

Development of a New Drought Tolerant Cotton Variety “BH-167” by Using Pedigree Method

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Abstract: "BH-167", a new drought and heat tolerant cotton variety with improved seed cotton yield and fibre quality traits was developed through a cross of two local varieties [VH-53 × BH-142] at Cotton Research Station, Bahawalpur, Pakistan. F₁ to F₆ progenies of this cross were advanced by pedigree method and a better performing line namely 1353/04 was bulked in F₆ and named as BH-167. The selected strain was then evaluated in a series of adaptability trials throughout the Punjab Province to compare its yield potential, drought tolerance and resistance to CLCuV with standard varieties BH-160 and CIM-496. The BH-167 produced 20.77% and 22.43% higher seed cotton yield compared to checks BH-160 and CIM-496 respectively at Cotton Research Station, Bahawalpur while in Provincial Cotton Coordinated Trials and National Coordinated Varietal Trials it produced 4.45% and 2.61% respectively higher yield compared to check CIM-496. Medium plant height, early maturity, highly tolerance to heat and drought, better fibre qualities (GOT 40.8%, staple length 28.0 mm, fibre fineness 5.0ug/inch, fibre strength 97.9 tpsi and uniformity index 82.9%), resistance to insect pests, tolerance to CLCuV and aptness for dry regions are the major characteristics of BH-167 that make it a superior variety for its target region i.e. Bahawalpur Division, Pakistan. Based on its better performance than the check varieties, Punjab Seed Council, Pakistan approved it for general cultivation in Bahawalpur Division.

Keywords: *Gossypium hirsutum*; BH-167; cotton variety; CLCuV resistance; fibre traits; seed cotton yield.

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1. Introduction

Pakistan is an agricultural country (Kumar et al., 2007) providing 19.5% of GDP, sustains 42.5% employment in the national labor force and is the main source of foreign exchange earnings. Cotton is cultivated on area of 32.6 million ha across the world with an annual production of 24.1 million tons, however, the major cotton producing countries are China, India, United States, Pakistan, and Uzbekistan (Rehman et al., 2017).

Cotton (*Gossypium* spp.) is vital cash crop throughout the world, grown for its excellent quality fiber and source of employment. It is also used as fuel and feed (Singh et al., 2018). During 1930s, with the

onset textile revolution in the subcontinent cultivation of *G. hirsutum* cultivation started in the areas comprising Pakistan today (Malik and Ahsan, 2016). It is commonly called as ‘white gold’. Pakistan is one of the main cotton producers in the world ranking 2nd among the largest exporters, 3rd in list of largest producer of yarn and 7th in the list of the largest cloth producers of cloth (Ahsan et al., 2017; Sajjad et al., 2015). Pakistan earns 60% of its total exports from cotton and its products (raw cotton, cotton waste, cotton yarn, cotton thread, cotton cloth, readymade garments, hosiery, bedwares and towels). The cotton has share of 1.0 percent in GDP and contributes 5.1 percent in agriculture value addition (Anonymous, 2016; Rehman et al., 2018; Ullah et al., 2016).

Therefore, cotton plays a key role in Pakistan's economy and foreign exchange earnings. Pakistan can be a largest exporter of cotton by the productivity enhancement. Although there is no significant difference in fibre characteristics of Pakistani cotton from that of other countries. However, the cotton yield per unit area is far behind as compared to other cotton producing countries of the world.

Cotton is grown in Pakistan largely in rotation with wheat (Nasrullah et al., 2017), mainly in areas of where daily maximum temperature may go beyond 45 °C. Moreover precipitation pattern is changing with strong predictions of decreasing availability of water for irrigation (Amin et al., 2018). Pakistan is among countries with highest vulnerability to changing climatic conditions (Nawaz et al., 2016), making cotton production in the country highly susceptible to the various aspects of climate change, with expanding yield gap (Malik and Ahsan, 2016). Generally cotton has varying degree of sensitivity against different abiotic and biotic stresses (Singh et al., 2018). Vertical tap root system of cotton provides certain degree of tolerance against high temperature and drought, however different growth stages vary in their tolerance. Flowering and ball formation stages are sensitive to water availability (Ullah et al., 2017). Growth and development show positive response to increase temperature below 32 °C, beyond which temperature cause thermal stress with varying degree at different growth stages (Ahmad et al., 2017).

Moreover, biotic stresses (cotton leaf curl virus disease, CLCuV), increasing intensity and frequency of insect pest attacks, seed adulteration, shortage of good quality seed) management (increasing prices of agricultural inputs e.g., fertilizer, insecticide, pesticide, seed, etc), marketing issues and crop insurance system significantly limiting cotton production in the country (Ahmad et al., 2017; Farooq et al., 2014; Iqbal et al., 2017; Khan et al., 2017; Malik and Ahsan, 2016). Primary objective of cotton breeders is to develop new cultivars not only with higher yield potential but also having better growth characteristics and fibre quality, insect pest resistance, better adapted changing climatic conditions and minimize existing yield gap (Farooq et al., 2014).

Bahawalpur division in Pakistan encompasses the major area of Cholistan Desert. Average rainfall of this zone is about 93.98mm per annum due to which this zone is very dry and hot. The temperature in

summer goes up to 50°C for day and 30°C at night which is beyond optimum condition required for cotton fertilization and cause shedding of the flower. The underground water is brackish whereas the canal water is insufficient to meet the irrigational requirements for lower yields and poor fibre quality in cotton. However, cultivars may differ in their response to water stress environment due to their morphology and genetic makeup. Screening of advanced genotypes on the basis of physiological parameters of stress tolerance may provide guidelines for breeders to develop varieties which may perform efficiently under water stress conditions. Keeping in view the climatic conditions of this region the Cotton Research Station, Bahawalpur previously evolved five cotton varieties namely Rohi (desi), Gohar-87, BH-118 (Tariq et al., 2003), BH-136 and BH-160 (Khan et al., 2006) which are popular among the farmers of this region. Now, a new variety "BH-167" has been released which is a result of devoted and untiring efforts of the researchers of this station. It is a drought and heat tolerant variety and tolerates water stress, requires less number of irrigations and possesses required traits to survive in harsh climatic conditions.

The plant of this newly developed variety has comparatively rough small foliage, with long sympodial balanced branches and bears fruit from bottom to the top. It is a high yielding variety with improved fibre characteristics, resistance to insect pests and tolerance to CLCuV as well. It is suitable for dry regions of Punjab i.e. Bahawalpur Division. Based on its better performance compared to check varieties, the Punjab Seed Council approved it with the name of BH-167 during the year 2012 for general cultivation in Southern Punjab. This paper describes all the events involved in the development of this new cotton variety BH-167.

2. Materials and Methods

2.1. Plant Material

The cross was made between two local varieties VH-53 (female) and BH-142 (male) at Cotton Research Station (CRS), Bahawalpur during 1998-1999 as described by Alam (1994). F₁ to F₆ progenies of this cross were advanced by pedigree method during the years 1999-2000 to 2005-06 and a better performing line namely 1353/04 was bulked in F₆ and named as BH-167.

Table 1. Pedigree record of BH-167

| Generations | Pedigree | Experimental Years | Yield Plant ¹ (g) | G.O.T. (%) | S. L. (mm) |
|----------------|----------------|--------------------|------------------------------|------------|------------|
| F ₀ | VH-53 × BH-142 | 1998-99 | - | - | - |
| F ₁ | 91-122-1/99 | 1999-00 | 170 | 39.0 | 28.4 |
| F ₂ | 299/00 | 2000-01 | 150 | 38.0 | 28.2 |
| F ₃ | 703/01 | 2001-02 | 145 | 40.4 | 28.0 |
| F ₄ | 2614/02 | 2002-03 | 150 | 37.0 | 28.1 |
| F ₅ | 1879/03 | 2003-04 | 160 | 39.7 | 29.0 |
| F ₆ | 1353/04 | 2004-05 | 158 | 38.5 | 28.5 |

GOT, ginning out turn; SL, staple length.

2.2. Yield Evaluation in Replicated Trials

To explore yield potential, fibre quality traits and wider adaptability this variety was tested in replicated yield trials in different environments and soil types and to compare it with check varieties BH-160 and CIM-496. The trials were conducted at Cotton Research Station, Bahawalpur from 2006-07 to 2010-11. Planting of on-station trials was done during May of each year. All the yield trials were laid out in RCBD with 4 replications. The row to row distance was maintained at 0.75m while plant to plant distance was kept 0.30m.

Planting was done with single row drill in 4 row plots of 5m length. The sowing time and crop husbandry practices were same at all the locations. The replicated yield data of individual locations were averaged and converted to kg ha⁻¹ for comparison. The yield performance of BH-167 was further tested during the years 2006-07 to 2007-08 in Provincial Cotton Coordinated Trial (PCCT), National Coordinated Varietal Trial (NCVT) and 1.25 acre (0.50 ha) trial. These trials were mandatory for approval of new varieties to assess their yield potential compared to check variety.

2.3. Screening Against Cotton Leaf Curl Virus (CLCuV)

Response to various insect pests and CLCuV reaction was separately recorded in field conditions in replicated trials during the years 2006 to 2011. All the plants of BH-167 were thoroughly observed for incidence/appearance of cotton leaf curl virus symptoms such as vein reticulation, vein thickening, leaf curling along stunting of plant etc. Any plant showing these symptoms was considered as “diseased/susceptible”. Data were recorded on fortnightly basis.

2.4. Morphological characteristics of BH-167

Various morphological traits including growth habit, plant height, number of sympodial and monopodial branches plant⁻¹, number of bolls plant⁻¹, boll weight, size and shape, leaf size and color, days to maturity, days to 50% flowering etc. were recorded at Cotton Research Station, Bahawalpur.

2.5. Physiological studies for drought tolerance

The impact of water stress on seed cotton yield and plant structure of BH-167 was studied by Central Cotton Research Institute, Multan to find out its drought tolerance in comparison with check variety (CIM-496). Two water stress levels i.e. no water stress at -1.6 ± 0.2 MPa and -0.2 ± 0.2 MPa leaf water potential. Water stress was imposed at squaring phase i.e. 30 days after planting and continued till crop maturity. Leaf water potential was measured by Pressure Chamber Technique and the quantity of water applied was measured by using “Cut Throat Flume” during the season.

2.6. Fiber Quality Data

The Expert Sub-Committee of the Punjab Seed Council collected composite samples of seed cotton during spot examination of candidate varieties and arranged their fibre quality analysis from three different fibre testing laboratories in Punjab Province i.e. National Institute of Biotechnology and Genetic Engineering (NIBGE) Laboratory, Faisalabad, Cotton Research Institute (CRI) Laboratory, Faisalabad and Central Cotton Research Institute (CCRI) Laboratory, Multan by using High Volume Instrument (HVI-1000, USTER Technologies Inc., Charlotte, NC, USA) as described earlier (Ahmad et al., 2015).

2.7. Statistical Analysis

The data of seed cotton yield were collected and subjected to Analysis of Variance by using MSTATC statistical package and the means were compared using Least Significance Difference (Steel and Torrie, 1980).

Table 2. Performance of BH-167 in yield trials at Cotton Research Station (CRS), Bahawalpur

| Year | Trial | Yield (kg ha ⁻¹) | | | LSD (5%) |
|------------------------------|--------|------------------------------|--------------|--------------|----------|
| | | BH-167 | BH-160 | CIM-496 | |
| 2006-07 | AVT-IV | 2370 | 2114 | 2017 | 135 |
| 2006-07 | AVT-II | 2091 | 2404 | 2033 | 113 |
| 2007-08 | AVT-I | 3528 | 3265 | 2954 | 211 |
| 2007-08 | AVT-II | 2799 | 2547 | 2655 | 145 |
| 2008-09 | AVT-I | 3721 | 2665 | 2834 | 223 |
| 2008-09 | AYT-I | 2873 | 2468 | 2930 | 133 |
| 2009-10 | AVT-I | 2123 | 1622 | 1686 | 183 |
| 2010-11 | AVT-I | 3235 | 1745 | 1470 | 269 |
| Average | | 2843 | 2354 | 2322 | |
| % increase over check | - | - | 20.77 | 22.43 | |

AVT: Advance Varietal Trial; AYT: Advance Yield Trial.

3. Results and Discussion

3.1. Yield Performance in Various Trials

3.1.1. Filial Generations

The new variety BH-167 performed better in filial generations from F₁-F₆ during the period from 1998-99 to 2004-05 in terms of seed cotton yield, GOT% and staple length (Table 1). Data showed that GOT of BH-160 ranged from 37.0 to 40.4% while staple length ranged from 28.1 to 29.0 mm. In F₆, when it was bulked, its yield per plant was 158 g. Similar results were reported by Tariq et al. (2003) and Iqbal et al (2014) for development of cotton varieties.

The new variety was also evaluated for its yield potential compared to check CIM-496 in Provincial Cotton Coordinated Trial at 11 locations throughout

Punjab including Core Cotton Region (Multan and Bahawalpur) and Non-Core Cotton Region (Faisalabad) during 2007-08. The trial was conducted under the supervision of the Director, Cotton Research Institute, Faisalabad. The data revealed that BH-167 produced 9.04% higher seed cotton yield (2266 kg ha⁻¹) than CIM-496 (2078 kg ha⁻¹) on the basis of average of 5 locations in Non-Core Cotton Region (Faisalabad) (Table 3).

In different locations of Core Cotton Region (Multan and Bahawalpur) BH-167 out yielded by producing 2719 kg ha⁻¹ yield as compared to the check CIM-496 (2685 kg ha⁻¹ seed cotton yield. Similar findings have been reported earlier for development of cotton varieties, new varieties performed better than the check varieties (Haidar and Aslam, 2016; Khan et al., 2006; Tariq et al., 2003).

Table 3. Performance of BH-167 in Provincial Cotton Coordinated Trials (PCCT) during 2007-08

| Region | Trial Locations/No. | Yield (kg ha ⁻¹) | | % increase over check | LSD (5%) |
|--|---------------------|------------------------------|---------|-----------------------|----------|
| | | BH-160 | CIM-496 | | |
| Non-Core Cotton Region (Faisalabad) | NIAB Faisalabad, | 2266 | 2078 | +9.04 | 117 |
| | CRS Sahiwal, | | | | |
| | CRI Faisalabad, | | | | |
| | CRSS Jhang | | | | |
| | ARI Faisalabad /5 | | | | |
| Core Cotton Region (Multan & Bahawalpur) | CCRI Multan | 2719 | 2685 | +1.2 | 99 |
| | CRS Multan | | | | |
| | CRSS PIPL | | | | |
| | PSC Khanewal | | | | |
| | CRI Rahim Yar Khan | | | | |
| CRS Bahawalpur /6 | | | | | |

ARI, Agronomic Research Institute; CCRI, Central Cotton Research Institute; CRI, Cotton Research Institute; CRS, Cotton Research Station; CRSS, Cotton Research Sub-Station; NIAB, Nuclear Institute for Agriculture and Biology; PCCT, Provincial Cotton Coordinated Trial; PSC, Punjab Seed Corporation.

Table 4. Performance of BH-167 in National Coordinated Varietal Trials (NCVT) during 2007-08

| Region | Trial Locations/No. | Yield (kg ha ⁻¹) | | % increase over check | LSD (5%) |
|--|---|------------------------------|-----------------|-----------------------|----------|
| | | BH-160 | CIM-496 (Check) | | |
| Non-Core Cotton Region (Faisalabad) | NIAB Faisalabad, CRS Sahiwal, CRI Faisalabad, NIBGE Faisalabad /4 | 2841 | 2780 | +2.20 | 85 |
| Core Cotton Region (Multan & Bahawalpur) | CCRI Multan, CRS Multan, CRS Vehari, PSC Khanewal, RARI Bahawalpur, CRS Bahawalpur /6 | 1983 | 1919 | +3.33 | 93 |

Source: Pakistan Central Cotton Committee, Karachi.

CCRI, Central Cotton Research Institute; CRI, Cotton Research Institute; CRS, Cotton Research Station; NCVT, National Coordinated Varietal Trials; NIAB, Nuclear Institute for Agriculture and Biology; NIBGE, National Institute for Biotechnology and Genetic Engineering; PSC, Punjab Seed Corporation; RARI, Regional Agricultural Research Institute.

Table 5. Performance of BH-167 at Punjab Seed Corporation (PSC) Farm, Khanewal

| Year | Trial | Yield kg ha ⁻¹ | | LSD (5%) |
|----------------|---------------------------|---------------------------|-------------|----------|
| | | BH-167 | BH-160 | |
| 2006-07 | AVT-I | 2655 | 2727 | 112 |
| 2007-08 | AVT-I | 2799 | 2547 | 135 |
| 2008-09 | AVT-I | 2632 | - | - |
| 2008-09 | 1.25 acres (21 Varieties) | 2777 | - | - |
| Average | | 2743 | 2637 | |

Source: Punjab Seed Corporation Farm, Khanewal. AVT, Advance Varietal Trials.

Table 6. Response of BH-167 against CLCuV at various locations

| Year | Name of Trial | CLCV (%) | | LSD (5%) |
|---------|----------------|----------|--------|----------|
| | | BH-167 | BH-160 | |
| 2010-11 | AVT-I CRS,BWP | 45.5 | 87.0 | 23 |
| 2009-10 | AVT-I CRS,BWP | 49.0 | 85.0 | 15 |
| 2007-08 | AVT-I CRS,BWP | 24.0 | 41.0 | 10 |
| 2007-08 | AVT-I PSC, KWL | 15.1 | 24.4 | 8 |
| 2006-07 | AYT-IV CRS.BWP | 4.4 | 10.7 | 5 |
| 2006-07 | AYT-I PSC KWL | 12.1 | 26.4 | 6 |

Source: Cotton Research Station, Bahawalpur. AVT, Advance Varietal Trial; AYT, Advance Yield Trials; CLCuV, Cotton leaf curl virus; CRS, Cotton Research

Station; BWP, Bahawalpur; PSC, Punjab Seed Corporation; KWL, Khanewal.

Table 7. Important varietal characteristics of BH-167

| S. No. | Characteristics | Value |
|--------|---------------------------|---|
| 1 | Day to maturity | 120-140 |
| 2 | Plant Height at maturity | Medium Tall (120-130 cm) |
| 3 | Growth Habit | Erect compact to semi-compact (no bushy type) |
| 4 | Branching Attitude | short to medium- long sympodial type |
| 5 | Monopodial per plant | 0-3 |
| 6 | Leaf Color | Green |
| 7 | No. of Bolls per plant | 40-45 |
| 8 | Boll Size | Medium |
| 9 | Boll Weight | 3.0-3.8gm |
| 10 | Leaf Hairiness | Medium |
| 11 | Days to 50% Flowering | 75-80 |
| 12 | Flowering Duration | 100 Days |
| 13 | Lodging | Resistant |
| 14 | Resistance to Insect Pest | Medium Tolerant |
| 15 | Boll Worms | Medium Tolerant |
| 16 | CLCV | Resistant |
| 17 | Heat & drought | Tolerant |
| 18 | Earliness | Early |

Table 8. Impact of water stress on seed cotton yield and its components and plant structure at maturity.

| Cultivar | Water stress | Seed cotton yield (kg ha ⁻¹) | Bolls per plant | Boll weight (g) | Main stem height (cm) | Number of nodes on main stem | Inter-nodal length (cm) |
|----------|-------------------------------|--|-----------------|-----------------|-----------------------|------------------------------|-------------------------|
| CIM-496 | No stress (-1.6± 0.2 Mpa) | 2130 | 23 | 3.20 | 110.3 | 36 | 3.04 |
| | Water Stress (-2.0± 0.2 (Mpa) | 1425 | 18 | 2.96 | 95.8 | 33 | 2.95 |
| BH-167 | No stress (-1.6± 0.2 Mpa) | 2400 | 28 | 2.88 | 131.8 | 40 | 3.28 |
| | Water Stress (-2.0± 0.2 (Mpa) | 2070 | 26 | 2.44 | 117.5 | 37 | 3.22 |
| LSD | Cultivars | 44.15** | 2.21** | ns | 8.92** | 2.40** | 0.18** |
| | Water Stress | 15.18** | 0.87** | 0.29** | 5.16** | 1.43** | 0.10* |
| | Interaction | 30.36** | 1.73* | ns | 10.32** | 2.87* | ns |

* ** significant at 5% & 1% level respectively; ns: non-significant. **Source:** Annual Progress Report 2008-09, Physiology Department, CCRI, Multan.

Table 9. Spatial variations in Fibre Characteristics of BH-167 (Code-A41)

| | NIBGE FSD | CRI FSD | CCRI MTN | Average |
|---------------|-----------|---------|----------|---------|
| GOT (%) | 40.83 | 40.83 | 40.83 | 40.8 |
| UHML (mm) | 28.46 | 27.5 | 27.9 | 28.0 |
| MIC (ug/inch) | 5.1 | 4.8 | 5.3 | 5.0 |
| U. I. (%) | 81.8 | 83.0 | 84.0 | 82.9 |
| Strength tpsi | - | 101.4 | 94.4 | 97.9 |
| g/tex | 34.2 | - | - | 34.2 |

Source: Director, Agronomic Research Institute, Faisalabad, Pakistan. CRI FSD, Cotton Research Institute Faisalabad; MIC, micronaire; NIBGE FSD, National Institute for Biotechnology and Genetic Engineering Faisalabad; CCRI MTN, Central Cotton Research Institute, Multan; UHML, upper -half mean length; UI, uniformity index.

The yield performance of BH-167 was further tested in Multan (Core Cotton Region) and Faisalabad (Non-Core Cotton Region) Zones at 10 locations in National Coordinated Varietal Trials (NCVT) conducted by the Pakistan Central Cotton Committee, Karachi in comparison with other candidate strains of cotton breeders of Punjab during 2007-08

In Faisalabad zone (Non-core cotton region) results of 4 locations showed that BH-167 gave comparatively high yield of seed cotton of 2841 kg ha⁻¹ than CIM-496 (2780 kg ha⁻¹) (Table 4). On the basis of average of 6 locations in Core Cotton Regions (Multan and Bahawalpur), BH-167 also

produced higher seed cotton yield (1983 kg ha⁻¹) as compared to CIM-496 (1919 kg ha⁻¹). Similar results have reported for the development of new varieties of cotton and wheat (Haidar and Aslam, 2016; Hussain et al., 2010a; Iqbal et al., 2014; Khan et al., 2006; Mustafa et al., 2007; Mustafa et al., 2008; Siddiqi et al., 2001; Tariq et al., 2003).

On the basis of average of three years in advance varietal trials and 1.25 Acres trial conducted by Punjab Seed Corporation (PSC) at PSC Farm, Khanewal, BH-167 produced 2743 kg ha⁻¹ seed cotton as compared to check BH-160 which produced 2637 kg ha⁻¹ (Table 5). In 1.25 acre (0.50 ha) trial during 2008-09, BH-167 secured 13th position out of 21 strains of various plant breeders and produced 2777 kg ha⁻¹ seed cotton.

3.2. Screening against Cotton Leaf Curl Virus (CLCuV)

Reaction of BH-167 to CLCuV was studied during 2006-07 to 2010-11 under environmental conditions of Bahawalpur and Khanewal. The data presented in Table 6 showed that BH-167 had comparatively less incidence of CLCuV than the check varieties which means that the new variety BH-167 has relatively high tolerance to CLCuV.

The variety is most suitable for the poor common growers who have meager facilities and knowledge regarding plant protection. New varieties of cotton and wheat required to be more resistant to locally prevailing diseases including CLCuV (cotton) and

rust (wheat) (Ahmad et al., 2010; Khan et al., 2006; Tariq et al., 2003).

3.3. Morphological Characteristics of BH-167

BH-167 has medium plant height, early in maturity, heat and drought tolerance, lodging resistance and tolerance to CLCuV. The important plant characteristics of BH-167 were recorded at Cotton Research Station, Bahawalpur and are presented in Table 7. Tariq et al. (2003), Khan et al. (2006), Mustafa et al. (2007), Mustafa et al. (2008) and Hussain et al. (2010a), Hussain et al. (2010b), Hussain et al. (2010c) reported similar results for new cotton and wheat varieties.

3.4. Physiological studies for drought tolerance

Data in the Table 8 revealed that under water stress conditions variety BH-167 produced 45.26% higher seed cotton yield (2070 kg ha^{-1}) as compared to check variety CIM-496 (1425 kg ha^{-1}). The yield of BH-167 was reduced only 330 kg ha^{-1} i.e. from 2400 kg ha^{-1} to 2070 kg ha^{-1} while yield of CIM-496 reduced considerably 705 kg ha^{-1} i.e. from 2130 kg ha^{-1} to 1425 kg ha^{-1} . BH-167 also produced more number of bolls (26) as compared to CIM-496 (18). BH-167 also showed good performance with respect to boll weight, main stem height, number of nodes on main stem and inter-nodal length as shown in the Table 8 (Anonymous, 2009). The better performance of BH-167 showed that it is a drought tolerant variety and best suited for the areas where water is insufficient to meet the irrigational requirements for the cotton crop.

3.5. Trend Analysis

The results of the seed cotton samples collected by the Expert Sub-committee of the Punjab Seed Council are summarized in Table 9. On the basis of average of three Laboratories reports GOT %age, staple length, fineness, uniformity index and fibre strength of BH-167 were found to be 40.8%, 28.0mm, 5.0ug/inch, 82.9% and 97.9 tpsi, respectively which are up to the standards required for approval of a new cotton variety. Similar results were reported earlier regarding approval of new cotton varieties (Tariq et al. (2003), Khan et al. (2006), Iqbal et al (2014) and Haidar and Aslam, 2016) shown similar results for approval of new cotton varieties.

4. Conclusion

BH-167 is a drought and heat tolerant cotton variety with high yield potential and improved fibre characteristics. It is resistant to insect pests and

tolerant to Cotton Leaf Curl Virus disease. Furthermore, it is early maturing and vacates the fields well in time and facilitates timely sowing of wheat. Therefore, it is fit in cotton-wheat-cotton rotation system. The quality of seed cotton obtained from BH-167 was good due to early shedding of its leaves which reduces cotton contamination. Contamination of cotton reduces the price of our cotton products by 5 cent a pound. This variety will potentially helpful in boosting the yields and cotton production in the cotton zone of Bahawalpur. Based on its better performance and good quality characters compared to check varieties, the Punjab seed Council, Lahore, approved it during the year 2012 (Anonymous, 2012). The decision of the Punjab seed Council, Lahore is reproduced as under: "The house approved BH-167 cotton variety for general cultivation in the Bahawalpur region (southern Punjab), being drought tolerant, CLCuV resistant, high yielding, and early maturing one". Seeds of BH-167 are available for commercial use, and can be obtained Cotton Research Station, Bahawalpur, Pakistan and other designated institutes and outlets of Government of Punjab

List of abbreviations: ARI, Agronomic Research Institute; AVT, Advance Varietal Trial; AYT, Advance Yield Trial; BH, Bahawalpur Hybrid; BWP, Bahawalpur; CCRI, Central Cotton Research Institute; CIM, Cotton Institute Multan; CLCuV, Cotton Leaf Curl Virus; CRI, Cotton Research Institute; CRS, Cotton Research Station; CRSS, Cotton Research Sub-Station; FSD, Faisalabad; GOT, ginning out turn; KWL, Khanewal; MIC, micronaire; MNH, Multan Hybrid ; MUL, Multan; NCVT, National Coordinated Varietal Trial; NIAB, Nuclear Institute for Agriculture and Biology; NIBGE, National Institute for Biotechnology and Genetic Engineering; PCCT, Provincial Cotton Coordinated Trial; PSC, Punjab Seed Corporation; RARI, Regional Agricultural Research Institute; RYK, Rahim Yar Khan; SL, Staple Length; SWL, Sahiwal; UHML, upper -half mean length; UI, uniformity index; VHR, Vehari.

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Author Contribution: SSMS, RM, SASS and SS were practically involved in the breeding and development of this new cotton variety BH-167; RM prepared the outlines and edited primary and subsequent draft of the article; SASS compiled the basic data and wrote the yield evaluation part; LHA and AS gave suggestions to improve the article. All authors read and approved the article.

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