ABSTRACT: Cotton is one of the most important cash crops in India. The productivity of cotton in the last five years has suffered a great setback due to cotton leaf curl disease (CLCuD) in Indian Punjab. The causal agent of CLCuD is a begmovirus complex and is transmitted by whitefly (Bemisia tabaci Genn.). Considering the importance of CLCuD in terms of seed cotton yield losses and quality characters, the present studies were conducted with an objective to estimate the losses in seed cotton yield and fibre characters of upland cotton. For this purpose the experiment was conducted for four years from kharif 2001 to kharif 2004 seasons at Punjab Agricultural University, Regional Station, Faridkot. Results of pooled data of four years indicated that on an average, there was 50.4% reduction in number of bolls due to CLCuD infection, reduction of 42.9% in the boll weight. Due to CLCuD the fibre length was reduced by 5.2%, strength by 5.4%, elongation by 10.0%, uniformity by 2.2% and micronaire value by 4.1% in diseased plants over (healthy plants). Therefore on the basis of four years studies it was concluded that CLCuD infection adversely affected seed cotton yield and quality characters of upland cotton fibre, which ultimately affected its market value within and outside the country.

Key words: Cotton leaf curl disease, seed cotton yield, quality characters

Cotton is one of the most important cash crops in India. Cotton season of 2004-2005 broke many records in the country. The present figures of harvest are 3.9 million ton of lint from 8.76 m hectare of the north, south and central zones of India respectively. The fibre productivity has crossed 436 kg hectare⁻¹. In Indian Punjab during kharif 2003-2004, cotton was cultivated on 0.469 m hectares area with a total production of 1955 X 10⁸ kg, and 552 kg hectare⁻¹ was the productivity (Anonymous, 2005). CLCuD is one of the major causes adversely affecting yield and quality characters of upland cotton. This disorder of cotton was first noted in Indian subcontinent (Pakistan) in late 1960s. It remained a minor sporadic problem for the following twenty years. Then, from 1992 to 1997, this malady has been estimated to have affected the Pakistan economy up to US $ 5.0 billion. The first CLCuD symptoms on cotton in the neighbouring Indian state of Punjab appeared in 1995 and the disease continues to spread eastwards, with the affected areas in the Punjab, Rajasthan and Haryana states steadily increasing (Briddon, 2003). Cotton leaf curl disease (CLCuD), has assumed serious proportions in the irrigated cotton belt of North India comprising an area of 15 lakh hectare (Monga et al., 2004). In India, the disease after its first report in patches around Sriganganagar district of Rajasthan state on G. hirsutum in 1993, spread to the entire North India in a span of 4-5 years (Narula et al., 1999). The disease is known to be caused by DNA-A/DNA-1/ DNA beta complex characteristic of monopartite begomo viruses (Briddon et al., 2001). During 2002 to 2004, the average incidence of CLCuD was from traces -83.1% (with 0-IVth grade disease severity) on different commercial varieties of G. hirsutum in different cotton growing areas of the Punjab state, at the same time the population of the whitefly vector was very high (Singh et al., 2005).
The symptoms of the disease were severe curling of leaves and stunting of growth giving a look of bunched top. Such plants do not bear flowers and bolls at all. The grown up more than a month old plants showed initial symptoms characterized by dark green bead like structures on the leaf lamina which subsequently turned into thickening of vein and veinlet prominently visible on the lower surface of the leaves. Two type of vein thickening i.e. SVT (small vein thickening ) and MVT (main vein thickening) have been observed depending upon the variety and age of the crop (Chauhan, 2004). Such leaves showed upward or downward curling with twisted petioles. Cup like structures from nectar gland known as enations the characteristic symptoms. Enations were also formed on the veinlets near distal end in the form of outgrowth on both sides of veinlets. The severely affected plants have bushy appearance with dark green colour, short internodes, without flowers and bolls. In the case of G. barbadense the internodes appeared to be elongated (Raj et al., 2002).

Grading was done, based on the symptoms viz., 0 grade: no disease symptoms: 1 grade: vein thickening in top 3-4 leaves no curling and cupping of leaves; 2 grade: vein thickening, curling and cupping of leaves, restricted to 1/3 part of the plant; 3 grade : vein thickening curling and cupping of leaves , one to many leafy enations, 2/3 part of the plant affected, boll number and weight reduced; 4 grade: vein thickening , curling and cupping of leaves , one to many leafy enations, more than 2/3 part of the plant affected, stunting of plants with no or very little boll setting, boll number and weight reduced.

Depending upon the stage of crop at the time of infection the loss in seed cotton yield varied from 10.5 to 92.2% in susceptible varieties of upland cotton (Singh et al., 1995; Monga et al., 1998). Massey (1934) made a quantitative examination and showed reduction in yield upto 50% on account of CLCuD. Andrew (1936) observed that this disease reduced weight of opened bolls by 48.6%, number of green bolls by 48.6%. Moskovet (1940) in USSR reported that leaf curl caused a reduction of 55% in the number of bolls. The disease affects the quality of cotton fibre, reducing length by 70.5% and strength by 3.3 to 16.6% in different varieties. Tarr (1957) stated that leaf curl disease outbreak in Gezira and Sudan caused 30-40% yield loss. Shafique et al. (1994) noted that due to high infection of the disease the average yield decreased to 50%. In Pakistan CLCuD causes 33.4% reduction in boll weight and 72.3% in the number of bolls in susceptible variety S 12. Due to CLCuD infection ginning out turn (GOT) was reduced by 3.8%, seed index by 17.3%, fibre length by 3.9%, strength by 1.0% and elongation up to 10.0% (Mahbub Ali et al., 1995). In India Monga et al. (1999) reported drastic reduction in seed cotton yield in diseased plants (68.1-79.2%). Considering the importance of the disease in terms of yield losses and quality characters, the present investigations were undertaken from kharif 2001 to kharif 2004 seasons with the objective to estimate the losses in terms of seed cotton yield and quality characters of upland cotton due to infection of CLCuD in Indian Punjab state.

MATERIALS AND METHODS

The experiment was conducted for four consecutive year from kharif 2001 to kharif 2004 seasons at Punjab Agricultural University, Regional Station, Faridkot with leaf curl susceptible variety, F 846; the crop was planted with a spacing of 67.5 and 30.0 cm between row to row and plant to plant respectively, in a randomized block design under natural epiphytotic conditions. There were five treatments based on the grades namely, (i) 0 grade plants (healthy, free from viral infection) and naturally virus infected plant depending upon symptoms categorised as, (ii) 1 grade plants (small veinlets thickening (SVT) (iii) 2 grade plants (vein thickening, curling, cupping) (iv) 3 grade plants (main vein thickening with enations) and (v) 4 grade plants (stunted with leafy enations on lower surface of leaf). CLCuD grading was done on the basis of symptoms. This grading system was decided by Cotton Pathologist of all the center of All India co-ordinated cotton improvement Project. This grading was used for the categorization of variety/hybrids into highly resistant, resistant, moderately resistant, susceptible category. Each treatment was replicated five times. In each treatment, 10 plants per grade were tagged in the month of August. All the 50 plants of each grade from each replication were taken for comparison of yield components at crop maturity (number of bolls and their weight) and quality characters of the fibre (length, uniformity,
strength, elongation, micronaire value). All the quality parameters were determined by using High Volume Instrument (HVI Spectrum) in the fibre technology section of Vardhman group of companies, India and data were statistically analysed as per norms.

RESULTS AND DISCUSSION

Effect of CLCuD on the number of bolls, seed cotton yield, uniformity, strength, elongation, micronaire value, ginning out turn (GOT) of upland cotton fibre: Figures 1 to 5 showed 0 to 4 grades symptoms of CLCuD on the leaves of the upland cotton plant.

The pooled data of four years indicated that the number of bolls and seed cotton yield in 0 grade (healthy plants) were 55.2 and 122.7g whereas in 1 grade symptom; 2 grade symptom; 3 grade symptom and 4 grade symptom as affected by CLCuD were 34.4, 31.8, 26.7, 16.7, with 87.1, 80.2, 73.2 and 39.7 g seed cotton yield respectively. There was significant differences in boll number and weight in healthy plants (disease free) and diseased plants having 1, 2, 3 and 4 grade symptoms of disease. Ginning out turn (GOT) and fibre characters was adversely affected by CLCuD. The quality characters like length, uniformity, strength, elongation and micronaire value were 25.3, 83.2, 25.9, 5.0, 4.9 in 0 grade plants as comparison to 24.4, 82.6, 24.8, 4.8, 4.8 in 1 grade symptom; 24.2, 81.8, 24.7, 4.5, 4.8 in 2 grade symptom; 24.0, 81.1, 24.5, 4.3, 4.6 in 3 grade symptom; 23.3, 79.9, 24.1, 4.3, 4.5 in 4 grade symptoms of plants (Table 1).

On an average the pooled data of four year showed that, there was 50.4% reduction in number of bolls due to CLCuD infection, reduction of 42.9% in the boll weight of plants. As an effect of CLCuD attack the fibre length reduced by 5.2%, strength by 5.4%, elongation by 10.0%, uniformity by 2.2% and micronaire value by 4.1% in diseased plants over the 0 grade (healthy plants) (Table 2).

These results are in confirmatory as Singh et al. (1995) estimated a reduction in seed cotton yield per plant from 10.5 to 92.2% in variety F 846 and 39.9 to 79.7% in variety Pakistani Narma (Niab 72), in number of bolls from 14.9 to 87.4% in variety F 846 and 30.7 to 68.85 in Niab 72 and boll weight up to 38.8% in variety F 846 and between 11.9 to 40.5% in variety Niab 72. Monga et al. (1999) found that a reduction in length up to 14.4% and micronaire value increased 5.8 g/inch in CLCuD infected plant as compared to healthy plants. Yield

<table>
<thead>
<tr>
<th>Disease grading**</th>
<th>Number* of bolls/plant</th>
<th>Seed cotton yield (g/plant)</th>
<th>Quality characters of fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>2.5% span length (mm)</td>
</tr>
<tr>
<td>0</td>
<td>55.2</td>
<td>122.7</td>
<td>25.3</td>
</tr>
<tr>
<td>1</td>
<td>34.4</td>
<td>87.1</td>
<td>24.4</td>
</tr>
<tr>
<td>2</td>
<td>31.8</td>
<td>80.2</td>
<td>24.2</td>
</tr>
<tr>
<td>3</td>
<td>26.7</td>
<td>73.2</td>
<td>24.0</td>
</tr>
<tr>
<td>4</td>
<td>16.7</td>
<td>39.7</td>
<td>23.3</td>
</tr>
<tr>
<td>CD at 5%</td>
<td>11.4</td>
<td>28.2</td>
<td></td>
</tr>
</tbody>
</table>

* Variety: F 846; Date of sowing: 22/05/2000, 9/05/2002, 28/04/2003, 29/04/2004; Replication: 5; Design: RBD

**Disease grading was done, based on the symptoms as given below:-

(i) 0 grade: no disease symptoms.
(ii) 1 grade: vein thickening in top 3-4 leaves no curling and cupping of leaves.
(iii) 2 grade: vein thickening, curling and cupping of leaves, restricted to 1/3rd part of the plant.
(iv) 3 grade: vein thickening curling and cupping of leaves, one to many leafy enations, 2/3rd part of the plant affected, boll number and weight reduced.
(v) 4 grade: vein thickening, curling and cupping of leaves, one to many leafy enations, more than 2/3rd part of the plant affected, stunting of plants with no or very little boll setting, boll number and weight reduced.
losses reported at Sriganganagar (Rajasthan, India), a reduction of 50.3\% in seed cotton yield and number of bolls, 12.3\% in boll weight and 16.1\% in height per plant was reported in variety F 846. In variety RST 9 the reduction in seed cotton yield was 32.9\%, in number of bolls 22.8\% and in height

35.0\% (Ajmera, 2000). The disease affected characters of fibre as indicated by reduction in length by 2.6\% in variety RST 9 and 3.5 \% in variety F 846, whereas strength reduced by 3.4\% in RST 9 and 6.1\% in F 846. The micronarie value increased to 2.2\% in RST 9 and 1.2\% in F 846. Similarly Singh et al. (2002) reported that CLCuD caused 64.7\% reduction in number of bolls per plant along with 49.6\% reduction in boll weight in susceptible variety F 846 and also remarkably deteriorating the quality characters in upland cotton i.e. fibre length reduced by 2.9\%, elongation by 13.0\%, uniformity by 1.6\% and micronaire value by 6.3\% in diseased plants having 1, 2, 3 and 4 grade symptom of disease over the 0 grade (healthy plants).
This study is the first systematic effort to study and affect of CLCuD infection on seed cotton yield and fibre quality of upland cotton under Punjab conditions. From the results it is evident that the disease needs to be managed well in advance using integrated disease management strategy to minimize the yield loss.

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REFERENCES


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