiole length(cm) 15–20 Leaf hairiness Medium <b>Boll characteristics</b> Boll bearing habit Solitary Boll shape Oblong Boll color Green Boll size Medium Boll length (cm) 3.5–3.9 Boll breadth (cm) 2.6–3.5 Boll broad at Middle Boll/plant 45–50/Plant Peduncle length (cm) 2.4 Boll surface Smooth Gossypol Normal Boll opening Open Boll weight (gm) 3.0–3.5 Picking Easy Bracteole length Medium Bracteole width Medium Calyx size Intermediate <b>Fiber Quality Characteristics</b> Fibre color White Got/lint (%) 40.2 Lint index (g) 4.8 Fibre length (mm) 28.3 Fibre group Medium Uniformity index (%) 83.4 Fibre fineness (micronaire) 4.2 Fibre strength (g/tex) 31.5 <b>YIELD (Seed Cotton) kg/ha</b> 3500–4000 <b>Yield (lint) kg/ha</b> 1400–1600	

**Table 2**  
Adaptability and Yield Potential of RH-647(Bt) (kg/ha) in cotton-based regions of Punjab in Provincial Co-Ordinated Cotton Trials (PCCT) 2014–2016.

Variety	2014–2015						2015–2016					
	CRS Bwp	CRI RYK	ARS Karore	CRS Vehari	CRS Bwp	CRI, RYK	NIAB FSD	CCRI Mul	AARI FSD	ARS KWL	ARS BWP	CRSS JHG
RH-647	1758	3806	2247	886	1686	2372	1393	839	1278	1088	1683	718
MNH-886 (Std)	1758	3962	2049	641	1041	3283	1308	857	1241	773	1140	658
FH-142 (Std)	2332	3734	4506	845	1202	2193	1013	812	1111	804	1371	1134

**Table 3**  
Adaptability and Yield Potential of RH-647(Bt) (kg/ha) in cotton based regions of Pakistan based on f results of National Co-Ordinated Cotton Trials (NCVT) 2014–2016.

	2014–2015		2015–2016					
	Baluchistan		Punjab			Sindh		
	AARI Khuzdar	CRS Sibbi	CRS BWP	CRS Vehari	CCRI SKD	CRS Ghotki	CRS M.Khas	NIA T. Jam
RH-647 (Bt)	3407	2000	1660	947	3408	2686	2870	1722
CIM-602 (Std-1)	2776	1803	1510	688	3519	2433	3319	2306
FH-142 (Std-2)	2821	2045	1017	383	2852	3138	2825	1695

Table 3). These results indicated that variety RH-647 has highly good range of agro-climatic adaptability in different ecological zones.

The results of varietal yield trials PYT and AYT are presented in tables 2 to 10. Yield performance as shown in table-2 of PYT and AYT conducted at CRI, Khanpur during 2011–12 and 2012–13 showed that RH-647 gave significantly higher yield than standard check variety MNH886. Zonal varietal trials (ZVT) conducted during 2014–16, RH-647 was tested at four locations in all Districts; Sadiqabad, Rahimyar Khan, Khanpur and Liaqatpur at farmer's fields of Bahawalpur division. In Zonal varietal trial, new variety RH-647 exhibited significantly higher yield 18% more than standard variety MNH-886 and FH-142 gave evident performance at various locations. The results of zonal trials indicated that variety RH-647 has good range of agro-climatic adaptability in different ecological zones (Annual Research Report, CRI, Khanpur 2014–15).

Moreover, RH-647 is early maturing and plant morphogenetic traits like bushy cylindrical shape catches more radiation from sunlight and aeration than compact form varieties were strongly observed have lesser attack of pink boll worm as plant growth habit bypasses most of critical physiological stage of PBW infestation and insect population to develop.

In sowing date trial, 2014–15 and 2015–16 at CRI, Khanpur RH-647 gave the better yield when it was sown on 16th May, RH-647 performed very well at P × P distance 12 with seed cotton yield of 2415 kg/ha 2014–15 and 2568 Kg/ha during 2015–16, respectively (Annual Research Report 2014–15 CRI, Khanpur). The experiments related to study of efficiency of new variety for input response to competitive yield, the fertilizer level 185Kg N, 86Kg P<sub>2</sub>O, 62 Kg K<sub>2</sub>O in three split doses was found significant high yield out 3948Kg/ha and 6 number of irrigations are enough to get maximum yield 2590 kg/ha in limited water availability systems depends on the intensity of weather conditions (Annual Research Report 2014–15 CRI, Khanpur). The production technology for new variety RH-647 was developed based on various agronomic studies contained in salient features which are summarized in (Table 4).

For getting maximum yield potential of RH-647, following production technology is recommended: 2–3 deep plough followed with cultivator and one-time rotavator soil preparation to cut hardpan, loosen and pulverize for good root development and

**Table 4**  
Recommended Production Technology for commercialization of Cultivation and of RH-647(Bt).

<b>Best sowing time</b>	1 <sup>st</sup> May–16th May
<b>Seed rate</b>	
Drill sowing	8–10 Kg/Acre
ridge sowing	6–08 Kg/Acre
<b>Plant Spacing and Bed Spacing</b>	12' 1 ft
<b>Dry hoeing</b>	2.5' 2.5 ft
<b>Irrigations</b>	2 dry hoeing before first irrigation & 2–3 hoeing after each irrigation
<b>1st irrigation</b>	6–7 Irrigations
<b>Subsequent irrigations</b>	30–35 after sowing for flat sowing
<b>Last irrigation</b>	15 days interval on flat sowing
<b>Fertilizer</b>	1st week of October
	DAP 1–1.5 bags + ½ bag Urea at sowing and 2–3 bag Urea with split irrigations and Last split dose fertilizer must be applied 15–25th August
<b>Plant protection</b>	According to insect pest situation

conservation of soil. Bed sowing is highly recommended for getting maximum yield of RH-647 as it is easy to maintain plant population, eradication of weeds and efficient use of fertilizer and finally to conserve water 3 bags Urea, 1.5 bag of DAP, 1 bag SOP are required. Fertilizer application must be completed before end of month of August. Bed sowing is recommended for RH-647, and 1st irrigation at sowing time followed by frequent 2nd irrigation by day 4th soon after sowing. After second irrigation, RH-647 needs 3 more irrigations after 10 days interval. After 6th irrigation, application of irrigation water depends on weather conditions and soil structure; stop the irrigation with start of October. As far as weed control and plant protection measures are concerned standard and recommended practices are recommended. The salient features of production technology illustrated in (Table 4).

#### 4. Discussion

Based on consolidated results of National and Provisional Attenuation and technology tests from highly reputed bio-labs trials, RH-647 was proven competitive and promising Bt variety of high yield

potential and strong adaptability to dry and drought agro-climatic zone is entirely developed from conventional breeding procedures. The studies related to production technology of RH-647 various levels of Planting distances and fertilizer levels and cultural practices were used to harmonize the highest yield potential of variety and its response to inputs according to adaptability.

Cotton Research Institute, Khanpur is honored to introduce many promising varieties like RH-112, RH-662, RH-668 & many more. Introduction of RH-647 is purely considering the climatic condition of area. Looking at the interest of beneficiaries both farmer and industry the research institute has successfully introduced RH-647 which is known for its better fiber traits, high yield and CLCuV resistance. This variety has the capacity to solve maximum challenges in better crop production of the area. More than hundred thousand cotton farmers from South Punjab and Sindh are registered with Rural Education and Economic Development Society (REEDS) Pakistan who will be introduced by this variety under Research and Education Development Program. Introduction of RH-647 variety is source of maintenance and enrichment of germplasm for which filial populations study was conducted (F1 - F6) after which preliminary trials for yield were conducted. Effect of temperature and humidity on CLCuV incidence, seed cotton yield and fiber quality were also tested and the results were statistically analyzed. After Provincial Coordinated Cotton Trial (PCCT) and National Coordinated Varietal Trial (NCVT) the variety is available commercially for farmers of Punjab and Sindh.

## 5. Conclusion

RH-647 is highly promising Bt- variety of Cotton Research Institute CRI, Khanpur possess high yield potential, drought and CLCuV disease tolerance approved and recommended for commercial release and general region has with fairly good adaptability to

agro-climatic conditions for general cultivation in South Punjab District Rahimyar Khan in Punjab, Pakistan.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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