

HEAT AND DROUGHT FORBEARING, UPLAND COTTON (*GOSSYPIUM HIRSUTUM* L.) VARIETY;
RH-668 FOR CULTIVATION IN SEMI-ARID REGION

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Abstract: Cotton variety: RH-668, produced by Cotton Research Institute, Khanpur, holds excessive tolerance against dry climatic stipulations and maintains superior fiber parameters. Parental combination; VH-259 × RH-620 was used in hybridization followed by Pedigree method of selection to extract uniform genotypes with superior phenotypes. These superior plants were then tested for yield under drought stress at station level before competing in series of adaptability trials in Punjab followed by provincial and national coordinated varietal trials in the course of 2013-2018. Due to governance incorporated by tolerance against heat & drought it outperformed others at various climatic conditions countrywide for yield and fiber linked characters in opposition to the Standard varieties FH-142 & CIM-602. In Provincial (PCCT) and National level (NCVT) it gave 29.0% & 8.8%, respectively more yield when compared to check variety; FH-142. Hence, Accredited by seed Council, Punjab in 2018 for generic cultivation with 39.4 Ginning outturn percentage, 4.5 micronaire value, staple length of 28.78 (mm) and seed-cotton yield prospective per acre of sixty two mounds. Due to fruiting from lower nodes; erect root development, Brittle leaf surface, lesser shedding of fruiting structures and protracted sympods with bead like bolls arrangement, it deliberately tolerates heat stress.

Keywords: RH-668 an upland cotton, heat, drought tolerance, tropical, less shedding

Introduction

Cotton is placed in family *Malvaceae* covering over 200 genera and nearly 2300 species. While, in spite of fifty species are accounted for to be related with *Gossypium* till present, which are natural to Asia, Africa, central/Southern America and Australia (Wendel & Grover, 2015). Only four species are far reaching and trained. Two diploid species (2n=26); *G. herbaceum* and *G. arboreum* have a place with Old World cotton have portion of 1% in world cotton fabricating. Other two species with tetra-ploidy level (2n=52) are *G. hirsutum* & *G. barbadense* (new world cotton) with absolute portion of 94% to world's total cotton creation. *G. barbadense* adds 4.0% offer, while *G. hirsutum* yields around 90% of the entire cotton foundation (Lu *et al.* 1997; Akhtar *et al.*, 2010).

Upland-cotton is a fundamental wellspring of Spinable fiber and tamed at in excess of 61 worldwide areas on a locale of approximately 29.30 (million hectares) region (ICAC report, 2018). Cotton and yarn focused endeavors have focal capability in the financial arrangement of Pakistan and positions

Fourth in expressions of region/area and manufacture following India, China and United states, while, third in terms of utilization and second spot in yarn fabricating all over the world (PCCC, 2019). The cotton crop has portion of 1.00 % in GDP share and 5.1 % in value-addition (Rehman *et al.*, 2018). Pakistan is one of the principal cotton makers on the planet positioning second among the biggest exporters, third in rundown of biggest maker of yarn and seventh in the rundown of the biggest material makers of fabric (Ahsan *et al.*, 2017). Nonetheless, in expressions of per section of land yield (679kg), Pakistan is slacking quite far at the rear of from Australia (1816kg), China (1719kg), Turkey (1826 kg) and USA (985kg) (ICAC, 2018).

In current occasions, outrageous temperature arisen as a transcendent gamble in cotton creation. It is normal that the global climate is getting warmed up by 0.40-0.80°C each year time (revealed by PMD, 2016). Along these lines, crop requires more water because of expanded evapo-transpiration.

Heat is crucial abiotic-stress controlling the cotton performance efficiency. In this way, Ali *et al.*, (2013); Ali *et al.*, (2014ab); Ali *et al.*, (2016)



revealed that screening of high-temperature resistance in cotton cultivars is complimented as time passes. Additionally, precipitation design is fluctuating areas of strength along with declining water availability for irrigation system (Amin *et al.*, 2018; Muhammad *et al.*, 2013). The temperature range is probable to ascend by 1.50-5.90°C during the century (Hodges and Mc Kinion, 1996). Subsequently, on the off chance that such warming pattern precedes, cotton creation will decline and bringing forth heat lenient varieties will be compulsory.

Cotton is delicate to extreme temperature stress during production stages; especially during blossoming and boll-formation time. Early examination by Reddy *et al.*, 1992 distributed that generally more number of bolls/plant and squares/plant hold occur at day to night temperature of 30 to 22 (°C). Temperatures mean ran between 27-32°C delivered appropriate for boll improvement and its development (Abbas *et al.*, 2016; Gipson 1968; Joham, 1968; Mauney, 1974; Mallano *et al.*, 2022; Freeland *et al.*, 2006). Plants yield unnecessary biomass and re-allocate it to squares and subsequently bolls at 30 to 20 (°C) day-night temperatures range as inspected by Reddy *et al.*, (1991). Further, Bibi *et al.* (2008) expressed that on behalf of carbon obsession most ardent temperature was 33°C and photosynthetic movement lessened thoroughly at 36°C and higher up. Temperature as high as 35 to 40°C were related with sterility and unfortunate boll-maintenance as reported by Reddy *et al.*, (1992b). Boll maintenance and no. of bolls diminished slowly as day temperature upsurge above 40°C and then some. The progressions in physiological tasks due to extreme temperature stress influence photosynthetic action (Schradler *et al.*, 2004). In current circumstance of huge temperature climb, it is craving of time to up bring the environment savvy varieties; suitable for such brutal climatic circumstances to create high return of seed cotton yield.

Keeping noticeable the environment of this locale, the Cotton Research station, Khanpur aforesaid advanced 5 cotton assortments particularly RH-1, RH-12, RH-647, RH-662 and presently RH-668. RH-668 is heat-stress tolerant variety that endures cruel climate and possesses needed traits to perform well in extreme environments. Plants of RH-668 have generally little leaves, long sympodial branches and it proves to be fruitful from lower nodes to the highest. RH-668 is high yielding assortment with promising fibre attributes, battles well to insect pest population and tolerate CLCuV, specifically. Seed committee gave its approval in 2018 for broad-range cultivation. This article envelops the careful subtleties of its successive turn of events and testing in different yield trials with extraordinary spotlight on heat pressure.

Materials and methods

Broad spectrum germplasm was utilized to produce different Parental cross combinations followed by escalated choice to create of existent variety. To consolidate hereditary based obstruction all suitable genepool was taken advantage of during its crossing program. First, a cross between two lines (VH-259× RH-620) was successfully attempted during spring season (2006-07) at Cotton Research station, Khanpur, district Rahimyar Khan, Pakistan. Amid guardians VH-259 Bt. Variety having late maturity, medium leaves, great boll weight, CLCuV resistance, promising fiber characteristics and heat & water stress tolerance due to Cry1AC quality. RH-620 with medium boll type, yellow colored pollens, profoundly lenient to CLCuV, medium size leaves, better GOT (%) and great fiber characteristics; acceptable to each partner.

The gathering of prevalent plants (F₁) was raised by incorporating single plant descendants in family strategy (Pedigree) during 2007-2008. Secondly, F₂ isolation/segregated populace was planted and extended by selecting superior, desirable plant qualities in pedigree selection during year; 2008-2009. Thirdly, Filial F₃ was then developed from single plant offspring selected in the field and used negative determination to uproot unwanted plants (roughing). Then plant descendants were brought up in field and useful single-plants attributes were distinguished. Fourthly, in 2010-to-2011 single-plant descendants were field planted to raise Filial; F₄ generation and emphasized determination to up bring further generations. These single-plants from each single-plants progeny were then Bulk planted. Followed by filial; F₅ generation that was sown in the field for seed-multiplication (2011-12). In Toto, top performing line; RH-668 was the selected from F₅ filial generation and then planted as Bulk-plot in F₆; named RH-668 (Bt.).

Yield Assessment in Repeated Replicated Preliminaries to discover its yield potential, adaptability and fiber quality characteristics was then carried in yield preliminaries (RCBD) at various conditions, areas and soil types to check it against commercial variety RH-142. In yield preliminaries we followed RCBD with three repeats. The row × row distance was 0.75m and plant × plant distance was 0.30m. The production technology and planting time were same at every one of the areas. Followed by; testing for yield potential in PCCT, NCVT, PSC, and 1.25-Acre-Trial. Information on morphology and quality traits were noted and analyzed by utilizing software; MS Stat-C to contrast it with standard approved variety. The means were looked at via. Steel and Torrie's, (1980), Least significance Differential test.

To look at the degree of dry/drought tolerance/resistance in contrast with check standards

(CIM-496 and FH-142), impression of H₂O-induced stress on seed-cotton yield and plant assembly of RH-668 was considered. Two water induced stress levels; (zero water pressure, @ -1.6±0.2 MPa and leaf water-potential @ -0.2±0.2 MPa) were used. H₂O actuated stress was enforced from buds/squares formation stage for example following 30 days of planting till development/picking. Pressure Chamber Strategy and cut-throat-Flume were utilized to find Leaf water potential and the amount of water applied, respectively with joint effort of another PhD researcher.

Results and discussion

Cotton variety; RH-668, having parental combination of VH-259 x RH-620 performed substantially well in filial generations during 2007 to 2013 (F1-F6) for

Table 1: Pedigree; RH-668

Filial Generation	Pedigree	Year	Yield/plant (g)	S.L. (mm)	Mic.	G.O.T. (%)
F ₀	VH-259 x RH-620	2006-07	177	29.0	4.2	41.0
F ₁	053-1/06	2007-08	165	29.4	4.7	39.8
F ₂	122/00	2008-09	172	28.8	4.7	39.9
F ₃	699/01	2009-10	170	28.9	4.4	39.7
F ₄	417/02	2010-11	168	28.7	4.4	40.1
F ₅	313/03	2011-12	166	28.9	4.6	39.8
F ₆	152/04	2012-13	162	29.1	4.5	39.7

Performance in station trials

New variety RH-668 (Bt.) in (Preliminary Yield Trial) produced 37.3 % and 10.7 % more seed cotton yield than the standard MNH-886 during 2013-14 and 2014-15 respectively at Cotton Research

yield/plant and fiber characters. During this period GOT% for RH-668 fluctuated from 39.7 to 41.0%, Staple length 28.7 to 29.4 mm and yield/plant went from 162 to 177g. Uniform prevalent offspring lines were chosen from filial generation F₅ were then concentrated as mass plots in 2012-13 (F₆). In F₆, when bulked, its yield per plant recorded as 162 g. (Table-1). Going on from 2013 assorted Preliminary and Advance Yield Preliminaries (PYTs & AYT), agronomic examinations, PCCT, NCVT, DUS and Biosafety trials were directed in consecutive movement to varietal endorsement. Equal outcomes were affirmed by Iqbal *et al.*, (2014) for improvement of cotton cultivars.

Institute, Khanpur. Whereas, same when tested in (Advance Yield Trial) AYT, exhibited 3.2 % and 20.5% uplifted seed Cotton yield compared against FH-142 (standard) (Table-2).

Table 2. Seed-Cotton Yield of RH-668 (Bt.) in PYT&AYT (On-station trials)

Trial type	Year conducted	No. of Entries	Entry name	Cotton Yield kg/ha	(%) increase Over Check
Preliminary Yield Trial	2013-2014	11+1	RH-668 (Bt.)	2111.0	37.3
			MNH-886 (Std.)	1537.0	
Preliminary Yield Trial	2014-2015	11+1	RH-668 (Bt.)	2832.0	10.7
			MNH-886 (Std.)	2558.0	
Advance Yield Trial	2015-2016	11+1	RH-668 (Bt.)	4153.0	3.2
			FH-142 (Std.)	4025.0	
Advance Yield Trial	2016-2017	11+1	RH-668 (Bt.)	3678.0	20.5
			FH-142 (Std.)	3053.0	

Source of verification: Annual-Report 2013-14 to 2016-17.

Performance in multi-location Yield trials

In PCCT during 1st year RH-668 was tested at 16 different locations. Praiseworthy increase of 29.0 % was recorded in seed cotton yield of RH-668 (2397 kg/ha) in examination with FH-142 (1858 kg/ha) (Standard). While, during 2nd year of testing at 13 different locations RH-668 (2633 kg/ha) exhibited 6.8 % increase for against check FH-142 (2465 kg/ha) (Table-3).

RH-668 competed in NCVT trails having two approved varieties (CIM-602 & FH-142) as standard at 13 different climatic localities for couple of years. During 1st year of experiment, RH-668 gave yield of 2680 kg/ha; 8.8% surplus compared with FH-142

(2463 kg/hectare) and 8.1% uplifted in comparison with CIM-602 (2479 kg/ha). Similarly, RH-668 produced 2867 kg/ha during 2nd year showing 15.2% and 8.8% increase over CIM-602 (2489 kg/ha) and FH-142 (2635 kg/ha) variety. Henceforth, it was proven that new variety/cultivar; RH-668 stood 1st for yield performance in Provincial and National coordinated varietal trials (Table-3). Haidar & Aslam, 2016; Hussain *et al.*, 2010a; Mustafa *et al.*, 2008; Khan *et al.*, in 2006 and Tariq *et al.*, in 2003 conveyed alike results for newly developed varieties. RH-668 with elite performance in PSC, Khanewal 1.25 acre trial documented 33.47 mounds/acre yield during 2017-18.

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Table 3. Yield of RH-668 in PCCT, NCVT & PSC, Khanewal (1.25 acre)

Trial name	Year Conducted in	Number of Sites tested on	RH-668. (Bt.)	Standard	
				FH-142. (Bt.)	% Increase over standard
Provincial coordinated Cotton Trials (PCCTs)	2016-17	16	2397 (kg/ha)	1858(kg/ha)	29.0
National Coordinated Cotton Trials (NCVTs)	2017-18	13	2633(kg/ha)	2465(kg/ha)	6.8
PSC, Khanewal (1.25 ACRE)	2016-17	13	2680(kg/ha)	2479(kg/ha)	8.1
	2017-18	13	2867(kg/ha)	2489(kg/ha)	15.2
	2017-18	-	33.47 (mounds)	-	-

Source: Annual Report (2016-17) & (2017-18)

NEWLY

Approved RH-668; A Bt. variety

Variety; RH-668 showed 2.6 µg/gram of protein concentration compared to 1.40(µg/gm) of FH-142 & 1.6 (µg/gm) for CIM-602 during Bt. Gene Quantification by ABRI, NIGAB, CEMB and NIBGE (after 80-days of sowing; µg/gm of freshly harvested leaves) through the ELISA-technique (Table-4).

Table 4. RH-668; a high yielding(Bt.) variety

	FH-142 (Standard. 1)					CIM-602 (Standard. 2)					RH-668				
	ABR I.	NIGA B.	ABRI .	AB RI.	AB RI.	ABR I.	ABR I.	CEM B.	NIB GE.	Av.	ABR I	NI-GAB	CEM B	NIBG E	Av.
Events	Mon-531.	Mon-531.	Mon-531.	Mo n-531.	Mo n-531.	Mon-531.	Mon-531.	Mon-531.	Mo n-531.	1.6	Mo n-531.	Mon-531.	Mo n-531.	Mo n-531.	2.6
Genes	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	1.6	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	Cry-1Ac.	2.6
Protein concentration (µg/gm)	1.12	0.84	2.19	-	1.4	1.15	0.78	2.99	-	1.6	1.54	3.54	2.69	-	2.6

Source: NCVT 2017

Fiber quality traits (spot examination)

The fiber quality tested by Central Cotton Research, Institute, Multan (CCRI), National Institute for Biotechnology and Genetic Engineering (NIBGE), Faisalabad, Cotton Research Station (CRS), Faisalabad and All Pakistan Textile Mills Association

(APTMA), Lahore during SPOT on 16th October, 2017 presented impressive figures for GOT (39.4 %), staple length (28.78 mm), Fibre-strength 34.40 (g/tex.), Uniformity Index (84.1%) and U.R. (48.18%) (Table-5).

Table-5. FIBER TESTING RESULTS OF RH-668 (Bt.) FROM DIFFERENT LABS. (dated:16-10-2017)

RH-668 (Bt.)	APTMA-(LHR.)	NIBGE-(FSD.)	CRS- (FSD.)	CCRI-(MTN.)	Av.
Staple Length (mm)	27.80	29.42	29.00	28.90	28.78
Micronaire (ug/inch)	03.83	04.47	04.90	04.80	04.50
Fibre-Strength (tppi /g/tex)	86.49	-	-	104.20	95.40
Fibre-Strength (g/tex)	-	34.83	40.20	28.30	34.40
Uniformity Index % (U.I. %)	-	84.10	-	-	84.10
U.R. (%)	48.18	-	-	-	48.18

Physiological studies for stress tolerance

Physiological study to check stress tolerance under water stress conditions revealed that RH-668 (2432

kg/ha) produced 42.89 % and 45.46 % more seed cotton yield than FH-142 (1702 kg/ha) & CIM-496 (1670 kg/hectare) respectively. When imposed with

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water stress RH-668 showed reduction of 300 kg/hectare; from 2732 kg/hectare to 2432 kg/hectare while seed-cotton-yield of FH-142 abridged by 795 kg/hectare i.e. from 2497 kg/hectare to 1702 kg/hectare. Percentage decrease in yield for CIM-496 was 477 kg/hectare; from 2147 kg/hectare to 1670 kg/hectare. More number off bolls was produced by RH-668 (26) under water stress condition as compared to CIM-496 (13) and RH-142 (16). All other yield associated traits studied; boll weight,

plant height, nodes/plant, fruiting node and inter-nodal distance produced better results under water induced stress in RH-668 depicting that it can survive better in areas with lesser water and higher temperature (Table-6).

Table-6 Results of imposed Water stress and its impression on seed-cotton yield and allied traits.

Varieties	H ₂ O stress level	Seed-Cotton (kg/ha)	Plant Height (cm)	Bolls per plant	Boll-weight (gm)	Inter-nodal distance (cm)	Nodes/Plant	1 st fruiting Node
FH-142	No-stress- (-1.6 ± 0.2 Mpa)	2497	139.20	23.00	3.16	3.18	38.00	12.00
	Water stress- (-2.0 ± 0.2 Mpa)	1702	117.30	16.00	2.94	2.94	33.00	15.00
CIM-496	No-stress (-1.6 ± 0.2 Mpa)	2147	119.70	20.00	2.71	3.07	39.00	11.00
	Water stress (-2.0 ± 0.2 Mpa)	1670	102.40	13.00	2.36	2.93	34.00	14.00
RH-668	No-stress (-1.6 ± 0.2 Mpa)	2732	141.20	29.00	3.20	3.22	36.00	9.00
	Water stress (-2.0 ± 0.2 Mpa)	2432	129.90	26.00	2.96	3.13	32.00	11.00
LSD	Varieties	56.77**	9.20**	2.37**ns	0.22**	2.36**	2.10**	2.16*
	H ₂ O stress level	17.11**	4.92**	0.91**	0.33**	0.11*	1.71**	1.22*
	Interaction	31.66**	9.49**	1.39**ns	0.09*	2.67	*2.97*	2.67*

Seed availability

The seed of RH-668 is available at cotton research institute with 1st come 1st serve basis for cultivation in Rahimyar Khan, Bahawalpur, Bahawalnagar, Dera Ghazi Khan, Lodhran, Vehari, Muzaffar-Garh, Multan, Khanewal and other semi-arid regions of Punjab with yield potential of 62 mound/Acre.

Conclusion

In the cotton producing regions of Pakistan, particularly Southern Punjab Region, numerous events of temperatures greater than 40°C come about between mid of June to mid of Aug. It is reported that optimal temperature range for cotton crop, during squaring and bolls-development stage is amongst 27-35°C. If global-warming effects follow as anticipated then cotton-seed produce will be abridged in the near future and cotton yield in semi-arid zones will be more extravagant. Consequently, present study signifies chronological development and field study of impression of heat stress on seed-cotton production of newly developed variety, RH-668. The consequences of this research designated that RH-668 possesses varied adaptability & sustains heat/drought stress and can be grown with minimum inputs. Moreover, RH-668 (Bt.); a high-yielding variety owning superlative fiber quality trait and performs best at P × P distance of 9 inch. Plants

show semi-erect growth pattern with single main stem and long sympodial branches; bearing medium sized bolls in bead form, pleasant for seed-cotton picking.

Conflict of interest

The authors declared absence of conflict of interest.

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