THE PAKISTAN COTTON

Volume-55, January–June, 2011, No.1–2

PAKISTAN CENTRAL COTTON COMMITTEE
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"The Pakistan Cotton" is an official journal of Directorate of Agricultural Research, Pakistan Central Cotton Committee.

Volume 55, January–June, 2011, No.1–2

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Evaluation of Two Methods Transmission Techniques of BSCV/ClcuV Disease and Their Response to Different Cotton Cultivars

By

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Abstract

Twenty cotton cultivars/strains were evaluated against BSCV/CLCuV transmitted by two methods (1) petiole grafting (2) side or approach grafting. All test cultivars showed more or less susceptible reaction and required different periods for symptoms developments while disease intensity in both techniques remained same. Eight cultivars viz; CRIS-493, CRIS-129, CRIS-121, CRIS-342, CRIS-550, CRIS-496, CIM-499 and, NIAB-111, exhibited susceptible reaction and displayed 5-6 disease intensity while these cultivars took 18-30 days for symptoms (vein thickening) development in petiole and side or approach grafting techniques respectively.

CRIS-486, CRIS-492, CRIS-548, CRIS-549, CIM-707, CIM-499, MNH-700, SLH-279 and FH-901 displayed comparatively less disease intensity (3-4) and attained 18-35 days for symptoms development in petiole and side grafting techniques methods respectively. CRIS-134, CRIS-9 and VH-114 proved the most susceptible cultivars and showed highest disease intensity (7) and attained minimum (17) days for symptoms development both methods.

Introduction

Cotton Leaf Curl Virus (CLCuV) is one of the most important diseases of cotton crop (Tarr, 1951). Leaf Curl Viruses of Cotton was first observed in Pakistan during 1967 in Multan area. However, the disease remained ignored due to its low intensities and did not attract serious attention until 1987, when it appeared as a epidemic cotton disease (Hussain and Ali, 1975, Saif et al., 1997). Hussain and Mahmood (1988) reported the incidence of CLCuV was upto 80% in certain fields. The cause of this disease was scientifically established in 1992 as a whitefly-transmitted Gemini virus (Hameed et al. 1994). The disease was thought to be restricted only to Punjab on the basis of departmental reports, the cotton crop in Sindh was considered disease free. Keeping in view, the magnitude of the disease in Punjab and whitefly (*Bemisia tabaci*) as its vector, a program of monitoring virus disease with emphasis on Gemini viruses including CLCuV was initiated in Sindh during 1996 and this disease was found near Obarvo, the area near to Punjab-Sindh border (Saif et al., 1997 and Mansoor et al. 1998).

The CLCuV incidence is an increasing side. The spread of disease have been started from Obavro (Ghotki district) and has reached upto Sakrànd (Nawabshah district). The disease is very dangerous, it affects whole cotton plant through showing its symptoms like upward curling of leaves. The veins of leaves become thick which are more pronounced on the lower surface, beside this, enation (leaf like out growth) on back side of leaf. In young leaves

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Thickening first appears on the lower surface of the small veins, being separated and gradually link together. This process makes the leaves curl. From the underside, affected veins appear abnormally dark green and not shining. New leaves developed after appearing of first symptoms are usually small and much distorted by curling (Watkins, 1981).

Keeping in view the importance of cotton crop in our National Economy and Potential Hazard due to leaf curl virus, the present studies were carried out to investigate the effectiveness of two transmission/reproduction of virus techniques used for successful breeding programme and their response to period required for symptoms development in different cotton varieties.

Materials and Methods

Twenty cotton cultivars were sown in pots during the month of May (2008-2009) in glass house transmission of BSCV/CLCuV disease through petiole and side grafting on different ages of the plant, cultivars of BSCV diseased plant. The grafting was made during the month of June (2008-2009) on five plants each age. The observations were taken daily after one week of grafting till the new leaf of the plant appears. BSCV plant brought from vehari was made by grafting it into all cultivars of Sindh and Punjab. The symptoms appeared on petiole grafting method after 18-30 days. The symptoms appeared on side grafting method after 20-35 days.

Petiole Grafting Method

In this method top of the healthy plants were removed and wedge shaped cleft was made on the top of the stem. A diseased leaf petiole end is pointed with sharp scalpel, is inserted as scion and bound with self sealing rubber tape. The grafted plants are covered with polyethylene bags just to avoid the chances of evaporation. After 4-5 days bags are removed and symptoms of virus are watched on the newly emerged leaves of the stock (Annual Report CCRI-Multan 1993-94).

Side or Approach Grafting

To transmit virus from diseased to healthy plants, all the grafting from vice versa was successful. In both the techniques, the test plants of each entry were kept in regular observations and period required for symptoms appearance on each test plant was recorded. The degree of vein thickening tends to change within certain limits and length of time, the plant has been infected. Therefore the fallow grading leaf symptoms on 0-7 scale (Siddique, 1968) were as under:

0 = Complete absence of BSCV /CLCV symptoms.
1 = Few small scattered vein thickening.
2 = small scattered vein thickenings.
3 = small groups of vein thickening.
4 = Large groups of vein thickening involved.
5 = All veins thickening involved.
6 = All veins thickening involved severe curling.
7 = Out growth (enation) present.

Results and Discussion

The data presented in Table-1 for evaluation of two BSCV/CLCuV transmission techniques on twenty cultivars against CLCuV revealed that intensity of the disease in both the methods was same in all the tests cultivars (Fig-2). However, period required for symptoms appearance was more (20-35 days) in 17 varieties out of 20 in side/approach grafting methods as compared to petiole grafting method, where these cultivars took 18-30 days (Fig-1). All the test cultivars exhibited more or less susceptible reaction. CRIS-9, CRIS-134 and VH-114 showed the highest susceptible reactions in both the methods. It required minimum time (17 days) for symptoms appearance and disease intensity graded to seven (7). Hussain *et al.* (1991) and Ali *et al.* (1992), also reported that S-12 and CIM-70 are the most susceptible varieties. Eight cultivars viz; CRIS-493, CRIS-129, CRIS-121, CRIS-342, CRIS-550, CRIS-496, CIM-494 and NIAB-11 came out with inherent susceptible reaction and recorded the development ranged 18-30 and 20-35 days in petiole grafting and side/approach grafting methods respectively. CRIS-486, CRIS-492, CRIS-548, CRIS-549, CIM-707, CIM-499, MNH-700, SLH-279 and FH-901 displayed comparatively less disease intensity (3-4) and attained 18-35 days for symptoms development in petiole and side grafting methods respectively.

It is concluded from the results that both the techniques related excellent results successful transmission/reproduction of virus on all the tests plants was recorded.

Different workers practices number of inoculation techniques for assaying or resistance in cotton cultivars (Siddique, 1969) budded the CLCuV infected bud with healthy plants. The percentage of success was 35% in early budded and 21% in late budded plants. Yaseen and Elnur (1970) developed a static cage technique and obtained more efficient transmission of CLCuV by using a single insect as vector. Nour and Nour (1964) and Yaseen and Nour (1965) devised a technique which was more handy for routine transmission tests especially for handling a large number of entries. The results of side or approach grafting method are more quick and reliable but it is bit laborious. This method cannot be adopted for screening on large scale. Where as, the results of petiole grafting technique was equally good and reliable method.

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Table-1: Response of cotton varieties/strains against BSCV/CLCuV disease by petiole and side/approach grafting methods.

S. No.	Variety/ Strain	Petiole grafting method		Side/approach grafting method	
		Average period for symptoms appearance after grafting (days)	Average disease intensity (0-7 scale)	Average period for symptoms appearance after grafting (days)	Average disease intensity (0-7 scale)
1.	CRIS-486	25	3	27	3
2.	CRIS-492	18	4	20	4
3.	CRIS-493	19	5	21	5
4.	CRIS-9	17	7+E	17	7+E
5.	CRIS-129	19	6	20	6
6.	CRIS-121	19	5	21	5
7.	CRIS-342	19	6	20	6
8.	CRIS-134	17	7+E	17	7+E
9.	CRIS-548	18	4	20	4
10.	CRIS-549	18	3	20	3
11.	CRIS-550	19	5	20	5
12.	CIM-707	28	4	30	4
13.	CIM-496	30	5	28	5
14.	CIM-494	30	6	29	6
15.	CIM-499	28	4	29	4
16.	MNH-700	27	3	35	3
17.	NIAB-111	29	5	30	5
18.	VH-114	17	7+E	17	7+E
19.	SLH-279	28	3	30	3
20.	FH-901	28	4	29	4

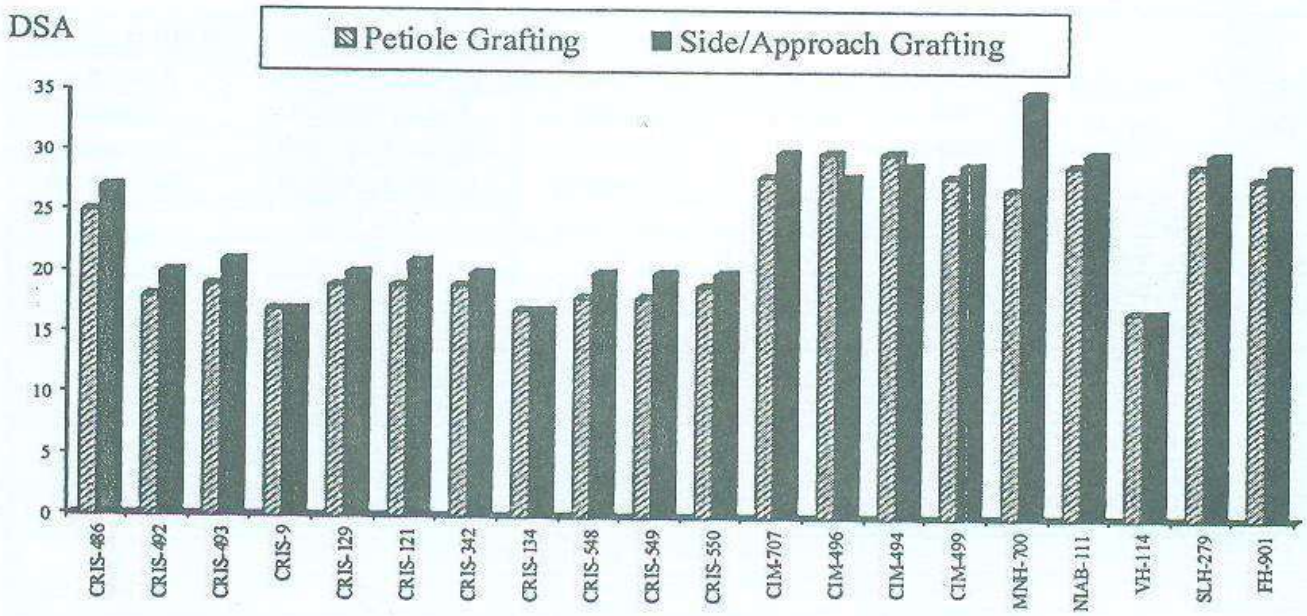

Fig.1: Varieties comparison for days taken to symptoms appearance (DSA) of CLCuV/BSCV.

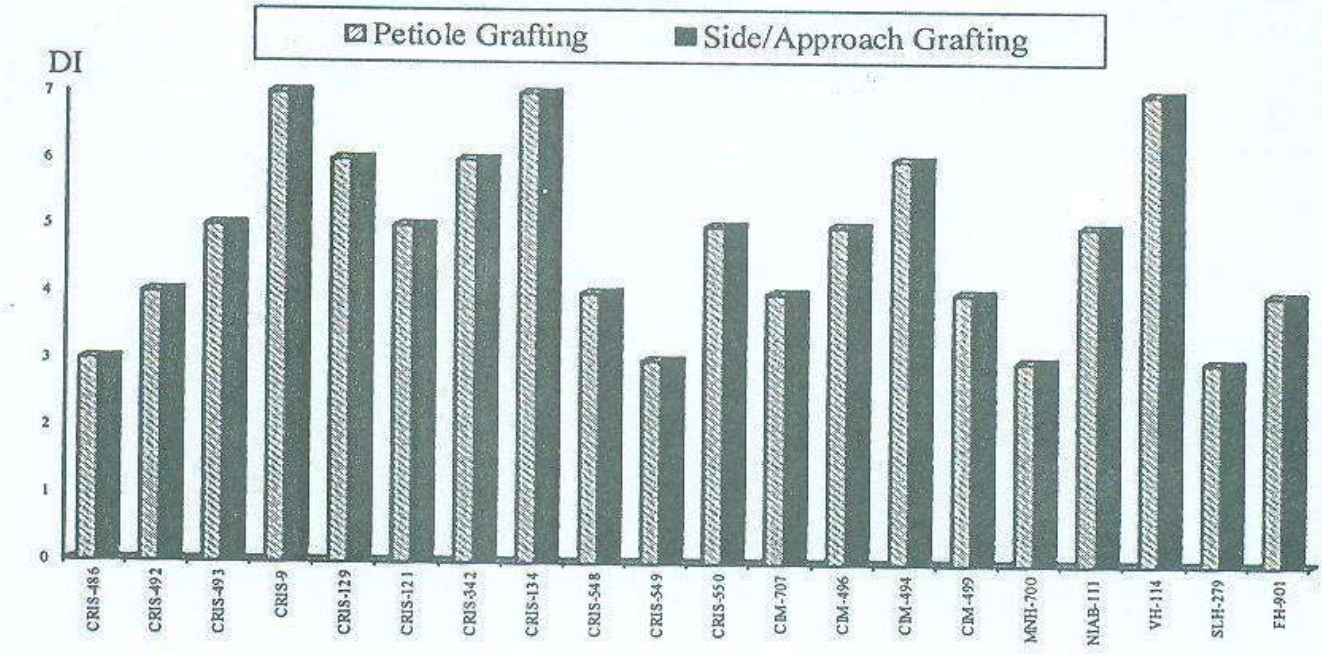

Fig.2: Varieties comparison methods for disease intensity (DI) of CLCuV/BSCV.

Combining Ability Estimates for Economic Traits inLine X Tester Crosses of Upland Cotton

By

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Abstract

Line x tester analysis involving four lines (CRIS-134, CIM-499, VH-209 and Reshmi) and three testers (CIM-496, CRIS-402, and VH-144) was carried out to study five economic traits in Upland cotton. The mean squares due to General Combining Ability (GCA) and Specific Combining Ability (SCA) were significant for seed cotton yield, boll weight, ginning out turn percent and fibre length. The significance of GCA and SCA variances thus suggested that both additive and non-additive genes were governing the characters. The estimates of SCA variances were greater than GCA variances for number of bolls per plant, boll weight, seed cotton yield per plant, ginning out turn percent and fibre length which showed the predominance of non-additive gene action for these characters. However, among the four female lines, CRIS-134 showed maximum positive GCA effects for number of bolls per plant, seed cotton yield per plant and lint percent. Among the testers, CIM-496 was desirable as it manifested higher estimates of GCA effects for all the characters. The hybrid CRIS-134 x CIM-496 exhibited maximum SCA effects for number of bolls per plant, seed cotton yield and fibre length; CRIS-1 34 x CRIS-402 for boll weight andCRIS-134 x VH-144 for ginning out turn percent.

Introduction

Cotton (*Gossypium hirsutum* L.) is the most important fiber crop in the world, and in Pakistan it is the mainstay of the economy (Ali and Khan, 2007). Cotton is the main source of foreign exchange earnings and brings about 65 % of the total annual earning from the export of raw cotton material and the finished products. Keeping in view the role of cotton crop in the economy of the country, the cotton breeders always focus their attention on bringing genetic improvement in cotton plant by exploiting the genetic resources. Cotton improvement program may be more effective if information on the genetic mechanism controlling economic characters is available to the breeders. In addition, to develop promising plant material through hybridization, availability of superior parents is essential. Combining ability studies help the research workers for the identification of parents for the development of high yielding hybrids. The Line x Tester mating design developed by Kempthorne (1957) is very useful and simple procedure for evaluation of parents for general combining ability and specific combining ability variances and effects through hybridization programme. Therefore in the present study, seven varieties of cotton were examined to obtain the knowledge of genetic mechanisms controlling the economic characters of cotton.

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Materials and Methods

The experimental material for the present investigation comprised of 12 hybrids developed by crossing 4 lines (CRIS-134, CIM-499, VH-209 and Reshmi) with 3 testers (CIM-496, CRIS-402 and VH-144) in a Line x Tester fashion at Central Cotton Research institute, Sakrand during crop season 2006-07. The seed of 12 crosses and seven parents were sown in May 2007 at experimental field of the institute. Randomized Complete Block Design was followed with three replications keeping plant-to-plant and row-to-row distance of 30 and 75 cm, respectively. All agronomical and plant protection measures were kept same for all hybrids and their parents. The data were recorded on bolls per plant, boll weight (g), seed cotton yield per plant, ginning outturn percent and fibre length (mm). After recording the data for each character, the analysis of variance was carried out to determine the significance of difference among the F1 hybrids according to Gomez and Gomez (1984). The mean squares due to general combining ability (GCA) and specific combining ability (SCA) variances and effects determined by line x tester analysis were calculated according to the procedure developed by Kempthorne (1957) and adopted by Singh and Choudhry (1979).

Results and Discussions

Analysis of variance (Table-1) showed that mean squares due to genotypes, lines and testers were highly significant for four studied traits viz., boll weight, seed cotton yield per plant, ginning out turn percent and fibre length. While mean squares due to lines were of a larger magnitude than those of testers and lines x testers for boll weight, seed cotton yield per plant, ginning out turn percent and fibre length which indicates greater diversity among lines for these traits. However, for number of bolls per plant greater diversity was observed in testers.

The mean squares due to GCA as well as SCA were significant for boll weight, seed cotton yield per plant, ginning out turn percent and fibre length (Table 1). Thus the significance of GCA and SCA implied that both additive and non-additive types of gene action were available for all the traits. The relative importance of gca and sca variance was assessed by the ratio as suggested by Baker (1978). The estimates of specific combining ability variances were higher than corresponding general combining ability variances for all the traits under study indicating preponderance of non-additive genetic components involved in the inheritance of these characters (Table 1). Similar results have already been reported by Shahani and Chang (1985), Khan and Ghafoor (1991), Yingxin and Xiangming (1998), Khorgade *et al.* (2000) and Iqbal *et al.* (2004) for boll weight, ginning out turn percent and fibre length while for number of bolls per plant, boll weight, and seed cotton yield Baloch and Bhutto (2003) and Neelima *et al.* (2004) obtained higher SCA variances than the GCA. However Simongulan (1980), Singh (1982), Ikram *et al.* (1993) and Baloch *et al.* (2000), Soomro *et al.* (2002), El-Dahan *et al.* (2003), Lyanar *et al.*(2005), and Kumboh *et al.* (2008) observed additive type of gene action for these parameters which may be due to different material used under different environmental conditions.

Table-1: Mean squares of analysis of variance for combining ability

Source of variation	D.F.	No of Bolls Plant^{-1}	Boll Weight (g)	Seed cotton Yield Plant^{-1}	GOT (%)	Fibre Length (mm)
Replication	2	9.03	0.16	273.20	0.14	0.22
Genotypes	18	76.40**	0.35**	1203.30**	9.12**	6.39**
Lines	3	37.14	0.59**	886.90**	21.57**	10.67**
Testers	2	71.36**	0.31**	803.08**	3.50**	0.88**
L X T	6	38.81	0.11	229.50	2.04**	1.06**
Parents GCA	6	30.11	0.21**	868.48**	10.09**	8.13**
Crosses SCA	11	44.27	0.28**	513.11**	7.64**	3.65**
Parents vs. Crosses	1	707.82**	1.98**	19596.4**	19.54**	25.95**
Error	36	25.40	0.05	108.43	0.37	0.062
σ^2 GCA Average		0.24	0.01	12.23	0.24	0.11
σ^2 SCA		4.47	0.02	40.38	0.56	0.33
σ^2 GCA / σ^2 SCA		0.05	0.35	0.30	0.43	0.34

** Significant at 5% and 1% level of probability, respectively

General Combining Ability (GCA) Effects

General Combining Ability (GCA) effects of the lines and testers for all the traits are presented in Table 2. Among the lines CRIS-134 expressed maximum positive GCA effects for number of bolls per plant (2.80) followed by CIM-499 (0.14) whereas among the testers, CIM-496 expressed maximum effects (1.61) followed by CRIS-402 (1.20). As regards boll weight, the line CIM-499 produced maximum GCA value (0.22) followed by CRIS-134 (0.18) whereas among the testers VH-144 expressed maximum (0.11) GCA effects. For seed cotton yield CRIS-134 surpassed all the lines by attaining the GCA value of 7.96 followed by CIM-499 (0.69) whereas among the testers, CIM-496 expressed maximum effects(9.84) followed by CRIS-402 (1.93).

For ginning out turn percent, again the line CIM-499 expressed maximum GCA effects (1.35) followed by CRIS-134 (1.32) whereas the tester CIM-496 expressed maximum GCA effects (0.60) followed by CRIS-402 (-0.15). As regards fibre length, the line VH-209 expressed the maximum GCA effects (1.65) followed by CRIS-134 (-0.46) whereas among the tester CIM-496 expressed maximum GCA effect (0.21) followed by CRIS-402 (0.19).

It is quite evident from the above discussion that among the lines parent CRIS-134 out yielded the rest of the lines in the experiment and proved to be the best general combiner for most o

f the characters like number of bolls, seed cotton yield and fibre length whereas line CIM-499 was the best general combiner for boll weight and ginning out turn percent. However VH-209 surpassed for fibre length. The tester CIM-496 proved to be the best general combiner for number of bolls, seed cotton yield, ginning out turn and fibre length. Since the lines CRIS-134, CIM-499 and testers CIM-496, CRIS-402 are the best general combiners for most of the

characters under study. Therefore, these parents might be exploited for varietal improvement in different cross combinations.

Table-2: Estimates of general combining ability (GCA) effects

S. No.	LINES	No of bolls Plant^{-1}	Boll Weight	Seed cotton Yield plant^{-1}	GOT (%)	Fibre Length (mm)
1	CRIS-134	2.80	0.18	7.96	1.32	-0.46
2	CIM-499	0.14	0.22	0.69	1.35	-0.53
3	VH-209	-1.19	-0.33	-0.76	-1.49	1.65
4	RESHMI	-1.75	-0.06	-7.89	-1.18	-0.66
	SE (gi -gj)	2.38	0.11	4.90	0.29	0.12
	TESTERS					
1	CIM-496	1.61	0.07	9.84	0.60	0.21
2	CRIS-402	1.20	-0.18	1.93	-0.15	0.19
3	VH-144	-2.81	0.11	-11.77	-0.45	-0.40
	SE (gi – gj)	2.06	0.09	4.25	0.25	0.10

Table-3: Estimates of specific combining ability (SCA) effects

S. No	CROSSES	No of bolls Plant^{-1}	Boll Weight (g)	Seed cotton Yieldplant^{-1}	GOT (%)	Fibre Length (mm)
1	CRIS-134 X CIM-496	4.70	0.02	9.59	-0.45	0.47
2	CRIS-134 X CRIS-402	-5.30	0.18	-10.83	-0.59	0.18
3	CRIS-134 X VH-144	2.02	-0.21	1.25	1.07	-0.66
4	CIM-499 X CIM-496	-0.39	0.09	4.70	0.79	0.20
5	CIM-499 X CRIS-402	0.36	-0.08	-3.39	-0.04	-0.59
6	CIM-499 X VH-144	0.04	-0.04	-1.31	-0.76	0.38
7	VH-209 X CIM-496	-3.05	0.05	-8.05	-0.17	-0.55
8	VH-209 X CRIS-402	3.28	-0.22	7.95	0.77	0.42
9	VH-209 X VH-144	-1.60	0.15	1.03	-0.62	0.12
10	Reshmi X CIM-496	0.18	-0.19	-5.30	-0.17	-0.13
11	Reshmi X CRIS-402	0.26	0.10	6.28	-0.14	-0.02
12	Reshmi X VH-144	-0.38	0.08	-0.97	0.31	0.14
	SE (Sij – Sik)	4.12	0.18	8.50	0.49	0.20

Specific Combining Ability (SCA) Effects

The Specific Combining Ability (SCA) effects of twelve cross combinations for all the characters under study are presented in Table 3. The cross CRIS-134 x CIM-496 showed the highest value (4.70) for number of bolls per plant followed by VH-209 x CRIS-402 produced 3.28 SCA value. Regarding boll weight, the crosses CRIS-134 x CRIS-402 and VH-209 x VH-144 were the best specific combinations. For seed cotton yield per se, cross CRIS-134 x CIM-496 expressed the highest value (9.59) followed by VH-209 x CRIS-402 (7.95). Cross of CRIS-134 x VH-144 gave highest SCA effects (1.07) for ginning out turn percent followed by CIM-499 x CIM-496 (0.79). For fibre length two crosses i.e., CRIS-134 x CIM-496 and VH-209 x CRIS-402 scored higher positive values for SCA and thus were best specific combinations for the character. The SCA effects results reveal that, for hybrid crop

development, CRIS-134 x CIM-496 could be the better choice for number of bolls, seed cotton yield and fibre length, CRIS-134 x CRIS-402 for boll weight and CRIS-134 x VH-144 for ginning out turn percent.

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Genetics of Plant characters Related to Earliness in Uplabd Cotton

By

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Abstract

A complete diallel cross experiment involving five genotypes/lines was conducted to obtain genetic information on traits related to earliness in Gossypium hirsutum L.. Joint regression analysis of data showed the adequacy of all the characters studied. The Vr/Wr graphs revealed the presence of overdominance type of gene action for position of first sympodial branch and earliness index, whilst presence of the genes acting cumulatively was revealed for days to squaring, days to flowering and seed cotton yield. The unit slope of regression analysis suggested absence of epistasis in the inheritance of all these characters. The relative position of parents along the regression lines showed that MNH-3570 contained maximum number of dominant genes for days to squaring and days to flowering and in contrast CIM-435 and BAR 12/1 contained more recessive genes for days to squaring and days to flowering respectively. BAR 12/1 exhibited more dominant genes and Bamboosa-49, more recessive genes for position of 1st sympodial branch, whilst for earliness index and seed cotton yield, bamboosa-49 and CIM-435 contained maximum number of dominant genes respectively and BAR12/1 contained more number of recessive genes for both the traits.

Key words: earliness, *Gossypium hirsutum*, genetic analysis, dominant genes

Introduction

Cotton is one of the most important crops of Pakistan. It provides raw material to local domestic cotton industry. In addition a substantial amount of foreign exchange is earned by exporting fibre-made products. Seed oil and seed cake are two major by-products of cotton plant. Due to immense importance of cotton crop in the economy of Pakistan, cotton breeders made tremendous efforts to make the plant more profitable.

Due to indeterminate growth habit of cotton earliness is a complex trait, and thus cannot be measured easily. However, some morphological features which provided an estimate of earliness in cotton had been reported in literature. For example, node of first fruiting branch, number of vegetative branches and percentage of bolls on vegetative branches are the reliable features clues to earliness in cotton (Ray and Richmond,1966). Richmond and Radwan (1962) reported that combined weight of first and second picking expressed as percentage of total seed cotton yield harvested had also been used as most practical method to compare earliness of cotton varieties. The study of literature revealed that very little work had been done on the genetics of earliness and the information reported revealed that both additive and non-additive gene effects controlled variation in these characters. The investigations of Gomma and Shaheen (1995), Gomaa *et al.* (1999) and Iqbal *et al.* (2003) showed that additive

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Gene effects controlled days to flowering and position of first sympodial branch, and non-additive gene effects for earliness index and seed cotton yield. In order to effect further improvement in the genetic material with respect to earliness, more information is needed. Therefore the objective of present study is to collect information on the pattern of inheritance of different plant characters related to earliness in *Gossypium hirsutum* L.

Materials and Methods

For the present study plant material was developed by crossing Bamboosa-49, CIM-435, MNH-3570, BAR 12/1 and MS-95 of *G. hirsutum* L. in a 5 x 5 complete diallel fashion.
The parents were grown in earthen pots in glasshouse during November 2003. Temperature and light were properly provided to plants during germination and growth. When the parents started to flower they were crossed in all possible combinations. To avoid alien pollen contamination of the genetic material all necessary precautions were taken at the time of emasculation and pollination. A large number of pollinations were attempted to produce sufficient quantity of hybrid seed. The seed of 20 F1 hybrids and five parents were field planted during May, 2004 in randomized complete block design with three replications. Each of the 25 entries in each replication was planted in a single row with 10 plants spaced 30 cm within the row and 75 cm between the rows. Data on days to squaring and days to flowering were collected at vegetative stage, and on position of 1st sympodial branch on the main stem were recorded at reproductive stage. At maturity, whole of the seed cotton was picked and weigh to calculate seed cotton yield and earliness index. The data was collected from five guarded plants, on the individual plant basis in field and laboratory.
In order to determine whether genotypes differed significantly, the data obtained on each of the characters were subjected to analysis of variance technique (Steel and Torrie, 1980). The characters showing significant genotypic differences were further analyzed for genetic interpretation using additive dominance model (Hayman, 1954; Jinks, 1954).

Results

Mean squares obtained from analysis of variance revealed significant differences among the genotypes for days to squaring, days to flowering, position of first sympodial branch, earliness index and seed cotton yield (Table-1). Adequacy of the data to simple additive-dominance model was tested through joint regression analysis. According to Hayman (1954) regression coefficient (b) must deviate significantly from zero, but not from unity if all the assumptions underlying the simple additive-dominance model are fulfilled. The regression coefficient given in Fig 1-5, revealed that data of days to squaring ($b = 0.95 \pm 0.25$), days to flowering ($b = 0.83 \pm 0.18$), position of first sympodial node ($b = 0.97 \pm 0.15$), earliness index ($b = 1.18 \pm 0.32$), and seed cotton yield ($b = 0.86 \pm 0.23$) all deviated significantly from zero and were equal to unity. Additive (D) and dominance (H_1 and H_2) components of genetic variation were significant for all the characters studied (Table-2) showing the presence of both additive and non-additive gene effects. The magnitude of additive component D (11.35) was almost similar to that of H_1 (10.31), showing the importance of both additive and non-additive gene effects controlling days to squaring, however the degree of dominance (H_1/D) almost complete as exhibited by the ratio (H1/D)0.5 or at 0.5(0.95). For days to flowering and seed cotton yield additive (D) component is higher than H_1 and H_2 component signifying the

involvement of the genes acting cumulatively. The regression line intercepted the Wr axis above the origin (Fig.2, 5) showing partial dominance.

For position of 1st sympodial branch and earliness index, higher magnitude of H_1 and H_2 than D indicated the importance of non-additive gene effects (Table-2). This situation was also confirmed by regression lines which intercepted the Wr axis below the origin (Fig.3, 4).

The unequal distribution of dominant and recessive genes in the parents was observed for all the characters as H_1 is different from H_2, also supported by $H_2/4H_1$ value as it is lower than 0.25. The positive value of F showed that there were more dominant genes for all characters under study. The ratio $(4DH_1)0.5+F/(4DH_1)0.5 -F$ also confirmed this statement as the ratio is more than 1(Table-2). The estimate of h_2, measure the direction of dominance, was positive showing that direction of dominance was towards the parents with (Table-2). The relative position of parents along the regression lines showed that MNH-3570 being nearest to the origin contained maximum number of dominant genes for days to squaring and days to flowering, whilst CIM-435 and BAR 12/1 contained more number of recessive genes for these characters respectively (Fig:1,2). Examination of Fig. 3 showed that BAR 12/1 carried more dominant genes, and in contrast Bamboosa-49 contained more recessive genes for position of 1st sympodial branch. For earliness index and seed cotton yield, CIM-435 and bamboosa-49 contained maximum number of dominant genes respectively while BAR12/1 contained more number of recessive genes for both the traits being farthest from the origin (Fig:4,5).

Discussion

Both additive (D) and non-additive (H_1) gene effects appeared to be significant controlling variation in all the characters, however the role of additive gene effects was predominant in controlling the inheritance of days to squaring, days to flowering and seed cotton yield. These results are in line with the findings reported by Murtaza *et al.* (1992), Han (1998), Iqbal *et al.* (2003), Neelima *et al.* (2004) and others. The genes, exhibited overdominance for position of first sympodial branch, earliness index and was in accordance with the reports of the previous workers like Gomma and Shaheen, (1995), Liu and Han, (1998), Rajan *et al.* (1999), Hendawy *et al.* (1999), Godoy and Palomo, (1999) and Shakeel *et al.* (2001) who also observed overdominance in the genetic control of these characters.

In the present genetic investigations, days to squaring, days to flowering and seed cotton yield were conditioned largely by the genes acting cumulatively and therefore estimates of h^2 non-significant were moderate, ranging from 25-64%. However, Falconer and Mackey (1996) stated that the estimates of heritabilities are subject to environmental variation, and therefore these must be reported and used with care while making selection for desirable combinations in segregation generation. Nonetheless these estimates suggest that the characters studied here may be improved through simple recurrent selection procedures.

In other characters like position of first sympodial branch, earliness index, overdominance type of gene action was present, suggesting the occurrence of heterosis. Thus, based upon this information, the present material may be used advantageously for exploitation of hybrid vigors in the character through the development of hybrid seed.

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Table-1: Mean squares obtained from analysis of variance of earliness related characters in *Gossypium hirsutum* L.

SOV	DF	Days to squaring	Days to flowering	Node no. for first sympodial branch	Earliness index	Seed cotton yield
Replication	2	1.712*	0.512	0.372	1.367	1.308
Genotypes	24	11.301**	5.596**	0.974**	274.577**	911.680**
Error	48	0.431	0.537	0.195	4.226	4.993

**, ** indicate differences significant and highly significant at 5% and 1% probability levels respectively.*

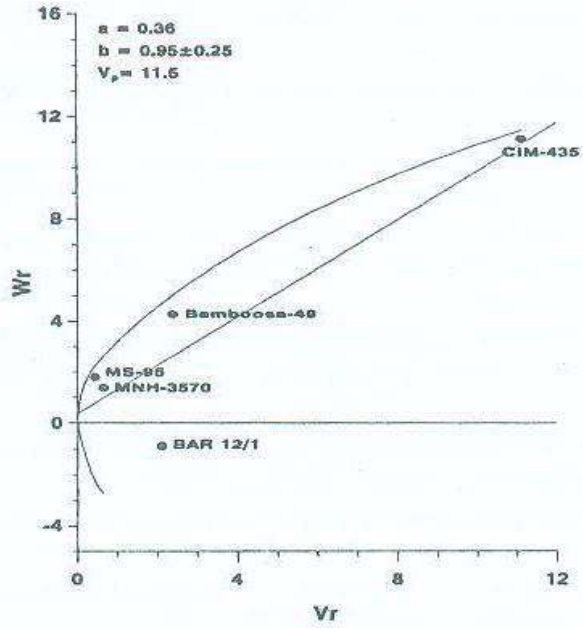

Fig.1 : Vr/Wr graph for days to squaring.

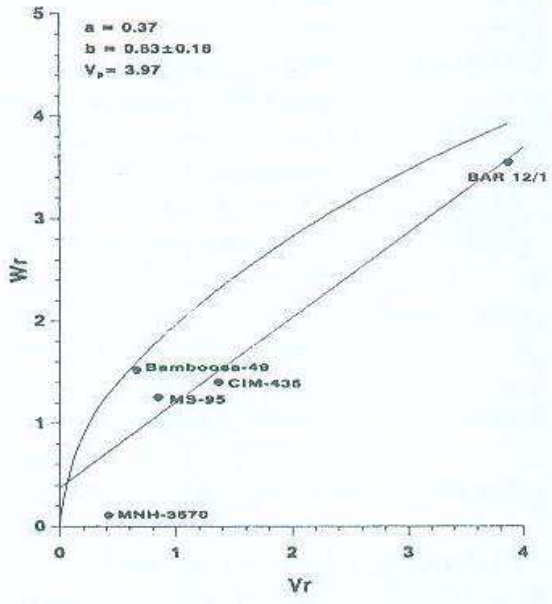

Fig.2 : Vr/Wr graph for days to flowering.

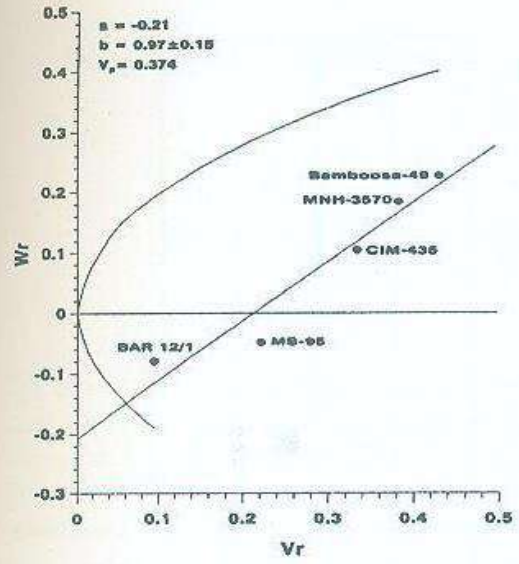

Fig.3 : Vr/Wr graph for position of 1st sympodial branch.

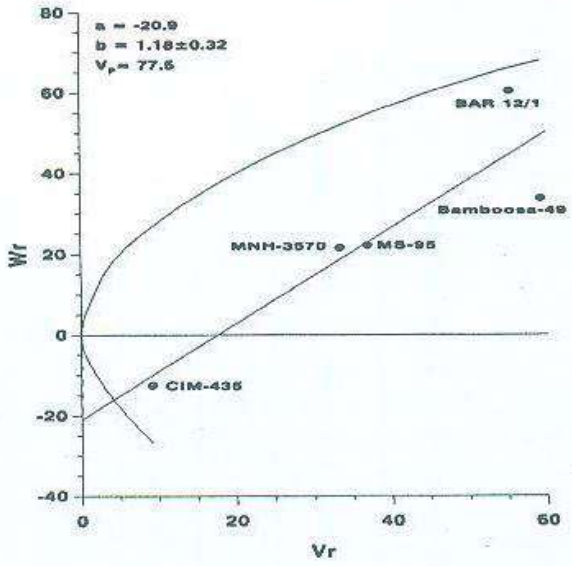

Fig.4 : Vr/Wr graph for earliness index.

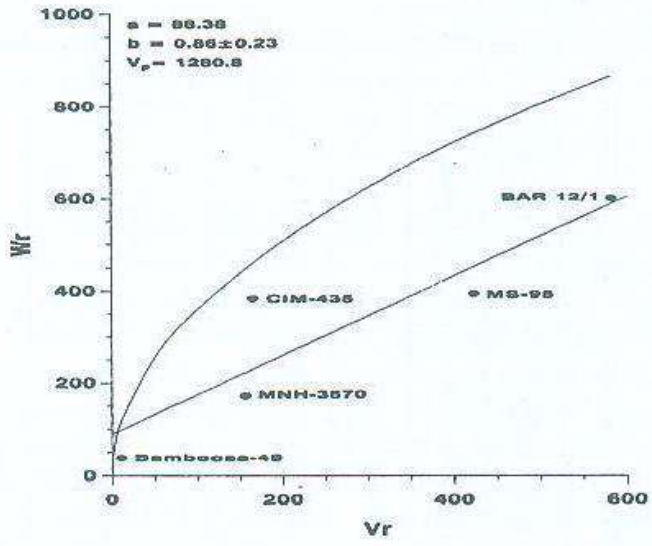

Fig.5 : Vr/Wr graph for seed cotton yield.

Table 2: Estimation of components of genetic variation in earliness related characters in Gossypium hirsutum L.

Components of variance	Days to squaring	Days to flowering	Node no. of first sympodial branch	Earliness index	Seed cotton yield
E	0.16 ± 0.61	0.18 ± 0.16	0.07* ± 0.011	1.37 ± 3.73	1.61 ± 30.63
D	11.35* ± 1.49	3.79* ± 0.39	0.31* ± 0.028	76.15* ± 9.14	1279.21*± 75.02
F	8.69* ± 3.72	1.47 ± 0.97	0.36* ± 0.070	53.24* ± 22.84	1291.23* ± 187.43
H_1	10.31* ± 4.02	2.98* ± 1.05	1.07* ± 0.076	129.04*± 24.7	1076.79* ± 202.61
H_2	8.39* ± 3.64	2.45* ± 0.95	0.83* ± 0.069	85.04* ± 22.39	691.26 *± 183.77
h^2	2.67 ± 2.46	4.079* ± 0.64	0.04 ± 0.046	24.96 ± 15.12	365.94 *± 124.07
$(H_1/D)0.5$	0.95	0.89	1.87	1.30	0.92
$H_2/4H_1$	0.20	0.20	0.19	0.16	0.16
(4DH1)0.5+ F/(4DH1)0.5 –F	2.34	1.56	1.91	1.73	3.44
Heritability (NS)	0.50	0.64	0.25	0.60	0.52

Screening of New Strains for Earliness with High Yield Potential in Upland Cotton

By

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Abstract

Six new strains of upland cotton viz. CRIS-512, CRIS-513, CRIS-514, CRIS-515, CRIS-516 and CRIS-517 and two commercial varieties CRIS-134 and CIM-496 were studied for seven characters to qualify the effect of these characters on earliness and Seed cotton yield during 2006 cotton crop season. The characters studied were appearance of first flower, 1st sympodial node number, first boll open, boll weight, seed cotton yield, GOT% and staple length. The data indicated that 1st flower was appeared in CRIS-512 (43 DAP) followed by CRIS-514 followed by CRIS-517 and CRIS-134 (44 DAP), lowest sympodial node number (6.0) was recorded by CRIS-517 and highest was recorded in CRIS-514 (6.8). First boll open by CRIS-512 at 89 days after planting followed by CRIS-134 (90.0). The maximum average boll weight 4.3 gm was produced in CRIS-514 and CIM-496 followed by CRIS-512 (4.1gm). As regards seed cotton yield, CRIS-512 gave highest yield (4089 kg/ha) followed by CRIS-513 (3934 kg/ha). The ginning outturn percentage data indicated that CRIS-512 gave maximum GOT% (40.6%) followed by standard variety CIM-496 (40.4%). Staple length data indicated that CIM-496 is long staple (29.3 mm) followed by new strain CRIS-513 (28.0 mm), thus it was concluded that CRIS-512, a new strain, has significant effect on various parameters in trial and can prove good performer in further breeding program.

Introduction

Cotton is a main crop and back bone for the economy of Pakistan. It is the major foreign earning commodity. Earliness of the crop maturity is important in the avoidance of frost damage; insect and disease build up, soil moisture depletion and weathering of the open cotton. Earliness in cotton cannot be measured easily because of the fact that cotton plant flowers and boll sets over a long period of time. Earliness is influenced by how easily the cotton plant begins to flower, rate at which flowers open and length of time require for bolls to mature. Kerby *et al* (1990), investigated the effect of plant density in a narrow-row (0.76 m inter row spacing) system on fruiting pattern, plant morphology and yield. The studies were conducted on five *Gossypium hirsutum* genotypes that differed in degree of determinacy. Earliness was associated with a lower node number of the first fruiting branch, more rapid production of early main stem nodes and increased retention of early fruiting forms.

Rehana Anjum *et al* (2001) while carrying out earliness studies on five genotypes by evaluating five characters viz, plant height, main stem node number, 1st sympodial branch, no of days to bloom 1st flower/boll, and no of days to attain 5 NAWF (nodes above white flower)

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stage for their effectiveness in measuring earliness opinion that character attaining date of 5 NAWF stage and date of opening 1st flower/boll were more reliable indicators of earliness. The main objective of present studies is to quantify the effect of different characters and parameters on earliness and seed cotton yield in upland cotton.

Material and Methods

Data was collected from field experiment which was conducted at the experimental area of cotton research institute, Sakrand during 2006 cotton season. Six advanced strains viz, CRIS-512, CRIS-513, CRIS-514, CRIS-515, CRIS-516 and CRIS-517 and with two commercial varieties CRIS-134 and CIM-496 were sown in Randomized Complete Block Design with four repeats. Five plants were taken randomly from each cultivar per replication were monitored for,

1. 1st white flower
2. 1st sympodial node no
3. 1st boll open.
4. Average boll weight
5. Seed cotton yield kg/ha
6. Ginning outturn percentage
7. Staple length (mm)

The data were statistically analyzed for analysis of variance (ANOVA) adopting Steel and Torrie (1980) procedure.

Result and Discussion

i) Number of days taken to open 1st flower

The ANOVA table showed significant difference among cultivars for this character (Table-1) CRIS-512 took 43 days to open 1st flower followed by 44 days in CRIS-515, CRIS-517, and CRIS-134 andCIM-496 respectively (Table-2).

ii) Number of days taken to open 1st bolls

ANOVA Table has shown the significant difference for the character days taken to open 1st boll (Table-1). In Table -2 it is demonstrated that among all cultivars CRIS-512 was earlier in opening of its first boll at 89 days and 43 days after opening of its 1st flower. Whereas CRIS-134 was also earlier significantly by opening its 1st boll at 90 DAP.

iii) First sympodial node number

Mean square data showed highly significant differences among new strains for main stem node number of first sympodial branch (Table-1). Mean performance data presented in Table-2 revealed that CRIS-513 had its first sympodial node number significantly at higher position (6.8) on main stem followed by CRIS-516 (6.7). Lowest node number was observed in CRIS-517 (6.0).

iv) **Average boll weight (gm)**

Non-significant differences among strains were recorded for this character (Table-1). However Table-2 revealed that new strain CRIS-514 gave maximum boll weight (4.3gm) also standard variety CIM-496 gave same boll weight (4.3gm) followed by CRIS-512 (4.1gm).

v) **Seed cotton yield kg/ha**

ANOVA table for seed cotton yield showed significant difference among cultivars, were observed that CRIS-512 yielded highest yield (4089 kg/ha) among all the strains followed by CRIS-513 (3934 kg/ha) while CIM-496 produced relatively less yield of (2989 kg/ha).

vi) **Ginning Out Turn percentage**

The data in Table-1 revealed the highly significant difference among strains for the character ginning outturn percentage. New strain CRIS-512 gave high GOT% (40.6 %) and it is suggested to be used developing high ginning outturn percent varieties whereas CIM-496 gave (40.4%) and CRIS-517 (39.6%) respectively.

vii) **Staple Length**

Significant differences were observed among strains for this trait. Table-2 revealed that CIM-496 measured longer staple length,(29.3 mm) than other strains but three strains also measured long staple length, CRIS-513, CRIS-514, and CRIS-517 (28.0, 27.7, 27.0 mm) respectively.

The growth and development of new strains of cotton were closely monitored for various parameters most of the traits are influenced by many genetic and environmental interactions that cause relatively minor changes in the plant but have major effects on earliness and yield (Oosterhuts *et al* 1992). Therefore it is suggested that the strains which perform better in experiment should be included in further breeding program.

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Table-1: Mean Squares from Analysis of Variance for Seven Traits

Source of variation	Degrees of freedom	Days taken to open 1st flower	Days taken to open 1st boll	1st sympodial node number	Average boll weight (gm)	Seed cotton yield kg/ha	Ginning Out Turn percentage%	Staple length (mm)
Replication	2	0.05	1.53	0.02	0.3 N.S	0.1	0.048	0.1
Genotypes	7	3.63**	9.86**	0.26**	0.48	2.71**	11.07**	8.1**
Error	14	0.06	1.0	0.038	0.2	0.5	0.242	0.15

**= Significant at 5% and 1% probability levels respectively.

Table-2: Mean Values of Seven Quantitative Traits of Upland Cotton Cultivars (*g.hirsutum* l.)

S. No.	Strain	Days taken to open 1st flower	Days taken to open 1st boll	1st sympodial node number	Average boll weight (gm)	Seed cotton yield kg/ha	GOT%	Staple length (mm)
1	CRIS-512	43	89	6.1	4.1	4089	40.6	26.0
2	CRIS-513	47	91	6.8	3.5	3934	39.1	28.0
3	CRIS-514	45	93	6.3	4.3	3443	39.0	27.0
4	CRIS-515	44	94	6.2	3.6	3503	38.0	26.4
5	CRIS-516	46	92	6.7	3.6	3622	37.0	24.0
6	CRIS-517	44	93	6.0	3.4	3600	39.6	27.7
7	CRIS-134	44	90	6.1	3.3	3347	35.0	26.5
8	CIM-496	44	92	6.5	4.3	2989	40.4	29.3

Impact of Picking, Handling and Ginning Process on the Quality of Raw Cotton in District Mirpurkhas

By

Liaqat Ali Khan[1] and Dr. Tassawar Hussain Malik[2]

Abstract

In order to evaluate the impact of picking, handling and ginning process on the quality of raw cotton in district Mirpurkhas 100 raw cotton samples were collected. 50 samples from conventionally operating growers and ginners and 50 samples from the field of progressive farmers and ginners having improved ginning operations were collected during the year 2008. The samples collected were scattered among the farmers and ginners located throughout Mirpur Khas district. The samples were examined for various quality characteristics of cotton and values were compared for both the categories.

The quality of cotton produced by progressive growers and ginners is significantly better than the cotton produced by conventional growers and ginners in relation to the quality traits studied. It is suggested that improved varieties may be cultivated and proper picking, handling, storage, transportation, ginning and quality based marketing may be ensured. Cotton cloth instead of synthetic fabrics must be used for packing, storage and transportation of seed cotton and provided by farmers and ginning factory owners to pickers for picking of seed cotton. Picking should start when about 60% bolls have opened at about 10 AM in sunshine by the time dew and humidity have evaporated and stored on pucca platforms. Cotton should be cleaned of contaminants properly and moisture should be maintained upto 8.5 percent.

Introduction

Cotton is the main stay of the national economy. Pak cotton as raw material alone atones for the spinning/ textile sector which is the single most important sector in the build up to national economy. Pakistan is the 4th largest producer of cotton, 3rd largest in consumption, 3rd largest in yarn production, 2nd largest yarn exporter, 3rd largest in cloth production and 3rd largest clothexporter (ICAC 2010). Cotton sector accounts for 8.2% of the value added in agriculture and 2% to GDP (Bilal Hassan, 2011). Cotton and cotton products contribute 10% to GDP (Bilal Hassan, 2011).

The entire value chain i.e. production of cotton, ginning, spinning, weaving and garment manufacturing is a major source of foreign exchange earnings and contributes 55% to the National Economy (Textile Commissioner Organization 2011).

Cotton Crop adheres for the bulk of export receipts being accrued through cotton and textiles. The quality traits are vital detrimental factors in determining the quality ensuring and fetching the incremental value of cotton and made ups. The enhancement of cotton quality as the

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raw material for spinning/textile sector is of prime importance as it has direct impact and immediate bearings on the entire chain of value addition till the finished goods subsequently fetching millions of dollars($s) for the national economy.

Cotton fiber quality is no longer an afterthought; it is becoming an increasingly important issue for producers. The previous mindset concerning cotton production has been to produce a crop so that yields were maximized and minimum quality standards were met (Culpepper *et al.* 2004). Research and breeding efforts in the past have also focused primarily on yield enhancement. However, current changes in spinning technology and the global quality based nature of the cotton market have necessitated the production of higher quality fiber (Bednarz *et al.* 2002). Basic knowledge of fiber development and how management practices enhance or preserve fiber quality are now a necessity. In the near future it is possible that the production of a cotton crop will no longer be deemed a success based solely on the number of bales produced per acre. A full understanding of the fiber development process in agronomic and environmental exposure and specifically picking, handling, storage & ginning are the major factors affecting the fiber quality of raw cotton for the maximum preservation of fiber properties thus rendering the issue imperative and should be intelligently addressed (Philip, 2005).

The quality consideration of raw cotton at all its stages i.e. Picking, handling, storage and ginning processes is of paramount importance. It collectively contributes in buildup of quality parameters in attaining the price where the quality of cotton fibers is pre-requisites. Fiber quality is a general term given to a set of measurements that describe a sample of fibers extracted from a bale of cotton (Bradow and Davidonis, 2000). These measurements are then compared to a set of United States Department of Agriculture (USDA) standards and are used to determine price premiums and discounts for the bale from which the sample was taken. The measurements taken include: length, uniformity, strength, color grade, trash, leaf grade, preparation, and extraneous matter (James. L. K. USDA, 2001).

Pakistan cotton is inherently of good quality but the country loses 10 to 15 % of its intrinsic value (raw cotton and its made-ups) due to improper picking, handling and ginning practices,high degree of contamination,non-implementation of cotton classing and grading system and improper ginning practices. Absence of pricing system based on quality i.e. Grade, Staple Length & other fibre properties subject to Premium/ Discount.

Objectives/Specific Objectives

1. To determine the impact of supervised proper picking, handling and ginning methods on the quality of raw cotton.

2. To determine the status and effect of picking and post-harvest handling techniques so as to enhance the quality and to ensure the real intrinsic value to the growers. Identifying the ways and means to improve raw cotton quality to provide foundation for the value addition resulting better income to all stakeholders and suggest measures for the production of high quality clean cotton.

3. Further recommending procedures for proper picking, handling and storing to preserve optimum fibre properties and proposed ginning practices for improvement of

raw cotton quality and identify the basic factors limiting the value addition in Pak Cotton.

Materials and Method

The study was carried in the areas of district Mirpurkhas (Sindh). Progressive growers & ginners and conventional growers & ginners in various representative areas of district Mirpurkhas were visited to collect the data. Most common commercial varieties were determined. 10 representative villages were selected at random in consultation with ginners. From each village 5 progressive growers were selected at random in consultation with Provincial Agriculture Department Sindh. Five Cotton Ginning Factories were selected at random to study the handling and ginning of seed cotton at the gins of progressive growers and conventional growers under standard proper procedure.

About 600 kgs of seed cotton requisite for one bale of lint cotton (aprox. 170 Kgs) were picked and transported under supervision from the field of selected progressive growers to the selected ginning factories and ginned under standard proper procedure. One sample from each bale of the progressive growers and conventional growers was drawn and tested at Cotton Fibre Testing Laboratory of international standard. The Laboratory was equipped with latest High Volume Instrument (HVI) 1000 Classing (Bargeron, J. D), Shirley Analyzer MK-II Atlas. To investigate the impact of supervised proper picking, handling and ginning process on the quality of raw cotton at district Mirpurkhas.

Result and Discussion

In order to investigate the impact of picking, handling and ginning process on the quality of raw cotton in district Mirpurkhas. A total of 100 samples were collected i.e. 50 samples from conventionally operating farmers and ginners and 50 samples from the fields of progressive farmers and the ginners having improved ginning operations. The sample collection was scattered among the farmers and ginners located throughout Mirpurkhas district. The impact of picking, storage, handling and ginning operations of two categories of producers and processors was investigated for ginning out-turn (GOT), SCI, moisture, micronaire, maturity index, upper half mean length (UHML), uniformity index (UI), short fiber index (SFI), strength of fiber (Str), fiber elongation (Elg), reflective degree of colour/brightness (Rd), degree of yellowness (+b), cotton grade (C-grade), trash count (Tr cnt), trash area (Tr area), leaf grade (Tr ID) and trash. In view of the statistical analysis the results in relation to impact on following quality traits are highly significant.

1. Grade	5. Micronaire
2. Colour (Rd% & +b)	6. Staple Length
3. Non Lint Content (NLC)	7. Strength
4. Moisture %	

(The results are presented in Table-1 to 8)

The comparative values for progressive growers and ginners vs conventional growers and ginners were: ginning outturn 34.83 ± 0.066 vs 33.68 ± 0.072%, SCI 100.12 ± 0.784 vs 98.58 ± 1.092, moisture content 8.236 ± 0.114 vs 7.864 ± 0.073%, value 4.939 ± 0.031 vs 4.566 ±

0.040, maturity index 0.879 ± 0.001 vs 0.871 ± 0.001, upper half mean length 1.027 ± 0.001 inch vs 1.012 ± 0.003, uniformity index 80.848 ± 0.083 vs 80.822 ± 0.075%, SFI 10.147 ± 0.119 vs 10.303 ± 0.166, fiber strength 26.21 ± 0.097 vs 25.73 ± 0.118 g/tex, fiber elongation 6.066 ± 0.101 vs 5.678 ± 0.056%, Rd 75.848 ± 0.157 vs 69.762 ± 0.187, +b (yellowness) 8.768 ± 0.044 vs 10.254 ± 0.061, C-grade 1.22 ± 0.077 vs 3.16 ± 0.052, trash count 35.68 ± 1.088 vs 75.46 ± 1.454, trash area 0.521 ± 0.023 vs 1.066 ± 0.034%, leaf grade 3.22 ± 0.059 vs 4.08 ± 0.039 and non-lint content 3.731 ± 0.082 vs 5.585 ± 0.057%.

Suggestions

Proper picking, storage and quality based marketing on the basis of Grade, Staple Length and other fibre properties subject to premium and discount of raw cotton must be ensured. Education/Awareness campaigns should be carried out by Provincial Agriculture Departments through mass media to the targeted segment for the production of clean cotton, cotton clothes instead of synthetic fabrics must be used for packing, storage, handling, and transportation of seed cotton and lint. Picking should start at 10 A.M. by the time dew and humidity has completely evaporated. Cotton should be stored on Pucca Platforms. Cotton Cloth Bags and open trolleys should be used for transportation of cotton from field to ginning factories. Payment to pickers should be made for quantity along with incentive for clean and better quality picked seed cotton. Sheds and platforms should be built properly in the market place (Mandi) where seed cotton is marketed and stored. Cotton Ginning Research & Training Institute should be established to conduct adaptive and applied research in ginning technology. The locally manufactured ginning machinery should be standardized.

Recommendations

- The country is incurring huge losses due to improper picking, handling, storage, transportation and ginning practices. The said areas may be focused and addressed through public and private agriculture extension services.
- The cotton standardization ordinance, 2002 and Provincial Cotton Control Act, 1966 providing for quality control of cotton should be implemented with letter & spirit to control contamination in cotton.
- Promotion, adoption and use of official cotton standards as common standards in domestic trade and international commerce.
- The Public and Private Sector buyers should purchase cotton on the basis of grade, staple length and other cotton fibre properties as in vogue all over the world.
- The present marketing system should shift to a quality based scientifically derived marketing system on the basis of grade, staple length and other fiber properties subject to premium / discount.
- Education/ awareness campaigns should be launched by Provincial Agriculture Extension Departments for proper picking, handling, transportation and ginning practices through out the cotton belt.
- On farm/ factory demonstration of proper picking, handling, storage and ginning practices may be arranged by Provincial Agriculture Extension Departments.
- Cotton Ginning Research & Training Institute should be established. To conduct adaptive and applied research in ginning technology to enhance the value of lint, preserve the quality of cotton fibres and to maximize the profit to the cotton growers, ginners, exporters and spinners.

- Ginning trials, assessment of cleaning efficiency and effect of ginning on fiber properties.
- The locally manufactured ginning machinery should be standardized.

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Table-1: Cotton grade of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	2.00	Super (0)	1.22	0.298	0.545	0.077
Conventional	4.00	3.00	3.160	0.137	0.370	0.052

Probability 0.0001
C.V. (%) 21.05
Remarks Highy Significant

Table-2: Analysis of variance for cotton grade

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	10.890	0.222	1.0461	NS
Between groups	1	94.090	94.090	442.8848	HS
Error	49	10.410	0.212	-	-
Total	99	115.390	-	-	-

NS= Non-Significant (P>0.05)
HS= Highly Significant (P<0.01)

Table-3: Rd (brightness) degree of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	73.30	78.20	75.848	1.225	1.107	0.157
Conventional	65.50	72.30	69.762	1.740	1.319	0.187

Probability 0.0001
C.V. (%) 1.86
Remarks Highy Significant

Table-4: Analysis of variance for Rd (brightness) degree

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	55.543	1.143	0.6191	NS
Between groups	1	925.985	925.985	505.720	HS
Error	49	89.720	1.831	-	-
Total	99	1071.247	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Table-5: +b (yellowness) degree of raw cotton managed by progressive and Conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	8.20	9.50	8.768	0.096	0.310	0.044
Conventional	9.30	11.60	10.254	0.187	0.433	0.061

Probability 0.0001
C.V. (%) 4.06
Remarks Highly Significant

Table-6: Analysis of variance for +b (yellowness) degree

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	6.603	0.135	0.9057	NS
Between groups	1	55.205	55.205	371.0566	HS
Error	49	7.290	0.149	-	-
Total	99	69.098	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Table-7: Non-lint contents (%) of raw cotton managed by progressive and Conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	2.30	4.70	3.731	0.334	0.578	0.082
Conventional	5.00	6.80	5.585	0.160	0.400	0.057

Probability 0.0001
C.V. (%) 10.84
Remarks Highly Significant

Table-8: Analysis of variance for Non-lint contents (%)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	11.706	0.239	0.9374	NS
Between groups	1	85.951	85.951	337.2559	HS
Error	49	12.488	0.255	-	-
Total	99	110.146	-	-	-

NS = Non-Significant (P > 0.05)
HS = Highly Significant (P < 0.01)

Table-9: Moisture content (%) of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	7.20	10.40	8.236	0.655	0.809	0.114
Conventional	7.20	9.90	7.864	0.263	0.513	0.073

Probability 0.0105
C.V. (%) 8.68
Remarks *Highly Significant*

Table-10: Analysis of variance for moisture content (%)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	21.040	0.429	0.8785	NS
Between groups	1	3.460	3.460	7.0780	HS
Error	49	23.950	0.489	-	-
Total	99	48.450	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Table-11: Micronaire value of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	3.990	5.220	4.939	0.047	0.216	0.031
Conventional	3.950	5.170	4.566	0.081	0.285	0.040

Probability 0.0001
C.V. (%) 5.34
Remarks Highly Significant

Table-12: Analysis of variance for micronaire value

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	3.120	0.064	0.9893	NS
Between groups	1	3.467	3.467	53.8710	HS
Error	49	3.154	0.064	-	-
Total	99	9.740	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Table-13: Upper half means length/UHML (inch) of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	1.007	1.063	1.027	0.000	0.013	0.002
Conventional	0.973	1.047	1.012	0.000	0.018	0.003

Probability 0.0001
C.V. (%) 1.55
Remarks Highly Significant

Table-14: Analysis of variance for upper half mean length (UHML)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	0.012	0.000	0.9879	NS
Between groups	1	0.005	0.005	20.9632	HS
Error	49	0.012	0.000	-	-
Total	99	0.030	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Table-15: Fiber strength (g/tex) of raw cotton managed by progressive and conventional growers and ginners in district Mirpurkhas

Growers/ Ginners	Minimum	Maximum	Average	Variance	Standard Deviation (±)	Standard Error (±)
Progressive	24.20	28.40	26.21	0.949	0.974	0.097
Conventional	24.20	27.20	25.73	0.674	0.833	0.118

Probability 0.0001
C.V. (%) 3.39
Remarks Highly Significant

Table-16: Analysis of variance for Fiber strength (g/tex)

Source of variation	Degrees of freedom	Sum of squares	Mean squares	F-Ratio	Remarks
Within groups	49	33.187	0.676	0.8576	NS
Between groups	1	23.184	23.184	28.1314	HS
Error	49	38.641	0.789	-	-
Total	99	93.962	-	-	-

NS = Non-Significant (P>0.05)
HS = Highly Significant (P<0.01)

Organic Cotton

By

Shahid H. Sheikh[1] *and Dr. Tassawar Hussain Malik*[2]

Cotton (*Gossipium sp*) is a major fibre and cash crop of our country, its cultivation history is very old as civilization of Harappa and Mohinjodaro. Cotton crop assumes a place of special significance in Pakistan's economy and is considered as silver fibre or white goldCotton is produced in number of countries of the world but major producing countries are Pakistan, India, China, Egypt, Sudan, Turkey, Uzbekistan and United States of America.

Due to demand of global fibre requirement, area under cotton and average yield is increased many fold. There is special requirement of cotton importing countries of Europe and USA that there should be minimum residual effects of toxic chemicals in cotton and its made up apparels with value addition. For that reason demand of organic cotton has increased in these countries including US.

What is Organic Cotton and Organic Agriculture ?

Cotton which is produced by farming system under Good Agriculture Practices according to established standards without the use of GMO seed, synthetic chemical fertilizers, pesticides, growth regulator and defoliant. Organic farming builds diverse agriculture system, replenish and maintain soil fertility, balance in natural biological organism and promote a healthy environment.

Organic cotton is now grown in more than 12 countries but still represent only a fraction of the total cotton production globally. Organic cotton production increased after 1997 onward and our neighboring country is leading country in organic agriculture.

Now 35 million hectares of agriculture land is certified according organic standards as reported by International Federation of Organic Agriculture Movement (IFOAM) and The Research Institute of Organic Agriculture (FiBL) at BioFach World Organic Trade Fair 2010 in Nuremberg, Germany.

The greatest share of the global organic surface area is in Oceania (34.7 percent), followed by Europe (23.4 percent) and Latin America (23 percent). With its vast grazing lands, Australia continues to account for the largest certified organic surface area, with 12 million hectares, followed by Argentina (4 million hectares), and China (1.9 million hectares). The global market for organic products reached a value of over 50 billion U.S. Dollars in 2008, with the vast majority of products being consumed in North America and Europe, according to Organic Monitor.

The History of Organic Cotton Production

The certified production and consumption of organic cotton dates back to the early1990s, when pioneers in the United States and Turkey started to create markets for cotton that was grown as

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a rotational crop on certified organic farms. The first organiccotton textiles brought to the market consisted of a limited range of 100% certifiedorganic cotton products, sold in a small number of dedicated shops and health food stores. They wereprimarily marketed for their ecological characteristics, rather than for their quality, design or fashionable appeal.
Overall, global demand for organic cotton remained more or less stable up until 2000.Most demand came from Europe, particularly from Germany and new strategies were required to increase organic cotton demand and subsequently production.

In 2006, many textile and clothing companies had followed the examples of Nike with others, and launched organic cotton conversion through business network Organic Exchange which was instrumental in that process since its foundation in 2002. The demand for organic cotton is increasing rapidly, with 100% organic cotton items now showing up in regular fashion fairs such as Magic (United States), Première Vision (France) and the London Fashion Week (United Kingdom).

Reliable data about the production, trade and consumption of organic cotton is difficult to establish. Data from third-party certifiers are not available for reasons of commercial confidentiality. Differences between the declared and the real volumes of traded organic fibre can be significant.The data presented in this chapter stem from a variety of sources, including documentary and Internet research.

Figure1. *Organic cotton production and trade worldwide (in tons of fibre, 1992–2006)*

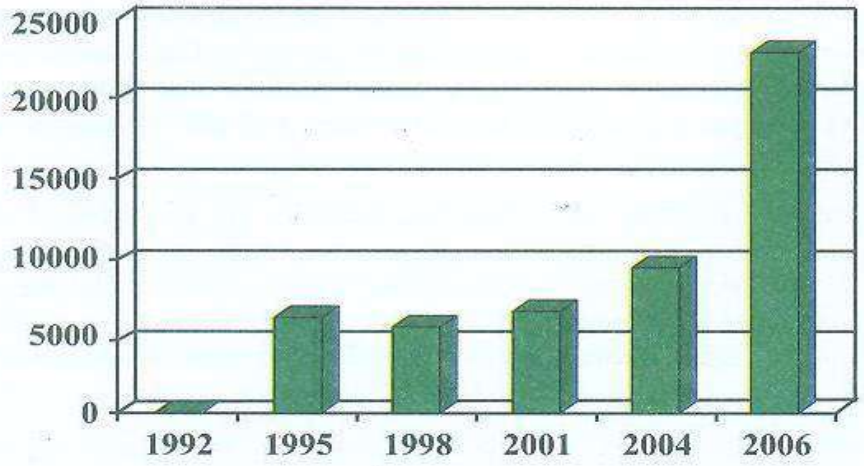
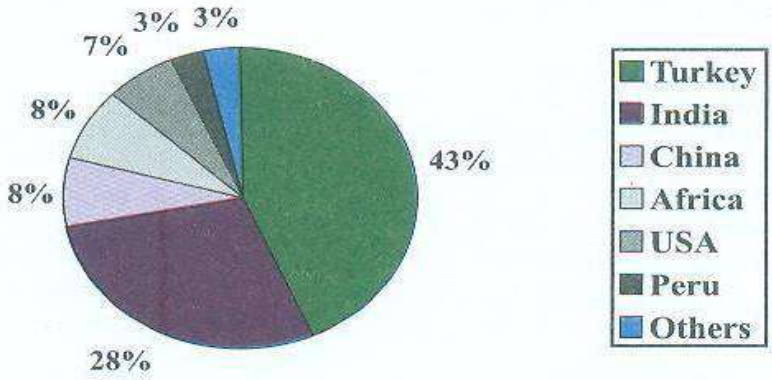


Figure 2. *Organic cotton production and trade per production area (in tons of fibre, 2006).*



Total production and trade in organic cotton fibre is estimated at 23,000 tons in2006. Production growth was an annual 70% over the period 2001–2006, and has reached 120 % per year since 2004. Despite this spectacular growth, the volume of organic fibre traded on the international market still represents only 0.09% of the 24.8 million tons of cotton fibre traded worldwide.

Organic cotton production is concentrated in Turkey (10,000 tons of fibre; 43% of total production) followed by India (6,500 tons of fibre; 28%), where growth has recently also been most spectacular. Together they now produce more than 70% of the world organic cotton supply. Other relevant producers in terms of volume are China (1,750 tons; 8%) and the United States (1,500 tons; 7%).The African countries together accounted for about 1,800 tons of fibre in 2006, or 8% of total production, mainly in Uganda and the United Republic of Tanzania, but also in Egypt and in French speaking West Africa (Mali, Burkina Faso, Benin). Countries that

recently started or restarted organic cotton production are Australia, Burkina Faso, Kenya, Kyrgyzstan, Nicaragua, Pakistan, South Africa and Zambia. Today, certified organic cotton is grown in 22 countries in the world (see table 1).

Cotton plays an important role in economy of Pakistan and it is known as back bone of our country's textile industry. The area under cotton cultivation has increased more than 2.6 mio hectares but yield is low due to multiple factors e.g. uncertified seed of low quality, short supply of fertilizer, significant losses due to insects pests and disease. Cotton is one of the most demanding crop in terms of insecticide / pesticides consumption. The crop is sprayed several times from toxic pesticides during the season from planting to harvesting. The effects of these pesticides on water channels, injurious to health of animals, human beings as well as environment including soil can be noticed.

Pakistani Farmers are aware about organic agriculture but there is misunderstanding among the farmers / growers that their income will be affected due to low yield if they shifted to organic cultivation from conventional farming. They do not realize that Organic cultivation will be cost effective, eco- friendly, healthy for plant, soil, animals and mankind, socially justifiable and good for rural economy as it will employ rural population.

Benefits of Organic Cotton Cultivation:

1- **Eco-friendly Fibre:** Bio control agents or Botanical pesticides are used for the control of insect pests and disease. These bio-control agents prevent pesticide residues in fibres which is carcinogenic to the end user.

2- **Effects on Soil:** Soil management is very important to keep natural equilibrium of beneficial soil organisms by way of organic farming.

   Soil need NPK as well as micronutrients and symbiotic relationships with fungi and other organisms to flourish, but getting enough nitrogen, and particularly synchronization so that plants get enough nitrogen at the right time is likely the greatest challenge for organic farmers.Good management will improve soils to maintain productivity and reduce risks and costs in the future Crop rotation and green manure ("cover crops") help to provide nitrogen through legumes (more precisely, the fabaceae family) which fix nitrogen from the atmosphere through symbiosis with the bacteria rhizobia.

   A healthy soil produces healthy crops with minimum amount of external inputs. Good soil management can improve water storage, drainage, nutrient availability and root development

   A biologically healthy soil harbours different organisms, microorganisms such as bacteria and fungi as well as large organisms like Nematodes, Ants, Insects larvae, Earthworms, and ground Beetles.Most of them are helpful to plants, enhancing the availability of nutrients and producing chemicals that stimulate plant growth.

   All these in turn influence crop defence mechanism and populations of potential beneficial insects and pests. These organisms contribute a great deal in promoting soil health. Inorganic and synthetic inputs results in destruction of beneficial soil organism and create an imbalance in natural population of predators of cotton pests.

3- **Environment Friendly Cotton:** Pakistan is facing widespread environmental degradation like many other countries. Inorganic fertilizer and toxic pesticide causing damages to environment in general and public in particular.

By cultivating organically, hazards of polluting air, water and soil are eliminated due to excessive use of fertilizers and pesticides. The discharge of pesticide mixed water, untreated and unprocessed effluents from manufacturing industries of textile and leather into canals and river causes serious health problem to man, cattle and fish.

4- **Insecticide Resistance:** Organic cultivation helps in preventing the development of resistant strains of insects against pesticides which produced by indiscriminate use of hazardous chemicals for pest control.

5- **Cost of Cultivation:** Organic cultivation uses resources available at farm and employ work force to utilize their skills fulfilling social responsibility thus reducing the expenses on application of fertilizer and pesticides.

Control Measures for major Insect Pests of Cotton:

Major insect pests and diseases and their damages are known to cotton growers but their control is different in organic cultivation. These are being described below in detail.

1. Control of Lepidopterous Pests:

i) Bollworm: Cultural practices

Do not plant other solanaceous crops after harvesting cotton. Avoid planting tomato near corn or cotton or other solanaceous crops to prevent heavy pest infestations.

Physical methods

Pheromone traps:

Now Pheromones are available in different countries for monitoring insect population which can be used before taking any control measure. Place pheromone traps at a distance of 3 meters. If use to monitor the pest, place 2-3 traps in a hectare field area. To make your own traps, make 10-12 holes into an old plastic bottle or 3 holes on each side of a used 1 liter ice cream container to allow moths to enter. Place a wire to suspend the bait. Half-fill the container with soapy water. Hang the pheromone capsule using a string or wire. Attach the trap to a stake or hang it on branch of a tree.

Handpicking of damaged fruits:

Handpick damaged fruits and collect those that fall down. Destroy the damaged fruits by cutting into small pieces or place them in sealed sacks and dry under the sun. Putting them immediately in compost pit or burying them will enable the matured larvae to pupate into the soil.

Plant extracts:

Ginger, garlic, and chilli extract:

Soak 50 g of peeled garlic overnight in 10 ml kerosene. Combine garlic, 25 g of green chilies, and 25 g of ginger. Add 50 ml of water to the mixture. Grind them. Add 3 liters of water for spraying.

Biological Control:

Apply HELICOVEX, a Nucleopoly-hedro virus (NPV) as biological control measure at the rate 200 ml / ha at 7 -14 days interval in the evening.

ii) **Army Worm: Cultural Practices;**

1. Practice proper field sanitation.
2. Remove weeds and Plant debris after harvesting regularly to reduce breeding sites and shelter for armyworm.
3. Employ proper seed selection when seeds for sowing are taken from the previous harvest. Adults might have laid eggs on the seeds during armyworm infestation.
4. Plow and harrow the field thoroughly. Sometimes, the small grains or grasses are plowed after the eggs are laid on them. As the field is planted and the plants begin to grow, the larvae will continue to develop and will start attacking the plants.

Physical control:

Deep ditch: Plow a deep ditch. Keep it filled with water. This method is helpful, when larvae are found to be moving towards your field from the adjacent fields. Another method is to dig a deep ditch with vertical sides to trap the larvae and prevent them from crawling out,

Plant extracts:

Chili and Neem leaves extract:

Pound 10-20 pieces of hot pepper and 2-2.5 kg fresh neem leaves. Add 1 liter of water. Let it standovernight and strain. Dilute the filtrate with 20 liters of water. Add 2 tbsp of powdered soap. Stir well before spray.

Garlic bulb extract:

Chop 85 grams of garlic. Soak in 50 ml of mineral oil (cooking oil) for 1 day. Add water to the filtrate to make a 1-liter extract. Add 10 ml of soap and stir well before spray.

Biological Control:

Apply SPEXIT a Nucleopoly-hedro virus (NPV) as biological control measure at the rate 200 ml / ha at 7 -14 days interval in the evening.

iii) **Spotted & Pink Bollworms: Cultural practices:**

1. Practice crop rotation. Avoid planting crops successively that are susceptible to bollworm like cotton, corn, sorghum, tobacco, soybean, and tomato.
2. Grow a row of castor as border crop. Castor plants attract caterpillars that feed on cotton. Sow seeds of sunflower, black gram, and or cowpea as trap crops in every 5 rows of cotton. These plants attract bollworm as well as provide habitat for natural enemies, which feed on bollworms.
3. Burn cotton branches and debris heavily infested by bollworm.

4. After harvest, plow-in plant residues immediately by incorporating these into the soil. Remove weeds surrounding your fields when your area is not planted with crops since these are the good laying sites for adults.

Physical control:

Light trap:

1. Install the light trap near or within the field where you want to trap the flying insects.
2. Mount the lamp or the bulb on the frame, 5 meters from the ground. When using electric bulb, make sure that the bulb and wiring are not in contact with water to avoid electrocution. Place the shallow basin with soapy water or the jute sack underneath the light.
3. Put the light trap from early evening until early morning.
4. Collect the trapped insects daily and dispose them properly.

Bird perches:

Bird perches are resting places for predatory birds to rest and to look for preys. Predatory birds prefer to look for prey in field crops where they have places to rest.

Plant extracts:

Ginger, garlic, and chili extract: Soak 50 g of peeled garlic overnight in 10 ml kerosene. Combine garlic, 25 g of green chilies, and 25 g of ginger. Add 50 ml of water to the mixture. Grind them. Add 3 liters of water.

2. Control of Sucking Pests:

i) Thrips: Cultural practices:

1. Cotton should not be planted following onions. Volunteer onion plants should be removed.
2. Keep plants well irrigated. Lack of water increases the susceptibility of plants to thrips damage.
3. Remove weeds as the thrips population builds-up on them.

Physical control

1. Collect thrips by gently shaking leaves and flowers onto a white sheet of paper or into a shallow cartoon box. This will not remove all the thrips but lowers its population density.
2. Bright blue or royal blue sticky traps. To make sticky trap, spread petroleum jelly or used motor oil on a blue shade painted plywood, 6 cm x 15 cm or up in size. Place traps near the plants with enough distance. The traps when hung should be positioned at a 61 cm zone above the plants. Thrips are attracted to blue colors.

Plant extracts

Neem leaf extract:

Pound gently 1-2 kg of neem leaves. Place in a pot. Add 2-4 liters of water. Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. Strain to get clear extract. Dilute 1 liter of neem leaf extract with 9 liters of water. Add 100 ml of soap. Stir well before spray.

Other substances:

Ammonia Spray: Mix 1 part Ammonia with 7 parts of water.

Flour spray: Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water. Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Soap spray: Mix 2 1/2 tablespoons of liquid soap to a gallon of water. Stir well before spray.

Another method is to mix 1 tablespoon of dish washing detergent with 1 cup of cooking oil, to make a stock solution.

ii) **White Flies: Cultural practices:**

1. Do not plant cotton near crops that have whitefly infestation. This would lead to early infestation of your crop and could ruin the whole field crop.
2. Even after the crops have been harvested, the whiteflies continue to live on the abandoned crop residues. To stop the lifecycle, plow the field immediately after harvest and incorporate the plant debris into the soil.
3. Whiteflies are attracted to Nicotiana, a flowering tobacco plant variety. Plant Nicotania as a trap crop.

Physical control:

Sticky board traps: Traps give early warning and serve as natural control method. To use, place 1 to 4 yellow sticky cards per 300 square meter field area. Replace traps at least once a week..

To make sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or above. Place traps near the plants , the traps can be hung and positioned at 61 cm zone above the plants.

Plant extracts

Madre de cacao & Neem: Shred 1 kg of Madre de cacao leaves and 1 kg of neem leaves. Soak leaves in 5 liters of water for 3 days. Strain and add water to make up 20 liters of filtrate. Spraying interval is 4-5 days.

Other solutions:

Ammonia Spray: Mix 1 part ammonia with 7 parts water and spray on plants.

Flour spray: Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water. Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Soap sprays: Mix 2 ½ tablespoons of liquid soap to a gallon of water. Stir well and spray thoroughly on plants.

Another method is to mix 1 tablespoon of dishwashing detergent with 1 cup of cooking oil, to make stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water.

iii) **Mealy Bugs:**

Same cultural and physical methods and plant extracts be used for the control of Mealy Bugs.

iv) **Spider Mite: Cultural practices:**

1. Provide plants with adequate water. Water-stressed plants are prone to damage by mites.
2. Avoid the use of broad-spectrum insecticide for this may cause a mites' outbreak. This practice kills the natural enemies of mites and stimulates mites' reproduction.

Physical control

1. Hosing with a strong jet of water knocks off mites and destroys their webs. Apply water to pathways and other dusty areas at regular intervals.

Plant extracts:

Coriander seed extract

Pound or crush 200 grams of coriander seeds. Boil in 1 liter of water for 10 minutes. Cool and strain. Dilute n extract with 2 liters of water.

Other solutions

Horticultural oil: Spray 2% solution against mites. To make a 2% solution, pour 1/3-cup oil into a 1-gallon container, and then fill with water to make a 1-gallon solution. Apply successive sprays at least 6 weeks apart. Horticultural oil is concentrated and must be mixed with water.

Flour spray: Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water. Add 1 tsp of soap as sticker. Stir the filtrate prior to application.

Soap spray: Mix 2 ½ tablespoons of liquid soap to a gallon of water. Stir well.

Another formulation is to mix 1 tablespoon of dishwashing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water.

Milk spray: Mix ½ liter of milk to 4.5 liters of water (Milk and water ratio is 1 part milk to 9 parts water). Spray at weekly interval as a preventive control measure.

3. Control of Diseases:

Anthracnose, Bacterial Leaf Blight, Fusarium Wilt, Leaf curl Virus:

1. Use resistant or tolerant cultivars from reliable source only.
2. Protect seedlings from whiteflies
3. Remove infected plants and bury them immediately.
4. Do not plant cotton near tomato and/or other crops susceptible to whiteflies or vice versa
5. Plow-under all plant debris after harvest or burn them when possible.
6. Proper fertilization and water management
7. Proper land preparation for better drainage, Proper plant spacing for proper air circulation and sunlight penetration within plants
8. Insect pest control as they may serve as the carrier of the bacteria
9. Weed control
10. Seed treatment with *Trichoderma viride* and Pseudomonas @ 2 g / kg of seeds.
11. In India Cow urine is recommended for seed treatment and spray.
12. Spray diluted lime water 10 % twice at interval of 10 days.
13. Apply 60-100 kgs of neem seed cake as basel manure.
14. Fumigate with *Acorus calamus* or Vaividanga (*Embelia ribes*)
    There is no known effective method to control *Fusarium* wilt. Follow the preventive measures to cushion the impact of the disease;

4. Control of Root Knot Nematodes:

1. Crop rotation. Broccoli, cauliflower, sorghum, Sudan grass, rape, and mustard seed are resistant to nematodes
2. Fallowing
3. Deep plowing
4. Use of resistant cultivars
5. Grow healthy plants
6. Remove weeds
7. Plant French marigold (Tagetes patula). Planting distance is 17.5 x 17.5 cm in between hills and rows.
   Two months after, plow them under.
8. Garlic oil emulsion. Mix 50 ml of garlic oil and 1 ml of soap. Blend well by stirring thoroughly. Add 950 ml of water. Stir again. To prevent oil from floating, apply extract immediately.
9. Fermented marigold extract
10. Fermented marigold extract
11. Fill-in drum with ½ - ¾ of flowering plants. Leave to stand for 5-10 days. Stir occasionally. Strain and dilute the filtrate with water at a ratio of 1:2. Add 1 tsp of soap in every liter of extract.

Natural enemies:

These insects are beneficial for the crop and provide natural control of harmful pests.Let them grow in the field to feed on unwanted insects. Indiscriminate use of pesticides will eliminate their population.

1. **Damsel bug:**
   Hosts: Aphids, armyworms, asparagus beetle, Colorado potato beetle eggs and nymphs, corn earworm, cornborer, imported cabbageworm, leafhoppers, mites, moth eggs, sawfly larvae, and tarnished plant bug nymphs. Although they can survive for about two weeks without food, they will eat each other if no other prey is available.
2. **Ground beetle:**
   Hosts: Slugs, snails, cutworms, cabbage root maggots, grubs and insect pupae, and small caterpillars.
3. **Hoverfly:**
   Hosts: Aphids, thrips, psyllids, scale insects, small caterpillars, and larvae of Helicoverpa.
4. **Ladybird beetles:**
   Hosts: Aphids, mealybugs, scale insects, spider mites, whiteflies.
5. **Spider:**
   Moths, caterpillars and any other insects they can catch.
6. **Trichogramma:**
   Trichogramma species parasitize eggs of over 200 species of moth and caterpillars. Among these are; therice and corn stem borer, cabbageworm, tomato hornworm, *Helicoverpa* species, codling moth, cutworm, armyworm, webworm, cabbage looper, fruit worms, and sugarcane borer.

Conclusion & General recommendations:

To make a plan for you to grow a healthy crop, the following tips are to be taken by the farmers:

1. Select the proper cotton variety that is well adapted to your local conditions
2. Always select good and diseased-free seeds
3. Have a healthy soil, but always keep in mind that over-fertilizing isn't necessarily better action.
4. Practice crop rotation by planting on the next cropping season- crops of different family group.
5. If possible practice intercropping to improve the field's diversity and to encourage natural enemies.
6. Planting at proper time
7. Prepare the soil thoroughly by proper tillage
8. Always practice proper field sanitation
9. Monitor your plants regularly

When controlling pests using the plant extracts and other homemade solutions, following are the standard procedures for their preparation and application;

1. Select plant parts that are free from diseases.
2. When storing the plant parts for future usage, make sure that they are properly dried andare stored in an airy container (never use plastic container), away from direct sunlight and moisture. Make sure that they are free from molds before using them.
3. Use utensils for the extract preparation that are not used for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every time after using them.
4. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
5. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.
6. Harvest all the mature and ripe fruits before plant extract application.
7. Always test the plant extract formulation on a few infested plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one.
8. Wear protective clothing while applying the extract.
9. Wash your hands after handling the plant extract.

References:

Organic Cotton Cultivation: K. Vijayalakshmi, Subhashini Sridhar, R. Sridevi and S. Arumugasamy, March 2005 published by Centre for Indian Knowledge System.

Field Guide to Non-chemical Pest Management in Cotton Production: Dr. Jewel Bissdorf published by Pesticide Action Network, Humberg Germany, 2005.

Technical Paper: Organic cotton: An Opportunity for Trade by Peter Ton, consultant on cotton published by International Trade Centre, Geneva 2007.

Table-1: Organic Cotton Production and Trade Worldwide (in tons of fiber; 1990-2006)[15]

Country	1990/91	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	1998/99	1999/00	2000/01	2004	2006
Argentina	-	-	-	-	75	75	-	-	-	-	-	-	-
Australia	n/a	n/a	479	500	750	400	300	300	-	-	-	-	100
Brazil	-	-	-	2	8	1	1	1	3	12	18	20	8
Benin	-	-	-	-	-	-	2	4	15	19	30	80	47
Burkina Faso	-	-	-	-	-	-	-	-	-	-	-	-	61
China	-	-	-	-	-	-	-	-	-	-	-	1,787	1,750
Egypt	-	11	38	140	598	650	630	500	350	200	200	200	240
Greece	-	-	-	-	308	161	128	110	75	50	50	50	-
India	-	-	206	268	393	934	850	1,000	825	1,150	1,000	2,050	6,500
Israel	-	-	-	-	-	50	50	20	140	180	530	380	400
Kenya	-	-	-	-	-	-	-	-	-	-	-	-	6
Kyrgyzstan	-	-	-	-	-	-	-	-	-	-	-	-	60
Mali	-	-	-	-	-	-	-	-	-	-	-	34	160
Mozambique	-	-	-	-	-	-	-	-	-	-	-	-	-
Nicaragua	-	-	-	-	16	20	20	20	-	-	-	-	7
Pakistan	-	-	-	100	75	50	50	50	-	-	-	-	100
Paraguay	-	-	200	685	894	900	600	650	650	500	555	500	75
Peru	-	-	-	-	-	2	11	14	54	122	208	20	750
Senegal	-	-	-	-	-	-	-	-	-	-	-	-	20
South Africa	-	-	-	-	-	-	-	-	-	-	-	-	5
Tanzania, United	-	-				-	-	-	-	-	-	-	
Rep	-	-	-	-	-	8	102	96	111	192	187	368	660
Turkey	5	60	120	198	610	720	850	1,000	1,200	2,000	1,750	2,000	10,000
Uganda	-	-	-	-	22	74	291	455	244	187	287	765	600
United States	n/a	n/a	977	1,938	2,433	3,367	1,540	1,293	1,956	2,916	1,624	1,100	1,500
Zambia	-	-	-	-	-	-	-	-	-	-	-	-	4
Zimbabwe	-	-	-	-	-	-	-	2	5	3	-	-	-
Subtotal	5	71	2,020	3,831	6,182	7,502	5,500	5,569	5,633	7,538	6,443	9,414	23,053

Source: *Elaborated by author, based on a variety of sources.*

[15] The data in this table relate to the volumes of fiber that are estimated to have been treaded as 'certified organic' up to the level of spinning. Most country figures, particularly

Standard Operating Protocols (SOPs) for testing, evaluation, monitoring, approval, release and registration of Genetically Modified (GM) crop varieties in Pakistan with emphasis on Bt Cotton

By

Dr Tassawar Hussain Malik[1]

Pakistan Biosafety Rules, 2005 and National Biosafety Guidelines, 2005 effectively cover the introduction, research and development activities related to the field of agricultural biotechnology. There was found a missing link when a few indigenous biotech crop varieties were developed and were to be released. Standardized Operating Protocols (SOPs) for testing and release of these varieties were urgently needed that were developed by Federal Seed Certification and Registration Department (FSC&RD) on behalf of Ministry of Food, Agriculture & Livestock (MINFAL).

SOPs on testing, evaluation, release, registration, production, certification, commercialization and post release monitoring system of biotech/ genetically modified (GM) crop varieties in Pakistan finally agreed by all the stake holders are stated as under.

1. These SOPs should be taken in complementation to various other plant/seed legislations like Seed Act, Seed Rules, and Plant Breeders Rights etc.

2. Similarly various regional and international agreements like Cartagena Protocols on Biosafety, International treaty on Sanitary & Phytosanitary (SPS) Measures etc. shall also be applicable.

3. The SOPs have been designed for application since a GM crop variety developed by any public or private research institute or seed company is ready for commercial release and registration after it got full confidence of the breeder/originator for commercial release.

4. The SOPs shall be applicable along with various provisions of Pakistan Biosafety Rules/Guidelines, 2005. Research & Development work of genetically modified (GM) crop varieties shall be regulated by these rules/guidelines. "Pakistan Biosafety Rules, 2005" are Federal Government Rules approved as S.R.O. (1)/336(1)/2005 dated 21st April 2005 under Section 31 of Pakistan Environmental Protection Act, 1997. Application of the rules includes manufacture, import and storage of microorganism and gene technological products for research under public or private sector, all work involved in the field trial of genetically manipulated organisms and import, export, sale and purchase of Living Modified Organisms (LMOs, substances or cells and products thereof for commercial purposes.

5. Authorization for commercial release of biotech/GM crop varieties/seeds is desired in accordance with the GM variety/seed regulation.

6. If the produce/grain of biotech varieties is intended for use in food, it also has to be authorized in accordance with the GM food & feed regulation.

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7. Like other traditional crop varieties, registration of genetically modified crop varieties (exot as well as indigenous) shall be mandatory before commercialization in Pakistan. Sub-sectio (b) of section 22(E) of Seed Amendment Act, 2007 states that *"No person shall import, sal stocks or exhibit for sale, barter or otherwise supplies any seed of any variety which is n registered under this act for cultivation in Pakistan"*

8. Section 22(G) of Seed Amendment Bill, 2007 will be followed which states that *"No withstanding anything contained in this Act, no registration of genetically modified plan variety shall be made if the application for registration does not accompany (a) an affidav from the applicant declaring that such variety does not contain any gene or gene sequenc involving terminator technology; and (b) a certificate from the National Biosafety Committe established by the Federal Government to the effect that the genetically modified variet shall have no adverse effect on the environment, human, animal or plant life and health"*

9. Also the variety will be registered only if it meets the criteria as regards Novelty, DU (Distinctness, Uniformity and Stability) test and VCU (Value for Cultivation and Us Variety registration shall be made according to provisions of Seed Registration Rules, 1987.

Three Tires Release Mechanism:

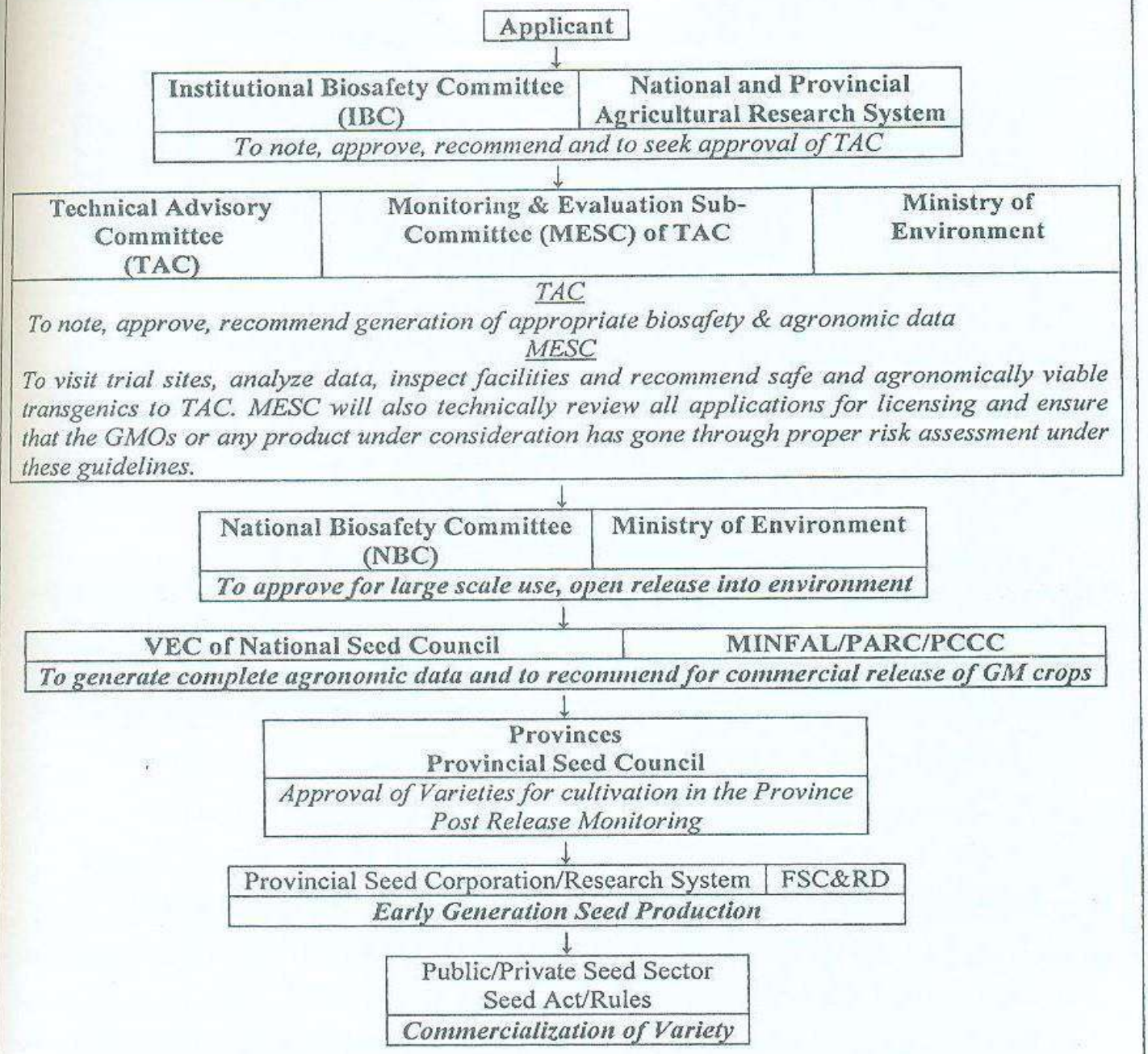
10. Pakistan Biosafety Rules/Guidelines provide three tires for the monitoring a implementation mechanisms for the release of GM crop varieties. These include Institution Biosafety Committee (IBC), Technical Advisory Committee (TAC) and National Biosafe Committee (NBC). Physical location, composition and functions of these committees are explained in the sections 4-9 of Biosafety Rules, 2005 as well as in National Biosafe Guidelines, 2005.

11. Four possible categories of GM crop varieties could be offered for release/registration by t breeder as given in Table 1. SOPs provide a fast track approach to make possible the exped release/registration of transgenic crop varieties. For Category A containing 'notified varieti with known gene' (pre-released, commercialized for more than thee years who Biosafety h already been confirmed) total two years testing will be conducted, one year house/containment trial by TAC while one year large scale Biosafety trials by NBC will mandatory for biosafety clearance. For varieties of Category B & C (candidate varieties w known/tested gene and approved varieties with novel gene, respectively) only one year t by TAC and two years trials by NBC shall be required with a total testing period of th years. For varieties of Category D (new strains with new gene(s)) two years trials by TA and two years trials by NBC shall be required with a total testing period of four years.

Table-1: Four possible types of GM crop varieties:

Category	Official Status of the		Years of Biosafety Trials		
	Variety	Gene/Event	TAC	NBC	Total
A	Notified	Known/Tested	1	1	2
B	Candidate	"	1	2	3
C	Notified	New Gene	1	2	3
D	Candidate	"	2	2	4

Diagram-A. An Outline of procedure for approval of biotech crops in Pakistan



1. Flow Diagram on the recommended Protocol for release/registration of "Known /Tested Gene in Notified Variety"

Institutional Biosafety Committee (IBC)
Concerned Biotech Institute

Preparation/submission of formal application and data to IBC for approval of TAC
Risk assessment of Category I & II (Category III with approval of TAC)

↓

Technical Advisory Committee (TAC)
M.O.Environment
Year 1 (One Year Trial)

Monitoring & Evaluation Sub-Committee (MESC) of TAC
Acceptance of the case, subject to the approval by NBC
Case verification and approval for biosafety studies through Lab & Greenhouse experiments and contained field trials and generation/confirmation of biosafety data
Recommendation to NBC

↓

National Biosafety Committee (NBC)
M.O.Environment
Year 2 (One Year Trial)

1	Generation/Confirmation of Data and Biosafety & Environmental Clearance	NBC
2	VCU Trials by VEC of PCCC for Cotton /PARC for other Crops (Crop-Specific Large Multi-locations Coordinated Field Trials)	PCCC/ PARC
3	Simultaneous Varietal Pre-Registration Trials by FSC&RD	FSC&RD

↓

Recommendation or otherwise of the case by VEC/NBC to Provincial Seed Council

↓

Approval for Commercial Release of the Variety by Provincial Seed Council
Registration of the Variety by FSC of FSC&RD

↓

Notification of Registration of Varieties by Ministry of Food, Agriculture & Livestock

↓

Post Release Multiplication of Variety by IBC to Produce Pre-Basic Seed of Open Pollinated Varieties (OPVs) and Hybrids under supervision of FSC&RD (Year 3)

↓

Basic and Certified Seed Production of OPVs and Hybrid Seed Production by Public/Private Seed Companies
Commercialization of Seed as per the relevant Seed Acts & Rules
(4th & Later)

↓

Post Release Monitoring (TAC/IBC/PrSC) in the subsequent years

2. Flow Diagram on the recommended Protocol for release/registration of
2.1. "Known /Tested Gene in Candidate Variety/Strain"
2.2. "New Gene in a Notified Variety"

Institutional Biosafety Committee (IBC)
Concerned Biotech Institute

Preparation/submission of formal application and data to IBC for approval of TAC
Risk assessment of Category I & II (Category III with approval of TAC)

↓

Technical Advisory Committee (TAC)
M.O.Environment

Year 1 (One Year Trial)

Monitoring & Evaluation Sub-Committee (MESC) of TAC
Acceptance of the case, subject to the approval by NBC
Case verification and approval for biosafety studies through Lab & Greenhouse experiments and contained field trials and generation/confirmation of biosafety data
Recommendation to NBC

↓

National Biosafety Committee (NBC)
M.O.Environment

Year 2&3 (Two Years Trials)

1	Generation/Confirmation of Data and Biosafety & Environmental Clearance	NBC
2	VCU Trials by VEC of PCCC for Cotton /PARC for other Crops (Crop-Specific Large Multi-locations Coordinated Field Trials)	PCCC/ PARC
3	Simultaneous Varietal Pre-Registration Trials by FSC&RD	FSC&RD

↓

Recommendation or otherwise of the case by VEC/NBC to Provincial Seed Council

↓

Approval for Commercial Release of the Variety by Provincial Seed Council
Registration of the Variety by FSC of FSC&RD

↓

Notification of Registration of Varieties by Ministry of Food, Agriculture & Livestock

↓

Post Release Multiplication of Variety by IBC to Produce Pre-Basic Seed of Open Pollinated Varieties (OPVs) and Hybrids under supervision of FSC&RD (Year 4)

↓

Basic and Certified Seed Production of OPVs and Hybrid Seed Production by Public/Private Seed Companies
Commercialization of Seed as per the relevant Seed Acts & Rules
(5th & Later)

↓

Post Release Monitoring (TAC/IBC/PrSC) in the subsequent years

3. Flow Diagram on the recommended Protocol for release/registration of "New Gene in Candidate Variety/Strain"

Institutional Biosafety Committee (IBC)
Concerned Biotech Institute

Preparation/submission of formal application and data to IBC for approval of TAC
Risk assessment of Category I & II (Category III with approval of TAC)

↓

Technical Advisory Committee (TAC)
M.O.Environment

Year 1&2 (Two Years Trials)

Monitoring & Evaluation Sub-Committee (MESC) of TAC
Acceptance of the case, subject to the approval by NBC
Case verification and approval for biosafety studies through Lab & Greenhouse experiments and contained field trials and generation/confirmation of biosafety data
Recommendation to NBC

↓

National Biosafety Committee (NBC)
M.O.Environment

Year 3&4 (Two Years Trials)

1	Generation/Confirmation of Data and Biosafety & Environmental Clearance	NBC
2	VCU Trials by VEC of PCCC for Cotton /PARC for other Crops (Crop-Specific Large Multi-locations Coordinated Field Trials)	PCCC/ PARC
3	Simultaneous Varietal Pre-Registration Trials by FSC&RD	FSC&RD

↓

Recommendation or otherwise of the case by VEC/NBC to Provincial Seed Council

↓

Approval for Commercial Release of the Variety by Provincial Seed Council
Registration of the Variety by FSC of FSC&RD

↓

Notification of Registration of Varieties by Ministry of Food, Agriculture & Livestock

↓

Post Release Multiplication of Variety by IBC to Produce Pre-Basic Seed of Open Pollinated Varieties (OPVs) and Hybrids under supervision of FSC&RD (Year 5)

↓

Basic and Certified Seed Production of OPVs and Hybrid Seed Production by Public/Private Seed Companies
Commercialization of Seed as per the relevant Seed Acts & Rules
(6th & Later)

↓

Post Release Monitoring (TAC/IBC/PrSC) in the subsequent years

Institutional Biosafety Committee (IBC):

12. Genetically modified plants will be approved in Pakistan only if the applicant/IBC presents a detailed biosafety monitoring plan. Should unexpected negative results occur before or after the approval has been granted, they can be detected through systematic monitoring. Depending upon the intended purpose of the GM crop – cultivation, import, feed or food, monitoring can focus on possible environmental effects as well as on compatibility with human and animal health. The monitoring plan will be assessed by the National Biosafety Committee (NBC) of Ministry of Environment and will form part of the approval of each GM plant.

13. Before they can be cultivated on large scale, GM crops are subject to comprehensive safety check. Authorization to cultivate the crop can be given only if no harmful effects can be expected for human health or the environment. Laboratory, green house and release trials will provide an important basis for decision making when it came to the environmental compatibility test.

14. The environmental monitoring programmes for genetically modified plants will be based on General Surveillance and Case Specific Monitoring.

15. The monitoring plan for a particular GM plant must be drawn up and implemented by the applicant/IBC under the supervision of TAC.

16. For small biotech research institutes/stations and private seed companies without an established IBC, the proposals/cases may be forwarded to the NBC through some notified IBC of main biotech research institutes after thorough biosafety testing and preliminary satisfaction of the event/variety.

17. For import of biotech seed of any crop (for testing/commercial purposes) IBC of an institute/company may apply through TAC/NBC to PCCC (cotton)/PARC (other crops) for import and collaborative testing of biotech material. Imported material shall be tested, registered and released in the same way like an indigenous variety. After fulfilling all the formalities VEC will recommend import of the variety to National Seed Council (NSC) of MINFAL which may grant necessary approval for import and commercialization of the biotech varieties. Import shall be subject to local seed production and transfer of technology basis. Furthermore, the seed import shall take policy according to provisions of Seed (Truth-in-Labeling) Rules, 1991 and National Seed Import Policy of FSC&RD/MINFAL.

18. The IBC may apply for specific provision to grant exempt status for laboratory /field work with GM varieties in the light of Chapter 13 of National Biosafety Guidelines, 2005 (NBG) or submit application for commercialization of GM varieties as laid down in the Chapter 12 of NBG.

19. The breeder/IBC will submit the formal application along with requisite data that must include a full evaluation of the environmental risks to IBC. The application shall be accompanied by the yield performance data, valid botanical description of the variety, particulars of the value/trait added to the variety, information about the gene developed by

the biotechnologist and utilized by the breeder and all other information necessary for the case.

20. The (IBC) through his Biosafety Officer (section 10 of Pakistan Biosafety Rules, 2005) will manage to study the risk observation in accordance with Article 15 and Annex III of the Cartagena Protocol as given in the Biosafety guidelines 2005. Risk assessment will include risks of category I and II (Minimal & Low Risk) involving crosses between the species, where donor and recipient are of the same species or donor species is capable of exchanging genetic material with recipient species under natural circumstance and it is not derived from microorganisms which cause diseases in human, plant or animals.

21. The IBC will generate a set of data on various prescribed General Information and Agronomic as well as Biosafety Parameters. Particulars of the subject parameters and their standard operational protocols will be developed in the form of "a formal risk assessment document" by Biosafety Officer (BSO) of IBC with the coordination of TAC, depending upon the nature of host crop.

22. General Information will include rational for development of transgenic crop varieties, description of the host plant, mode of pollination, centers of origin/ diversity of the crop species, geographical distribution of the target crop and sexually compatible plant species including wild relatives etc.

23. Biosafety Parameters will include genetic/molecular parameters, environmental parameters, toxicity parameters like histo-pathological studies and Allergenicity parameters and study to ensure that the gene, plant, seed or food product does not contain any biological threat for man, animals as well as environment.

24. Agronomic Parameters will include efficacy of the gene at phenotypic level, yield levels, growth and development al parameters, response to major diseases and insect pests, quality parameters and economic evaluation/ cost: benefit ratio etc.

25. The IBC will generate data on various prescribed Agronomic/Biosafety Parameters. A set of parameters under study in various countries is given as under;

A. General Information:

- Rational for development of transgenic crop varieties
- Description of the host plant
- Mode of pollination
- Centers of origin/ diversity of the crop species
- Geographical distribution of the target crop and sexually compatible plant species including wild relatives

B. Biosafety Parameters:

a. Genetic/Molecular Parameters:

- Genetic analysis including copy number of inserts
- Stability of the gene
- Level, site(s) and duration of expression of transgene
- Characterization of expressed gene product
- Efficacy/utility of the gene product
- Compositional analysis

b. Environmental Parameters:

- Potential of 'Gene flow' and potential environmental effect from Introgression
- Potential to become a weed of agriculture
- Potential to become invasive of natural habitats
- Impact on biodiversity
- Implication of out crossing
- Effect on target and non-target organisms
- Effect on Soil biota
- Effects on/change in normal cultivation practices
- Any other harm on the environment

c. Toxicity parameter including histo-pathological studies (need based):

Food/feed safety evaluation in animals such as effects on small laboratory animals, effect on livestock animals (representative goat studies on large animals), effect on fish/rabbit etc.

d. Allergenicity Parameters:

- Primary skin irritation test in rabbit
- Irritation to mucous membrane test in rabbit
- Immunological responses in suitable animal system

e. Agronomic Parameters:

- Efficacy of the gene at phenotypic level
- Yield levels
- Growth and development al parameters
- Response to major diseases and insect pests
- Quality parameters
- Economic evaluation/ Cost : benefit ratio

f. Study to ensure that the gene, plant, seed or food product does not contain anybiological threat for man, animals as well as environment.

g. Particulars of the subject parameters and their standard operational protocols will be developed in the form of "a formal risk assessment document" by Biosafety Officer (BSO) of IBC with the coordination of TAC, depending upon the nature of host crop.

26. The (IBC) on the basis of data will give approval of category I and II experiments and in case of Category risk III, seek approval of TAC and submit complete information/data to the Technical Advisory Committee (TAC).

Technical Advisory Committee (TAC):

27. Acceptance of the case by TAC will be subject to the approval by NBC. TAC will deal with case verification and approval for biosafety studies through laboratory & greenhouse experiments and contained field trials and generation/confirmation of biosafety data during first 1-2 years of the trials.

28. The Monitoring & Evaluation Sub-Committee (MESC) of TAC will have the major responsibility to visit trial sites, analyze data, inspect facilities and recommend safe and agronomically viable transgenics to TAC. MESC will also technically review all applications for licensing and ensure that the GMOs or any product under consideration has gone through proper risk assessment under these guidelines.

29. The TAC will perform verification of the case submitted by the IBC with category II &III risk assessment.

30. MESC of TAC must issue an opinion which will take the form of an "assessment report".

31. After submission of a recommendation by TAC, NBC will give the approval of conduct of Agronomic/VCU (Value for Cultivation and Use) trials. These crop-specific large scale multi-locations coordinated field (LSMCF) trials will be carried out by Variety Evaluation Committee (VEC) in collaboration with various stakeholders of federal and provincial governments.

32. Experimental trial specification for large scale multi-locations coordinated field trials is given in Table-1. Information about various plant parameters will be recorded in Yield Data Book including Pest-predator dynamics, Yield and quality data.

33. For Cotton trials will be conducted at seven different ecological locations throughout the country (3 in Punjab + 2 in Sindh + 1 in NWFP + 1 in Balochistan) while for other crops concerned crop coordinators of PCCC/NARC will submit their protocols and procedures.

34. Agronomic/VCU trials will be conducted by PCCC (cotton)/ NARC (other crops), Pre-registration/DUS trials will be conducted by FSC&RD.

35. VCU trials will be conducted by using appropriate plot size, statistical design and experimental layout mentioning the particulars of experimental and non-experimental area, use of non-Bt material as refuge, size of boarders, number of standard varieties,

recommended and special agronomic and plant protection measures etc. as approved by a seasoned statistical expert.

36. Recommendation or otherwise of the case will be submitted by VEC/NBC to Provincial Seed Council that will finally Approve the commercial release of the variety in that particular province.

National Biosafety Committee (NBC):

37. Generation/confirmation of data forwarded by TAC and biosafety and environmental clearance will be issued by NBC of Ministry of Environment.

38. NBC will also network and use the existing expertise of relevant national laboratories and academic institutions/universities as and whenever required.

39. After getting clearance from NBC/VEC, the crop breeder/IBC will submit its proposal to the Provisional Seed Council for grant of Approval of commercial release of the variety/hybrid.

Table-1: Experimental Trial Specifications for Large Scale Multi-locations Coordinated Field Trials

Sr.	Specifications	
1	Crop Season/Year	Kharif/Rabi, 200...
2	Date of Sowing	
3	Date of Harvesting	
4	LST size	
5	Sub-plot size	
6	Plot size	
7	Design	Randomized Complete Block Design (RCBD)
8	Number of replications	3-4
9	Number of rows per plot	6
10	Number of plants per row	Minimum 10
11	Plant to plant spacing (cm)	
12	Row to row spacing (cm)	
13	Space between replication (m)	
14	Number of plants per plot	
15	Row Length (m)	
16	Row width (m)	
17	Space between experimental area and refuge	
18	Plot Length (m)	
19	Plot width (m)	
20	Plot size (Square meters) (LxB)	
21	Bt crop area (Square meters)	
22	Non-Bt crop area	
23	Gross experimental area	
	Specifications on entries	
1	Bt crop varieties	
2	Non-Bt crop varieties	
	Specifications on check	
1	Recently released Bt crop varieties as check (zone wise)	
2	National Check (Non-Bt)	
3	Regional/Zonal Check (ruling non Bt crop variety of the zone)	
	Number of Locations	Total =
1	Punjab	
2	Sindh	
3	NWFP	
4	Balochistan	
5	AJK	
6	FATA/NAs	

Phases of Testing to Release a GM Variety:

Category	Official Status of the		Phases of Trials to Release		
	Variety	Gene/Event	Tseting-I	Testing-II	Testing-III
			TAC	NBC VCU DUS	FSC&RD Production/ Import
A	Notified	Known/Tested	1	2	1
B	Candidate	"	2	2	1
C	Notified	New Gene	2	2	1
D	Candidate	"	2	2	1

Recommendation/ Approval and Release of GM Variety:

40. Breeder will also submit a patent certificate in favour of the gene introduced in the variety from the patent office of Intellectual Property Organization (IPO) of Pakistan.

41. The originator of the variety will also need to submit an NOC from the institute that developed the gene(s) utilized by him in the variety submitted for release and registration.

42. The consent and Agreement of the Breeder/Institute of "Initial Variety" will be submitted to FSC&RD for registration by the breeder using initial variety to get the approval of an "Essentially Derived Variety".

43. VEC of PCCC/PARC will recommend the release of the variety to Provincial Seed Council subject to qualification of the variety through VCU & DUS trials.

44. Provincial Seed Council will make notification of release the varieties in the province subject to recommendations forwarded by VEC of MINFAL, as well as NBC of M.O.Environment.

45. Conditions for release of each specific variety will be issued by NBC and Provincial seed council

Registration and Notification of GM Variety:

46. FSC&RD simultaneous to VCU trials will conduct pre-registration trials under the provision of Seed Registration Rules, 1987 and Amendment Seed Registration Rules 2003.

47. After release from Provincial seed council the breeder is eligible to get his variety registered with Federal Seed Committee (constituted under section 22(I) of the Seed Amendment Act, 2007) of MINFAL.

48. Breeder will submit an application for registration of a variety on prescribed form.

49. Breeder shall submit a DNA fingerprint of the variety to FSC&RD.

50. Breeder shall submit a five years maintenance breeding/multiplication of early generation seed plan, to FSC&RD.

51. Ministry of Agriculture (MINFAL) will register and notify the variety through National Seed Council.

52. First approvals for the release of GM variety shall be limited to a maximum period of ten years.

Seed Multiplication and Commercialization:

53. Post release seed multiplication and commercialization of seeds will be carried out as per the relevant Seed Acts & Rules.

54. After a variety is approved by provincial seed council for general cultivation, next step is to multiply the variety by the breeder(s) in the premises of their institute/station in collaboration with IBC to produce highest quality Breeder-Nucleus Seed (BNS) through single plant selections and further selection from progeny rows and progeny blocks.

55. Under the collaboration of FSC&RD, a reasonable quantity of Pre-Basic Seed will be produced by the breeder for distribution to public sector seed companies for multiplication and production of Basic Seed under the supervision of FSC&RD using the prescribed limitation of generation system and ensuring the following of prescribed procedures of certification and field/seed standards.

56. Pre-basic seed would also be made available to private sector companies approved by FSC&RD for production of basic seed (Seed Amendment Act, 2007).

57. Basic Seed will be offered for multiplication on large scale to the private sector companies for production of Certified Seed according to the prescribed procedures.

58. Pre-mature release of varieties and testing of varieties at private farms shall not be allowed at any level in any case.

59. **Labeling of Biotech/GM Seeds:** Labeling informs the purchaser or user of the GM seed about the biotech nature of the material, hence allowing them to make an informed choice. Generally speaking, for all pre-packed GM seeds require that company indicate boldly on the label "Genetically Modified Seed". Thus GM seeds will be subject to such specific labeling requirements imposed through legislation. Labeling/marking on the bag shall also be ensured to clearly distinguish the transgenic/ biotech seeds from organic and traditional seeds.

60. **Post Release Monitoring:** Post release monitoring of the released GM varieties shall be mandatory including on long term effects associated with the interaction with other GMOs and the environment. Post release monitoring of the transgenic crops may be managed by the IBCs/Provincial Seed Corporation under the supervision of TAC and reports may be sent to NBC for any action, if necessary. Post release monitoring will include aspects like;

- gene flow to wild relatives and non-target crop species
- building up of resistance
- observance of maintenance of refuge and
- other post release requisites.

61. **Co-existence between GM and Organic crops:** 'Co-existence' is about giving farmers the practical choice between conventional, organic and GM crop production in compliance with the legal obligations for labeling and purity standards.

The cultivation of GM crops will have implications for the organization of agricultural productions. Pollen flow between adjacent fields is a natural phenomenon. Because of the labeling requirements of for GM seeds, this may have economic implications for farmers who want to produce traditional organic plants.

Guidelines should be developed in a transparent way, based on technical guidelines and in cooperation with all stakeholders concerned. The guidelines should ensure an equitable balance between the interests of farmers of all production types. Management measures to ensure co-existence should be efficient and cost effective as well as specific to different types of crops. These guidelines containing management measures and strategies concerning co-existence of GM crops with conventional and organic farming should be implemented.

Farmers should be able to choose the production type they prefer, without forcing them to change patterns already established in the area however the farmers who introduce the new production type should bear the responsibility of implementing the actions necessary to limit admixtures.

Continuous monitoring and evaluation and the timely sharing of best practices are indicated as imperative for improving the measures adopted.

62. **Enforcement of Biosafety Regulations:** FSC&RD (Seed Amendment Bill-2007 & other Seed Rules), M.O. Environment (Environment Protection Act, 1997 & Biosafety Rules, 2005) and Agriculture Department of Provincial Governments (Cotton Control Ordinance, 1966, Amended 2002) shall be the stakeholders in enforcement of GM crops/ seeds.

63. FSC&RD through coordination with biotech institutes and other sources will manage identification and detection of GM crop varieties, trait purity analysis etc. to facilitate post market inspection and control.

64. All the new rules/ guidelines introduced will be inline with regional and international agreements including TRIPs of WTO, Cartagena protocol on biosafety of CBD. Rules will be developed and followed regarding storage and transboundary movement of GM crop varieties in order to ensure, on a global scale, the protection of biodiversity and of human health.

65. **Capacity Development and Handling of Crop Biotechnology:** In order to get maximum benefit of this technology, government will ensure the capacity building of its regulatory department and research sector to efficiently handle and manage this technology along with

its full protocol. Public/private sector seed companies dealing with business of biotech products (crop varieties) will also ensure their capacity development for proper handling and commercialization of this technology.

66. **Media Resource Centers:** will be set up by biotech business sector for the safe and responsible use of biotechnology.

67. **Public Awareness:** on matters relating to agricultural biotechnology will be mandatory by biotech companies.

Efficacy of Different Insecticides against American Bollworm *Helicoverpa Armigera* Hubner., and their Impact on Yield

By

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Abstract

Efficacy of five different insecticides viz. Tracer (spinosad), Thiodan (endosulfan), Lorsban (chlorpyrifos), Deltaphos (deltamethrin + trizophos), Cure (abamectin) and Curacron (profenophos) were evaluated against American bollworm Helicoverpa armigera Hubner., on cotton crop during kharif season 2006. Highly significant differences were observed amongst insecticides and had an inadequate degree of control in respect of decreasing larval population and damage of fruiting parts such as squares, flowers and bolls, thus seed cotton yield increased. Tracer was the most effective insecticide in reducing the larval population followed by Deltaphos, Cure, Curacron, Thiodan and Lorsban. Whereas in decreasing damage of fruiting parts, Tracer had also showed best control followed by Cure, Deltaphos, Lorsban and Curacron, whereas Thiodan was found to be the least effective insecticide under this study. Similarly, the maximum seed cotton yield per hectare was also obtained with Tracer, whereas Curacron showed the minimum increase of seed cotton yield per hectare.

Key words: Cotton, American bollworm, insecticides, fruiting parts, damage, seed cotton yield

Introduction

The cotton bollworm, *Helicoverpa armigera* Hubner., generally known as American bollworm, is most serious and a highly polyphagous pest (Zalucki, *et al*, 1986). Marwan (2001) reported that cotton bollworm, *Helicoverpa zea* (Boddie.) and tobacco budworm *Heliothis virescens* (F.) are the key insect pests of cotton in U.S. The estimated cotton crop losses due to *Helicoverpa armigera* Hubner, ranged between 47-90% in India (Fakrudin, *et al*, 2003). Bollworm starts to damage the crop from vegetative growth stage and persists up to boll formation and in severe conditions, its attack remains throughout crop season. Naqvi (1980) reported that critical damage is mostly caused in post monsoon period in the months of August and September.

The use of pesticide was considered as one of the best and efficient control methods to manage this pest but indiscriminate uses and continuous reliance on pesticide, developed pesticide resistance. Allen *et al* (1999) reported that increased resistance to insecticides made the control of insect pests more difficult. American bollworm has developed resistance to all major groups (synthetic pyrethroids, organophosphates, organochlorines and carbamates) of insecticides used against it (Ahmed *et al*, 1999, Kranthi *et al*, 2002, Regupathy *et al*, 2003 and Ramasubramanian and Regupathy, 2004). The constant reliance on pyrethroid insecticides as the major control measures for the *Heliothine* complex resulted in increased levels of resistance in the bollworms (Bagwell *et al*, 1999, Brown *et al*, 1998 and Sparks *et al*, 1993).

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Development of resistance to insecticides has been responsible for inability to manage *Heliothine* pests (Sparks *et al.*, 1993).

To combat the development of resistance in insect pests against pesticides, Bt (*Baccillus thuringiensis*) cotton was introduced, but unfortunately after some period of time the insect pest especially bollworms developed resistance against the Bt cotton. Leonard *et al* (1997) reported that Bt cotton alone had shown to provide excellent mortality on tobacco budworm but is less effective on the American bollworm. Anonymous, (2002) reported that Bt cotton had been effective against tobacco budworm (*Heliothis virescens*) and pink bollworm (*Pectinophora gossypiella*), but less effective in controlling cotton bollworms (*Helicoverpa zea* and *Helicoverpa armigera*). Qayam and Kiran, (2003) reported from India that Monsanto's Bollgard cotton failed to control cotton bollworms.

Recently new insecticides are developed to control the cotton bollworm effectively like Tracer, Intrepid, Denim, and S-1812. Jack *et al* (2001) reported that Tracer, Intrepid, Denim, and S-1812 provided better *Heliothine* control than traditional pyrethroid insecticides. David *et al* (2005) reported that new insecticides, like Thiodicarb. Indoxacarb and spinosad showed better efficacy for the management of *H. armigera* in grain crops. Tracer is a biologically based insect control product with many favorable characteristics. Thompson *et al* (1996 a) reported that the bacterium organism *Saccharopolyspora spinosa*, produces the secondary metabolite spinosad, which is the active ingredient in Tracer. Tracer has a high efficacy on target insects including Heliothine species, while maintaining little effect on beneficial insects (Jack *et al* 2001).

Keeping in view the importance of new insecticide Tracer, the present study was carried out to evaluate the response of Tracer in comparison with other traditional insecticides against American bollworm, *Helicoverpa armigera*.

Materials and Methods

The study was conducted to evaluate the efficacy of new insecticide Tracer with five different insecticides (Table-1) against American bollworm *(H. armigera)* on cotton *Gossypium hirsutum* L. during 2006, at Cotton Research Station Mirpurkhas.

The experiment was laid out into randomized complete block design with six treatments. Each treatment was repeated four times. The variety CRIS-9 was sown on 8th May-2006, at row to row distance of 75 cm and plant to plant distance was 22.5 cm. The plot size was 25 m^2 (4.5 m x 5.4 m). The first spray of insecticides was applied with hand sprayer on 15th July in each treatment and thereafter two more sprays were done at 15 days intervals.

Table-1: Insecticides and their doses applied in the experiment

Insecticides used		Group	Dose ml/ha
Local Name	Common Name		
Thiodan 35 EC	Endosulfan	Organochlorine	2500
Deltaphos 2.5 EC + 40 EC	Deltamethrin + Triazophos	Pyrethroid + Organophosphate	1500
Cure 1.8 EC	Abamectin	Pyrethroid	750
Tracer 480 SC	Spinosad	Naturalyte	200
Lorsban 40 EC	Chlorpyrifos	Organochlorine	2500
Curacron 500 EC	Profenophos	Organophosphate	2500

The data was recorded on five plants, which were randomly selected from each treatment and observations were recorded 24 hours before (as pre-treatment) and after 96 hours, one week and 2 week of each spray. Number of live larvae on squares, flowers and bolls, and damage of fruiting parts were recorded. The reduction percentage of larvae was recorded by counting total number of live larvae before and after spray, and fruiting parts damage percentage was recorded by counting the total number of fruiting parts and damaged by the pest. The observations were calculated according to Henderson and Tilton (Anonymous, 1981) in order to determine the efficacy of insecticides. The seed cotton yield data were recorded at the time of harvest. The data obtained were analyzed statistically and finally means were compared by using Duncan's new Multiple Range Test (Steel and Torrie, 1984)

Results and Discussions

The data collected on the efficacy of new pesticide Tracer in comparison with other traditional pesticides, tested against American bollworm on cotton, was highly significant and is presented in Table-2 and 3, whereas the data of seed cotton yield is presented in Table-4.

(i) Reduction percentage of larval population

The consolidated composite data of all three sprays are shown in Table-2. The results revealed that the new insecticide Tracer was found most effective in controlling the larval pest population among all the insecticides tested at 96 hours, one week and two weeks, followed by Deltaphos, Cure, Curacron, Thiodan and Lorsban. The average minimum larval population was recorded with Tracer (1.26), followed by Deltaphos (1.70), Cure (1.74), Lorsban (1.82), Curacron (1.84), whereas maximum larval population was recorded with Thiodan (1.93). The maximum reduction percentage of larval population 62.82% was recorded with Tracer, followed by Deltaphos (51.70%), Cure (49.86%), Curacron (47.58%) and Thiodan (47.41%), whereas Lorsban resulted in the minimum reduction percentage with 46.94%. It was observed that Tracer gave the best performance to reduce population as compared to other traditional insecticides.

Table-2: Reduction percentage of live larvae of American bollworm with different insecticides at different intervals (Mean of three sprays)

Insecticide used	Number of live larvae / 5Plants					Reduction % age
	Pre-treatment observation	Post-treatment observation recorded at				
		96 hours	One week	two weeks	mean	
Thiodan	3.67	1.21 e	1.87 e	2.72 e	1.93	47.41
Deltaphos	3.52	1.06 b	1.63 b	2.41 b	1.70	51.70
Cure	3.47	1.11 c	1.56 cd	2.56 cd	1.74	49.86
Tracer	3.38	0.93 a	0.52 a	2.32 a	1.26	62.82
Lorsban	3.43	1.37 d	1.55 c	2.54 c	1.82	46.94
Curacron	3.51	1.21 e	1.71 d	2.61 d	1.84	47.58

(ii) Reduction percentage of fruiting parts damage

The consolidated composite results of all three sprays in respect of damage reduction percentage of fruiting parts are presented in Table-3. The results showed that Tracer was most effective amongst all insecticides tested at all intervals (such as 96 hours, one week and two weeks), followed by Curacron, Cure, Deltaphos, Lorsban and Thiodan. The average minimum percentage of damage of fruiting parts was 4.59 recorded with Tracer, followed by Curacron (6.40), Cure (6.50), Deltaphos (6.56) and Lorsban (6.58), whereas the maximum damage of fruiting parts was recorded with Thiodan (6.80). The maximum reduction percentage of damage was recorded with Tracer (57.22%) followed by Cure (40.91%), Deltaphos (40.74%), Lorsban (39.47%) and Curacron (39.05%), whereas the lowest 37.21% reduction in damage was recorded with Thiodan. It was observed that in comparison to all other traditional insecticides tested, maximum reduction in damaged fruiting parts (at all intervals) was recorded from the plots treated with Tracer.

Table-3: Average reduction percentage in fruiting parts damage at different intervals of three sprays with different insecticides

Insecticide used	Damage % age					Reduction % age
	Pre-treatment observation	Post-treatment observation recorded at				
		96 hours	One week	two weeks	mean	
Thiodan	10.83	6.87 e	3.70 f	9.83 e	6.80	37.21
Deltaphos	11.07	6.77 d	3.27 e	9.63 b	6.56	40.74
Cure	11.00	6.67 bc	3.03 bc	9.80 cd	6.50	40.91
Tracer	10.73	4.40 a	2.97 a	6.40 a	4.59	57.22
Lorsban	10.87	6.87 e	3.10 d	9.77 c	6.58	39.47
Curacron	10.50	6.60 b	2.97 b	9.63 b	6.40	39.05

(iii) Seed Cotton Yields

The data regarding seed cotton yield (Table-4) showed highly significant differences among insecticides. Tracer resulted in maximum seed cotton yield (2124 kg/ha) followed by Deltaphos (2100 kg/ha), Cure (2076 kg/ha), Lorsban (2016 kg/ha), Thiodan (1992 kg/ha), whereas the minimum 1924 kg/ha seed cotton yield was obtained from the plot treated with Curacron. It was noted that the maximum seed cotton yield was achieved with the Tracer as compared with other traditional insecticides.

Table-4: Seed Cotton yield obtained from the plots treated with different insecticides against bollworm, *H armigera* Hubner

Insecticide used	Mean Yield data		
	kg/plot	Kg/acre	Kg/ha
Thiodan	4.98 f	806	1992
Deltaphos	5.25 b	850	2100
Cure	5.19 c	840	2076
Tracer	5.31 a	860	2124
Lorsban	5.04 d	816	2016
Curacron	4.81 e	779	1924

Conclusion

It was concluded from present studies that Tracer was most effective against (American bollworm, *H. armigera*) activities and resulted in the maximum reduction of larval population and minimum damage of fruiting parts in comparison to other traditional insecticides application on cotton crop, whereas the seed cotton yield (kg/ha) was also increased with Tracer as compared with other insecticides. The results are in agreement with David *et al*., (2005), Salgado *et al* (1997) and Ruberson and Tillman, (1999) who reported that the insecticide Tracer had a high efficacy on target insects, including *Helicoverpa* spp., Similarly Johnson *et al* (1997) reported Tracer to be effective against pyrethroid-resistant tobacco budworm.

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Genotypic response of Cotton (*Gossypium hirsutum* L) Varieties in respect of Seed Cotton Yield and its Components

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Abstract

A five parent complete diallel mating design was conducted to study the genetic mechanism of yield and yield related traits in cotton (Gossypium hirsutum L.). The graphical representation of variance (Vr) and Co-variance (Wr) suggested over dominance type of gene action for plant height, number of monopodial branches, number of sympodial branches, number of bolls plant[-1], yield of seed cotton, boll weight and seed index .This type of gene action can be explained by developing hybrid varieties because over dominance effects can be fixed in F_1 hybrid. Number of monopodial branches showed additive type of gene action with partial dominance. Such situation can be exploited by direct selection.

KEY WORDS: *Gossypium hirsutum* L.; Over-dominance; additive genes; yield and yield components.

Introduction

Cotton plant, which is called as 6f plant i.e. fiber, Food, fertilizer, fuel, fodder and forage (Arshad *et al* 2004) is considered a white gold of our national economy. Furthermore the immense importance of cotton crop is clear from the fact that when a human come to this world he is gifted with a piece of cloth to hide his tinny body and when he lefts this world he takes a piece of cloth with him in the form of Coffin (Khan 2008). Yield in cotton like other crops is contributed by different components, such as number of bolls, average boll weight, lint percentage, seed index and other components. Genetic information like additive, non –additive and epistasis regarding these traits is necessary approach for their improvement. A vigorous and effective selection criterion is required for evaluating a large number of crosses in self pollinated generation.

Diallel analysis is used for studying the genetic mechanism in gene behaviors (additive dominance or epistasis). This approach has been frequently used to improve certain traits by different scientists i.e. Abbas *et al.* 2008 conducted a research of 5X5 full diallel cross including five cotton varieties and studied the characteristics i.e. monopodial branches, number of sympodial branches, boll weight, and yield of seed cotton, lint percentage, staple length, fibre fineness and fibre strength. All the characters showed considerable genetic variations among the genotypes and the data for all the characters were partially fit for additive dominance genetic model because all the characters showed additive type of gene effects with partial dominance.

Azhar and Rana (1993a) analyzed a 4x4 diallel cross experiment to have genetic information on various morphological and economic characters. Their results indicated that characters like plant height, bolls plant^{-1} and staple length were controlled by additive type of gene action while boll weight and ginning out turn %age were controlled by over dominance type of gene action. Haq and Khan

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(1993) conducted a 4x4 diallel cross to study genetic analysis of plant height, number of bolls, boll weight, seed cotton yield and ginning percentage Additive gene action with partial dominance appeared to control the plant height, whereas over dominance gene action was noted for number of bolls plant^{-1}, boll weight, seed cotton yield and ginning outrun percentage. Iqbal *et al.* (2003) and Nadeem and Azhar (2004) revealed additive type of gene action with partial dominance, whilst Bertini *et al.* (2001) and Subhan *et al.* (2003) reported the presence of genes showing over-dominance for number of monopodial and sympodial branches plant^{-1}. May and Green (1994) noted that additive genetic effects were operated for yield plant^{-1}, number of boll plant^{-1}, boll weight lint percentage, staple length, lint index and seed index, while non-additive genetic effects were observed for plant height. Saeed *et al.* (1996) made intra-specific crosses in a diallel fashion to study the gene action for main stem height, number of bolls plant^{-1}, lint percentage and seed cotton yield. They reported that all the characters were controlled by additive type of gene action. Amin *et al.* (1997) observed additive gene action for plant height, number of monopodial branches and boll weight while over dominance type of gene action for seed cotton yield plant^{-1} and number of bolls plant^{-1} in a complete diallel analysis involving four genotypes. Kumaresan *et al.* (1999) conducted a 6x6 diallel analysis in order to study combining ability and the nature of gene action for four quantitative characters i.e.; plant height, boll weight, number of seeds boll^{-1} and seed cotton yield. Both additive and non additive gene effects were reported for these traits.

Keeping in view the above mentioned facts, the diallel study in cotton was performed to identify potential parents for hybridization and recombinants selection.

Materials and Methods

Five parents of cotton (*Gossypium hirsutum* L.) were selected from the gene pool maintained at the Breeding and Genetics Section of Central Cotton Research Institute Multan Pakistan, on the basis of differences in their phenotypic characteristics. Experimental material comprised of a complete diallel set of crosses among five cultivars of cotton viz: RH-362, VH-137, Cocker-CQ, B-598 and Karishma. Parents were grown in a glass house under controlled weather and environmental conditions e.g. temperature in the greenhouse was maintained with in the range of 60°F to 90°F by using steam-electric heaters. All possible crosses including self, reciprocal among parents at flowering time were made by hand emasculation. At the time of flowering the following measures were taken to avoid contamination of genetic material at the time of crossing. Maximum number of pollinations was made to produce sufficient number of F_0 seed.

Some of the buds were covered with butter paper bags to obtain selfed seed. The F_1 population was grown together in a field during June 2001 in a randomized complete block design with three replications. The seed of 20 F_1 hybrids and five parents was planted in a single rows with plants spaced at a distance of 30cm with row to row distance of 75 cm., and thus there were 12 plants in each row. At maturity ten plants were selected from each genotype and the data pertaining to plant height, number of monopodial and sympodial branches, number of bolls plant^{-1}, boll weight, seed index and yield of seed cotton was recorded. Analysis of variance was conducted according to Steel & Torrie (1984) methodology, whereas genetic analysis was made according to the method outlined by Hayman (1954) and Jinks (1955).

Results and Discussion

Differences among genotypes were highly significant (Table I), which allowed us to use Hayman-Jinks model for diallel analysis of the data. Before analyzing the data the adequacy of the simple additive dominance model was performed to verify the fulfillment of the assumptions underlying the model. For this purpose, both the scaling tests, i.e. analysis of regression coefficient (b) and analysis of variance results for (Wr+Vr) and (Wr-Vr) were carried out and results are presented in (Table II).

Results of two scaling tests suggested that data were adequate for plant height, number of monopodial branches, boll weight, seed index while partially adequate for number of sympodial branches, of yield of seedcotton, and inadequate for number of bolls plant^{-1} . The partial failure of the additive dominance model may be attributed due to the failure of any of the diallel pre-requisites like presence of non- allelic interaction, linkage and non-independent distribution of the genes among the parents. The variance and covariance values were used to construct V_r/W_r graph (Fig: 1-6), for characters showing adequacy of the additive dominance model. The results obtained for each character are as under.

Plant height

The analysis of variance revealed that genotypes, parents and crosses showed highly significant differences while parents vs. crosses showed significant differences (Table I). The regression line ($b= 0.993 \pm 3.10$) for plant height differed significantly from zero ($P\leq0.01$) and non-significantly from unity ($P\geq0.05$), whereas the differences ($P\leq0.01$) between arrays (W_r+V_r) and within the arrays (W_r-V_r) significant and non-significant respectively, indicating the presence and dominance and absence of epistasis, respectively (Table II). The results of these tests suggested that model was fully adequate; (Fig. 1) indicating the over dominance type of gene action governing the character under study. The distribution of array point on regression line revealed that VH-137 and Karishma possessed maximum dominant genes being closest to the origin whereas cocker-CQ had maximum recessive genes being farthest from the origin. Variety Karishma showed maximum array mean (89.05) and seemed to be the best general combiner for plant height. The best specific combining ability of this variety was exhibited in combination with RH-362 (Table III).

Azhar and Rana (1993), Haq and Khan (1993), Shah *et al.* (1993), Murtaza *et al.* (1995), Saeed *et al.* (1996) and Amin *et al.* (1997) obtained additive type of gene action with partial dominance in plant height whereas Rehman and Khan (1993) observed over dominance type of gene action for this trait. The differences in the results might be attributed to the differences in gene frequencies in the experimental material and the environmental conditions of the experiments.

Number of monopodial branches

Analysis of variance indicated highly significant differences among various genotypes, with in the parents, F_1 hybrids and between parents and crosses for number of monopodial braches per plant^{-1} (Table I).

The regression coefficient (b= 0.099±0.194) for monopodial branches differed significantly from zero (P≤0.01) and non-significantly from unity (P≥0.05) whereas significant differences (P≤0.01) between the arrays (W_r+V_r) and non-significant differences within the arrays (W_r-V_r) were observed (Table 2). The tests suggested that model was fully adequate for genetic analysis according to additive dominance model (Table II).Significant difference for (W_r+V_r) and non-significant ones for (W_r-V_r) indicated the presence of dominance and absence of epistasis, respectively (Table II).The graphical presentation (Fig 2) showed that the regression line intercepted the W_r – axis above the origin revealing partial dominance with additive type of gene action. The distribution of array points on regression indicated that RH-362 and Karishma possessed maximum dominant gene being the closest to the origin while VH-137 had maximum recessive genes being farthest from the origin. The variety VH-137 showed maximum array mean (3.24) and turned up to be the best general combiner for number of monopodial branches (Table 4). The best specific combining ability was observed for this variety in combination with RH-362 (Table II). The best specific combining ability was observed of this variety in combination with RH-362. The present results of additive partial dominance, type of gene action controlling the number of monopodial branches plant^{-1} are partially in accordance with Abbas *et al.* (2008), Iqbal *et al.* (2003) and Nadeem and Azhar (2004), Shah *et al.* (1993), Rauf *et al.* (1994), and Khan *et al.*(1995) who also reported additive type of gene action. In another study Bertini *et al.* (2001) and Subhan *et al.* (2003), Khan and Khan (1993), Shah *et al.* (1993), Murtaza *et al.* (1995), Saeed *et al.* (1996), Amin *et al.* (1997) reported over dominance type of gene action.

Number of sympodial branches

Analysis of variance for number of sympodial branches revealed highly significant differences for all components of variation (Table I).The regression line (b= 0.94±0.295) deviated significantly from zero (P≤0.01) but non-significantly from unity (P≥0.05), whereas the differences in arrays of both (W_r+V_r) and (W_r-V_r) were significant (P≤.0.01). The tests suggested that model was partially adequate for genetic analysis of sympodial branches.

Significant (P≤0.01) difference in arrays of both (W_r+V_r) and (W_r-V_r), showed presence of dominance and epitasis (Table II).The regression line intercepted the W_r –axis below the origin revealing over dominant type of gene action as reported earlier by Ahmad *et al.* (2000), Bertini *et al.* (2001) and Subhan *et al.* (2003) but in contrast with research work of Abbas *et al.* (2008), and Iqbal *et al.* (2003) and Nadeem and Azhar (2004), due to the difference of the genetic materials they used in their research program. The distribution of array point on regression line showed that the variety RH-362 possessed maximum dominant gene being closest to the origin while the variety B-598 had maximum recessive genes being farthest from the origin. Variety B-598 showed maximum array mean (17.58) and seemed to be the best general combiner for number of sympodial branches (Table 5). The best specific combining ability of this variety was exhibited with Karishma. (Table V).

Number of bolls plant^{-1}

Analysis of variance showed highly significant differences for number of bolls plant^{-1} (Table I) for all components of variation The joint regression analysis of the data on number of bolls plant^{-1} showed that regression line (b= 1.29±0.62) did not deviate statistically from zero, and was also not significantly different from unit slope making the model inadequate for genetic analysis. Significant differences with in the arrays of (W_r+V_r) and (W_r-V_r) were found (Table II).This indicated that dominance coupled with epistasis was governed predominant expression of number of bolls plant

[1].These results collaborates the findings of, Haq and Khan (1993), Murtaza *et al.* (1995), and Shakeel *et al.* (2001).

Boll weight

Analysis of variance showed significant ($P \leq 0.01$) differences among all the components of variation in case of boll weight (Table I).The joint regression analysis for boll weight, showed that regression line (0.977±0.31) significantly deviated from zero ($P \leq 0.01$) and non-significantly from unity ($P \geq 0.05$).This indicated the absence of non-allelic interaction (Table II). Significant differences between arrays ($P \leq 0.01$) (W_r+V_r) and non-significant differences ($P \geq 0.05$) with in arrays (W_r-V_r) showed presence of dominance and absence of epistasis, respectively (Table II). Thus the results of these two tests suggested that the simple additive dominance model was fully adequate for boll weight.

Regression line (Fig.6) intercepted the W_r – axis below the origin showing over dominance type of gene action. These results are in agreement with the research work of Bertini *et al.* (2001) and Subhan *et al.* (2003), Shah *et al.* (1993), and Murtaza *et al.* (1995), who reported over dominance type of gene action governing the expression of boll weight, but in contrast with research work of Abbas *et al.* (2008), Iqbal *et al.* (2003) and Nadeem and Azhar (2004) due to the difference of the genetic materials they used in their research program. The position of the array point along the regression line make it obvious that the variety Karishma and RH-362 have maximum number of dominant genes and VH–137 the minimum dominant genes being in vicinity and away from origin. The highest array mean of variety B-598 (3.95) proved that this variety was the best general combiner and its cross with VH-137 (3.94333) was the best specific combination for boll weight trait (Table VII).

Seed index

Highly significant variation was observed among the genotypes, parents and F_1 hybrids, while parents *vs.* crosses showed non significant differences (Table I). The data was fit for additive dominance model as the regression line deviated significantly from zero but not from unity and the differences between arrays (Wr+Vr) were significantly while within arrays (Wr-Vr) were not significant (Table II) . Graph of V_r/W_r shown in fig 7 revealed that regression line b intercepted the W_r–axis below the origin, indicating the over dominance type of gene action. The highest array means (Table VIII) of variety RH–362 (9.38) proved that this variety was the best general combiner and its cross with B–598 (10.5) was the best specific combination for seed index trait (Table 8). The distribution of arrays point indicated that VH-137 and Karishma was located near the origin and B-598 farthest from the origin indicating the presence of maximum number of dominant genes in B-598 for seed index (Fig 7). Regression coefficient b intercepted the W_r – axis below the origin (Fig7), thus indicating the over dominance type of gene action. Regression line was of unit slope and deviated significantly from zero to b (1.25 ± 0.28). These results are in agreement with Sayal and Suleman (1996), who reported over dominance type of gene action governing the expression of seed index.

Seed-Cotton yield

Analysis of variance indicated highly significant differences among genotype, parents, and F1 progenies and between parents vs. crosses for yield of seed cotton plant[-1] (Table I). Value of b (0.98±0.25) deviated significantly from zero ($P \leq 0.01$) and non-significantly from unity ($P \geq 0.05$) whereas the differences between arrays of both (W_r+V_r) and (W_r-V_r) were significant ($P \leq 0.01$) which suggested that model was partially adequate for genetic analysis of yield of seedcotton (Table2).The

graph of Vr/Wr (Fig.5) showed that regression line intercepted the W_r – axis below the origin revealing over dominance type of gene action. Epistasis was absent as the regression line did not deviate significantly from unit slope. The results are in agreement with the finding of Haq and Khan *(1993),* Iqbal *et al* (2003) and Nadeem and Azhar (2004), Murtaza et al. (1995), Shah *et al.* (1993), Subhan et al. (2002) and Murtaza et al. (2002),Rauf *et al.* (1994), Saeed *et al.* (1996), who reported additive type of gene action while in contrast with research work of Bertini *et al.* (2001) and Subhan *et al.* (2003. Cocker- CQ possessed the maximum dominant gene while B-598 had the maximum recessive genes due to their nearest and distant position from the origin respectively. The examination of data indicated that the variety cocker-CQ scoring the maximum array mean (132.5043) proved to be the best general combiner and it made best combination with RH-362 (182.5833) mean for this character (Table IX).

In crux, data reported here provided valuable informations about genetic mechanism of quantitative characters of different cotton varieties and their cross combinations. The results of genetic analysis showed that plant height, sympodial branches, yield of seed cotton, boll weight and seed index were governed by over dominance. This type of gene action can be utilized by the breeders to develop hybrid varieties because over dominance effects can only be fixed in F_1 hybrid. Additive type of gene action with partial dominance was observed in case of monopodial branches which can be exploited by direct selection. For further improvement in yield, more different type of variation is needed because the genotypes studied here did not truly represent a random sample of all cotton germplasm. Inferences drawn from the present data apply only to five parental lines and their hybrids. The informations derived here are limited and uncertain for whole germplasm of cotton. It is suggested that to get complete comprehensive and sound information, experiment on large number of genotypes are imperative.

Table I: Analysis of variance for different traits in five cotton varieties

Characters	Mean Squares					
	Replications	Genotypes	Parents	Crosses	Parents Vs Crosses	Error
	(DF = 2)	(DF = 24)	(DF = 4)	(DF = 19)	(DF = 1)	(DF = 48)
Plant height	47 ^{NS}	250.06**	540.10**	200.04**	10.10*	455.64
Number of Monopodial branches	0.22**	0.57**	1.84**	0.25**	1.37**	0.038
Number of sympodial branches	180 ^{NS}	33.91**	25.61**	27.27**	1794.05**	1.07
Number of bolls plant^{-1}	2.70 ^{NS}	171.84**	257.80**	130.58**	611.90**	7.13
yield of seed cotton	22.54 ^{NS}	4767.20**	2227.32**	3643.50**	36277.12**	10.20
Boll weight	0.06*	0.31**	0.13**	0.13**	1.05**	0.02
Seed index	0.22 ^{NS}	2.12**	2.40**	2.20**	0.01 ^{NS}	0.87

Table II: Scaling tests to show the validity of additive-dominance model for various traits in cotton

Sr.#	Characters	Regression analysis			Analysis of Wr+Vr and Wr-Vr		
		b	b_0	b_1	Wr+Vr	Wr-Vr	Adequacy
1	Plant height	0.993±0.31	3.20 *	0.022^{NS}	28196.81**	2118.09^{NS}	Adequate
2	Number of monopodial branches	0.99± 0.194	5.09 **	0.057^{NS}	0.33 **	0.008^{NS}	Adequate
3	Number of sympodial branches	0.94±0.295	3.19*	0.201^{NS}	477.09 **	31.63 *	Partially Adequate
4	Number of bolls per plant	1.29± 0.62	2.10 ^{NS}	0.201 ^{NS}	11760.68 * *	2220.41*	Inadequate
5	Yield of seed cotton.	0.98± 0.25	3.87 *	- 0.481 ^{NS}	5717153* *	270319.1 **	Partially adequate
6	Boll weight	0.977 ± 0.31	3.19 *	0.075 ^{NS}	0.01 *	0.001 ^{NS}	Adequate
7	Seed index	1.25 ± 0.28	4.55 *	-0.917 ^{NS}	1.36 *	0.07 ^{NS}	Adequate

* *Significant* ** *Highly-significant* ^{NS} *Non-Significant*

Adequate characters = 9 In-adequate characters = 1 partially adequate = 5

Table III: Mean array table of parents and F_1 hybrids for plant height in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	71.43	77.67	91.33	75.99	94.35	410.73	71.43
VH-137	77.67	90.38	80.67	86.05	91.9	426.66	90.38
Cocker-CQ	91.33	80.67	99.6	68.54	85	425.14	99.6
B-598	75.95	86.05	68.54	66.93	90.53	388	66.93
Karishma	94.35	91.9	85.0	90.53	83.47	445.25	83.47
Totals	410.73	426.66	425.14	388.00	445.25	2095.78	411.81
Means	82.15	85.33	85.03	77.60	89.05	419.16	82.36
Vars	101.67	37.41	135.77	109.31	21.51	405.68	180.03
Co-vars	87.17	10.01	100.43	27.10	-33.49	191.22	

Table IV: Mean array table of parents and F_1 hybrids for monopodial branches in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	3.2	3.03	3.13	2.5	3.23	15.1	3.2
VH-137	3.03	4.44	2.93	2.96	2.83	16.2	4.44
Cocker-CQ	3.13	2.93	2.4	2.43	2.46	13.36	2.4
B-598	2.5	2.96	2.43	2.66	3.03	13.6	2.66
Karishma	3.23	2.83	2.46	3.03	3.26	14.83	3.26
Totals	15.1	16.2	13.36	13.6	14.83	73.1	15.97
Means	3.02	3.24	2.67	2.72	2.96	14.6	3.19
Vars=	0.09	0.45	0.11	0.073111	0.1	0.83	0.61
Co-vars=	0.05	0.46	0.16	0.146133	0.05	0.002	

Table V: Mean array table of parents and F_1 hybrids for sympodial branches in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	12.14	16.23	19.66	19.66	15.86	83.57	12.14
VH-137	16.23	14.33	20.46	21.56	13.3	85.9	14.33
Cocker-CQ	19.66	20.46	16.2	17.16	12.86	86.36	16.2
B-598	19.66	21.56	17.16	9.4	20.1	87.9	9.4
Karishma	15.86	13.3	12.86	20.1	16.26	78.4	16.26
Totals	8357667	85.9	86.36	87.9	78.4	422.14	68.34
Means	16.71	17.18	17.27	17.58	15.68	84.42	16.66
Vars=	9.81	13.52	9.12	23.42	8.37	64.26	8.53
Co-vars=	-0.16	-5.2	-3.8	9.97	-6.58	-5.82	

Table VI: Mean array table of parents and F_1 hybrids for boll number plant in cotton^{-1}

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	20.26	36.13	38.44	34.5	30.13	159.47	20.26
VH-137	36.13	29.89	42.56	40.78	26.81	176.19	29.89
Cocker-CQ	38.44	42.56	29.13	28.33	21.6	160.07	29.13
B-598	34.5	40.78	28.33	14.4	36.16	154.18	14.4
Karishma	30.13	26.815	21.6	36.16	38.33	153.04	38.33
Totals	159.47	176.19	160.07	154.18	153.04	802.96	132.03
Means	31.89	35.23	32.01	30.83	30.6	160.59	26.4
Vars=	51.49	46.17	70.74	104.28	46.58	319.28	85.92
Co-vars=	12.92	42.78	-22.62	66.57	-2.36	11.72	

Table VII: Mean array table of parents and F_1 hybrids for boll weight in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	2.93	2.95	3.135	3.01	3.67	15.71	2.93
VH-137	2.95	3.33	3.31	3.94	3.15	16.7	3.33
Cocker-CQ	3.13	3.31	2.83	3.69	3.6	16.58	2.83
B-598	3.01	3.94	3.69	3.23	3.47	17.35	3.23
Karishma	3.67	3.15	3.6	3.47	3.17	17.08	3.17
Totals	15.71	16.70	16.58	17.35	17.08	83.43	15.5
Means	3.14	3.34	3.316	3.17	3.416	16.68	3.1
Vars=	0.09	0.13	0.12	0.13	0.057	0.54	0.04
Co-vars=	0.004	0.03	0.05	0.02	-0.04	0.07	

Table VIII: Mean array table of parents and F_1 hybrids for seed index in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	9.86	8.85	8.01	10.5	9.68	46.91	9.86
VH-137	8.85	7.99	7.73	8.12	9.2	41.91	7.99
Cocker-CQ	8.01	7.73	8.65	8.93	9.62	42.95	8.65
B-598	10.5	8.12	8.93	9.92	8.48	45.97	9.92
Karishma	9.68	9.2	9.62	8.48	8.31	45.29	8.31
Totals	46.91	41.91	42.95	45.97	45.29	223.05	44.74
Means	9.38	8.38	8.59	9.19	9.05	44.61	8.94
Vars=	0.93	0.38	0.56	0.99	0.4	3.27	0.79
Co-vars=	0.56	0.05	-0.011	0.86	0.04	1.51	

Table IX: Mean array table of parents and F_1 hybrids for yield of seedcotton in cotton

	RH-362	VH-137	Cocker-CQ	B-598	Karishma	Totals	Parents
RH-362	52.1	106.53	182.58	110.77	125.41	577.41	52.1
VH-137	106.53	98.06	141.8	171.34	77.55	595.3	98.06
Cocker-CQ	182.58	141.8	100.46	90.48	147.19	662.52	100.46
B-598	110.77	171.34	90.48	43.25	167.33	583.18	43.25
Karishma	125.41	77.55	147.19	167.33	91.71	609.2	91.71
Totals	577.41	595.3	662.52	583.18	609.20	3027.62	385.59
Means	115.48	119.06	132.50	116.63	121.84	605.52	77.11
Vars	2180.18	1392.75	1400.67	2916.64	1398.48	9288.74	742.43
Co-vars	817.27	-493.03	-42.11	976.93	-601.51	657.53	

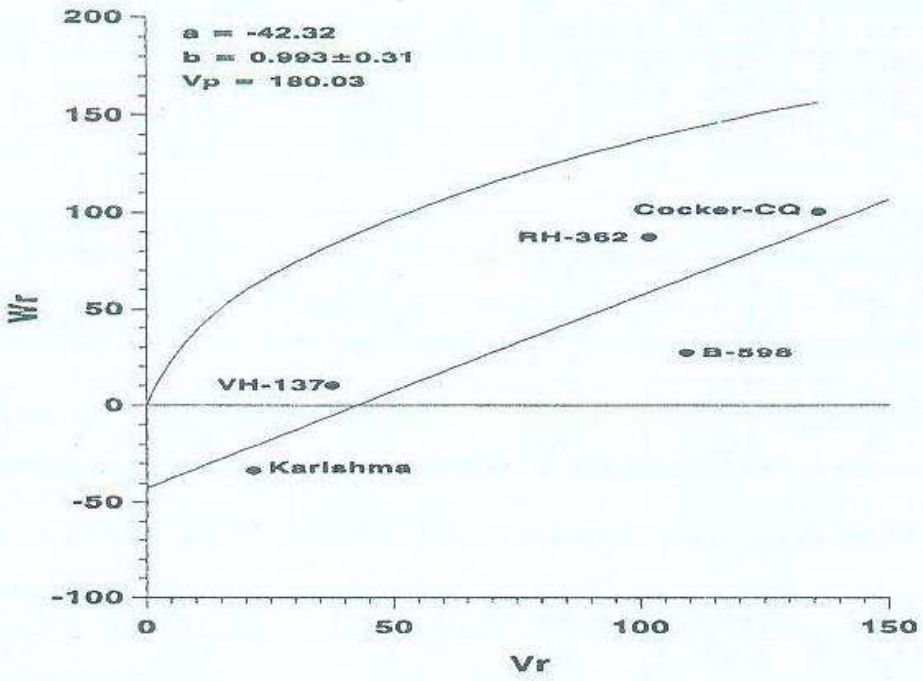

Fig.1 : Vr/Wr graph for plant height.

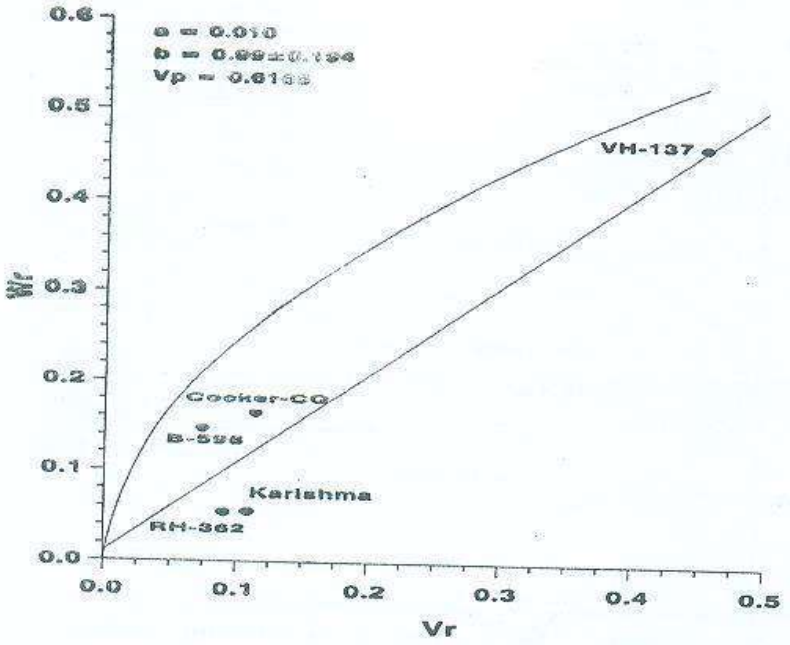

Fig.2 : Vr/Wr graph for monopodial bramches.

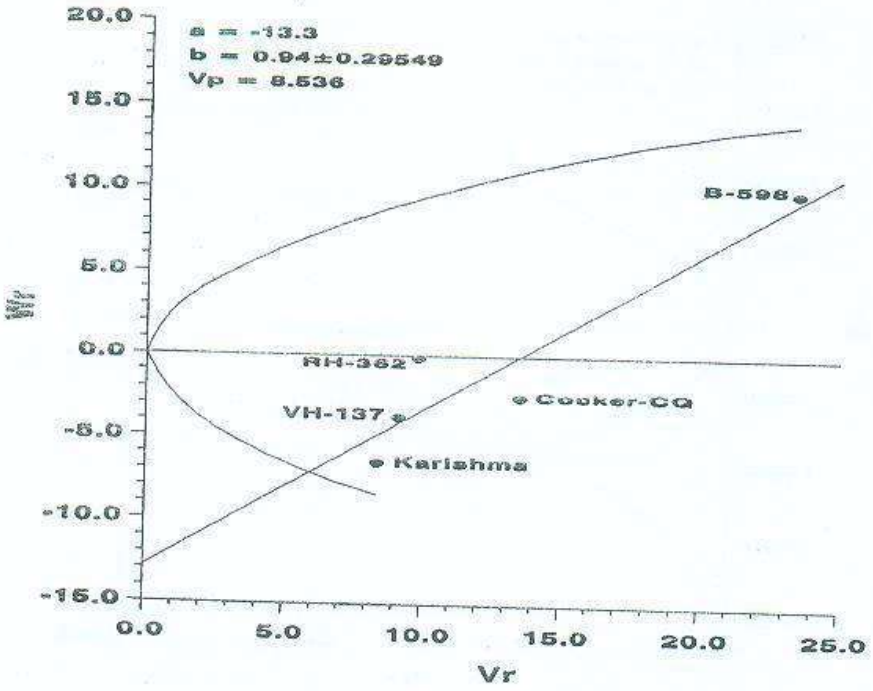

Fig.3 : Vr/Wr graph for Sympopdial branches.

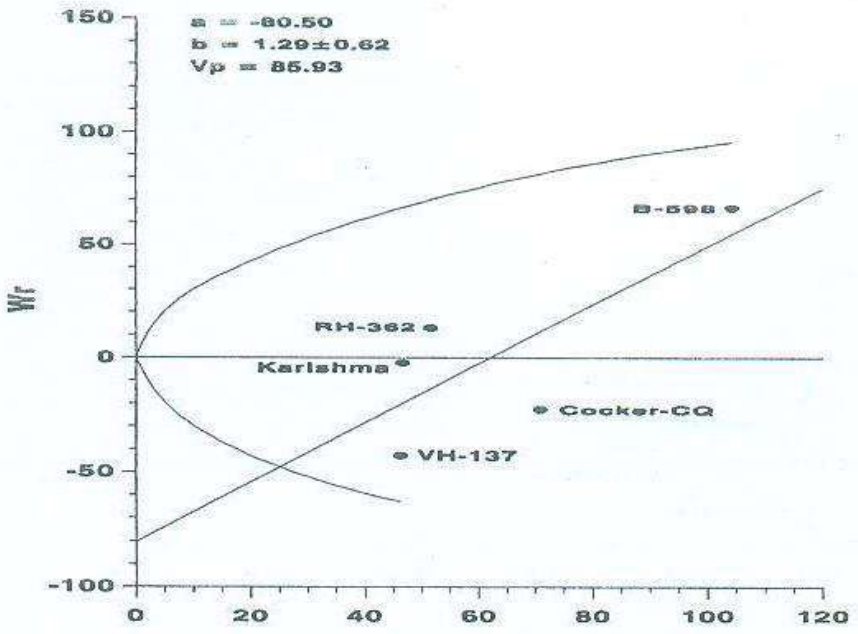

Fig.4 : Vr/Wr graph for boll number per plant.

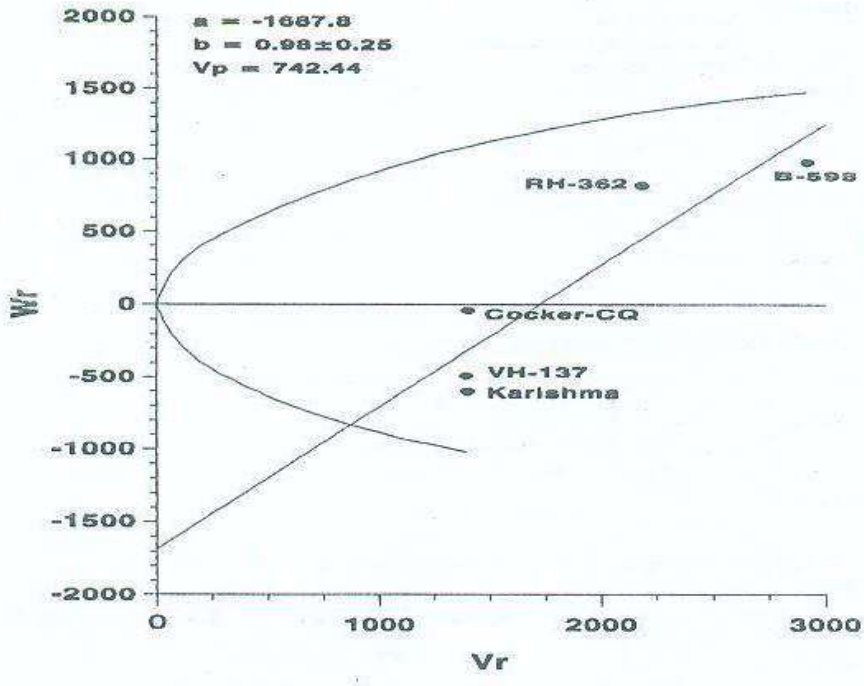

Fig.5 : Vr/Wr graph for yield of seed cotton.

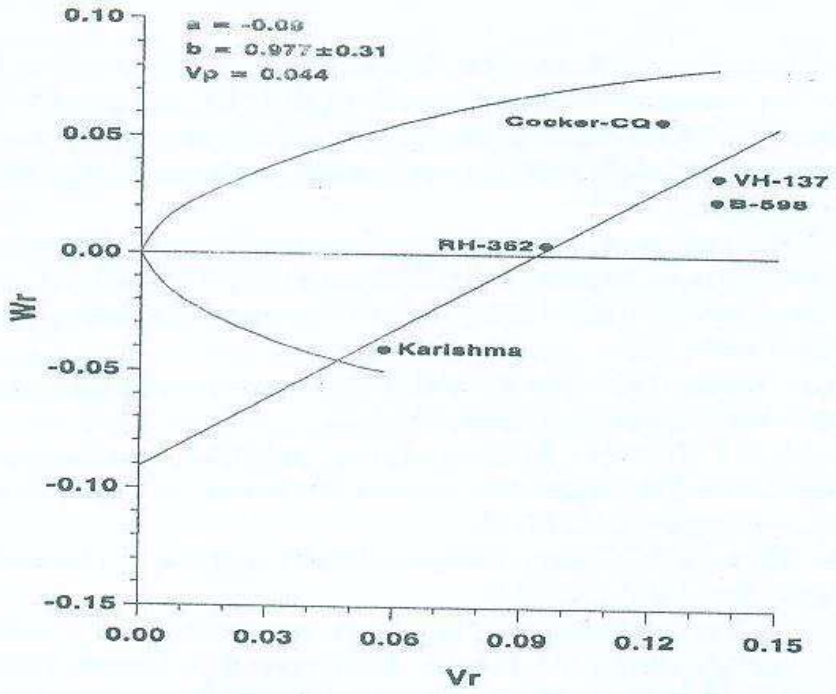

Fig.6 : Vr/Wr graph for boll weight.

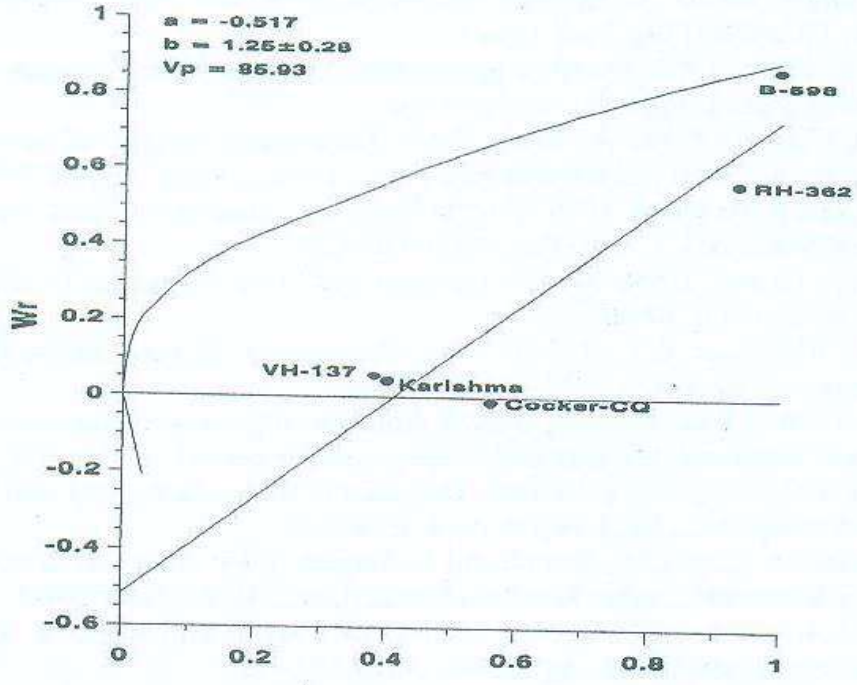

Fig.7 : Vr/Wr graph for seed index.

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Statement by the Pakistan Delegation to the 69th Plenary Meeting of International Cotton Advisory Committee held at Lubbock, Texas, USA, September 20-25, 2010 - *Country Report*

By

Ch, Muhammad Arshad [1]

1. Cotton Production Potential

Cotton crop is the lifeline of Pakistan's economy as it accounts for more than 60 percent of export earnings and about 85 percent of domestic oil production. It is an occupation of more than 1.5 million farming families and a source of livelihood for several million of labour in the cities and towns. In cotton growing areas, the sale of cotton produce may account as much as 40% of cash income of rural household.

On a global basis Pakistan is the fourth largest cotton producing country of the world after China, India and USA. Pakistan's share of total world cotton production in 2004/2005 stood at 9.47 percent (Cotton Statistical Bulletin, 2006). Pakistan is 3rd largest consumer with 10 percent of world production, 3rd largest yarn producer with 9 percent, 2nd largest yarn exporter with 26 percent, 3rd largest cloth producer with 7 percent and 3rd largest cloth exporter with 14 percent of world cotton production (ICAC, 2005).

Cotton crop is mainly grown in Punjab and Sindh provinces in Pakistan contributing 81 and 17 percent in cotton production respectively. Rest of the production comes from Khyber Pakhtoon Khawah (KPK) and Balochistan province. Apart from the main cotton growing areas in the Punjab province, Balochistan has emerged as potential area for cotton production and it has been identified as most suitable area for organic cotton cultivation as well. There exists much possibility to enhance cotton production fulfilling the future needs of the domestic textile sector as well as for export purposes. The government is, therefore, determined to accelerate the cotton research and development process necessarily required to accelerate cotton production as well as the qualitative improvement matching the spinners' requirements. Accordingly, the Ministry of Food and Agriculture (MINFA) has prepared a long term Cotton Vision for sustained growth in cotton production and the possible improvement in the quality of raw cotton with following envisaged targets by 2015:

1. Cotton Production	:	20.70 Million Bales
2. Cotton Yield / hectare	:	1,060 kgs
3. Mill Consumption of Cotton	:	20.10 Million Bales
4. Exportable Cotton Surplus	:	0.60 Million Bales*
5. Improved Yarn Recovery Rate through clean / contamination free cotton production	:	92 %(from current average of 84%).

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1.1 Area (000 ha)

The province-wise cotton area (000 hectare) is tabulated as under:

Year	Province				Pakistan
	Punjab	Sindh	Balochistan	KPK	
2000-01	2386	523	17.3	0.2	2929
2001-02	2561	523	40.4	1.6	3114
2002-03	2156	542	40.8	1.9	2751
2003-04	2387	561	39.1	2.0	2994
2004-05	2550	610	37.1	2.1	3210
2005-06	2430	620	37.8	2.1	3100
2006-07	2460	570	40.0	2.0	3072
2007-08	2400	590	40.0	5.0	3035
2008-09	2248	526	37.5	1.0	2812

Source: Agricultural Statistics of Pakistan

1.2 Average Yield (kg per hectare)

The province-wise average lint yield (Kg per hectare) is tabulated as under:

Year	Province				Pakistan
	Punjab	Sindh	Balochistan	KPK	
2000-01	613	715	495	340	627
2001-02	558	780	502	436	595
2002-03	599	753	543	412	626
2003-04	549	680	426	425	571
2004-05	767	836	432	421	773
2005-06	717	727	439	421	713
2006-07	726	716	382	425	719
2007-08	630	797	425	340	653
2008-09	696	937	453	340	732

Source: Agricultural Statistics of Pakistan

1.3 Average Lint Production (000 Metric tons)

The province-wise average lint production (000 metric tons) is tabulated as under:

Year	Province				Pakistan
	Punjab	Sindh	Balochistan	KPK	
2000-01	1462.59	374.15	8.57	0.07	1836.73
2001-02	1428.57	408.16	20.29	0.70	1853.74
2002-03	1292.52	408.16	22.14	0.78	1723.30
2003-04	1309.86	381.46	16.65	0.85	1711.05
2004-05	1955.78	510.20	16.04	0.88	2482.99
2005-06	1743.20	450.68	16.62	0.88	2210.88
2006-07	1785.71	408.16	15.31	1.70	2210.88
2007-08	1513.61	510.20	17.01	1.70	1981.29
2008-09	1564.63	493.20	17.01	1.70	2057.82

1 bale = 170 kgs

Source: Agricultural Statistics of Pakistan

1.4 Average Lint Export / Import per Year (000 Metric tons)

Year	Lint Exports (000 metric tons	Lint Imports (000 metric tons)
2000-01	120.75	113.95
2001-02	45.58	183.67
2002-03	44.22	193.54
2003-04	37.07	393.20
2004-05	119.73	382.48
2005-06	59.86	293.88
2006-07	47.28	502.04
2007-08	58.50	850.85

Source: Federal Bureau of Statistics, Government of Pakistan

1.5 Number of Cotton Research Institutes and Stations

a) Cotton Research Institutes

1. Central Cotton Research Institute, Multan, Punjab
2. Central Cotton Research Institute, Sakrand, Sindh
3. National Institute of Biotechnology & Genetic Engineering (NIBGE), Faisalabad, Punjab
4. Nuclear Institute of Agriculture & Biology (NIAB), Faisalabad, Punjab
5. Nuclear Institute of Agriculture (NIA), Tandojam, Sindh
6. National Institute of Genomics & Advanced Biotechnology (NIGAB), Islamabad
7. Cotton Research Institute, Ayub Agriculture Research Institute, Faisalabad
8. National Center of Excellence in Molecular Biology (CEMB), University of the Punjab, Lahore

b) Cotton Research Stations

1. Cotton Research Station, Multan, Punjab
2. Cotton Research Station, Rahim Yar Khan, Punjab
3. Cotton Research Station, Vehari, Punjab
4. Cotton Research Station, Bahawalpur, Punjab
5. Cotton Research Station, Sahiwal, Punjab
6. Cotton Research Station, Ghotki, Sindh
7. Cotton Research Station, Tandojam, Sindh
8. Cotton Research Station, Mirpur Khas, Sindh
9. Cotton Research Station, Sibbi, Balochistan
10. Cotton Research Station, D.I. Khan, NWFP
11. Cotton Research Sub-Station, Kot Shutta, D.G. Khan, Punjab
12. Cotton Research Sub-Station, Jhang, Punjab
13. Cotton Research Sub-Station, Raiwand, Lahore, Punjab

2. Technical Structure of Research Institute

Central Cotton Research Institute (CCRI), Multan, Pakistan was established in 1970 by Pakistan Central Cotton Committee under the administrative control of Ministry of Food &Agriculture, Government of Pakistan. This is a multidisciplinary institute comprising of ten research disciplines, i.e., (i) Agronomy, (ii) Plant Breeding & Genetics, (iii) Cytogenetics, (iv) Entomology, (v) Fiber Technology, (vi) Plant Pathology, (vii) Plant Physiology/Chemistry, (viii) Statistics (ix) Transfer of Technology (x) Marketing & Economic Research. In addition to these departments, (xi) Biotechnology Lab (xii) Virology Lab, (xiii) Mass Rearing Bio Factory, (xiv) Toxicology Lab, (xv) Agronomic Lab and (xvi) Technology Transfer Center, have also been added to the technical structure of the Institute. All these disciplines are working with integrated coordinated approach in cotton research, development and production. The Institute is well-equipped with Research Laboratories (16 labs), Greenhouses (02 numbers), Library, Experimental Farm (110 acres), automatic meteorological observatory, ginnery (8, 10, 20, 40 saws), farm machinery, stores, hostel (06 beds 02 suits), and other necessary facilities to carry out research work.

2.1 Experimental Area of Institute

The Institute is having a total of 115 acres (47 hectare). Out of which, 90 acres (37 hectares) are kept for experimental purpose and the rest 25 acres (10 hectares) are under roads, buildings and laboratories.

2.2 Number of Cotton Researchers

Sr. No.	Department / Section	Degrees		
		BSc	MSc	PhD
1.	Agronomy	-	4	1
2.	Plant Breeding & Genetics	-	6	-
3.	Cyto-genetics	1	3	-
4.	Entomology	-	7	1
5.	Plant Pathology	-	5	-
6.	Plant Physiology / Chemistry	-	2	2
7.	Transfer of Technology	-	4	-
8.	Fibre Technology	1	2	-
9.	Statistics	-	1	-
10.	Marketing & Economic Research	-	2	-
	Total	2	36*	4

** Out of 36 MSc scientists, 10 are enrolled for the PhD programme and will be completing research by the year 2010.*

2.3 Cotton Breeding Section

2.3.1 Main subjects in cotton breeding

Following main subjects in cotton breeding are being practiced.

a) Seed cotton yield

Seed cotton yield is our main objective with special emphasis upon number of bolls plant^{-1}, boll weight, locks boll^{-1} and percentage of lint.

b) **Fibre quality**
The most important fibre quality parameters enforced by Govt. of Punjab are (i) fibre length above 28mm, (ii) lint percentage more than 37.5 and above (iii) Fineness 3.8-4.9 ug/inch (iv) fibre strength 92 and above (tppsi) (v) uniformity ratio 48% (vi) fibre maturity 80%.

c) **Earliness**
Generally early maturing cultivars/varieties are selected and sown to vacant land for wheat sowing.

d) **Drought tolerance**
Due to shortage of canal water for irrigation in Pakistan emphasis is laid upon development of drought resistant/tolerant varieties using upland cotton as well as wild *Gossypium* species which are perennial xerophytic shrubs indigenous to desert area.

e) **Heat tolerance**
High temperatures become harsh for cotton crop in summer season as a consequence of which fruit shedding results and yield decreases. To avoid yield decrease heat tolerant varieties are being developed.

f) **Salt tolerance**
Due to salinity problem, the cultivated land is becoming baron. Salt tolerant varieties are in pipe lines.

g) **Diseases resistance**
Major disease is cotton leaf curl virus (Burawala strain of cotton virus) which is a serious threat to economy of Pakistan. Efforts are being made to develop virus resistant genotypes transferring disease resistant genes from wild species into upland cotton.

h) **Insect resistance**
Hairy varieties have been evolved which tolerate jassid.

i) **Male sterility (CMS/GMS)**
The GMS lines are utilized for production of commercial cotton hybrid seed.

j) **Inter-specific hybridization**
To transfer the desirable characters of the wild species into cultivated species inter-specific hybridization is conducted.

k) **Polyploidy**
Most of the wild species and two cultivated species are diploid (2n =26 chromosomes) and cultivated upland cotton is tetraploid (2n =52 chromosomes). When upland cotton and wild species are crossed there is a triploid which is sterile, to make it fertile polyploidy is induced.

2.3.2 Breeding techniques

a) **Introduction**
It is the direct adoption of native/developed germ plasm from elsewhere. At present the exotic material is generally smooth leaved, susceptible to virus, high temperature and stunting, it is used only for crossing purposes.

b) **Selection**
It is the process of planned improvement in the performance of specific cultivars for certain traits through conscious choice.

c) **Hybridization**
It is crossing between two genetically different parents for the sake of creating variability for the purpose of obtaining genotypes with trans-gressive performance. It includes single cross, double cross, three-way cross and back cross.

d) **Pedigree selection/progeny row selection**
The hybrid population in the F2 generation is subjected to the selection of single plants which are grown in individual rows in the F3 generation. The best performing in the F3 generation are selected. Such a procedure is repeated for 3-4 generation until the material is homozygous.

e) **Testing and approval of a variety**
The homozygous selected material (strains) is tested in micro Varietal and Varietal trials; then passed through National Coordinated Varietal Trial (NCVT) and Provincial Coordinated Cotton Trial (PCCT) to be approved as a variety.

2.3.3 **Genetic stock situation**

i) Cultivated: About 2000 genotypes. Genotypes with special morphological traits such as pubescence, glaberous, glandless, high gossypol, nectariless, frego bract and okra leaf are also available.
ii) Wild: About 31 *Gossypium* species.

a) **Yield potential**

3000-5000 kg / ha

b) **Suitable genotypes for machinery harvest**

No genotype is suitable for machinery harvest

c) **Genotypes for abiotic stresses**

i) Drought tolerant:
Cyto 87, CIM-1100, MNH-554, CIM-534, CIM-496, NIBGE-2, MNH-786, CRIS-134, Marvi

ii) Heat tolerant:
Cyto 85, Cyto 94 CIM-70, CIM-240, CIM-132, CIM-534, NIAB-111, CIM-506, BH-160, NIAB-999, CIM-473, MNH-786, NIBGE-2, MNH-901, CRIS-134, CRIS-121, CRIS-342, Sindh-1, Chandi, Haridost, Sadoori, Sohni

d) **Genotypes for resistant to diseases or insects**

i) Disease tolerant (Virus): Cyto hybrids, NIBG-2, CIM-557, MNH-786, MNH-2007, CRIS-467
ii) Insects tolerant (Jassid): CIM-534, CIM-496, CIM-473, CIM-446, NIBGE-2, MNH-786, CRIS-134, CRIS-342

e) **High lint quality genotypes**

i)	G.O.T. (%)	:	37.5-48.5
ii)	Staple length (mm)	:	27.5-32.2
iii)	Fineness ug/inch.	:	4.2-4.8
iv)	Strength (tppsi)	:	90.5-101.0

f) Early maturity genotypes

CIM-534, CIM-496, MNH-786, NIAB-111, NIAB-99, BH-160, FH-901, FH-1000, CIM-506, CRIS-134, CRIS-342

g) Natural color cotton genotypes

i) Cultivated : 2
ii) Wild : 25

2.3.4 Situation / Status of using Biotechnology on cotton and carry on projects

At present two local institutions viz., Centre of Excellence in Molecular Biology (CEMB) and National Institute of Biotechnology & Genetic Engineering (NIBGE) are working on biotechnology on cotton and these organizations have developed their own biotech genes for effective insect resistance in the cotton plant. CEMB has evolved two biotech cotton genotypes viz., CEMB-1 and CEMB-2 which are in National Coordinated Varietal Trial. The material of NIBGE is in greenhouse stage. According to an agreement made between Ministry of Food & Agriculture (MINFA), Govt. of Pakistan and Monsanto Projects on development of biotech cotton will be soon carried on at other institutes dealing with cotton production.

2.3.5 Situation of Transgenic cotton productions and policy

Three local seed companies i.e. Auriga, Agri Farm and Guard have recently made agreements with M/s Biocentury who will transform a few selected local varieties in China. The transformed varieties will be tested in Pakistan. According to policy approval for marketing of biotech seed is to be sought from Regulatory Authorities which are Institutional Biosafety Committee (IBC), Technical Advisory Committee (TAC) and National Biosafety Committee (NBC).

2.3.6 Country policies for import and export breeding seeds

For utilization of *Gossypium* germplasm in hybridization, limited quantity of seed (500 gms in case of cultivated cottons and about 50 seed of wild species) can be imported in coordination with Pakistan Central Cotton Committee, Karachi or exported with the permission of Plant Quarantine Department, MINFA, Islamabad according to country policy after fulfilling the requirements of the said department.

2.4 Cotton Agronomy Section

2.4.1 Meteorological data of Cotton Production periods:

The normal sowing period of the area where maximum cotton is produced starts from beginning May to onward depending upon the land available after wheat harvesting.

2.4.2 Fertilization techniques

Fertilizer is one of the single most effective inputs to achieve optimum seed cotton yield. Since the cost of fertilizer is very high as compared to other inputs, it is quite imperative not only to make judicious use but also to make them more effective and economical.

a) Nitrogen: The cotton crop is grown on different soil with pH value above 8. Among the major nutrients, nitrogen requirement is higher as compared to other nutrients. The amount of

nitrogen need depends upon the soil and its previous cropping history. Generally 150 kg nitrogen per hectare is applied in cotton where excessive growth and late maturity are not a problem. On bottom soil or sites where excessive growth is problem 100 kg nitrogen per hectare or less is considered.

b) Phosphorous: The amount of phosphorus in cotton plant is low compared to levels of nitrogen but its fertilization is important to cotton production. Generally, 50 kg P2O5 per hectare is advocated and after wheat crop where recommended dose of P2O5 is given, cotton can be grown on residual phosphorus.

c) Potassium: It is not uncommon to see potash deficient plants. Therefore, soil tests are necessary to determine the need of potash in cotton. However, without soil test, 50 kg K2O per hectare can be applied.

Among the micro-nutrients, Boron and Zinc are seldom used. However, foliar fertilization of Boron and Zinc is gaining popularity in the cotton growing areas of the country. Foliar fertilization is particularly important where soil condition like pH and calcareousness adversely affect the availability of the nutritients. In Pakistan, cotton growing areas the pH is generally above 8 and soils are calcareous therefore the need of Boron and Zinc is being felt. The farmers use both these nutrients as foliar.

2.4.3 Irrigation techniques

Water regulates plant growth and development. Excessive irrigation and water stress both adversely affect the cotton productivity. Water is becoming the most precious input in crop production. Canal and tube well irrigation systems are used in the country for cotton production. The irrigation water is applied through flood irrigation technique or through bed-furrow. In case of flood irrigation more water is required as compared to bed-furrow. For making bed-furrow special implements are needed which are not still common with every farmer. Therefore, flood irrigation is still dominant. Any how, some farmers are using bed-furrow irrigation.

2.4.4 Soil tillage techniques

In major cotton growing areas, the cotton comes after wheat crop. Therefore, after wheat harvesting, the land is prepared with cultivator or disc harrow as preparatory tillage. Afterwards in flat planting system, the soaking dose for seed bed preparation is applied and when it comes to workable conditions, the land is prepared with cultivator and planker. In bed-furrow planting system, the bed-furrow are prepared for sowing.

2.4.5 Planting techniques

All cotton is planted in rows 75 cm apart. Two methods of planting are in use: Planting by drill in flat soil after seed bed preparation and manual planting on bed-furrows.

i) Flat planting: In this method, after soaking irrigation, the seed bed is prepared at workable condition with tractor tynes and planked with planker. Sowing is done with tractor drill with delinted cotton seed.

ii) Bed-furrow planting: The land is prepared and bed-furrow are made with bed-furrow implement. Cotton seed are dibbled manually after or before irrigation at a required plant-plant distance. After about 72 hours irrigation is applied to achieve germination of all seeds. The second irrigation is given with a view to soak the un-soaked area with first irrigation when the seed is dibbled.

2.4.6 Harvest techniques

All cotton is hand picked. Manual picking is slow but better preserves fibre characteristics of cotton. The farmers with small land holding pick cotton frequently after the first boll is opened whereas the other only pick hardly two times due to short of pickers. Still there is no mechanical picking in the country at farmers' level.

2.4.7 Rotations

In main cotton growing areas, the most dominant rotation is cotton-wheat-cotton. About 70 percent cotton is planted after wheat harvesting. The rest of the rotations are cotton-fallow-cotton, cotton-green manuring-cotton, cotton-maize-cotton, cotton-sunflower-cotton etc.

2.4.8 Seed preparation (using acid delinted seed)

The success or failure of any crop primarily depends upon the seed quality. The quality includes seed vigour, free from seed borne diseases, healthy seedling production, approved variety etc. Fuzz is removed with commercial sulphuric acid at 4 litre acid for 40 kg seed, dried and bagged for sowing. In some cases, it is treated with insecticide against sucking insects.

2.5 Lint Technology Section

2.5.1 Parameters of lint quality

The lint quality characters in Pakistani cotton are as under:

Staple Length (mm)	Fibre Strength (000 lbs inch^{-2})	Maturity Index (%)	Micronaire (µg inch^{-1})	Uniformity Index (%)	RD	+b
27.2 ~ 32.5	92.0 ~ 103.7	78 ~ 81 & Above	4.2 ~ 5.2	81 ~ 87	75 ~ 80	8 ~ 12

2.5.2 Situation of standardization

Pakistan cotton is inherently of good quality. However, improper handling, poor ginning practices, absence of quality control measures and high degree of contamination as well as non-existence of a marketing mechanism based on premia and discounts lead to depreciation of the value of raw cotton and the textile products. Being cognizant of these problems, the government had launched a project in mid-eighties for improvement in cotton quality through standardization of cotton to bring it at par with the international standards. The purpose of the project was to improve the competitiveness of Pakistan's raw cotton and to ensure better returns to cotton growers, ginners, spinners, exporters and to increase foreign exchange earnings for the country. After completion of the project in December 1994, an institution, Pakistan Cotton Standards Institute was established. In order to ensure qualitative improvement in cotton production and marketing, the government has thus undertaken the following measures:

- Cotton Standardization Ordinance, 2002 has been promulgated.
- Cotton Standards Institute has been established.
- National Cotton Grades have been developed and approved.

- Intervention price of seed cotton being fixed on grade basis.
- Karachi Cotton Association has now been issuing spot rates on grade and staple basis.
- Contamination free cotton production programs were launched with visible success.
- HVI equipped fibre testing labs in major cotton growing districts are being set up.
- Provincial Governments have amended the Cotton Control Act to eliminate contamination problem.

With the above measures taken by the government, the benefits of the cotton standardization and grading system in the form of better grades and contamination free cotton at the grass root level are expected soon in view of the general realization among all the stakeholders that under the post quota regime the quality would rule the market.

2.5.3 Situation of contamination

In Pakistan although cotton is hand picked yet it is contaminated with different types of non-lint contents (NLC). Contamination mainly occurred during transportation of seedcotton from farmers' fields to the ginning factories through different stages. The contamination of leaf trash, burs, pieces of cotton sticks and grasses etc; takes place at the farmers' field during picking. Most of the small farmers sell their produce to the middle men/agents of ginning factories. At this stage other contaminations like human hair, poultry feather, pieces of biscuits packets, toffee wrappers, threads and pieces of polythene bags are added due to careless handling,. Pieces of jute thread were major source of contamination which get mixed in seed cotton when jute bags are cut open in the ginning factories. However, during the last five years, government has taken various measures to improve the cotton quality. For this purpose, Clean Cotton programme was being launched by the government in various selected cotton growing districts. Pakistan Cotton Standards Institute (PCSI) also developed grades for seedcotton and lint. Now, the Clean Cotton programme is implemented throughout cotton growing districts.

2.5.4 Number of quality laboratory in the country

Pakistan Cotton Standards Institute (PCSI) has set up 10 fibre testing labs throughout the country dully equipped with High Volume Instrument (HVI). This has helped in testing, evaluation and monitoring cotton fibre quality. Moreover, Pakistan Central Cotton Committee (PCCC) has also set up two quality laboratories at Karachi and Multan for the purpose. Similarly, Synthetic Fibre Development & Application Center (SFDAC), Karachi, Textile Institute of Pakistan (TIP), University of Agriculture, Faisalabad, National Textile University, Faisalabad, Nuclear Institute of Agriculture & Biology (NIAB), Faisalabad, National Institute of Biotechnology & Genetic Engineering (NIBGE), Faisalabad and many private sector have also set up quality labs for fibre testing and analysis.

2.5.5 Ginning and stock situation in the country

A rapid growth in ginning industry was witnessed in the cotton growing areas of Pakistan after independence in 1947. Most of the industry is in the hands of local traders who have upgraded their enterprise from commission agent operations or cotton intermediary trading by installing saw gins. By the nature of ginning activity, it is more entrepreneurial trading than a processing activity, since the ginner has to play with the market risks of lint and cotton seed prices. There are 1,221 ginning factories in Pakistan. The ginning industry operates in 80-120 saws type. However, the majority of ginning factories have saw gins of 90 saw blades type. The production capacity of ginning industry in Pakistan ranges from 12 million bales to 35 million bales.

2.6 Plant Protection Section

2.6.1 Main cotton diseases and protection techniques

Cotton diseases are taking a toll of the crop every year in Pakistan. The major diseases of this crop in Pakistan are leaf curl (virus transmitted by whiteflies), stunting (cause yet not known), boll rot (caused by various primary and secondary pathogens), bacterial blight (incited by *Xanthomonas campestris* pv. *malvacearum*), and root rot (caused by *Rhizoctonia solani*) while minor diseases enlisted in this country area seedling rot (various pathogens associated with seed or already present in the soil), anthracnose *Collectotrichum capsici* and *C. gossypii*), alternaria leaf spot *(Alternaria macrospera* and other species), cercospora leaf spot (*Cercospera gossypina*), myrothecium leaf spot (*Myrothecium roridum*), choanephora wet rot (*Choanephora cucurbitarum*) and the diseases caused by nematodes.

a) Leaf Curl Virus

Cotton leaf curl is a viral disease associated with whitefly transmitted Gemini virus. In Pakistan, the disease was first noticed in the late sixties but because of its casual appearance, it remained confined to the local areas. After 1988 the cotton area affected by cotton leaf curl virus increased year after year in almost geometrical progression. Due to the disease more than 7.2 million bales have been lost during the last decade. This disease causes upward curling of leaves. Veins of the leaves become thickened which are more pronounced on the under side. Vein thickening is seen common under our field conditions. It is characterized by small green bead-like thickening on the young leaves. These irregular thickening gradually extends and coalesces to form a continuous reticulation of the small veins. In extreme, but not infrequent cases, formation of the cup shaped or leaf laminar outgrowth called "enation" appears on the underside of the leaf. The affected plants give fewer yields due to reduced number of bolls and boll weight. Fibre qualities especially staple length is also reduced.

Alternate hosts are also known to play a significant role in spreading this virus to cotton crop as well as they provide inoculum to the vector for transmitting to cotton. So far more than hundreds plant have been found hosts for whitefly. Out of these plants some of the important hosts of cotton leaf curl virus are okra (*Hibiscus esculentus*), China rose (*H. rosa-sinensis*), Sunkukra (*H. cannabinus*), Saklai (*H. titiaceus*) and Poinsettia etc. that have been confirmed as the hosts of cotton leaf curl virus. Melons, Tobacco, Tomatoes, Black nightshade, Datura, Sasamum and Chilies are carry the symptoms similar to cotton leaf curl virus.

Resistance varieties should be planted. Fallow the recommended production technology given by the breeders. It is always advisable to plant more than one variety as to create greater barrier. Inter-cropping of cotton in orchards may be avoided. Weeds in and around cotton fields may be removed. The seed treatment with systemic insecticide will help to control whitefly. The crop may also be protected from other sucking pests as well. Normal practices of fertilizer, irrigation and plant protection may be followed.

b) Stunting

This disease is of common occurrence in the early planted exotic varieties. Many fungi were isolated from stunted plants but these fungi could not reproduce the disease. Stunting may express its effects from seed germination to boll formation. The seed from the stunted plant has low germination capacity and reduced vigour.

The stunting condition is expressed in the plants within one to eight weeks of germination. The cotyledonary and true leaves turn downward and hang parallel to the main stem. No sign of yellowing or wilting is seen and often the leaves look to be normal. The upper leaves at a later stage are bronze

colored, whilst stem and petiole become dark red at the time of the manifestation of the symptoms as against the dark green of the healthy plants. The internodes of the main stem and lateral branches become shortened, leaves are reduced and bolls and other parts remain small. The color of the vascular system of the plant remained unchanged, which is in contrast to many wilt diseases. Some of the affected seedling may die during the hot summer days but majority of them continue to struggle on in the same condition. No new growth from the lower nodes is initiated. The plants, which apparently do not display early symptoms of stunting, may grow normally and vigorously for sometime and then suddenly become affected. This may be physiological disorder, expressing its effects under specific environmental condition.

In order to avoid the problem, June sowing is best for this purpose and will save the crop from the disease attack.

c) Boll Rot

Boll rot of cotton is world-wide in its distribution and the disease takes heavy toll of the crop during hot and humid days of the crop season. The problem of boll rot has become very serious in Pakistan due to planting of bushy and broad leave varieties. Many organisms have been reported to be associated with boll rot.

Boll rots are more sever where cotton makes rank growth and rains are frequent during the period of boll development and opening. Losses due to boll rots may also occur where excessive irrigation water is applied late in the season along with higher doses of fertilizer. These factors make the crop more conducive for the attack of the disease. Consequently, boll rot problem is increasing in importance throughout the cotton belt in general and in humid areas in particular.

Due to the number of organisms causing boll rots, the symptoms very considerably. In some instances discolored, sunken areas develop on the boll surface. In others external symptoms may be inconspicuous but complete destruction of seed and fibre occurs. Often infected bolls will open with the locks partially fluffed and stained. In many cases, the no fluffed and; stained fibre is knocked to the ground. This stained and non-fluffed fibre when ginned, results in lower and spotted fibre grades.

Control of the disease is accomplished by avoiding practices that promote rank growth especially excessive use of nitrogenous fertilizers. Correct timing and control of irrigation is also helpful. The last irrigation should not be applied later than first week of October in the Punjab and probably mid of September in Sindh. Effective control of late season insects is also necessary to minimize the losses. Mixing fungicide (Benlate @ 250 g per acre) with compatible insecticides to spray the crop is very effective in the control of this disease. Keeping cotton crop free of weeds will also help in reducing the chances of boll rot. Growing short stature varieties as compared to late, bushy and tall ones will also minimize the chances of boll rot attack.

2.6.2 Main cotton insects and protection techniques

Cotton crop is attacked by a large number of insect and mite pests. These are divided into two major groups of sucking and bollworms.

Sucking insect pests

The major sucking insect pests are thrips (*Thrips tabaci*), whitefly (*Bemisia tabaci*), jassid (*Amrasca devastans*), and two spotted mites (*Tetranychus urticae*). Cotton mealy bug (*Phenacoccus solani*) was also detected in Pakistan in 2005. From 2007, onwards it is regarded one of the major causes in

decline of cotton production. These sucking insect pests suck the cell sap of the plant, reducing its vitality and adversely affect the fruiting capacity of the cotton plant.

Bollworms

The major bollworm insects are spotted bollworms (*Earias insulana, Earias vittella*), pinkbollworm (*Pectinophora gossypiella*) and American bollworm (*Helicoverpa armigera*) and armyworms (*Spodoptera litura & Spodoptera exigua*). The bollworms damage the bolls by affecting the quality and quantity of the produce considerably. The armyworm is sporadic work which damage the leaves as well as fruit buds.

Economic threshold level and Plant Protection

The economic threshold levels of different pests at which insecticide sprays are being applied arerecommended as under:

Insect	Level
Jassid	1-2 insect/leaf
Whitefly	4-5 insects/leaf
Thrips	8-10 insects/leaf
Spider mites/Aphids	10-15/leaf
Heliothis armigera	5 larvae or 5 brown eggs/25 plants
Spotted bollworm	3 larvae/25 plants.
Pink bollworm	5% damage

Name of chemicals used for the control of insect pests of cotton

Sucking pests: Thrips (*Thrips tabaci*), whitefly (*Bemisia tabaci*), jassid (*Amrasca devastans*)	Imidacloprid, Thiamethoxam, Acetamiprid, Diafenthiuron
Bollworms: Spotted bollworms (*Earias insulana, Earias vittella*), pinkbollworm (*Pectinophora gossypiella*), American bollworm (*Helicoverpa armigera*) and armyworms (*Spodoptera litura & Spodoptera exigua*)	Spinosad, Emamectin Benzoate, Abamectin, Chlorpyrifos, Chlorfenapyr, Indoxacarb, Profenofos, Thiodicarb, Bifenthrin, Deltamethrin, Cypermethrin, Beta-Cyfluthrin, Cyhalothrin

Protection Techniques

i) Chemical Control

Chemical control is one of the important components of cotton IPM. The major pesticides belong to organophosphate and pyrethroids groups. In multi pest situations, the mixtures of pesticides have commonly been used for controlling the cotton pest complex. Most of the farmers apply 6-7 sprays. The pesticides are applied mostly by the growers themselves. Tractor mounted boom sprayer is widely used by large farmers and knap sack hand sprayers are popular with the small farmers.

ii) Sex Pheromones

Use of sex pheromones against pink bollworm was introduced in 1974 in Pakistan. This made mass trapping and mating disruption possible for the control of pink bollworm. Experiments conducted

during the last many years showed good control of pink bollworm through mating disruption, especially early in the season.

iii) Sticky Traps

Recently yellow sticky traps have been introduced to reduce the attack of whitefly. They are getting popular with the farmers who have found them useful.

iv) Destruction of left-over bolls and ginning waste

It has been established that the main source of carry over of pink bollworm is from left-over bolls on the cotton sticks, kept for fuel purpose by the farmers. Destruction of the left-over bolls helped to reduce the use of insecticides against this pest. It is recommended that animals should be grazed in the field so that left-over bolls are eaten up by them and sticks can be kept for fuel purposes. Similarly, ginning waste is also a source of pink bollworm carry-over. The destruction of ginning waste is important to minimize the attack of pink bollworm.

2.6.3 Main cotton weeds and protection techniques

i) Main cotton weeds

There are some weeds which do germinate in cotton season but are less harmful because of their slow growing habit but some are very rapid in their growth habit. Such weeds cause tremendous loss in the yield of seed cotton if not controlled at proper time. The important and main weeds are as under:

Botanical Name	Local Name
Trianthema monogyna	It-Sit
Cyperus rotundus	Deela
Eleusine indica	Madhana
Echinocloa colonum	Swanki ghass
Cynodon dactylon pers	Khabbal ghass
Setaria verticillate	Loomar ghass
Digera arvensis	Tandla
Cucumis melo	Chibbar
Tribulus terrestris	Bhakhra
Convolvulus arvensis	Lehli
Euphorbia heliescopia	Dhodak
Euphorbia pilufiera	Hazardani
Corchorus tridens	Jangli Patsun
Portulaca spp.	Kulfa
Amaranthus viridis	Chulai
Eleusine indica	Madhana
sorghum halepense	Beru

ii) Protection Techniques

Weeds are very efficient users of resources. Therefore, control of weeds is essential to reduce the yield gap between actual and potential yield. Generally integration of cultural, mechanical and chemical control measures are used to eradicate weeds. Cultural control includes weed free seed of the crop, clean cultivation, crop rotation, inter-cropping etc. Under mechanical control, hoeing and inter-culturing methods are adopted. Mechanical weed control methods are generally used by each and

every farmer to control weeds. Use of herbicide is also an effective way to control weeds but limited farmers use herbicides weed control programme. Pre and post emergence herbicides are mostly used on bed-furrow planted cotton for efficient weed control.

2.6.4 Situation of Biological Protection Techniques

In Pakistan many predators are present early in the season. The most important predators are the green lace wing (*Chrysopa carnea*), flower bug (*Orius* sp.) and syrphid fly, other predators incudes *Geocorus* sp., *Corams* sp., *Rhynocoris* sp., staphylinid beetles, spiders and birds. Usually, two peaks population of predators occurs first in the months of June-July and second in the months of September-October. Laboratory reared *Trichogrammachilonis* was released from August to October for control of bollworm these parasites reduced bollworms infestations considerably. Thirteen species of predators and newly discovered parasitoid (*Aenasius* sp.) have been recorded on cotton mealy bug.

2.6.5 Situation of Integrated Pest Management

- Clean cultivation and safe disposal of alternative hosts during and off-cotton season will help to reduce sucking pests attack on the new cotton crop.
- Vegetative growth is more attractive for these pests. Dense canopy makes poor droplets penetration and coverage resulting unsatisfactory control. To avoid this, do not over irrigate nor apply nitrogen in excess.
- Seed dressing with imidacloprid and thiamethoxam can reduce the sucking pests attack for one month. The chemicals must be used where very early sucking pests control is desired
- Scout the crop regularly and apply insecticides only if the number of insect pests has reached the economic threshold level.
- Use of simple pyrethroids and their combinations against sucking pests complex during early in the season must be avoided.
- Don't use mixtures if a single product can do the job.
- Apply alternate insecticide classes with different modes of action to avoid resistance development.
- Don't apply insecticides to which resistance has developed.
- Use proper application equipment for good coverage.

2.6.6 Situation of Certificated Pesticide

Central Cotton Research Institute, Multan is monitoring development of resistance in cotton pests since 1991. Presently *H. armigera*, *B. tabaci* and *Earias vitella* have developed a high level of resistance to various insecticides.

i) Resistance in *Helicoverpa armigera*

Resistance levels to insecticides in *Helicoverpa armigera* from 1991 to 2007.

Insecticide	Resistance factor	
	1991	2007
Endosulfan	194	17
Profenofos	13	4
Chlorpyrifos	33	7
Thiodicarb	7	9
Cypermethrin	105	120
Alphacypermethrin	57	-
Zetacypermethrin	213	-
Deltamethrin	55	325
Lambdacyhalothrin	44	703
Bifenthrin	52	15
Cyfluthrin	55	-

The highest resistance in *H. armigera* was found to endosulfan and pyrethroids. Resistance to profenofos and chlorpyrifos was low. However, there was yet very low resistance to thiodicarb.

ii) Resistance in Whitefly (*Bemisiatabaci*)

Resistance Levels to Insecticides in *Bemisiatabaci* was high in endosulfan, Profenofos, bifenthrin, lambdacyhalothrin and fenpropathrin during 1991 to 2007.

Insecticides	Resistance factor	
	1991	2007
Endosulfan	3	6.64
Profenofos	1	28
Bifenthrin	32	43
Lambdacyhalothrin	8	66
Fenpropathrin	9	15

iii) Resistance in *Earias vitella*

Resistance levels in *Earias vittella* based on LC50 values (ppm) revealed maximum increase in cypermethrin, deltamethrin, zetacypermethrin, bifenthrin, lambdacyhalothrin and esfenvalerate during 2000 to 2007.

Insecticides	LC50 Values (ppm)		Increase during 2007
	Year 2000	Year 2007	
Cypermethrin	0.13	9.78	74.2 times
Deltamethrin	0.14	0.54	2.8 times
Zetacypermethrin	0.076	1.44	17.9 times
Bifenthrin	0.024	4.78	198.2 times
Lambda-cyhalothrin	0.019	5.86	307.4 times
Esfenvalerate	0.78	8.89	10.4 times

2.7 Organic Cotton Section

2.7.1 Organic cotton production and yield

Growing cotton organically entails using cultural practices, natural fertilizers and biological controls rather than synthetic fertilizers and pesticides. The vast area of Balochistan province is quite suitable for cultivation of organic cotton. The land is virgin, fertile and pest attack on cotton is negligible. Organic cotton can be successfully be grown in districts of Bolan, Jhal Magsi, Khuzdar, Lasbella, Chagi and Sibbi. At present, cotton is being grown on about 37800 hectares with a production of around 17000 metric tonnes. The additional availability of water under Mirani Dam promises the cultivation of organic cotton on a large area along the Coastal Area of Balochistan. The average seed cotton yield is about 1600 to 2000 kg ha^{-1}. Moreover, there is no systematic arrangement to pay premium due to loss in production to the farmers.

2.7.2 Organic agriculture policy

Government of Pakistan is making concerted efforts to promote organic cotton cultivation in the vast areas of Balochistan province and the Piedmount areas of the Punjab province. Currently, Pakistan Central Cotton Committee has launched a project" Cotton cultivation in Mirani Dam command area (Balochistan) and other new areas including organic cotton" since crop season 2007-08. This project is being financed by Ministry of Food and Agriculture, Government of Pakistan at the cost of US$ 0.49 million.

2.8 Strength, Weakness, Opportunity and Threat (Swot) in ourCountry

a) Current Strengths in Cotton Production

Pakistan is the land of cotton. The production of cotton rose steadily with ups and downs over the years. The area increased from 1.23 to 3.10 million hectares with concurrent production from 1.1 to 14.6 million bales. This phenomenal growth in production is attributed to introduction of high yielding varieties having better fibre quality characteristics, heat tolerant, wider adaptability and introduction of improved cotton production technologies, across the cotton belt. Currently, the production is fluctuating around 11.0 million bales (1 bales=170 kg). The lowering of cotton productivity has resulted in a wide gap between production and consumption. Therefore, about 4-5 million bales are being imported to meet the growing demand of the local textile industry. In context of raising the yield, the varietals potential and agro-climatic conditions are the determining factors. The soils of the cotton belt are quite suitable for exploitation of full yield potential of the present commercial varieties under irrigated. Therefore, there is much scope for vertical enhancement in cotton productivity, as expansion in area is limited one.

b) Weaknesses in Production

Despite an improvement in the size of cotton crop, current hectare yield of cotton is below the levels being obtained in other cotton growing countries of the world. The prime reason for lower national average is the big difference between the hectare yields being realized by the medium/large sized farms and the small growers, who are in the bulk, (85% of the total). They lack capacity to adopt or have not been educated about the scientific and pest management technology. The common farmer is harvesting 1700 kg ha^{-1}, whereas, progressive farmer is obtaining 3500 kg ha^{-1} seed cotton yield.

c) Opportunities in Enhancing Productivity

The landscape of cotton research and development is being transformed from Classical to Gene Revolution. Much advances have been made at the advent of emerging technologies Genetic

Engineering and Molecular Biology. The cultivation of transgenic cotton commonly known as Bt (*Bacillus thuringiensis*) has revolutionized the research and development of cotton crop. The gene transformation technology has paved the way in the development of cotton varieties having in built tolerance/resistance against biotic and abiotic stresses. The application of Molecular Marker Assisted Selection (MAS) technique has put the breeding program on fast track rather than Classical Combining Ability Technique. The frontiers of MAS Techniques have extended to genetic fingerprinting, introgression of allien genes and identification of chromosomal regions associated with Quantitative Trait Loci (QTL). Furthermore, great opportunities exist in promotion of integrated pest management (IPM) technology with emphasis on biological control through mass release of predators and parasites. This will result in reducing cost of production and environmental pollution. The improvement in fertilizer-use-efficiency (FUE) and water-use-efficiency (WUE) are the critical areas which are needed to be addressed. At present, efficiencies of fertilizer and water are achieved around 30 to 40 percent and could be improved upto 70 to 80 percent.

This could be achieved by practicing different nutrients application techniques i.e., side-dressed and/or foliar coinciding with the need of crop and use of slow release fertilizers. The economy of water could be augmented by using High Efficiency Irrigation System (Drip and sprinkler).

The fine-tuning of cotton production technologies is a continuous phenomenon in the realm of changing socio-economic and global warming environments. The success of the advanced technologies depends upon the awareness and skills of know-how for using agricultural innovations by the cotton farmers. The practice of regular and quick transfer of technologies through electronic and print media is the most efficient way (than conventional absence of sustained linkages with knowledge sources and gender barriers).

However, at the advent of new mass media technologies, viz. geographical information system (GIS), websites, weather forecast system etc. must be introduced for efficient dissemination of farm production technologies. The possibility of joint ventures among public and private sectors service providers could be a prospective area to enhance farm and crop productivity.

d) Threats for Cotton Production

Despite an improvement in the size of cotton crop, the lower hectare yield may be attributed to the ravages of cotton leaf curl virus (CLCV) disease, heavy insect-pest pressure (especially Mealybug), absence of tolerant/resistant varieties to biotic and abiotic stresses, poor seed quality and large number of farmers cultivating on small and uneconomic land holdings. There are number of threats, which are needed to be addressed for vertical improvement in production.

i) Poor Quality of Planting Seed

Seed is a vehicle that transports the technology from Research to the Farm. It alone can transform the fortune of the cotton farmers. The poor crop stand and heterogeneous plants in true-to-type results in poor productivity. The planting of good quality seed of recommended varieties is the need of hour.

ii) Cotton Leaf Curl Virus Disease

Cotton leaf curl virus (CLCV) disease is a continuous threat to cotton crop. It played havoc during 90's. However, with the advent of CLCV resistant varieties developed by Central Cotton Research Institute (CCRI), Multan, cotton crop gained momentum. But unfortunately, commercial varieties fell to prey to new mutated form of CLCV, commonly known as Burewala strain of cotton virus (BSCV) during 2002. The efforts are under way to breed varieties resistant to BSCV through classical breeding, mutation breeding, inter-specific hybridization and genetic engineering technologies. A number of cotton lines/germplasm have shown promise to be resistant to CLCV. The

material is being tested and screened under greenhouse and field conditions for their reaction to CLCV disease.

iii) Major Insect Pests

The inefficient plant protection measures have resulted in excessive use of pesticides, resulting in increasing cost of production and environment pollution. In the recent past, wide spread attack of Mealybug has caused substantial loss in yield. The population of other sucking insects, namely, whitefly and jassid are also on rise presumably due to cultivation of Bt cotton.

iv) Water Availability

The irrigation water supply is on decline over the years. This scarce resource commodity is being economized by brick-lining of canals, on-farm water management, and promotion of drip and sprinkler irrigation technologies. Moreover, bed-furrow technology in cotton is being practiced to economize water by 30 to 40%.

v) Economic Issues

The cots of farm inputs (fuel, fertilizers pesticides) have increased to phenomenal levels. The low investment with concurrent absence of sustainable marketing system has lowered down the farm and crop productivity.

vi) Clean Cotton

The production of clean lint depends upon clean picking, free from contaminants/ trash and low moisture content at the field level. The efforts are being made to produce contamination free cotton at farm and ginning factory levels.

Roadmap to Cotton Vision 2015

> 19.1 MB

40-60%

30-50%

2-10%

0-5%

172-225%

11 MB

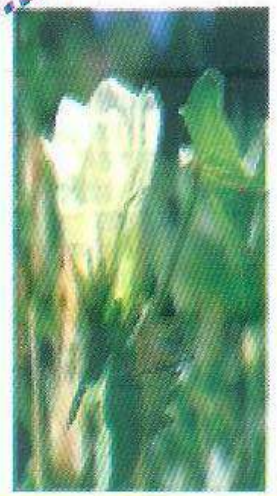
100%

Germplasm Improvement

Farm/Crop Management

Land Gain

Post harvest losses



Area of Impact

Current Status-2010

Targets 2015