

Review of Cotton Leaf Curl Virus (CLCuV) along-with its strains (CLCuMuV and CLCuBuV)

Hamza Rafiq

Keywords: Cotton Leaf Curl Virus, CLCuMuV, CLCuBuV, Cotton Production of Pakistan, Historical prospective, Multan Epidemic, burewala Epidemic.

Abstract

Cotton produces exceptional quality fiber which has prime importance in textile industry. As the textile industry expanded cotton industries started running side by side for which substantial factor is sustainable cotton production. To follow through, the related diseases were studied thoroughly, especially Bacterial Blight and Cotton Leaf Curl Virus. A viral disease of genus Begomovirus has been intractable for the last 3-4 decades. CLCuV is bipartite and 18-20nm in diameter and 30nm in length. It attacks on the leaves causing curling and enation type symptoms which decreases seed size thus declining fiber quality. Virus has different strains like CLCuV-Alabad, Bangalore, Gezira, Kokhran/Burewala, Multan. In region like Indo-Pak Subcontinent, Multan and Burewala strains are in possession. It was first reported in Africa, a century ago but even then, causes pandemic losses in Pakistan & India.

In Pakistan, during early 1990s, farmers got bumper crop with 12.4 million bales production but three years later (1994), this production reduced to 7.9 million bales due to CLCuV (Multan epidemic). To accomplish the loss researchers of Central Cotton Research Institute, Multan (CCRI) put their efforts and succeeded to cross records in 2004 by producing 14.5 million bales. After a decade in 2013-14 (Burewala-epidemic), new viral strain broke resistance of every available germplasm which lead towards a drastic decline in yield. This strain was recombinant of CLCuMuV and CLCuKoV. The varieties like CIM-1100, CIM-448, VH-53 and MNH-554 were resistant against CLCuMuV were inevitable by its attack. For sustainable cotton yield solution after resistant variety development was to kill its vector (*Bemisia tabaci*). Imidacloprid+Acetameprid insecticides produced brilliant results when applied in early morning. Destroying alternate host and burning of previous crop stubbles also effectively manage CLCuV. Following the future perspectives, breeders can also consider *Gossypium herbaceum* and *Gossypium arboreum* as resistant germplasm sources for CLCuV new strain.

Introduction

Cotton which is now used widely in textile industry have a very enormous historical background. Since, 6000 B.C., cotton is used as a lint fiber which now dominates the textile industry of today (Mehboob-ur-rehman, 2011). Cotton was sown, grown and woven into clothes since 3000 B.C. in Indus River Valley of Pakistan (Malik & Ahsan, 2016). Arab sellers transported cotton prepared clothes to Europe for vending during 800 A.D (Rehman et al., 2017). Columbus discovered America in 1492 and came to know that cotton was grown on Bahama Island. Till, 1500 every country in the world recognize cotton crop and fiber woven clothes.

History

Cotton produces brilliant quality fiber which has key importance in textile industry for hundreds of years. As the textile industry extended cotton industries started running side by side for which substantial factor is sustainable cotton production (Malik & Ahsan, 2016). To follow through the diseases of cotton were deeply studied. These diseases embrace different microbial diseases i.e. fungal, bacterial and viral diseases. Some of the most important diseases are Bacterial blight of Cotton, Cotton Leaf Curl Virus (CLCuV) etc. in different countries of the world Cotton Leaf Curl Virus (CLCuV) is the promising threat for cotton production. CLCuV was first reported and testified in 1912,

in Nigeria (Kirkpatrick, 1931). Later, it spread throughout the World like Philippines and Pakistan in 1959 and 1967 respectively. At that time, it was not fetched into superior interest up until 1992 (Briddon and Markham, 2001). Hence in 1992, it causes massive losses of equal to 2 million bales. Thus, it is believed to be the most dangerous risk to cotton production.

Cotton Leaf Curl Disease

Cotton leaf curl disease is a viral disease of genus Begomovirus (Bean Golden Mosaic Virus) and family Geminiviridae. Virus transmitted through White fly (*Bemisia tabaci*) vector and overwinter on substitute host (Humza et al., 2016). This virus has been intractable for the last three to four decades and caused losses of Million and Billions of bales all over the year. This virus had 2.8 kilo bases with bipartite in nature. It had 18-20 nm in diameter with length of 30nm. It outbreaks on the chlorophyll rich areas of the leaf i.e. leaf begins curling, veins become thickened with small cup-shaped structure on the lower side of leaf which is known as enation (Zafar et al., 1997) (Figure 1, 2 & 3). Owing to these seed size decreases which outcome in less oil production and declining of the fiber quality.



Figure 1 Cup-shaped enation on the lower side of leaf



Figure 2 Thickening of veins due to Cotton Leaf Curl Infection



Figure 3 Leaves shows upward or downward curling because of CLCuV attack

Strains

Cotton leaf curl virus (CLCuV) have different strains in different regions of the world. Cotton Leaf Curl Multan Virus (CLCuMuV), Cotton Leaf Curl Bangalore Virus (CLCuBaV), Cotton Leaf Curl Kokhran Virus / Cotton Leaf Curl Burewala Virus (CLCuKoV / CLCuBuV), Cotton Leaf Curl Gezira Virus (CLCuGeV) and Cotton Leaf Curl Alabad Virus (CLCuAIV) are some of the most significant strains of Begomovirus. In regions like Indo-Pak Subcontinent,

Name: Hamza Rafiq

Afiliation: University of Agriculture, Pakistan

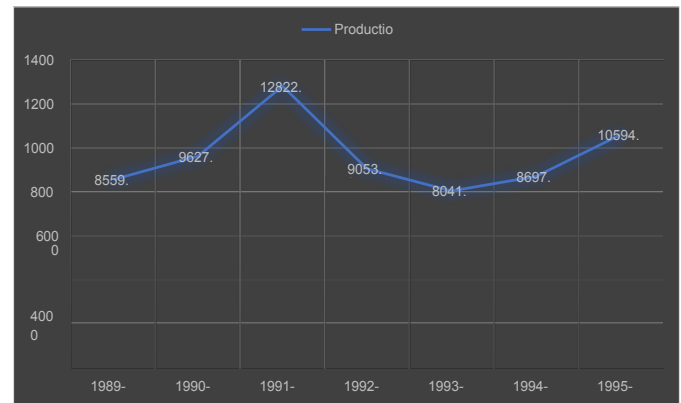
Email: hamzaraqiq463@gmail.com

Multan and Burewala strains are in Possession. First case of Cotton Leaf Curl Virus reported a century back but even then, it causes pandemic losses in Pakistan and India. These all strains are important but with respect to cotton crop, 2 strains are most important, Cotton Leaf Curl Multan Virus (CLCuMuV) and Cotton Leaf Curl Burewala Virus (CLCuBuV) (Hassan et al., 2016).

Emergence of Multan Strain and Multan Epidemic

In early periods of epidemic of CLCuD in Pakistan there were 2 epidemics triggered due to this virus. Where 1st is the Multan epidemic. During early 1990s, the cotton production of Pakistan was at the peak of that time. Production of Cotton in Pakistan during 1991-1992 was 12.8 million bales (Table 1). Then in 1994, first epidemic of cotton leaf curl disease started which lead to decline of cotton production which is 8.04 Million bales (Table 1) (Figure 4). That was the worst condition for Pakistan textile industry which is recognized to be one of the best in the world. This pandemic was due to Cotton Leaf Curl Multan strain. This strain was associated with different monopartite begomoviruses, Cotton Leaf Curl Multan Virus (CLCuMuV), Cotton leaf curl Kokhran Virus (CLCuKoV) and Cotton Leaf Curl Alabad Virus (CLCuAIV) (Hassan et al., 2016). This reasons in pandemic losses in Pakistan as well as India.

These losses were overcome in Pakistan by the introduction of CLCuV tolerant genes in different varieties of Cotton against virus i.e. CIM-240 and MNH-147 which were produced and released by scientists working at CCRI, Multan and CRS, Multan respectively. Due to these tolerant genes, the cotton production started to increase and touched its ultimate value at the end of this pandemic season.



Scientists were able to get minimum losses and yield increases up to 8 to 11.4 million bales between next seasons of epidemic which were great comparing to previous pandemic years. Here comes the year 2004-05, which could be identified as the bumper year for cotton production. In this year cotton production was at its maximum limit which is 14.2 million bales. But Cotton leaf curl virus complex is in a state of continuous change. These changes could be either through any type of mutation or through recombination or transformation from environment. Through these processes, it changed its genetic makeup and broke the resistance against CLCuMuV. Now, the 2nd wave of epidemic started in next season which is known as Burewala Epidemic.

Year	Area	Production	Yield
1967-68	1785.0	3043.1	290
1968-69	1745.4	3101.7	302
1969-70	1755.5	3148.7	305
1970-71	1733.3	3189.1	314
1971-72	1957.6	4159.4	360
1972-73	2010.0	4125.6	350
1973-74	1844.8	3871.7	360
1974-75	2031.1	3728.6	314
1975-76	1851.6	3020.5	277
1976-77	1864.7	2557.3	233
1977-78	1843.2	3380.0	312
1978-79	1891.2	2782.6	250
1979-80	2081.0	4282.0	350
1980-81	2108.5	4201.0	339
1981-82	2214.1	4398.3	338
1982-83	2262.9	4843.9	364
1983-84	2220.7	2907.7	223
1984-85	2241.6	5930.4	450
1985-86	2364.1	7154.5	515
1986-87	2505.2	7759.7	527
1987-88	2567.8	8632.9	572
1988-89	2619.4	8385.1	544
1989-90	2598.5	8559.8	560
1990-91	2662.2	9627.7	615
1991-92	2835.5	12822.2	769
1992-93	2835.9	9053.8	543

1993-94	2804.6	8041.1	488
1994-95	2652.8	8697.1	557
1995-96	2997.3	10594.9	601
1996-97	3148.6	9304.8	503
1997-98	2959.7	9183.8	528
1998-99	2922.8	8790.2	512
1999-00	2983.1	11240.0	641
2000-01	2927.5	10731.9	624
2001-02	3115.8	10612.6	579
2002-03	2793.6	10210.6	622
2003-04	2989.3	10047.7	572
2004-05	3192.6	14265.2	760
2005-06	3103.0	13018.9	714
2006-07	3074.8	12856.2	711
2007-08	3054.3	11655.1	649
2008-09	2820.0	11819.0	713
2009-10	3105.6	12913.4	707
2010-11	2689.1	11460.1	725
2011-12	2834.5	13595.0	816
2012-13	2878.8	13030.7	770
2013-14	2805.7	12768.9	774
2014-15	2961.4	13959.6	802
2015-16	2901.9	9917.4	581
2016-17	2488.9	10670.6	729
2017-18	2700.3	11945.6	752

Sources: Table 1 Area, Production and Yield of Cotton in Pakistan from 1968-2018

*MINFAL

*Agriculture Statistics of Pakistan 2011-12

*Agriculture Statistics of Pakistan 2019-20

*According to the statistics of Pakistan Cotton Ginners Association the production of cotton during year 2018-19 is 10,777,818 bales.

Emergence of Burewala Strain and Burewala Epidemic

Next wave of epidemic arises due to emergence of new strain of virus which is known as Cotton Leaf Curl kokhran virus Burewala (CLCuKoV-Bur) which was Cotton leaf curl Burewala virus (CLCuBuV) in previous years. This virus strain has its 2 sequences from 2 different viruses. one is from Cotton leaf curl Kokhran Virus (CLCuKoV) in orientation of Virion-Sense genes while the other one is from the Cotton Leaf Curl Multan Virus (CLCuMuV) in orientation of genes of complementary-sense (Saleem et al., 2016). These both viruses were the cause of the prior epidemic. Appearance of this strain was even worse than the previously available virus strain. This resulted in the decline of production from

14.5 million bales in 2005 to 11.6 million bales in 2007-08 (Table 1) (Figure 5). Because of the combination of two resistant viruses there is no tolerant or resistant variety available against this burewala strain (Mahmood et al., 2003). That's why this virus create even worse epidemic than the previous years.

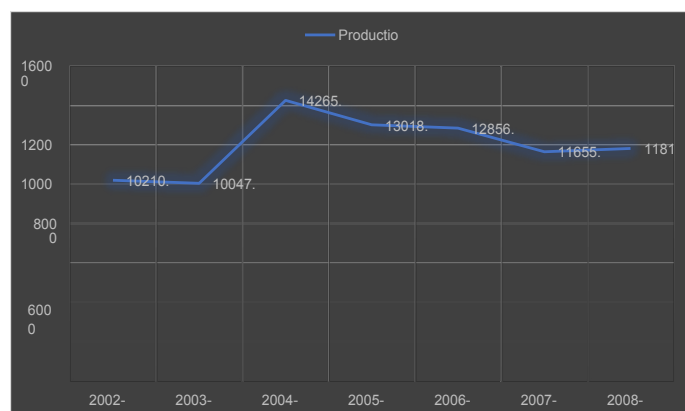


Figure 5 Production Decrease due to Cotton Leaf Curl Burewala Virus

Management

To overcome these epidemics, scientists are working to manage Cotton Leaf Curl virus. The most productive and inexpensive technique in this regard is to produce resistant varieties. Resistance for white fly is most effective in this regard because if white fly attack is low then virus will not be able to spread to neighboring fields (Malik et al., 2016). The wild *Gossypium* species are most effective against Insect and diseases. *G. tomentosum*, *G. thurberri* and *G. raimondii* are being used to create resistant for white fly (main vector for CLCuD spread). In CLCuD, virus overwinter on the alternative host like *lehl*, *Datura* etc. These weeds act as the source of primary inoculum and white fly spread the disease by using these inoculum

sources. Eradication of weeds may act as a management activity because in this way white fly doesn't have inoculum to spread. Use of systemic insecticides before sowing help the plant in early days i.e. 50-60 days of sowing. Even if disease appear in later stage the severity of disease will be low. If incidence of disease again starts, another spray of Insecticide can be useful to kill white fly (Smalling et al., 2013). Application of different type of nutrient also help the plant to overcome severe stage of infection. These nutrients include Nitrogen (N) and Potassium (K) (Iqbal, et al., 2014).

All these management techniques are effective to control the appearance of Cotton Leaf Curl Infection and help increase productivity.

Conclusion

Cotton is the most important crop of Pakistani Textile Industry. CLCuV is the most important disease of cotton crop because it caused losses from 22.38-68.5%. CLCuV have different strains including most severe strains i.e. Cotton Leaf Curl Multan Virus and Cotton Leaf Curl Burewala Virus. There are some tolerant varieties available against CLCuMuV but there is not a single variety resistant against CLCuBuV. Wild cotton species are the resistant sources of CLCuV. Other management techniques include eradication of stubbles and weeds, application of Nutrients like Nitrogen and Potassium, seed treatment with insecticides and Application of Insecticides after white fly attack. All these methods are effective against controlling of CLCuV.

References

- Mehboob-ur-rehman, T. Shaheen, N. Tabbasum, M.A. Iqbal, M. Ashraf, Y. Zafar and A.H. Paterson.
2011. Cotton genetic resources. A review. *Agron. Sustain. Dev.*
- Malik, T.H. and M.Z. Ahsan. 2016. Review of cotton market in Pakistan and its future prospects.
- OCL, DOI: 10.1051/ocl/2016043
- Rehman, M., Khan, A.Q., Rehman, Z., Iqbal, M.A., and Zafar, Y. 2017. Genetics and genomics of cotton leaf curl disease, its viral causal agents and whitefly vector: A way forward to sustain cotton fiber security. *Front. Plant Sci.* 8:1157.
- Kirkpatrick, T.W. 1931. Further studies on leaf-curl of cotton in Sudan. *Bull. Entomol. Res.* 22, 323-363.
- Briddon, R.W. and Markham, P.G. 2001. Cotton leaf curl disease. *Virus Res.* 71, 151-159.
- Humza, M., B. Iqbal, S. Ali. 2016. Management of Cotton Leaf Curl Virus disease and its Vector through In-Vivo Evaluation of Organic Nutritional Amendments, Organic Oils and Insecticides. *J. Plant Pathol. Microbiol.* 7:387.
- Zafar, Y., Bashir, A., Mansoor, S., Saeed, M., Asad, S., Saeed, N.A., Briddon, R., Markham, P.G., Fauquet, C.M. and Malik, K.A. 1997. Cotton leaf curl virus epidemic in Pakistan: Virus characterization, diagnosis and development of virus resistant cotton through genetic engineering. <http://www.researchgate.net/publication/237208188>
- Hassan, F., Qayyum, A., Malik, W., Maqbool, A., Hassan, M., Rehman, M.A., Shoaib, M., Shehzad, M., Ahmad, S., Ahmad, L. and Arshad, M. 2016. Cotton Leaf Curl Virus (CLCuV) Disease in Pakistan: A Critical Review. *Appl. Sci. Bus. Econ.* 3(1): 08-14.
- Saleem, H., Nahid, N., Shakir, S., Ijaz, S., Murtaza, G., Khan, A.A. et al. 2016. Diversity, Mutation and recombination analysis of cotton leaf curl geminivirus. *PLoS ONE*, 11(3): e0151161.
- Mahmood, T., Arshad, M., Gill, M.I., Mahmood, H.T., Tahir, M. and Hussain, S. 2003. Burewala strain of cotton leaf curl virus: A threat to CLCuV cotton resistant varieties. *Asian J. Plant Sci.*, 2(13):968-970.
- Malik, H.J., Raza, A., Amiin, I., Scheffler, J. A., Scheffler, B.E., Brown, J.K., et al. 2016. RNAi-mediated mortality of the whitefly through transgenic expression of double stranded RNA homologous to acetyl cholinesterase and ecdysone receptor in tobacco plants. *Sci. Rep.* 6:38469.
- Smalling, K.L., Kuivila, K.M., Orlando, J.L., Phillips, B.M., Anderson, B.S., Siegler, K., et al. 2013. Environmental fate of fungicides and other current-use pesticides in a central California estuary. *Mar. Pollut. Bull.* 73, 144-153.
- Iqbal, M., Naeem, M., Aziz, U., Afzal, J., and Khan, M.A. 2014. An overview of cotton leaf curl virus disease, persistent challenges for cotton production. *Bulg. J. Agric. Sci.*, 20:405-415.