Management of Cotton Leaf Curl Virus Disease in India

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ABSTRACT

Cotton leaf curl viral disease (CLCuV) incidence has increased in northern states of India (Punjab, Haryana and Rajasthan) since 1993. CLCuV reduces the number of harvestable bolls by 15-87 per cent and seed cotton yield by 11-92 per cent, depending on the extent and time of infection. The whitefly (Bemisia tabaci) and inoculum are present throughout the year. Several weeds (Sida sp. Abutilon indicum and Xanthium strumarium) and crops okra (Abelmoscus esculentus) are alternate hosts. G. arboreum cultivars LD 327 and RG 8, G. hirsutum upland cultivars LRK 516, CSH 15, CSH 19, HH 1156, LK 861, CNH 1018, HH 62, HH 70, HH 75, HH 76, HH 79 and HH 98 and G. hirsutum hybrid LHH 144, Kasturi 2 and Kasturi 18 appear resistant to CLCuV while upland cultivars H-1180, HS-90-80, LRA 5166, RS 875, RS 2013 and Kanchana are tolerant. Systemic insecticides and seed treatment with imidacloprid and thiamethoxam failed to check disease transmission. Triazophos 40 EC and ethion 50 EC were effective against B. tabaci. Recommendations for CLCuV management include cultivating resistant cultivars, destruction of alternate hosts; uprooting and destruction of infected plants; avoidance of upland cotton in orchards; effective management of whitefly and avoidance of insecticides that cause resistance in whitefly.

Introduction

Cotton is the most important fiber crop in India. Recently, production and productivity have declined and are in a crises phase in many parts of India, especially in the North Zone states of Punjab, Haryana and Rajasthan. Production has declined in the Punjab from 2.4 million bales in the early 1990's to 0.75 million bales in 1998 as a result of many factors, insect pests and diseases being the major causes. Cotton leaf curl viral disease (CLCuV) is among the most damaging cotton diseases. It was first found on *Gossypium barbadense* in Nigeria (Africa) in 1912 (Bird and Maramorosch, 1978). Its viral nature was established in 1926. The whitefly, *Bemisia tabaci*, was confirmed as vector in 1930 (Tarr, 1949). CLCuV was first reported in Asia on upland cotton in 1967 in Multan (Pakistan) where it was considered a minor disease until 1987. It spread over 60 ha in Khanewal district of Pakistan in 1989. By 1991, it had infected 14,000 ha and by 1992-93, 1,17,600 ha causing a huge production and monetary loss. (Ahmed and Ali, 1998; Anon., 1993). CLCuV was first reported in India in Sri Ganganagar (Rajasthan) during 1993 and in Punjab (India) in 1994 (Singh *et al.*, 1994; Kapur *et al.*, 1994). It is now widespread over the North zone, posing a major threat to cotton production. The virus causes vein thickening followed by formation of veinal net on under surface of leaves and a few exhibited enations. The infected leaves curl upward, the diseased plants remain stunted with considerable loss in yield.

Losses caused by CLCuV. The losses caused by CLCuV depend on the stage of development of the plant at the time of infection. Plants are susceptible at cotyledon, seedling, vegetative and fruiting phases. Early infection result in greater yield losses (Table 1), causing 14.9 to 87.4 % reduction in harvestable bolls and up to 38.8 % loss in boll weight. It reduces seed cotton yield by 10.5 % when confined to apical leaves only, 58.1 % when it infects the upper plant canopy and 68.7% in both upper and lower canopies.

Seasonal occurrence of B. tabaci. In the Punjab, *B. tabaci* is active on various crops throughout the year (Table 2). Some weeds and ornamentals also harbour whitefly adults (Table 3). Whitefly numbers vary from 0.5 to 10 adults/30 leaves on *Ageratum conizoides*, *Althea rosea*, *Datura metel* Potato, (*Solanum tubrosum*), wild tobacco and wild mint (*Mentha longifolia*) from January to the end of April with up to 35 adults/30 leaves on brinjal (*Solanum melongena*) in late May. *B. tabaci* invades cotton at the cotyledon stage. Typically adult numbers remain low (less than one per three leaves) from the cotyledon to 4-5 leaf stage, increasing rapidly from the end of September during the fruiting stage.

Sources of CLCuV inoculum. Okra (*Abelmoscus esculantus*) and the weeds *Sida* sp., *Abutilon indicum*, *Xanthium strumarium* were confirmed as source of CLCuV inoculum (Table 2). CLCuV has also been inoculated in *D. metel* and tomato (*Lycopersicum esculantum*) plants using whitefly as vector, leading to CLCuV symptoms. The presence of CLCuV was confirmed in tomato and Datura in laboratory tests (R.

Bridden, personal communication). *A. conizoides* is a perennial weed along the water channels around cotton fields. It harbours *B. tabaci* and shows CLCuV like symptoms. However, back transmission from *A. conizoides* to upland cotton is needed to confirm its status as alternate host of CLCuV.

Management Tools

Approaches being investigated to manage CLCuV:

1. ***Resistant plant material.*** Cotton germplasm from various sources has been screened for resistance to CLCuV following the method described by Singh et al (1994). The Indian upland cotton varieties LRK 516, LK 861, CSH 15, CSH 19, H 1156, CNH 154, CNH 1018, HH 62, HH 70, HH 75, HH 76 and *G. hirsutum* cotton hybrids LHH 144, Kasturi 2, Kasturi 18 remained free from CLCuV symptoms. Upland. varieties H-1180, HS-90-80, LRA 5166, RS 875, RS 2013, CSH 10, CSH 11, CSH 20, Kanchana exhibited 20 to 43 per cent infection with mild CLCuV symptoms. Similarly, 14 to 60 per cent of plants of *G. hirsutum* hybrids Kasturi 21, Kasturi 22 were infected with mild CLCuV symptoms. *G. arboreum* cultivars RG 8 and LD 327 predominate in North India. Both were free of symptoms in the screen house and field. Laboratory tests failed to show the presence of the virus in LD 327 inoculated by viruliferous whiteflies. This information was given to leading cotton breeders to assist in their programmes.

2. ***Cultural control measures.*** Work on the incidence of CLCuV has highlighted factors influencing its spread to cotton and other crops.

   a) CLCuV disease develops earlier in the season on upland cotton that is inter-cropped in orchards of citrus, guava and peach than on cotton grown in the open. The orchards appear to act as "hot spots" for the spread of CLCuV to the adjoining cotton crop. Overall results for 3 years in 16 locations showed the mean number of whitefly adults per 3 leaves in June was 17.9 on upland cotton inside and 1.1 outside orchards. Corresponding figures CLCuV infected plants were 56.5 and 14.5 %, respectively. The higher incidence of whitefly in orchards might be due to more favourable micro-environment during June. Presence of CLCuV on volunteer cotton plants and on alternative hosts in orchards could increase the proportion of viruliferous adult vectors. Orchards are therefore a potential source for the initial spread of the disease.

   b) Cultivation of okra and cucurbits as inter-crops with cotton, the raising of okra as a seed crop and the cultivation of tomato hybrids adjacent to cotton promotes the multiplication and spread of *B. tabaci*. CLCuV was successfully inoculated into tomato from cotton under screen house conditions. Okra has been confirmed as an alternate host of CLCuV through successful back transmission of the disease to cotton.

   c) There was a higher incidence of CLCuV in early sown cotton due to early invasion of viruliferous adult vectors from off-season hosts and their subsequent multiplication and spread in these fields. Screen house experiments showed a progressive decrease in the transmission of CLCuV as the season advanced (Table 4).

3. Many factors influence the spread of CLCuV including (i) the level of inoculum in alternative hosts and availability of these hosts in and outside the cotton season, (ii) the proportion of CLCuV infected cotton plants during the seedling and vegetative phases; (iii) the intensity of CLCuV during flowering and fruiting stage that determines the carryover of viruliferous whiteflies from cotton to off-season host plants and (iv) the density of whiteflies on different hosts throughout the year.

4. Reduction or complete eradication of alternative hosts through co-ordinated campaigns before sowing cotton could be effective for breaking the cyclic availability of disease inoculum.

5. The incidence of CLCuV generally remains low (0-6 per cent) during the initial stages of cotton growth. It increases (8-83 per cent) as the crop progresses. Uprooting and destruction of infected cotton plants early in crop growth over a large area is a proposition for checking the spread of CLCuV that needs careful consideration.

6. ***Chemical control measures.*** Triazophos 40EC and ethion 50 EC have been effective insecticides against *B. tabaci* in the Punjab. Repeated applications (5-6) of acephate, quinalphos, endosulfan, profenophos, fenvalerate, cypermethrin and alphamethrin to control the bollworm, *Helicoverpa armigera* (Hübner) cause resurgence of whiteflies. Treatment of cotton seed with imidacloprid 70 WS at 5 g per kg seed or thiamethoxam 70 WS at 8.56 g per kg seed did not prevent transmission of CLCuV. Sprays of oxydemeton-methyl 25 EC at 750 ml, dimethoate 30 EC at 625 ml and diafenthiuron 50 EC at 1500, 2000 and 3000 ml, triazophos 40 EC at 1500 ml and ethion 50 EC at 2000 ml per hectare at first leaf stage also failed to check transmission of CLCuV (Table 5). Opportunities to combat CLCuV by chemical means appear very limited.

Management of CLCuV Disease

The following recommendations for minimizing CLCuV are based on work to date:

- Grow only virus tolerant varieties/hybrids.
- Grow only *G. arboreum* cotton in orchards.
- Destroy alternative hosts: *Sida* sp. *A. indicum*, *D. metel* and volunteer cotton plants before sowing.

- Avoid okra and cucurbits in or around cotton fields. Uproot and destroy CLCuV infected plants up to initiation of fruiting phase of crop.
- Avoid potato, brinjal, tomato, sunflower and cucurbits in cotton areas outside cotton season.
- Manage whitefly using the most effective insecticides including triazophos and ethion.
- Avoid insecticides that cause whitefly resurgence.

These recommendations are being evaluated.

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Table 1. CLCuV losses in *G. hirsutum* cultivar F846 at Chaksherewala (Punjab: India).

Extent of disease at harvest	No. harvestable bolls/plant*	Boll weight (g)	Seed-cotton yield per plant (g)
Plant free from CLCuV	34.2	3.6	120.1
Apical leaves only	29.1(-14.9)	3.6 (-0.0)	107.5 (-10.5)
Upper plant canopy only	14.6(-57.3)	3.3 (-8.0)	50.3 (-58.1)
Upper and middle plant canopy	11.3 (-66.9)	3.3 (-8.0)	37.5 (-68.7)
Entire plant infected	4.3 (-87.4)	2.2 (-38.8)	9.4 (-92.2)

* Mean of total bolls from 50 plants in each category.
- Figures in parentheses are % reduction compared to virus free plants.

Table 2. Crops harbouring *B.tabaci* and sources of CLCuV inoculum in Punjab (India).

Month	Crop host plant of *B.tabaci*	Weeds/crops showing CLCuV-like symptoms
January-April	Potato (*Solanum tuberosum*), sunflower (*Helianthus annuus*), cucurbits, tomato (*Lycopersicum esculantum*), chillies (*Vigna* sp.) rapeseed, brinjal (*Solanum melongena*), beans (*Vigna* sp.), cotton (*G. hirsutum).*	*Sida* sp.*, *Abutilon indicum**, *Xanthium strumarium**, *Hibiscus rosasinensis*, *Althea rosea*, *Ageratum conizoides*, tomato *(L. esculantus*), volunteer ratoon cotton *(G. hirsutum*) plants.
May-June	cotton (*G.hirsutum*), sunflower, brinjal (*S.melangena*) tomato, curcurbits, chillies (*C. annuus*) summer moong (*Vigna* sp.), okra (Abelmoschus esculantus), mentha (*Mentha* spp.).	*Sida* sp., *Abutilon indicum*, *Xanthium strumarium*, *Datura metel*, *Hibiscus rosasiensis*, *Althea rosea*, *Ageratum conizoides*, tomato (*L. esculantus*) okra (*A. esculantus*), cotton (*G.hirsutum*).
July-December	Cotton (*G. hirsutum*) okra (*A. esculantus*), beans (*Vigna* sp.), cucurbits, chillies, brinjal (*S. melangena*), potato (*S.tuberosum*).	*Sida* sp. , *Abutilon indicum*, *Xanthium strumarium*, *Datura metel*, *Hibiscus rosasinsis Althea rosea*, *Ageratum conizoides*, okra (*A. esculantus*) cotton (*G.hirsutum*).

* CLCuV presence demonstrated.

Table 3. Weeds supporting *B. tabaci* in cotton in the Punjab.

Common Name	Scientific Name	Family
Chula	*Amaranthus spinosus* L.	Amaranthaceae
Puthkanda	*Achyranthes aspera* L var. *Prophyristacha* Hook	Amaranthaceae
Tandla	*Digera muricata* L.	Amaranthaceae
Ageratum	*Ageratum conizoides* L.	Asteraceae
Gutputna	*Xanthium strumarium* L.	Asteraceae
Hirankhuri	*Convolvulus arvensis* (L.)	Convolvulaceae
Dodhak	*Euphorbia hirta* L.	Euphorbiaceae
Kanghibuti	*Sida* sp.	Malvaceae
Peelibuti	*Abutilon indicum* (L.)	Malvaceae
Sonchal	*Malva parviflora* L.	Malvaceae
Makru	*Eleusine indica* (L.)	Poaceae
Datura	*Datura metel* L.	Solanaceae
Makoh	*Solanum nigrum* L.	Solanaceae
Janglijute	*Corchorus capsularis L*	Tiliaceae

Table 4. Influence of period of inoculation of cotton leaf curl virus on Gossypium *hirsutum* cotton variety F 846.

Date of inoculation	Plants showing symptoms (%)	Symptoms at maturity

July 12	100	Veinal net, curling and enation
July 31	70	Veinal net and curling
August 7	70	Veinal net and curling
August 19	40	Veinal net and curling
September 6	30	Veinal net and curling

- 10 plants inoculated at first leaf stage; 10 viruliferous whitefly adults per seedling used
- Acquisition and inoculation access period; 24 hours

Table 5. Effect of insecticidal sprays on transmission of CLCuV by *B. tabaci* on *Gossypium hirsutum* variety F 846.

Treatment	Dose (ml/ha)	Days to appear symptoms		
		Small vein thickening / Main vein thickening	Curling	Enation
Metasystox 25 EC (oxydemeton methyl)	750	5-11	No curling	No Enation
Hostathion 40 EC (triazophos)	1500	5-11	15-19	No Enation
Rogor 30 EC (dimethoate)	625	5-11	No curling	No Enation
Fosmite 50 EC (ethion)	2000	5-11	No curling	18-20
Polo 50 % SC (diafenthurion)	3000	5-11	No curling	No Enation
	2000	5-11	No curling	No Enation
	1500	5-11	No curling	No Enation
Control (No Spray)	-	5-11	15-20	No Enation

- 10 plants inoculated at 1st leaf stage using 10 viruliferous whitefly adults/seedling