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PERFORMANCE OF SOME ADVANCED GENOTYPES OF COTTON IN TERMS OF CMT, CLCuV AND YIELD

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ABSTRACT. Cotton leaf curl virus (CLCuV) and heat stress are the major threats to cotton productivity in Pakistan. Both these factors inflicted huge losses in recent years. Thirty one genotypes of *Gossypium hirsutum* L. were sown in the experimental area of Cotton Research Institute, Faisalabad, Pakistan, on 25th of May for the purpose of screening against aforementioned stresses. Analysis of variance revealed significant variation among the tested genotypes. Some of the genotypes showed promising results in terms of CLCuV and also showed fair stability of their membranes. The strain FH-142 showed excellent tolerance level against CLCuV and heat stress by showing the values of 0.4% for cotton leaf curl virus and membrane stability of 46.1%. The other genotypes that showed promising results in terms of CLCuV % are FH-330, MNH-886, MNH-814 and FH-312 and regarding heat stress MNH-456, FH-142, FH-118, CRSM-38 and NIAB-112 exhibited promising results by showing the CMT % of 46.4%, 46.1, 45.5, 45.5, 44.1, and 41.9%, respectively. The findings of the experiment may be helpful in designing breeding programmes regarding CLCuV and heat tolerance as material had considerable potential for better yield as well.

Key words: CLCuV%; CMT%; Cotton; Pakistan.

INTRODUCTION

Cotton is the major industrial crop in many countries of the world including Pakistan (Imran *et al.,* 2012). It is grown in most of the warmer regions of the country (Riaz *et al.,* 2013). The biotic and abiotic factors are major threats to agriculture and food security (Farooq *et al.,* 2011). The cotton plant responds actively to management and changes in the environment. Among various factors affecting seed cotton yield, high temperature act as a key control on the rate of cotton plant growth (Baker, 1965). The ideal temperature for cotton growth is from 20 to 30ºC (Reddy *et al.,* 1991), with the optimum temperature for

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photosynthesis is 28ºC (Burke *et al.,* 1988). Temperature stress affects seedling growth, root growth, vegetative growth, flowering, fruit set ultimately yield and fiber quality (Singh *et al.,* 2007). The environmental stress have damaging effect on yield as it is estimated that crops achieve only about 25% of their potential yield (Boyer, 1982) including heat stress. These stresses are variable in frequency, intensity and to some extent are location-specific, and can occur at any stage of plant growth and development (Khan *et al.,* 2008). In Pakistan temperature during summer approaches about 50 C and this beyond limit temperature stress severely affect seed cotton yield and fiber quality (Khan *et al.,* 2008; Rahman, 2006). The precise methodology to screen out germplasms against stress tolerance under natural conditions is expensive as well as laborious (Blum and Ebercon, 1981). Relative cell injury level from leaf disks by inducing high temperature has been proposed as a reliable screening method for heat tolerance studies in plants (Sullivan, 1972). Cell membrane thermostability method of screening against heat is simpler, quicker and less expensive than the whole plant screening. It can be used at early vegetative stage leaf tissues from plants grown in field nursery environments (Ismail and Hall, 1999). Like temperature cotton leaf curl virus disease also influence on yield and fiber quality traits (Farooq *et al.,* 2013). During last 20 years yield in Pakistan is severely affected by this notorious disease. Several efforts and screening methods have been proposed to screen out material against this disease. Present studies aimed at screening genotypes from all over Pakistan against heat stress and CLCuV tolerance that may be exploited as parental material in the development of heat and virus tolerant cultivars.

MATERIALS AND METHODS

Plant material and site characteristics

A total of 31 diverse genotypes were evaluated at the experimental area of Cotton Research Institute, Faisalabad, Pakistan, during the year 2010-2011. The material was sown on 25th of May to observe their tolerance ability regarding CLCuV and heat stress.

Experimental design, plot size and cultural practices

Layout of the experiments was randomized complete block design (RCBD) with three replicates. For each entry, plot size measured 4.572 m × 3.048 m, comprising four rows set 75 cm apart. Distance between plants within rows was 30 cm. Normal agronomic and cultural practices (irrigation, weeding, hoeing, and fertilizer applications) were adopted as and when required.

Measurement of CMT (%) and CLCuV tolerance

Measurement of CMT (%)

The genotypes were assessed for heat tolerance at reproductive stage following the methodology previously used in cotton by Gorham *et al*., 1998 and in wheat by Farooq *et al.* 2011 a and b. For measurement of CMT% five leaves of each plant of each entry were taken at the

reproductive phase. The collection of samples continued for two week, at temperatures ranging between 32 and 40°C. Two discs of equal size were taken from each of the sampled leaves with a sharp steel pipe of 12.5 mm diameter and rinsed twice with demonized water. Ten discs taken from each experimental plant were placed in 16 × 150 mm test tubes containing 20 ml deionized water. The test tubes were kept in a water bath at 49°C for 30 min, taking care the contents of the test tube was submerged in the water. After the treatment period the tubes were held overnight at room temperature 25ºC and the leakage of electrolytes (conductance) was measured with electrical conductivity meter (Model N° Jenway-4510 Sr. No-02370 Barlow World Scientific Limited, UK) in the next morning. The samples in the test tubes were then autoclaved (Model N° HVA-85 Hrayama Manufacturing Company, Japan) at 120°C and 0.10 MPa for 10 min at 120°C and conductance was measured again when the temperature of the tubes reached that of room. Membrane thermal stability (MTS) was calculated using the following formula: MTS = (1 – T1/T2) × 100, where: T1, T2 refers to conductivity readings after heat treatment and autoclaving, respectively.

CLCuV disease incidence (%) methodology

CLCuV disease incidence (%) and reaction of the genotypes was determined using the disease scale (*Table 1*) described by Akhtar *et al.*, 2010 and suggested by Farooq *et al.,* 2011. Then % age of CLCuV disease incidence was calculated by using the following formula: CLCuV disease incidence (%) = Sum of all disease ratings/total number of plants ×16.16

Seed cotton was picked when the crop was mature and recorded as kg / plot and extrapolated in kg / hectare.

Table 1 - Rating scale for cotton leaf curl virus (CLCuV) symptoms

Symptoms	Disease rating	Disease index (%)	Disease reaction
Absence of symptoms.	0	0	Immune
Thickening of a few small veins or the presence of leaf enations on 10 or fewer leaves of a plant.	1	0.1- 1	Highly resistant
Thickening of a small group of veins.	2	1.1- 5	Resistant
Thickening of all veins but no leaf curling.	3	5.1-10	Moderately resistant
Severe vein thickening and leaf curling on the top third of the plant.	4	10.1 – 15	Moderately susceptible
Severe vein thickening and leaf curling on the half of the plant.	5	15.1 – 20	Susceptible
Severe vein thickening, leaf curling, and stunting of the plant with reduced fruit production.	6	>20	Highly susceptible

Statistical analysis

The data of various CMT %, CLCuV and yield of 31 cotton genotypes were subjected to analysis of variance (ANOVA) using the Mstatc package (Russell, D. Freed, Michigan State University, USA). Where the "F" statistics indicated significance, the means were separated using Fisher's protected Least Significance Difference test (LSD) at P = 0.05.

RESULTS

In the present experiment 31 genotypes were screened for heat stress and CLCuV tolerance. For screening against heat stress CMT % method was employed to obtain genotypes that can be exploited in future breeding programmes. Analysis of variance revealed highly significant differences among the genotypes studied for CMT %, CLCuV % and seed cotton yield traits *Table 2*. With respect to CMT % the genotypes namely MNH-456, FH-142, FH-118, CRSM-38 and NIAB-112 exhibited promising results by showing the CMT % of 46.4%, 46.1, 45.5, 45.5, 44.1, and 41.9%, respectively *Fig. 1*.

Table 2 - Mean squares of CMT%, CLCuV% and yield kg/ha of 31 genotypes of cotton

SOV	Df	CMT (%)	CLCuV (%)	Yield (kg/ha)
Reps	2	9.085^{NS}	0.846^{NS}	11374^{NS}
Treatment	30	320.199**	586.171**	411447**
Error	60	0.448	1.643	7291
Grand Mean		28.016	26.139	1694.3
CV %		2.39	1.90	5.04

**Significant at P≤ 0.01; NS, Non-significant at P> 0.05

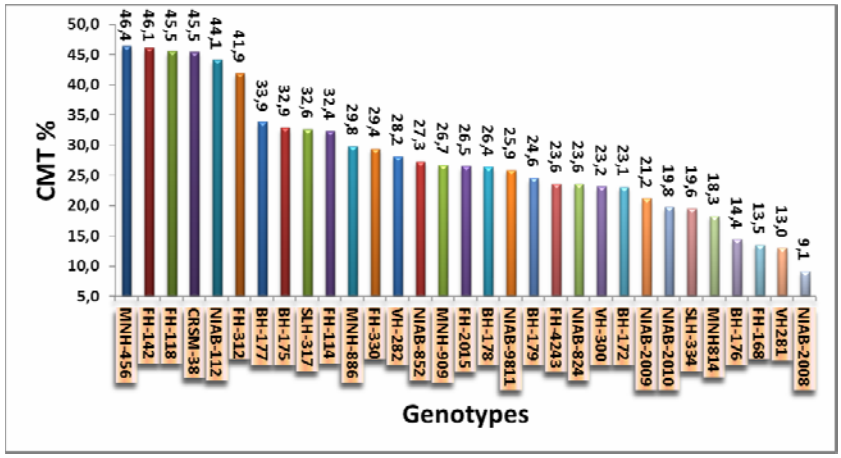

Figure 1 - Performance of various genotypes of cotton *Gossypium hirsutum* L. in terms of CMT (%)

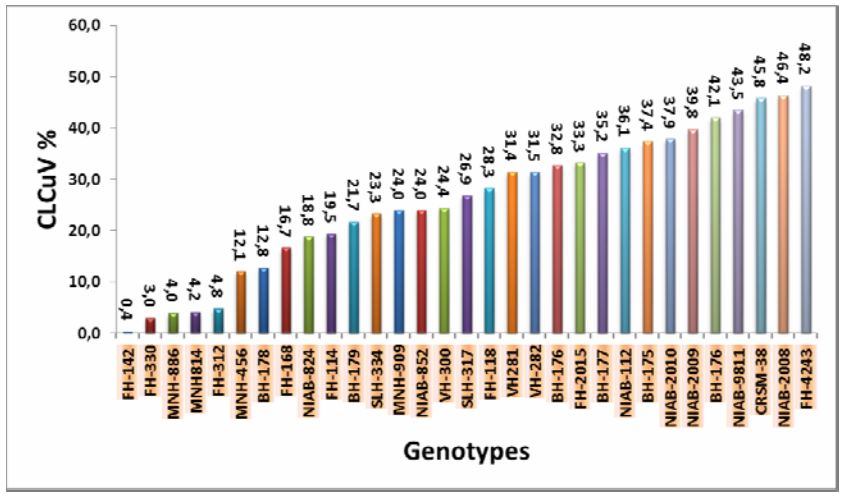

Figure 2 - Performance of various genotypes of cotton *Gossypium hirsutum* L. in terms of CLCuV (%)

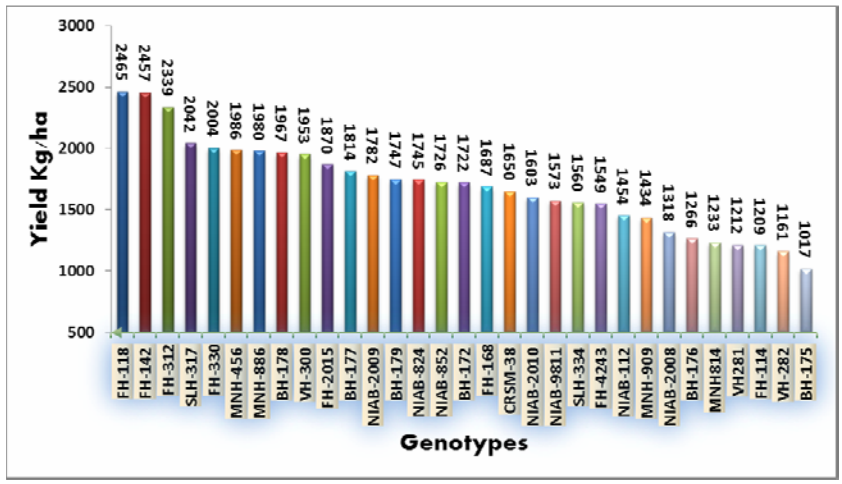

Figure 3 - Performance of various genotypes of cotton *Gossypium hirsutum* L. in terms of yield (kg/ha)

Other genotypes did not showed better results in terms of CMT%. Regarding CLCuV studies genotypes FH-142 which showed good performance in terms of CMT% also showed very good tolerance ability and showed a CLCuV % of only 0.4%. The other genotypes that showed promising results in terms of CLCuV % are FH-330, MNH-886, MNH-814 and FH-312. These genotypes showed CLCuV % of less than 5%. The varieties that showed most susceptible values include FH-

4243, NIAB-2008, CRSM-38, NIAB-9811 and BH-176 which showed above 40% CLCuV incidence *Fig. 2*. With respect to seed cotton yield FH-118 and FH-142 secured top position by giving seed cotton yield of 2465 kg/ha and 2457 kg/ha, respectively *Fig. 3*. However, the genotypes FH-312, MNH-886, SLH-317, FH-330 MNH-456 and BH-178 also showed promising results in terms of yield. Collectively the genotype FH-142, MNH-886, FH-312, and FH-330 are better in all three studied traits. The genotype FH-118 though showed best yield because of its long duration nature and heat tolerance ability but it is deficient in virus tolerance so may be considered for specific cultivation in areas with less attack of virus or may be sown early to avoid virus stress.

DISCUSSION

The optimum sowing time for cotton in Pakistan is in the month of May and the crop natures near the month of September to November. During the cotton growing season air temperature remains between 45-50°C which is quite high though cotton is a sun loving plant. High temperature not only accelerates the plant development but also badly affect the membrane structure (Reddy *et al*., 1997 a and b). High temperature showed strong negative association with lint yield and quality (Ziska *et al.,* 1997; Singh *et al.,* 2007). Similarly, Cotton leaf curl virus influences seed cotton yield and previous studies have shown that this disease causes huge losses to cotton productivity in Pakistan. Farooq *et al.,* 2011 reported that cotton leaf curl virus is the most devastating natural calamity that inflicted huge losses to cotton productivity during the last two decades. In Pakistan both temperature stress and CLCuV infestation come almost at the same time resulting severe losses to final produce. So, before designing a breeding programme in the current scenario screening of the material against heat and CLCuV tolerance should be the necessary practice. In the present set of experiment 31 genotypes were evaluated for these two major factors. From this experiment some very interesting results were obtained including the moderately susceptible variety showing best yield and most tolerant genotype showing the best results. These results may be due to the fact that the genotype FH-118 avoided virus stress during peak flowering season and also have the ability to counter heat stress. Kakani *et al*., (2005) in cotton and Farooq *et al.*, 2011 in wheat confirmed that membrane leakage was the most sensitive technique for quantifying temperature tolerance under field conditions. Significant amount of variability was found for both CMT % and CLCuV% which could be exploited in future breeding programmes to develop heat and CLCuV tolerant varieties. The genotypes including FH-142, MNH-886, FH-330, FH-312 and MNH456 proven to be the future breeding stock

to counter heat and virus stress as all these genotypes possessed high degree of tolerance against both these natural calamities.

CONCLUSION

It was concluded on the basis of the results from the present findings that CMT % calculation method using leaf discs and screening for CLCuV % using the current method may be exploited as selection criteria for the development of heat and virus tolerant varieties.

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