GENETIC ANALYSIS FOR YIELD, FIBRE ANL SEED QUALITY CHARACTERISTICS IN UPLAND COTTON

By

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To

The Controller of Examinations,
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We, the Supervisory Committee, certify that the contents and forms of thesis submitted by Saif Ullah Khan Ajmal have been found satisfactory and recommend that it be processed for evaluation by the external examiner(s) for the award of the degree.

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(SAIF ULLAH KHAN AJMAL)

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CHAPTER I

INTRODUCTION

The importance of cotton plant (*Gossypium hirsutum* L.) in Pakistan does not need any emphasis. The cotton fibre, in addition to being a raw material of the local textile industry, is also a major export commodity of the country. It contributes about 68% to the total annual foreign exchange earnings, thus the cotton plant is the mainstay of the economy of Pakistan.

Concerted efforts of the breeders across the country could develop promising cotton materials through hybridization and selection, which possessed greater yield potential combined with improved fibre characteristics. The wider adoption of high yielding varieties under varying climatic conditions of the country brought about significant breakthrough in the national cotton production scenario. The seed-cotton yield of 157 kg ha^{-1}, at the time of independence (1947), increased to 769 kg ha^{-1} during 1991-92. Similarly total lint production of the country increased from 1156 thousand bales to 12822 thousand bales during the same period (Afzal, 1993), thus Pakistan attained the position of fourth biggest cotton producer of the world.

A great deal of research work has been done in the domain of cotton breeding, however, the changing circumstances in the country necessitate the cotton breeder for further exploitation of its genetic potential.

Cotton seed in addition to fibre, is also a major source of edible oil as it adds about 75% to the local oil production in Pakistan (Khan and Khan, 1995). The edible oil expelled from conventional and non-conventional oilseed crops is insufficient to meet the local requirements of the country, therefore, the government has to spend over 15 billion rupees on the import of edible oils, which is second after the import of petroleum (Anonymous, 1993).

In Pakistan the American cotton, since its introduction, is being primarily cultivated for the production of fibre, and the efforts done in the past remained focused on increasing their acre-yield. Therefore, in the unidirectional breeding programme of the past the potential of oil and protein in the cotton germplasm remained unexploited. It is only in the recent years that the importance of cotton plant as a source of edible oil has been realized. There are reports which show that variability in cotton germplasm for oil and protein does exist, and this potential may be exploited to increase the oil content (Kohel and Cherry, 1983; Bhale *et al.*, 1989).

Keeping in view the importance of cotton plant as a source of fibre and oil, a research programme was undertaken with the objective of studying the inheritance pattern of different plant characters alongwith oil and protein content in the existing germplasm, so that the appropriate genetic resources may be utilized to bring about improvement in the desired characters.

Diallel analysis technique developed by Hayman (1954 a,b) and Jinks (1955) is a biometric method commonly used by the breeders. It provides useful information on the genetic mechanism of variation in different plant characters and therefore, this technique was followed in the present investigations. When the information about different components of variation i.e. additive, non-additive, epistasis and linkage in plant material is available, the selection of desirable combinations in segregating generations becomes easier. Similarly the nature of association of yield with its components and cause-effect relationship may also be helpful to a breeder looking for desirable combination of characters in the segregating material. The improvement in a plant character may be more effective and rapid if understanding about the transmissibility of variation in a character is developed. Therefore, analyses of correlation and path coefficient of F_2 data along with estimates of heritability have also been carried out in the present studies.

CHAPTER II

REVIEW OF LITERATURE

Genetic Analysis

Jinks (1954) for the first time used diallel cross data on *Nicotiana rustica* L. varieties, and he said that regression of array covariance on variance had an expected slope of unity. This was found to be true in case of flowering time, whilst the remaining characters deviated to varying degrees from the expected slope. The cause of the failure of the assumptions was genetic interaction in some of the F_1 progenies. The deletion of such progenies from the data gave the regression line of unit slope.

Hayman (1954 a) followed the same technique in order to understand the genetic basis of variation in some quantitative characters of *Nicotiana rustica* L. plant material. He demonstrated an easier way of extracting genetic information from a diallel cross data by plotting the covariance of each array against its variance. In another study, Hayman (1954 b) not only affirmed the formulae given by Jinks(1954), but also found that the following assumption must be fulfilled before analysis of the data i.e. i) diploid segregation, ii) no difference between reciprocals, iii) independent action of non-allelic genes, iv) no multiple allelism, v) homozygous parents and vi) independent distribution of genes among the parents.

Jinks (1955) continued the use of diallel cross analysis of the data on other crops i.e. maize, flax and egg plant. He observed that over-dominance in the genes was the result of interaction between non-allelic genes. After omitting all crosses involving significant non-allelic interaction, a drop in the degree of over dominance was observed.

White and Kohel (1964) applied diallel technique to study the inheritance pattern of 14 agronomic characters of 51 lines of *Gossypium hirsutum* L. The data, they collected, showed the existence of additive variation in all the characters, however a degree of dominance was detected in case of plant yield, boll size, number of bolls plant^{-1} and vegetative weight.

White (1966) studied inheritance of some quantitative characters like yield of seed cotton plant^{-1}, boll weight, lint percentage and seed index in *Gossypium hirsutum* L. and observed that these characters were under additive genetic control.

Al-Rawi and Kohel (1969) observed that additive gene effects were more important than non additive genes for yield of seed cotton and other agronomic characters of upland cotton plant. They further noted that all the characters were within the range of partial dominance and under polygenic control.

Salam and Khan (1969) studied 6x6 diallel cross of *Gossypium arboreum* L., and reported that lint percentage and staple length were controlled by additive type of gene action while genes for seed cotton yield showed over-dominance complicated by non-allelic interaction.

Gupta and Singh (1970) studied the genetic system of six ginning and fibre properties in an eight-parent diallel cross of upland cotton. They reported that both additive and dominance variances were highly significant for lint percentage and fibre fineness. Estimates of dominance variance were relatively higher than additive variance. The graphic analysis revealed the presence of high epistatic component for fibre strength and low epistatic effects for ginning outturn, lint index and fibre length.

Pathak and Singh (1970) studied the inheritance pattern of yield and its components in parental, F_1, F_2 and back cross populations of *Gossypium hirsutum* L. The data showed that dominance genetic effects were more important than additive genetic effects for yield of seed cotton and boll number while genes showing additive effects appeared to control other components of yield. There was also indication of presence of epistatic effects for almost all the characters studied.

Singh *et al.* (1971) inferred the genetic mechanism of yield and its components using diallel cross data with diverse varieties of cotton (*Gossypium hirsutum* L.). The data showed that both additive and non-additive genetic variances were significant for the characters under study. The graphic analysis showed the involvement of epistasis in the genetic mechanism of all the characters.

Meredith and Bridge (1972) noted additive genetic effects for variation in lint percentage and seed index whilst dominance genetic effects were greater for boll size. The characters like staple length and lint yield were controlled by both additive and dominance type of gene action.

Patil and Mensenkai (1972) carried out analysis of diallel cross data for some economic characters in diploid cotton and reported overdominance for seven characters studied. Duplicated epistasis was found for yield plant^{-1}, boll weight and lint percentage, while complementary epistasis was observed for number of bolls plant^{-1} and lint index.

Chandramathi and Memon (1973) observed that high additive genetic components were responsible for flower production, number of bolls plant^{-1} and yield of seed cotton and high dominance component for plant height.

Anwar and Khan (1974) conducted 8 x 8 diallel cross analysis of *Gossypium hirsutum* L., and the results revealed that yield of seed cotton, number of bolls plant^{-1} and fibre strength appeared to be controlled by overdominance type of gene action without non-allelic interaction, whilst lint percentage, staple length and fibre fineness were conditioned by additive type of gene action with partial dominance.

Mirza and Khan (1974) studied the genetic basis of yield and its components in cotton and observed that overdominance and non-allelic interaction were important for yield of seed cotton as well as number of bolls plant^{-1} whilst plant height and boll weight exhibited the presence of additive genetic effects.

Radwan and Abo-El-Zahab (1974) observed that effects of genes controlling lint percentage, lint index and halo length were additive in action.

Singh *et al.* (1974) reported that additive and non-additive components of genetic variation were important for plant height, boll number, lint percentage and yield of seed cotton per plant.

Gridley (1975) reported that genetic control of yield and its components were largely additive in nature, although some non-additive genetic effects were also present.

Gururajarao (1975) conducted a six-parental diallel cross of cotton plant and reported that additive genetic component was more important for lint percentage and seed and lint indices. The presence of non-additive genetic mechanism was more important for fibre length and strength while overdominance was observed for fibre strength and partial dominance for other characters.

Selim *et al.* (1978) studied inheritance of lint percentage and its correlation with fibre strength in cross between two varieties of Egyptian cotton. They reported that lint percentage was inherited quantitatively with partial dominance and was found to be highly heritable and correlated with fibre strength.

Khan *et al.* (1979a) studied genetic behaviour of cotton plant and reported that yield of seed cotton, number of bolls plant^{-1} were influenced by additive effects of genes with varying degree of dominance, whilst boll weight was chiefly controlled by overdominance effects of genes.

Singh and Sandhu (1979) conducted a study in order to ascertain the effects of genes on the genetic control of fibre and seed characters in *Gossypium hirsutum* L. The data showed that additive-dominance genetic model was adequate to explain the genetic variance of four plant characters except for lint percentage in cross 231 R x Cocanadas White, in which case epistasis was predominantly involved in the pattern of inheritance. Additive effects of genes predominated in the expression of lint index, while dominance effects were more important than additive effects in the inheritance of lint percentage and halo length. Both additive and dominance effects were significant for seed index except in 231 R x Cocanadas

White, in which only dominance effects were important.

Akhmedov (1980) observed that for yield of seed cotton overdominance was prominent in most of the crosses. The genes for boll weight showed intermediate in their effects. The hybrids were close to the poor parents for fibre yield. Over-dominance for long fibre was found in eleven crosses and complete or partial dominance in the remainders.

Khan *et al.* (1980) made genetic analysis in a diallel cross involving six varieties of *Gossypium hirsutum* L., and reported that lint percentage, staple length, 100 seed weight and lint weight were controlled additively with partial dominance.

Simongulyan and Hossan (1980) made six-parent diallel cross and made genetic analysis of the data for various economically useful plant characters. The yield of seed cotton and its components were controlled by the genes showing both additive and dominance effects. Overdominance occurred in a number of cases, whilst incomplete dominance was found for fibre length and strength.

Singh and Singh (1980) studied genetic behaviour of ginning characters in nine varieties of *Gossypium hirsutum* L. and their 36 progenies. Both additive and non-additive genetic variances were significant for lint percentage, lint index and seed index. Lint percentage was mainly governed by dominant genes but recessive genes predominated by 10-13 percent for lint and seed indices.

Singh *et al.* (1980) tested five quantitative characters in different cross combinations of *Gossypium hirsutum* L. and observed that all the characters were affected by both additive