

RESISTANCE OF NEWLY DEVELOPED COTTON GENOTYPES AGAINST INSECTS PESTS COMPLEX

DOI: 10.1515/cerce-2016-0003

Available online: www.uaiasi.ro/CERCET_AGROMOLD/

Print ISSN 0379-5837; Electronic ISSN 2067-1865

Cercetări Agronomice în Moldova
Vol. XLIX, No. 1 (165) / 2016: 29-39**EVALUATION OF INNOVATIVE COTTON
GENOTYPES AGAINST INSECT PEST PREVALENCE,
FIBER TRAIT, ECONOMIC YIELD AND VIRUS
INCIDENCE IN PAKISTAN****H. KARAR^{1*}, M. SHAHID², S. AHAMAD²*** E-mail: haider853@gmail.com

Received August 27, 2015. Accepted: January 26, 2016. Published online: April 08, 2016

ABSTRACT. Cotton (*Gossypium hirsutum*) is known as important commodity globally. The experiment was conducted at Cotton Research Station, Multan, Punjab-Pakistan, to evaluate resistance of nine innovative cotton cultivars against insect pest complex were used along with their fiber traits, economic yield and virus incidence. Population of jassid, whitefly and thrips was recorded by using leaf turn method, bollworms by counting whole fruiting parts (buds, flowers and bolls), virus by counting healthy and virus effected plants per plot, yield of seed cotton was determined by hand harvesting method, while qualitative fiber properties were measured through HVI spectrum-1 (high volume instrumentation) method. Cotton genotype NIAB-Bt-2 is resistant to jassid, whitefly and thrips with maximum GOT, staple length. In case of bollworms, all genotypes are resistant to spotted and american bollworm, except FH-142 and MNH-988. No genotype is resistant to pink

bollworm in leftover bolls. Best yield performance was recorded on FH-142 (2041.54 kg/ha) with minimum CLCuV incidence. Further our research should recognize the share of one pest species on the yield and fiber quality of cotton by managing other pest species to define better management strategies. Our studies concluded that the genotype NIAB-Bt-2 has less insect attack i.e., sucking pest as well as bollworms, virus and other fiber characteristics like GOT, staple length as compared with other cotton genotypes should be recommended for general cultivation and being a resistant germplasm it should be included in breeding program for the development of new cotton strains.

Key words: Whitefly; Jassid; Thrips; Bollworm; Yield; CLCuV; Fiber traits.

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INTRODUCTION

Cotton is a widely considered crop and is the topmost basis of natural fiber globally (Riaz *et al.*, 2013). It occupies a unique location in the agrarian economy of Pakistan. It is chief cash crop and lifeline of the textile industry. To meet increasing fiber demands the adequate production of cotton for ever increasing world's population is now universally realized (Farooq *et al.*, 2013). Production as well as the superiority of the agricultural commodities is affected by both biotic and abiotic stresses of the environment. Among biotic pressures insect pest are responsible for huge crop losses. Among snags, responsible for low yield insect pests are the major yield reducing factors causing losses 30-40% (Haque, 1991) 20-30% (Ahmad, 1999) in cotton. For the control of insect pests farmers depend on the usage of chemical control (Arif *et al.*, 2007), leading to resistance in the insects, ecological contamination and imbalance between biotic fauna in agroecosystem (Soerjani, 1998). Thus, an integrated pest management program, that uses biocontrol agents (Shahid *et al.*, 2007), cultural control especially host plant resistance, with judicious use of insecticides, is needed for sustainable management of arthropod pests (Hallett *et al.*, 2009). Cotton pest management has always been an immeasurably challenging task for entomologists all over the

world. So it is very important to overcome the incidence of insect pests attack in order to fulfill the food and clothing requirements of the country. One of the most promising way to increase cotton production is to grow insect resistant varieties, which is most effective, economical, and environment friendly tactics (Pedigo, 1989). Host plant resistance is an effective tool for controlling insect pest and is the key component of integrated pest management, because it enables plants to avoid tolerate or recover from the effects of insect pest attack (Painter, 1951; Tingey, 1986; Pedigo, 1996). The practical application of insect pest control via host plant resistance is increasing day by day, particularly due to food protection alarms of World Trade Organization (Al Chaabi *et al.*, 2000). With the introduction of transgenic varieties of different crops, incidence of lepidopterous pests has been controlled, now problem is of sucking insect pest attack on cotton (Kranthi *et al.*, 2005).

Keeping in view the importance of cotton genotypes the present project was planned to evaluate resistance in cotton varieties against sucking insect pest, virus incidence, yield potential, fiber characteristics of transgenic germplasm, in the best interest of growers, ginners community and country. Further screened genotypes will be the guide line for the breeders for the selection of the best parentage.

MATERIAL AND METHODS

Nine cotton promising genotypes viz. VH-327, FH-326, FH-142, NIAB-Bt-2, IBU-63, AGC-Nazeer, AA-926, MNH-988 and FH-Noor were sown on 27.05.2014 at Cotton Research Station, Multan, Pakistan, under randomized complete block design (RCBD) under three replications. The net plot size was 20' x 10' and the distance between rows were 75 cm and plants were 30 cm, respectively. The recommended field practices were conducted.

Data on population of sucking pests. Population of jassid (adults and nymphs), whitefly (adults) and thrips (adults and nymphs) per leaf was recorded early in morning at weekly intervals starting from July 24 to September 18, 2014. Fifteen leaves from each plot was randomly selected from fifteen different plants. These leaves were observed in such a sequence that first leaf from upper one third of the first plant, second leaf from middle of the second plant and third leaf from the lower portion of the third plant (Karar *et al.*, 2013) and so on. The average population/leaf of sucking pest

for each genotype was calculated by the simple arithmetic means using the following formula:

$$X = \frac{X1 + X2 + X3 + \dots + X14 + X15}{N}$$

where N = Total numbers of leaves, X = Mean leaves⁻¹, and X1+X2+X3+...+X14+X15 = Number of observed leaves.

Population of spotted and American bollworms. The population of spotted, american and pink bollworms larvae were recorded from ten plants per plot selected at random. Further rosette flowers were recorded weekly. Average population per plant was calculated by the simple arithmetic means using the formula given above.

Population of pink bollworms. The population of pink bollworm larvae in the left over bolls was recorded by plucking the total left over bolls from each plot and was kept in lab for 3-4 days. After such period the bolls were opened with knife and count the pink bollworm larvae. Percent larvae was calculated by the formula:

$$\% \text{ damage} = \frac{\text{Number of bolls with pink bollworms}}{\text{Total bolls}} \times 100$$

Application of pesticides. The crop was sprayed regularly with insecticides on recommended dose, when the populations of the sucking pest increase above the ETL level.

Yield. The total yield was recorded from each genotype kept separately and weighed. Then convert it in to per hectare yield by maintaining plants population.

Cotton leaf curl virus (CLCuV) incidence. The incidence of cotton leaf curl virus (CLCuV) was known by counting all healthy and affected plants/plot throughout the season. The virus percentage was calculated through the formula:

$$\text{Virus percentage} = \frac{\text{Virus infested plants}}{\text{Total number of plants}} \times 100$$

Fiber characteristics. The seed cotton was picked carefully on full maturity of the crop and dried under the sun shine. After which one samples was taken from each repeat of each genotype. These

samples were ginned by experimental small ginning machine. The ginning out turn percentage was calculated by following formula:

$$\text{Ginning out turn (GOT)\%} = \frac{\text{Lint weight}}{\text{Weight of seed cotton}} \times 100$$

An amount of 40 grams of lint from each sample was taken in a paper envelope signifying the name of genotype and ginning number on envelope and sent to fiber testing laboratory of CRS, Multan, for the fiber quality analysis i.e., GOT (%), staple length (mm), fiber fineness (micro g/inches), staple strength (G tex⁻¹), and fiber strength (G/tex) on machine HVI spectrum¹ (Manufacturer Uster Company made in USA).

Determination of yield components. The yield of seed cotton from all tested genotypes was determined by hand harvesting method for the total yield comparison of each genotype. Seed cotton sub samples (250 g) from each genotype were ginned with 12-saw laboratory gin to determine the lint GOT. Qualitative fiber properties were measured using the high volume instrument (HVI) method (Sasser, 1981).

Statistical analysis. The data were subjected to analysis of variance (ANOVA) using Statistix software (release 8.1; Lawes Agricultural Trust Rothamsted Experimental Station, Rothamsted, UK). The means were separated by Tukey's HSD (Honestly Significant Differences).

RESULTS

Cotton genotypes played a significant role on the population of sucking insect pest of cotton. The genotype AGC-Nazeer, IBU-63,

FH-Noor and FH-142 has maximum attack of jassid per leaf i.e., 0.93, 0.91, 0.87 and 0.87 and are statistically at par with each other and shows susceptible response towards jassid. The genotype FH-326 having 0.60 jassid per leaf and are statistically similar to MNH-988 (0.47), AA-926 (0.40). The genotype NIAB-Bt-2 has minimum attack of jassid per leaf i.e., 0.32 per leaf and is considered resistant (*Table 1*).

It was found that the maximum number of whitefly was recorded on FH-NOOR having 7.33/ leaf statistically similar to genotypes IBU-63 having 6.47 whitefly per leaf, followed by VH-327 (5.53/leaf). The genotypes MNH-988 having 3.87 whitefly/leaf statistically similar to FH-142 (3.60), AGC-Nazeer (3.27) and FH-326 (2.60), followed by AA-926 (2.40) population of whitefly/leaf having intermediate response. The genotype NIAB-Bt-2 having minimum population of whitefly/leaf i.e., 0.67. It was found that the maximum number of thrips was recorded on MNH-988 and FH-Noor having 6.93 and 6.00/leaf, followed by VH-327 (3.33/leaf), which is statistically similar to IBU-63 and AGC-Nazeer with 2.07, 1.87 thrips /leaf. The genotypes FH-142

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(0.67) and FH-326 (0.61) having statistically similar population, followed by NIAB-Bt-2 (0.29) population of thrips/leaf. The genotype AA-926 having minimum population of thrips/leaf i.e., 0.20.

Table - 1 Mean population of sucking and bollworm insect pest on tested genotypes of cotton

Genotypes	Jassid	Whitefly	Thrips	Spotted	American	PBW rosette Flowers	Pink bollworm in left over bolls
	Mean± SE	Mean± SE	Mean± SE	Mean± SE	Mean± SE	Mean± SE	Mean± SE
VH-327	0.47 ± 0.02 bc	5.53 ± 0.16 b	3.33 ± 0.04 b	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	66.67 ± 2.45 a
FH-326	0.60 ± 0.01 b	2.60 ± 0.07 cd	0.61 ± 0.02 cde	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	64.29 ± 2.58 a
FH-142	0.87 ± 0.02 a	3.60 ± 0.16 cd	0.67 ± 0.09 cde	0.33 ± 0.01 a	0.00 ± 0.00	0.00 ± 0.00	67.00 ± 2.36 a
NIAB-Bt-2	0.32 ± 0.02 c	0.67 ± 0.04 e	0.29 ± 0.09 de	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	34.00 ± 1.94 b
IUB-63	0.91 ± 0.04 a	6.47 ± 0.18 ab	2.07 ± 0.07 bc	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	75.00 ± 1.72 a
AGC-Nazeer	0.93 ± 0.05 a	3.27 ± 0.03 cd	1.87 ± 0.04 bcd	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	78.72 ± 0.85 a
AA-926	0.40 ± 0.01 bc	2.40 ± 0.09 d	0.20 ± 0.02 e	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	38.46 ± 1.08 b
MNH-988	0.53 ± 0.02 bc	3.87 ± 0.06 c	6.93 ± 0.20 a	0.00 ± 0.00 b	0.33 ± 0.19	0.00 ± 0.00	70.00 ± 2.13 a
FH-Noor	0.87 ± 0.02 a	7.33 ± 0.33 a	6.00 ± 0.28 a	0.00 ± 0.00 b	0.00 ± 0.00	0.00 ± 0.00	41.67 ± 0.81 b
Tukey HSD	0.24	1.37	1.62	0.28	Ns	ns	17.43

In case of bollworms, only FH-142 has 0.33 larvae of spotted/plant. Similarly, in case of american bollworm MNH-988, have 0.33 larvae/plant, statistically similar to all other genotypes having zero larvae/plant. In case of PBW, no rosette flowers were recorded on genotypes of cotton.

It was found that the maximum number of pink bollworms larvae were recorded in left over bolls of genotypes AGC-Nazeer (78.72), IBU-63 (75.00) MNH-988 (70.00), FH-142(67.00), VH-327 (66.67) and FH-326 (64.29), which are statistically similar and followed by FH-Noor (41.67, AA-926 (38.46) and NIAB-Bt-2 (33.99).

The maximum and statistically similar GOT was recorded in IUB-63, FH-142, AA-926, AGC-Nazeer, MNH-988, NIAB-Bt-2, FH-326, and FH-Noor i.e., 44.90, 44.10, 44.10, 43.0,

42.10, 41.70, 41.30, 41.10 and 40.30%. The minimum percent GOT was recorded in VH-327 i.e., 37.0% as shown in Fig. 1.

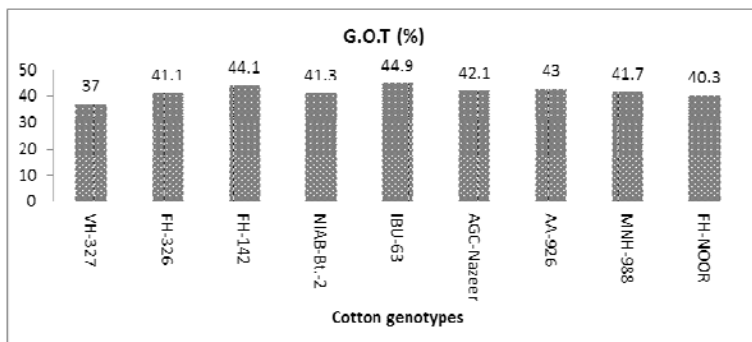


Figure 1 - Graphical presentation regarding yield of tested cotton cultivars

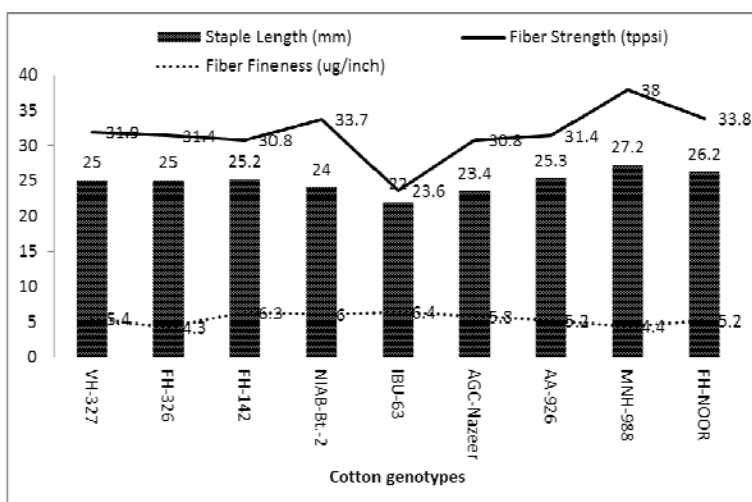


Figure 2 - Graphical presentation regarding staple length, fiber strength, fiber fineness of tested cotton cultivars

The maximum staple length was recorded in MNH-988 i.e., 27.20 mm statistically, similar to FH-Noor, AA-926, FH-142, VH-327 and FH-326 i.e., 26.20, 25.30, 25.20, 25.0 and 25, followed by NIAB-Bt-2 having 24.0. The minimum staple length was

recorded in IUB-63 i.e., 22 mm. The maximum fiber fineness was recorded in IUB-63 and FH-142 i.e., 6.40 and 6.30 ug/inch statistically, similar to NIAB-Bt-2 and AGC-Nazeer having 6.0 and 5.80 ug/inch, followed by VH-327, AA-926 and FH-Noor

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having 5.40, 5.20 and 5.20. The minimum fiber fineness was recorded in FH-326 i.e., 4.30 ug/inch. The maximum fiber strength was recorded in MNH-988 i.e., 38.00 (G Tex⁻¹), followed by FH-Noor, NIAB-Bt-2, VH-327, AA-926, FH-326, FH-142

and AGC-Nazeer, having 33.80, 33.70, 31.90, 31.40, 31.40, 30.80 and 30.80 G Tex⁻¹. The genotypes IUB-63 having 23.60 G Tex⁻¹ have minimum fiber strength (G Tex⁻¹) (Fig 2)

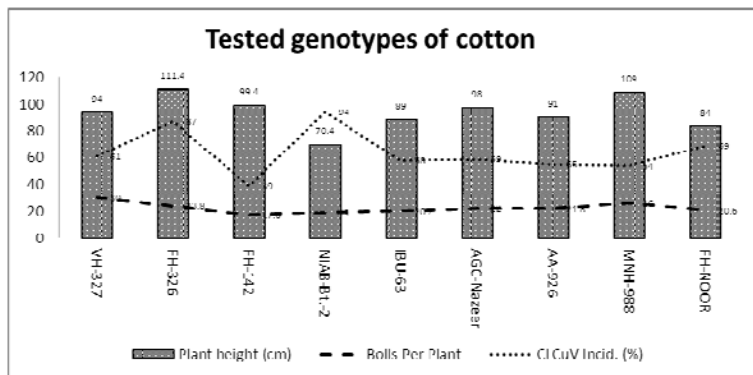


Figure 3 - Graphical presentation regarding plant height, bolls per plant and CLCuV incidence of Bt genotypes of cotton

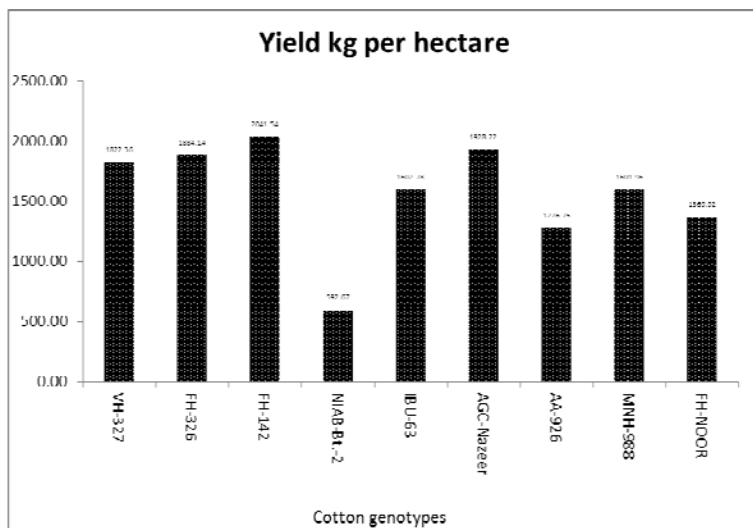


Figure 4 - Graphical presentation regarding yield of tested cotton genotypes

The maximum plant height in were recorded in FH-326 and MNH-988 i.e., 111.40 and 109.00 cm,

followed by FH-142, AGC-Nazeer, VH-327 and AA-926 i.e., 99, 98, 94 and 91 cm, followed IUB-63 having

89 cm. The genotype FH-Noor has 84 cm height. The minimum height was recorded in NIAB-Bt-2 i.e., 70.40. High numbers of bolls were recorded in VH-327 and MNH-988 i.e., 30 and 26 /plant. High infestation of CLCuV was recorded NIAB-Bt-2 having 94% and minimum 39% on FH-142 (Fig 3).

The seed cotton yield of tested genotypes ranged from 592.67 kg/ha to 2041.54 kg ha⁻¹. The maximum yield was recorded in FH-142 i.e., 2041.54 kg ha⁻¹ statistically similar to AGC-Nazeer, FH-326 and FH-327 with 1928.22, 1884.14 and 1822.37 kg ha⁻¹, followed by IBU-63 and MNH-988 with 1602.78 and 1601.96 kg ha⁻¹. The genotypes FH-Noor (1369.92) and AA-926 (1276.75) gave statistically similar yield. The minimum yield was recorded in NIAB-Bt-2 i.e., 592.67 kg ha⁻¹ as shown in (Fig 4).

DISCUSSION

Resilient genotypes are one of the critical components determining the success of the Integrated Pest Management (IPM). Selection germplasm against insect pest complex and to identify good quality is vital for increasing yield and value of the agricultural produce. This paper describes the insect pest incidence, fiber quality, virus and yield, on advanced transgenic Bt genotypes of cotton in Pakistan. From a practical standpoint it helps in understanding farmer complaints related to susceptibility

of transgenic Bt cotton varieties toward the incidence of insect pests complex. By the use of resistant cultivars, helpful in the reduction of broad-spectrum insecticides would result in conservation of non-target organisms, natural enemies, decrease soil and water contamination, and bring health benefits to the farm workers and others who come in contact with these insecticides (Krattiger, 1997). Our result suggests that there is variation among various cotton genotypes regarding insect pest attack. The study indicated that the NIAB-Bt-2 is resistant to jassid, whitefly and thrips. All the genotypes proved resistant against bollworm, except FH-142 has spotted bollworm and MNH-988 has american bollworm. No genotypes were resistant to pink bollworm in leftover bolls. The present findings are inconformity with the results of Karar *et al.* (2012), who reported that variation of resistance levels is varied against sucking pests in crops genotypes. For example, aphid attack on pecan cultivars, so cultivar selection is an important decision for lower level of aphids requires fewer aphicides. Various researchers, such as Karar *et al.* (2013) worked on onion genotypes, Babar *et al.* (2013) and Shahid *et al.* (2015) on cotton cultivars, Karar *et al.* (2015) on mango cultivars and found that there is variation among resistance levels among different crops. Among other investigators Nath *et al.* (2000), Shad *et al.* (2001) and Amjad *et al.* (2009) reported that differences of resistance

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levels is different cotton genotypes against sucking pests complex. Further our results suggest that the maximum GOT was recorded in IUB-63, FH-142, AA-926, AGC-Nazeer, MNH-988, NIAB-Bt-2, FH-326, and FH-Noor and maximum staple length was recorded in MNH-988. Similarly, maximum fiber fineness was recorded in IUB-63 and FH-142 and maximum fiber strength was recorded in MNH-988. The maximum plant height in cm was recorded in FH-326 and MNH-988. High number of bolls was recorded in VH-327 and MNH-988 and the maximum yield was recorded in FH-142. Nearly similar results were found by Trebuil *et al.* (1993), who found such differences in G.O.T %, fiber strength (Faircloth, 2007), fiber fineness (Copur, 2006; Ehsan *et al.* 2008) and lint (Munk and Kurby, 1993) in different cotton genotypes.

CONCLUSION

Our consequences concluded that NIAB-Bt-2 is resistant to sucking insect pests like Jassid, whitefly and thrips while the genotypes FH-142 and AGC-Nazeer gave maximum yield. Less CLCuV was recorded on genotype FH-142. Moreover it was concluded that IUB-63 has more GOT%, MNH-988 has more staple length, FH-142 and IUB-63 has good fiber fineness, more fiber strength was recorded in FH-Noor. So fiber characteristics are the most important, should be considered important while devising a successful breeding

program of cotton to increase seed cotton yield.

Acknowledgements. Current studies were conducted at Cotton Research station Multan-Punjab Pakistan with the coordination of Cotton botanist, Multan, Government of the Punjab, Agricultural Department.

REFERENCES

- Ahmad Z., 1999** - Pest problems of cotton. A Regional Perspective. Proc. Regional Consultation, Insecticide Resistance Management in Cotton. Pakistan Central Cotton Committee, Pakistan, pp. 5-21.
- Al Chaabi S., Darwech A.R., Esmael F., Mando J., Numan S., Matrod L., Al Saleh A., Aswad F., 2000** - Assessment of the phytosanitary status of stone fruit trees and grapevine in Syria. Arab Journal of Plant Protection, 18(1): 17-23.
- Amjad M., Bashir M.H., Afzal M., 2009** - Comparative resistance of some cotton cultivars against sucking insect pests. Pak. J. Life Soc. Sci., 7:144-147.
- Arif M.J., Abbas G., Saeed S., 2007** - Cotton in danger, p: 4. Dawn, The Internet Edition (<http://DAWN.com>), March 24th, 2007.
- Babar T.K. Karar H., Hasnain M., Shahazad M.F., Muhammad Saleem M., Ali A., 2013** - Performance of some transgenic cotton cultivars against insect pest complex, virus incidence and yield Pak. J. Agri. Sci., 50(3), 367-372.
- Copur O., 2006** - Determination of yield and yield components of some cotton cultivars in semiarid conditions. Pak. J. Biol. Sci., 9(14): 2572-2578.
- Ehsan F., Ali A., Nadeem M. A., Tahir M., Majeed A., 2008** - Comparative yield performance of new cultivars of

- cotton (*Gossypium hirsutum* L.). Pak. J. Life Social Sci., 6(1): 1-3.
- Faircloth J. C., 2007** - Cotton variety trials. Virginia cotton production guide. Virginia Polytechnic Inst. and State Univ. Coop. Ext. Publ. 424-300. Virginia Polytechnic Inst. State Univ., Blacksburg. pp.8-15.
- Farooq J., Anwar M., Riaz M., Mahmood A., Farooq A., Iqbal M.S., Iqbal M.S., 2013** - Association and path analysis of earliness, yield and fiber related traits under cotton leaf curl virus (CLCuV) intensive conditions in *G. hirsutum* L. Plant Knowledge Journal, 2(1): 43-50.
- Hallett R.H., Mao C., Sears M.K., Shelton A.M., 2009** - Insecticide management strategies for control of swede midge (Diptera: Cecidomyiidae) on cole crops. J. Econ. Entomol., 102(6): 2241-2254.
- Haque H., 1991** - Imported generic pesticides need to be checked before marketing. PAPA (Pakistan Agriculture Pesticides Association) Bulletin. pp. 16-17.
- Karar H., Abbas G., Dutcher J.D., 2012** - Pecan cultivar Differences in Aphid Reproduction and Abundance. J. Entomol. Sci., 47(1):86-91.
- Karar H., Babar T.T., Shahzad M.F., Saleem M., Ali A., Akram M., 2013** - Performance of novel vs. traditional insecticides for the control of *Amrasca biguttula biguttula* (Hemiptera, Cicadellidae) on cotton. Pak. J. Agri. Sci., 50(2), 223-228.
- Karar H., Abbas G., Hameed A., Shahzad M.F., Ahmad G., Ali A., Saleem M., 2013.** Relative susceptibility of onion (*Allium cepa*) genotypes of Pakistan to onion Thrips (*Thrips tabaci*) (Thysanoptera: Thripidae). Pak. J. Agri. Sci., Vol. 50(3), 351-357.
- Karar H., Arif M. J., Arshad M., Ali A., Abbas Q., 2015** - Resistance/ susceptibility of different mango cultivars against mango mealybug (*Drosicha mangiferae* G.). Pak. J. Agri. Sci., 52(2), 367-377.
- Kranthi K.R., Kranthi S., Rameash K., Nagrare V.S., Barik S., 2005** - Advances in cotton IPM (Technical Bulletin) Central Institute for cotton Research Post Bag No. 2, Shankar Nagar, PO, Nagpur (MS), India.
- Krattiger A.F., 1997** - Insect resistance in crops: a case study of *Bacillus thuringiensis* (Bt) and its transfer to developing countries. ISAAA Briefs, 2: 42.
- Munk D.S., Kerby T.A., 1993** - Acala cotton varietal response to late season water stress. Proc. Cotton Conf. ,1340-1341.
- Nath P., Chaudhary O.P., Sharma P.D., Kaushik H.D., 2000** - Studies on incidence of important insect pests of cotton with special reference to desi-cotton. Indian J. Entom., 62 (4): 391-395.
- Painter R.H., 1951** - Insect Resistance in Crop Plants. Lawrence: University of Kansas Press, N.Y.
- Pedigo I.P., 1989** - Entomology and Pest Management. Prentice Hall of India (Pvt.) Ltd. New Delhi-110001, 413 p.
- Pedigo L.P., 1996** - Plant resistance to insects. In: Entomology and pest management. Prentice hall of India Private Limited, New Delhi, pp. 413-424.
- Riaz M., Naveed M., Farooq J., Farooq A., Mahmood A., Rafiq Ch. M., Nadeem M., Sadiq A., 2013** - AMMI analysis for stability, adaptability and GE interaction studies in cotton (*Gossypium hirsutum* L.). J. Anim. Plant Sci., 23(3): 865-871.
- Sasser P.E., 1981** - The basics of high volume instrumentation for fiber testing, pp..191-193. In: Proc. Beltwide Cotton Prod. Res. Conf., New Orleans, LA 4-8 Jan.1981, Natl. Cotton Council. Am., Memphis, TN.
- Shad S.A., Waseem A., Rizwan A., 2001** - Relative response of different cultivars of cotton to sucking insect

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- pests at Faisalabad. Pak. Entomol., 23(1/2): 79-81.
- Shahid M.R., Farooq J., Mahmood A., Iqbal M.S., Mahmood K., Abbas H.G., 2015** - Economic yield, fiber trait and sucking insect pest incidence on advanced genotypes of cotton in Pakistan. Cercetări Agronomice în Moldova, Vol. XLVIII, No. 1 (161), Iași, Romania.
- Shahid M.R., Suhail A., Arif M.J., Gogi M.D., Shahzad M.A., Hussain S., 2007** - Effectiveness of *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae) against sugarcane stem borer (*Chilo infuscatellus* Snellen) (Lepidoptera: Pyralidae). Pak. Entomol., 29(2):141-146.
- Soerjani M., 1998** - Current trend in pesticide usage in some Asian countries. Reviews of Applied Entomology, 77: 219-234.
- Tingey W.M., 1986** - Techniques for evaluating plant resistance to insects. In: Insect-plant interactions. (Eds): Miller, J.R., T.A. Miller and M. Berenbaum), Vol. 9, Springer-Verlag, New York. pp. 251-284.
- Trebuil G., Weerathawon P., Nguyen T.B., 1993** - Preliminary evaluation of promising IRCT glandless cotton varieties in Thailand. Kasetsart J. Sci., 27(4): 484-493