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# Management of Cotton Crop Under High *Cotton leaf curl virus* Attack

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**Abstract:** The objective of this study was to compare yield, yield components and fiber traits of different genotypes/varieties under different plant spacings and nitrogen fertilizer levels. Field experiment was conducted during 2006-2007 to evaluate the effect of genotype, plant spacing and nitrogen fertilizer on cotton. Five genotypes (MNH-786, MNH-789, MNH-6070, CIM-496 and BH-160), three plant spacings (15, 30 and 45 cm) and three nitrogen fertilizer levels (6.5, 8.6 and 11 bags of urea $ha^{-1}$) were studied. Results showed that significant differences exit for plant height, no. of bolls $m^{-2}$, seed cotton yield kg $ha^{-1}$ due to genotypes, interaction of genotype and plant spacing and nitrogen fertilizer levels. Where as boll weight (B. wt.), Ginning out turn percentage (G.O.T %), staple length (SL) and fiber fineness were not affected significantly by the plant spacing, nitrogen fertilizer but effect due to genotype was significant for these traits. CLCuV (*Cotton leaf curl virus*) infestation % varied significantly due to genotypes while all other factors i.e., plant spacing and nitrogen fertilizer has non-significant effect. As the major objective of cotton cultivation is lint production for country and seed cotton yield for the farmers, the genotypes grown in narrow plant spacing 15 cm and higher nitrogen fertilizer level 11.0 bag of urea $ha^{-1}$ produced maximum seed cotton yield under higher CLCuV infestation % (CIM-496, MNH-789 and BH-160) while the variety MNH-6070 gave maximum yield under 30 cm plant spacing and 8.6 bag of urea $ha^{-1}$ as the 2.3% CLCuV infestation was observed upon this variety. From the present study it is concluded that the genotypes that are severally affected by CLCuV can be managed with increasing plant population and nitrogen fertilizer to achieve optimum seed cotton yield.

**Key words:** *Gossypuim* sp. CLCuV, yield components, fiber characters

## INTRODUCTION

CLCV is a disease of cotton (*Gossypuim* sp.) caused by the *cotton leaf curl virus* (CLCuV), which is transmitted through white fly, (*Bemisia tabaci* Genn.) and belong to the genus, Begonovirus Family Geminiviridoe, (EL-Nur, 1967), Gemini virus subgroup III (Hameed *et al*., 1994). The symptoms of diseases include upward curling of leaf margins, thickening of veins which is pronounced on the lower surface of leaves and formation of minute foliar out growth called enations (Hussain and Ali, 1975). The affected veins appear abnormally dark green and opaque on the under surface (Watkins, 1981). Cotton leaf curl virus disease was first reported during 1967, in 1992-1993, CLCuV disease appeared in epidemic form which caused decrease in seed cotton yield (Mahmood, 1999).

After the development and introduction of resistant varieties in cotton belt yield losses were recovered gradually and production regained to 11.17 m bales during 1999-2000 (Anonymous, 2001).

In 2001 a new race of CLCuV appeared in the District Vehari and all the commercial varieties that were resistant to Multan CLCuV fell prey to new race of CLCuV (Tariq *et al*., 2003). The results of Tahir and Mehmood (2005) experiments strongly suggest the emergence of resistance-breeding strain of CLCuV in Pakistan. The cotton crop faced a new threat with the emergence of new strain of CLCuV called Burewala strain. As all the genotypes and varieties of upland cotton present in Pakistan (CCRI, Multan, NIAB, FSD, NIBGE, FSD, NIA. TandoJam, CCRI, Sakrand, CRI, FSD and CRS, Multan etc.) are susceptible to this variant of virus. The available genepool and source parents for resistance used in previous CLCuV resistant genotype found susceptible to new variant of CLCuV (Tariq *et al*., 2003). There are two options to solve these problems:

- To develop genetically resistant varieties to CLCuV B. Wala.
- To live with CLCuV presence and manage the cotton crop with management practices to minimize losses.

The CLCuV effected plants showed stunted growth, less number of bolls and reduction in boll size.

Deterioration in fiber quality (in upland cotton (Tanveer and Mirza, 1996).

The study was conducted to find out the impact of different management practices on the improvement of above mentioned traits.

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## MATERIALS AND METHODS

A field experiment was conducted during 2005-2006 at CRS, Multan to evaluate the CLCuV % infestation of thirty-five varieties developed from different research organization including obsolete varieties. On the basis of CLCuV infestation following five varieties were selected for this study. The main characters of varieties are as:

| Varieties | CLCuV % | B. wt. (g) | GOT | SL | Mike |
|---|---|---|---|---|---|
| CIM-496 | 79 | 2.8 | 40.2 | 28.7 | 5.1 |
| MNH-786 | 23 | 4.3 | 39.2 | 27.8 | 4.8 |
| MNH-789 | 83 | 3.9 | 38.8 | 31.5 | 4.4 |
| MNH-6070 | 03 | 3.1 | 41.8 | 27.1 | 4.9 |
| BH-160 | 65 | 3.4 | 36.2 | 28.4 | 4.5 |

A field experiments was laid down during 2006-2007 at CRS, Multan with following variable/treatments.

- Varieties = 5 (CIM-496, MNH-786, MNH-789, MNH-6070 and BH-160)
- $N_1$ = 2.5, $N_2$ = 3.5 and $N_3$= 4.5 bag of urea $ac^{-1}$
- Plant spacing = S1 = 6//, S2// = 12// and S3 = 18//)

Treatments were arranged in split-split randomized complete block design keeping the varieties in main plot, Nitrogen fertilizer in sub-plot and spacing in sub-sub-plot. Planting date was 2nd week of May 2006 and sowing was done by dibbling method, on ridges. Nitrogen fertilizer was applied in four split doses starting from 50 days after planting. All other cultural practices (Weeds management, irrigation and plant protection measures etc.) were performed to optimize the seed cotton yield. Data were collected for the following traits,

- Final plant height (cm)
- No. of bolls $m^{-2}$
- Average boll weight (g)
- Seed cotton yield (kg $ha^{-1}$)
- Ginning out turn percentage (G.O.T.%)
- Staple length (mm)
- Fiber fineness (µg $inch^{-2}$)
- CLCuV % (Based on total plant population of plot on 20th August, 2006.

All data were subjected to analysis of variance by using M. Stat computer software. Means were separated using Fisher's protected Least Significant Difference (LSD) test and in all statistical test significance was determined at p = 0.05.

## RESULTS AND DISCUSSION

From analysis of variance Table 1, it is indicated that effect due to genotypes is significant for plant height, No. of bolls $m^{-2}$, B. wt., seed cotton yield, G.O.T.%, staple length, fiber fineness and CLCuV, while plant spacing has significant effects on plant height, CLCuV, seed cotton yield whereas non-significant effect was observed for No. of bolls $m^{-2}$, G.O.T.%, staple length and fiber fineness. The interaction of plant spacing and genotype was significant for plant height, No. of bolls $m^{-2}$ seed cotton yield and CLCuV.

Nitrogen fertilizer has significant effect on plant height, No. of bolls $m^{-2}$ and seed cotton yield while non-significant effects were observed for B. wt., GOT, staple length, fiber fineness and CLCuV % while interaction of nitrogen fertilizer and plant spacing was significant only for yield.

CLCuV infestation is one of the destructive diseases of cotton (Nelson *et al*., 1998) caused by Begonovirus (Hameed *et al*., 1994) is transmitted by white fly (Nelson *et al*., 1998).

Development of CLCuV resistant variety is the most promising control option. At present all the genotypes of (*G. hirsutum* L.) are susceptible to CLCuV but susceptibility and intensity of severity varies among genotypes.

It is evident that significant differences for CLCuV exit among genotypes which is due to genetic make up and the genotype MNH-6070 showed higher resistance to CLCuV infestation as compared to other genotypes under study (Table 2). Similarly, significant differences among all genotypes exits for all traits under study which is

Table 1: Means squares for analysis of variance for plant height yield and yield components

| SOV | df | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | GOT% | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|---|
| Reps | 2 | 10.2 | 1.5 | 0.030 | 535.60 | 0.000 | 0.340 | 0.028 | 8.08 |
| Variety | 4 | 15107.5** | 2801.6** | 10.600** | 9595138.90** | 56.800** | 73.510** | 2.259** | 48984.60** |
| Error (a) | 8 | 6.3 | 7.6 | 0.040 | 1960.90 | 0.380 | 0.770 | 0.340 | 7.20 |
| Plant spacing | 2 | 2093.4** | 32.3 | 0.003 | 600.74 | 0.020 | 0.052 | 0.012 | 16.90 |
| V×S | 8 | 22.1** | 1944.9** | 0.013 | 2731563.90** | 0.210 | 0.013 | 0.007 | 5.00 |
| Error (b) | 20 | 9.0 | 94.0 | 0.012 | 5847.40 | 0.170 | 0.031 | 0.009 | 2.10 |
| Nitrogen | 2 | 4768.4** | 1112.0** | 0.008 | 3454358.20** | 0.004 | 0.026 | 0.021 | 5.70 |
| V×N | 8 | 35.7** | 122.9 | 0.027 | 212518.80** | 0.277 | 0.027 | 0.006 | 18.70** |
| S×N | 4 | 9.4 | 416.9 | 0.011 | 241033.20** | 0.024 | 0.022 | 0.003 | 4.70 |
| V×S×N | 16 | 16.6** | 212.3 | 0.016 | 201197.30** | 0.294 | 0.043 | 0.007 | 5.60** |
| Error | 60 | 3.8 | 170.7 | 0.013 | 4871.70 | 0.238 | 0.032 | 0.008 | 2.30 |
| Total | 134 | | | | | | | | |

*: p<0.05; **: p<0.01

assumed due to different genetic constitution of genetic material used in experiment (Table 1, 2). Interaction among genotype, plant spacing and nitrogen fertilizer was significant only for plant height, seed cotton yield and CLCuV infestation. The significant difference in plant height leads to conclude that genotypes, plant spacing and nitrogen fertilizer changed the plant height which increase by increasing nitrogen fertilizer and decreased with increasing plant to plant spacing (Table 3, 4), while response of plant spacing and nitrogen fertilizer on plant height varies with genetic constitution of genotypes. (Table 5, 6), whereas differences within genotypes are due to different growth habit.

The genotype MNH-6070 attained 145.1 cm height as compared to 86.2% and 97.4 cm of BH-160 and CIM-496 respectively. Both these varieties have high CLCuV (86.5 and 87.8%) infestation, respectively (Table 2), which indicated that plant height reduced due to CLCuV. These findings are in according to Tariq *et al.* (2003) and Brown (2001) who reported decreased in plant height due to CLCuV. The no. of bolls $m^{-2}$ and B. wt. are the major yield components which are non-significantly affected by the interaction of genotypes, plant spacing and nitrogen fertilizer but nitrogen fertilizer has significant effect on no. of bolls $m^{-2}$ (Table 1), as maximum No. of bolls $m^{-2}$ (125.8) were observed at $N_3$ level (11 bags of urea $ha^{-1}$) and minimum (105.2) were observed under $N_1$ (6.5 bags of urea $ha^{-1}$). Similar findings were reported by Oosterhuis and Bondada (2001). Nitrogen fertilizer increase the chlorophyll contents (Oosterhuis and Bondada, 2001) which leads to enhance the vegetative growth if plant is not in reproductive phase. The genotypes showed different behaviour in blooming and growth habits due to the reason the response of nitrogen fertilizer and spacing varied genotype to genotype and interaction of genotypes and plant spacing is also significant (Table 5-7), Seed cotton yield is significantly affected by

Table 2: Effect of different genotype on plant height, yield and yield components

| SOV | Height | No. of bolls $m^{-2}$ | B. wt. | Yield | G.O.T.(%) | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|
| $V_1$ | 123.50 | 128.0 | 4.400 | 3483.00 | 38.40 | 27.40 | 4.600 | 19.100 |
| $V_2$ | 126.00 | 121.3 | 3.600 | 2559.30 | 39.10 | 31.20 | 4.200 | 88.800 |
| $V_3$ | 97.40 | 117.9 | 3.100 | 2396.90 | 40.20 | 28.30 | 4.700 | 87.800 |
| $V_4$ | 86.20 | 114.1 | 2.700 | 2058.50 | 39.20 | 27.80 | 4.600 | 86.500 |
| $V_5$ | 145.10 | 140.0 | 3.300 | 3245.00 | 42.10 | 27.00 | 4.900 | 2.300 |
| CD 5% | 0.27 | 0.3 | 0.008 | 4.89 | 0.06 | 0.09 | 0.005 | 0.118 |

$V_1$: MNH-786, $V_2$: MNH-789, $V_3$: CIM-496, V4: BH-160, $V_5$: 6070

Table 3: Effect of plant spacing on plant height, yield and yield components

| SOV | Plant spacing (cm) | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | G.O.T.(%) | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|---|
| $S_1$ | 15 | 123.10 | 123.4 | 3.4 | 2839.0 | 39.8 | 28.3 | 4.6 | 56.3 |
| $S_2$ | 30 | 114.20 | 124.4 | 3.4 | 2788.1 | 39.8 | 28.4 | 4.6 | 57.0 |
| $S_3$ | 45 | 109.70 | 125.1 | 3.4 | 2618.4 | 39.8 | 28.3 | 4.6 | 57.5 |
| | | 0.35 | NS | NS | NS | NS | NS | NS | NS |

NS: Non significant

Table 4: Effect of Nitrogen level on plant spacing, plant height, yield and yield components

| SOV | Nitrogen fertilizer bag $ha^{-1}$ | Height | No. of bolls $m^{-2}$ | B. wt. | Yield | G.O.T.(%) | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|---|
| $N_1$ | 6.20 | 105.20 | 121.90 | 3.4 | 2454.00 | 39.8 | 28.3 | 4.6 | 55.3 |
| $N_2$ | 8.60 | 116.00 | 130.00 | 3.4 | 2787.70 | 39.8 | 28.3 | 4.6 | 57.1 |
| $N_3$ | 11.0 | 125.80 | 120.90 | 3.4 | 3003.90 | 39.8 | 28.3 | 4.6 | 58.3 |
| | | 0.23 | 1.58 | NS | 8.48 | NS | NS | NS | NS |

NS: Non Significant

Table 5: Means performance under interaction of varieties and plant spacing

| SOV | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | G.O.T.% | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|
| $V_1 \times S_1$ | 129.80 | 108.50 | 4.4 | 2877.60 | 38.6 | 27.4 | 4.6 | 17.6 |
| $V_1 \times S_2$ | 123.00 | 130.60 | 4.4 | 3627.40 | 38.2 | 27.4 | 4.6 | 19.8 |
| $V_1 \times S_3$ | 117.60 | 144.80 | 4.4 | 3943.80 | 38.3 | 27.4 | 4.6 | 19.8 |
| $V_2 \times S_1$ | 134.50 | 138.00 | 3.6 | 3275.20 | 39.0 | 31.2 | 4.2 | 87.6 |
| $V_2 \times S_2$ | 125.40 | 118.50 | 3.6 | 2370.00 | 39.2 | 31.2 | 4.1 | 89.5 |
| $V_2 \times S_3$ | 118.20 | 117.60 | 3.1 | 2899.60 | 40.2 | 28.3 | 4.8 | 87.4 |
| $V_3 \times S_1$ | 160.00 | 107.50 | 3.7 | 2032.00 | 39.2 | 31.1 | 4.2 | 89.2 |
| $V_3 \times S_2$ | 96.10 | 112.70 | 3.1 | 2264.40 | 40.3 | 28.3 | 4.7 | 87.6 |
| $V_3 \times S_3$ | 90.20 | 123.30 | 3.0 | 2026.60 | 40.2 | 28.2 | 4.7 | 88.5 |
| $V_4 \times S_1$ | 92.50 | 125.20 | 2.7 | 2433.00 | 39.2 | 27.8 | 4.6 | 86.7 |
| $V_4 \times S_2$ | 83.50 | 116.00 | 2.7 | 1999.70 | 39.1 | 27.9 | 4.6 | 85.4 |
| $V_4 \times S_3$ | 82.60 | 101.20 | 2.7 | 1742.70 | 39.2 | 27.7 | 4.6 | 87.4 |
| $V_5 \times S_1$ | 152.60 | 127.60 | 3.3 | 2709.60 | 41.1 | 27.0 | 5.0 | 2.0 |
| $V_5 \times S_2$ | 143.00 | 144.00 | 3.3 | 3679.20 | 42.2 | 27.0 | 5.0 | 2.5 |
| $V_5 \times S_3$ | 139.80 | 148.50 | 3.3 | 3346.20 | 42.3 | 27.0 | 4.9 | 2.5 |
| CD 5 % | 0.45 | 3.03 | NS | 16.42 | NS | NS | NS | NS |

NS: Non Significant

Table 6: Means performance under interaction of varieties and nitrogen

| SOV | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | G.O.T.% | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|
| $V_1 \times N_1$ | 113.20 | 124.5 | 4.3 | 3426.50 | 38.70 | 27.5 | 4.6 | 18.550 |
| $V_1 \times N_2$ | 125.00 | 130.1 | 4.4 | 3475.60 | 38.20 | 27.4 | 4.6 | 19.600 |
| $V_1 \times N_3$ | 132.20 | 129.4 | 4.4 | 3446.80 | 38.30 | 27.4 | 4.6 | 19.200 |
| $V_2 \times N_1$ | 116.20 | 119.2 | 3.7 | 2201.20 | 39.00 | 31.1 | 4.2 | 86.400 |
| $V_2 \times N_2$ | 127.70 | 128.8 | 3.6 | 2525.50 | 39.20 | 31.3 | 4.1 | 87.800 |
| $V_2 \times N_3$ | 134.20 | 116.0 | 3.7 | 2951.20 | 39.20 | 31.1 | 4.2 | 92.100 |
| $V_3 \times N_1$ | 85.00 | 116.1 | 3.1 | 1960.10 | 40.20 | 28.3 | 4.8 | 84.700 |
| $V_3 \times N_2$ | 96.10 | 128.1 | 3.0 | 2486.70 | 40.20 | 28.3 | 4.7 | 88.400 |
| $V_3 \times N_3$ | 111.20 | 109.5 | 3.1 | 2743.80 | 40.30 | 28.3 | 4.7 | 90.400 |
| $V_4 \times N_1$ | 75.70 | 109.8 | 2.7 | 1693.50 | 39.30 | 27.7 | 4.6 | 84.700 |
| $V_4 \times N_2$ | 86.80 | 119.6 | 2.7 | 2085.40 | 39.20 | 27.8 | 4.6 | 87.700 |
| $V_4 \times N_3$ | 96.10 | 112.8 | 2.7 | 2396.50 | 39.20 | 27.8 | 4.6 | 87.100 |
| $V_5 \times N_1$ | 135.80 | 140.0 | 3.2 | 2988.50 | 41.90 | 27.0 | 4.9 | 2.100 |
| $V_5 \times N_2$ | 144.50 | 143.3 | 3.4 | 3365.30 | 42.20 | 27.0 | 4.9 | 2.100 |
| $V_5 \times N_3$ | 155.10 | 136.8 | 3.3 | 3381.20 | 42.20 | 27.0 | 5.0 | 2.800 |
| Cd 5% | 0.50 | 3.2 | NS | 14.69 | NS | NS | NS | 0.465 |

NS: Non Significant

Table 7: Means performance under interaction of plant spacing and nitrogen fertilizer levels for height, yield and yield components

| SOV | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | G.O.T.% | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|
| $N_1 \times S_1$ | 113.0 | 122.8 | 3.4 | 2711.10 | 39.8 | 28.3 | 4.7 | 55.1 |
| $N_2 \times S_1$ | 123.0 | 128.2 | 3.4 | 2793.00 | 39.8 | 28.3 | 4.6 | 55.8 |
| $N_3 \times S_1$ | 133.0 | 119.2 | 3.4 | 3013.00 | 39.7 | 28.4 | 4.6 | 57.9 |
| $N_1 \times S_2$ | 103.9 | 124.3 | 3.3 | 2431.60 | 39.8 | 28.4 | 4.6 | 55.2 |
| $N_2 \times S_2$ | 114.0 | 133.2 | 3.4 | 2869.40 | 39.8 | 28.4 | 4.6 | 57.3 |
| $N_3 \times S_2$ | 124.7 | 115.6 | 3.4 | 3063.40 | 39.8 | 28.4 | 4.6 | 58.5 |
| $N_1 \times S_3$ | 98.6 | 118.6 | 3.4 | 2219.20 | 39.8 | 28.3 | 4.6 | 55.6 |
| $N_2 \times S_3$ | 111.2 | 128.6 | 3.4 | 2700.70 | 39.8 | 28.3 | 4.6 | 58.3 |
| $N_3 \times S_3$ | 119.4 | 128.0 | 3.5 | 2935.40 | 39.8 | 28.3 | 4.7 | 58.3 |
| Cd 5% | NS | NS | NS | 13.79 | NS | NS | NS | NS |

NS: Non Significant

genotypes, plant spacing, nitrogen fertilizer and their interaction. Lowest seed cotton yield 1605, 1630 and 1741 kg ha$^{-1}$ was obtained from $V_3 \times S_3 \times N_1$, $V_4 \times S_3 \times N_1$ and $V_2 \times S_3 \times N_1$ (Table 8). The varieties $V_3$ (CIM-496), $V_4$ (BH-160) and $V_2$ (MNH-789) are highly susceptible to CLCuV % (Table 2). The highest seed cotton yield 3896 kg ha$^{-1}$ was observed under $V_5 \times S_2 \times N_2$ and followed by $V_5 \times S_2 \times N_3$ (3803 kg ha$^{-1}$), but difference was non significant (Table 8). The variety $V_5$ (MNH-6070) showed minimum CLCuV infestation (2.3%) as compared to other varieties (Table 2). It indicated that seed cotton yield decrease significantly under higher CLCuV infestation similar findings were reported by Moskovetz (1941) and Tariq *et al.* (2003). The decrease in yield under high CLCuV infestation can be managed by increasing plant population and nitrogen fertilizer and low spacing ($S_1$). High nitrogen fertilizer avoids the stunted growth in highly CLCuV infested genotype which leads to continuity in plant growth and ultimately leads to increase seed cotton yield. As the CLCuV affected plants showed less vegetative growth and plant height keeping low plant spacing (high plant population) and higher nitrogen fertilizer compensate the No. of bolls m$^{-2}$ (Table 3, 4, 8).

The highly CLCuV infested genotypes showed better response to low plant spacing and high nitrogen fertilizer (Table 8). From the present study it is concluded that the optimum yield of seed cotton can be achieved by increasing the plant population (decreasing plant to plant spacing) and nitrogen fertilizer. It is also concluded that the genotypes which are less susceptible to CLCuV showed negative response to high nitrogen fertilizer and low spacing i.e., MNH-6070 (Table 8). The genotypes showed maximum seed cotton yield (3896) under $S_2$ (p×p = 30 cm) and $N_2$ (8.6 bag of urea ha$^{-1}$).

It is evident that the genotype $V_3$ (CIM-496) is highly susceptible to CLCuV (90.3%) which gave maximum yield (3391 kg ha$^{-1}$) under $S_1$ (p×p = 154 cm) and $N_3$ (11.0 bag of urea ha$^{-1}$) (Table 8). The response of genotype to nitrogen fertilizer and spacing varied due to CLCuV infestation, as the CLCuV infested plants showed stunted and less vegetative growth, by increasing the nitrogen fertilizer and decreasing the plant spacing improve the plant growth and No. of bolls m$^{-2}$ which ultimately leads to high seed cotton yield.

The unique findings of present study are as:

- ClCuV infestation varies among genotypes.
- Highly ClCuV infested varieties response positively to low plant spacing.
- High nitrogen fertilizer gives positive response in high ClCuV infestation.

Table 8: Means performance under interaction of genotype, plant spacing and Nitrogen Fertilizer levels for height, yield and yield components

| SOV | Height | No. of bolls $m^{-2}$ | B.wt. | Yield | G.O.T.% | SL | Micronaire | CLCuV |
|---|---|---|---|---|---|---|---|---|
| $V_1 \times S_1 \times N_1$ | 120.30 | 115.0 | 4.2 | 3394.00 | 39.6 | 27.5 | 4.6 | 17.300 |
| $V_1 \times S_1 \times N_2$ | 131.60 | 119.3 | 4.5 | 2816.60 | 38.1 | 27.2 | 4.6 | 17.600 |
| $V_1 \times S_1 \times N_3$ | 137.60 | 101.3 | 4.3 | 2422.30 | 38.1 | 27.5 | 4.6 | 18.000 |
| $V_1 \times S_2 \times N_1$ | 113.00 | 119.6 | 4.4 | 3335.60 | 38.2 | 27.5 | 4.6 | 19.000 |
| $V_1 \times S_2 \times N_2$ | 122.30 | 134.0 | 4.4 | 3683.30 | 38.2 | 27.6 | 4.7 | 20.000 |
| $V_1 \times S_2 \times N_3$ | 133.60 | 138.3 | 4.3 | 3863.30 | 38.4 | 27.3 | 4.6 | 20.600 |
| $V_1 \times S_3 \times N_1$ | 106.30 | 139.0 | 4.3 | 3550.00 | 38.3 | 27.5 | 4.6 | 19.300 |
| $V_1 \times S_3 \times N_2$ | 121.00 | 145.0 | 4.3 | 3926.60 | 38.2 | 27.4 | 4.7 | 21.300 |
| $V_1 \times S_3 \times N_3$ | 125.60 | 148.6 | 4.4 | 4355.00 | 38.3 | 27.4 | 4.6 | 19.000 |
| $V_2 \times S_1 \times N_1$ | 127.00 | 128.3 | 3.7 | 2823.30 | 38.5 | 31.1 | 4.7 | 87.000 |
| $V_2 \times S_1 \times N_2$ | 135.30 | 136.3 | 3.6 | 3236.60 | 39.2 | 31.2 | 4.3 | 83.600 |
| $V_2 \times S_1 \times N_3$ | 141.30 | 149.3 | 3.7 | 3765.60 | 39.1 | 31.2 | 4.1 | 92.300 |
| $V_2 \times S_2 \times N_1$ | 116.30 | 118.6 | 3.6 | 2038.60 | 39.4 | 31.2 | 4.3 | 87.000 |
| $V_2 \times S_2 \times N_2$ | 125.00 | 131.0 | 3.6 | 2296.60 | 39.2 | 31.0 | 4.2 | 98.300 |
| $V_2 \times S_2 \times N_3$ | 135.00 | 106.0 | 3.7 | 2774.60 | 39.1 | 31.5 | 4.1 | 92.300 |
| $V_2 \times S_3 \times N_1$ | 105.30 | 102.6 | 3.7 | 1741.60 | 39.2 | 31.1 | 4.2 | 85.300 |
| $V_2 \times S_3 \times N_2$ | 123.00 | 106.3 | 3.6 | 2043.30 | 39.2 | 31.1 | 4.2 | 90.600 |
| $V_2 \times S_3 \times N_3$ | 126.30 | 113.6 | 3.7 | 2313.30 | 40.1 | 31.1 | 4.2 | 91.600 |
| $V_3 \times S_1 \times N_1$ | 93.30 | 108.0 | 3.1 | 2460.30 | 40.2 | 31.1 | 4.2 | 85.000 |
| $V_3 \times S_1 \times N_2$ | 101.30 | 116.0 | 3.1 | 2847.00 | 40.2 | 31.1 | 4.9 | 87.000 |
| $V_3 \times S_1 \times N_3$ | 123.30 | 129.0 | 3.2 | 3391.60 | 40.5 | 28.3 | 4.8 | 90.300 |
| $V_3 \times S_2 \times N_1$ | 84.60 | 101.4 | 3.1 | 1815.00 | 40.3 | 28.4 | 4.7 | 84.300 |
| $V_3 \times S_2 \times N_2$ | 96.60 | 114.0 | 3.1 | 2405.00 | 40.2 | 28.3 | 4.7 | 89.300 |
| $V_3 \times S_2 \times N_3$ | 107.00 | 123.0 | 3.1 | 2673.30 | 40.1 | 28.4 | 4.7 | 89.300 |
| $V_3 \times S_3 \times N_1$ | 77.00 | 98.0 | 3.1 | 1605.00 | 40.2 | 28.3 | 4.8 | 85.000 |
| $V_3 \times S_3 \times N_2$ | 90.30 | 103.0 | 2.9 | 2208.30 | 40.2 | 28.3 | 4.8 | 89.000 |
| $V_3 \times S_3 \times N_3$ | 103.30 | 105.0 | 3.0 | 2266.60 | 39.5 | 28.2 | 4.7 | 91.600 |
| $V_4 \times S_1 \times N_1$ | 82.00 | 120.3 | 2.8 | 1974.30 | 39.1 | 28.3 | 4.8 | 85.000 |
| $V_4 \times S_1 \times N_2$ | 94.30 | 124.1 | 2.7 | 2358.00 | 39.2 | 28.2 | 4.7 | 89.000 |
| $V_4 \times S_1 \times N_3$ | 101.30 | 131.0 | 2.7 | 2866.60 | 39.1 | 27.7 | 4.6 | 86.300 |
| $V_4 \times S_2 \times N_1$ | 72.60 | 120.0 | 2.7 | 1830.30 | 39.0 | 28.0 | 4.5 | 83.000 |
| $V_4 \times S_2 \times N_2$ | 83.00 | 128.3 | 2.7 | 2066.30 | 39.2 | 27.7 | 4.6 | 86.000 |
| $V_4 \times S_2 \times N_3$ | 95.00 | 99.6 | 2.7 | 2302.60 | 39.3 | 27.8 | 4.5 | 87.300 |
| $V_4 \times S_3 \times N_1$ | 72.60 | 89.3 | 2.8 | 1776.00 | 39.3 | 27.8 | 4.6 | 86.300 |
| $V_4 \times S_3 \times N_2$ | 83.30 | 99.3 | 2.8 | 1832.00 | 39.1 | 28.0 | 4.6 | 88.300 |
| $V_4 \times S_3 \times N_3$ | 92.00 | 115.0 | 2.7 | 2020.30 | 41.3 | 27.7 | 4.6 | 87.600 |
| $V_5 \times S_1 \times N_1$ | 142.60 | 126.6 | 3.2 | 2803.60 | 42.3 | 27.6 | 4.6 | 1.300 |
| $V_5 \times S_1 \times N_2$ | 152.60 | 122.0 | 3.4 | 2706.60 | 42.1 | 27.9 | 5.1 | 2.000 |
| $V_5 \times S_1 \times N_3$ | 162.60 | 121.3 | 3.2 | 2618.60 | 42.1 | 27.0 | 5.0 | 2.600 |
| $V_5 \times S_2 \times N_1$ | 133.00 | 142.0 | 3.3 | 3338.30 | 42.2 | 27.0 | 4.9 | 2.600 |
| $V_5 \times S_2 \times N_2$ | 143.00 | 150.0 | 3.4 | 3896.00 | 42.2 | 27.0 | 4.9 | 2.000 |
| $V_5 \times S_2 \times N_3$ | 153.00 | 133.0 | 3.4 | 3803.30 | 42.4 | 26.9 | 5.0 | 2.000 |
| $V_5 \times S_3 \times N_1$ | 132.00 | 149.1 | 3.3 | 2823.70 | 42.2 | 27.1 | 5.0 | 3.000 |
| $V_5 \times S_3 \times N_2$ | 138.00 | 138.0 | 3.3 | 3493.30 | 42.2 | 27.1 | 4.9 | 2.300 |
| $V_5 \times S_3 \times N_3$ | 149.60 | 143.3 | 3.4 | 3721.60 | 42.3 | 27.1 | 5.0 | 2.300 |
| CD 5% | 0.91 | NS | NS | 27.49 | NS | NS | NS | 0.662 |

NS: Non Significant

- Plant height and No. of bolls $m^{-2}$ improve at low plant spacing and high nitrogen fertilizer under high ClCuV infestation.

It is suggested that further studies should be carried in wider ecological conditions to assess the response of recommended commercial varieties/new strain to nitrogen fertilizer and plant spacing.

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