Genetics and Combining Ability of Leaf Curl Virus Resistance in Cotton (*Gossypium hirsutum* L.)

L.S. Randhawa, B.L. Chopra, P.S. Nagi, H.S. Dhami and B. Indu
Department of Plant Breeding, Punjab Agricultural University,
Ludhiana-141 004, Punjab, India

ABSTRACT

The cotton leaf curl virus (CLCV) disease caused by Gemini viruses has resulted in failure of the cotton crop in many countries. The losses caused by this disease range from 20 to 80 percent depending upon the stage of viral infection by virulent cotton white fly (Bemisia tabaci). The only permanent approach of combating this menace is through resistant varieties and hybrids. An understanding of the genetics and combining ability of CLCV resistance is a pre-requisite for breeding cultivars resistant to this disease. The present investigation was undertaken for that purpose. The experimental material consisted of 90 crosses involving resistant and susceptible parents and segregating generations. The experiments were conducted at Punjab Agricultural University, Ludhiana under artificial conditions and at the Cotton Research Station, Abohar, under disease epiphytotic conditions. The CLCV resistance was controlled by more than two genes along with inter-allelic interactions. Good general combining parents included LH 1134, IL 85, IL 89 and IL 99 as females and F 54 as male parent for virus resistance. PIL 43 x PIL 8 (LHH 144), LH 1832 x F 54, LH 1818 x F 54, and LH 1556 x R 27 were good specific combining crosses for CLCV resistance. The resistant crosses involved either one or both resistant/tolerant parents. The breeding approaches for CLCV resistance are discussed.

Introduction

The cotton leaf curl virus (CLCV) disease caused by Gemini viruses has resulted in crop failure in many countries, especially Pakistan and northern India. In India, CLCV appeared for the first time along the Pakistan border in the Abohar area in 1994 (Kapoor *et al.*, 1994). The losses caused by this disease range from 20 to 80 percent, depending upon the stage of viral infection by virulent cotton white fly (*Bemisia tabaci*).

Though all the varieties recommended in the northern cotton belt of India are susceptible to this disease, sources of resistance have been identified in the gene pool. Knowledge of the nature and magnitude of gene action is important for breeding CLCV resistant varieties and hybrids. In previous work Randhawa *et al.* (1998) identified a cross (LHH 144) that was highly resistant to CLCV under artificial and field conditions. Wilson and Brown (1991) studied the inheritance of cotton leaf crumple virus, but the literature pertaining to genetics, combining ability and heterosis for CLCV resistance is scanty so this investigation was undertaken to study these factors.

Material and Methods

The experimental material consisted of 9 lines used as female, *viz*. LH 1556, LH 1818, LH 1832, LH 1587, F 1378, LH 1134, IL 85, IL 89, IL 99 and 10 testers, namely, CF, DD 5, TH 13, TH 27, R 12, R 14, R 65, F 24, F 54 and R 27. Ninety F_1 crosses, 19 parents, F_2 and backcross generations of PIL 43 x PIL 8, PIL 8 x F 846 and F 846 x PIL 8 crosses and 84 hybrids were evaluated in three separate randomized complete blocks (RBD) with three replications during *kharif* 1997 at the Cotton Research Station, Abohar and Punjab Agricultural University, Ludhiana. Recommended agronomic practices were followed to raise the crop.

The data recorded included leaf curl incidence (%), plant height (cm) and seed cotton yield (g). The data on plant height and seed cotton yield were recorded at maturity while data on leaf curl incidence were taken at 90 days and again at 120 days after sowing. The appearance of primary vein thickening and secondary vein thickening was scored as susceptible and percent incidence was calculated based on the number of susceptible plants among the total plants/plot/ replication. Means were used to estimate combining ability effects by line x tester analysis. The generation mean analysis was conducted for segregating and parental generations. The straight and reciprocal cross combinations were evaluated for per se incidence of CLCV.

Results and Discussion

The mean squares due to female and male parents for CLCV incidence, seed cotton yield and plant height were significant (Table 1) indicating genetic variation in the material under investigation. The parent vs. hybrid comparison for all the characters indicated presence of a high degree of heterosis for CLCV incidence and seed cotton yield. The general combining ability effects of female and male parents

Proceedings of the World Cotton Research Conference-2. Athens, Greece, September 6-12, 1998. pp.338-341.

(Table 2) indicated that parents can be identified for developing CLCV-resistant specific cross combinations along with high seed cotton yield per plant. Analysis of quantitative data indicated that non-additive gene effects governed CLCV incidence and seed cotton yield, whereas additive and non-additive components of variation were important for plant height. A dominance component involving duplicate type of epistasis was also observed in the genetic control of leaf crumple virus by Wilson and Brown (1991).

General combining ability (gca). Estimates of the general combining ability (gca) of female and male parents are presented in Table 2. The female lines LH 1134, IL 85 and IL 89 had significantly negative gca for CLCV incidence, whereas LH 1556 and LH 1832 had significantly positive gca for seed cotton yield. Among male parents, F 54 recorded significantly negative gca (-19.91) for CLCV incidence. The male parents TH 27 (57.11), R 12 (52.26), F 24 (37.96) and F 54 (17.29) recorded significantly positive gca for seed cotton yield (Table 2). R 12 was a good combining parent for short height, and F 54 and DD 5 recorded significantly positive gca for tall plant height. The female parents LH 1556, LH 1134, and IL 89 and male parents F 54 and TH 13 were good combining parents for heterosis breeding aimed at high seedcotton yield and CLCV resistance on the basis of gca effects and per se performance. LH 1818 was a good combiner for short plant height while IL 89 and LH 1134 were good combiners for tall plant height.

Specific combining ability (sca). The specific combining ability (sca) of selected crosses are presented in Table 3. For CLCV resistance seven crosses, namely LH 1832 x DD 5, LH 1832 x F 54, LH 1818 x F 54, LH 1832 x R 65, LH 1818 x TH 13, LH 1587 x R 27, and LH 1556 x R 27 recorded significant negative sca. A CLCV-resistant cross combination, LH 1832 x F 54, showed highly significant negative effects and involved both parents being tolerant to CLCV. LH 1818 x F 54 also had both parents tolerant to CLCV, but the hybrid was resistant both on the basis of sca and per se performance. This indicated that many genes with complementary effects are involved in the genetic control of CLCV resistance. The genes present in both the parents gave resistant hybrids due to complementary gene action for CLCV resistance.

The sca effects and the per se performance for seed cotton yield revealed that 19 crosses recorded significant positive and 18 recorded significant negative sca effects. The top five crosses showing significant sca effects for seedcotton yield were LH 1134 x R 65, LH 1818 x F 54, F 1378 x R 12, LH 1134 x F 24 and LH 1832 x R 12 which involved susceptible x resistance cross combinations. For plant height seven crosses showed significant negative sca with highest estimates by cross LH 1134 x R 27 followed by LH 1832 x TH 13 and LH 1832 x R 27 (Table 3). Three cross combinations, namely LH 1818 x F 54, F 1378 x F 54 and IL 85 x TH 27, involving one resistant parent gave 90 to 100 percent heterosis for CLCV resistance, whereas a cross combination involving two susceptible parents (LH 1832 x R 27) showed 178.67 percent heterosis for CLCV incidence (Table 4).

The results of generation mean analysis involving parental and segregation generations in the crosses among resistant x resistant (PIL 43 x PIL 84), resistant x susceptible (PIL 43 x F 846) and susceptible x resistant (F 846 x PIL 8) parents indicated that more than two genes showing inter-allelic interactions are present for CLCV resistance in the material under study (data not shown). In another trial, 84 straight and reciprocal crosses were screened under artificial and field conditions for CLCV incidence (Table 5). Twenty-two cross combinations involving at least one resistant parent showed CLCV resistance in the hybrids. The cross combinations PIL 43 x PIL 8, PIL 43 x PIL 10, PIL 8 x PIL 43, PIL 5 x PIL 79 and PIL 63 x PIL 79 showed high seedcotton yield coupled with CLCV resistance. The resistant hybrids included either two resistant/tolerant parents or at least one resistant parent. No susceptible x susceptible progeny were resistant to CLCV in this material.

The immediate breeding approach for combating the CLCV disease in infested areas is the development of a hybrid involving at least one resistant parent or both resistant or moderately resistant parents. Longer term, varieties combining multiple genes for CLCV resistance can be developed by intermating resistant plants in the F_2 and backcross segregating generations.

References

Kapoor, S.P., J. Singh, B.L. Chopra, A.S. Sohi, H.S. Rewal and D.D. Narang. (1994): Cotton leaf curl in Punjab. Plant Disease Res. 9:86-91.

Randhawa, L.S., T.H. Singh and B. Indu. (1998): LH 144 - the first cotton leaf curl virus resistant hybrid in the world. Journal of Research, Punjab Agricultural University, Ludhiana (submitted).

Wilson, F.D. and J.K. Brown. (1991): Inheritance of response to cotton leaf crumple virus infection in cotton. Jour. Hered. 82:508-509.

Table 1. Analysis of variance for combining ability.

Source	d.f.	Mean Square		
		CLCV incidence (%)	Seed cotton yield (g)	Plant height (cm)
Females (F)	8	5452.86**	40238.54**	3106.82**
Males (M)	9	685.44**	38997.14**	1730.56**
F x M	72	320.24**	4611.74**	496.06**
Error	178	160.87	4160.30	302.42
σ^2A	-	385.81	2106.12	269.84
σ^2D	-	212.49	27268.59	258.18

Table 2. Estimates of general combining ability effects of the parents.

Parent	gca effects		
	Plant height (cm)	CLCV incidence (%)	Seedcotton yield (g)
Females			
LH 1556	-2.97	39.53**	-4.60
LH 1818	17.29**	5.13	-17.07**
LH 1832	17.43**	46.56**	-5.54
LH 1587	5.91**	-2.47	-3.54
F 1378	11.76**	-12.97	-6.20
LH 1134	-5.72**	17.29	9.26**
IL 85	-14.69**	-79.17**	3.86
IL 89	-14.25**	1.29	16.90**
IL 99	-14.69**	-15.17	6.93
S.E.	1.98	10.09	2.72
Males			
CF	-0.54	-43.71**	-11.76**
DD 5	-1.66	-21.63*	8.54**
TH 13	-0.24	-7.15	3.24**
TH 27	1.62	57.11**	5.61
R 12	2.59	52.26**	-12.13**
R 14	6.25**	-1.83	-32.34**
R 65	-0.16	-28.34**	-8.72**
F 24	1.64**	37.96**	5.46*
F 54	-11.91**	17.29	6.02*
F 27	5.69**	-31.45**	5.57*
S.E.	2.10	10.70	2.89

Table 4. Estimates of % heterosis for CLCV.

Cross	Heterosis
LH 1818 x F 54	-100.00
LH 1832 x R 27	178.67
F 1378 x F 54	-90.45
IL 85 x TH 27	-100.00

Table 3. Estimates of desirable specific combining ability effects and *per se* performance of the hybrids.

Cross	SCA effect	X
CLCV Incidence (%)		
LH 1818 x F 54	-20.06**	0.00
LH 1832 x F 54	-20.21**	0.00
LH 1556 x R 27	-12.64*	4.70
LH 1818 x TH 13	-13.23*	18.50
LH 1832 x DD 5	-26.30**	4.17
LH 1832 x R 65	-14.70*	17.27
LH 1587 x R 27	-13.19*	13.10
S.E	5.95	
Seedcotton yield		
LH 1556 x TH 27	67.33*	415.00
LH 1818 x F 54	206.54**	480.00
LH 1832 x R 12	151.48**	501.33
F 1378 x R 12	164.68**	455.00
LH 1134 x R 65	208.34**	348.33
LH 1134 x R 27	118.11**	355.00
IL 85 x CF	85.17**	213.30
IL 89 x R 27	124.11**	345.00
S.E.	30.27	
Plant height		
LH 1818 x R 12	-17.67**	124.33
LH 1832 X TH 13	-20.91	148.00
LH 1832 x R 27	-18.91**	152.33
LH 1134 x R 27	-21.71**	157.67
IL 85 x CF	-16.64*	146.67
S.E.	8.16	

*,**Significant at 5 and 1 percent level of significance, respectively.

Table 5. CLCV incidence on straight and reciprocal crosses.

Cross	CLCV in parents	CLVC in hybrids	CLVC incidence (%)
PIL 43 x PIL 8	RxR	R	0.0
PIL 8 x PIL 43	RxR	R	0.0
PIL 43 x PIL 10	RxS	R	0.0
PIL 43 x PIL 91	RxS	R	0.0
PIL 43 x PIL 106	RxS	R	0.0
PIL 43 x PIL 86	RxS	R	0.0
PIL 28 x PIL 43	SxR	R	0.0
PIL 10 x PIL 43	SxR	R	0.0
PIL 5 x PIL 43	SxR	MR	0.6
PIL 18 x PIL 60	SxR	MR	1.0
PIL 3 x PIL 79	SxR	R	0.0
PIL 5 x PIL 79	SxR	R	0.0
PIL 6 x PIL 43	SxR	R	0.0
PIL 42 x PIL 97	SxS	S	13.7
PIL 44 x PIL 55	SxS	S	28.4
PIL 25 x PIL 91	SxS	S	40.8
PIL 3 x LRS 1	SxS	S	44.4
PIL 4 x PIL 104	SxS	S	49.8