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STUDIES IN YIELD OF SEED COTTON AND ITS RELATION TO LEAF NUMBER IN HIGH GRADE COTTONS

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Regular studies in yield of seed cotton and its relationship with leaf number in high grade cottons were conducted at Lyallpur during the years 1962–63 and 1963–64. Selection for low leaf number was found to be well combined with high yield of seed cotton, as 40 families in the first year and 24 families in the second year surpassed L.S.S. the commercial variety of Lyallpur zone in this respect, the actual range being 76.4–127.1 g in 1962–63 and 82.9–129.5 in the second year as compared to 74.5 and 81.3 g for L.S.S. during the 2 years. Fourteen families in the first year and 21 families in the second year possessed the least foliage and high yield and showed clear indications of success in developing high grade cottons.

The improvement of yield and quality of cotton crop has received considerable attention from the cotton breeders in Pakistan and other countries during the last 65 years and tremendous allround progress has also been recorded in yield and various quality characters of the cotton crop in the former Panjab by Afzal[1] and Khan.[2–5] The average yield of lint per acre has increased from 76.7 lb in the 1st decade of this century to 254 lb; ginning outturn of indigenous cotton (*Gossypium arboreum* L) has gone up from 33.0% to 40.5% and in Panjab American Cottons belonging to *Gossypium hirsutum* L) from 32.0% to 40.0%; staple length has increased from 0.70 in to 1.25 in and over; fibre fineness i.e., micronaire reading has moved down from 7.0 to 8.0, to 3.5 and to 4.0; fibre strength has increased from 60 to 70 thousand lb/in^2 to 105 thousand/lb in new strains to 113 thousand lb/in^2 and spinning performance has recorded a spectacular increase from 8'S to over 70'S and strains capable of spinning 100'S are in hand.

It is, rather surprising, however that in spite of these achievements, no research work was at all undertaken for improvement of the grade of cotton crop of this area, which is the major factor in determining its price, utility in processing and manufacturing and the appearance of yarn and fabrics. The demand for higher grades in world markets has further added to its importance and it is a very serious problem in areas of labour shortage like U.S.A. where mechanical picking resulted in lowering of quality and grades and in cotton exporting countries, which must offer higher grade cotton to capture foreign markets.

The grade of cotton is composed of 3 factors; colour, foreign matter and ginning preparation, which are directly or indirectly affected appreciably by the variety, its extent of foliage at the picking time, size and type of burs and bracts etc. Considerable progress has already been made in chemical defoliation of cotton crop to obtain higher grades in foreign countries and Khan and Stroman[6] studied effect of chemical defoliation on yield and quality of cotton.

Realizing the great complications and financial implications of chemical defoliation especially for less developed countries like Pakistan and the grave financial position of the poor cotton growers, the senior author started regular research work in 1960 for breeding of cotton varieties shedding leaves before first picking for obtaining higher grades of cotton, early crop, and less boll damage.

The findings of these researches have already been partly reported by Khan,[3–4] and Khan[7] and it is proposed to give further details of these researches and findings in this paper.

Review of Literature

Findings of researches on this aspect of the cotton crop are briefly reviewed here:

Ludwig[8] stated that the artificial defoliation done early in the season resulted in loss of yield and weak lint.

Crowther[9] observed that heavy defoliation in the months of October and November under Sudan conditions were associated with drastic reduction in yield.

Afzal[10] stated that there was maximum shedding of leaves during August–September i.e., during third and fourth month after sowing. The leaves at the lower nodes were short lived and the age of the leaves increased at higher nodes and maximum age was recorded in the case of leaves at the top of the plant and the very top most leaves were again very short lived.

Bailey[11] reported maximum shedding of leaves in Sudan during December and January i.e., from the fifth month after sowing. Joshi, *et al.*[12] stated that the longest lived leaves developed in the month of October. Gull and Dunnam[13] stated that chemical defoliation resulted in early opening of bolls and it reduced the total green and dry leaf material collected by the picking machine. They further stated that defoliation resulted in early maturity of cotton by 2–3 weeks.

Sokolova[14] stated that too early removal of the cotton leaves before mechanical harvesting of the crop resulted in marked reduction in yield.

Hall[15] stated that there was a high negative correlation between sensitivity to defoliation and the starch content of the leaves and that the susceptibility of a cotton field to chemical defoliation could be predicted fairly accurately by determining the percentage of starch in the leaves.

Hall and Lane[16] stated that the percentage rate of abscission was higher when sugar was added to defoliant alone.

Afzal and Ali[17] stated that on the whole defoliation of cotton plants had adverse affect on yield and quality. Khan and Stroman [6,18] reported breeding of cotton varieties for higher grades and for those adaptable to mechanization.

Brown[19] and Brown and Rhyne[20] stated that boll maturity determined the effectiveness of defoliation, as plants bearing bolls 38–60 days old were better defoliated than those with bolls 10–25 days old.

Khan and Stroman[21] reported effectiveness of "Shell A" defoliant in remaining large number of leaves from the treated crop but it adversely affected yield and quality of cotton.

Khan and Mirza[21,24] and Khan, Shah and Neguib[25] stated that researches for development of cotton varieties shedding leaves before picking were under way and that the breeding material and especially selections of Pak-111 were more outstanding in leaf shedding before pickings at Lyallpur. Their findings should have appreciable scope for evolution of high yielding varieties shedding leaves before picking and indicated that systematic research work was undertaken in 1962 by the senior author at Lyallpur and interesting results had been obtained during the year 1962-63, which have been partly reported by Khan, Khan and Neguib.[25]

Material and Methods

Regular studies for breeding of cotton varieties shedding leaves before picking, were undertaken in the year 1962 and continued for two years 1962–63 and 1963-64 in the Department of Genetics and Plant Breeding of the West Pakistan Agricultural University, Lyallpur. The experiment was arranged by the senior author in 1962 and 1963 and the former year included 48 families consisting of 26 selections of Pak-111 and 18 selections of Pak–8, AC-306, AC134, AC192, AC158, AC275, 320F, AC256, AC157 and AC301. This breeding material was selected on the thorough screening of the original collection and testing during the previous year 1961–62.

The details of the breeding material under study during the two years are given below:

DETAILS OF 1962–63 MATERIAL

(i) Number of progenies, 44; (ii) Standards (LSS, AC134, AC307 and Pak-111), 4; (iii) Total number of progenies, 48; (iv) Replications, 6; (v) Number of plants per repeat, 5; (vi) System of layout, Complete randomization; (vii) Range of yield, 49.0 to 149.5 g.; (viii) Range of ginning outturn, 30–40%; (ix) Range of staple length, 23.5—27.0 mm.; (x) Rainfall in Cotton season, 6.37″; (xi) Rotation, Cotton Berseen.

The entire material was thoroughly studied in the field and laboratory for yield and other characters including the number of leaves on plants and the percentage shedding in different families. 44 families were finally selected from the 1962–63 material on basis of yield, ginning outturn, staple length and leaf shedding quality, for further studies during the year 1963–64.

DETAILS OF 1963–64 MATERIAL

(i) Number of progenies, 44: (ii) Standards (L.S.S., AC134, AC307 and Pak-111), 4; (iii) Total number of progenies, 48; (iv) Replications, 6; (v) Number of plants per repeat, 5; (vi) System of layout, Complete randomization; (vii) Range of yield, 91.7 to 325.0 g.; (viii) Range of ginning outturn. 33.2 to 43.4; (ix) Range of staple, 21.5 to 24.5 mm.; (x) Rotation, Cotton Bureau, Cotton.

Yield.—Three picks were taken at regular intervals during the season. The produce of each pick was separately collected in bags and weighed in the end of the season. The total yield was obtained by sunning up yield of different picks.

The Number of Leaves.—The number of leaves was counted before first picking. The leaves of each plant of all the families were counted individually and the average of the family was determined.

Percentage of Foilage on First Picking.—The total number of leaves was counted before first picking and then recounting was done at the time of first picking. The percentage of leaves at the first picking to the original total, was found out by the following formula.

$$\text{Percentage of foliage} = \frac{\text{Leaves present at first pick}}{\text{Total number of leaves}} \times 100$$

Statistical Method Applied.—The entire data for yield of seed cotton was subjected to statistical analysis according to methods suggested by Goulden (1936)[27] and Fisher[28] (1941).

Experimental Results

The yield results obtained from the present studies are presented in Tables 1–4.

It will be seen from data given in Table 1 that the range of yield of different families during the first year of experiments *i.e.*, 1962–63 was 53.6 to 127.1 g, and the yield of L.S.S., AC134, AC307 and Pak-111 standards was 72.1, 84.2, 104.6 and 87.9 g per plant respectively. It will be further seen that 40 families outyielded L.S.S. whereas 34, 13 and 30 families surpassed AC134, AC307 and Pak-111 standards in yield per plant respectively. The statistical analysis, however showed non-significant differences between various families and the standards, inspite of appreciable actual differences between yields of different families and standards. Selections of AC306, 320F, Pak-111, AC256 and AC192 and Pak-8 were outstanding in yield per plant, although the differences in yield were non-significant, but the trends were decidedly clear.

The range of yield of seed cotton for different families for the 2nd year given in Table 3 was 49.7 to 129.5 g and the average yield for standards L.S.S., AC134, AC307 and Pak-111 was 81.3, 71.2, 122.0 and 82.9 g respectively. Twenty four families outyielded L.S.S. the commercial variety of Lyallpur zone, whereas 36, 1 and 23 families surpassed AC134, AC307 and Pak-111 respectively. The yield differences between families were significant. No family showed significantly higher yields than AC307, but only 4, 10 and 3 families showed significant differences over L.S.S., AC134 and Pak-111.

TABLE 1.—ADJUSTED YIELD OF DIFFERENT FAMILIES FOR THE YEAR 1962–63.

S. No.	Family	Origin	Yield (g)
1.	1139–62	AC306	127.1
2.	1147–62	320F	124.7
3.	1123–62	Pak-111	121.0
4.	1148–62	AC256	115.1
5.	1118–62	Pak-111	114.8
6.	1114–62	Pak-111	112.5
7.	1143–62	AC192	110.0
8.	1150–62	AC256	108.4
9.	1136–62	Pak-8	107.9
10.	1125–62	Pak-111	107.7
11.	1115–62	Pak-111	106.2
12.	1132–62	Pak-111	105.8
13.	1130–62	Pak-111	105.2
14.	AC-307	Standard	104.6
15.	1142–62	AC192	101.7
16.	1121–62	Pak-111	101.3
17.	1127–62	Pak-111	99.4
18.	1140–62	AC134	98.6
19.	1138–62	AC306	98.1
20.	1120–62	Pak-111	97.9
21.	1129–62	Pak-111	97.8
22.	1137–62	Pak-8	97.8
23.	1113–62	Pak-111	97.6
24.	1135–62	Pak-111	97.3
25.	1122–62	Pak-111	96.9
26.	1134–62	Pak-111	92.7
27.	1141–62	AC134	92.1
28.	1131–62	Pak-111	91.8
29.	1116–62	Pak-111	89.9
30.	1124–62	Pak-111	89.3
31.	Pak-111	Standard	87.9
32.	1144–62	AC158	86.3
33.	1133–62	Pak-111	85.9
34.	1153–62	AC301	85.4
35.	AC134	Standard	84.2
36.	1146–62	320F	82.5
37.	1119–62	Pak-111	82.2
38.	1110.62	Pak-111	81.5
39.	1113–62	Pak-111	79.9
40.	1126–62	Pak-111	76.4
41.	L.S.S.	Standard	74.5
42.	1117–62	Pak-111	72.1
43.	1151–62	AC157	72.1
44.	1152–62	AC157	72.1
45.	1128–62	Pak-111	70.2
46.	1111–62	Pak-111	67.1
47.	1149–62	AC256	53.6

TABLE 2.—ANALYSIS OF COVARIANCE FOR YIELD DATA OF PROGENY ROW TEST 1962–63.

Variation due to	D.F.	SX2	SY2	SXY	$b=\frac{SXY}{SX2}$	b. SXY	Deviation from regnesion		
							SY2-b. SXY	D.F.	M.S.	F.
Blocks	5	34.90	92023.83	1855.02						
Families	46	75.30	1244097.65	6834.59	90.76	620307.39	624920.14	46	13585.22	1-170NS.
Error	230	396.50	5782262.02	34322.72	56	2970974.64	2811287.38	229	12276.36	
Families and error	276	471.80	7026359.67	41157.31	87.23	3590152.15	3436207.52	275	12495.30	
Total	281	506.70	7118383.50	43012.33						

$$\text{F before Adjustment} = \frac{27045.60}{25140.27} = 1.076^{NS}.$$

$$\text{Relative precision of Results} = \frac{5782262.20}{230} \div \frac{2811287.38}{229} = \frac{25140.27}{12276.36} = 2.048$$

(It shows reduction in error from adjustment by foliage percentage is quite market). Both F values before and after adjustment of yield is insignificant but there is sufficient improvement after adjustment to indicate that method is sound.)

F value at 1% = 1.64; F value at 5% = 1.43.

TABLE 3.—ADJUSTED YIELD OF DIFFERENT FAMILIES FOR THE YEAR 1963–64.

S. No.	Family	Origin	Yield (g).
1.	1021–63	AC158	129.5
2.	AC–307	Standard	122.0
3.	1017–63	AC306	115.1
4.	1018–63	AC-306	107.0
5.	1024–63	AC158	102.6
6.	1028–63	AC256	102.2
7.	1014–63	Pak-8	101.5
8.	1011–63	Pak-111	100.2
9.	1008–63	Pak-111	98.7
10.	1027–63	AC256	97.2
11.	987–63	Pak-111	91.7
12.	966–63	Pak-111	91.7
13.	1015–63	AC-306	91.1
14.	1006–63	Pak-111	90.4
15.	1026–63	AC275	90.4
16.	1022–63	AC158	90.2
17.	999–63	Pak-111	88.2
18.	1004–63	Pak-111	87.3
19.	1012–63	Pak-111	86.2
20.	1007–63	Pak-111	85.0
21.	990–63	Pak-111	84.6
22.	1005–63	Pak-111	84.2
23.	1013–63	Pak-8	83.6
24.	Pak-111	Standard	82.9
25.	L.S.S.	Standard	81.3
26.	992–63	Pak-111	81.0
27.	1001–63	Pak-111	80.4
28.	1019–63	AC-134	79.3
29.	995–63	Pak-111	76.3
30.	1003–63	Pak-111	76.0
31.	985-63	Pak-111	75.1
32.	991–63	Pak-111	75.4
33.	988–63	Pak-111	74.5
34.	997–63	Pak-111	73.4
35.	1020–63	AC-134	72.4
36.	1023–63	AC-158	72.1
37.	AC–134	Standard	71.2
38.	994–63	Pak-111	71.1
39.	1025–63	AC275	71.0
40.	1009–63	Pak-111	70.8
41.	1002–63	Pak-111	70.3
42.	1016–63	AC-306	70.3
43.	989–63	Pak-111	67.9
44.	998–63	Pak-111	67.5
45.	1010–63	Pak-111	66.1
46.	993.63	Pak-111	63.2
47.	1000–63	Pak-111	49.7

TABLE 4.—ANALYSIS OF COVARIANCE FOR YIELD DATA OF PROGENY ROW TEST FOR 1963–64.

Variation due to	D.F.	SX2	SY2	SXY	$b=\frac{SXY}{SX2}$	b. SXY	SY2-b. SXY	D.F.	M.S.	F.
Blocks	5	16.04	785023.20	1908.06						
Families	46	94.41	1762107.34	7799.58	82.61		1128105.82	46	24524.04	2.89
Error	230	221.30	3031177.80	15508.94	70.08	1086866.51	1944311.29	229	8490.44	
Families and error	276	315.71	4793285.14	23308.52	73.83	1720868.03	3072417.11	275	11172.43	
Total	281	331.75	5578308.34	25216.58						

$$\text{F value before Adjustment} = \frac{38306.68}{13179.03} = 2.91$$

S.E. of mean = 37.617 $\sqrt{\frac{s2}{r}}$

S.E.D.M. = 53.45 $\sqrt{\frac{2s^2}{r}\left[1+\frac{SX^2 \text{ for t}}{(t-1)\ SX^2 \text{ for error}}\right.}$

C.D. 1 = 21.06 g per plant

C.D. 2 = 27.80 g per plant

It is interesting to note that during the 2nd year again, selections of AC306, AC256, Pak-111 and Pak-8 proved better in yield than other types and AC158 selections showed better performance than during the previous year.

Total Leaf Number.—The total number of leaves in different families are given in Tables 5 to 8.

It will be clear from data presented in Table 5 that the range of leaf number in various families and standards for the year 1962–63 was 231.8 to 586.7, whereas it was only 53.1 to 178.3 per plant as shown in Table 7, which shows that the vegetative growth was more in all families in the first year as compared to the 2nd year and that L.S.S. the commercial variety had the maximum vegetative growth during both the season with the only exception of Family No. 111-62, a selection of Pak-111 during the year 1962–63.

Only 5, 18 and 22 families possessed larger number of leaves than Pak-111, AC134 and AC 307 during the first year and 4, 2 and 6 families recorded higher leaf number than the same standards during the second year.

The differences in leaf number of various families and standards were non-significant during the first year 1962–63 and highly significant during the second year 1963–64.

Selection of AC256, AC306, AC134, AC192 showed fairly high leaf number per plant during both the years, whereas bulk of the Pak-111 selections showed lesser leaf number in general.

The percentage values of leaves present at the first pick are given in Tables 9–12.

It will be observed from Tables 9 to 12 that the range of foliage percentage on the plants at the time of first picking ranged from 17.6 to 69.0% in the first year and 46.2 to 83.6% in the second year which shows that percentage of leaf shedding during the first year was higher than that during the second year.

It will be further seen that the percentage of foliage in case of the L.S.S., the commercial variety of L.S.S. zone was 33.7 and 75.7 during the first and the second year respectively, whereas the foliage percentage in case of other standard varieties AC134, AC307 and Pak-111 was 24.8, 35.6 and 52.8 in the first year and 68.4, 76.5 and 74.4 percentage during the second year, which clearly shows that 13 families during 1962–63 and 39 families during the year 1963–64 had a higher rate of leaf shedding than L.S.S.; the present commercial variety of Lyallpur area; similarly 6 and 21 families were superior to AC134 in leaf shedding during the two years; 17 and 42 families surpassed AC307 in this respect for the same period whereas 29 and 36 families showed s superiority over Pak-111 during the two years.

The differences in foliage percentage at the first picking during both the years were found to be significant.

Consolidated Data for Yield and Leaf Number.—The data pertaining to both the characters i.e., yield and leaf number for all the families are presented separately for 1962–63 and 1963–64.

TABLE 5.—ADJUSTED TOTAL NUMBER OF LEAVES OF DIFFERENT FAMILIES DURING 1962–63.

S. No.	Family	Origin	Total leaves
1.	1111–62	Pak-111	586.7
2.	L.S.S.	Standard	399.4
3.	1126–62	Pak-111	367.3
4.	1150–62	AC256	360.7
5.	1134–62	Pak-111	355.7
6.	Pak-111	Standard	348.7
7.	1139–62	AC306	342.7
8.	1118–62	Pak-111	340.4
9.	1138–62	AC306	339–8
10.	1115–62	Pak-111	338.2
11.	1143–62	AC192	333.5
12.	1140–62	AC134	327.1
13.	1125–62	Pak-111	321.1
14.	1128–62	Pak-111	316.6
15.	1120–62	Pak-111	315.1
16.	1124–62	Pak-111	308.6
17.	1123–62	Pak-111	308.2
18.	1129–62	Pak-111	307.9
19.	AC134	Standard	304.1
20.	1149–62	AC256	302.1
21.	1110–62	Pak-111	301.7
22.	1114–62	Pak-111	300.1
23.	AC301	Standard	299.7
24.	1132–62	Pak-111	298.9
25.	1136–62	Pak-8	291.5
26.	1144–62	AC158	291.4
27.	1112–62	Pak-111	289.2
28.	1113–62	Pak-111	286.0
29.	1117–62	Pak-111	276.1
30.	1144–62	320F	275.5
31.	1127–62	Pak-111	274.8
32.	1131–62	Pak-111	274.0
33.	1116–62	Pak-111	269.7
34.	1121–62	Pak-111	266.3
35.	1133–62	Pak-111	231.8

TABLE 6.—ANALYSIS OF COVARIANCE FOR TOTAL NUMBER OF LEAVES OF PROGENY ROW TEST FOR 1962–63.

Variation due to	D.F.	SX2	SY2	SXY	$b=\frac{SXY}{SX2}$	b. SXY	SY2-b.SXY	D.F.	M.S.	F.
Blocks	5	26.27	2638886.41	7916.30						
Families	34	56.70	5567451.79	13476.02			2365421.92	34	69571.23	0.80NS.
Error	170	238.73	28679846.93	57849.04	242.32	14017979.37	14661867.56	169	86756.61	
Families and error	204	295.43	34247298.72	71325.06	241.43	17220009.24	17027289.48	203		
Total	209	321.70	36886185.13	79241.36						

TABLE 7.—ADJUSTED TOTAL NUMBER OF LEAVES OF DIFFERENT FAMILIES FOR 1963–64.

S. No.	Family	Origin	Total number of leaves
1.	L.S.S.	Standard.	178.3
2.	1018–63	Pak-111	175.7
3.	AC134	Standard	174.5
4.	1013–63	Pak-111	170.6
5.	Pak-111	Standard.	169.2
6.	1008–63	Pak-111	164.2
7.	AC307	Standard.	157.4
8.	985.63	Pak-111	152.0
9.	1019–63	AC134	148.4
10.	1014–63	Pak-8	143.6
11.	1017–63	AC306	142.1
12.	1028–63	AC256	141.5
13.	1003–63	Pak-111	139.7
14.	1006–63	Pak-111	138.4
15.	1027–63	AC256	138.3
16.	1026–63	AC275	136.3
17.	1015–63	AC306	134.5
18.	990–63	Pak-111	132.9
19.	1005–63	Pak-111	130.5
20.	989–63	Pak-111	129.5
21.	988–63	Pak-111	128.9
22.	1011–63	Pak-111	127.0
23.	1012–63	Pak-111	124.4
24.	1002–63	Pak-111	124.2
25.	1025–63	AC274	119.6
26.	996–63	Pak-111	113.7
27.	1021–63	AC158	112.9
28.	992–63	Pak-111	112.3
29.	1007–63	Pak-111	111.9
30.	1004–63	Pak-111	110.7
31.	987.63	Pak-111	109.2
32.	1020–63	AC134	105.0
33.	987–63	Pak-111	104.2
34.	995–63	Pak-111	103.4
35.	1016–63	AC306	99.8
36.	1010–63	Pak-111	97.1
37.	1024–63	AC158	96.3
38.	997–63	Pak-111	95.5
39.	994–63	Pak-111	90.1
40.	1022–63	AC158	85.6
41.	1000–63	Pak-111	84.7
42.	998–63	Pak-111	83.7
43.	991–63	Pak-111	74.8
44.	1023–63	AC158	72.3
45.	993–63	Pak-111	53.1

TABLE 8.—ANALYSIS OF COVARIANCE FOR TOTAL NUMBER OF LEAVES OF PROGENY ROW TEST FOR 1963–64.

Variation due to	D.F.	SX2	SY2	SXY	$b=\frac{SXY}{SX2}$	b. SXY	SY2-b.SXY	D.F.	M.S.	F.
Blocks	5	20.39	2045545.18	3282.35						
Families	44	159.60	5915526.88	9961.79			6288173.70	44	142913.04	6.00
Error	220	103.78	8894646.99	19527.15	188.16	3674228.54	5220418.45	219	23837.53	
Families and error	264	263.38	14810173.87	29488.94	111.96	3301581.72	11508592.15	263		
Total	269	283.77	16855719.05	32771.29						

S.E. of mean = 63.031; S.E.D.M. = 90.68; C.D. 1. at t 5% = 35.73 per plant; C.D. 2 at t 1% = 47.15 per plant.

TABLE 9.—PERCENTAGE OF FOLIAGE ON FIRST PICK 1962–63.

S. No.	Family	Origin	Foliage %
1.	1132–62	Pak-111	69.0
2.	1112–62	Pak-111	67.1
3.	1120–62	Pak-111	66.0
4.	1142–62	AC192	65.5
5.	1134–62	Pak-111	65.1
6.	1110–62	Pak-111	64.1
7.	1118–62	Pak-111	61.8
8.	1141–62	AC134	61.7
9.	1139–62	AC306	61.1
10.	1121–62	Pak-111	60.8
11.	1153–62	AC301	60.5
12.	1140–62	AC134	60.0
13.	1138–62	AC306	59.8
14.	1126–62	Pak-111	57.8
15.	1144–62	AC158	57.2
16.	1136–62	Pak-8	56.3
17.	1113–62	Pak-111	55.7
18.	Pak-111	Standard	52.8
19.	1148–62	AC256	48.3
20.	1150–62	AC256	47.4
21.	1117–62	Pak-111	46.2
22.	1130–62	Pak-111	45.1
23.	1124–62	Pak-111	44.5
24.	1133–62	Pak-111	44.4
25.	1116–62	Pak-111	40.9
26.	1149–62	AC256	40.6
27.	1128–62	Pak-111	40.1
28.	1135–62	Pak-111	39.2
29.	1146–62	320F	37.7
30.	AC307	Standard	35.6
31.	1137–62	Pak-8	35.4
32.	1152-62	AC157	35.4
33.	1129–62	Pak-111	34.4
34.	L.S.S.	Standard	33.7
35.	1131–62	Pak-111	31.4
36.	1111–62	Pak-111	31.4
37.	1115–62	Pak-111	31.4
38.	1119–62	Pak-111	30.3
39.	1127–62	Pak-111	29.6
40.	1125–62	Pak-111	25.9
41.	AC134	Standard	24.8
42.	1151–62	AC157	24.2
43.	1123–62	Pak-111	23.4
44.	1122–62	Pak-111	23.4
45.	1147–62	320F	23.2
46.	1143–62	AC192	23.1
47.	1114–62	Pak-111	17.6

TABLE 10.—ANALYSIS OF VARIANCE FOR PERCENTAGE OF FOLIAGE ON FIRST PICK 1962–63.

Variation due to	D.F.	S.S.	M.S.	F. Ratio
Blocks	5	116.53		
Families	46	22861.70	496.99	37.48
Error	230	3048.90	13.26	
Total	281	26027.13		

TABLE 11.—PERCENTAGE OF FOLIAGE ON FIRST PICK 1963-64.

S. No.	Family	Origin	Foliage%
1.	985–63	Pak-111	83.6
2.	1026–63	AC275	83.1
3.	1027–63	AC256	81.6
4.	1028–63	AC256	79.9
5.	AC307	Standard	76.5
6.	1008–63	Pak-111	76.5
7.	1025–63	AC275	75.8
8.	L.S.S.	Standard	75.7
9.	1014–63	Pak-8	75.4
10.	1007–63	Pak-111	74.5
11.	Pak-111	Standard	74.4
12.	1013–63	Pak-8	74.2
13.	1017–63	AC306	73.9
14.	996–63	Pak-111	73.9
15.	987–63	Pak-111	73.7
16.	1012–63	Pak-111	72.6
17.	1024–63	AC158	71.9
18.	988–63	Pak-111	71.5
19.	997–63	Pak-111	71.4
20.	1011–63	Pak-111	71.3
21.	1005–63	Pak-111	71.1
22.	1009–63	Pak-111	70.5
23.	1015–63	AC306	70.4
24.	1022–63	AC158	70.2
25.	1003–63	Pak-111	68.7
26.	AC134	Standard	68.4
27.	1002–63	Pak-111	68.3
28.	990.63	Pak-111	67.9
29.	1021–63	AC158	67.6
30.	989–63	Pak-111	67.4
31.	1023–63	AC158	67.3
32.	992–63	Pak-111	67.1
33.	1000–63	Pak-111	66.3
34.	995–63	Pak-111	65.9
35.	1016–63	AC306	65.9
36.	994–63	Pak-111	65.4
37.	1004–63	Pak-111	65.2
38.	991–63	Pak-111	64.5
39.	1006–63	Pak-111	63.8
40.	1018–63	AC306	62.4
41.	1001–63	Pak-111	62.1
42.	1010–63	Pak-111	61.5
43.	1025–63	AC275	58.8
44.	998–63	Pak-111	56.6
45.	1019–63	AC134	52.5
46.	999–63	Pak-111	49.9
47.	993–63	Pak-111	46.2

TABLE 12.—ANALYSIS OF VARIANCE FOR PERCENTAGE OF FOLIAGE ON FIRST PICK 1963–64.

Variation due to	D.F.	S.S.	M.S.	F. Ratio
Blocks	5	1417.81		
Families	46	9448.94	205.41	3.63**
Error	230	12997.73	56.51	
Total	281	23864.48		

** Highly significant.

It will be seen from Table 13 that during the year 1962–63, 14 families had a very desirable combination of less number of leaves at the first picking and a higher yield as compared to the standard variety L.S.S., whereas 5 families had leaves less than 80 per plant as compared to 134.6 per plant in case of L.S.S.

On the other hand during the second year 1963–64, 44 families possessed lesser number of leaves at the first pick (Table 14) and 24 families showed a very desirable combination of low leaf number and high yield than L.S.S.

Discussion

The experimental results obtained from the present studies are discussed below:

During the year 1962–63, 40 families surpassed L.S.S., the commercial variety of Lyallpur zone in average yield, the actual being 74.5 grams for L.S.S. and 76.4 to 127.1 grams in the higher yielding families, and only six families gave lower yield than L.S.S., the yield range in this group being 53.6 to 72.1 grams. On the other hand only 24 families gave higher yield than L.S.S., in the second year 1963-64, the mean yield of L.S.S., being 81.3 grams and yield range of higher yielding families being 82.9 to 129.5 grams. The yield range of low yielding 22 families was 49.7 to 81.0 grams. The differences in yield were, however, non-significant during the first year and significant during the second year.

The total average number of leaves was on the whole highest in case of L.S.S. being 399.4 and 178.3 during the first and second year respectively, whereas the range of leaves in the entire material excepting Family No. 1111–62 was 231.8 to 367.3 in 1962-63 and 53.1 to 175.7 during the second year 1963–64.

The percentage of foliage present at the time of first picking in 1962–63 was 33.7 in case of L.S.S. and 33 families possessed a higher percentage of foliage at this stage and only 13 families showed higher percentage of shedding with a range of foliage present being only 17.6 to 31.4%. During the second year, however, the total number of leaves was comparatively very low due to shortage of irrigation supplies and less rainfall during the cotton season; but the percentage of foliage present at the time of first picking was rather high in the entire material, L.S.S., showed 75.7% foliage at this stage and only 7 familes possessed higher percentage of foliage than L.S.S.; whereas 39 families showed higher leaf shedding percentage than L.S.S. or lesser percentage foliage at the first picking.

A close study of Tables 13 and 14 show a very interesting and desirable combination of important characters i.e., yield and less foliage at the time of first picking. 14 families during 1962-63 surpassed L.S.S. in this respect with a leaf number range of 52.8 to 110.3 and yield range of 82.5 to 121.0 grams against mean leaf number of 134.6 and mean yield of 74.5 grams for L.S.S.

Similarly during the second year 24 families showed a better combination of high yield and low leaf number at the first picking as compared to L.S.S., the range of leaf number being 30.3 to 126.6 and yield range being 82.9 to 129.5 grams against 134.9 leaves and 81.3 grams mean yield for L.S.S.

The present findings are very interesting and it seems proper planning of cotton breeding programmes and careful selection can indeed be a most helpful in combining characters like high yield and low foliage at first picking.

The present findings seem to be of far reaching economic, significance as the findings of earlier research workers Ludwig[8] Crowther[9] Afzal and Ali[10] and Khan and Stroman[14] had clearly shown adverse effect of chemical or mechanical leaf shedding or defoliation on yield of cotton crop.

Ludwig[8] stated that artificial defoliation done early in the season resulted in reduced yield and weak lint. Crowther[4] observed from experiments in Sudan that heavy defoliation in October and November was associated with drastic reduction in yield. Afzal and Ali[10] concluded that on the whole, defoliation of plants had deleterious effects both on yield and quality. Khan and Stroman[14] recorded adverse effect of chemical defoliation with on yield and fibre quality. Similar were the findings of other workers i.e., Afzal[2] Bailey[3] Sokalova[8], Hall[9] Hall and Lane[11] Brown[13] Brown and Rhyne.[16]

The present findings have further confirmed the results already reported by Khan and Mirza[19–21] and Khan, Shah and Neguib[26] pertaining to the scope of breeding of cotton varieties shedding leaves before first picking.

Summary

The research work on the problem of breeding of cotton varieties shedding leaves before first picking for improvement of grades was under taken at Lyallpur during the years 1962–63 and 1964–65. The findings of these researches are summarised herewith.

The studies revolved that careful selection for higher leaf shedding character was effective in combining low leaf number at first pick with higher yield. 40 families in the first year and 24 families during the second year surpassed L.S.S., the commercial variety of Lyallpur zone in yield of seed cotton. The yield of 40 families during 1962–63 ranged from 76.4 to 127.1 grams against 74.5 grams in case of L.S.S. The range of yield in superior 24 families during the second year was 82.9 to 129.5 grams against 81.3 grams for L.S.S.

L.S.S., possessed the maximum number of leaves during both the years, excepting one family during

TABLE 13.—CONSOLIDATED DATA FOR YIELD AND LEAF NUMBER 1962–63.

S. No.	Family	Origin	Total leaves	Foliage % first pick	Actual leaf No. first pick	Yield (grams)
1.	1114–62	Pak-111	300.1	17.6	52.8	112.5
2.	1122–62	Pak-111	289.2	23.4	67.7	96.9
3.	1123–62	Pak-111	308.2	23.4	72.1	121.0
4.	AC134	Standard	304.1	24.8	75.4	84.2
5.	1143–62	AC192	335.5	23.1	70.0	110.0
6.	1127–62	Pak-111	274.8	29.6	81.3	99.4
7.	1125–62	Pak-111	321.1	25.9	83.1	107.7
8.	1131–62	Pak-111	274.0	31.4	86.0	91.8
9.	1133–62	Pak-111	231.8	44.4	102.9	85.9
10.	1146–62	320F	275.5	37.7	103.9	82.5
11.	1129–62	Pak-111	307.9	44.4	105.9	97.8
12.	1115–62	Pak-111	338.2	31.4	106.2	106.2
13.	AC307	Standard	298.7	35.6	106.7	104.6
14.	1116–62	Pak-111	269.7	40.9	110.3	89.9
15.	1149–62	AC256	302.1	40.6	122.6	53.6
16.	1128–62	Pak-111	316.6	40.1	126.9	70.2
17.	1117–62	Pak-111	276.1	46.2	127.5	72.1
18.	L.S.S.	Standard	399.4	33.7	134.6	74.5
19.	1124–62	Pak-111	308.6	44.5	137.3	89.3
20.	1113–62	Pak-111	286.0	55.7	159.3	97.6
21.	1121–62	Pak-111	266.3	60.8	161.9	101.3
22.	1136–62	Pak-8	291.6	56.3	164.1	107.9
23.	1144–62	AC158	291.4	57.2	166.7	86.3
24.	1150–62	AC256	360.7	47.4	170.9	108.4
25.	Pak-111	Standard	348.7	52.8	184.1	87.9
26.	1111–62	Pak-111	586.7	31.4	184.2	67.1
27.	1110–62	Pak-111	301.7	64.1	193.3	81.5
28.	1140–62	AC134	327.1	60.0	196.3	98.6
29.	1138–62	AC306	339.8	59.8	203.2	98.1
30.	1132–62	Pak-111	298–9	69.0	206.4	105.5
31.	1120–62	Pak-111	315.1	66.0	207.9	97.9
32.	1118–62	Pak-111	340.4	61.8	210.3	114.8
33.	1139–62	AC306	345.8	61.1	211.3	127.1
34.	1126–62	Pak-111	367.3	57.8	212.3	76.4
35.	1134–62	Pak-111	355.7	65.1	231.5	92.7

TABLE 14.—CONSOLIDATED DATA OF YIELD AND LEAF NUMBER 1963–64.

S. No.	Family	Origin	Total leaf number	Foliage% first pick	Actual leaf No. first pick	Yield (grams)
1.	993–63	Pak-111	53.1	46.2	24.5	63.2
2.	1012–63	Pak-111	124.4	72.6	30.3	86.2
3.	998–63	Pak-111	83.7	56.6	47.4	67.5
4.	991–63	Pak-111	74.8	64.5	48.2	75.4
5.	1023–63	AC158	72.3	67.3	48.6	72.1
6.	999–63	Pak-111	104.2	49.8	51.9	88.2
7.	1000–63	Pak-111	84.7	66.3	56.2	49.7
8.	1010–63	Pak-111	97.1	61.5	57.7	66.1
9.	994–63	Pak-111	90.1	65.4	58.9	71.1
10.	1022–63	AC158	85.6	70.2	60.1	90.2
11.	997–63	Pak-111	95.8	71.4	61.4	73.4
12.	1020–63	AC134	105.0	58.8	61.7	72.4
13.	1016–63	AC306	99.8	65.9	65.7	70.3
14.	995–63	Pak-111	103.4	65.9	68.1	76.3
15.	1024–63	AC158	96.3	71.9	69.2	102.6
16.	1004–63	Pak-111	110.7	65.2	72.2	87.3
17.	992–63	Pak-111	112.3	67.1	75.4	81.0
18.	1021–63	AC158	112.9	67.6	76.3	129.5
19.	1019–63	AC134	148.4	52.5	77.9	79.3
20.	987–63	Pak-111	109.2	73.7	80.5	91.7
21.	1007–63	Pak-111	111.9	74.5	83.4	85.0
22.	996–63	Pak-111	113.7	73.9	84.0	91.7
23.	1002–63	Pak-111	124.2	68.3	84.8	70.3
24.	989–63	Pak-111	129.5	67.4	87.3	67.9
25.	1006–63	Pak-111	138.4	63.8	88.3	90.4
26.	990–63	Pak-111	132.9	67.9	90.2	84.6
27.	1011–63	Pak-111	127.0	71.3	90.5	100.2
28.	1025–63	AC275	119.6	75.8	90.6	71.0
29.	988–63	Pak-111	128.9	71.5	92.2	74.5
30.	1005–63	Pak-111	130.5	71.1	92.8	84.2
31.	1015–63	AC306	134.5	70.4	94.7	91.1
32.	1003–63	Pak-111	139.7	68.7	95.9	76.0
33.	1017–63	AC306	142.1	73.9	104.9	115.1
34.	1014–63	Pak-8	143.6	75.4	108.3	101.5
35.	1018–63	AC306	175.7	62.4	109.6	107.0
36.	1027–63	AC256	138.3	81.6	112.8	97.2
37.	1028–63	AC256	141.5	79.9	113.1	102.2
38.	1026–63	AC275	136.3	83.1	113.2	90.4
39.	AC134	Standard	174.5	68.4	119.4	71.2
40.	AC307	Standard	157.4	76.5	120.4	122.0
41.	1008–63	Pak-111	164.2	76.5	125.6	98.7
42.	Pak-111	Standard	169.2	74.4	125.9	82.9
43.	1013–63	Pak-8	170.6	74.2	126.6	83.6
44.	985–63	Pak-111	152.0	83.6	127.0	75.1
45.	L.S.S.	Standard	178.3	75.7	134.9	81.3

1962–63; the range in other families being 231.8 to 367.3 against 399.4 for L.S.S. in the first year and 53.1 to 175.7 against 178.3 for L.S.S. during the second year. 13 families showed less percentage of foliage than L.S.S., at first pick in 1962–63, and 39 families were better than L.S.S., on this respect during the second year.

Fourteen families showed a desirable combination of less leaf number and higher yield than L.S.S. in 1962–63 and 24 families were superior to L.S.S. in this respect during the second year, showing considerable scope for successful breeding of cotton varieties shedding leaves before first picking for obtaining high grades of cotton.

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