

Full Length Research Paper

Comparative performance of Bt cotton with some elite conventional cotton cultivars under arid to semi-arid conditions

Ahsan Aziz^{1*}, Naeem Akhtar¹, Muhammad Afzal¹, Muhammad Ashraf¹, Asif Tanveer², Rashid Ahmad³, Muhammad Ehsan Safdar¹ and Salman Ahmad¹

¹University College of Agriculture, University of Sargodha, Sargodha- 40100, Pakistan.

²Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan.

³Department of Crop Physiology, University of Agriculture, Faisalabad-38040, Pakistan.

Accepted 26 May, 2021

To identify the superior genotype, we studied the comparative growth and yield performance of four cotton cultivars namely, CIM-496, BH-162, VH-144 and Bt-121, grown on sandy clay loam soil, having pH 8.4, EC 1.0 dS m⁻¹, SAR 7.8 (mmolL⁻¹)^{1/2} and TSS, 10.0 meL⁻¹. The site was located at latitude 31.65°N, longitude 72.36°E and altitude 157.65 m. The results revealed that plant growth parameters like plant height, number of bolls plant⁻¹ and seed cotton weight boll⁻¹, were differed significantly (P < 0.05) among Bt and non-Bt cotton cultivars. Seed cotton yield and fiber quality parameters such as maturity percentage, micronaire value, staple length, fiber strength and virus infection percentage were also significantly (P < 0.05) different among different cultivars. Bt⁻¹21 had maximum value for seed cotton weight boll⁻¹ and maturity percentage and produced 26% higher seed cotton yield than all other cultivars. Furthermore, it also showed 58% less cotton leaf curl virus infection compared to other cultivars. BH -162 produced fiber with maximum length and fineness but it appeared most vulnerable to virus attack. It was concluded that Bt⁻¹21 performed best in most of the studied traits than other cultivars and may be recommended for cultivation in areas having arid to semi-arid climatic conditions.

Key words: Genotypes, cotton, micronaire, ecological conditions, virus infection, yield performance.

INTRODUCTION

Total area of the world occupied by cotton crop is 30,760 million hectares which produces 107.48 million bales, giving an average seed cotton yield of 761 kg ha⁻¹. Seed cotton yield of Pakistan and other developing nations is far below that of technologically advanced, cotton growing countries like Australia, China and USA etc (USDA, 2010). Realizing the importance of cotton crop, there is constant need to improve per hectare yield of seed cotton. Presently, there is an acute need to further exploit the available agricultural and agronomic resources for greater benefits.

Owing to increasing population growth rate, the demand for food and clothes is more than before. Low yield per hectare of cotton besides many other factors, may be attributed to varieties with low yield potential, on account of their inability to cope with biotic and abiotic stresses. Although, many high yielding cotton varieties have been evolved and recommended for general cultivation in the past but their performance under farmer's condition is not up to mark. The reason behind is that, either these varieties have lost their adaptability to changing edaphic and environmental conditions or have become susceptible to various pests and diseases.

Introduction and evolution of Bt cotton genotypes have provided an alternate solution for improving yield. Bt cotton genotypes have built-in ability to produce toxins against various insect pests of cotton (Perlack et al., 1990)

*Corresponding author. E-mail: drahsanaziz@gmail.com. Tel: 092-048-3703662, 092-0344-6686255. Fax: 092-048-3703665.

Table 1. Mean performance of growth, yield and yield components of four cotton cultivars (Means of three replications).

| Plant traits | Cultivars | | | | LSD value (5%) |
|-------------------------------------------|---------------------|----------|---------|----------|----------------|
| | VH ⁻¹ 44 | BH-162 | Bt-121 | CIM-496 | |
| Plant height (cm) | 96.67 d | 108.67 b | 98.55 c | 111.67 a | 0.594 |
| Number of bolls plant ⁻¹ | 15.58 a | 15.05 b | 11.47 d | 14.63 c | 0.133 |
| Seed cotton weight boll ⁻¹ (g) | 2.26 c | 2.59 b | 3.56 a | 2.57 b | 0.064 |
| Seed cotton yield (t ha ⁻¹) | 2.220 d | 2.376 c | 3.013 a | 2.610 b | 0.0797 |

Means having different letters in a row differ significantly at 5% probability

thus lowering production cost and giving better returns to farmers (Thirtle et al., 2003). Plant breeders and policy makers are always keen to make comparative studies between Bt and non-Bt crops, to determine their benefits on real grounds.

The present study was therefore, planned to compare yield potential, quality traits and disease resistance of Bt and non-Bt cotton cultivars under arid to semi-arid climatic conditions. Such studies can be instrumental in producing and evaluating high yielding genotypes, suitable for cultivation in arid to semi-arid regions of the world and ultimately in enhancing seed cotton yield (Tahira et al., 2007).

MATERIALS AND METHODS

The experiment was conducted at Government Reclamation Farm, Mian Channu; located at latitude 31.65°N, longitude 72.36°E and altitude 157.65 m during year 2007 to '08. The climate of the location was characterized to be arid to semi-arid with seasonal average rainfall of 21.6 mm/month and average maximum temperature ranging from 15 to 52°C and minimum temperature ranging from 12 to 42°C during experimental period. Four cotton cultivars namely BH-162, CIM-496, Bt-121 and VH-144 were sown in randomized complete block arrangement with three replications.

The experimental soil was found to be sandy clay loam with slightly alkaline nature having pH of 8.4, 1dSm⁻¹, EC 10.0 meL⁻¹, TSS 7.8 SAR and saturation percentage of 34.5. The plot size for this experiment was 6 x 10 m². The recommended seed rate 20 kg ha⁻¹ was used. The cotton seed was drilled in 75 cm apart rows with a single row hand drill. The inter-plant distance was maintained at 30 cm by two thinnings, first at 15 cm and second at 23 cm plant height, to achieve same plant population in each plot. Recommended cultural practices were done in each plot throughout the growing period. Data of plant height, number of bolls per plant, virus infection percentage and seed cotton weight per boll were recorded by taking the average of ten competitive plants selected at random in each plot. Seed cotton yield of the whole plot was taken and then converted into kg ha⁻¹. Fiber maturity percentage, strength, micronaire value and staple length were measured with High Volume Instruments (HVI-900 SA) manufactured by M/s Zellweger Ltd., Switzerland.

All recorded data were subjected to Fischer's analysis of variance technique and means were compared, using least significant difference (LSD) test, at 5% probability level (Steel et al., 1997).

RESULTS

Among the 4 cotton genotypes, significant differences (P

< 0.05) were observed in plant height. The mean comparison of plant height (Table 1) shows that c.v. VH-144, had dwarf plants with an average height of 96.67 cm while the CIM-496, had maximum plant height with an average of 111.67 cm. It was followed by BH-162 while cultivar Bt-121 produced intermediate plant height.

Data pertaining to seed cotton yield and its related yield components such as, number of bolls per plant and seed cotton weight per boll are given in Table 1. It reveals that four cotton cultivars varied significantly (P < 0.05), indicating that cotton cultivar VH-144 produced maximum number of bolls per plant (15.58) followed by BH-162 which had 11.47 bolls per plant, whereas Bt-121 showed minimum number of bolls per plant. Maximum seed cotton weight per boll was produced by Bt-121 with an average of 3.56 g while VH-144 had minimum seed cotton weight (2.26 g) whereas CIM-496 and BH-162 were intermediate and statistically similar with respect to seed cotton weight per boll. It is also evident from the data given in Table 1, that under similar conditions, seed cotton yield of four cotton cultivars varied significantly. Maximum seed cotton yield of 3.013 t ha⁻¹ was obtained with Bt-121 which was followed by CIM-496 and next to it was BH-162 while VH-144 produced minimum seed cotton yield (2.22 t).

Results obtained in the present study indicate that significant variation exists in virus infection percentage amongst the cotton genotypes examined (Figure 1). Among four cotton varieties, c.v BH-162 depicted maximum (42.27%) whereas Bt-121 showed minimum virus infection (17.41%) while the remaining cultivars were intermediately susceptible to virus infection. There were significant differences among studied cotton varieties for fiber maturity percentage (Figure 2). Cotton cultivar Bt-121 showed maximum maturity percentage (84%) which was followed by VH-144 (82.97%) and next to it was CIM-496 while BH-162 depicted minimum fiber maturity percentage value.

The perusal of data regarding fiber quality parameters like micronaire value and staple length recorded from four cotton cultivars, presented in Figures 3 and 4, showed significant differences. Cotton cultivar BH-162 showed minimum micronaire value (4.36) while Bt-121 had maximum micronaire value (5.30). The remaining cultivars were intermediate, showing slightly better micronaire value in case of VH-144 (4.83) as compared

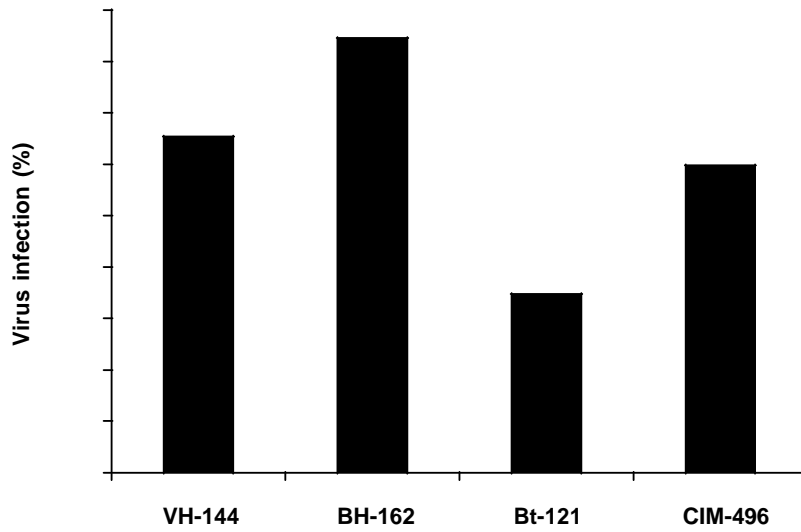


Figure 1. Susceptibility (%) of four cotton cultivars to virus infection.

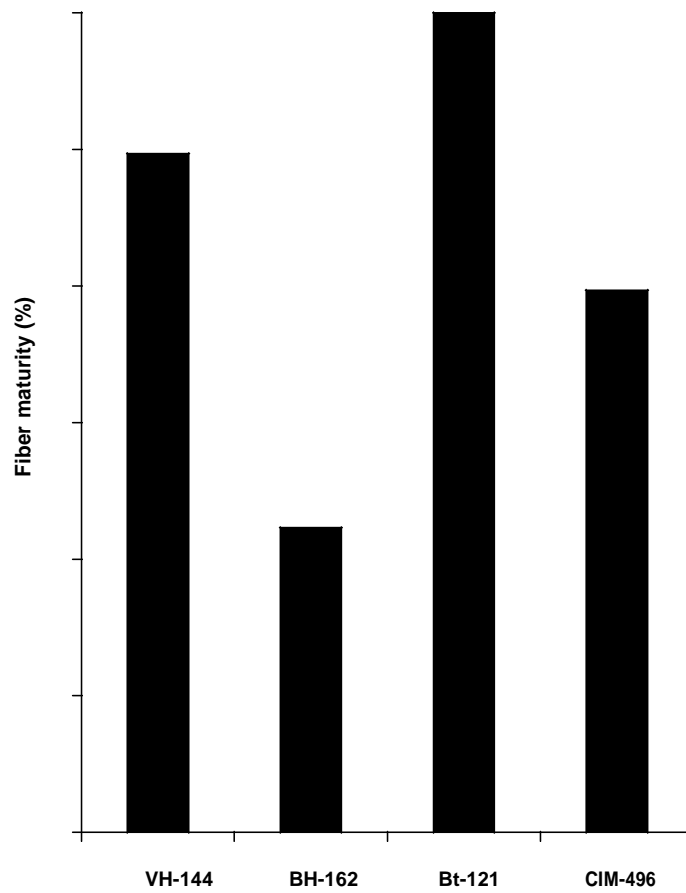


Figure 2. Comparison of fiber maturity (%) of different cotton cultivars.

to CIM-496 (4.60). As regards staple length, it was measured that staples of cotton cultivar BH-162 were

statistically longer than VH-144 and Bt-121. The cultivar CIM-496 was at par with BH-162 and Bt-121 for staple

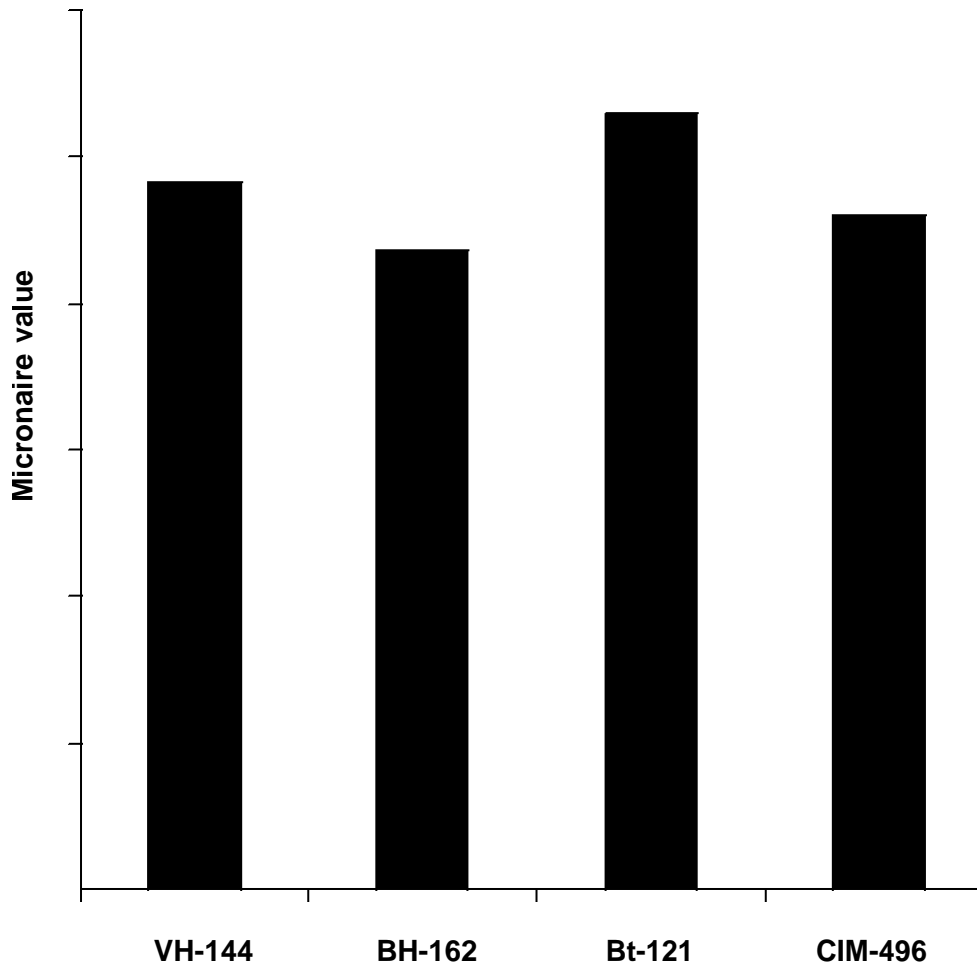


Figure 3. Comparison of fiber micronaire value of different cotton cultivars.

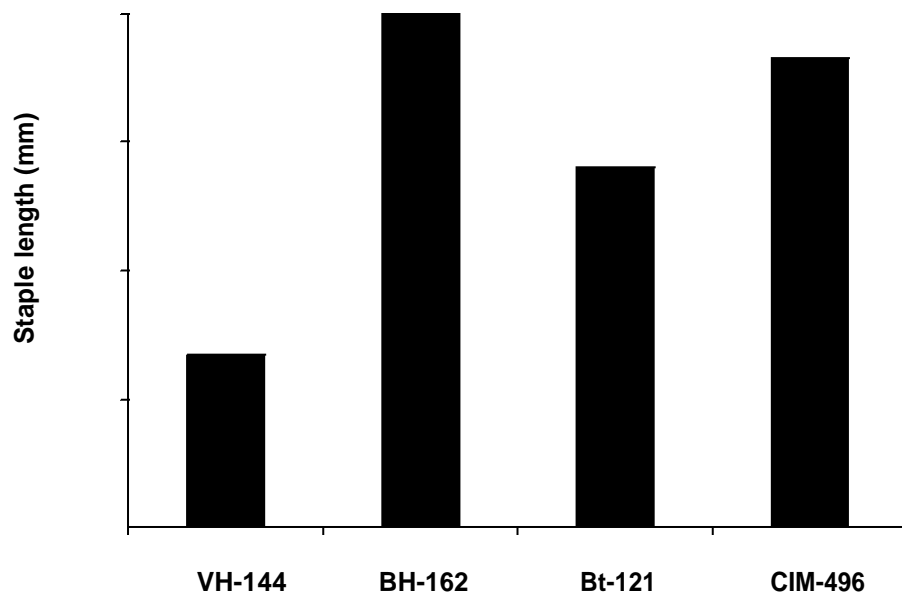


Figure 4. Comparison of staple length (mm) of different cotton cultivars.

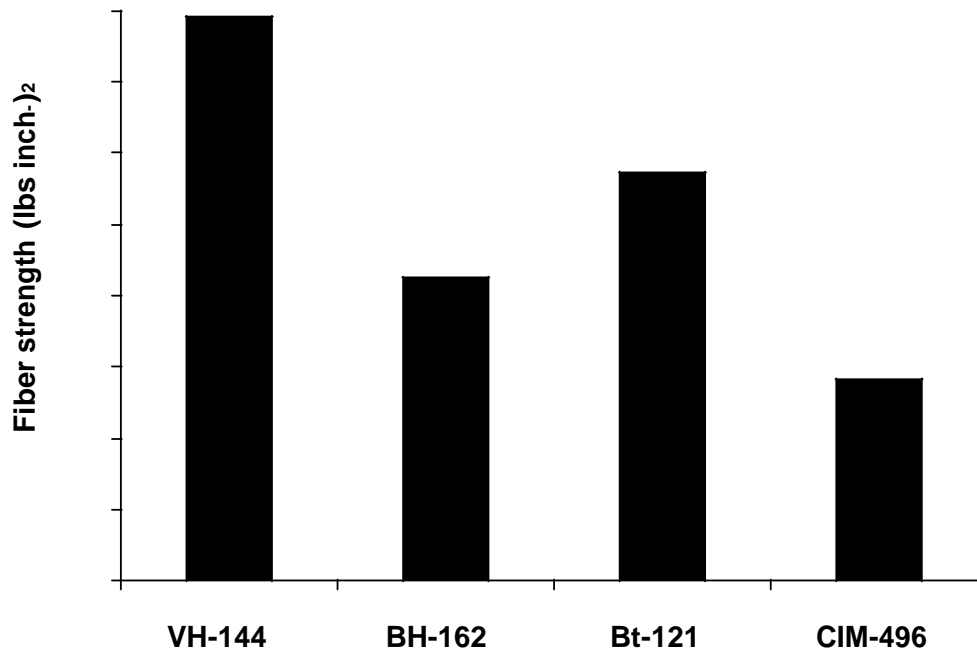


Figure 5. Comparison of fiber strength (lbs inch⁻²) of different cotton cultivars.

length. Minimum staple length was recorded with c.v VH-144.

The fiber strength values shown in Figure 5 indicate that, four cotton cultivars were significantly different. Maximum staple strength (99.87 lbs inch⁻²) was noted with VH-144 which was followed by Bt-121 (95.47 lbs inch⁻²). Minimum (89.67 lbs inch⁻²) value was recorded for CIM-496 whereas BH-162 depicted better staple strength (92.53 lbs inch⁻²) than CIM-496.

DISCUSSION

The growth characteristics and adaptations that permit a crop cultivar to exploit natural resources efficiently, determine the competitive fitness of one over the other. Plant height is an important characteristic which enables the crop plants to compete specifically with weeds and generally with other pests for light interception and photosynthetic activities. Four cotton varieties responded differently in attaining plant height. This may be due to variation in genetic make up of these cultivars.

However, Bt-121 with medium plant height gave better yield in arid climatic conditions because of abundant sunshine and better response of short statured cultivars to high doses of fertilizers. This consistent with the studies of Naveed et al. (2006), Nisar et al. (2007) and Tahira et al. (2007). Seed cotton yield is mainly a function of boll number per plant. The significant differences in boll number per plant among different cotton cultivars observed in the present experiment might be due to

inherent capacity and inability of some genotypes to provide photosynthates to large no of bolls. Similarly, Asad et al. (2002) and Tahira et al. (2007) reported inequality in the number of bolls per plant with different cotton varieties, when grown under identical conditions.

The virus infection is a major hurdle for yield improvement in cotton crop and the cultivars which showed resistance against virus infection are preferred for general cultivation as compared to susceptible varieties (Khan et al., 1993). The highest resistance in Bt-121 against cotton leaf curl virus, may be due to genetic alteration created in this genotype and less susceptibility to insects, that are considered to play a role in the transfer of virus from one plant to another. This argument is supported by Azhar et al. (1999) and Asad et al. (2002) who narrated that low susceptibility of Bt cotton to virus infection, may be due to inherited resistance against boll worms.

Seed cotton weight per boll plays a pivotal role in determining final yield of a cotton cultivar which is influenced directly or indirectly by the growing conditions and its genetic ability to perform in the prevailing environmental conditions. Variation in seed cotton weight per boll among cotton genotypes may arise from variation in photosynthetic capacity, as well as partitioning of these assimilates to various parts of the plant body. The loss of young fruiting forms by the entomological factors was less in Bt-121 than its non-Bt counterparts. As a consequence, Bt-121 may have more early formed bolls which contributed to higher biomass and seed cotton yield. These results are in agreement with the findings of

Hebbar et al. (2007) who found that, seed cotton weight per boll was more with Bt as compared to non-Bt cotton cultivars.

Maturity percentage determines the quality of fiber. The mature fiber has good spinning quality as compared to immature fiber. The results of this study showed that all the four cotton cultivars differed in maturity percentage and that the performance of Bt-121 was better than other cultivars used for comparison. It might be due to the ability of this cultivar to produce medium sized plants and hence, transfer more photosynthates to developing bolls for rapid maturity. A similar variation in fiber maturity percentage was reported by Ahmad (2001) when he compared the fiber properties of newly approved varieties CIM-482 and BH-118 with existing cotton cultivars CIM-443 and CIM-446.

Fiber fineness is associated with diameter of the fiber and the thickness of the fiber wall. The micronaire value determines the spinning quality of cotton varieties. In the present experiment, LSD comparison showed significant differences among four cotton varieties, depicting that BH-162 had maximum fiber fineness as compared to other varieties. A very similar variation in micronaire value of different cotton cultivars had also been reported by Asad et al. (2002), Naveed et al. (2006) and Nisar et al. (2007).

Staple length directly contributes to the quality of yarn. Variation in fiber length was found within a cultivar or even within a single boll. Uniformity in staple length improves spinning performance. The maximum staple length seen in variety VH-162, is in conformity with the results obtained by Azar et al. (1999) and Hussain et al. (2007).

Fiber strength is an important parameter in determining yarn spinning value. High fiber strength is difficult to obtain without sacrificing yield. The LSD comparison revealed that, all the cotton varieties were significantly different from each other with respect to fiber strength. Cultivar VH-144 produced very strong fibers but its seed cotton yield was the lowest indicating that, this quality trait might have been influenced by the yield potential of a cultivar. These results get confirmation with the findings of Asad et al. (2002), Hussain et al. (2007) and Nisar et al. (2007). Seed cotton yield per unit area (ha^{-1}) is formulated by the accumulated effect of various yield components which are affected, in turn by the growing conditions and management practices. Cotton cultivar Bt-121 produced maximum seed cotton yield per hectare which indicates that, this cultivar has demonstrated its better adaptability in arid to semi-arid climatic conditions. Higher proportion of early formed bolls on the lower canopy of Bt-121, may have contributed to higher biomass and seed cotton yield (Hebbar et al., 2007).

These results are also in agreement with the findings of Azar (1984), Asad et al. (2002), Nisar et al. (2007) and Tahira et al. (2007), when they made a varietal comparison for identifying the best performing variety. The increase in yield of Bt cotton could be traced back to, a

significant increase in seed cotton weight per boll at harvest over non-Bt cotton cultivars. Similar increase in this yield contributing character was also reported by many scientists (Biradar et al., 2003; Fitt et al., 1994), Bacheler and Mott (1996), Harris et al. (1996) and Mayee et al. (2004).

Conclusion

From the results of all studied parameters, it was concluded that Bt-121 is the most suitable cotton variety for good quality higher seed cotton yield and is recommended for general cultivation in arid to semi-arid tropics. No doubt BH-162 and CIM-496 yielded fiber with better staple length and fineness but unfortunately, agronomic performance of these cultivars was unacceptable which was likely due to several factors such as, susceptibility to virus infection, lack of ability to exploit a long season environment while tolerating intermittent periods of heat and drought stress. There is also a dire need to screen more genotypes and to verify their usefulness for cultivation in broader agro-ecological zones of the world.

ACKNOWLEDGEMENT

We would like to thank the Directorate of Land Reclamation, Lahore, Punjab, Pakistan; for providing us land, materials and labour to conduct research.

REFERENCES

- Ahmad I (2001). A comparative study of the physical properties and spinning performance of newly approved varieties CIM-482, BH-118 with existing varieties CIM-443, and CIM-446. Master's thesis. University of Agriculture, Faisalabad, Pakistan.
- USDA (2010). Cotton: World Markets and Trade. United States Department of Agriculture, Foreign Agricultural Service, Circular Series. FOP: 01-10.
- Asad MA, Azhar FM, Iqbal Z (2002). Association of yield with various economic traits in *Gossypium hirsutum*. Int. J. Agri. Biol., 4: 105-106.
- Azhar FM, Abid AR, Khan MA (1984). Association of yield with various economic characters in *G. hirsutum*. The Pak Cottons 28: 127-134.
- Azhar FM, Hussain SS, Khan IA (1999). Association of seed cotton yield with other quantitative plant characters of *G. hirsutum*. Pak. J. Biol. Sci., 2(3): 700-701.
- Bacheler JS, Mott DW (1996). Potential utility and susceptibility of transgenic Bt-cotton against bollworms, European corn borer, fall armyworm and stink bugs in North Carolina. In: Proceedings of Beltwide Cotton Conferences held at National Cotton Council, Memphis, TN, USA, pp. 927-931.
- Biradar DP, Hegde M, Nidagund JM (2003). Evaluation of Bt genotypes for bollworms damage. Paper presented at the World Cotton Research Conference-3, Cape Town, South Africa.
- Dahar MH, Soomro ZA, Tunio MA (2007). Evaluation of cotton genotypes using correlation and path coefficient analysis. Life Sci. Int. J., 1: 224-228.
- Fitt GP, Mares CL, Liewellyn DJ (1994). Field evaluation and potential ecological impact of transgenic cotton in Australia. Biocontrol Sci. Tech., 4: 535-548.
- Harris FA, Furr RE, Calboun DS (1996). Cotton insect management in transgenic Bt cotton in Mississippi Delta, 1992-5. In: Proceed. Beltwide Cotton Conference, 2: 854-855.

- Hebbar KB, Perumal NK, Khadi BM (2007). Photosynthesis and plant growth response of transgenic Bt cotton (*Gossypium hirsutum* L.) hybrids under field condition. *Photosynthetica* 45: 254-258.
- Hussain M, Haq AUL, Zameer SI (2007). Evaluation of Agro-qualitative characters of five cotton cultivars (*Gossypium hirsutum* L.) grown under Toba Teik Singh, Pakistan. *Pak. J. Agric. Sci.*, 44: 575-580.
- Khan MA, Sadaqat MA, Khan FA, Ahmad Z (1993). Predicting breeding potential of some cotton strains through their performance in hybrid combination. *The Pak. Cottons* 37: 81-90.
- Mayee CD, Singh P, Punit M, Agarwal DK (2004). Evaluation of Bt transgenic intra *hirsutum* hybrids for yield and fibre properties. *Ind. J. Agric. Sci.*, 74: 46-47.
- Naveed M, Mukhtar N, Farooq J, Ilyas M, Islam NUL (2006). Evaluation of some new strains of *Gossypium hirsutum* L. for seed stability across environments. *J. Agric. Soc. Sci.*, 2: 117-119.
- Nisar GK, Naveed M, Islam NUL, Iqbal MS (2007). Assessment of new upland cotton genotypes (*Gossypium hirsutum* L.) for yield stability and adaptability. *Asian J. Pt. Sci.*, 6: 1012-1015.
- Perlack FJ, Deaton RW, Armstrong TA, Fuchs RL, Sims SR, Greenplate JT, Fischhoff DA (1990). Insect resistant cotton plants. *Biol. Technol.*, 8: 939-943.
- Steel RGD, Torrie JH, Dickny DA (1997). *Principles and Procedures of Statistics, A Biological Approach* (ed. 3rd). McGraw Hill Book Company, NY, USA. pp. 352-358.
- Tahira J, Abro H, Larik AS, Soomro ZA (2007). Performance of different cotton varieties under the climatic conditions of Jamshoro. *Pak. J. Bot.*, 39: 2427-2430.
- Thirtle C, Beyers L, Ismael Y, Piesse J (2003). Can GM-technologies help the poor? The impact of Bt cotton in Makhatini Flats, KwaZulu Natal. *World Dev.*, 31(4): 717-732.