Breeding Short Duration, Compact, Leaf Curl Resistant Variety of Cotton in Double Cropping System of North India

C.J. Kapoor and R.P. Bhardwaj
Rajasthan Agricultural University, Agricultural Research Station,
Sri Ganganagar - 335 001, Rajasthan, INDIA

ABSTRACT

Genotypes with dwarf, compact stature and short duration, are suitable for agronomic manipulation. These genotypes could be planted in thick stands to harvest high seed cotton yield per unit area and per unit time, an important breeding objective. Varieties with a short sympodial habit and duration are most suitable for cotton-wheat rotation followed in the north-west region of India and are also ideal for machine picking. Leaf curl virus disease, caused by 'gemini virus,' is a threat to cotton cultivation. It was observed in 1993 in North Indian major cultivated varieties. The endeavour has been to search for a stable, broad spectrum resistance source for cotton diseases like leaf curl. This breeding approach resulted in the determination of the disease status and strategies in North India, identification of leaf curl virus resistant genotypes and the development of variety RS-875.

Introduction

The Northern cotton zone of India, comprising the states of Punjab, Haryana and Northern Rajasthan, includes the most productive areas of cultivation known as the "Cotton Basket" of India. It recorded an average lint yield of 532 kg/ha in 1994 against 319 kg/ha for India as a whole. The development of varieties with high yield potential and superior production technology have been mainly responsible for this jump in production. The increase in the area under cotton since independence has been facilitated by the release of short duration cotton variety Bikaneri Narma in the early 1970's. Cotton was essentially a monocrop in the zone as existing varieties like LSS, 320 F, and J- 34 had long duration (250-270 days). The genetic modification of the cotton plant in short duration varieties of 180 to 190 days duration is the most significant development in the zone. The reduction in maturity period resulted in a cotton-wheat rotation, considered impossible till then, becoming a routine practice, leading to large scale "cotton-wheat" double cropping. Ganganagar Ageti, F- 414 and H- 777 and RST- 9 varieties paved the way for farmers to harvest an additional wheat crop of 30-35 q/ha. Further increase in yield with shorter duration (150-160 days), compact plant types in varieties LH 900 and RS 875 enabled wheat or mustard to follow cotton. Genetic improvement of cotton, not wheat, enabled this rotation to occupy practically all of north India (Table 1). Short season (145 days maturity) cultivars are also very useful in Brazil (Ramahlo, 1994).

Breeding short duration, compact types

A large number of crosses were attempted to breed early maturing, compact plant types. Pedigree selection in segregating populations advanced desirable crosses and elite cultures in F_6 generation were evaluated against check varieties RST 9 and LH 900. The cross C 1412 x Deltapine-66 designated as RS 875 recorded the higher yield over both controls (Table 2). This line is 25-30 days earlier maturing, it has an ideal plant type, a high harvest index and a height of 100-110 cm with an evergreen canopy. Table 3 summarizes the quality characteristics.

Compact short duration plant types such as RS 875 have many agronomic and entomological benefits. Conventional varieties with heavy canopy and long duration are subject to environmental stresses, including insect pest pressure, in the poly crop system. Cotton productivity can be increased with plant types that facilitate suppression of insect pests with xenobiotics and bio-agents. Earliness renders RS 875 less vulnerable bollworm attack.

In additional to the earliness and compact habit of RS 875, it is resistant to leaf curl virus, giving it a distinct advantage over susceptible varieties in North India. Cultivation of resistant varieties is the only eco-friendly and sustainable approach for effectively combating plant diseases.

Present Status of Leaf Curl Virus in North India

Leaf curl of cotton, caused by 'Gemini virus,' was first reported by on *G. barbadense* varieties *G. peruvianum* and *G. vitifolium* in Nigeria (Farque-Havson, 1912) and Tanzania (Jones and Mason, 1926). It was

observed near Multan in Pakistan in 1967 on varieties of *G. hirsutum* (Hussain Ali, 1995). Its incidence in Pakistan has increased substantially and acquired epidemic proportion in 1992-93 and 1993-94 affecting 889,000 hectares (Mahbub Ali *et al.* 1995). The disease was first noticed at IARI, New Delhi in India on the collections of *G. barbadense*. It was observed on *G. hirsutum* near Sri Ganganagar in Rajasthan in 1993 (Ajmera, 1994) and in the states Punjab and Haryana in 1994.

Thickening and darkening of fine veins are the first symptoms on the top young leaves. As more veins thicken, upward (rarely downward) curling and cupping of leaves occur. Round or long leaf shaped emanations then develop from the main veins on the lower side of leaves. The plants then become stunted, shed squares and buds and set fewer bolls. Shortened internodes and leaves have also been seen in plants with early infection. The symptoms observed in India are similar to those reported in Pakistan.

Cotton leaf curl virus causes heavy yield losses and threatens cotton cultivation in North India. It affects the size and number of bolls, the seed cotton yield and plant height. A reduction of 50.3% in seed cotton yield, 50.3% in the number of open (harvestable) bolls, 12.3% in boll weight and 16.1% in plant height was estimated in variety F 846. There was a reduction of 32.9%, in seed cotton yield, 22.76% in opened bolls and 3.5% in height in RST-9 in Rajasthan with there was no reduction in boll weight (Ajmera 1996). In Punjab, seed cotton yields were reduced by 10.5 to 92.2% and by 30.7 to 68.6% and boll weight by up to 38.8% and from 11.9 to 40.5% in of varieties F846 and NIAB-72, respectively (Joginder Singh *et al.* 1994) (Table 5).

Genetic and varietal resistance

Intensive agriculture has tended to increase the incidence of insects and diseases. Genetic resistance is a crucial component of integrated pest management. Improved genetic resistance is cheap and effective, it is eco-friendly and does not require any effort on part of farmers. Screening for insects and diseases resistance is initiated during early segregating generations. Diverse germplasm, including that from related species, needs evaluation for incorporation of desirable traits into the breeding programme.

Resistance to this disease depends on a large number of genes with very small individual effects (Knight, 1954 b). Inter-allelic interactions are also involved. Many Qtl and modifiers are involved in the genetics of CLCV resistance and breeding strategies for resistant aimed at pyramiding Qtl are suggested.

Varieties offer the most economical means of control of the disease. All the American varieties grown in Punjab, Haryana and Rajasthan (Sri Ganganagar) and varieties Pakistani Narma (NIAB 72), F 846, RST- 9, LH- 900, F- 505, H- 777, Bikaneri Narma, Ganganagar Ageti, LH- 1134 were found to be susceptible to the disease. However, variety RS- 875 and Hybrids LH-144 and GK-151were resistant under heavy infection. *Arboreum* cottons such as RG-8 and HD-107 were found free from disease (Table 4). The incidence of the disease varied with variety and location, depending on time of infection, presence and population of whitely vectors and climatic conditions. In 1994 the incidence of the disease ranged from traces to 95% but during 1995 and 1996 it decreased. There was an outbreak of leaf curl virus in 1997 but in 1998 it was delayed, appearing on scattered plants during mid June.

Strategies for managing leaf curl disease

Creating genetic barriers

a) Development of resistant varieties is the only dependable measure. The entire belt should grow only *Gossypium arboreum* or resistant varieties of *G. hirsutum* like RS- 875 and LHH - 144, GK- 151 (Hybrids).

b) Cultivation of susceptible varieties like F 846, Pakistani Narma, RST- 9, F- 505, HS-6, etc is banned.

c) The entire belt adjoining international border should grow *G. arboreum* or a non-cotton crop to form a buffer zone.

Monitoring the disease

There should be regular surveys to monitor the spread and intensity of the disease and vector *B. tabaci* and identify weed flora affected with leaf curl.

Chemical Protection

To prevent further spread of the disease and establishment of the virus in cotton growing areas, regular insecticidal treatment should be given in all affected areas to control whitefly. Cultivators should be educated about the disease and advised to rogue out affected plants.

Identifying resistant and susceptible genotypes

Few germplasm lines of *G. hirsutum* have been screened at this Centre through selection pressure in a "hot spot" area. Transfer of resistance from known resistant donors through back crosses breeding is in progress. Few resistant genotypes with medium quality have been isolated (RS- 810, RS- 2013, RS- 992) and they are under further tests.

Conclusions

Shortening the growing season can provide increased profits. The ideal would be to shorten the season without sacrificing yield. Variety RS- 875 contributed the first break through in North India where leaf curl virus disease appeared in 1993-94. Research efforts to develop leaf curl resistant varieties are undertaken in North India at Agricultural Research station (Rajasthan Agricultural University), Rajasthan, which

is a "hot spot" for the disease. A number of resistant genotypes including RS 810, RS 2013 and RS 992 have been developed. Future targets include early maturing varieties with leaf curl resistance and with high yield potential. Identification and development of resistant varieties is the surest way of combating the disease. It is cheap and requires little effort on the part of farmers

Acknowledgement

Authors are thankful to Director Research Rajasthan Agricultural University Bikaner and Associate Director Research, Agricultural Research station Sri Ganganagar for providing necessary facilities for conducting investigation. We are also indebted to Director (P and M) Rajasthan Agricultural University Bikaner for providing funds to attend this conference.

References

Ajmera, B.D. (1994): Occurrence of leaf curl virus on American cotton (*G. hirusutm*) in north-Rajasthan, Paper presented in National seminar-Cotton production challenges in 21st Century at C.C.S. H.A.U. Hissar. Abstract Pp. 86.

Ajmera, B.D. (1996): Status and strategies of leaf curl of cotton in North India. Paper presented at National Seminar on "Century of cotton in India" at Main Cotton Res. Stn., G.A.U. Surat.

Ali, M., Z. Ahmad, M. Tanveer and T. Mahmood. (1995): Cotton leaf curl virus (CLCV) in the Punjab, Current situation and review of work. Central Cotton Research Institute, Multan/CLCV Project Report.

Farquehavson, C.O. (1912): A report of Mycologist. A report Agric. Dept. Nigeria. In Cotton growth in Gezira environment. M.A. Siddique and .C.Hugus (Ed). W. Haffer and Sons Ltd. Cambridge, England. Pp. 196.

Hussain, T. and M. Ali. (1995): A review of cotton diseases of Pakistan. The Pak. Cott. 19(2):71-86.

Jones, G.H. and T.G. Mason (1926): Studies on two obscure disease of cotton. Ann Bot., 1: 160:759-772.

Knight, R.L. (1954 b) Breeding Sudan cotton. Emp. Cott. Gr. Rev 31:1-11.

Mansoor, S., I.D. Bredford, M.S.Pinner, J.Stainley and P.G.Markham. (1993): A whitefly transmited gemini virus associated with cotton leaf curl disease in Pakistan. Pak. J. Botany. 25(1):105-107.

Ramahlo, F.B. (1994): Perspective on cotton insect pest management in Brazil. Annual Review of Entomology, Entomological Society of America.

Singh, J., A.S Sohi, H.S. Mann and S.P. Kapoor (1994): Studies on whitefly, *Bemisia tabaci* transmitted cotton leaf curl disease in Punjab. J. Insect Sci, 7(2):194-197.

Verma, A. (1990): Annual Progress Report (1989-90), I.A.R.I., New Delhi.

Table 1. Effect of early maturity varieties on cropping system.

Variety	Year Released	Maturity Group	Maturity	Possibilities
L.S.S. Bikaneri Narma, Ganganagar Ageti H-777, F-505, RST-9	1933 1970-93	Late Medium	250-270 180-190	No Cotton/Wheat rotation. Cotton/Wheat rotation
RS - 875	1995	Early	150-160	Cotton/Wheat and Cotton/Mustard rotation

Table 2. Yield performance of Rs - 875 from 1993 - 97.

Year	Trial	Average seed cotton yield kg/ha		
		RS-875	LH-900	RST-9
1993-95	Research (10)	2293	1629	1413
1996-97	Adaptive (20)	2573	1119	1215

Figures in parenthesis indicates number of locations.

Table 3. Quality of fiber (Report through CIRCOT, Bombay).

Variety	RS - 875	LH 900	RST - 9
2.5% Span Length (mm)	27.30	24.00	23.30
Micronaire Value	4.40	4.60	5.00
Tenacity (Corrected CSP) 30s	2094	2034	2076

Table 4. Incidence of leaf curl disease of cotton in different varieties of cotton grown in North India.

Species	Varieties	State	Maximum disease Incidence (%)			
			1994	1995	1996	1997
1. *G.hirsutum*	RST - 9	Rajasthan	95	90	70	80
	F - 846	Punjab	90	80	50	80
	LH - 900	Punjab	80	60	40	70
	HS - 6	Hayrana	50	20	20	70
	F 1054	Punjab	60	5	-	10
	Ganganagar Ageti	Rajasthan	5	5	5	50
	Bikaneri Narma	Rajasthan	10	5	5	15
	Maru Vikas Hybrid	Rajasthan	-	<10	<10	60
	Fateh (Hybrid)	Punjab	-	10	10	70
	Dhan Luxmi	Haryana	-	<10	8	60
	RS - 875	Rajasthan	-	0	0	0
	LHH - 144	Punjab	-	0	0	0
	Hybrid Pakistani Narma	----	95	90	80	80
2. *G. arboreum*	RG - 8	Rajasthan	0	0	0	0
	HD -107	Haryana	-	0	0	0

Table 5. Estimation of losses due to leaf curl disease in cotton.

Variety / Place	Percent Reduction/Plant			
	Height (cm)	Harvestable boll (No.)	Boll Weight (g)	Seed cotton yield (g)
Sri Ganganagar (Raj.)				
(a) F - 846	16.09	50.26	12.31	50.31
(b) RST - 9	3.55	22.76	0.00	32.86
P A U Ludhiana				
(a) F - 846	14.9-87.4	38.80	10.5-92.2	
(b) Pakistani Narma (NIAB -72)		30.7-68.6	11.9-40.5	39.9-79.7