This Thesis

is

DEDICATED

to

the memory of

a dear friend,

the late

ALHAJI MUSTAFA TIJABE, M.P.S.

INVESTIGATIONS OF THE ENVIRONMENTAL AND GENETIC FACTORS AFFECTING EARLINES3 IN COTTON, GQSSYPIUM HIRSUTUM L.

A Thesis

Submitted to the Faculty of Agriculture,

Ahmadu Bello University Zaria,

In Partial Fulfilment of the Requirements

for the Degree

of

Doctor of Philosophy

by V

Shettima Mustafa

JULY 1979

DECLARATION

I hereby declare that this disseration is a report of my own original work. It has not previously been submitted for a degree or any other qualification. All references consulted are given in the bibliography.

Date: 24 July 1979

SHETTIMA MUSTAFA

ACKNOWLEDGEMENTS

I am greatly indebted to my major Professor Dr. Wyman E. Nyquist of the Department of Agronomy, Purdue University, West Lafayette, Indiana, U.S.A. for the invaluable help rendered in the analysis and the interpretation of the data. My gratitude also goes to my supervisors Dr. L.B. Olugbemi and Dr. M.M. El-Rouby both of the Department of Plant Science, Ahmadu Bello University, Zaria, for their guidance and inspiration from the conception of this project through to the end. I must not fail to mention the tremendous co-operation and assistance I received from Messrs Lucius A. Nace, Yusufu Garkida, Paul Ekeyi, and Joel Oloye in the selfing and crossing work, as well as in the actual collection of data in the field, and from Mr. David A. Orkar who ran all the lint quality tests on these materials; and also from the several other members of staff of the Fibre Breeding Section of the Institute for Agricultural Research, Samaru.

I also wish to express my sincere gratitude to Dr. Marvin W. Phillips, Head, Department of Agronomy, Purdue University for placing the facilities of his department at my disposal and to Purdue University for offering me a Visiting Scholar status which enabled me to go over to Purdue and write

up this thesis. Messrs Carl B. Pennington and Richard S. Burns of the Department of Agronomy, Purdue University, and Mr. S. Abed and his colleagues of the I.A.R. Statistical Service Unit have also helped with computer analyses. The useful suggestions made by Drs. L.G. Lombin, A. Omran, and O.A. Okafor after going through the draft of the thesis are hereby acknowledged.

I wish to place on record all the wonderful hospitality my family and I enjoyed from Dr. and Mrs. Nyquist at the time of our arrival and during our stay at Lafayette. Similarly I wish to use this opportunity to say a big 'thank you' to M. Abdulkadir Benisheikh and his wife, Aisa, both of Ahmadu Bello University for taking over some of the responsibilities for part of my family while the rest of us were away in the U.S.A. to finish this work; and to my family and close friends who bore the year-long separation.

Lastly, I wish to express my gratitude to the Director, Institute for Agricultural Research, for his support and encouragement; to Ahmadu Bello University, Zaria, for awarding me the study fellowship, and finally to the government of Borno State of Nigeria for the financial grant, all of which enabled me to travel to the United States of America to complete this thesis.

TABLE OF CONTENTS

	Page
Acknowledgements	i
List of Tables	vi
List of Figures	xv
Abstract	xvi
CHAPTER ONE	
INTRODUCTION	1
CHAPTER TWO	
LITERATURE REVIEW	5
1. Measures of earliness	5
2. Effects of environmental factors on earliness ..	7
3. The genetic aspects of earliness	10
CHAPTER THREE	
MATERIALS AND METHODS	16
1. Experimental materials	16
2. Cultural practices for early-sown, sprayed crop	19
3. Cultural practices for late-sown, unsprayed crop	19
4. Characters studied	20
5. Experimental details	24
5.A Agronomic studies	24
5.A.1 The 1975 experiment: 3 x 3 factorial (Experiment 1)	24

Page

5.A.2 The 1977 experiment: 3 x 2 factorial (Experiment 6) 25

5.A.3 Statistical analyses 26

5.B Genetic studies 31

Series I: Diallel cross studies, June and July sown, 1976 and 1977 (Experiments 2, 3, 7 and 7) 31

5.B.I.1 Statistical analyses 33

Series II: Individual crosses between varieties of different maturities, 1976 and 1977 (Experiments 4, 5 and 9) 39

5.B.II.1 Statistical analyses 42

CHAPTER FOUR

RESULTS AND DISCUSSION 49

1. Preliminary studies 49

2. The main studies 52

A. Agronomic studies 52

2.A.1 The combined analysis for 1975 and 1977 52

2.A.2 The individual year analyses 60

2.A.3 Conclusion 75

B. Genetic studies 77

Series I: The diallel cross analysis ... 77

2.B.I.1 Combined analysis over years and dates 77

2.B.I.2 Combined analysis over 2 years for June sowing (D1) 87

2.B.I.3 Combined analysis over 2 years for July sowing (D2) 93

2.B.I.4 Analyses of the individual experiments 102

		Page
2.B.I.5	Analysis of the lint quality data ...	107
2.B.I.6	Conclusion	110
Series II:	Studies of specific crosses ...	111
2.B.II.1	Stripper (early) x UK66 (late) cross grown in 1976 (Experiment 4) ...	111
2.B.II.2	2421 (early) x Samaru 71 (intermediate) cross, grown in 1976 (Experiment 5)	118
2.B.II.3	Stripper (early) x UK66 (late) cross grown in 1977 (Experiment 9) ...	124
2.B.II.4	Conclusion	127

CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSIONS	128
1. Future considerations	131
BIBLIOGRAPHY	133
APPENDIX	141

LIST OF TABLES

Table		Page
1	Origin and maturity grades of the varieties studied	17
2	Sources, degrees of freedom, and expected mean squares for the analyses of the agronomic experiments (adopted from Snedecor and Cochran, 1974)	29
3	Sources, degrees of freedom, and expected mean squares for the analyses of the diallel experiments	35
4	Sources, degrees of freedom and expected mean squares for the analysis of variance of different generations of specific crosses in 1976 ...	45
5	Means and their standard errors for replicated plots in 1970, 1971 and 1972(i) and means of non-replicated plots in 1972(ii) and 1973 for many variables	50
6	Mean squares from a combined analysis of variance over 2 years, 3 sowing dates, 2 nitrogen levels and 7 varieties	53
7	Varietal means from a combined analysis of variance over 2 years, 3 sowing dates, and 2 nitrogen levels (1975 and 1977)	56
8	Mean squares from the analysis of an experiment involving 3 sowing dates, 3 nitrogen levels and 7 varieties conducted in 1975	61
9	Means averaged over replications and nitrogen levels of the sowing date x variety interaction, and means of nitrogen (bottom part) averaged over all other factors in 1975 for earliness characters	64
10	Means averaged over replications and nitrogen levels of the sowing date x variety interaction, and means of nitrogen (bottom part) averaged over all other factors in 1975 for yield characters and GP	69

Table		Page
11	Mean squares from the analysis of an experiment involving 3 sowing dates, 2 nitrogen levels and 7 varieties conducted in 1977	73
12	Varietal means averaged over replications, sowing dates and nitrogen levels; and means of dates averaged over all other factors	74
13	Mean squares from an overall combined analysis of variance of a seven-parent diallel cross over 2 years and 2 sowing dates (June and July)	78
14	Mean squares for the general and specific combining ability of a seven-parent diallel cross from an overall combined analysis over 2 years and 2 sowing dates	82
15	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in an overall combined analysis over 2 years and 2 sowing dates	84
16	Mean squares from a combined analysis of variance of a seven-parent diallel cross over 2 years for June-sown trials	88
17	Mean squares for general and specific combining ability of a seven-parent diallel cross from a combined analysis over 2 years for June-sown trials	89
18	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in a combined analysis over 2 years for June-sown trials	91
19	Mean squares from a combined analysis of variance of a seven-parent diallel cross over 2 years for July-sown trials	94
20	Mean squares for general and specific combining ability of a seven-parent diallel cross from a combined analysis over 2 years for July-sown trials	96

Table		Page
21	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in a combined analysis over 2 years for July-sown trials	97
22	Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for June-sown trial in 1976	103
23	Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for July-sown trial in 1976	104
24	Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for June-sown trial in 1977	105
25	Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for July-sown trial in 1977	106
26	Mean squares from the separate analyses of variance for lint quality tests of the diallel cross	108
27	Mean squares from an analysis of variance from the untransformed data from individual plants of the cross Stripper x UK66 grown in 1976 ...	112
28	Means, standard errors, mid-parent values and the A,B,C, scales for the additive dominance model, and also the D,H,E component of phenotypic variance from the untransformed data of the cross Stripper x UK66, grown in 1976	113
29	Mean squares of the analysis of variance of untransformed data from individual plants of the cross 2421 x Samaru 71 grown in 1976 ...	119
30	Means, their standard errors, mid-parent values and the A,B,C scales for the additive-dominance model, and also the D,H,E components of phenotypic variance from the untransformed data of the cross 2421 x Samaru 71, grown in 1976 ...	120

Tables		Page
31	Mean squares from an analysis of variance from the untransformed data from individual plants of the cross Stripper x UK 66, grown in 1977 ...	125
32	Means, their standard errors, and mid-parent values from the untransformed data of the cross Stripper x UK 66 grown in 1977	126
	APPENDIX TABLES	
A1	Total monthly rainfall in mm at Samaru at 10-day intervals for 1975, 1976 and 1977 ...	141
A2a	Estimates of the linear (l) and quadratic (q) contrasts of the sowing date x variety interaction for earliness characters in 1975 and 1977 (only BP in 1977)	142
A2b	Estimates of the linear (l) and quadratic (q) contrasts of the sowing date x variety interaction for yield component characters and GP in 1975	144
A3	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven-parent diallel cross in an overall combined analysis over 2 years and 2 sowing dates	145
A4	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven-parent diallel cross in an overall combined analysis over 2 years and two sowing dates	146
A5	NSB per meter of PHT for the parental$^+$ (main diagonal), F1 (bottom left half and F_2 (top right half) generations in the overall combined analysis over 2 years and 2 sowing dates	147

Tables		Page
A6	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) in an overall combined analysis over 2 years and 2 sowing dates	148
A7	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures generations for NSB (bottom left half) and PHT (top right half) in an overall combined analysis over 2 years and 2 sowing dates	149
A8	NSB per meter of PHT for the parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) for the June-sown (bottom left half) and July-sown (top right half) trials combined over 2 years	150
A9	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross in a combined analysis over 2 years for June sown trials	151
A10	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross in a combined analysis over 2 years for June sown trials	152
A11	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) for the June sown trials combined over 2 years	153
A12	Means of parental (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) for the June sown trials combined over 2 years	154

Tables		Page
A13	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for July sowing	155
A14	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for July sowing ...	156
A15	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of seven-parent diallel cross in a combined analysis over 2 years for July sowing ...	157
A16	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) of seven-parent diallel cross in a combined analysis over 2 years for July sowing ...	158
A17	Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for July sowing	159
A18	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) for the July sown trials combined over 2 years	160
A19	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) for the July sown trial combined over 2 years	161
A20	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) for the July sown trial combined over 2 years	162

Tables		Page
A21	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) for July sowing combined over two years	163
A22	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) for July sowing combined over 2 years ...	164
A23	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross for June sown trial in 1976	165
A24	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross for June sown trial in 1976	166
A25	Means of parental (main diagonal), F_1 (bottom left half) and F_2 (top right half) generations for TFP in a seven-parent diallel cross for June sown trial in 1976	167
A26	Means of parental (main diagonal), F_1 (upper figures and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for June sown trials in 1976	168
A27	General combining ability effects in the F_1 (top half) and F_2 (bottom half) generations of a seven-parent diallel cross for July sown trial in 1976	169
A28	Means of parental (main diagonal), (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of seven parent diallel cross for July sown trial in 1976	170
A29	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of a seven-parent diallel cross for July sown trial in 1976	171

Tables		Page
A30	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of seven parent diallel cross for July sown trial in 1976	172
A31	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) of a seven parent diallel cross for July sown trial in 1976	173
A32	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven-parent diallel cross for July sown trial in 1976	174
A33	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross for June sown trial in 1977	175
A34	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven parent diallel cross for June sown trial in 1977	176
A35	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of a seven parent diallel cross for June sown trial in 1977	177
A36	Means of parental (main diagonal) F_1 (upper figures) F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross for June sown trial in 1977	178
A37	Means of parental (main diagonal), F_1 (upper figures) generations for Yield (bottom left half) and TFP (top right half) of a seven parent diallel cross for June sown trial in 1977	179

Tables		Page
A38	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for June sown trial in 1977	180
A39	General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross for July sown trial in 1977	181
A40	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven parent diallel cross for July sown trial in 1977	182
A41	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of a seven parent diallel cross for July sown trial in 1977	183
A42	Means of parental (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross for July sown trial in 1977	184
A43	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) of a seven-parent diallel cross for July sown trial in 1977	185
A44	Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent-diallel cross for July sown trial in 1977	186
A45	Means of lint quality test results for the parental (main diagonal), F_1 (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven parent diallel cross for June sown trial in 1976	187

Tables

		Page
A46	Means of lint quality test results for the parental (main diagonal), F_1 (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for July sown trial in 1976	188
A47	Means of lint quality test results for the parental (main diagonal), F_1 (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for June sown trial in 1977	189
A48	Means of lint quality test results for the parental (main diagonal), EL (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven parent diallel cross for July sown trial in 1977	190
A49	Mean squares from an analysis of variance from a log transformed data of the cross Stripper x UK66; and also the mean squares for the generations (bottom), grown in 1976	191
A50	Means, their standards errors, mid-parent values and the A, B, C, scales for the additive dominance model, and also the D,H,E components of phenotypic variance from a log transformed data of the cross Stripper x UK 66, grown in 1976	192
A51	Means squares from an analysis of variance from the log transformed data of the cross 2421 x Samaru 71; and also the mean squares for the generations grown in 1976	194
A52	Means, their standard errors, mid-parent values and the A, B, C, scales for the additive dominance model; and also the D,H,E components of phenotypic variance from a log transformed data of the cross 2421 x Samaru 71, grown in 1976	195

Figure

1	Graph showing the rainfall patterns at Samaru at 10-day intervals for 1975, 1976 and 1977	58

ABSTRACT

Agronomic and genetic aspects of early maturity in cotton were investigated using seven varieties of cotton originating from diverse backgrounds. The varieties used are: 2421 - K.4489 (V), Striper 61-15: 62-7 (V_2), Arkansas 52-21 (V3), Samaru 71 (V_4), Samaru 72 (V5), Samaru 26J (V6) and UK66 (V7).

The agronomic trials were conducted in 1975 and 1977. Three sowing dates and three levels of nitrogen were employed in 1975 whereas three sowing dates and two nitrogen levels were used in 1977. In the genetic trials, two series of experiments were conducted in 1976 and in 1977. Firstly, a diallel cross series involving all the seven varieties, their F1's, and F2 's were put into trials under two contrasting conditions of June and July plantings in each year. Secondly, a series of selected specific crosses involving parents of different maturity dates, their F1 's, F2 's and backcrosses were tried under June sown conditions only in the two years. In each case, observations were made on several earliness and yield characters.

When the two-year results of the agronomic trials were combined, none of the characters was influenced by planting

dates or nitrogen levels. There **were,** however, significant interactions between the year and each of these two main factors for days to first flower (DFF), and between the year and the dates for seed weight and number of seed. In this respect, both the node of the first fruiting branch (NFB) and DFF can be regarded as reliable measures of earliness. The individual analyses showed that early sowing date had favourable influence on most of the earliness and yield characters in both years, while higher nitrogen levels favourably influenced yield and related characters more than those of earliness in 1975. Combined first and second picks as a percentage of the total pick (E2%) was also found to be a good measure of earliness as it showed a most distinguishing effect between the early and the late types. However, there was a considerable change of ranking between the early and the intermediate varieties for various characters. Nevertheless, V and V were consistently early maturing.

In the diallel studies, there was no significant difference in maturity between crop sown in June and that sown in July, but on the average, the 1976 crop took longer to mature than the 1977 crop. The general combining ability (gca) mean squares were very large while the specific combining ability (sea) mean squares were very small (or even zero) for all characters in both the F and the F analyses. This would seem to

indicate that the varieties were heterogeneous and probaly heterozygous also. F1 hybrids of early maturing parents were found to be earlier than hybrids of late maturing parents, and some of the hybrids, especially those involving V1 V2 and possibly V , combined earliness with high productivity. Positive and negative gca effects for the different characters also indicate that some of the varieties had combinations of characters favourable for the expression of earliness. Hence their initial improvement through breeding seemed promising. The significant year x gca and year x sea interaction would necessitate measuring these effects over years. When the two planting conditions were considered separately, it was noticed that NFB and DFF were reliable measures of earliness for the June planting and E2% for the July planting conditions.

In the specific cross studies, there was an indication of dominance for earliness in both the early x late and the early x intermediate crosses, but the nature of the variances would not permit a reliable estimation of the genetic parameters. There were a few cases of heterotic effect when measured as the difference between the F1 and the mid-parent value, but in general heterosis was not frequent in these studies. In addition, the total number of sympodial branches on the main stem (MSB) per meter of plant height was also measured. Considering

this as some measure of relative productivity, it was noticed that, the early maturing varieties had higher NSB/meter of PHT than the late ones, despite the fact that the former wore shorter plants and had fewer NSB. Narrow sense heritability (h2) estimates showed high values for most earliness characters in both the early x late and the early x intermediate crosses, thus indicating that these characters would respond favourably to selections.

In the genetic studies, it was generally noticed that the variances of the non-segregating generations were larger than those of the segregating generations for some characters. This was largely due to the bulking of selfed seed from different rent individual plants which presumably increased the variability of the parental generation. Nevertheless, it is possible to breed for earliness in these varieties at least initially without the complications of dominance and epistasis.

CHAPTER ONE

INTRODUCTION

INTRODUCTION

The broad aim of the cotton breeding programme in Nigeria is to develop high yielding, early maturing varieties with improved ginning percentages, resistance to pests and to diseases and of acceptable lint quality from the point of view of the Nigerian textile industry. Hitherto, the emphasis has been on standard quality (short staple), high yielding and bacterial blight resistant varieties, but the quality aspect came into prominence with the decision to develop medium staple cotton. Since 1970, breeding for early maturity has assumed increasing importance.

The history of the improved varieties of cotton in Nigeria started with the introduction of an American upland type, the Allen Long Staple, from Uganda in 1912. From this stock improvements were made through selection, leading to subsequent development of the Nigerian Allen and later the Samaru Allen (Choyce, 1968). Satisfactory levels of yield, resistance to bacterial blight and lint quality characteristics have been achieved in the Samaru Allen compared to its ancestors. Several commercial varieties (Samaru 26J, Samaru 68, Samaru 69, Samaru 70 and Samaru 71) have been developed from Samaru Allen which thus forms the basic stock of Nigeria's cotton breeding

programme. However, since the early nineteen sixties many cul-tivars, some with very distinctive characteristics have been introduced into Nigeria from different parts of the world and tested at Samaru. Among these, 2421-K4489 from the U.S.S.R., Stripper 61-15:62-7 and Arkansas 52-21 from the U.S.A., and G.105.4.6SR from Australia were found to be considerably earlier maturing than the Samaru varieties, while UK66, a Tanzanian type was much later maturing. Four of these and three of the Samaru varieties were included in this study.

The bulk of the Nigerian cotton crop which is rainfed is almost entirely grown in the northern states of Nigeria (an area approximately 700,000 km^2) extending from latitude $7^{o}30N$ to $13^{o}N$ and from longitude $4^{o}E$ to $13^{o}E$ with very little in Bendel and Oyo States. This region of major cotton production is characterised by pronounced fluctuations in local and seasonal climatic conditions. Of all the climatic factors which influence the pattern and productivity of rainfed agriculture in Nigeria, availability of moisture is by far the most important. Pronounced differences exist in the length of growing season due to the differences in the distribution and amount of annual rainfall, ranging from the extreme south where crops may be grown throughout the year to the extreme north where the growing season is only about 100 days (Kowal and Kassam, 1973, and Walter 1967).

The latter region forms a large proportion of the area of major cotton production. These climatic extremes have become rather more pronounced since 1970. Meteorological observations at Samaru (latitude 11° 11'N, longitude 70°35'E and altitude 685m) over the past few years showed that in 1970 rainfall was below expectation in April, June and early July as well as at the end of the season in late September and early October. Similar observations were reported for 1971 (Faulkner, 1973) and 1972 (Kowal and Adeoye, 1973, and Faulkner, 1974) and also for 1973 (Hayward, 1975). This indicated a below average rainfall for four consecutive years (i.e. drought years) in this relatively dry region which seriously affected the establishment and the performance of crops. In some cases it might also have affected the pest complex of the late sown cotton crop. The rainfall data for 1975, 1976 and 1977 is given in Table A1.

The factors enumerated above are compounded by a diversity of husbandry practices which provide no buffer for the crop against its environment. In most areas, the majority of farmers sow late, usually in late July or in early August, and hardly ever apply the appropriate doses of fertilizers or proper pest control measures despite the recommendations. All these add up to affect seriously the total production of cotton. Hence, the restricted wet season and the practice of sowing cotton late

following the planting and establishment of food crops in the cotton growing region, necessitate the development of early maturing cotton varieties. This will be facilitated by an understanding of the factors contributing to earliness which is the object of this study. Accordingly, preliminary observations were made during 1972/73 and 1973/74 seasons on the flowering pattern and other earliness traits of many local and introduced varieties which eventually led to the selection of those involved in the present study.

The work reported here was carried out under two broad aspects: agronomic and genetic, resulting in a series of experiments being conducted between 1975 and 1977 for those purposes.

CHAPTER TWO

LITERATURE REVIEW

LITERATURE REVIEW

1. Measures of Earliness

Earliness of maturity in cotton is measured in a number of ways including harvest data (seedcotton and lint yield) and morphological features of the plant. Ludwig (1931) used the period of squaring (number of days from square initiation to anthesis) and of bolling (number of days from anthesis to boll split), and Brown (1951) used the period from sowing to first flower opening and date of peak flowering. Various measures, such as the first pick as percentage of the total, date of flowering, days from sowing to the ripening of 50% of the bolls, squaring and bolling periods and mean maturity date (MMD) were given by Christidis and Harrison (1955). They reported that earliness was more of a result of early flowering and/or of a short bolling period, and concluded that MMD when secured over a number of years might provide an accurate determination of the relative earliness of cotton varieties.

Richmond and Radwan (1962) compared seven methods of measuring earliness, three of which dealt with time, namely, number of days from planting to first square (E_1), to first flower (E_2) and to first boll split (E_3) while the remaining four dealt with various proportions of the crop harvest data

expressed as percentage of the total harvest. The ratio of the number of open bolls at the first pick (E_4), ratio of the number of open bolls at the combined first and second picks (E_5), percentage weight of the first pick (E_6) and percentage weight of the combined first and second picks (E_7). They considered E_7 as the most practical measure of earliness. Richmond and Ray (1966) used the amount of crop harvested at a specified date (ACH), percentage of crop harvested in a specified harvest (PCH), and MMD, and found that MMD was the most useful criterion. They however pointed out that no single measure could be considered completely acceptable in all breeding situations or under all conditions, but reasonably reliable measures for estimating earliness are available for application to specific objectives. Using morphological features such as node of the first fruiting branch (NFB), number of vegetative branches (NVB) and percentage of bolls on monopodial branches (PBV) as measures of earliness in cotton, Ray and Richmond (1966) considered NFB as the most reliable and most practical measure. They concluded that NFB and MMD when used together form a reliable basis for estimating earliness in genetic studies as well as in breeding programmes.

Mooseberg (1969) measured earliness in terms of the rate of flower production, bolling period and PCH at first harvest in the variety Arkansas 52-21 and concluded that earliness was

the summation of a reduced number of days to first flower, an advance in fruiting rate and a reduced bolling period. Munro and Farbrother (1969) gave a detailed description of the composite plant diagrams which can be used for estimating the flowering and fruiting behaviour of cotton. Munro (1971) studying earliness in cotton gave the vertical flowering interval (VFI, the period in days between the opening of flowers of similar node number on successive fruiting branches up the mainstem), horizontal flowering interval (HFI, the period in days between the opening of flowers at successive nodes along each fruiting branch), date of the first flower (DFF) from which he estimated the date of standard flower (DSF) and NFB as factors of earliness. Bilbro and Quisenberry (1973) proposed a production rate index (PRI) as a measure of earliness and indicated that the values were generally more suitable than MMD values as they also relate to yield.

2. Effects of environmental factors on earliness

A number of environmental factors are known to influence earliness in cotton. These include moisture stress, atmospheric temperature, fertility levels, sowing dates and many others. Spooner, Caviness and Spurgeon (1958) reported that bolling period (BP) in cotton was delayed by irrigation while severe moisture stress led to earlier boll opening. On the contrary,

Morris (1964) found that excessive dry conditions at flowering and at bolling do not shorten, but may lengthen the period of boll maturation. He also observed that in Uganda higher temperatures shorten the mean maturity period. In a dry season experiment at Samaru, Nigeria, Mustafa (1976) reported that low temperature greatly delayed the period from sowing to first square but did not affect NFB in the varieties studied. Yfoulis and Fasoulas (1978) indicated that there was a "minimum limit" of night temperature (16^{o}C) below which boll maturation was adversely affected, and a "maximum limit" of day temperature (32^{o}C) above which boll maturation was delayed in Greece.

From the fertility standpoint, the effect of nitrogen fertilization on earliness in cotton has received a considerable attention. Wadleigh (1944) indicated that fruiting period (presumably the period during which the plants remain reproductive) was consistently lengthened by the higher nitrogen levels. He also reported that the growth of the main axis, the number of fruiting branches and the number of nodes on the fruiting branches were determined by the levels of nitrogen applied but vertical and horizontal flowering intervals were not. Both rates of flower and boll production per day were greatly increased by high levels of nitrogen. Perkins and Douglas (1965) have shown that percent first pick (E_6) was not affected by nitrogen.

Apparently, the most suitable time to take the first pick varies with different situations. However, deficiency of nitrogen especially at the early growth stages adversely affected fruiting in cotton (Gardener and Tucker, 1967). Ashley et al (1974) reported that addition of nitrogen resulted in enhanced rate of flowering. Thompson et al (1976) also found that cotton plants grown under low nitrogen flowered later, produced fewer fruits and fewer mainstem nodes and had increased number of NFB than those grown under higher levels of nitrogen. They however noticed that delayed fruiting was associated with the higher nitrogen levels.

The effect of sowing dates on earliness in cotton seemed to have received less attention than did some of the other environmental factors. Nonetheless, Christidis and Harrison (1955) working in Greece reported that date of sowing had a considerable effect on the date of maturity since both flowering and bolling periods were lengthened by late planting. Morris (1964) on the other hand, showed that the mean maturation periods of bolls set on corresponding days in relation to the time of the first flower, do not differ for the early and the late sowing dates. Bilbro and Ray (1973) testing cotton cultivars under five sowing dates reported that, the earlier the maturity of a cultivar, the less adversely were its yield and fibre properties

affected by late plantings. They calculated the MMD and PRI for the three cultivars from their 1963 data, averaged over sowing dates, and showed that the cultivars differed among themselves for these measures of earliness. Planting dates affected yield and quality characteristics more than MMD and PRI. However, the MMD and PRI were observed in three of the five planting dates.

The effects of other environmental factors such as row width and plant spacing on earliness have been reported in the literature. Tugwell and Waddle (1964) showed that more seed-cotton was harvested at the first pick (E_6) when there were two to five plants per hole than when there was only one, thus indicating a delay in fruit development due to the single plant per hole. Kirk, et al (1969) at Lubbock, Texas, reported that higher percentage of the crop had opened on wider row-width and wider plant spacing than on the narro' row-width and narrow spacing. They also reported that NFB was not influenced by either row width or plant spacing.

3. The genetic aspect of earliness

Harland (1939) in a study of crosses between low NFB and high NFB plants in cotton, found the F_1 to be intermediate between their two parents and the majority of the F_2 plants had low NFB. In a backcross to the high NFB parent, he obtained a

segregation ratio which suggested a three factor genetic control of this character. Studying characters in crosses of upland cotton over a period of 3 years, Kime and Tilley (1947) found that the F_1 produced significantly more flowers and open bolls (total number of open bolls just before the first pick) than the earlier parent. Both the F_1 and the F_2 means were considerably higher in these paramters than the higher parental mean and they concluded that hybrid vigour was expressed for these characters. Jones and Loden (1951) reported that the F_1 generation mean for E_6 was significantly higher than that of the parental generation. They however found no such heterosis for NFB or the height of NFB from the ground level. In both of these characters the F_1's were approximately intermediate between their two parents. Miller and Marani (1963) measuring percent heterosis by using the deviation of the F_1 from the mid parental value $[(F_1-MP)/MP]$ reported significant heterosis for E_6 and for lint yield and lint quality characters.

In a study of the genetics of bolling period in three varieties of cotton, Hintz and Green (1954) indicated the presence of additive genetic effects. Although they conducted their experiments over two years, they did not draw any inferences on the genotype x environment interactions because of the presence of heterozygosity in the parental materials studied.

White and Richmond (1963) reported significant general combining ability effects for this trait, thus showing additive effects to be more important. White and Kohel (1964) studied several earliness traits including NFB, days to anthesis, relative fruitfulness (number of bolls per 100g aerial vegetative weight), fruiting index (ratio of the weight of fruiting to vegetative parts), E_7 and number of bolls per plant. They conducted Bartlett's test for homogeneity of variances computed over replications and found significant chi-square values for all characters except E_7, thus suggesting heterogeneity of variances thereby rendering the validity of their analysis questionable. However, they conducted the Wr-Vr analysis of variance and the analysis for the components of the diallel in which significant additive effects for NFB and fruiting index and significant dominance effects for bolls per plant were noticed. They also indicated the ~~ence of maternal influence on days to anthesis and reciprocal differences for E_7. White (1966) reported that multiple allelism controlled E_8.

For the character PCH, Richmond and Ray (1966) found evidence for dominance of earliness in two early x late crosses and for dominance of lateness in a late x late cross. They reported large environmental variances for ACH, PCH and MMD

with very low heritabilities only after a certain number of harvests have been made for the first two characters. Hence they concluded that all three can be reasonably utilized in a breeding programme, although the selection of the critical harvest date could be extremely important in the genetic analysis of ACH. In another study involving the same three crosses as above, Ray and Richmond (1966) gave broad sense heritability estimates of 0.60 and 0.43 for NFB in the two early x late crosses with average degree of dominance of 0.54 and 1.18 for NFB and MMD respectively. These observations suggested that genes with incomplete or partial dominance control NFB but those associated with MMD have complete dominance.

Studying earliness and other traits in OK-66 (an early parent) and Acala 44 (a late parent), their F_1's, F_2's and backcrosses, Murray and Verhalen (1969) showed that the genetic control of E_6 was primarily additive with narrow sense heritability estimates of 0.55 in 1961 and of zero in 1962 for this trait. This indicated a differential effect of the environment on the non-segregating generations. Mooseberg (1969) indicated that earliness which was a summation of reduced period to first flower, advanced fruiting rate and reduced bolling period was heritable in combination with other desirable characters.

Al-Rawi and Kohel (1969) in a 9-parent diallel cross study in cotton reported significant heterotic effects for all the characters studied. The cause of the heterosis for total number of nodes and DFF was the presence of dominance only, but for E_6 it was due to epistatic gene action only while for plant height (PHT) it was due to both dominance and epistatic effects. There was no reciprocal difference for total number of nodes, PHT, E_6 and NFB thus agreeing with White and Kohel (1964). Thus Al-Rawi and Kohel (1969) tested the various assumptions for the Jinks-Hayman (1953) diallel analysis and found indications of epistasis in PHT and E_6 and of interaction and multiple allelism in DFF. However, Al-Rawi (1970) using the same materials failed to obtain evidence for epistasis in E_6 in 1966. Differences in the additive effects for this trait among parents were significant and did not interact with the environment (i.e. were constant over years), but the dominance effects did interact. Dominance was in the direction of earliness and over-dominance appeared to be involved. The effective gene number and narrow-sense heritability for E_6 were both low and hence concluded that mass selection would be ineffective as a breeding method for E_6.

Using the joint scaling test method of analysis of Mather and Jinks (1971), Quisenberry (1975) in a cross between

Lubbock Dwarf and TM.1 showed that PHT, number of nodes on the mainstem, NFB, and other characters, adequately fitted the additive dominance model. There were significant additive but not dominance effects for all characters indicating that dominance was not a major factor in inheritance of these characters. Quisenberry (1975) also found significant correlation between NFB and PHT and also between NFB and number of nodes on the mainstem. In another study of plant height and crop maturity characteristics in diallel crosses involving six semidwarf strains of cotton, Quisenberry (1977) found genetic variation among these strains to be primarily additive with small but significant dominance components for both trait groups. There was small but significant heterosis for PHT, internode length, and NFB, and heritability was relatively low for PHT, intermediate for NFB, and high for MMD. There were no genotype x environment interactions. He tested the general assumptions underlying the Jinks-Hayman diallel analysis and found that those assumptions were generally valid for these traits although some residual heterozygosity that still remained in the parents influenced the estimation of certain parameters.

CHAPTER THREE

MATERIALS AND METHODS

MATERIALS AND METHODS

1. Experimental Materials

Seven varieties of upland cotton (Gossypium hirsutum L) differing in earliness characteristics and originating from diverse backgrounds were selected for this study (Table 1). They were chosen on the basis of previous observations made on their flowering patterns and several other traits of interest.

2421 was introduced into Nigeria from Azerbaijan, U.S.S.R., in January 1970. The history of its development has been referred to by Veliev (1969). Both Stripper and Arkansas were received from the University of Arkansas, Fayetteville, U.S.A., in May 1971 and June 1970, respectively (see Mooseberg (1969) for their developmental history). All the three varieties are short-statured, short-staple, smooth-leaved with very poor levels of resistance to bacterial blight (caused by Xanthomonas malvacearum L) but early maturing. Samaru 71 is a high yielding and a high ginning variety with a staple length of 25.4 mm (1 inch). It is a derivative of Samaru Allen and is so far the highest yielding of all Samaru varieties. Samaru 72 has a satisfactory yield level and ginning percentage with a medium staple length of 27.0mm ($1\frac{1}{16}$ inch). It was selected from the derivatives of a cross SA(55)44 x Albar 51/474, the latter parent

Table 1: Origin and maturity grades of the varieties studied

Code	Variety	Country of origin	Maturity(1)
V_1	2421-K4489	U.S.S.R.	Early
V_2	Stripper 61-15:62-7	U.S.A.	Early
V_3	Arkansas 52-21	U.S.A.	Early
V_4	Samaru 71	Nigeria	Intermediate
V_5	Samaru 71	Nigeria	Intermediate
V_6	Samaru 26J	Nigeria	Late
V_7	UK66	Tanzania	Very late

(1) Grade scores based on combined first and second picks as percentages of the total.

having been introduced from Uganda on the basis of good resistance to bacterial blight. Of all the varieties developed at Samaru up to 1977, Samaru 72 had the highest lint quality characteristics. Both Samaru 71 and Samaru 72 are of medium height, hairy-leaved with satisfactory levels of resistance to bacterial blight and of medium maturity. Samaru 26J used to be the main commercial variety grown all over the cotton growing zones of Nigeria from 1959 when it was first released until fairly recently when it was completely replaced by Samaru 71 and

Samaru 72. It is a tall, short-staple, hairy-leaved variety with a fair resistance to bacterial blight but late maturing. It is a derivative of Allen Longstaple. UK66 was introduced from Tanzania in June 1970. It is a derivative of Ukiriguru 1/686 which was itself selected from the derivatives of a cross involving Sea Island cotton (Gossypium barbadense L). It is medium in height, short-staple, and has very hairy-leaves with good blight resistance but very late maturing.

The selection of these seven varieties followed a series of observation trials conducted between 1970/71 and 1973/74 seasons at Samaru in which these and several other introduced as well as locally developed types were grown. From their flowering and fruiting habits, morphological features and several other traits, the varieties showed a cluster pattern into early, intermediate and late maturing types, hence the selection of these three early, two intermediate and two late types for this study. In each season, flowers were selfed to produce pure seed for the next season's trials, and by 1974/75 season, each variety had at least two seasons of selfing. In that season the first set of diallel crosses were made and the work continued in the following season, 1975/76, thus producing F_2's, backcrosses, additional F_1's and selfed parents for more elaborate genetic studies in 1976/77 and 1977/78 seasons.

The work to be reported here consisted of agronomic and genetic studies. Most of the descriptions of the methods given below are general and apply to almost all the experiments in the two aspects of the investigation. Departure from, or additional details of the experimental procedure for each experiment or set of experiments will be given under the appropriate heading.

2. Cultural practices for early-sown, sprayed crop

Six treated seeds per hole were planted in mid June on ridges 91 cm (36 in) apart at 45 cm (18 in) spacing between holes along the ridges. The seedlings were thinned to two plants per hole after 3 weeks. Weeding started early and was regular. Boronated single superphosphate (with 5% borax as source of boron) was applied at the rate of 250 kg ha^{-1} before ridging, followed by 250 kg ha^{-1} of calcium ammonium nitrate (nitrochalk) at thinning. Eight weekly sprays of insecticide were applied starting 9 to 10 weeks after sowing. For each of the first four sprays, 1.68 kg ha^{-1} of DDT plus 0.17 kg ha^{-1} of gamma BHC (Vetox 20) were applied, and for each of the last four, 1.68 kg ha^{-1} of carbaryl (85% carbayl as Vetox 85) was applied.

3. Cultural practices for late-sown, unsprayed crop

Sowing was done in mid July using the same specifications

for seed and spacing as for the June sown crop. No nitrogenous fertilizer or insecticide applications but 62.5 kg ha^{-1} of boronated single superphosphate were applied.

4. Characters studied

In all the agronomic and the genetic studies the following variables were observed on a number of randomly selected individual plants within each plot:

4.1 First pick of seedcotton as a percentage of the total (E1%)

4.2 Cumulative first and second picks of seedcotton as a percentage of the total (E2%)

4.3 Mean maturity date (MMD), from the formula

$$\text{MMD (in days)} = \sum_{i=1}^{n} w_i d_i / \sum_{i=1}^{n} w_i$$

where

$w_i (i=1,\ldots,n)$ are actual weights of seedcotton at picks $1,2,\ldots,n$, respectively.

$d_i (i=1,\ldots,n)$ are number of days from a specified date to the dates of pick 1, pick 2,...pick n.

4.4 Production rate index (PRI) in cg, g, or kg of seedcotton per plant or per ha per day, given by the formula

$$\text{PRI} = \sum_{i=1}^{n} w_i/\text{MMD} \text{ or } \left(\sum_{i=1}^{n} w_i\right)^2 / \sum_{i=1}^{n} w_i d_i$$

where

w_i and d_i are as in MMD above.

4.5 Node of the first fruiting branch on the mainstem (NFB); the cotyledonary node was regarded as zero node, and counts started from the one immediately above it up the mainstem.

4.6 Number of days from planting to first flower opening (DFF).

4.7 Dates of subsequent flower opening; this would enable the estimation of vertical flowering interval (VFI) and horizontal flowering interval (HFI).

4.8 Number of days from first flower to first boll opening: i.e. the bolling period (BP) of the first boll.

4.9 Dates of subsequent boll opening; this would enable the estimation of average bolling period i.e. the period from flowering to boll opening of each boll (ABP).

4.10 Seedcotton yield in kg ha^{-1} for the agronomic experiments and in g/plant for the genetic experiments (yield).

4.11 Seedcotton in g/boll (boll weight).

4.12 Weight of 100 seed in cg or g (seed index).

4.13 Number of seed/boll (number of seed).

4.14 Total number of fruiting points on a plant (TFP): i.e. the potential fruiting capacity of the plants. (It was

originally intended to study total number of actual open bolls as a measure of yield potential, but was not possible).

4.15 Total number of primary sympodial branches on the main-stem (NSB).

4.16 Plant height in cm (PHT).

Some of the observations listed above were made during the growing period while others were made at harvest or after. When the crop was ready for harvesting a minimum of three harvests were taken usually at two-week intervals from the selected plants and/or the entire plot. All produce were weighed and ginned in the laboratory where their ginning percentages were also determined and in some cases quality tests were conducted on random samples of lint. In the June sown diallel experiment of 1976, lint samples were randomly drawn from the bulked plots for each genotype, while in all the remaining genetic experiments in both 1976 and 1977 lint samples were taken from only two randomly selected plants within each plot of a replication. The small number of samples was due to physical limitations. This provided additional traits like ginning percentage (GP), effective length (EL), bundle strength (BS) and micronaire (Mic.) for further analysis if need be. Ginning was done on a 40-saw gin, while EL, BS and

Mic were determined by the photoelectric stapler, pressley stelometer at $\frac{1}{8}$ in gauge and micronaire, respectively. Ten bolls were also randomly taken from each plot just before the second pick for the analysis of yield components such as boll weight, seed weight and number of seed in the agronomic experiments. Stand counts were also made at harvest time, and were used to effect necessary adjustments for plots which had less than the maximum number of stands.

Individual plants destined for the earliness studies were selected at the time of thinning or shortly afterwards, taking care to avoid extremes, and were conspicuously labelled. At flowering, a paper tag was used to record the date of flower opening on one side and subsequently the date of boll opening on the other side if and when the flower matures into a seed-cotton boll. The tags were hung on the fruiting branches just below the base of the peduncle such that even if the flower was shed the tags remained on the plants and could be recorded.

In all, nine separate experiments were conducted during the 3-year study period. The first being agronomic was carried out in 1975/76; experiments 2,3,4 and 5 (all genetic) were in 1976/77 while in 1977/78, experiments 6 (agronomic), 7,8 and 9 (all genetic) were conducted. In the remaining portion of this report, the seasons will be referred to by the first year

e.g. 1975 for 1975/76 season, etc., unless there is reason to refer to the season specifically.

5. Experimental details

5.A Agronomic studies

Two trials, one in 1975 and the other in 1977, involving the seven varieties were conducted at Samaru under differing sowing dates and nitrogen levels. Each trial was a split-plot in a randomised complete-block design with two replications. The small number of replications was due to the physical limitations imposed by the volume of work to be involved with more replications. In each case the different combinations of sowing date and nitrogen formed the main treatments while the varieties constituted the sub-treatments.

5.A.1 The 1975 Experiment: 3 x 3 factorial (Experiment 1)

In this experiment the following treatments were used; three sowing dates (D_1, D_2, and D_3) corresponding to 31 May, 25 June and 22 July, respectively, and three levels of nitrogen (N_1, N_2, and N_3) equivalent to 0, 32.5 and 65 kg ha^{-1} of nitrogen applied as calcium ammonium nitrate at 4 weeks after planting. The experiment also received 0.6 kg ha^{-1} of boron applied as boronated single superphosphate at the rate of 250 kg ha^{-1} just before sowing in order to ensure that boron and phosphate were not limiting, especially at the highest level of

N. In anattempt to control pest early enough to enable observations to be made on square formation, insecticide spraying began with half the recommended dose of Vetox 20 (0.84 kg ha^{-1} DDT plus 0.08 kg ha^{-1} gamma BHC) at 4 weeks after sowing in the first sowing date. After three weekly sprayings, adverse effects (widespread leaf scorching) were noticed on the young seedlings. Consequently, only one quarter of the recommended dosage was used starting at 6 weeks (instead of 4 weeks) after sowing in the second and third sowing dates. Full dose was used on all sowing dates from the ninth week and thereafter.

The plot size was 14.4 m^2 (3 ridges of 5.25m x 0.91m) with a maximum of 12 stands or hills per ridge or 36 stands or hills per plot. Three to four weeks after sowing, two plants were selected for the observations enumerated above. At 4 weeks after the first boll split, five harvests were taken per plot at weekly intervals in each sowing date. Lint quality tests were not made in this trial.

5.A.2 The 1977 experiment: 3 x 2 factorial (Experiment 6)

Three sowing dates, 10 June, 8 July, and 3 August, and two levels of nitrogen, equivalent to 0 and 65 kg ha^{-1} of nitrogen applied as 0 and 250 kg ha^{-1} of nitrochalk, were the treatment combinations in this experiment. As in experiment 1, a dose of 250 kg ha^{-1} of boronated single superphosphate was

applied before sowing. The weekly pest control method was one quarter concentration at 6 weeks until full dose at 9 weeks after sowing in all the three sowing dates.

Plot size was 19.2 m^2 (2 ridges of 10.5 m x 0.91 m) giving a maximum of 24 stands or hills per ridge or 48 stands per plot. Two plants were randomly chosen and labelled for single plant observations and at 3 weeks after the first boll split, three harvests were taken at fortnightly intervals in each sowing date. Lint quality tests were not conducted.

5.A.3 Statistical analyses

A separate analysis of variance was made for each experiment and a combined analysis over years following the models of Steel and Torrie (1960) which were slightly modified to accommodate the various factors as follows:

(a) Individual analyses

$$X_{ijkl} = u + B_i + D_j + N_k + DN_{jk} + a(ijk) + V_l + DV_{jl} + NV_{kl} + DNV_{jkl} + b(ijkl)$$

where

X_{ijkl} = observation of any variable in the i^{th} block for the j^{th} sowing date, k^{th} nitrogen level and the l^{th} variety.

u = overall population mean.

B_i = effect of the i^{th} block (fixed), i = 1, 2.

D_j = effect of the j^{th} sowing date (fixed) j = 1,2,3.

N_k = effect of the k^{th} level of nitrogen (fixed),
k = 1,2,3 (year 1) and k = 1,2 (year 2).

$a_{(ijk)}$ = random error effect of the ijk^{th} whole unit.

V_l = effect of the l^{th} variety (fixed), l = 1,..., 7.

$b_{(ijkl)}$ = random error effect of the $ijkl^{th}$ sub-unit.

Interactions are denoted by multiple symbols; thus DN_{jk} is the contribution of the date x nitrogen interaction, DNV_{jkl} is the date x nitrogen x variety interaction in these experiments.

(b) Combined analysis over years (model modified from (a) above to include the year effect).

$$X_{ijklm} = u + Y_i + B_{(i)j} + D_k + YD_{ik} + N_l + YN_{il} + DN_{kl} + YDN_{ikl} + a_{(ijkl)} + V_m + YV_{im} + DV_{km} + YDV_{ikm} + NV_{lm} + YNV_{ilm} + DNV_{klm} + YDNV_{iklm} + b_{(ijklm)}$$

where

Y_i = effect of the i^{th} year (random), i = 1,2.

The other terms are as in the model for the individual analyses, as well as the various two-factor, three-factor, and four-factor interaction terms involving years. In the combined analysis, each main effect or its interaction was tested by its

corresponding interaction with year which in turn was tested by error (a) or error (b) accordingly. See expected mean squares given in Table 2. Note that o^2 denotes the variance of a random effect and K^2 denotes the variance of a fixed effect.

In the case of a significant interaction of varieties with either date or nitrogen, the two-way interaction table was further examined for linear and quadratic effects according to Snedecor and Cochran (1974). In nearly all cases Duncan's new multiple range test was conducted on the means according to Steel and Torrie (1960).

Table 2: Sources, degrees of freedom, and expected mean squares for the analyses of the agronomic experiments (adopted from Snedecor and Cochran, 1974).

Sources	d.f°	Expected mean squares	
		Individual analyses	Combined analysis
Years	(y-1)	-	$o_b^2 + vo_a^2 + rdnvo_Y^2$
Blocks/ years	y(r-1)	$o_b^2 + vo_a^2 + dnvK_B^2$	$o_b^2 + vo_a^2 + ydnvK_B^2$
Date	d-1)	$o_b^2 + vo_a^2 + rnvK_D^2$	$o_b^2 + vo_a^2 + rnvo_{YD}^2 + yrnvK_D^2$
YD	(y-1)(d-1)	-	$o_b^2 + vo_a^2 + rnvo_{YD}^2$
Nitrogen	(n-1)	$o_b^2 + vo_a^2 + rdvK_N^2$	$o_b^2 + vo_a^2 + rdvo_{YN}^2 + yrdvK_N^2$
YN	(y-1)(n-1)	-	$o_b^2 + vo_a^2 + rdvo_{YN}^2$
DN	(d-1)(n-1)	$o_b^2 + vo_a^2 + rvK_{DN}^2$	$o_b^2 + vo_a^2 + rvo_{YDN}^2 + yrvK_{DN}^2$
YDN	(y-1)(d-1)(n-1)	-	$o_b^2 + vo_a^2 + rvo_{YDN}^2$
Error(a)	y(r-1)(dn-1)	$o_b^2 + vo_a^2$	$o_b^2 + vo_a^2$

(Cont'd next page)

Table 2: (continued)

Sources	d.f.*	Expected mean squares	
		Individual analyses	Combined analysis
Varieties	(v-1)	$o_b^2 + rdnK_V^2$	$o_b^2 + rdno_{YV}^2 + yrdnK_V^2$
YV	(y-1)(v-1)	-	$o_b^2 + rdno_{YV}^2$
DV	(d-1)(v-1)	$o_b^2 + rnK_{DV}^2$	$o_b^2 + rno_{YDV}^2 + yrnK_{DV}^2$
YDV	(y-1)(d-1)(v-1)	-	$o_b^2 + rno_{YDV}^2$
NV	(n-1)(v-1)	$o_b^2 + rdK_{NV}^2$	$o_b^2 + rdo_{YNV}^2 + yrdK_{NV}^2$
YNV	(y-1)(n-1)(v-1)	-	$o_b^2 + rdo_{YNV}^2$
DNV	(d-1)(n-1)(v-1)	$o_b^2 + rK_{DNV}^2$	$o_b^2 + ro_{YDNV}^2 + yrK_{DNV}^2$
YDNV	(y-1)(d-1)(n-1)(v-1)	-	$o_b^2 + ro_{YDNV}^2$
Error(b)	ydn(r-1)(v-1)	o_b^2	o_b^2

* y,r,d,n and v are number of years, blocks, sowing dates, nitrogen levels and varieties, respectively.

5.B Genetic studies

This aspect of the investigation was in two series, the first series (series I below) dealt with the diallel cross of the seven varieties conducted under contrasting conditions of June (early) and July (late) sowing. The second series (Series II below) dealt with specific crosses conducted under early sown conditions only. Both series were run for two years 1976 and 1977.

Series I: Diallel cross studies - June and July sown, 1976 and 1977 (Experiments 2,3,7 and 8)

All possible crosses were made between the seven varieties in 1974. In 1975, all the 42 F_1 crosses were grown from which F_2 seed were produced by selfing and similarly parental seed were produced by bulking selfed seed from many individual plants in each of the seven parents. Additional F_1's were also produced using the same parents. All selfing and crossing were made by hand. Selfed and crossed bolls were differently tagged. Plots selected for crossing work were thinned to one plant per hole in order to ensure ease of handling and production of enough seed on each plant. At the end of the 1975 season, seed from all the seven varieties, all the F_1's and all the F_2's were available for elaborate genetic trials in 1976 and 1977 seasons. However, only the 7 parents, the 21 F_1's and their 21 F_2's (no

reciprocals) were included in each season's trial. A randomised complete block design with three replications was used. But for reasons of physical limitations a higher number of replications could have been used.

Experiments 2 and 3 were conducted in 1976 while 7 and 8 were conducted in 1977. Experiments 2 and 7 were sown on 17 June 1976 and 16 June 1977, respectively, hence the recommended cultural practices for early sown cotton applied to both. Three harvests were taken from experiment 2 on a plot basis only and three harvests from experiment 7 on the basis of both the selected single plants and the plots. Experiments 3 and 8 were sown on 15 July 1976 and 15 July 1977, respectively, in accordance with the cultural practices for July sown crop and hence neither nitrogenous fertilizer nor insecticide sprays were applied. In experiment 3 it was possible to take three harvests from the selected plants but only one final harvest from the remaining plants in the plot, while in experiment 8 it was possible to take three harvests from both the selected plants as well as the plots. In all these 4 experiments, harvests were taken at fortnightly intervals beginning 4 to 5 weeks after the first boll split was seen in each experiment. The plot size of experiments 2 and 7 was 19.2 m^2 (2 ridges of 10.5 m x 0.9 m) and that of experiments 3 and 8 was 9.6 m^2 (1 ridge of 10.5 m x 0.9 m).

In all genetic experiments in the first series and also in the second series (mentioned below), wherever there was a shortage of seed for any of the entries or where there were missing stands at the time of thinning, seed of red leaf cotton was used to fill up the gaps. Red leaf cotton was so conspicuously different from the rest of the plants in the plot, that no mistakes could have been made at observations and at the same time the problems of unnecessary gaps were considerably reduced.

5.B.I.1 Statistical analyses

The analyses of this series of trials involving experiments 2,3,7 and 8 were done in stages:

Stage 1

An analysis of variance was conducted for each experiment separately using Steel and Torrie's (1960) model for subsampling:

$$X_{ijk} = u + B_i + G_j + e_{(ij)} + s_{(ijk)}$$

where

X_{ijk} = observation of any variable in the i^{th} block for the j^{th} genotype on the k^{th} plant.

u = overall population mean.

B_i = effect of the i^{th} block (fixed), $i = 1,2,3$.

G_j = effect of the j^{th} genotype (fixed), j = 1,2,...49.

$e_{(ij)}$ = random plot error.

$s_{(ijk)}$ = random sampling error.

The mean square expectations are given in column 3 of Table 3.

Stage 2

Since the experiments were conducted under two sowing dates within each of two years, and since year is a random factor, an analysis of variance was conducted for each sowing date combined over years using the model:

$$X_{ijkl} = u + Y_i + B_{(i)j} + G_k + YG_{ik} + e_{(ijk)} + s_{(ijkl)}$$

where

Y_i = effect of the i^{th} year (random), i = 1,2;

the other factors are the same as those of the model in stage 1, plus the two-factor interaction term involving years. The expectations of mean squares are given in column 4 of Table 3.

Stage 3

An overall combined analysis of variance involving all the four experiments (2 sowing dates x 2 years) was carried out using the model:

$$X_{ijklm} = u + Y_i + D_j + YD_{ij} + B_{(ij)k} + G_l + YG_{il} + DG_{jl} + YDG_{ijl} + e_{(ijkl)} + s_{(ijklm)}$$

Table 3: Sources, degrees of freedom, and expectated mean squares for the analyses of the diallel experiments

Sources	d.f.*	Expected mean squares		
		Individual analyses	Combined over years/date	Combined over years and dates
Years (Y)	(y-1)	-	$o_s^2 + po_e^2 + rgpo_Y^2$	$o_s^2 + po_e^2 + drgpo_Y^2$
date (D)	(d-1)	-	-	$o_s^2 + po_e^2 + rgpo_{YD}^2 + yrgpK_D^2$
YD	(y-1)(d-1)	-	-	$o_s^2 + po_e^2 + rgpo_{YD}^2$
B/YD**	yd(r-1)	$o_s^2 + po_e^2 + gpK_B^2$	$o_s^2 + po_e^2 + gpK_B^2$	$o_s^2 + po_e^2 + gpK_B^2$
G	(g-1)	$o_s^2 + po_e^2 + rpK_G^2$	$o_s^2 + po_e^2 + rpo_{YG}^2 + yrpK_G^2$	$o_s^2 + po_e^2 + drpo_{YG}^2 + ydrpK_G^2$
YG	(y-1)(g-1)	-	$o_s^2 + po_e^2 + rpo_{YG}^2$	$o_s^2 + po_e^2 + drpo_{YG}^2$
DG	(d-1)(g-1)	-	-	$o_s^2 + po_e^2 + rpo_{YDG}^2 + yrpK_{DG}^2$
YDG	(y-1)(d-1)(g-1)	-	-	$o_s^2 + po_e^2 + rpo_{YDG}^2$
Error (plot)	yd(r-1)(g-1)	$o_s^2 + po_e^2$	$o_s^2 + po_e^2$	$o_s^2 + po_e^2$
Error (Sampling)	ydrg(p-1)	o_s^2	o_s^2	o_s^2

* y,d,r,g,p indicate number of years, dates, blocks, genotypes and plants per plot, respectively.

** B/YD is the block effect within the year-date combinations and not the block x year x date interaction.

where

D_j = effect of the j^{th} date (fixed), j = 1, 2; regarded as fixed because June and July plantings are the recommended planting dates for cotton in northern Nigeria;

all the other factors are essentially the same as those in the model for stages 1 and 2, plus the two and three-factor interaction terms involving sowing dates. The mean square expectations are given in column 5 of Table 3. The models used for the analyses in both stage 2 and stage 3 were essentially the same as that used for stage 1 but modified to accommodate the additional factors.

The 48 degrees of freedom for the genotypes[5] were partitioned into 6 for the parents, 20 each for the F_1 and the F_2 and 2 for among generations. In the separate individual analyses the experimental error term with 96 degrees of freedom was used to test the effects of blocks and genotypes and the partitioned sources of the latter. However, preceding this, Bartlett's test for homogeneity of variance of the different sources making up the experimental error term was made. For those characters in which the different error sources were homogeneous, the pooled experimental error was used for testing; otherwise the experimental error term corresponding to the

particular source was used to test it.

Stage 4

Having performed the analysis of variance and especially since there were significant differences between the genotypes generally, or more specifically among the F_1's and among the F_2's, further analysis was done for the general combining ability (gca) and specific combining ability (sca) on the F_1 and F_2. The 20 degrees of freedom for each was partitioned into 6 for gca and 14 for sca using Griffing's (1956) method 4 model I. This method was chosen for its simplicity and also considered the most appropriate for the present purpose. However, method 2 which involves the parents and one set of F_1's, could have been used, except that since the parents were a selected set for earliness, it was felt that using method 2 would probably not add much information. The calculations for the sums of squares, mean squares, the gca effects and the sca effects were made with a computer program for the analysis of diallels by Littlewood, Carmer, and Hittle (1964). For the three levels of analyses of variance enumerated above, the mean squares for the gca and sca and those of their interaction with years were obtained in the manner enumerated below. These interactions are part of the overall year x genotype interaction which was used as the error to test the gca and sca

source while their interactions with years were tested by the plot error.

(i) Analysis of the individual experiments for combining ability

The F_1 generation from each experiment was analysed separately for gca and sca with 3 replications. This then formed the basis for the higher order calculations. The F_2 generation was analysed similarly.

(ii) Combined analysis over years

For each sowing date this analysis was carried out for both the F_1 and the F_2 combining together data from date 1 in year 1 with those from date 1 in year 2 as if they were from the same experiment with 6 (y x r) replications.

(iii) Combined analysis over dates

Within each year the two sowing dates were combined and analysed together with 6 (d x r) replications in a similar fashion to (ii) above.

(iv) Overall combined analysis, over years and dates

Data from all the four experiments were analysed together as if they were from one big experiment with 12 (y x d x r) replications for both the F_1 and the F_2.

The above four steps enabled the estimation of the appropriate gca and sca sums of squares (SS) together with the

respective year x gca and year x sca interaction terms as follows:

For the year x combining ability interaction within each sowing date:

SS year x gca (within date 1) = SSgca (year 1/date 1) + SSgca (year 2/date 1) - SSgca (combined/date 1).

SS year x sca (within date 1) was obtained by substituting sca in above and similarly for within date 2.

For the year x combining ability interaction over years and dates:

SS year x gca (overall combined) = SSgca (year 1) + SSgca (year 2) - SSgca (overall combined).

SS year x sca (overall combined) was obtained by substituting sca in above.

The analysis of the date x gca or date x sca has not been presented because the date factor and its interaction terms were not significant for all the characters except plant height and also for the limited nature their interpretation may have.

Series II. Individual crosses between varieties of different maturities, 1976 and 1977 (Experiments 4,5 and 9)

The experiments in this series were also conducted over

two seasons, 1976 and 1977 at the same time as those in the first series. The experimental materials were taken from the diallel cross. In 1975 when the crosses were being made, each of the 21 F_1's was backcrossed to its two parents so that at the end of that season enough seeds were available for trials involving specific crosses in the following seasons. Two crosses were involved in this series.

(i) Stripper x UK66: an early by late cross grown in two years, designated as experiment 4 in 1976 and as experiment 9 in 1977.

(ii) 2421 x Samaru 71: an early by intermediate cross designated as experiment 5 and conducted in 1976.

But for the shortage of seed, Stripper x Samaru 71 could have been used for the early x intermediate cross for the sake of consistency. There were six entries in a randomised complete block design in each experiment in 1976 made up of a total of 13 rows (rows of BC_1, F_2 and BC_2 non-randomised) per block as follows:

(1)	Parent 1	(P_1)	1 row,
(2)	Backcross to parent 1	(BC_1)	3 rows,
(3)	F_1	(P_1)	1 row,
(4)	F_2	(F_2)	4 rows,
(5)	Backcross to parent 2	(BC_2)	3 rows,

(6) Parent 2 (P_2) 1 row.

In 1976, single plots measuring 9.6 m^2 (1 row,X 10.5 m long) were alloted to the non-segregating generations, P_1, F_1, and P_2. Both backcross generations had plots measuring 28.8 m^2 (3 rows,X10.5 m long) and the F_2 plots were 38.4 m^2 (4 rows,X 10.5 m long). Ten plants were randomly selected in each plot having P_1, F_1 or P_2, 30 plants in each BC plot and 40 plants in each F_2 plot for the single plant observations.

In 1977 the layout for experiment 9 was modified making each plot of the same size of 19.2 m^2 (2 rows,X10.5 m long) and ten plants per plot selected for the single plant observations but this time the number of plots per replication difered for the different generations. P_1, P_2 and F_1 each had 1 plot, each BC had 4 plots while the F_2 had 6 plots, making a total of 17 plots of the same size for the 6 entries per block instead of 1 plot of different size per block for the entries as in the previous year. However, because additional F_1 and BC seeds were not produced in 1976, the remainder of the F_1 seed from the 1975 crosses (used in experiment 4 in 1976) was used for the 1977 trial, while the BC seed were obtained from selfed BC plants of the 1976 trial. This modification would necessitate the use of different coefficients for the additive (D) and the dominance (H) components of variance of the BC

generation. Both the selfed parental and the F_2 seeds were freshly produced in 1976.

The harvests from the selected plants in each plot for each treatment were handled in the laboratory separately from the rest of the plants in the plot, but the weights of the seedcotton from them were added to the rest to obtain a total plot weight. The weights of all subsequent harvests after the first, were cumulative; which was easier to handle than to have separate bags for each harvest. The weight of the final harvest thus included those of all the previous harvests.

5.B.II.1 Statistical analyses

As in the case of the diallel, the analyses were again carried out in stages:

Stage 1

Analysis of variance was made involving the two parents, their F_1, F_2, and the two backcrosses as if each row or plot within a block was a separate entry. Subsequently the sums of squares for the among generations with 5 degrees of freedom for the 1976 experiments and with 4 degrees of freedom for the 1977 experiment (the F_1 was eliminated from the analysis because it was missing in 3 of the 4 replications) were obtained by subtraction. The error term representing variation among repeated plots within different generations was

calculated accordingly. However, these mean squares for the variation among repeated plots within different generations were tested by Bartlett's test for homogeneity. When variances were homogeneous or only occasionally heterogeneous (.05) the pooled variance was used as the error; otherwise each source was used as the error term accordingly. A combined analysis over years was not done since the entries or the generations were not quite the same, and only individual analyses were made using the model:

$$X_{ijkl} = u + B_i + G_j + BG_{ij} + e_{(ij)k} + s_{(ijk)l}$$

where

X_{ijkl} = observation of any variable in the i^{th} block for the j^{th} generation of the k^{th} repeated plot and the l^{th} plant.

u = overall population mean

B_i = effect of the i^{th} block (fixed), i = 1,2,3,4.

G_j = effect of the j^{th} generation (fixed), j = 1,2,..6 (parent 1 and parent 2 regarded as different generations).

BG_{ij} = block x generation interaction.

$e_{(ij)k}$ = random effect of the k^{th} repeated plot in the j^{th} generation in the i^{th} block, $k \geq 1$ for backcross and F_2 generations.

$s_{(ijk)l}$ = random effect of the l^{th} plant in the k^{th} repeated plot in the j^{th} generation in the i^{th} block.

This analysis was made using Snedecor and Cochran's (1974) analysis of variance with unequal but proportionate subsample numbers.

Table 4 gives the breakdown of factors and their expected mean squares. This analysis differs slightly from the diallel analysis as it involved different numbers of plots per generation within each block. The 1977 experiment was analysed in the same way as those of 1976 except that the F_1 was eliminated, and had more number of plots for the segregating generations.

Stage 2

Secondly the scaling test of Mather and Jinks (1971) involving A, B and C scales was used to test for epistatic effects. In some cases the data were transformed to log scale. The A, B, and C scales are as follows:

$$A = 2\overline{BC}_1 - \bar{F}_1 - \bar{P}_1$$

$$B = 2\overline{BC}_2 - \bar{F}_1 - \bar{P}_2$$

$$C = 4\bar{F}_2 - 2\bar{F}_1 - \bar{P}_1 - \bar{P}_2$$

Table 4: Sources, degrees of freedom and expected mean squares for the analysis of variance of different generations of specific crosses in 1976

Sources	d.f.	Expected Mean Squares
Blocks	(b-1)	$o_w^2 + po_e^2 + 0.679487pK_{BG}^2 + 13pK_B^2$
Generations	(g-1)	$o_w^2 + po_e^2 + 0.123077pK_G^2$
B x G	(b-1)(g-1)	$o_w^2 + po_e^2 + 0.030769pK_{BG}^2$
Error	$\sum_{i=4}^{6}(n_i-1)^*$	$o_w^2 + po_e^2$
Among BC_1 plots/blocks	$b(n_4-1)$	
" F_2 plots/blocks	$b(n_5-1)$	
" BC_2 plots/blocks	$b(n_6-1)$	

Cont'd next page

Table 4: (cont'd)

Sources	d. f.	Expected Mean Squares
Plants within plots	$b\sum_{i=1}^{6} n_i(p-1)$	σ_w^2 = see below
Among plants/P_1 plots*	$1b(p-1)$	$\sigma_{P_1}^2$
Among plants/BC_1 plots	$3b(p-1)$	$\sigma_{BC_1}^2$
Among plants/F_1 plots	$1b(p-1)$	$\sigma_{F_1}^2$
Among plants/F_2 plots	$4b(p-1)$	$\sigma_{F_2}^2$
Among plants/BC_2 plots	$3b(p-1)$	$\sigma_{BC_2}^2$
Among plants/P_2 plots	$1b(p-1)$	$\sigma_{P_2}^2$

$$\sigma_w^2 = \frac{b(p-1)\sigma_{P_1}^2 + 3b(p-1)\sigma_{BC_1}^2 + b(p-1)\sigma_{F_1}^2 + 4b(p-1)\sigma_{F_2}^2 + 3b(p-1)\sigma_{BC_2}^2 + b(p-1)\sigma_{P_2}^2}{b\sum_{i=1}^{6} n_i(p-1)}$$

* n_i = number of repeated plots within a generation in a block, i=1..6
equals 1,1,1,4,6,4 for P_1, P_2, F_1, BC_1, F_2 and BC_2, respectively.

with variances

$$V(A) = 4V(\overline{BC}_1) + V(\overline{F}_1) + V(\overline{P}_1)$$

$$V(B) = 4V(\overline{BC}_2) + V(\overline{F}_1) + V(\overline{P}_2)$$

$$V(C) = 16V(\overline{F}_2) + 4V(\overline{F}_1) + V(\overline{P}_1) + V(\overline{P}_2)$$

and the standard errors are the respective square roots of the above variances. A t-test was used to test the hypothesis that the true value of each was equal to zero.

No scaling test was made for the 1977 experiment because of the elimination of the F_1.

Stage 3

The additive (D), dominance (H), and environmental (E) components of variance for the 1976 experiments were estimated according to Mather's (1949) method:

$$V(F_2) = \tfrac{1}{2}D + \tfrac{1}{4}H + E \qquad \text{(a)}$$

$$V(BC_1) + V(BC_2) = \tfrac{1}{2}D + \tfrac{1}{2}H + 2E \qquad \text{(b)}$$

$$(E) = \frac{V(P_1) + V(F_1) + V(P_2)}{3} \qquad \text{(c)}$$ (Allard, 1960)

and for the 1977 experiment the following methods were used for estimating the variances of the selfed backcrosses $V(BC_{1s})$, $V(BC_{2s})$ and those of the environments V(E):

$$V(BC_{1s}) = \tfrac{1}{4}D + \tfrac{1}{8}H + E \qquad \text{(e)}$$

$$V(BC_{2s}) = \tfrac{1}{4}D + \tfrac{1}{8}H + E \qquad \text{(f)}$$

(Mather and Jinks, 1971).

$$E = \sqrt{V(P_1) + V(P_2)} \qquad \text{(g)}$$

The (E) in equation (c) and (g) were differently calculated because in 1977, the F_1 generation was eliminated from the analysis, and furthermore because of the additional restrictions due to using selfed backcross generations, the entire 1977 trial could not be further analysed using the above calculations. The degree of dominance $\sqrt{H/D}$ and the narrow sense heritability ($h^2 = \frac{D}{D+H+E}$) were also estimated where possible.

CHAPTER FOUR

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

1. PRELIMINARY STUDIES

The results of the preliminary observations made between 1970 and 1973 are presented in Table 5. Observations in 1970, 1971 and 1972(i) were made from replicated plots while those in 1972(ii) and 1973 were from non-replicated plots. These results indicated that 2421 (V_1), Stripper 61-15:62-7 (V_2), Arkansas 52-21 (V_3) and G.105.4.6.SR were early maturing; Samaru 71 (V_4) and Samaru 72 (V_5) were medium, while Samaru 26J (V_6) and UK66 (V_7) were late maturing, based on the sum total of the various earliness characters like E2%, NFB, SP, DFF, BP, VFI and HFI. The Australian variety, G.105.4.6.SR was not included in the studies.

It should be pointed out that data from non-replicated trials might not be reliable enough for the purpose of identifying the parents in the present study. However, the choice was made largely because the trends were similar in the data from the replicated and the non-replicated trials.

Table 5: Means and standard errors for replicated plots in 1970, 1971 and 1972(i) and means of non-replicated plots in 1972(ii) and 1973 for many variables

Year	Variety	E2%*	NFB	DFS	SP	OFF	BP	VFI	HFI	ABW	MNS	MNF
1970	Samaru 71	76.0±3.51										
	Samaru 72	78.0±3.51										
	Samaru 26J	66.3±3.51										
	UK66	58.2±3.51										
1971	2421	60.9±1.75										
	G105.4.6.SR	66.1±1.75										
	Samaru 71	33.6±1.75										
	Samaru 72	29.3±1.75										
	Samaru 26J	15.0±1.75										
	UK66	8.5±1.75										
1972(i)	2421	56.0**	4.0±0.10	31.1±0.40	30.0±0.42		41.1±1.16	3.1±0.05	8.0±0.12	4.1±0.11	5.4±0.12	12.6±0.1
	G105.4.6.SR	67.0	3.8±0.11	28.8±0.42	27.0±0.45		36.1±1.23	2.8±0.05	6.9±0.13	3.8±0.11	5.4±0.13	13.9±0.2
	Samaru 71	43.0	4.8±0.10	31.4±0.41	29.0±0.44		44.4±1.19	3.1±0.05	8.0±0.12	3.8±0.11	6.7±0.13	14.9±0.1
	Samaru 26J	30.0	4.9±0.11	32.1±0.42	30.0±0.45		44.8±1.23	3.4±0.05	8.1±0.13	3.8±0.11	6.6±0.13	15.1±0.

Cont'd next page

Table 5 (cont'd)

ear	Variety	E2%	NFB	DFS	SP	DFF	BP	VFI	HFI	ABW	MNS	MNF
972(ii)	2421		3.6	28.4	30.0		42.1	3.5	7.7	4.9	4.6	12.4
	G105.4.6.SR		3.5	28.4	29.5		40.5	2.8	7.3	3.6	5.2	12.0
	Stripper		5.0	30.4	28.2		38.4	3.1	7.6	5.0	5.8	13.6
	Arkansas		4.8	31.2	29.0		39.6	2.8	7.7	3.4	5.8	13.6
	Samaru 71		5.0	34.0	31.0		41.5	2.9	7.8	3.6	6.7	14.7
	Samaru 26J		5.0	33.2	34.2		43.7	3.3	8.2	4.4	6.7	15.0
1973	2421	61.0	4.4			67.5	41.6	3.0	7.6			
	Stripper	59.0	4.8			65.5	42.3	3.1	7.6			
	Arkansas	58.0	5.0			67.3	45.0	3.1	7.8			
	Samaru 71	24.0	5.1			69.9	49.2	3.0	7.6			
	Samaru 72	28.0	5.1			69.9	47.1	3.0	7.8			
	Samaru 26J	16.0	5.5			73.1	48.5	3.2	7.9			
	UK66	8.0	6.3			82.1	51.8	3.3	8.3			

* E2% * first 2 picks as a percent of total pick, NFB = node of the first fruiting branch, DFS = days from planting to the first square, SP = days from square to anthesis, DF = days from planting to first flower, BP = days from anthesis to boll split (bolling period), VFI = vertical flowering interval, HFI = horizontal flowering interval, ABW = average boll weight in gram, MNS = total number of mainstem nodes at first square, MNF = total number of mainstem nodes at first flower.

** Not analysed, only means given.

2. THE MAIN STUDIES

2.A Agronomic Studies

2.A.1 The combined analysis for 1975 and 1977

A combined analysis of variance for two earliness and three yield characters over the 2 years is presented in Table 6. In this combined analysis, differences due to years, sowing dates or nitrogen were not significant for NFB. The varieties however differed at the 0.01 level of probability and did not interact with dates and/or nitrogen. For DFF, the year and the year x date interaction were significant at 0.01 level of probability. The linear as well as the quadratic components of the year x date interaction were significant (0.01). The varieties showed significant (0.01) differences but no interaction with any of the other factors for DFF. When the results are considered over years, the agronomic factors studied did not affect NFB and DFF in these varieties. This does not seem to agree with the findings of other workers who reported that delayed sowing date lengthens the maturity of cotton by delaying the period to flowering (Christidis and Harrison, 1955).

The mean squares for date and its linear component for both NFB and DFF appeared to be large, but were nonsignificant, probably because of the smaller number of degrees of freedom involved in their tests. However, since the year x nitrogen and

Table 6: Mean squares from a combined analysis of variance over 2 years, 3 sowing dates, 2 nitrogen levels and 7 varieties

Sources	d.f.			Yield characters		
		NFB(1)	DFF	boll weight (g)	Seed index	Number of seed
Year (Y)	1	7.29	191.79**	0.40	1.60	264.75
Blocks/Years (B/Y)	2	1.93	5.34	0.90	0.77	53.60
Dates (D)	2	162.50	2476.83	3.76	13.61	162.82
linear (l)	1	258.00	4092.22	6.87	3.19	7.98
quadratic (q)	1	67.00	861.44	0.65	24.03	317.66*
Y x D	2	75.60+	739.45**	1.71+	16.16	9.36
Y x D(l)	1	32.18	308.89**	0.25	10.37*	7.25
Y x D(q)	1	119.00	170.00**	3.18	21.95**	11.48
Nitrogen (N)	1	301.34	34.83	7.95	4.00	23.50
Y x N	1	33.48	145.79**	4.08+	3.92	10.44
D x N	2	12.50	96.22	1.12	1.58	12.33
D(l) x N	1	14.00	130.72	1.99	0.58	16.44
D(q) x N	1	11.00	61.71	0.25	2.58	82.11
Y x D x N	2	23.21	12.39	1.74	2.62+	37.11
Error (a)	10	27.02	11.29	1.09	1.44	59.29

Table cont'd next page

Table 6 (cont'd)

Sources	d.f.	Earliness characters		Yield characters		
		NFB(1)	DFF	boll weight (g)	seed index	number of seed
Variety (V)	6	612.85**	314.03**	3.95**	7.37	165.33**
Y x V	6	26.04	10.02	0.89*	2.32	23.20
D x V	12	63.89	9.93	1.10	1.70	64.98
Y x D x V	12	52.68	6.29	0.53	1.24	34.13
N x V	6	27.03	6.22	0.72	1.49	38.06
Y x N x V	6	19.59	6.86	0.53	0.42	16.79
D x N x V	12	15.28	4.17	0.38	0.32	16.17
Y x D x N x V	12	19.74	5.23	0.25	0.27	19.28
Error (b)	72	22.78	5.21	0.36	1.10	18.48

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

+ significant at the 0.25 level of probability (Pearson and Hartley, 1958), for the purpose of pooling only.

(1) mean squares for NFB are multiplied by 10^2

the year x date x nitrogen interaction terms for NFB were not significant at the 25 percent level of probability, the mean squares for these interaction terms were pooled with the mean square for error (a) for this character. When this pooled mean square was used as the error, the nitrogen main effect, but not the date x nitrogen interaction, became significant at the 0.01 level for NFB. The justification for such a test, using the pooled error, is that these interaction terms were not significantly different from the error (a) itself at 0.25 probability level.

The means given in Table 7 indicate clearly that V_1 (see Table 1 for varietal codes) and V_2 had the lowest NFB while V_6 and V_7 had the highest. Similarly V_2 and V_3 had the shortest DFF while V_7 had the longest with a difference of about 10 days between V_2 and V_7. It is interesting to note the positions of V_3 for NFB and of V_1 for DFF among the early group. It appeared that these two varieties attained earliness in slightly different ways. For example V_1 had lower NFB than V_3 while the latter had shorter DFF. Except for V_1 which showed intermediate value for DFF, the ranking of the varieties in order of earliness has been consistent for the earliness characters.

Final yield data were not available but its three components, weight of seedcotton per boll (boll weight), weight of

Table 7: Varietal means[1] from a combined analysis of variance over two years, three sowing dates, and two nitrogen levels (1975 and 1977)

Varieties	Earliness characters		Yield components		
	NFB	DFF	boll weight(g)	seed weight(g)	No. of seed
V_1	4.1 a	64.3 b	4.5 a	7.9	34 a
V_2	4.1 a	61.4 a	4.3 ab	9.4	28 b
V_3	4.5 b	62.7 a	3.7 c	8.4	26 b
V_4	4.8 c	64.4 b	4.1 bc	8.8	28 b
V_5	4.9 c	66.1 b	4.0 bc	9.1	28 b
V_6	5.3 d	69.6 c	3.8 c	8.5	27 b
V_7	5.3 d	71.4 d	3.3 d	8.0	26 b

(1) Means followed by the same letter (s) within each character are not significantly different at the 0.05 level of probability.

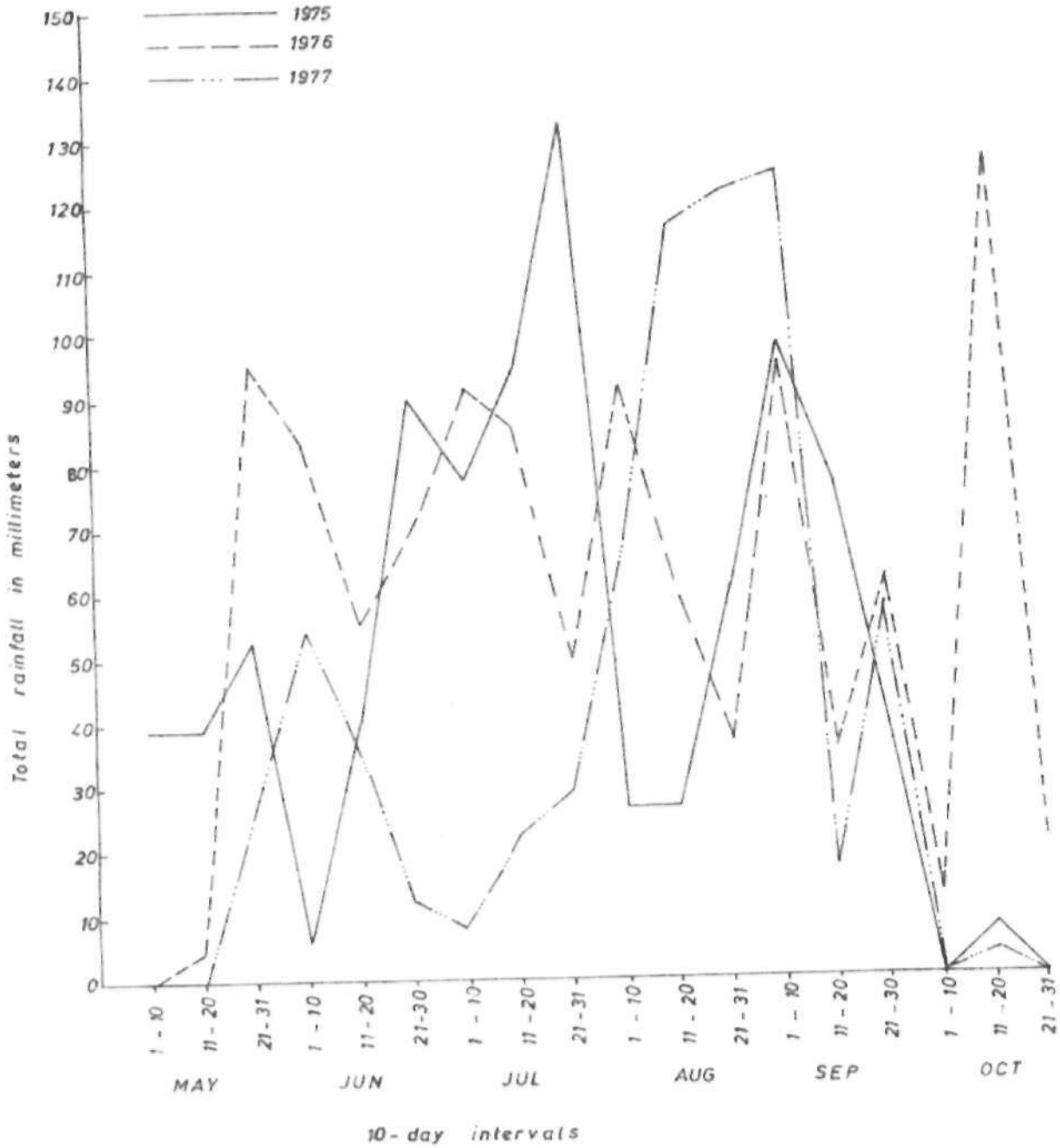
100 seed (seed index), and the number of seed per boll (number of seed) were included in the combined analysis and their mean squares are also given in Table 6.

Date or nitrogen did not significantly affect any of the three characters. However, the year x date interaction was significant (0.01) for seed index and the quadratic component of date was also significant (0.05) for number of seed. The varieties differed significantly for boll weight and number of seed, but not for seed index. Even when the interaction terms of the date and nitrogen with years was pooled with error (a) as in the case of NFB, no significant effect of the main factors was detected for number of seed.

Averaged over all other factors, V_1 had significantly the highest value (4.5 g) for boll weight, while V_7 had the least (3.3 g). As for number of seed, V_1 again had the greatest number and was significantly different from the rest which did not differ significantly among themselves but showed a range of 26 to 28 seeds per boll.

The failure to observe significant effects of the main factors in the combined analysis might partly be due to the differences in the corresponding sowing dates pooled together for the purpose of the combined analysis. For instance, in 1975, the sowing dates were May 31, June 25 and July 22 while

Figure 1. Graph showing the rainfall pattern at 10-day intervals at Samaru for 1975, 1976, 1977



in 1977 they were June 10, July 8, and August 3. The weather pattern at Samaru is such that a 10-day period, even though in different years, might have some effect. This is obvious from Figure 1 that the rainfall patterns for 1975 and 1977 were markedly different and almost opposite in trend, especially from mid-June to late August, the period of active crop growing. It could have been safer therefore, to refer to the sowing dates as May/June (D1), June/July (D2), and July/August (D3) when discussing the combined analysis. In addition, there might also be stability factors specific to the varieties which would tend to cancel out when the data from these two years with almost opposite trends in rainfall were pooled together in the combined analysis.

Although the combined analysis in the present study did not show significant effects of either dates or nitrogen, it is important to point out that Faulkner et. al (1975) have reported a highly significant effect of nitrogen rates from an analysis combining 3 sites and 2 years.

2.A.2 The individual year analyses

In each of the 2 years, 1975 and 1977, data were collected on a number of characters most of which were not common to both years, and so a combined analysis over years was not possible. Nevertheless, some of these characters are important enough to merit the individual analyses. It should however be pointed out that the interpretation from such analyses will be of a limited value.

The mean squares of the characters observed in 1975 are given in Table 8. Dates had a highly significant (0.01) effect on all earliness characters and also on yield, but significant only at 0.05 level for boll weight, seed index and ginning percentage (GP). Number of seed was not affected by sowing date. The linear component of date was significant for all characters except E2% while the quadratic effect was significant for all the earliness characters except PRI, and for none of the yield characters. Nitrogen and its linear component showed a significant effect for three earliness characters, PRI, NFB and DFF, as well as for all yield characters; ginning percentage was not affected. It is however worth noting that PRI is partly a function of yield. There was no significant date x nitrogen interaction for any character. The varieties differed significantly (0.01) for all characters. Date x

Table 8: Mean square from the analysis of an experiment involving 3 sowing dates, 3 nitrogen levels and 7 varieties conducted in 1975

Sources	d.f.	Earliness characters				Yield characters						C
		E1%(1)	E2%	MMD(2)	PRI kg/ha/day	NFB(3)	DFF	Yield kg/ha	boll wt (g)	seed index	number of seed	
Blocks	1	375.48	3604.94°	123.59	0.13	0.097	0.51	29442.0	0.60	0.58	23.98	0.01
Dates	2	14305.61°°	10032.76°°	1797.47°°	430.70°°	3.121°°	3140.24°°	11650371.4°°	1.52°	1.44°	44.26	4.26°
linear	1	17584.81°°	521.41	3152.17°°	854.03°°	3.241°°	5099.65°°	23175964.2°°	2.69°	2.15°	14.82	3.50°
quadratic	1	11026.41°°	19544.10°°	442.76°°	7.38	3.001°°	1183.83°°	124779.8	0.34	0.72	73.68	5.03°
Nitrogen	2	482.33	2312.80	79.45	178.67°°	1.341°	95.98°	4180265.5°°	3.37°°	3.99°°	78.47°	2.63
linear	1	212.04	850.97	4.19	354.20°°	2.679°°	161.57°°	8198776.0°°	6.07°°	7.91°°	117.15°	0.01
quadratic	1	752.62	3774.80°	154.71	3.14	0.004	30.38	161755.3	0.66	0.03	39.92	0.04
D x N(4)	4	575.23	1331.46	66.72	11.17	0.100	21.55	385817.8	0.30	0.29	7.12	1.75
l x l	1	1499.82	5135.65°	238.76°	22.91	0.362	69.75°	904580.9	0.53			
l x q	1	519.31	165.85	24.96	17.32	0.134	1.25	514544.6	0.00			
q x l	1	129.13	1.33	2.05	4.38	0.134	4.18	119896.9	0.02			
q x q	1	152.65	23.03	1.12	0.05	0.012	11.01	4248.7	0.64			
Error (a)	8	303.45	561.68	32.24	12.38	0.204	11.69	311661.7	0.31	0.21	17.07	0.51

Table 8 (cont'd)

Sources	d.f.	Earliness characters					Yield characters					GP
		E1%(1)	E2%	MMD(2)	PRI kg/ha/day	NFB(3)	DFF	Yield kg/ha	boll wt (g)	seed index	number of seed	
Varieties	66	1169.60**	4502.57**	196.93**	10.30**	5.909**	279.16**	258684.8**	2.02**	5.82**	86.97**	24.
D x V(4)	12	293.24**	902.40**	39.03**	3.39**	1.063**	12.66**	66538.2	0.73**	0.91	56.45**	1.
D(1) x V	6	2828.19**	10207.99**	404.99**	37.94**	8.460**	108.78**		4.67**		[illegible]	21.
D(q) x V	6	690.49**	1580.70**	63.36**	2.89	4.200**	42.97**		4.10**		261.85**	1.
N x V	12	57.48	93.59	5.11	2.04	0.325	6.51	55971.0	0.28	0.46	13.53	0.
D x N x V	24	65.49	123.40	5.94	3.01*	0.223	6.61	80844.1*	0.20	0.28	7.77	0.
Error (b)	54	51.65	100.32	5.09	1.70	0.202	3.66	46685.9	0.27	0.46	9.02	0

*, **, significant at the 0.05, 0.01 levels of probability, respectively.

(1) E1% = first pick of seedcotton as a percent of total pick, E2% = first 2 picks as a percent of total pick, MMD = mean maturity date calculated from a point 28 days before the first pick, PRI = production rate index in kg/ha/day, NFB = node of the first fruiting branch, DFF = days from planting to first flower, GP = ginning percentage.

(2) MMD (and hence PRI) calculated from the date the first boll split was noticed in each case

(3) mean square for NFB is multiplied by 10^2

(4) linear and quadratic components of some interaction terms are not worked out.

variety interaction was highly significant for eight of the 11 characters. Both the linear and the quadratic components of this interaction were significant (0.01) except for GP. There was no significant nitrogen x variety interaction for any of the characters.

Since the date x variety interaction was significant and especially since both are fixed factors, the interaction means for the earliness characters were further examined (Table 9). The mean nitrogen effects are given at the foot of the table for those characters in which nitrogen showed significant effects. Estimates of the linear and quadratic contrasts for the date x variety interaction for the earliness characters are also given in Table A2a.

The second planting date reduced both E1% and E2% most in all the varieties. The third sowing date also reduced E1% in all varieties but affected E2% differentially, with increase in some and reduction in others. One possible explanation for this could be that more seedcotton opened during the 2-week period between the first pick and the second pick in the early varieties than in the late ones. This can be shown for the third date in which 53.8% (86.8% - 23.0%) of the crop opened in V_2 compared to V_6 or V_7 in which only 21.2% (21.8 - 0.6%) opened during this 2-week period. This suggests that where late

Table 9: Means[1] averaged over replications and nitrogen levels of the sowing date x variety interaction, and means of nitrogen (bottom part) averaged over all other factors in 1975 for earliness characters

	E1%				E2%				MMD[2]			
	D1	D2	D3	Var means	D1	D2	D3	Var means	D1	D2	D3	Var means
V_1	58.0	15.6	23.7	32.4 a	72.9	57.3	75.5	68.6 a	148.7	145.8	136.1	143.5 a
V_2	37.9	8.9	23.0	23.3 b	58.6	41.1	86.8	62.2 a	153.5	149.0	134.6	145.7 b
V_3	31.8	4.6	17.1	17.8 c	50.0	35.2	75.9	53.7 b	155.5	150.4	137.0	147.6 c
V_4	51.5	2.2	2.9	18.9 c	69.7	23.2	45.4	46.1 c	150.0	152.4	143.2	148.6 c
V_5	45.0	3.1	5.8	18.0 c	69.6	23.6	50.1	47.8bc	151.0	152.3	142.2	148.5 c
V_6	25.6	0.7	0.6	9.0 d	45.7	13.3	21.8	26.9 d	157.0	154.0	146.9	152.6 d
V_7	26.6	1.0	0.9	9.5 d	45.8	16.3	22.1	28.1 d	156.9	153.6	146.8	152.4 d
Date means	39.5e	5.2f	10.6f		58.9e	30.0f	53.9e		153.2e	151.2e	141.0f	
Nitr means	N1 N2 N3 not signif.				N1 N2 N3 not signif.				N1 N2 N3 not signif.			

Table 9 cont'd next page

Table 9 (cont'd)

Varieties	PRI kg/ha/day				NFB				DFF			
	D1	D2	D3	Var means	D1	D2	D3	Var means	D1	D2	D3	Var means
V_1	11.1	7.1	4.9	7.7 c	3.1	4.7	3.9	3.9 a	52.9	70.3	69.8	64.3 b
V_2	10.3	7.1	4.8	7.4 c	3.3	4.3	4.5	4.1 a	52.2	66.2	68.0	62.1 a
V_3	9.1	7.2	5.5	7.3 c	3.8	4.8	4.8	4.5 b	52.7	68.3	70.8	63.9 b
V_4	12.8	8.5	5.7	9.0 ab	4.8	4.9	4.7	4.8 c	55.2	68.8	70.4	64.8 b
V_5	13.1	8.9	5.9	9.3 a	4.6	4.8	4.8	4.8 c	56.7	70.8	70.9	66.1 c
V_6	12.1	8.0	4.5	8.2 bc	5.0	5.1	5.5	5.2 d	59.8	74.3	77.8	70.6 d
V_7	12.0	7.7	4.4	8.0 c	5.8	5.5	5.1	5.5 d	65.8	76.7	76.6	73.0 e
Date means	11.5d	7.8e	5.1f		4.4e	4.9f	4.8f		56.5f	70.8g	72.0g	
Nitr means	N1 6.2g	N2 7.9g	N3 10.3h		N1 4.8g	N2 4.7gh	N3 4.5h		N1 68.2h	N2 65.7i	N3 65.4i	

(1) means followed by the same letter(s) are not significantly different at the 0.05 level of probability within each character.

(2) MMD (and hence PRI) calculated from the date of planting for each sowing date.

planting of cotton is a common practice, E2% would be a better measure of earliness since it showed a greater differentiation between the early and the late varieties. Except for V_3 which was intermediate for both E1% and E2%, the ranking of the varieties remained consistent for these two characters when averaged over dates.

Mean maturity date (MMD) measured from the date of planting was considerably reduced by the third sowing date, but this reduction was not uniform for all the varieties. It appeared that the earlier maturing varieties were more sensitive to late planting than the late varieties. In that respect, the third sowing date (D3) showed the most distinguishing effect with more than 12 days between the earliest and the latest variety, but about 8 days in the first (D1) or the second (D2) sowing date. Later plantings also decreased the production rate index (PRI) of all the varieties linearly. While the difference between V_3, the least producer, and V_5, the highest producer, was 4.0 kg/ha/day of seedcotton in D1, this difference was reduced to 1.5 kg/ha/day in D3. Under all the three sowing dates, V_4 and V_5 had the highest production rate and when averaged over dates, the order of earliness in the varieties appeared to be reversed. This may be due to the fact

that PRI, as a measure of earliness, takes yield into consideration also, hence the higher yielding Samaru varieties, V_4 and V_5, which also had a history of selection for E1% and E2% came out with higher values of PRI than the remaining varieties.

Node of the first fruiting branch (NFB) and DFF were both increased by late planting. Although averaged over all varieties, D2 and D3 did not differ significantly for either NFB or DFF, yet as in the case of E1% there was an indication, at least in some varieties, of a more severe effect of D2 on NFB. Thus, later planting would produce late crop based on NFB and DFF as criteria for measuring earliness. However, averaged over dates, the varieties showed consistency of ranking for NFB but not for DFF. Nevertheless, the late varieties came out late and V_2 came out the earliest.

The highest level of nitrogen increased PRI but decreased NFB and DFF which indicates that an early maturing crop can be produced at high rather than at low levels of nitrogen if PRI, NFB and DFF gave a good measure of earliness.

It is interesting to point out an apparent contradiction between MMD and DFF both of which measure earliness in number of days from planting up to a certain physiological stage in the development of the plant. MMD as presented in Table 9 was greatly reduced or shortened in D3 than in D1 or D2, while DFF

was greatly increased or lengthened in D2 and D3 than in D1. Since MHD is a function of the individual picks and would also include the DFF, it was possible that the late planting influenced the period of boll development (the period from anthesis to boll opening) more than the preceding period. The rainy season in this area of Nigeria is normally short, and any delay in planting tends to restrict the growing period of the plants especially toward the end of the season when the bolls are developing. Thus, there would be more physiological pressure on the plants to mature in a shorter period of time than they would normally do under earlier planting date.

The date x variety interaction means for the yield characters and for ginning percentage (GP) are given in Table 10. The mean nitrogen effects are also given at the foot of this table, while the linear and the quadratic contrasts are presented in Table A2b. In the case of yield and seed index, this interaction was not significant. Averaged over the sowing dates, V_4 and V_5 together with the two late types, V_6 and V_7, had higher seedcotton yields while the early maturing varieties, except V_1, were low yielding. Means for dates clearly showed that the later the planting date, the less was the yield of seedcotton. The overall trend for boll weight was a linear decrease with later plantings in all varieties except

e 10: Means[1] averaged over replications and nitrogen levels of the sowing date x variety interaction, and means of nitrogen (bottom part) averaged over all other factors in 1975 for yield characters and GP

ie-s	Yield kg/ha				boll weight (g)				seed index				number of seed				GP			
	D1	D2	D3	Var means	D1	D2	D3	Var means	D1	D2	D3	Var means	D1	D2	D3	Var means	D1	D2	D3	Var means
	1670	1035	669	1125 bc	4.4	5.1	4.5	4.7a	7.8	8.3	8.5	8.2c	31	36	33	33a	36.7	36.3	34.4	35.8 a
	1584	1060	645	1096 c	4.8	4.6	4.5	4.6a	9.8	9.5	9.8	9.7a	28	30	29	29b	32.5	33.3	33.4	33.1 d
	1417	1087	748	1084 c	3.6	4.0	4.0	3.9b	9.2	9.3	8.3	8.9b	23	25	30	26c	34.5	35.1	34.8	34.8 b
	1935	1270	814	1340 a	5.0	4.0	4.2	4.4a	8.4	8.6	9.2	8.7b	34	27	28	30b	35.4	35.5	35.4	35.4 a
	1965	1353	834	1384 a	4.8	4.0	3.7	4.2ab	8.6	9.0	8.9	8.8b	32	27	27	29b	34.4	34.5	33.1	34.0 c
	1898	1236	652	1262ab	4.4	3.7	4.0	4.0b	8.2	8.7	8.4	8.4bc	31	26	31	29b	33.0	33.1	32.9	33.0 d
	1891	1175	644	1237abc	4.2	3.8	3.7	3.9b	7.3	8.1	8.5	8.0c	33	28	29	30b	33.5	34.0	33.4	33.6 c
te ans	1766d	1174e	715f		4.5c	4.2d	4.1d		8.5d	8.8e	8.8e		30	28	29		34.3e	34.5e	33.9f	
tr ans	N1 931g	N2 1167g	N3 1556h		N1 3.9e	N2 4.3g	N3 4.5f		N1 8.4f	N2 8.7f	N3 9.0h		N1 28f	N2 30g	N3 30g		N1	N2	N3	
																	not signif.			

1) means followed by the same letter(s) are not significantly different at the 0.05 level of probability within each character.

V_1 and V_3. For boll weight, V_4 and V_5 appeared to be the most sensitive to D2 and D3 while V_2 and V_3 were not so affected. For seed index, the verietal means averaged over dates, differed, with V_2 having the heaviest seed and V_1 and V_7 the lightest. The varieties showed differential response to the sowing dates for number of seed. All the yield characters were significantly increased by higher levels of nitrogen.

Dates of planting and higher levels of nitrogen influenced most of the characters studied in 1975. This agreed with earlier findings, that, highest yields of seedcotton were obtained from early to mid June sowing (Choyce and Reed, 1961; Faulkner, Hayward, Mustafa and Smithson, 1974). Similarly boll weight and seed weight were increased by higher levels of nitrogen (Wadleigh, 1944).

In 1975, the studied varieties attained their various degrees of earliness by a combination of different characters favourable to earliness. If for instance the weight of the first two picks as a percent of the total pick (E2%) was used as the overall measure of earliness (as is often the case at Samaru), it could be seen that V_1 combined the lowest values for MMD and NFB; moderate values for DFF and the greatest values for boll weight and number of seed. It however had low PRI. V_2 combined the lowest values for PRI, NFB and DFF but

only low MMD; moderate values for number of seed and the greatest values for boll weight and seed index. V_3 had moderate to low values for all but number of seed. V_4 and V_5 combined moderate values for all characters except PRI for which these two varieties had the highest. Except for PRI, V_6 and V_7 combined the lateness aspects of each earliness character with moderate to high values for yield characters.

The mean squares from the analysis of the 1977 trial are presented in Table 11. Date was significant for DFF, BP, and seed index only, with significant linear and quadratic effects. Nitrogen did not significantly influence any character, but there was a significant date x nitrogen interaction for DFF. The varieties differed significantly for all characters studied, with a significant date x variety interaction for BP.

The means of dates and varieties which are given in Table 12 show that V_1 and V_2 had the lowest NFB while V_6 and V_7 had the highest. V_2 and V_3 had the shortest DFF, but as in 1975 the later plantings increased DFF. Bolling period (BP) was shortest in D2. As for the yield characters, V_1, V_4, V_5 and V_6 had heavier seeds than the other varieties. Again as in 1975, V_1 had the greatest number of seed but the least seed index. Plant height (PHT) was not influenced by any of the factors except that the varieties differed significantly. Two of the early varieties

were the shortest while V_6 was the tallest.

In 1977, V_1 combined the lowest values for NFB and BP; low DFF and the greatest values for boll weight and number of seed. V_2 had the lowest values for NFB and DFF, but only low BP, the highest boll weight and seed index.

As mentioned earlier, the meaningfulness of any inference from the individual year analysis is questionable. It is felt that the observations reported for the second sowing date of 1975 might have been exaggerated. From previous experience in trials at Samaru, mid June planting (though slightly later in this case) was considered to be the best especially for high yields (Choyce and Reed, 1961). Even for the earliness characters some of the observations especially on E1%, E2%, and NFB might not be quite realistic. Part of the reason for the observed behaviour of the June planting in 1975 could be toxicity due to insecticide. When the plants of the first sowing date were being sprayed at 5 and 6 weeks after planting, the seedlings of the second sowing date were just emerging and/or establishing. Although no visible injury was noticed at that time, it is feared that some latent adverse effect might have been caused to them by the insecticide which was relatively too concentrated at their tender age. In addition to this factor, there was also a dry spell during the squaring stage of the plants sown under the second sowing date (see Figure 1).

Table 11: Mean[(1)] squares from the analysis of an experiment involving 3 sowing dates, 2 nitrogen levels and 7 varieties conducted in 1977

Sources	d. f.	Earliness characters			Yield characters			PHT
		NFB	DFF	BP	boll wt (g)	seed index	number of seed	
Blocks	1	0.03	10.01	0.58	0.01	1.53	40.05	154.71
Dates	2	0.29	604.65**	288.16*	2.67	29.27*	52.10	1892.15
linear	1	0.54	1076.25**	53.04	4.87	12.56	0.01	1207.14
quadratic	1	0.04	133.04*	523.29**	0.47	45.99**	104.19	2577.17
Nitrogen	1	0.67	19.04	109.71	0.32	0.00	14.09	495.43
D x N	2	0.17	71.65*	46.08	0.40	4.12	18.49	423.68
D(l) x N	1	0.00	61.11*	45.54	0.04	1.97	9.04	151.14
D(q) x N	1	0.33	82.18*	46.62	0.04	6.28	27.93	696.21
Error (a)	5	0.26	8.90	22.10	0.80	2.75	42.16	884.51
Varieties	6	2.78*	125.48**	109.42**	0.97**	5.47*	80.78*	3031.35**
D x V	12	0.39	6.22	27.30	0.11	2.19	13.84	179.84
N x V	6	0.26	3.47	11.67	0.26	1.16	6.72	253.62*
D x N x V	12	0.19	4.11	17.49	0.13	0.25	6.93	191.33*
Error (b)	36	0.22	5.81	9.77	0.12	1.65	9.34	91.13

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

Table 12: Varietal means[1] averaged over replications, sowing dates and nitrogen levels, and means of dates averaged over all other factors

Varieties	Earliness characters			Yield characters			PHT
	NFB	DFF	BP	boll wt (g)	seed wt (g)	number of seed	
V_1	4.2 a	63.9 b	44.1 a	4.4 a	7.5 c	35 a	62 b
V_2	4.1 a	60.5 a	47.4 b	4.2 ab	9.0 ab	29b	51 a
V_3	4.5 ab	61.5 a	47.5 b	3.7 cd	8.0 bc	28 b	46 a
V_4	4.8 bc	63.5 b	53.1 d	4.2 ab	8.9 ab	29 b	75 c
V_5	5.1 cd	65.8 c	50.7 cd	4.0 bc	9.4 a	27 b	77 c
V_6	5.2 d	67.6 cd	51.5 cd	4.1 b	8.6 abc	30 b	92 d
V_7	5.2 d	69.5 d	49.4 bc	3.6 cd	8.1 bc	29 b	66 b
Date means							
D1	not signif.	59.4 e	51.8 e	not signif.	8.5 de	not signif	not signif
D2		66.4 f	45.6 f		9.6 d		
D3		68.1 f	49.9 e		7,5 e		

(1) means followed by the same letter(s) are not significantly different at the 0.05 level of probability within each character.

The significant effects reported for the individual years, might be due to the fact that the variance of the main effects contained the variance involving their interaction with the respective year in which the trial was carried out.

2.A.3 Conclusion

When the results were combined over years, the characters NFB and DFF were found to be strongly varietal, as they were little affected by the agronomic factors studied. These characters can be used reliably as morphological criteria for identifying early maturing plant types. Two of the varieties, V_1 and V_2, appeared to be the most consistent for earliness in spite of the different agronomic factors under which they were tested. They were also found to combine low NFB, short DFF with higher values of some yield characters.

Taking the individual years separately, the results of the 1975 trial indicated that V_1 would have been the best choice followed by V_4 and V_5 for planting under D1, assuming other things being equal. Under D2 and D3, especially when all the six earliness characters, (E1%, E2%, MMD, PRI, NFB and DFF) are considered, V_1, V_2, or V_3 would be the choice. It also seems that an early crop can be produced under early planting date based on NFB and DFF; and also from higher level of nitrogen based on PRI, NFB and DFF, assuming that these characters gave

a good measure of earliness.

Although correlation studies were not done, the intermediate and the late maturing varieties were higher yielding than the early maturing ones, and that later sowing linearly decreased yields.

Considering all the results of the agronomic trials, V_2 was the most consistent variety for earliness, though when averaged over the main factors, the early and the late types were distinctly different. However, because of low yields, very poor resistance to bacterial blight, low ginning percentages and poor lint quality of the early maturing varieties, their direct utilisation for cultivation is not possible.

B. Genetic Studies

Series I: The diallel cross analysis

2.B.I.1 Combined analysis over years and dates

The overall combined analysis of variance over 2 years and 2 sowing dates involving all the 49 entries (7 parents, 21 F_1's and 21 F_2's) is presented in Table 13. The three separate picks were not made on the single plants in the June sown trial of 1976, therefore, only five of the ten characters were included in this combined analysis.

All five characters showed highly significant (0.01) effect of years. The average values of 1976 and 1977 for NFB were 4.95 and 4.70 nodes, and for DFF were 68.90 and 66.19 days, respectively; thus, crop grown in 1976 took longer to mature on the average. There were more fruiting points (TFP) in 1976 (28.9) than in 1977 (21.1) and more sympodial branches (NSB) in the first year (15.73) than in the second (12.42), while plants were, on the average, taller in the first year. The different rainfall patterns of 1976 and 1977 might have influenced the expression of these characters.

Sowing dates did not significantly influence any of the five characters, but it can be seen in Table 13 that the mean square for date was fairly large in three of the five characters, compared with that of the year x date interaction against

Table 13: Mean squares from an overall combined analysis of variance over 2 years and 2 sowing dates (June and July)

Sources	d.f.	Earliness characters		Productivity characters		PHT
		NFB(1)	DFF	TFP(2)	NSB	
Year	1	9062.93**	10319.15**	90985.87**	16001.71**	1840411.00**
Date	1	5409.80	73408.53	65053.63	921.70	7042.39
Y x D	1	1920.00**	8031.36**	1032.53*	8172.22**	210445.80**
Blocks/YD	8	179.51	225.98	1033.71	373.32	4308.87
Genotype	48	571.75**	654.76**	588.44	135.28**	19509.90**
generations	2	239.96	1320.49**	4367.25**	150.89	1850.00
parents	6	1532.06**	1685.16*	330.00	154.33*	44913.63**
F_1's	20	417.02**	466.40**	557.89	139.51**	18497.72**
F_2's	20	471.76**	467.47**	317.73	123.77*	14666.95**
Y x G	48	132.72**	75.92**	396.45**	56.98*	3446.75**

Table 13 cont'd next page

Table 13 (cont'd

Sources	d. f.	Earliness characters		Productivity characters		PHT
		NFB(1)	DFF	TFP(2)	NSB	
Y x gener.	2	23.62	27.21	1037.71	38.92	2598.78*
Y x par.	6	11.35	79.01*	587.97**	123.76**	7641.42**
Y x F_1	20	110.49	104.10**	512.30**	52.76	2602.62**
Y x F_2	20	202.26**	51.69	159.02	42.98	3117.27**
D x G	48	73.68	41.93	447.09	59.76	1785.90**
D x gener,	2	7.64	45.78	906.64	96.73	313.49
D x par.	6	122.06	33.69	499.29	67.72	1811.73*
D x F_1	20	79.30	47.04	572.69	80.59	1882.86**
D x F_2	20	60.16	38.91	259.88	32.84	1828.54*
Y x D x G	48	65.00	29.31	309.00	45.34	783.21
Error (plot)	384	76.19	33.90	201.66	37.11	702.52
Error (samp.)	5292	48.97	10.49	62.42	10.84	339.05

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) mean squares for NFB multiplied by 10^2

(2) TFP = total number of fruiting points on the mainstem, NSB = number of sympodial nodes on the mainstem, PHT = plant height (cm).

which it was tested. For NFB it was 2.8 times as large; for DFF, it was over 9 times and for TFP, it was 63 times as large. Since there was only 1 degree of freedom for each of the two sources mentioned, the test for date was not sensitive enough to detect significant effects. The year x date interaction itself was highly significant (0.01) for all characters except TFP in which the significance level was 0.05, indicating that the effect of the dates was not consistent over the years. However, no further examination of this interaction was made, but combined analyses over years were carried out for each sowing date.

Genotypes were highly significantly different for all characters except TFP. The sums of squares for genotypes were partitioned into four components (i.e. between generations, among parents, among F_1's and among F_2's). The between generations source was highly significant for DFF and TFP. The grand parental, F_1, and F_2 means for DFF were 68.38, 66.78, and 68.03 days, respectively, indicating that the F_1's flowered about 1.5 days earlier than the average of the parents. The parents differed significantly at the 0.01 level or lower for NFB, DFF and PHT but only at the 0.05 level for NSB. This is not surprising, since there had not been any conscious or direct selection for NSB nor for TFP in these varieties. The

different crosses within the F_1 and within the F_2 generations showed highly significant differences for all characters except TFP.

The year x genotype interaction was also significant at the 0.01 level of probability for all characters except NSB (0.05 level) indicating a differential performance of the genotypes over the years. A further partitioning of this interaction indicated that, for NFB it was the differential response of the F_2 to years that constituted the major portion of this interaction; while for DFF, it was that of the parents as well as of the F_1; and still for NSB, it was the differential response of the parents and the F_2. For PHT, all the four components of the year x genotype interaction were significant.

The analysis for combining ability using only the F_1 and the F_2 but excluding the parents was conducted according to Griffing's (1956) method 4 model 1. The results of the combining ability analysis are presented in Table 14. The general combining ability (gca) was significant at the 0.01 level for NFB, DFF, NSB and PHT, the four characters for which the F_1 crosses were significantly different. The specific combining ability (sca) was not significant for any of the characters. In fact the mean square for sca was smaller than that of the

Table 14: Mean squares for the general and specific combining ability of a seven-parent diallel cross from an overall combined analysis over 2 years and 2 sowing dates

Sources	d.f.	Earliness characters		Productivity characters		PHT
		NFB(1)	DFF	TFP	NSB	
Genotype	48	571.75**	654.76**	588.44	135.28**	19509.90**
F_1	20	417.02**	466.40**	557.89	139.51**	18497.72**
gca	6	1191.25**	1450.29**	1113.04*	295.89**	59682.99**
sca	14	85.21	44.73	319.97	72.50	846.89
F_2	20	471.76**	467.47**	317.73	123.77*	14666.95**
gca	6	1256.21**	1473.96**	469.38	290.68**	44491.99**
sca	14	135.57	36.00	252.74	52.23	1884.79
Y x G	48	132.72**	75.92**	396.45**	56.98*	3446.75**
Y x F_1	20	110.49	104.10**	512.30**	52.76	2602.62**
Y x gca	6	215.33**	103.19**	471.50*	34.29	4400.30**
Y x sca	14	65.56	104.49**	529.79**	60.67	1832.19**
Y x F_2	20	202.26**	51.69	159.02	42.98	3117.27**
Y x gca	6	224.54**	52.83	209.24	51.23	6246.98**
Y x sca	14	192.71**	51.21	137.50	39.45	1775.96**
Error	384	76.19	33.90	201.66	37.11	702.52

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) mean squares for NFB multiplied by 10^2

year x genotype interaction for each character except NSB. The F_2 also showed a similar trend.

The year x gca interaction in the F_1 analysis was highly significant for NFB, DFF, TFP (0.05) and PHT, and the year x sca interaction was also highly significant for DFF, TFP and PHT. In the F_2 analysis both the year x gca and the year x sca interactions were highly significant for NFB and PHT only. It is however interesting to note that TFP which showed virtually no significance for the main factors, did so for the year x genotype interaction and its components while the pattern for NSB was the opposite.

Although all the trials were conducted at only one location, the results of the combined analysis over years will allow a meaningful inference to be drawn about these varieties and their hybrid crosses. It is of interest from a plant breeding point of view to examine further, the gca and the sca effects from the above analysis. Hence the gca effects are presented in Table 15 and those of the sca effects in Tables A3 and A4.

An examination of the top half of Table 15 shows that V_1, V_2 and V_3 each had negative gca effects for each character, while each of the remaining varieties showed a positive effect for the four characters that showed significance. Again in

Table 15: General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in an overall combined analysis over 2 years and 2 sowing dates

Parents	Earliness characters		Productivity characters		PHT
	NFB(1)	DFF	TFP+	NSB	
For F_1					
1	-2.23	-0.55	-1.48	-0.71	- 4.30
2	-1.13	-1.78	-0.28	-0.73	-10.81
3	-0.46	-1.84	-1.04	-0.76	-14.53
4	0.07	0.11	0.24	0.28	5.74
5	0.02	0.15	0.81	0.84	7.01
6	0.09	2.03	-0.78	0.52	12.04
7	0.20	1.86	2.54	0.54	4.83
s.e.++	0.066	0.503	1.150	0.436	3.390
For F_2					
1	-0.22	0.08	-1.17	-0.94	- 3.64
2	-0.13	-2.25	-0.67	-0.82	-10.13
3	-0.18	-1.52	-0.22	-0.25	-11.63
4	0.07	0.23	-0.61	0.41	5.46
5	-0.02	-0.19	1.20	0.88	7.12
6	0.10	1.25	0.01	0.58	10.35
7	0.22	2.40	1.02	0.14	2.47
s.e.++	0.066	0.503	1.150	0.436	3.390

\+ TFP not significant but presented here for the sake of completeness.

++ s.e. of the difference between two effects.

the F_2 (lower half of Table 15), V_1, V_2 and V_3 showed negative effects for each character except V_1 for DFF (which was positive but fairly low). V_5 also showed negative effects for NFB and DFF, while V_4, V_6 and V_7 showed positive effects.

If NFB, DFF and NSB can be used together to determine earliness in these varieties, then a combination of negative gca effects for the first two characters and positive effects for the third character would be desirable. In doing so, any variety that combines these effects would have lower NFB, shorter DFF and more fruit bearing branches. This did not appear to be so in the F_1 analysis (see the top half of Table 15), but in the F_2 analysis, V_5 (though small values) seemed to have the desired combination of the effects for these three characters. This would indicate that V_5 was the earliest maturing by this standard. This apparent contradiction to previous observations may be due to the fact that in terms of absolute numbers, the early maturing varieties had less NSB and were shorter plants than the late types. However, when the NSB per meter of plant height is considered (as some measure of relative productivity of sympodial branches) it can be seen that the early maturing varieties had higher NSB for their given height (Table A5).

The means of all the genotypes for NFB and DFF are presented in Table A6, and for NSB and PHT in Table A7 for the overall combined analysis. A multiple range test on the parental means

shows that V_1 and V_2 had significantly (0.05) the lowest NFB, while V_2 and V_3 had the shortest DFF and were the shortest in terms of PHT, with V_2 having the least NSB. V_7 had the highest NFB, V_6 and V_7 had the longest DFF, and V_5 and V_7 had the greatest NSB. Hybrids with the lowest NFB were found among the arrays of V_1 and V_2 while those with the highest NFB were found among the arrays of V_6 and V_7. The hybrid with the lowest NFB was that of the $V_1 \times V_2$ cross and that with the highest NFB involved $V_4 \times V_7$. Smaller values for DFF were found among the hybrids of V_1, V_2 and V_3 with the cross $V_2 \times V_3$ having the shortest DFF although this might not differ significantly from the hybrids of $V_1 \times V_2$ and $V_2 \times V_4$ or even $V_3 \times V_5$. The F_1 of all the three crosses had DFF values shorter than their earlier parent. The highest NSB per meter of PHT were obtained in the $V_1 \times V_2$, $V_1 \times V_3$ crosses.

The estimate of sca variances associated with each parent in the F_1 analysis were very low, in fact they were negative for all characters except NSB for which V_1, V_2, V_4 and V_7 had positive mean squares which were relatively high. The low values of the sca mean squares for all the characters per parent indicates that hybrids involving the particular varieties have performed as would be expected on the basis of their gca (Sprague and Tatum, 1942), and that those varieties uniformly transmitted NFB, DFF and PHT to all their F_1's (Griffing, 1956).

2.B.I.2 Combined analysis over two years for June sowing (D1)

The results of the analysis of variance are presented in Table 16. The years had highly significant (0.01) effects for all characters and showed higher values in 1976 than in 1977. The genotypes differed at the 0.01 level of probability for NFB, DFF, NSB and PHT. The among generations source was significant only for DFF, and the grand means for the parental, F_1 and F_2 generations were 64.98, 63.35 and 64.35 days, respectively, showing the F_1 to have flowered 1.63 days earlier than the parents on the average. The F_2 mean was between the parental and the F_1 generation means. There were highly significant (0.05 for NSB) differences among the parents and among the F_1's for the four characters, while the F_2 differed (0.01) for NFB, DFF and PHT but not for NSB.

The year x genotype interaction together with its components were highly significant for TFP, NSB and PHT but not for NFB and DFF. The year x parents and the year x F_1 interactions were significant for these three characters while the year x F_2 was significant for PHT only, and the year x generations for TFP only.

In both the F_1 and the F_2 analyses, the gca was highly significant for each of the four characters for which these generations showed significance, but the sca was not (Table 17).

Table 16: Mean squares from a combined analysis of variance of a seven-parent diallel cross over 2 years for June-sown trials

Sources	d.f.	Earliness characters		Productivity characters		PHT
		NFB(1)	DFF	TFP	NSB	
Years	1	9662.89**	18746.86**	3631.63**	651.52**	403088.60**
Blocks/Y	4	30.07	220.44	954.14	361.09	4008.18
Genotypes	48	367.80**	349.27**	688.62	128.89**	14175.37**
generations	2	107.67	550.25**	4232.07	180.11	988.80
parents	6	958.02**	801.99**	693.12	152.87*	30714.79**
F_1	20	270.72**	282.02**	684.06	160.12**	14347.11**
F_2	20	313.82**	260.61**	337.48	85.33	10360.46**
Y x G	48	90.04	51.71	555.36**	59.19**	2080.37**
Y x generation	2	3.36	28.13	928.93*	3.52	452.20
Y x parents	6	14.37	27.75	659.11*	103.27**	3921.53**
Y x F_1	20	70.10	56.74	818.75**	77.38**	1869.72**
Y x F_2	20	141.36	56.22	223.49	33.34	1901.49**
Error (plot)	192	90.48	34.39	225.23	28.84	529.55
Error (sample)	2646	53.24	11.76	63.52	9.16	252.10

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) mean square for NFB multiplied by 10^2

Table 17: Mean squares for general and specific combining ability of a seven-parent diallel cross from a combined analysis over 2 years for June-sown trials

Sources	d. f.	Earliness characters		Productivity characters		PHT
		NFB(1)	DFF	TFP	NSB	
Genotypes	48	367.80**	349.22**	688.62	128.89**	14175.37**
F_1	20	270.72**	282.02**	684.06	160.12**	14347.11**
gca	6	735.56**	881.22**	1274.30	390.43**	45805.24**
sca	14	71.88	25.23	431.10	61.42	865.05
F_2	20	313.82**	260.61**	337.48	85.33	10360.46**
gca	6	745.65**	804.23**	688.08	214.59**	33074.05**
sca	14	128.75	27.63	187.22	29.94	626.07
Y x G	48	90.04	51.71	555.36**	59.19**	2080.37**
Y x F_1	20	70.10	56.74	818.75**	77.38**	1869.72**
Y x gca	6	131.48	47.29	615.34*	44.90	2270.64**
Y x sca	14	43.82	60.80	905.92**	91.30**	1697.89**
Y x F_2	20	141.36	56.22	223.49	33.34	1901.49**
Y x gca	6	132.21	52.29	367.20	65.36	3242.32
Y x sca	14	145.27	57.90	161.91	19.62	1326.84**
Error (plot)	192	90.48	34.39	225.23	28.84	529.55

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) mean square for NFB multiplied by 10^2.

In fact the mean squares of the sca were considerably smaller than the year x genotype interaction mean square for each character except NFB. This was an indication that gca was more important than sca for these characters in these varieties under the June-sown conditions.

The year x gca interaction in the F_1 was significant for TFP (0.05) and for PHT (0.01), while the year x sca interaction was significant (0.01) for TFP, NSB and PHT. In the F_2 both the year x gca and the year x sca interactions were highly significant for PHT.

The gca effects are presented in Table 18. Both F_1 and F_2 showed very similar patterns with V_1, V_2 and V_3 showing negative effects for all four characters; and V_4 and V_5 showing negative or relatively low values for DFF. This indicates that V_1, V_2 and V_3 combined low NFB and NSB with short DFF and short plant stature, but V_2 and V_3 had higher NSB per meter of PHT (see bottom half of Table A8). V_4 and V_5 combined fairly low values of some characters with high values of others. The sca effects were fairly uniformly low for all characters. See Table A9 (for NFB and DFF) and A10 (for NSB and PHT).

The means for NFB and DFF are presented in Table A11 and those for NSB and PHT in Table A12. V_1, V_2 and V_3 had the lowest NFB, with V_2 and V_3 having the shortest DFF also, while

Table 18: General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in a combined analysis over 2 years for June-sown trials

Parent	Earliness characters		Productivity characters		PHT
	NFB	DFF	TFP	NSB	
For F_1					
1	-0.21	-0.13	-1.40	-1.35	- 6.38
2	-0.10	-2.01	-1.84	-0.94	-14.17
3	-0.12	-2.03	-2.65	-1.33	-17.15
4	0.87	-0.08	1.76	1.02	8.89
5	0.17	-0.07	3.66	1.07	8.47
6	0.63	1.83	-1.04	0.74	13.53
7	0.26	2.47	1.50	0.77	6.82
s.e.+	0.077	0.587	1.611	0.628	3.724
For F_2					
1	-0.24	-0.19	-0.26	-1.10	- 4.66
2	-0.14	-2.27	0.40	-0.74	-10.85
3	-0.04	-1.53	-1.44	-0.75	-15.65
4	0.05	-0.23	-2.67	0.25	4.63
5	0.01	0.17	1.83	0.95	7.09
6	0.14	1.71	0.13	0.83	12.58
7	0.22	2.36	2.02	0.56	6.86
s.e.+	0.077	0.587	1.611	0.628	3.724

+ s.e. of the difference between two effects.

2.D.I.3 Combined analysis over years for July sowing (D2)

Three picks were taken from the July-sown trials in both 1976 and 1977, and this enabled a combined analysis of variance as well as gca and sca analysis to be carried out for all the ten characters. The analysis of variance is given in Table 19. The first six columns of the Table are various measures of earliness, the next three are yield and other characters related to productivity.

Years had highly significant effect on all characters except DFF. Higher values were recorded for eight and lower values for two (MMD and NFB) of the ten characters in the first year than in the second. This might be due to the rainfall which was adequate in 1976 but poor in 1977. The genotypes differed significantly for all characters except NSB. There were significant differences between the generations for E1%, MMD, PRI, DFF, yield and TFP; with the F_1 generation having higher values for E1%, PRI, yield and TFP, but equal or slightly lower values for MMD and DFF than the parental generation. This indicates that the F_1 generation was earlier maturing on the average. The parents showed significant differences for five of the six earliness characters and also for PHT but not for yield, TFP or NSB. Both the F_1 and the F_2 showed differences for most of the characters for which the

19: Mean squares from a combined analysis of variance of a seven-parent diallel cross over 2 years for July-sown trials

:es	d.f.	Earliness characters						Productivity characters			PHT
		E1%	E2%	MMD(1)	PRI(2) g/plant/day	NFB(2)	DFF	Yield g/plant	TFP	NSB	
	1	128550.00**	297811.70**	17389.34**	2670.67**	1320.03**	103.64	10533.75**	55701.77**	23522.40**	1647768.00**
	4	1888.09	1146.56	125.79	216.55	328.95	231.51	3473.96	1113.27	385.55	4609.55
	48	5801.48**	3141.87**	344.02**	85.51**	277.64**	347.41**	1009.31**	346.91**	66.15	7120.48**
ner.	2	12167.83**	3648.36	572.06**	747.53**	137.94	816.02**	8879.40**	1041.82**	67.51	1174.70
rents	6	9683.28**	5608.96**	603.99**	73.68	696.11**	916.85**	1049.26	139.17	69.18	16910.57**
	20	5466.28**	3035.43*	331.41**	70.27	225.60**	231.41**	748.81	446.52**	59.98	6033.47**
?	20	4355.40**	2457.31	253.85**	38.11	218.10**	245.73**	470.81	240.13	71.27	6135.03**
G	48	1984.85*	1313.92	113.09	49.29**	107.67**	53.53*	572.36**	150.09	43.13	2149.60**
x gener.	2	820.13	240.65	9.06	150.63**	42.24	6.88	1520.46*	300.57	49.45	2589.33
x par.	6	3280.02*	1634.29	148.72	36.93	50.56	62.16	422.86	168.63	49.99	5005.53**
x F_1	20	1425.69	1297.53	93.95	67.66**	78.19	72.48**	763.67**	134.40	41.63	1384.05
x F_2	20	2312.93*	1341.52	131.94	24.51	160.83**	36.65	331.09	145.16	41.94	2014.39**
or (p)	192	1372.97	981.22	84.13	23.22	61.90	33.40	322.80	178.08	45.38	875.49
or (s)	2646	709.31	564.44	42.62	11.13	44.70	9.21	148.42	61.32	12.52	426.00

**, significant at the 0.05, 0.01 levels of probability, respectively.

) MMD (and consequently PRI) are calculated from the date the first boll split was noticed (about 28 days before the first pick)

) mean squares are multiplied by 10^2.

parents were significantly different. The year x genotype interaction was significant for E1%, PRI, NFB, DFF, yield and PHT. However, no particular partition of that interaction was uniformly significant.

In the F_1 analysis, the gca was highly significant for E1%, E2%, MMD, NFB, DFF, TFP and PHT, but the sca was not significant for all characters except TFP (Table 20). Similarly in the F_2, the gca was significant for these same characters as well as NSD, while the sca was not significant for any of the characters. As in the case of the June-sown trial, the mean squares for the sca source were considerably smaller than the year x genotype interaction mean square. There was a significant year x gca interaction for PRI, DFF, yield and PHT; and also a significant year x sca interaction for PRI and DFF in the F_1 analysis. The year x gca in the F_2 was significant for E1%, NFB and PHT, but the year x sca interaction was nonsignificant for any character. This indicates that it would be necessary to measure gca and sca over years for some of these characters in these varieties.

The gca effects are given in Table 21. The positive and negative gca effects in each line in both F_1 and F_2 suggests that there were some favourable combinations of these characters for earliness in these varieties. For instance, in a

Table 20: Mean squares for general and specific combining ability of a seven-parent diallel cross from a combined analysis over 2 years for July-sown trials

Sources	d.f.	Earliness characters						Productivity characters			PHT
		E1%	E2%	MMD (1)	PRI (2) g/pl/day	NPB (2)	DFF	Yield g/plant	TFP	NSB	
G	48	5801.44**	3141.87**	344.02**	85.51*	277.64**	347.41**	1009.31**	346.91**	66.15	7120.4
F_1	20	5466.28**	3035.43*	331.41**	20.27	225.60*	231.41**	748.81	466.52**	59.98	6033.4
gca	6	13779.64**	7636.48**	866.07**	73.81	555.38**	644.55**	600.15	535.66**	54.63	17953.
sca	14	1903.46	1049.09	105.36	70.25	84.27	54.35	812.52	408.32**	62.28	924.
F_2	20	4335.40*	2457.31	253.85*	38.11	218.10*	245.73**	470.81	240.13	71.27	6135.
gca	6	11656.10**	5999.25**	706.31**	30.93	544.65**	731.42**	285.39	379.47*	131.09*	15685.
sca	14	1198.46	936.19	59.80	39.32	78.22	37.57	550.28	180.42	45.63	2042.
Y x G	48	1984.85*	1313.92	113.09	49.29**	107.67**	53.53*	572.36**	150.09	43.13	2149.
Y x F_1	20	1425.69	1297.53	93.95	67.66**	78.19	72.48**	763.67**	134.40	41.63	1384.
Y x gca	6	1005.21	1364.40	121.25	105.79**	133.86	87.01*	1790.23**	137.94	40.59	2632.
Y x sca	14	1606.99	1268.93	82.22	51.32**	54.33	66.26*	323.72	132.88	42.07	849
Y x F_2	20	2312.93*	1341.52	131.94	24.51	160.83**	36.65	331.09	145.16	41.94	2014
Y x gca	6	2978.04*	1453.40	149.90	16.75	277.00**	20.36	309.73	152.22	10.90	3936
Y x sca	14	2027.24	1293.34	124.20	27.82	111.05	43.63	340.25	142.14	55.24	1190
Error (p)	192	1372.97	901.22	84.13	23.22	61.90	33.40	322.80	178.08	45.38	875

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) MMD (and consequently PRI) are calculated from the date the first boll split was noticed (about 28 days before the first pick)

(2) mean squares for PRI and NPB are multiplied by 10^2.

Table 21: General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross in a combined analysis over 2 years for July-sown trials

Parents	Earliness characters						Productivity characters			PHT
	E1%	E2%	MED(1)	PRI(2) g/pl/day	NFB(2)	DFF	Yield g/pl	TFP	NSB	
For F_1										
1	6.28	6.41	-1.76	0.055	-0.236	-0.97	1.27	-0.27	-0.05	- 2.21
2	6.89	4.18	-1.60	0.031	-0.126	-1.55	0.65	1.01	-0.53	- 7.44
3	5.97	3.13	-1.45	-0.012	0.024	-1.66	-1.70	-0.95	-0.19	-11.91
4	-2.58	-2.57	0.77	-0.033	0.047	0.30	-0.62	-1.61	-0.46	2.60
5	-1.56	-0.65	0.36	0.028	0.024	0.37	1.32	0.41	0.61	5.56
6	-11.47	-8.64	2.86	-0.091	0.124	2.24	-1.97	-0.91	0.30	10.55
7	- 3.53	-1.86	0.81	0.022	0.0144	1.26	1.04	2.27	0.32	2.85
s.e.+	3.638	2.960	0.868	0.0573	0.0847	0.597	1.953	1.000	0.536	3.786

Table 21 cont'd next page

Table 21 (cont'd)

Parents	Earliness characters						Productivity characters			PHT
	E1%	E2%	MMD(1)	PRI(2) g/pl/day	NFB(2)	DFF	Yield g/pl.	TFP	NSB	
For F_2										
1	2.90	-1.44	-0.26	-0.029	-0.194	0.34	-1.23	-0.59	-0.78	-2.62
2	10.46	7.96	-2.68	0.036	-0.121	-2.22	0.01	-1.13	-0.90	-9.41
3	2.38	2.44	-0.69	0.006	0.003	-1.51	0.03	1.68	0.25	-7.61
4	-4.76	-1.27	0.93	0.025	0.080	0.68	1.51	-0.33	0.57	6.29
5	1.67	1.29	-0.44	0.029	-0.041	-0.55	0.74	1.53	0.80	7.15
6	-4.89	-2.92	1.14	-0.046	0.060	0.80	-1.17	-0.48	0.32	8.13
7	-7.77	-6.07	2.01	-0.022	0.213	2.43	0.11	-0.68	-0.27	-1.92
s.e.+	3.638	2.960	0.868	0.0573	0.0847	0.597	1.953	1.000	0.536	3.786

+ s.e. of the difference between two effects.

(1) MMD (and consequently PRI) are calculated from the date of first boll split (about 28 days before the first pick)

(2) mean squares for PRI and NFB are multiplied by 10^2.

situation where both earliness and yield can be taken into consideration together, then a balancing or combination of negative values for MMD, NFB and DFF with positive values for the remaining earliness and yield or productivity characters would have been ideal. Except for TFP and NSB, two varieties, V_1 and V_2, came close to this ideal situation in the F_1 analysis, while V_2 and V_5 did so in the F_2. As previously pointed out, there had not been any selection for TFP and NSB in these varieties. Although the gca effects for NSB were negative in the early maturing varieties, the NSB per meter of PHT given in Table A8 (top right half) showed relatively high values for V_2 and V_3. This is very much similar to the situation under the June sowing.

The sca effects for the ten characters are presented in Tables A13, A14, A15, A16 and A17. For most characters the sca effects were generally low, indicating the relative importance of the gca for these characters in the varieties studied.

The means of the ten characters are presented in Tables A18, A19, A20, A21 and A22. Higher values of E1% and E2% and lower values of MMD, NFB and DFF were found among the hybrids of V_1, V_2 and V_3, with the F_1 hybrid of $V_1 \times V_2$ having the highest E1%, E2% and PRI, as well as the lowest values of MMD,

NFB and DFF. The F_1 of V_2 x V_7 had the highest mean yield. Hybrids involving V_5 also appeared to have favourable mean values for certain characters.

The different combined analyses of the diallel revealed a highly significant effect of years for all the characters studied. This might have been due to the different rainfall patterns in the two years. In 1976, the rains in Samaru had an earlier start (mid to late May) and ended later (late October) than in 1977. This would tend to influence the productivity of the crops as well as the growing period, and might have contributed to the significant year x date interaction and might also have masked the effects of sowing dates as observed in the overall combined analysis.

The nonsignificant year x genotype interaction for certain characters, when averaged over all environmental factors or when the June-sown and the July-sown conditions are considered separately, would indicate the reliability of using such characters as measures of earliness in these varieties over the years.

The mean squares associated with the gca for each character were large and more important than the mean squares associated with sca which were considerably smaller, irrespective of the cultural conditions under which the crop was grown.

Miller and Marani (1963) have reported large and significant gca variances in cotton for E1% and lint yield relative to the very small sca variances. They also reported that the variances of the interactions of the gca and the sca with locations were generally small and nonsignificant. White and Richmond (1963) also reported highly significant gca variances for E2%, DFF, total yield of lint and PHT. The observations relating to the gca and sca mean squares reported in this study agreed with those of other workers cited above.

There was a very close agreement between the estimates of gca effects from the F_1 and F_2 generations, as well as a marked tendency for ranking of these varieties for gca effects based on parental performance for earliness characters as reported elsewhere in this thesis.

Heterosis, measured as the difference between the F_1 and the parent with the higher or lower attribute depending on the particular character under consideration, was observed only infrequently in these hybrids. Only very few crosses showed heterosis for some characters on this scale; for example E2% (Table A18), PRI (Table A19), DFF (Table A6, A11 and A20) and PHT (Table A12).

2.B.I.4 Analyses of the individual experiments

Each of the four experiments (2, 3, 7 and 8) was analysed separately and the results are presented in Tables 22, 23, 24 and 25, respectively. The mean squares due to the various components of the error mean square (replication x genotype) are given in the Tables. In addition, mean squares due to plant to plant variation within the parental, F_1 and F_2 plots were also given at the bottom of these Tables. It is not intended to discuss the results of these analyses since the results of the combined analyses have already been discussed and are the most meaningful. However, the results of the 1977 June-sown trial (Table 24) in which E1%, E2%, MMD, PRI and yield were analysed but not included in the overall combined analysis or the combined analysis for the June-sown, will be briefly considered.

The genotypes differed significantly for all the five characters but the parents differed for only E1% and MMD. The F_1 source was also significant for all five characters and the F_2 for E1%, E2% and MMD. The gca was significant for five characters in the F_1 and for three in the F_2, while the sca was significant for PRI in the F_1, and E1% and MMD in the F_2. Again, in the individual analyses the gca was relatively more important than the sca. The gca effects and the means of the individual experiments are given in Tables A23 to A44.

Table 22: Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for June-sown trial in 1976

Sources	d.f.	Earliness char.		Productivity char.		PHT
		NFB(1)	DFF	TFP	NSB	
Blocks(B)	2	23.33	92.06	606.69	328.41**	1215.22
G	48	283.94**	203.48**	730.63**	80.72**	11530.81**
gen.	2	60.66	170.61**	4539.46**	112.42**	66.65
par.	6	534.13**	437.93**	872.81**	140.55**	26915.78**
F_1	20	211.00**	168.21**	729.76**	74.27**	11108.07**
gca	6	581.08**	498.77**	1085.76**	183.18**	33061.01**
sca	14	52.67	26.54	577.19*	27.74*	1699.06**
F_2	20	303.97**	171.71**	307.95	65.96**	8484.48**
gca	6	600.86**	448.00**	633.30*	182.80**	10935.93**
sca	14	176.73**	53.00	168.52	15.89	1185.75*
B x G (err)	96	75.07	31.79	263.68	15.13	630.75
B x gen	4	58.41	35.28	46.17	2.01	137.69
B x par	12	77.46	18.03	209.02	16.40	767.28
B x F_1	40	63.67	23.94	381.00	16.61	731.02
B x F_2	40	87.42	43.43	184.51	14.57	538.82
Plants/plots	1323	51.59	8.44	69.44	5.22	344.73
plants/par	189	31.91	5.98	61.42	4.94	145.52
plants/F_1	567	46.42	7.86	75.97	4.33	186.53
plants/F_2	567	63.32	9.83	65.59	6.21	569.34

*,** significant at the 0.05, 0.01 levels of probability, respectively.

(1) mean square for NFB multiplied by 10^2

: 23: Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for July-sown trial in 1976

ces	d.f.	Earliness characters						Productivity characters			PHT
		E1%	E2%	MMD(1)	PRI(2) g/pl/day	NPB(2)	DFF	Yield g/pl	TFP	NSB	
	2	1296.84	2096.76*	151.05*	72.80	17.60	64.61	417.88	1356.36**	603.09**	6940.74**
	48	2882.60**	930.07**	141.58**	86.54	174.94**	194.77**	962.24**	242.97	71.51	7239.61**
n.	2	4735.77**	1067.20	219.48*	780.45**	165.80	337.70**	14495.47**	1220.12	112.29	1052.35
r.	6	5230.51**	1457.57*	235.91**	52.80	311.12**	566.17**	700.22*	52.83	41.42	16794.51**
	20	2467.14**	973.70**	127.49**	77.18**	137.64**	155.87**	735.51**	283.95	78.69	5458.91**
gca	6	5999.23**	2094.81**	314.93	98.81**	330.20**	383.52**	805.35*	356.28	73.63	16551.29**
sca	14	953.38	493.22*	47.16	67.90**	55.11	58.30**	731.30*	252.95	80.86	705.03
	20	2408.38**	714.48	119.57**	36.64	172.30**	107.96**	485.97*	161.33	69.29	6772.57**
2											
gca	6	5228.40**	1898.62**	307.46**	27.58	461.30**	319.16**	298.39	90.30	47.70	16310.93**
sca	14	3440.61	206.96	39.02	38.84	27.02	17.45	566.36*	191.77	78.54	2684.70*
G (err)	96	978.51	716.04	46.96	26.57	55.60	21.34	280.16	181.51	57.06	740.66
x gen.	4	533.50	571.62	15.60	51.00	20.65	40.00	448.03	262.85	42.84	224.34
x par	12	1371.77	729.60	63.56	16.55	91.10	11.31	137.62	100.80	8.78	412.01
x F_1	40	726.72	232.30	27.07	29.06	52.11	16.31	298.28	112.14	49.75	510.81
x F_2	40	1156.82	727.28	65.01	24.65	51.95	27.52	288.03	266.96	80.29	1220.74
ants/plots	1323	691.20	395.33	33.51	14.17	38.78	7.72	148.40	59.07	16.93	684.15
plants/par	189	852.57	449.22	36.24	9.14	50.11	4.96	94.62	37.30	9.25	303.15
plants/F_1	567	630.88	358.32	31.26	18.57	33.42	6.73	192.79	75.08	18.60	333.60
plants/F_2	567	697.74	414.30	34.87	11.44	40.37	9.63	121.95	50.31	17.82	1161.71

** significant at the 0.05, 0.01 levels of probability, respectively.

1) and (2) as in Table 21 except that (1) was calculated from the date of sowing.

ble 24: Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for June-sown trial in 1977

ources	d.f.	Earliness characters						Productivity characters			PHT
		E1%	E2%	MMD(1)	PRI(2) g/pl/day	NFB(2)	DFF	Yield g/pl.	TFP	NSB	
	2	9868.45**	2596.01**	404.41**	251.45*	36.80	348.83**	1542.22	1324.35**	393.77**	6801.15**
	48	6762.27**	341.92**	232.52**	154.66**	173.90*	197.50**	1603.32*	506.26**	107.35**	4724.93**
gen.	2	644.70	7271.36	23.40	629.50**	50.00	407.76**	2190.57	464.56	71.03	1374.31*
par.	6	16992.65**	110.81	617.72**	86.15	438.33**	391.82**	702.23	438.02*	115.59*	7720.54**
F_1	20	5699.93**	707.96*	194.59**	190.20*	129.65	170.55**	2077.82**	773.80**	163.13**	5108.76**
gca	6	13907.18**	1679.30**	494.39**	258.51*	285.96*	429.75**	2961.59*	803.89**	252.15**	15014.87**
sca	14	2182.27	291.67	66.10	160.98*	62.64	59.48	1699.05	759.83**	124.99*	863.28*
F_2	20	5367.27**	552.26	175.80	92.20	151.20	145.12**	902.32	248.36	52.71	3777.47**
gca	6	11927.27**	813.81*	226.13**	154.08	277.00*	408.51**	1312.17	421.98	97.15*	10799.19**
sca	14	2555.84*	440.17	154.23**	65.68	97.29	32.23	726.67	180.61	33.67	768.16*
B x G (err)	96	1185.99	301.17	43.53	81.08	105.90	37.00	972.04	194.72	42.55	428.36
B x gen.	4	1177.62	419.95	56.37	49.25	180.00	20.91	478.80	61.06	15.51	124.71*
B x par.	12	1167.48	325.32	36.85	64.03	185.83	27.35	855.40	219.72	30.87	212.22
B x F_1	40	1132.82	359.53	46.03	72.60	76.10	39.51	881.67	143.55	29.48	282.80
B x F_2	40	1245.56	223.67	41.75	97.88	104.30	38.99	1146.74	251.77	61.83	669.12**
Plants/plots	1323	491.22	136.52	17.15	19.38	54.89	15.08	227.66	60.02	13.10	159.48
plants/par.	189	348.56	153.13	13.32	13.54	55.77	13.82	169.00	58.13	13.82	139.80
plants/F_1	567	457.11	146.23	17.55	24.16	51.15	16.34	273.31	62.83	14.81	169.94
plants/F_2	567	572.89	121.27	18.03	16.53	58.29	14.25	201.57	57.84	11.15	155.59

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) and (2) as in Table 21. except that (1) was calculated from the date of sowing.

e 25: Mean squares from an analysis of variance and of gca and sca of a seven-parent diallel cross for July-sown trial in 1977

ces	d.f.	Earliness characters						Productivity characters			PHT
		E1%	E2%	MMD (1)	PRI (2) g/pl/day	NFB (2)	DFF	Yield g/pl	TFP	NSB	
	2	2479.33	196.37	88.06	381.50**	640.50**	398.41**	6530.04**	866.42	168.01	2278.37
	48	4903.69**	3525.72**	274.85**	50.48	191.48**	201.74**	619.43*	275.77	37.42	2040.42**
en.	2	7842.17*	2821.84	315.07	137.00**	14.50	485.20**	1801.50*	148.52	4.67	2711.67
ar.	6	7732.79**	5705.69**	450.37**	58.83*	435.50**	412.84**	771.90	248.99	77.75	4221.59**
1	20	4424.84**	3359.27**	261.32**	63.10**	166.15**	148.03**	758.97**	361.57	22.92	1958.62*
gca	6	8785.94**	6939.07**	543.22**	80.79**	359.17**	348.04**	1585.03**	317.32*	21.59	4034.17**
sca	14	2557.06	1824.80	140.49	55.52	83.49	62.31	404.95	288.25	23.49	1069.10
2	20	4235.95**	3084.58**	231.70**	26.70	206.65**	163.77**	315.94	210.72	43.10	1400.76
gca	6	9409.07**	5554.71**	498.92**	20.10	360.17**	432.62**	296.73	441.39*	94.28	3310.77**
sca	14	2025.83	2026.25	117.12	28.31	140.86	63.75	324.17	130.78	22.34	548.03
x G (err.)	96	1767.44	1447.60	105.67	20.66	77.64	47.68	365.44	189.64	33.88	1005.35
B x gen.	4	1912.62	2000.73	136.16	36.00	22.50	9.58	662.97	292.52	84.46	1257.55
B x par.	12	2151.82	743.66	97.61	11.92	31.75	56.75	216.67	110.57	24.29	604.75
B x F_1	40	1877.02	1303.16	103.53	25.35	66.45	44.65	449.20	205.31	35.91	1216.52
B x F_2	40	1528.02	1747.92	107.18	17.05	108.10	51.81	296.56	187.29	29.66	889.13
lants/plots	1323	727.41	733.55	45.05	8.41	50.61	10.70	148.44	73.41	8.11	167.85
plants/par.	189	621.16	676.40	40.00	6.06	48.84	9.03	144.16	43.94	7.41	155.41
plants/F_1	567	764.10	727.97	47.72	11.08	45.84	10.42	192.47	111.19	8.87	186.37
plants/F_2	567	726.15	758.20	44.08	6.53	55.98	11.53	115.84	66.63	7.58	153.48

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

(1) and (2) as in Table 21, except that (1) was calculated from the date of sowing.

2.B.I.5 Analysis of the lint quality test data

The mean squares for the three lint quality characters, micronaire (Mic), effective length (EL) and bundle strength (BS) for three of the four experiments are presented in Table 26. The genotypes showed a consistently significant difference only for EL in the three trials analysed. They were significantly different for Mic. in July 1976 and for BS in July 1977. No further analyses were carried out along the lines of the earliness and yield characters, but the genotypic means for the June and July experiments in each of the two years are given in Tables A45 to A48.

The Mic. mean of the parents ranged from 2.90 for V_6 to 3.50 for V_1 in June 1976; from 3.02 for V_7 to 3.73 for V_1 in July 1976; from 2.65 for V_2 to 3.48 for V_7 in June 1977; and from 3.50 for V_2 to 4.00 for V_6 in July 1977. The highest Mic. value of 3.60 was recorded for the F_1 of $V_1 \times V_3$ in June 1976 while the F_1 of both $V_1 \times V_2$ and $V_1 \times V_3$ crosses showed high values in July 1976. The F_1 hybrid of crosses involving V_5 and V_6 also showed high Mic. values in July 1977. It seemed that the derivatives of the crosses involving V_1 (and probably V_5) have consistently high Mic. values.

The longest EL among the parents was recorded for V_5 under all the four environmental conditions. Derivatives of crosses

Table 26: Mean squares from the separate analyses of variance[1] for lint quality tests of the diallel cross

Sources	Micronaire		Effective Length		Bundle strength	
	d.f.	(Mic)	d.f.	(EL)	d.f.	(BS)
July 1976						
Blocks	2	0.551	2	10.311	2	3.236
Genotypes	48	0.521*	48	15.268**	48	3.765
B x G (err)	96	0.266	96	4.217	96	2.528
Error (s)[2]	142	0.198	142	3.180	142	1.649
June 1977						
Blocks	2	4.431**	2	0.228	2	7.798
Genotypes	48	0.398	48	16.674	48	5.741
B x G (err)	96	0.377	96	3.572**	96	4.176
Error (s)[2]	142	0.370	147	2.760	147	2.890
July 1977						
Blocks	2	6.380**	2	9.973	2	23.905**
Genotypes	48	1.523	48	18.868**	48	7.689*
B x G (err)	96	1.211	96	4.383	96	4.620
Error (s)[2]	130	0.282	147	3.550	147	3.190

*, **, significant at the 0.05, 0.01 levels of probability, respectively.

(1) the June 1976 trial was not analysed.

(2) there were missing values for some of the plants.

involving V_5 and V_6 had longer EL than most of the remaining hybrids. As for BS, V_5 and V_7 and their hybrid derivatives showed high values.

It was not possible to carry out general and specific combining ability analyses nor combined analyses over years for these traits, as such it is difficult to discuss results of these separate analyses as had been done for the earliness and yield characters. However, a trend was noticeable in which some of the varieties and their hybrids showed high values for these lint quality characteristics.

2.B.I.6 Conclusion

The results of the combined analyses showed a considerable degree of reliability of using certain characters as measures of earliness over a period of years. For the June-sown crop, NFB and DFF, while for the July-sown crop, E2% and MMD, offered reliable measures of earliness in these varieties. The varieties showed consistency of ranking (even though broadly) for earliness scores irrespective of the different cultural or environmental factors involved. One or more of the three early varieties, V_1, V_2 and V_3 came out to be significantly earlier than the medium or late maturing varieties for different characters under the different conditions of growth. These three and probably also V_5 combined more favourable earliness as well as yield characters, but V_2 was the most consistent of them, while V_1 and V_3 behaved similar to V_4 and V_5 for certain characters. The hybrids of V_1, V_2 and V_3 and more especially of V_2 and also of V_5 appeared to have the most desirable combinations of characters for the expression of earliness.

The gca mean squares were large compared with the sca mean squares which were fairly uniformly low for all characters. This shows that these varieties are genetically heterogeneous for earliness and method of breeding which utilises gca would be more appropriate for their improvement at least initially. However, the gca will have to be measured over years since there was a significant year x gca interaction.

Series II: Genetic component analysis

In the two 1976 trials, only two (the second and the third but not the first) picks were made, and as a result E1% could not be estimated, and the estimates for MMD and PRI were thus based on fewer parameters. In 1977, all the three picks were made.

2.B.II.1 Stripper (early) x UK66 (late) cross grown in 1976 (Experiment 4)

The analysis of variance and the mean squares for the six generations are presented in Table 27. The generations differed significantly for all characters. There was a significant replication x generation interaction for E2%, MMD, PRI, DFF, yield, TFP and NSB, which might have been due to the non-randomness of the rows of the segregating generations within each block (replication).

The means, standard errors, together with the A, B, and C scales, as well as the D, H, and E components of variation are given in Table 28. The means showed that P_1 was significantly earlier than P_2 for all earliness characters except PRI; and the F_1 mean was in the direction of the earlier parent for these characters, while for PRI the F_1 had a higher mean (though not significantly) than P_2, the higher parent. For yield, TFP, and NSB, P_1 had significantly lower values than P_2, but had higher

27: Mean squares from an analysis of variance of the untransformed data of individual plants for the cross Stripper x UK66 grown in 1976

ces	d.f.	Earliness characters						Productivity characters			PHT(2)
		E2%	MMD	PRI(1)	NFB(1)	DFF	BP	Yield	TFP	NSB	
ications	3	494.58	9.67	48.25	21.22	46.33	132.75	11693.75	2776.93	6.84	8968.80
rations	5	2665.37**	52.23**	83.96**	1624.38**	243.71**	89.16**	20711.70**	3123.26**	85.96**	16284.53**
G	15	325.53*	6.38*	17.18*	95.37	76.21**	17.47	4162.41**	536.01*	24.64*	1022.99
or	28	138.25	2.71	6.01	89.94	22.07	18.83	1264.33	214.43	11.31	3354.23
lots/reps/BC_1	8	114.07	1.35	6.90	154.04	12.24	16.98	1639.29	392.87	14.22	393.63
lots/reps/F_2	12	160.80	4.33	7.57	72.08	12.90	24.21	1857.24	142.40	10.58	7217.22
lots/reps/BC_2	8	128.59	1.63	2.76	66.67	45.64	12.63	668.83	144.02	9.59	520.33
ants/plots	468	94.07	1.84	1.89	77.03	15.94	10.10	463.31	118.02	6.72	176.07
within P_1	36	28.80	0.56	0.99	37.78	2.19	4.29	171.30	92.46	3.55	68.85
within BC_1	108	82.82	1.23	1.99	42.87	6.96	10.48	475.67	122.95	5.48	256.73
within F_1	36	31.61	0.62	1.14	31.67	2.94	5.89	274.70	211.87	6.90	133.26
within F_2	144	124.75	2.42	2.48	82.64	33.83	13.86	633.94	131.48	9.53	258.37
within BC_2	108	75.09	1.47	1.85	59.35	14.34	9.57	451.74	81.74	6.45	235.65
within P_2	36	69.73	1.97	1.03	41.94	3.15	5.55	259.04	89.98	3.07	72.43

*, ** significant at the 0.05, 0.01 levels of probability respectively.

(1) mean squares for PRI or NFB are multiplied by 10^2.

(2) The mean squares for the components of the error for PHT are not homegeneous at the 25% level.

Table 28: Means, standard errors, mid-parent values and the A,B,C, scales for the additive dominance model, and also the D, H, E component of phenotypic variance from the untransformed date of the cross Stripper x UK 66, grown in 1976

Generation	Total no. of plants	Earliness characters					
		E2%	MMD	PRI	NFB	DFF	BP
P_1	40	93.83±1.859	153.86±0.260	18.78±3.870	4.30±0.150	61.75±0.743	49.48±0.686
BC_1	120	92.03±1.073	154.12±0.150	17.02±2.238	4.33±0.087	62.54±0.429	50.32±0.396
F_1	40	86.26±1.859	154.92±0.260	46.25±3.876	4.70±0.150	63.95±0.743	51.10±0.686
F_2	160	86.26±0.930	154.92±0.130	27.34±1.938	5.00±0.075	66.59±0.372	50.88±0.343
BC_2	120	84.72±1.073	155.14±0.150	26.63±2.238	5.13±0.087	68.25±0.429	52.20±0.396
P_2	40	72.45±1.859	156.85±0.260	43.73±3.876	5.88±0.150	72.83±0.743	53.45±0.686
P_1P_2		83.14±1.315	155.36±0.184	31.26±2.741	5.09±0.106	67.29±0.525	51.47±0.485
Scales							
A		3.97±2.067	-0.54±0.266	-30.99±3.458	-0.34±0.178	-0.62±0.598	0.06±0.777
B		10.73±2.130	-1.49±0.298	-36.72±3.405	-0.32±0.195	-0.28±0.794	-0.15±0.778
C		6.24±3.821	-8.87±0.665	-45.65±3.748	0.42±0.366	3.86±1.952	-1.61±1.490
Variance Comp.							
D		183.18	4.28	2.24	136.30	92.72	15.34
$H^{(2)}$		-14.20	-1.76	0.31	-90.56	-61.16	3.79
E		36.71	0.72	1.05	37.13	2.76	5.24
$\sqrt{(H/D)}$		-	-	0.372	-	-	0.497
h^2% (narrow sense)		83.31	85.60	62.22	78.59	97.11	62.95

Table 28 cont'd next page.

Table 28 (cont'd)

Generation	Total no. of plants	Productivity characters				PHT
		Yield	TFP	NSB	NSB/(1) PHT	
P_1	40	28.86±5.622	35.70±2.315	15.05±0.532	20.43	74.48±3.137
BC_1	120	26.22±3.246	37.28±1.337	14.38±0.307		71.74±1.811
F_1	40	71.62±5.622	55.50±2.315	17.48±0.532	18.95	93.67±3.137
F_2	160	42.45±2.811	39.31±1.157	15.40±0.266		94.56±1.568
BC_2	120	41.38±3.246	36.98±1.337	15.71±0.307		100.63±1.811
P_2	40	66.67±5.622	48.75±2.315	17.45±0.532	15.28	114.67±3.137
P_1P_2		48.77±3.975	42.23±1.637	16.25±0.376	17.86	94.58±2.218
Scales						
A		-48.04±5.197	-16.64±3.42	-3.77±0.666		-24.67±3.689
B		-57.53±5.329	-30.29±2.301	-3.51±0.681		- 7.08±3.605
C		-70.97±10.08	-38.21±6.756	-5.86±1.345		1.75±6.534
Variance Comp.						
D		680.94	116.54	14.26		48.72
H(2)		58.47	232.92	- 8.44		570.00
E		235.00	131.44	4.51		91.51
$\sqrt{(H/D)}$		0.293	-	-		3.42
h^2 (narrow sense)		69.88	47.00	75.97		6.86

(1) NSB/PHT not analysed.

(2) negative values of H are regarded as zero.

NSB per meter of PHT than P_2. The F_1 mean was higher than that of P_2 for yield and TFP (significantly) but similar for NSB. For E2%, MMD, NFB, DFP, and BP, the backcross generations had means which lay between the F_1 and the respective backcross parent.

The generations were tested for conformity to the additive-dominance model of Mather and Jinks (1971). The scales and their standard errors given in Table 28 indicate that this model may only hold for DFP, BP, and probably NFB; since the A, B, and C scales of the remaining characters had values significantly different from zero. The data were reanalysed using a log transformation and the results are presented in Table A49. The means, standard errors and the scales from the transformed analysis are also presented in Table A50. The results were similar to those in Tables 27 and 28, respectively. In this trial then, changing to the log scale had no effect in making the data conform to the additive-dominance model.

Next, an attempt was made to estimate the D (additive), H (dominance), and E (environmental) components of phenotypic variance. The estimates obtained are given at the bottom of Table 28. The nature of the variances of the generations as given in Table 27 was such that the estimation of the H component was non-negative for only PRI, BP, yield, and PHT, for which the degree of dominance $\sqrt{(H/D)}$ were 0.372, 0.497, 0.293 and

3.420, respectively. Narrow sense heritability (h^2) was estimated for all the characters (except NSB/PHT) and given at the bottom of Table 28. Where the H component was negative, it was ignored in the estimation of h^2. From the estimates obtained E2%, MMD, NFB, DFF and NSB had high values and would respond to selection favourably.

Although the mean squares of the non-segregating generations were small compared to those of the segregating generations for most characters, estimation of the H component produced negative values in most cases. This was because the mean square of the F_2 generation was relatively so large that large estimates of the D component resulted when the formula ($2V_{F_2} - V_{BC_1} + V_{BC_2} = \frac{1}{4}D$) was used. In addition, there were cases in which the mean squares of the non-segregating generations were larger than those of the segregating generations especially for MMD, TFP, and NSB. This suggests that, the parents were themselves heterogeneous and probably heterozygous to start with. It is believed that they were not homozygous pure lines since each parent was composited from selfed seed of different single plants each year; and these selfed single plants were not specifically selected for any of the traits but just randomly chosen from the varieties which were broadly classified as early, intermediate and late.

For the cross Stripper x UK66, it would seem that there were other genetic factors involved besides the additive and dominance factors in the inheritence of most of the characters studied. It is tempting to speculate the dominance of earliness and of higher productivity as well as the presence of epistatic factors although no test was conducted in that respect. The interpretation is further complicated by the heterogeneous and/or heterozygous nature of the parents themselves. Nevertheless, a very clear picture of the relative importance of additive factors compared to the dominance, environmental or other factors has emerged.

2.B.II.2 2421 (early) x Samaru 71 (intermediate) cross grown in 1976 (Experiment 5)

Table 29 gives the results of the analysis of variance for this cross. The generations showed significant differences for all characters and there was no significant replication x generation interaction. The means, their standard errors and the A, B, and C scales, as well as the D, H, and E components are given in Table 30. P_1 was significantly earlier than P_2 for all the earliness characters except PRI, for which it had a lower value. For yield, TFP, NSB and PHT, P_1 had significantly lower values than P_2. The F_1 was significantly different from the mid-parent value and towards the earlier parent for E2%, MHD and PRI, but similar to the mid-parent value for NFB, DFF and BP. For yield and NSB, the F_1 means were similar to the mid-parent value but significantly lower than those of the higher parent (P_2); and for TFP it was significantly higher than the mid-parent value but similar to the higher parent. For PHT, the F_1 mean was in the direction of the shorter parent (P_1).

The A, B, and C scales showed that the additive-dominance model was adequate for only BP and NSB in this cross on the basis of the untransformed data. The D, H, and E components as well as the degree of dominance were calculated for all but four characters (NFB, DPP, TFP, and NSB) for which the estimate

Table 29: Mean squares from an analysis of variance of untransformed data of individual plants for the cross 2421 x Samaru 71 grown in 1976

Sources	d.f.	Earliness characters						Productivity characters			PHT
		E2%	MMD	PRI(1)	NFB(1)	DFF	BP	Yield g/pl	TFP	NSB	
Replications	3	289.00	5.67	14.96*	33.59	4.63	110.67**	3558.96*	1393.05**	116.68**	35
Generations	5	2065.15**	40.47**	40.19**	295.40**	56.80**	317.58**	12902.21**	1054.91**	165.22**	1210
R x G	15	263.13	5.16	3.46	30.13	7.73	21.09	832.90	109.67	13.84	84
Error	28	138.40	2.71	4.35	26.70	5.67	13.56	1051.47	198.56	10.38	60
Plots/reps/BC_1	8	175.85	3.44	1.50	11.67	5.95	6.90	355.94	139.36	11.38	2
Plots/reps/F_2	12	161.62	3.16	5.10	50.21	4.61	11.50	1251.96	184.68	7.42	5
Plots/reps/BC_2	8	66.12	1.30	6.06	51.67	6.97	23.32	1446.27	278.60	13.83	10
Plants/plots	468	129.55	2.54	1.92	43.64	5.95	8.40	470.97	76.20	6.99	3
Plants within P_1	36	32.00	0.63	0.16	29.17	3.06	5.04	35.80	36.24	4.61	1
" " BC_1	108	92.30	1.81	1.02	31.30	5.35	5.98	239.86	62.90	5.20	1
" " F_1	36	53.31	1.05	1.02	37.33	4.21	4.06	247.18	108.11	5.69	
" " F_2	144	182.77	3.58	2.76	64.38	8.56	11.31	686.00	89.03	7.85	
" " BC_2	108	162.70	3.19	2.96	40.56	5.34	10.45	723.29	66.36	8.32	
" " P_2	36	102.81	2.02	0.80	27.78	3.73	5.61	206.17	100.84	8.63	

*, ** significant at the 0.05, 0.01 levels of probability respectively.

(1) Mean squares for PRI and NFB are multiplied by 10^2

Table 30: Means, their standard errors, mid-parent values and the A, B, C scales for the additive-dominance model, and also the D,H, E components of phenotypic variance from the untransformed data of the cross 2421 x Samaru 71, grown in 1976

Generations	Total no. of plants	Earliness					
		E2%	MMD	PRI	NFB	DFF	BP
P_1	40	94.93±1.860	153.71±0.260	10.30±3.297	4.08±0.082	62.85±0.376	49.33±0.582
BC_1	120	91.30±1.132	154.22±0.150	15.88±1.903	4.35±0.047	62.53±0.217	50.54±0.336
F_1	40	92.67±1.860	154.03±0.260	28.31±3.297	4.45±0.082	63.33±0.376	52.60±0.582
F_2	160	87.85±0.980	154.70±0.130	22.81±1.649	4.54±0.041	63.56±0.188	51.96±0.291
BC_2	120	89.15±1.132	154.52±0.150	25.00±1.903	4.65±0.047	62.03±0.217	54.41±0.336
P_2	40	73.56±1.860	156.70±0.260	39.45±3.297	4.80±0.082	64.85±0.376	55.95±0.582
P_1P_2		84.25±1.315	155.21±0.184	24.88±2.331	4.44±0.058	63.85±0.266	52.64±0.412
Scales							
A		-5.00±2.360	0.70±0.320	-0.06±0.025	-0.18±0.164	-0.82±0.600	-0.85±0.653
B		12.07+3.050	-1.69±0.430	-0.17±0.038	-0.42±0.173	-3.82±0.614	0.27±0.768
C		-2.43±5.340	0.33±0.690	-0.13±0.061	0.38±0.311	0.48±1.202	-2.64±1.343
Variance comp.*							
D		221.08	4.338	3.073	1.138	12.834	12.389
$H^{(1)}$		38.09	0.735	2.250	-0.958	- 6.117	0.863
E		62.71	1.230	0.660	0.314	3.668	4.901
$\sqrt{(H/D)}$		.415	0.412	0.732	-	-	0.264
h^2 (narrow sense)		68.68	68.82	51.36	78.37	77.77	68.25

Table 30 cont'd next page.

Table 30 (cont'd)

Generations	Total no. of plants	Productivity characters			PHT
		Yield	TFP	NSB	
P_1	40	15.89±5.127	27.03±2.228	14.13±0.509	90.18±3.895
BC_1	120	24.43±2.960	34.83±1.286	15.00±0.294	95.80±2.249
F_1	40	43.32±5.127	39.20±2.228	15.95±0.509	107.25±3.895
F_2	160	35.38±2.563	33.84±1.114	15.59±0.254	102.28±1.948
BC_2	120	38.75±2.960	37.93±1.286	16.52±0.294	115.01±2.249
P_2	40	61.79±5.127	41.70±2.228	18.40±0.509	132.85±3.895
P_1P_2		38.84±3.625	34.37±1.575	16.27±0.360	111.52±2.754
Scales					
A		-10.35±3.882	3.43±2.389	-0.08±0.656	-5.83±4.318
B		-27.61±5.953	-5.04±2.730	-1.31±0.797	-10.08±4.789
C		-22.80±9.328	-11.77±4.211	-1.07±1.181	-28.41±7.899
Variance comp*					
D		817.700	96.600	4.368	420.980
H(1)		456.400	-164.400	-2.571	57.210
E		163.050	81.73	6.314	189.300
$\sqrt{(H/D)}$		0.747	-	-	0.369
h^2(narrow sense)		56.90	54.17	40.89	63.07

(1) Negative values of H are regarded as zero.

of H gave negative values due to the same reasons mentioned for the Stripper x UK66 cross. In this early x intermediate cross too, it was noticed that the mean squares of the non-segregating generations were equal to or larger than those of the segregating generations for PRI, NFB, yield, TFP, NSB, and PHT.

Further analysis was made using a log transformation and the results are presented in Table A51. These results were similar to those in Table 29. There was a significant replication x generation interaction for MMD and PRI. The means, scales and the components for the transformed data are given in Table A52. In the log transformation, the additive-dominance model was adequate for NFB, BP, TFP, NSB and NSB/meter of PHT. In this cross, changing to the log scale had more effect than in the early x late cross. Positive H values were obtained for only E2% and MMD, hence the degree of dominance for these characters were 0.400 and 0.333, respectively. The narrow sense heritability in this cross given at the bottom of Table 30 indicated high h^2 for NFB and DFF, moderately high values for E2%, MMD, BP and PHT. It is worth noting that E2%, MMD, NFB and DFF had high values of h^2 in this cross also but NSB which had high h^2 in the Stripper x UK66 cross had low value in the 2421 x Samaru 71 cross while PHT with extremely low value in the first cross had moderately high values in the second cross.

There was an indication in this cross of dominance of earliness for E2%, MMD and PRI; while there was dominance for higher productivity for TFP. However, as in the case of the early x late cross, the additive component was relatively larger than the dominance or the environmental components for all characters except NSB, in which the E component was larger.

2.B.II.3 Stripper (early) x UK66 (late) cross grown in 1977 (Experiment 9)

The results of the analysis of variance and the mean squares of the generations are given in Table 31. As in the two previous trials, the mean squares of the generations were similarly disorderly in this case. Whatever might have been the cause of the inflation of the mean squares of some of the generations, a further complication has been brought about in the 1977 trial because the backcrosses were selfed backcrosses from 1976.

The means and standard errors are presented in Table 32. The elimination of the F_1 in the analysis coupled with the selfed nature of the backcross generations made the estimation of the A, B, and C scales as well as the estimation of the D, H, and E components impossible. For this trial, an analysis based on transformed data was unnecessary and further discussion and interpretation thus becomes unrealistic.

The lint quality test data were not analysed for this series.

ble 31: Mean squares from an analysis of variance from the untransformed data of individual plants from the cross Stripper x UK66, grown in 1977

urces	d.f.	Earliness characters							Productivity characters			PHT
		E1%	E2%	MMD	PRI	NFB	DFF	BP	Yield	TFP	NSB	
plications	3	8850.22**	737.85**	279.59**	46.83**	1.17	15.55	312.66	8630.49**	2658.26	459.91**	3775.74**
nerations	4	10560.35**	1433.65**	384.34**	19.87*	7.80**	865.85**	20.22	3032.69	284.50	59.81	7553.79**
x G	12	675.96	152.73	26.00	4.20	0.45	31.88	32.02	740.35	230.80	48.71	398.32
ror	44	421.13	106.63	14.55	7.82	0.69	22.18	35.54	1397.18	309.33	58.69	492.82
Plots/reps/BC_1	12	218.34	76.50	7.04	10.14	0.59	21.23	24.67	1747.98	175.82	43.10	467.57
Plots/reps/F_2	20	452.20	74.45	13.55	9.08	0.80	22.57	27.28	1625.69	403.34	83.33	502.33
Plots/reps/BC_2	12	572.15	190.40	23.74	3.41	0.61	22.48	60.17	665.51	286.15	33.21	502.21
lants/Plots(1)	576	206.13	98.94	8.07	1.37	0.45	13.69	25.39	245.86	79.84	17.20	155.50
within P_1	36	166.68	59.59	5.79	0.84	0.49	15.77	7.44	138.30	52.80	15.62	99.41
within BC_1	144	167.83	76.96	6.62	1.51	0.37	13.96	9.17	269.60	75.96	18.09	148.34
within F_2	216	227.40	105.87	9.05	1.83	0.47	13.47	8.57	326.47	107.86	20.71	132.45
within BC_2	144	244.09	104.98	8.67	0.86	0.53	12.60	75.28	162.25	58.01	13.70	201.49
within P_2	36	199.35	160.42	7.93	0.62	0.36	19.19	9.57	109.31	41.64	8.22	194.64

*, ** significant at the 0.05, 0.01 levels of probability.

(1) F_1 was eliminated from the analysis because three of the four plots were missing.

Table 32: Means, their standard errors, mid-parent values from the untransformed data of the cross Stripper x UK 66 in 1977

Generations	Total no. of plants	Earliness characters						
		E1%	E2%	MDD	PRI	NFB	DFF	BP
P_1	40	81.66±3.245	93.41±1.633	129.49±0.603	26.11±4.422	4.50±0.131	57.68±0.745	49.68±0.943
BC_1	160	71.71±1.622	90.82±0.816	131.25±0.301	32.94±2.211	4.46±0.065	59.34±0.372	50.86±0.472
F_2	240	67.42±1.325	90.32±0.677	131.92±0.246	31.99±1.805	4.77±0.054	60.49±0.304	50.34±0.385
BC_2	160	55.66±1.622	84.95±0.816	134.31±0.301	25.08±2.211	5.01±0.065	64.27±0.372	49.99±0.472
P_2	40	52.27±3.245	83.09±1.633	135.33±0.603	24.52±4.422	5.10±0.131	65.65±0.745	50.15±0.943
P_1P_2		66.97±2.295	88.25±1.155	132.41±0.426	25.32±3.127	4.80±0.093	61.67±0.527	49.92±0.667

		Productivity characters			PHT
		Yield	TFP	NSB	
P_1	40	33.83±5.910	24.93±2.781	12.60±1.211	56.75±3.510
BC_1	160	43.29±2.955	26.88±1.390	13.59±0.605	65.60±1.755
F_2	240	42.28±2.413	29.18±1.135	14.72±0.495	69.47±1.433
BC_2	160	33.84±2.955	26.60±1.390	14.03±0.605	79.16±1.755
P_2	40	33.18±5.910	28.20±2.781	14.73±1.211	83.48±3.510
P_1P_2		33.51±4.179	26.57±1.966	13.67±0.856	70.12±2.482

2.B.II.4 Conclusion

The initial objective of running the genetic component analysis was to be able to estimate the components of genetic variation in order to enable a reasonable and meaningful interpretation of the results, and also to learn more about the genetic control of earliness and other characters in these varieties. But the data as they were in these trials would not permit the fulfilment of such an objective. It is felt that one of the most critical causes of this might be the heterogeneity and/or heterozygosity of the samples which was brought about by the bulking of seed from selfed single plants throughout the study period. Small sample size, especially of the segregating generations might also have some influence in the trends observed. It was also noticed that the mean squares of the replication were considerably large for most characters, indicating that the blocks had differential effects. Nevertheless, in these trials, it was noticed that the additive factors were relatively more important than the dominance factors for most characters. Any future attempt at similar studies involving these varieties should take into consideration the problems enumerated above.

CHAPTER FIVE

GENERAL DISCUSSION AND CONCLUSIONS

GENERAL DISCUSSION AND CONCLUSIONS

Generally, earliness in the cotton varieties studied was little influenced by the environmental or agronomic factors under which this study was conducted, especially when results of different years were combined. The reason for this lack of effect was primarily in the nature of the statistical test made. In the combined analysis of the agronomic trials, the date and the nitrogen main effects were tested by the respective interaction of these factors with years, since the inference was to be made over years. These interactions had very small degrees of freedom that the test became insensitive. In addition, there was the heterogeneity of the varieties involved as well as a fair degree of stability especially in the Samaru varieties. Faulkner (1974) has reported the stability of performance of Samaru 26J over different environmental conditions in several years.

There was also the marked difference in the rainfall patterns of the 1975 and 1977 (for the agronomic trials) and the 1976 and 1977 (for the genetic trials) seasons; 1977 being the poorer in each set of seasons. In this respect, it can be concluded that an early maturing variety would mature relatively

early irrespective of the planting date or the levels of fertilisation. However, yield and related characters were influenced more by both factors especially in 1975.

In the diallel studies, it was noticed that there were considerably large general combining ability mean squares for both earliness and productivity characters with very low and non-significant specific combining ability mean squares. In the genetic component studies, it was found that the D (additive) component of genetic variation was considerably larger for most characters than the H (dominance) component which in most cases was negative or zero. This supports the observations made from the diallel analyses about the importance of gca relative to sca in these varieties for the characters studied. Similar observations in other varieties have been reported by Quisenberry (1975).

There was an indication of dominance of earliness in the two specific crosses studied. Similar observations on crosses involving other varieties of cotton were made by Richmond and Ray (1966). Observations in the genetic component study, showed that the within parental variance was occasionally as large as the F_2 phenotypic variance, indicating that the varieties were heterogeneous and possibly also heterozygous. If heterozygosity existed, the procedure of

selfing and bulking the selfed seed for two years would only increase the heterogeneity within these varieties. Although the selfed individual plants would tend to be homozygous, they may be so for only different alleles (genes) such that when seed from different plants are bulked together they became more heterogeneous than the original population from which they were derived. In this respect, these varieties can be regarded as similar to unimproved genetic stocks with tremendous potential for initial improvement through breeding. The moderate to high heritabilities of some of the characters supports this view.

It appears from this that bulking was the major problem, hence, any future study of this nature should consider selfed single plants and their progenies from the start rather than the progenies of several selfed plants bulked together. The sample size, given the limitations of space, labour, funds, time and other related factors, should also be large enough to make meaningful observations possible.

These studies have shown that earliness as measured by the various characters can be bred for, at least initially, by breeding methods which utilize additive or general combining ability effects, since most of the F_1 hybrids involving the early parents showed considerable earliness over their late

parent or over the mid-parental value. It is also possible to combine earliness with yield, and related characters in the hybrids since these parents showed a good general combining ability for the traits. Mooseberg (1969) made similar conclusions on the possibility of combining earliness with other desirable characteristics. This was even more consistent where V_2 and V_5 were involved, and it is hoped that future improvements in the breeding for earliness will make use of V_2 and those that showed promise as reported in this thesis.

Correlation studies between the characters were not done in this work primarily because the seven varieties were a selected set for maturity.

Future Considerations

All the varieties involved in the present study and their hybrid progenies are known to have very poor level of resistance to bacterial blight and in order to improve their level of resistance, a blight resistant line RASA (76) 23 developed at Samaru was crossed onto a sample from each of the 49 genotypes in 1977. The seed from these crosses were harvested and replanted in 1978 for further backcross using the same RASA (76) 23. The intention was that during the time

when this study is being written up, the level of resistance to bacterial blight in these genotypes would be improved by backcrossing this resistant line onto them, so that breeding for earliness would go hand in hand with that for resistance to bacterial blight. It is also hoped that some good combinations will be found among the progenies for use in the development of early maturing, bacterial blight resistant types with good or satisfactory levels of any other desirable characteristics.

BIBLIOGRAPHY

1. Allard, R.W. (1960). Principles of plant breeding. John Wiley & Sons Inc. N.Y. Chp. 10: 99-108.

2. Al-Rawi, K.M. (1970). A genetic study of earliness in cotton using the diallel cross analysis and a breeding study to determine the possibility of developing an early, long fibered strain of cotton. Ph.D. Thesis. Oklahoma State University. Ann Arbor Michigan, p. 55.

3. Al-Rawi, K.M. and Kohel, R.J. (1969). Diallel analysis of yield and other agronomic characters in Gossypium hirsutum L. Crop Sci. 2: 779-783.

4. Ashley, D.A., Elsner, J.E., Brooks, O.L. and Perry, C.E. (1974). Factors affecting early growth of cotton and subsequent effects on plant development. Agron. J. 66: 20-23.

5. Bilbro, J.D. and Quisenberry, J.E. (1973). A yield related measure of earliness for cotton Gossypium hirsutum L. Crop Sci. 13: 392-393.

6. Bilbro, J.D. and Ray, L.L. (1973). Effect of planting date on the yield and fibre properties of cotton cultivars. Agron. J. 65: 606-609.

7. Bridge, R.R., Meredith Jr., W.R. and Chism, J.F. (1971). The influence of planting date on agronomic and fibre properties of cotton. Miss Agr. Expt. Stn. Bull 786 (May): pp. 15.

8. Brown, C.A. (1951). Earliness. Emp. Cott. Grow. Rev. 28: 253-255.

9. Choyce, M.A. (1968). A review of cotton development in Nigeria. Samaru Agric. Newsl. 10 (3): 44-57.

10. Choyce, M.A. and Reed, W. (1962). Sowing date of sprayed cotton. Progr. Rep. Exp. Sta. Northern Nigeria 1960-61.

11. Christidis, B.G. and Harrison, G.J. (1955). Cotton growing problems. McGraw-Hill Book Co. Inc. N.Y.: 3-28 and 355-368.

12. Faulkner, R.C. (1972). The research programme. Cotton Res. Rep. 1970-71, Northern States, Nigeria.

13. Faulkner, R.C. (1973). The research programme. Cotton Res. Rep. 1971-72, Northern States, Nigeria.

14. Faulkner, R.C. (1974). The research programme. Cotton Res. Rep. 1972-73, Northern States, Nigeria.

15. Faulkner, R.C. (1974). Stability of performance of a control variety of cotton in Nigeria. Cotton Grow. Rev. 51: 1 - 15.

16. Faulkner, R.C., Hayward, J.A., Mustafa, S. and Smithson, J.B. (1974). Agronomic investigations. Cotton Res. Rep. 1972-73, Northern States, Nigeria.

17. Faulkner, R.C. et. al. (1975). Agronomic investigations. Cotton Res. Rep. 1973-74, Northern States, Nigeria.

18. Gardener, B.R. and Tucker, T.C. (1967). Nitrogen effects on cotton: I. Vegetative and fruiting characteristics. Soil Sci. Soc. Am. Proc. 31: 780-785.

19. Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel cross systems. Austr. J. Biol. Sci. 9: 463-493.

20. Harland, S.C. (1939). The genetics of cotton. Jonathan Cape Ltd. London. p. 193.

21. Hayward, J.A. (1975). The research programme. Cotton Res. Rep. 1973-74, Northern States, Nigeria.

22. Hintz, G.D. and Green, J.M. (1954). Components of earliness in upland cotton varieties. Agron. J. 46: 114-118.

23. Jinks, J.L. and Hayman, B.I. (1953). The analysis of diallel crosses. Maize Genetics Co-op. Newsletter 27: 48-54.

24. Jones, J.E. and Loden, H.D. (1951). Heterosis and combining ability in upland cotton. Agron. J. 43: 514 - 516.

25. Kime, P.H. and Tilley, R.H. (1974). Hybrid vigour in upland cotton. Agron. J. 39: 303 - 317.

26. Kirk, I.W., Brashears, A.D. and Hudspeth Jr., E.B. (1969). Influence of row width and plant spacing on cotton production characteristics on the high plains. Texas Agric. Exp. Stn. Misc. Publ. MP 937 (Dec.): pp. 11.

27. Koli, S.E. and Morrill, L.G. (1976). Influence of nitrogen, narrow rows, and plant population on cotton yield and growth. Agron. J. 68: 897-901.

28. Kowal, J.M. and Adeoye, K.B. (1973). An assessment of aridity and the severity of the 1972 drought in Northern Nigeria and neighbouring countries. Savanna 2 (2): 145-158.

29. Kowal, J.M. and Kassam, A.H. (1973). Water use, energy balance and growth of maize at Samaru, Northern Nigeria. Agricultural meteorology 12: 391-406.

30. Littlewood, R.K., Carmer, S.G. and Hittle, C.N. (1964). Computer program for estimating combining abilities in relation to diallel crossing systems. Crop Sci. 4: 662-663.

31. Ludwig, C.A. (1931). Some factors concerning earliness in cotton. J. Agr. Res. 43: 637-659.

32. Mahmud, I. and Kramer, H.H. (1951). Segregation for yield, height and maturity following a soyabean cross. Agron. J. 43: 605-609.

33. Mather, K. (1949). Biometrical genetics. 1st edition. Methuen, London:

34. Mather, K. and Jinks, J.L. (1971). Biometrical genetics. Chapman and Hall Ltd., London, pp. 382.

35. Miller, P. A. and Marani, A. (1963). Heterosis and combining ability in diallel crosses of upland cotton Gossypium hirsutum L. Crop Sci. 3: 441-444.

36. Mooseberg, C.A. (1969). Breeding for earliness of maturity in upland cotton. Ark. Agr. Exp. Snt. Bull. 739: pp. 17.

37. Morris, D.A. (1964). Variation in the boll maturation period of cotton. Emp. Cott. Grow. Rev. 41: 114-123.

38. Munro, J.M. (1971). An analysis of earliness in cotton. Cott. Grew. Rev. 46: 261-282.

39. Munro, J.M. and Farbrother, H.G. (1969). Composite plant diagrams in cotton. Cott. Grow Rev. 48: 28-41.

40. Murray, J.C. and Verhalen, L.M. (1969). Genetic studies of earliness, yield and fibre properties in cotton (Gossypium hirsutum L.). Crop Sci. 2: 752-755.

41. Mustafa, S. (1976). Effects of low temperature conditions on earliness characteristics in cotton (Gossypium hirsutum L.). Samaru Conference Paper No. 12: p. 10.

42. Pearson, E.S., and Hartley, H.O. (1958). Biometrika tables for statisticians. Vol. I: 157. Cambridge at the University Press.

43. Perkins, H.F. and Douglas, A.G. (1965). Effects of nitrogen on the yield and certain properties of cotton. Agron. J. 57: 383-384.

44. Quisenberry, J.E. (1975). Inheritence of plant height in cotton. I. A cross between Lubbock dwarf and Texas Marker 1. Crop. Sci. 15: 197-199.

45. Quisenberry, J.E. (1977). Inheritence of plant height in cotton. II. Diallel analysis among six semi dwarf strains. Crop. Sci. 17: 347-350.

46. Ray, L.L. and Richmond, T.R. (1966). Morphological measures of earliness. Crop Sci. 6: 527-531.

47. Richmond, T.R. and Radwan, S.R.H. (1962). A comparative study of seven methods of measuring earliness of crop maturity in cotton. Crop Sci. 2: 397-400.

48. Richmond, T.R. and Ray, L.L. (1966). Product-quantity measures of earliness of crop maturity in cotton. Crop. Sci. 6: 235-239.

49. Snedecor, W.G. and Cochran, G.W. (1974). Statistical methods. 6th ed. 7th printing. Iowa State Univ. Press, Ames. Iowa.

50. Spooner, A.E., Caviness, C.E. and Spurgeon, W.I. (1958). Influence of timing of irrigation on yield, quality and fruiting of upland cotton. Agron. J. 50: 74 - 77.

51. Sprague, G.F. and Tatum, L.A. (1942). General vs specific combining ability in single crosses of corn. Jour. Amer. Soc. Agron. 34: 923-932.

52. Steel, R.G.D. and Torrie, J.H. (1960). Principles and procedures of statistics. McGraw-Hill Book Co. Inc. N.Y., pp. 481.

53. Thompson, A.C., Lane, H.C., Jones, J.W., and Hesketh, J.D. (1976). Nitrogen concentration of cotton leaves, buds and bolls in relation to age and nitrogen fertilization. Agron. J. 68: 617-621.

54. Tugwell, N.P. and Waddle, B.A. (1964). Yield and lint quality of cotton as affected by varied production practices. Ark. Exp. Stn. Bull 682.

55. Veliev, I.M. (1969). The role of cotton breeding in increasing yield. Pl. Breeding Abstr. (1973) 42: (2977): 357.

56. Wadleigh, C.H. (1944). Growth status of the cotton plant as influenced by the supply of nitrogen. Ark. Agric. Exp. Stn. Bull. 446: pp. 138.

57. Walter, M.W. (1967). Length of rainy season in Nigeria. Journ. Geogr. Assn. Nigeria 10 (2): 123-126.

58. White, T.G. (1966). Diallel analysis of quantitatively inherited characters in Gossypium hirsutum L. Crop. Sci. 6: 253-255.

59. White, T.G. and Kohel, R.J. (1964). A diallel analysis of agronomic characters in selected lines of cotton Gossypium hirsutum L. Crop Sci. 4: 254-257.

60. White, T.G. and Richmond, T.R. (1963). Heterosis and combining ability in top and diallel crosses among primitive, foreign, and cultivated American upland cotton. Crop Sci. 3: 58-62.

61. Yfoulis, A. and Fasoulas, A. (1978). Role of minimum and maximum temperature on maturation period of cotton boll. Agron. J. 70: 421-425.

Table A1: Total monthly rainfall in mm at Samaru at 10-day intervals for 1975, 1976, and 1977

Month	Interval	Year		
		1975	1976	1977
April	1 - 10			
	11 - 20			
	21 - 30			
May	1 - 10	38.9	0.0	0.0
	11 - 20	38.9	4.5	0.0
	21 - 31	52.3	94.4	50.0
June	1 - 10	6.4	82.1	54.0
	11 - 20	39.4	55.7	35.3
	21 - 30	89.7	69.1	12.4
July	1 - 10	77.6	91.1	7.6
	11 - 20	94.5	86.1	22.4
	21 - 31	131.4	49.2	29.0
August	1 - 10	26.7	91.5	65.1
	11 - 20	26.4	60.0	116.3
	21 - 31	60.3	36.6	121.3
September	1 - 10	97.3	94.0	123.3
	11 - 20	76.3	35.5	18.2
	21 - 30	38.6	61.5	58.0
October	1 - 10	0.5	13.4	0.0
	11 - 20	7.8	126.8	4.3
	21 - 31	0.0	22.0	0.0
ANNUAL TOTAL		903.0	1073.5	717.2

Table A2(a): Estimates of the linear (l) and quadratic (q) contrasts of the sowing date x variety interaction for earliness characters in 1975 and 1977 (only BP in 1977)

Variety	E1%				E2%				MMD				PRI		
	l	q	MS_l	MS_q	l	q	MS_l	MS_q	l	q	MS_l	MS_q	l	q	MS_l
V_1	-205.8	302.4	3529.5**	2540.2**	15.6	202.8	20.3	1142.4**	-75.6	-40.8	476.3**	46.2**	-37.2	10.8	115.3**
V_2	- 89.9	258.7	673.5**	1859.0**	169.2	379.2	2385.7**	3994.2**	-113.6	-59.4	1071.6**	98.0**	-33.0	5.4	90.8**
V_3	- 87.8	238.0	642.4**	1573.4**	155.4	333.0	2012.4**	3080.3**	-111.0	-49.8	1026.8**	68.9**	-21.6	1.2	38.9**
V_4	-291.6	299.8	7085.9**	2496.7**	-145.8	412.2	1771.5**	4719.7**	- 40.8	-69.6	138.7**	134.6**	-42.6	11.4	151.2**
V_5	-235.2	266.8	4609.9**	1977.3**	-117.0	435.0	1140.8**	5256.3**	- 52.8	-68.4	232.3**	130.0**	-42.6	6.6	151.2**
V_6	-150.2	148.4	1880.0**	611.7**	-143.4	245.4	1713.6**	1672.8**	- 60.6	-24.6	306.0**	16.8	-45.6	3.6	173.1**
V_7	-154.6	152.8	1991.8**	648.6**	-142.2	211.8	1685.1**	1246.1**	- 60.6	-21.0	306.0**	12.3	-45.6	6.0	173.*

*, ** significant at the 0.05, 0.01 levels of probability respectively.

l, q, linear and quadratic contrasts, respectively.

MS_l, MS_q mean squares for linear and quadratic contrasts, respectively.

Table A2(a) cont'd next pa

Table A2(a)(cont'd)

Variety	NFB				DFF				BP			
	l	q	MS_l	MS_q	l	q	MS_l	MS_q	l	q	MS_l	MS_q
V_1	4.8	-14.4	1.9	5.8**	101.4	-107.4	856.8**	320.4**	-8.4	1.2	8.8	0.
V_2	7.2	- 4.8	4.3**	0.6	94.8	- 73.2	748.9**	148.8**	-24.4	34.8	74.4**	50.
V_3	6.0	- 6.0	3.0**	1.0	108.6	- 78.6	982.8**	171.6**	-25.2	30.8	79.4**	39
V_4	-0.6	- 1.8	0.1	0.1	91.2	- 72.0	693.1**	144.0**	- 7.6	76.4	7.2	243
V_5	1.2	- 1.2	0.1	0.1	85.2	- 84.0	604.9**	196.0**	- 7.2	36.8	6.5	56
V_6	3.0	1.8	0.8	0.1	108.0	- 66.0	972.0**	121.0**	- 2.0	64.4	0.5	172
V_7	-4.2	- 0.6	1.5	0.1	64.8	- 66.0	349.9	121.0	20.4	52.4	52.0	11

*, ** significant at the 0.05, 0.01 levels of probability, respectively.

l, q, linear and quadratic contrasts, respectively.

MS_l, MS_q , mean squares for linear and quadratic contrasts, respectively.

Table A2(b): Estimates of the linear (l) and quadratic (q) contrasts of the sowing date x variety interaction for yield component characters and GP in 1975

Variety	Boll weight				No. of seed				GP			
	l	q	MS_l	MS_q	l	q	MS_l	MS_q	l	q	MS_l	MS_q
V_1	0.6	-7.8	0.03	1.69*	9.0	-50.4	6.8	70.6**	-14.1	-8.7	16.6**	2.1*
V_2	-1.8	0.6	0.27	0.01	9.6	-13.2	7.7	4.8	5.2	4.0	2.2*	0.
V_3	2.4	-2.4	0.48	0.16	44.0	12.6	159.9**	4.4	1.6	-5.0	0.2	0.7
V_4	-4.8	7.2	1.92*	1.44	-33.6	50.4	94.1*	70.6**	-0.5	-1.3	0.02	0.05
V_5	-6.6	3.0	3.63**	0.25	-34.8	34.8	100.9**	33.6	-8.1	-8.3	5.5**	1.9
V_6	-2.4	6.0	0.48	1.00	- 1.8	6.12	0.3	104.0**	-0.7	-1.7	0.04	0.1
V_7	-3.0	1.8	0.75	0.09	-27.0	41.4	60.8*	47.6	-0.4	-6.4	0.01	1.1

*, ** Significant at the 0.05, 0.01 levels of probability, respectively.

l, q, linear and quadratic contrasts, respectively.

MS_l, MS_q = Mean square for linear and quadratic constracts, respectively.

Table A3: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven-parent diallel cross in an overall combined analysis over 2 years and 2 sowing dates

Parents	1	2	3	4	5	6	7
1		-0.183	0.707	-0.207	0.045	0.005	-0.367
		0.073	0.603	-0.641	0.108	0.083	-0.226
2	-0.015		0.578	-0.893	-0.225	0.402	0.322
	0.062		-0.036	-0.354	-0.281	0.636	-0.039
3	-0.015	-0.025		-0.112	-0.243	-0.842	-0.088
	0.040	-0.012		-0.132	-0.101	0.324	-0.659
4	-0.095	-0.063	0.037		1.143	-0.387	-0.318
	-0.045	-0.088	-0.085		0.931	-0.252	0.448
5	0.118	0.058	-0.042	0.078		-0.562	-0.158
	-0.085	-0.020	0.075	0.048		-0.962	0.304
6	-0.038	-0.023	0.093	-0.028	-0.040		0.610
	0.163	0.037	-0.027	0.097	-0.160		0.171
7	0.045	0.068	-0.048	0.072	-0.173	0.037	
	-0.135	0.022	0.008	0.073	0.143	-0.110	

	NFB	DFF
s.e. of the difference between effects of two crosses having one parent in common within F_1 or F_2	± 0.1327	± 1.0061
s.e. of the difference between effects of two crosses having no parent in common within F_1 or F_2	± 0.1149	± 0.8713

Table A4: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven-parent diallel cross in an overall combined analysis over 2 years and 2 sowing dates

Parents	1	2	3	4	5	6	7
1		1.778 -0.433	2.495 1.610	-3.430 -2.083	0.567 -4.178	-0.923 5.128	-0.487 -0.043
2	1.297 0.301		-0.378 -0.113	0.513 2.935	-3.415 -0.893	2.495 -2.320	-0.993 0.825
3	0.626 0.946	-0.196 -0.829		1.455 -1.413	2.443 6.550	-1.005 -6.743	-5.010 0.110
4	-0.956 0.119	0.322 -0.206	0.084 -0.027		-1.657 -4.727	0.128 0.528	2.990 0.008
5	-0.516 -0.821	-1.213 0.238	0.224 0.391	-0.324 -0.644		-1.067 1.402	3.128 1.847
6	-0.273 0.043	0.264 0.484	-0.283 -0.571	0.386 0.811	0.559 -0.237		0.372 -2.747
7	-0.178 -0.589	-0.474 0.011	-0.454 0.089	0.489 -0.054	1.271 1.073	-0.653 -0.531	

	NSB	PHT
s.e. of the difference between effects of two crosses having one parent in common within F_1 or F_2	± 0.8716	± 6.7791
s.e. of the difference between effects of two crosses having no parents in common within F_1 or F_2	± 0.7549	± 5.8709

Table A5: NSB per meter^{+} of PHT for the parental (main diagonal), F_1 (bottom left half) and F_2 (top right half) from an overall combined analysis over 2 years and 2 sowing dates

Parents	1	2	3	4	5	6	7
1	18.06	18.97	20.65	16.97	16.47	14.83	15.95
2	20.89	21.74	20.71	17.20	18.70	18.20	18.14
3	20.78	22.76	24.10	19.43	18.23	19.03	19.62
4	16.34	18.52	18.86	15.45	16.60	15.57	16.42
5	16.50	17.87	19.22	17.60	16.04	15.34	17.53
6	15.76	16.93	17.76	15.64	15.25	13.71	15.69
7	17.21	18.40	20.53	16.49	17.66	14.96	17.73

+ values not statistically analysed but calculated from the respective means.

Table A6: Means of the parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) in an overall combined analysis over 2 years and 2 sowing dates

Parents	1	2	3	4	5	6	7
1	66.51ab	64.28	65.10	66.14	66.43	68.28	67.73
		65.93	67.19	67.69	68.03	69.44	70.28
	4.37a	65.29	63.74	64.23	64.93	67.44	67.19
2	4.47		64.23	65.66	65.31	67.68	68.14
	4.57	4.43a	64.29a	64.94	64.85	66.13	66.72
3	4.53	4.63		66.61	66.23	68.09	68.25
	4.66	4.69	4.52ab	67.78b	68.19	69.32	68.44
4	4.57	4.71	4.88		69.00	69.26	71.10
	4.66	4.70	4.82	4.92c	67.82b	68.41	68.64
5	4.73	4.78	4.75	4.98		68.13	70.54
	4.53	4.68	4.89	4.95	4.74bc	72.50c	71.29
6	4.65	4.78	4.96	4.95	4.89		71.85
	4.90	4.86	4.91	5.11	4.78	5.03c	74.45c
7	4.84	4.98	4.93	5.16	4.87	5.15	
	4.72	4.96	5.06	5.21	5.19	5.06	5.35d

+ means followed by the same letter(s) are not significantly different at the 0.05 level of probability.

	NFB	DFF
Parental grand mean	4.77	68.38
F_1 grand mean	4.82	66.78
F_2	4.85	68.03

	NFB	DFF
s.e. of any treatment mean within F_1 or F_2	± 0.105	± 0.795
s.e. of the difference between two means within F_1 or F_2	± 0.148	± 1.125

Table A7: Means of the parental (main diagonal), F_1 upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) in an overall combined analysis over 2 years and 2 sowing dates.

Parents	1	2	3	4	5	6	7
1	74.04b	67.87 65.90	64.86 66.45	79.21 79.84	84.48 79.41	88.01 91.95	81.24 78.89
2	13.37abc 14.18 12.50	54.18a 11.78a	55.48 58.23 52.90a	76.64 78.37 73.86 72.53	73.98 76.20 76.12 82.15	84.92 78.01 77.69 72.09	74.23 73.27 66.48 71.06
3	13.48 13.72	12.63 12.06	12.77ab	92.77cd	92.29 87.96	99.10 101.20	94.76 88.04
4	12.94 13.55	14.19 13.34	13.93 14.09	14.33bc	92.73cd	99.18 98.98	96.17 91.54
5	13.94 13.08	13.22 14.25	14.63 14.98	16.24 14.60	14.87c	102.00d	98.43 90.18
6	13.87 13.64	14.38 14.20	13.80 13.72	15.51 15.76	15.12 15.18	13.98bc	
7	13.98 12.58	13.66 13.29	13.65 13.94	15.63 14.46	16.98 16.05	14.73 14.15	14.81c

	NSB	PHT
Parental grand mean	13.70	78.89
F_1 grand mean	14.32	81.19
F_2 grand mean	13.96	80.11
s.e. of any treatment mean within F_1 or F_2	± 0.689	± 5.359
s.e. of the difference between two means within F_1 or F_2	± 0.975	± 7.579

Table A8: NSB per meter[+] of PHT for the parental (main diagonal), F_1 (upper figure) and F_2 (lower figures) for the June sown (bottom left half) and July sown (top right half) trials combined over 2 years.

Parents	1	2	3	4	5	6	7
1	17.87	19.79	20.90	15.94	16.48	15.80	17.67
		19.21	19.91	16.92	14.46	15.04	15.59
	18.25	20.55	21.64	18.01	16.70	16.31	17.06
2	22.10		19.36	16.79	18.52	17.59	18.09
	18.68	23.00	22.34	18.33	19.25	16.54	21.02
3	20.69	24.04		19.06	17.12	20.18	19.87
	21.42	22.23	26.05	15.65	15.13	14.96	15.80
4	16.71	19.30	19.42		16.74	15.15	16.98
	17.03	17.25	19.84	15.25	16.39	16.63	17.24
5	16.53	18.98	19.17	17.43		15.11	18.27
	16.79	18.88	19.58	16.47	15.70	13.53	14.60
6	15.72	17.57	19.01	16.23	16.14		16.06
	14.65	18.77	17.92	16.01	15.55	13.87	16.58
7	16.75	19.81	20.06	17.10	18.03	15.29	
	16.26	18.19	19.39	15.92	16.89	15.38	18.71

+ Values not statistically analysed but calculated from the means.

Table A9: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for June sown trials

Parents	1	2	3	4	5	6	7
		0.46	0.14	-0.18	-0.34	-0.03	-0.56
		0.38	-0.03	-0.81	0.79	0.29	-0.61
			0.59	-1.08	-1.17	0.60	0.61
2	0.032		0.29	-0.78	-0.18	0.68	-0.37
	0.012			0.27	0.13	-0.54	-0.59
3	-0.084	-0.061		0.26	0.12	-0.25	-0.36
	0.092	0.046			1.04	-0.02	-0.04
4	-0.138	-0.014	-.052		0.26	0.44	0.64
	-0.118	-0.131	-0.051			0.12	0.21
5	0.099	0.039	-0.078	0.036		-1.43	0.44
	-0.034	0.036	0.066	0.106			-0.13
6	0.002	-0.041	0.242	-0.061	-0.024		0.27
	0.246	0.016	0.104	0.119	-0.298		
7	0.089	0.046	-0.071	0.126	-0.071	-0.118	
	-0.198	0.022	-0.048	0.076	0.126	0.022	

	NFB	DFF
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 0.1550	± 1.174
s.e. of the difference between two effects having no parent in common within F_1 or F_2	± 0.1342	+ 1.017

Table **A10:** Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross in a combined analysis over 2 years for June sown trials

Parent	1	2	3	4	5	6	7
		2.97	7.80	-3.69	-2.85	-1.96	-2.27
		-3.34	3.40	-3.49	-2.61	6.89	-0.84
2	1.75		1.01	-1.70	-0.74	1.18	-2.73
	-0.72		0.29	3.80	-0.72	-0.96	0.93
3	1.60	-0.08		-2.74	1.87	-3.39	-4.55
	1.40	-0.50		-1.54	1.76	-3.88	-0.02
4	-0.96	-0.60	-0.71		0.71	3.08	4.34
	-0.13	-0.11	-0.09		-0.43	1.56	0.10
5	-1.10	-0.60	-0.12	0.54		-1.56	2.56
	-0.45	0.06	0.15	-0.16		-0.72	2.72
6	-0.50	-0.10	0.08	0.88	-0.09		2.65
	0.14	1.08	-0.98	0.73	-0.41		-2.89
7	-0.79	-0.38	-0.77	0.85	1.36	-0.27	
	-0.24	0.19	0.02	-0.23	0.81	-0.55	

	NSB	PHT
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 1.256	± 7.448
s.e. of the difference between two effects having no parent in common within F_1 or F_2	± 1.088	± 6.450

Table A11: Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) for the June sown trials combined over 2 years

Parents	1	2	3	4	5	6	7
	63.60bc	61.67	61.33	62.97	62.82	65.02	65.62
		62.07	62.60	63.12	66.12	66.15	65.90
1	4.12a	61.65ab	59.90	60.18	60.10	63.77	64.42
			60.12	61.07	62.07	64.47	64.08
2	4.45						
	4.38	4.32a	60.73a	61.52	61.38	62.62	63.20
3	4.32	4.45		62.85	63.12	64.28	64.82
	4.57	4.62	4.40a		64.25	65.08	65.70
4	4.47	4.70	4.75		64.55	66.27	67.12
	4.45	4.53	4.72	4.78b	64.77c	65.23	65.97
5	4.63	4.68	4.55	4.87		64.80	67.32
	4.48	4.65	4.78	4.92	4.75b	69.70d	67.52
6	4.58	4.65	4.92	4.82	4.78		68.68
	4.90	4.77	4.75	5.07	4.60	5.13c	70.11d
7	4.87	4.93	4.80	5.20	4.93	4.93	
	4.53	4.85	4.88	5.10	5.13	5.13	5.20c

	NFB	DFF
Parental grand mean	4.67	64.98
F_1 grand mean	4.73	63.35
F_2 grand mean	4.75	64.35
s.e. of any treatment mean within F1 or F2	± 0.123	± 0.928
s.e. of the difference between two treatment means within F_1 or F_2	± 0.173	± 1.313

+ means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table A12: Means of parental (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) for the June sown trials combined over 2 years.

Parents	1	2	3	4	5	6	7
	71.52b	64.85	66.70	81.25	81.67	87.62	80.60
		62.00	63.95	77.33	80.68	95.67	82.22
1	13.05ab	52.73a	52.12	74.45	75.98	82.97	72.35
2	14.33		54.65	78.43	76.38	81.63	77.80
	11.58	12.13a	50.17a	71.43	75.62	75.42	67.55
3	13.80	12.53		68.30	74.07	73.92	72.05
	13.70	12.15	13.07ab	96.53	100.50	107.93	102.48
4	13.58	14.37	13.87		92.15	99.63	92.45
	13.17	13.53	13.55	14.72abc	95.65cc	102.87	100.28
5	13.50	14.42	14.50	17.52		99.82	97.53
	13.55	14.42	14.50	15.18	15.12bc	107.30c	105.43
6	13.77	14.58	14.34	17.52	16.60		97.42
	14.02	15.32	13.25	15.95	12.52	14.88abc	90.08c
7	13.50	14.33	13.55	17.52	18.08	16.12	
	13.37	14.15	13.97	14.72	16.47	14.98	16.85c

	NSB	PHT
Parental grand mean	14.25	80.56
F_1 grand mean	14.87	82.43
F_2 grand mean	14.14	80.86
s.e. of any treatment mean within F_1 or F_2	± 0.993	± 5.888
s.e. of the difference of two treatment means within F_1 or F_2	± 1.405	± 8.327

Table A13: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for July sowing.

Parents	1	2	3	4	5	6	7
		1.35	-0.45	4.76	-6.67	1.65	-0.64
		-0.15	-4.48	0.94	1.67	0.11	1.92
			0.55	-3.90	4.39	-0.10	-2.29
			-0.55	2.55	4.53	-6.71	0.34
2	3.69			2.24	-2.61	4.24	-3.97
	1.87			-0.67	-0.90	8.86	-2.26
3	-7.83	-1.85			-1.44	-6.24	4.58
	-3.36	0.90			-4.65	1.64	0.19
4	7.20	-3.12	6.64			2.23	4.10
	-0.32	-4.38	6.46			-2.17	1.53
5	-5.90	7.03	-1.52	-6.37			-1.78
	-1.40	8.11	-6.83	-1.79			-1.73
6	2.82	-0.53	4.59	-6.09	1.24		
	4.23	-6.66	1.00	2.48	0.32		
7	0.02	-5.22	-0.02	1.74	5.52	-2.03	
	-1.02	0.16	1.82	-2.46	2.23	-0.74	

	E1%	E2%
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 7.275	± 5.919
s.e. of the difference between two effects having no parent in common.	± 6.301	± 5.126

Table A14: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of seven-parent diallel cross in a combined analysis over 2 year for July sowing.

Parents	1	2	3	4	5	6	7
		0.120	-0.103	-0.013	-0.009	0.025	-0.018
		0.050	-0.099	0.065	-0.006	-0.008	-0.002
			-0.222	0.035	-0.008	0.006	0.070
2	-0.78		-0.116	-0.005	0.078	-0.053	0.045
	-0.27			0.132	0.094	0.152	-0.053
3	1.30	-0.17		0.084	0.073	0.011	0.047
	1.07	-0.37			-0.113	-0.069	0.029
4	-1.78	1.10	-1.09		-0.155	0.080	-0.069
	0.05	0.33	-0.72			-0.025	0.061
5	1.82	-1.66	0.63	1.12		0.001	0.009
	0.04	-1.69	1.25	0.27			-0.088
6	-0.59	0.29	-1.19	1.45	0.44		-0.031
	-0.55	2.01	-1.49	-0.40	0.47		
7	0.04	1.22	0.52	-0.80	-1.47	0.49	
	-0.35	-0.01	0.25	0.47	-0.34	-0.03	

	MMD	PRI
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 1.737	±0.1146
s.e. of the difference between two effects having no parent in common within F_1 or F_2	± 1.504	±0.0993

Table **A15:** Specific ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of seven-parent diallel cross in a combined analysis over 2 years for July sowing.

Parents	1	2	3	4	5	6	7
		-0.82	1.27	0.24	0.43	0.04	-0.68
		-0.24	1.24	-0.47	-0.57	-0.12	0.16
2	-0.062		0.57	-0.71	0.72	0.21	0.04
	0.111		-0.34	0.07	-0.38	0.59	0.29
3	0.054	0.011		-0.49	-0.61	-1.15	0.42
	-0.012	-0.069		-0.52	-0.32	0.90	-0.95
4	-0.052	-0.112	0.021		1.24	0.79	-0.59
	0.028	-0.046	-0.119		1.60	-0.94	0.26
5	0.138	0.078	-0.006	0.121		-1.24	-0.53
	-0.136	-0.076	0.084	-0.009		-0.50	0.17
6	-0.079	-0.006	-0.056	0.004	-0.056		1.35
	0.081	0.058	0.051	0.074	-0.022		0.07
7	0.001	0.091	-0.026	0.018	-0.276	0.191	
	-0.072	0.021	0.064	0.071	0.158	-0.242	

	NFB	DFF
s.e. of the difference between two effects having one parent in common within F1 or F2	± 0.1694	± 1.195
s.e. of the difference between two effects having no parent in common within F1 or F2	± 0.1467	± 1.035

Table A16: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) of a seven-parent diallel cross in a combined analysis over 2 years for July sowing.

Parents	1	2	3	4	5	6	7
1		1.58	-1.36	-2.15	0.63	1.34	-0.03
		0.47	-0.37	1.61	0.09	-0.88	-0.91
2	2.97		-2.26	0.80	-4.34	0.30	3.94
	1.70		-0.76	-1.39	0.20	0.09	1.39
3	-2.68	-7.99		3.55	2.19	-0.63	-1.48
	-3.12	-4.35		0.14	2.09	-0.55	-0.53
4	-0.96	1.78	4.43		2.04	0.84	-0.99
	2.79	0.39	2.33		-3.72	3.07	0.29
5	0.99	-0.69	3.09	-3.70		1.58	1.99
	-0.31	1.47	3.77	-6.19		-0.07	1.41
6	0.56	0.04	5.14	-2.15	-0.84		-3.42
	-0.57	-1.15	-0.47	3.18	0.50		-1.65
7	-0.88	3.89	-2.00	0.59	1.15	-2.76	
	-0.50	1.93	1.83	-2.50	0.75	-1.52	

	Yield	TFP
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 3.907	± 2.001
s.e. of the difference between two effects having no parent in common within F_1 or F_2	± 3.383	± 1.733

Table A17: Specific combining ability effects in the F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of seven-parent diallel cross in a combined analysis over 2 years for July sowing.

Parent	1	2	3	4	5	6	7
		0.58	-2.81	-3.17	3.98	0.12	1.30
		2.48	-0.18	-0.68	-5.75	3.37	0.75
			-1.77	2.73	-6.09	3.81	0.74
2	0.85		-0.52	2.07	-1.07	-3.68	0.72
	1.32			5.65	3.02	1.38	-5.47
3	-0.35	-0.31		-1.29	11.34	-9.61	0.24
	0.49	-1.16			-4.02	-2.82	1.64
4	-0.95	1.24	0.87		-9.02	9.00	-0.09
	0.37	-0.30	0.04			-0.57	3.69
5	0.06	-1.83	0.57	-1.19		3.52	0.97
	-1.19	0.41	0.63	-1.13			-1.91
6	-0.05	0.62	-0.64	-0.11	1.21		-2.61
	-0.05	-0.11	-0.16	0.90	-0.06		
7	0.44	-0.57	-0.14	0.13	1.18	-1.04	
	-0.94	-0.17	0.16	0.12	1.33	-0.51	

	NSB	PHT
s.e. of the difference between two effects having one parent in common within F_1 or F_2	± 1.072	+7.571
s.e. of the difference between two effects having no parent in common within F_1 or F_2	± 0.929	+6.557

Table A18: Means of the parental[+] (main diagonal), F1 (upper figures) and F2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) for the July sown trial combined over 2 years.

Parents	1	2	3	4	5	6	7
1	76.78ab	89.10	86.25	85.76	76.26	76.59	81.07
		80.14	70.29	71.99	75.29	69.52	68.19
	53.26abc	87.84a	85.01	74.87	85.08	72.60	77.19
2	69.48		83.62	83.00	87.55	72.09	76.01
	61.80	68.98a	81.89a	79.96	77.03	75.89	74.46
3	57.04	63.63		74.27	76.61	82.15	67.88
	48.50	60.32	61.26ab	75.93ab	72.50	59.72	77.32
4	63.52	53.81	62.64		69.14	71.22	66.62
	44.39	47.90	50.67	50.35bc	81.47a	70.11	78.75
5	51.43	64.98	55.51	42.11		69.97	70.52
	49.75	66.81	43.80	41.70	54.28abc	67.00bc	64.89
6	50.25	47.51	51.72	32.48	40.84		63.06
	48.81	45.49	45.07	39.41	43.03	42.82cd	59.05c
7	55.38	50.76	55.04	48.25	53.04	35.59	
	40.69	49.42	43.01	31.59	42.70	33.18	29.59d

	E1%	E2%
Parental grand mean	51.50	75.80
F_1 grand mean	52.62	77.16
F_2 grand mean	46.57	73.77
s.e. of any treatment mean within F1 or F2	± 4.784	± 4.044
s.e. of the difference between two means within F_1 or F_2	± 6.765	± 5.719

+ means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table A19: Means of the parental[+] (main diagonal), F1 (upper figures) and F2 (lower figures) generations for MMD* (bottom left half) and PRI (top right half) for the July sown trial combined over 2 years.

Parents	1	2	3	4	5	6	7
1	50.58	88.32	62.63	69.97	76.37	67.32	74.53
		62.03	44.98	62.97	56.10	47.77	50.95
	38.16abc	50.13b	48.25	71.90	73.58	62.40	80.95
2	34.21		48.33	62.45	70.72	50.08	62.42
	36.44	34.46a	39.73c	77.80	79.12	72.22	58.87
3	36.44	35.13		67.78	67.42	53.22	58.87
	39.79	35.93	36.09ab	64.97a	56.72	49.30	70.42
4	35.58	38.62	36.59		45.78	62.53	49.87
	40.39	38.24	39.19	39.05bc	63.95a	59.93	79.10
5	38.78	35.45	37.90	40.60		55.07	58.35
	38.99	34.85	39.78	40.43	37.58abc	39.45c	52.98
6	38.86	39.90	38.58	43.43	41.14		45.80
	39.99	40.13	38.63	41.33	40.82	40.76cd	39.93c
7	37.45	38.78	38.24	39.13	38.06	42.51	
	41.07	38.99	41.24	43.07	40.89	42.78	44.16d

* MMD and PRI (mg/plant/day) are estimated from the date of first boll split (28 days before first pick)

	MMD	PRI
Parental grand mean	38.61	49.82
F_1 grand mean	38.35	68.47
F_2 grand mean	39.67	56.36
s.e. of any treatment mean within F_1 or F_2	± 1.184	± 0.062
s.e. of the difference between two means within F_1 or F_2	± 1.675	± 0.088

+ means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table 20: Means of the parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) for the July sown trial combined over 2 years.

Parents	1	2	3	4	5	6	7
1	69.42ab	66.88	68.87	69.32	70.05	71.53	69.83
		69.60	71.78	72.27	70.94	72.73	74.65
	4.68a	68.93ab	67.58	68.27	69.77	71.12	69.97
2	4.48		67.65	70.25	68.57	70.88	72.22
	4.75	4.55a	67.85a	68.37	68.32	69.65	70.23
3	4.75	4.82		70.37	69.33	71.50	71.68
	4.75	4.77	4.60a	71.25b	72.13	73.55	71.18
4	4.67	4.72	5.00		73.45	72.25	75.08
	4.87	4.87	4.92	5.05b	70.87b	71.58	71.32
5	4.83	4.88	4.95	5.10		71.47	73.77
	4.58	4.72	5.00	4.98	4.73a	75.30c	75.07
6	4.72	4.90	5.00	5.08	5.00		75.02
	4.90	4.95	5.07	5.17	4.95	5.00b	78.78d
7	4.82	5.02	5.05	5.12	4.80	5.37	
	4.90	5.07	5.23	5.32	5.28	4.98	5.50c

	NFB	DFF
Parental grand mean	4.87	71.77
F_1 grand mean	4.91	70.22
F_2 grand mean	4.95	71.71
s.e. of any treatment mean within F_1 or F_2	± 0.102	± 0.746
s.e. of the difference between two means within F_1 or F_2	± 0.144	± 1.055

+ means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table A21: Means of the parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) for July sowing combined over two years.

Parents	1	2	3	4	5	6	7
1	21.85	24.97	20.07	18.62	23.42	22.80	24.62
	18.90ab	20.08	22.05	22.02	22.37	19.38	19.15
2	30.37	19.55	20.38	28.78	19.67	22.98	29.80
	22.07	17.27ab	21.12	18.48	21.93	19.82	20.92
3	22.37	16.43	20.27	23.57	24.23	20.08	22.42
	17.27	17.27	14.00ab	22.82	26.63	21.98	21.80
4	25.17	27.28	27.58	20.27	19.37	20.90	22.25
	24.65	23.48	25.45	24.67b	18.82	23.60	20.62
5	29.05	26.75	28.18	22.47	22.28	23.67	27.25
	20.78	23.80	26.12	17.63	24.17b	22.32	23.60
6	25.33	24.20	26.95	20.73	23.98	17.75	20.52
	18.62	19.27	19.97	25.10	21.65	15.15ab	18.53
7	26.90	31.05	22.82	26.48	28.98	21.78	19.55NS
	19.97	23.63	23.55	20.70	23.18	19.02	17.07ab

	Yield	TFP
Parental grand mean	18.75	20.22
F_1 grand mean	55.47	22.59
F_2 grand mean	21.58	21.33
s.e. of any treatment mean within F_1 or F_2	± 2.319	± 1.723
s.e. of the difference between two means within F_1 or F_2	± 3.280	± 2.436

+ means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.
NS = parental means not significant.

Table A22: Means of the parental* (mean diagonal), F_1 (upper figures) and F_2 (lower figures generations for NSB (bottom left half) and PHT (top right half) for July sowing combined over 2 years.

Parents	1	2	3	4	5	6	7
1	76.57	70.88	63.02	77.17	87.28	88.40	81.88
		69.80	68.95	82.35	78.13	88.23	75.57
	13.68ab	55.62a	58.83	77.83	71.98	86.87	76.10
2	14.03		61.82	78.30	76.02	74.38	68.73
	13.41	11.43a	55.83a	76.28	76.62	79.97	65.42
3	13.17	11.73		76.75	90.23	70.27	70.07
	13.73	11.97	12.47ab	89.00bc	84.08	90.27	87.03
4	12.30	14.02	13.98		83.77	102.77	83.63
	13.93	13.15	14.63	13.93ab	89.80bc	95.48	92.05
5	14.38	12.02	14.75	12.72		98.15	85.55
	12.60	14.08	14.45	14.02	14.72b	96.70c	91.43
6	13.97	14.17	13.23	13.50	15.88		82.95
	13.27	13.08	14.18	15.57	14.83	13.08ab	77.02b
7	14.47	12.98	13.75	13.75	15.87	13.35	
	11.78	12.43	13.92	14.20	15.63	13.32	12.77ab

	NSB	PHT
Parental grand mean	13.15	77.22
F_1 grand mean	13.76	79.95
F_2 grand mean	13.77	79.35

s.e. of the treatment in F_1 or F_2

s.e. of the difference between two means within F_1 or F_2

+ Means on the main diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table A23: General combining ability effects in the F_1 and F_2 generations of a seven-parent diallel cross for June sown trial in 1976

Parent	NFB	DFF	TFP	NSB	PHT
For F_1					
1	-0.27	-0.30	-4.12	-1.56	-8.14
2	-0.09	-2.09	-1.32	-0.87	-17.10
3	-0.21	-2.50	0.41	-0.91	-20.43
4	0.20	0.73	2.40	1.34	13.18
5	0.05	0.05	1.26	0.35	9.76
6	0.08	1.74	-0.25	0.97	14.46
7	0.24	2.38	4.14	0.67	8.28
s.e.+	0.100	0.651	1.875	0.449	2.900
For F_2					
1	-0.34	-0.83	-3.21	-1.56	-9.00
2	-0.20	-2.64	-0.82	0.52	-11.46
3	0.01	-1.16	-1.05	-1.31	-19.62
4	0.04	-0.16	3.42	1.02	9.58
5	0.10	0.74	0.86	0.72	8.19
6	0.17	1.84	0.92	0.82	13.92
7	0.21	2.22	-0.10	0.82	8.40
s.e.+	0.100	0.651	1.875	0.449	2.900

+ s.e. of the difference between two effects within F_1 or F_2

Table A24: Means of the parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven-parent diallel cross for June sown trial in 1976

Parents	1	2	3	4	5	6	7
1	66.30	63.77	64.70	66.43	64.43	64.90	67.70
		65.53	65.00	65.50	67.63	67.33	65.93
	4.23d	63.40	62.37	64.07	64.10	64.63	66.60
2	4.63		63.40	63.10	64.23	66.53	65.07
	4.40	4.50c	63.00	64.20	63.20	64.93	64.07
3	4.37	4.63		65.50	66.83	66.40	68.13
	4.87	5.00	4.60c	66.67	66.23	69.43	69.27
4	4.70	4.87	5.07		67.73	69.07	69.37
	4.43	4.70	4.87	5.03b	66.67	68.17	69.67
5	4.73	5.03	4.57	5.23		67.83	70.53
	4.67	4.93	5.10	5.17	4.87bc	71.00	70.57
6	4.77	4.80	4.97	5.10	5.03		73.13
	5.03	4.73	4.80	5.30	4.90	5.30a	73.50NS
7	4.93	5.07	4.83	5.50	5.13	5.23	
	4.50	4.80	5.00	5.33	5.33	5.67	5.37a

	NFB	DFF
1. Parental grand mean	4.84	67.22
2. F1 grand mean	4.91	66.00
3. F2 grand mean	4.93	66.85
4. s.e. of any treatment mean within F_1 or F_2	± 0.158	± 1.030
5. s.e. of the difference between two means within F_1 or F_2	± 0.224	± 1.456

6. + Means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability;

NS = not significant (parental means).

Table A25: Means of the parental[+] (main diagonal), F_1 (bottom left half) and F_2 (top right half) generations for TFP in a seven-parent diallel cross for June sown trial in 1976

Parents	1	2	3	4	5	6	7
1	23.80b	22.65	24.22	26.08	23.48	25.99	29.20
		27.05ab	23.90	26.15	27.12	29.12	30.30
2	28.82		25.58ab	23.02	28.77	26.13	28.03
3	30.92	24.50		27.02ab	26.23	26.85	27.57
4	28.15	31.02	28.22		27.70ab	27.45	31.55
5	26.23	30.83	31.77	34.48		26.73ab	27.23
6	25.88	29.57	30.03	30.93	29.07		34.63a
7	28.02	29.18	30.77	39.42	35.42	33.10	

	TFP
Parental grand mean	30.32
F_1 grand mean	34.73
F_2 grand mean	29.54
s.e. of any treatment mean within F_1 or F_2	± 2.965
s.e. of the difference between two means within F_1 or F_2	± 4.193

+ Means on the diagonal followed by the same letter(s) are not significantly different at the 0.05 level of probability.

Table A26: Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for June sown trial in 1976

Parents	1	2	3	4	5	6	7
1	71.52c	64.85	66.70	81.25	81.67	87.62	80.60
		62.00	63.95	77.33	80.68	95.67	82.22
	13.05b	52.73d	52.12	75.45	75.98	82.97	72.35
2	14.33		54.65	78.43	76.38	81.63	77.80
	11.56	12.13bc	50.12d	71.43	75.62	75.42	67.55
3	13.80	12.53		68.30	74.07	73.92	72.05
	13.70	12.15	13.07b	96.53ab	100.50	107.93	102.48
4	13.58	14.37	13.87		92.15	99.63	92.45
	13.17	13.53	13.55	14.72ab	95.65ab	102.87	100.28
5	13.50	14.42	14.50	17.52		99.82	97.53
	13.55	14.42	14.50	15.18	15.02ab	107.30a	105.43
6	13.77	14.58	14.37	17.52	16.60		97.42
	14.02	15.32	13.25	15.95	15.52	14.88ab	90.08b
7	13.50	14.33	13.55	17.52	18.08	16.12	
	13.37	14.15	13.97	14.72	16.47	14.98	16.85a

	NSB	PHT
1. Parental grand mean	14.62	92.63
2. F_1 grand mean	15.32	93.50
3. F_2 grand mean	14.60	93.09
4. s.e. of any treatment mean within F_1 or F_2	± 0.710	± 4.585
5. s.e. of the difference between two means within F_1 or F_2	± 1.004	+ 6.485

6. + Means on the diagonal followed by the same letter(s) are significantly different at the 0.05 level of probability.

Table A27: General combining ability effects in the F_1 (top half) and F_2 (bottom half) generations of a seven-parent diallel cross for July sown trial in 1976

Parents	E1%	E2%	MMD(1)	PRI	NPB	DFF	Yield	TFP	NSB	PHT
For F_1										
1	5.41	3.43	-1.26	-0.013	-0.271	-0.31	-2.56	-1.04	-0.23	-3.25
2	3.56	1.82	-0.81	-0.031	-0.014	-1.33	-1.85	0.32	0.80	-8.58
3	6.82	2.35	-1.44	0.009	-0.077	-2.67	1.01	0.06	0.34	-17.63
4	-1.04	-2.24	0.49	-0.000	0.103	0.74	0.51	-1.80	-1.00	4.42
5	-1.24	2.00	0.06	0.015	0.003	0.32	1.82	0.86	0.89	8.53
6	-12.12	-7.36	2.82	-0.018	0.090	2.05	-2.39	-1.18	0.24	12.65
7	-1.39	0.01	0.26	0.021	0.183	1.21	3.46	2.77	0.54	3.85
s.e.+	3.612	2.620	0.791	0.060	0.086	0.533	1.933	1.558	0.872	3.143
For F_2										
1	4.31	0.99	-0.85	-0.009	-0.257	0.04	-1.89	-0.31	-0.72	-4.23
2	7.31	5.36	-1.92	-0.003	-0.084	-2.07	-0.29	-0.05	-0.76	-11.13
3	3.92	3.60	-1.25	-0.009	0.090	-1.43	-1.71	1.44	0.07	-14.18
4	-5.76	-2.18	1.27	0.012	0.143	0.97	1.45	-1.01	0.62	7.94
5	1.64	-0.38	-0.11	0.009	-0.017	-0.26	1.39	0.49	0.45	9.39
6	-8.93	-4.38	1.98	-0.003	-0.131	0.48	-0.10	-0.19	0.45	12.58
7	-2.49	-3.01	0.87	0.003	0.256	2.28	1.15	-0.37	-0.11	-0.37
s.e.+	3.612	2.620	0.791	0.060	0.086	0.533	1.933	1.558	0.872	3.143

(1) MMD (and consequently PRI) are calculated from the date of sowing.

\+ s.e. of the difference between two effects.

Table A28: Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of seven parent diallel cross for July sown trial in 1976

Parents	1	2	3	4	5	6	7
1	80.32	96.38	89.47	90.48	86.77	89.10	85.49
		92.88	87.51	81.79	84.79	77.94	85.29
	42.86cd	93.47	87.92	84.18	93.29	76.64	91.22
2	76.08		92.96	83.62	89.63	68.36	84.60
	69.64	78.66a	93.63	84.81	91.76	84.83	93.56
3	61.42	63.66		84.29	86.46	86.63	85.39
	61.76	67.58	64.88ab	86.14	89.00	75.06	85.84
4	62.52	60.99	70.92		84.79	79.30	80.53
	49.50	40.80	59.34	58.26bc	92.11	81.69	88.04
5	56.71	64.85	68.70	58.22		77.23	80.47
	52.31	69.32	55.32	57.41	61.88ab	78.31	76.44
6	60.90	47.81	55.00	43.54	42.47		73.89
	51.29	54.20	41.80	40.78	46.35	51.65bc	79.01NS
7	64.17	59.17	69.08	53.38	57.62	44.34	
	59.03	56.97	55.80	45.33	49.47	42.95	40.84d

Item				E1%	E2%
1	...	...	...	57.00	86.14
2	...	...	...	46.11	67.56
3	...	...	...	39.49	63.33
4	...	...	...	± 7.676	± 6.946
5	...	...	...	± 10.855	± 7.982
6 +					

Items 1 - 6 see bottom of Table A24 for explanation.

Table A29: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for MMD* (bottom left half) and PRI (top right half) of a seven parent diallel cross for July sown trial in 1976

Parents	1	2	3	4	5	6	7
1	0.42b	0.78	0.66	0.77	0.77	0.77	0.86
		0.78	0.50	0.69	0.61	0.53	0.60
	38.86a	0.51ab	0.51	0.91	0.88	0.65	0.91
2	32.13		0.50	0.54	0.82	0.61	0.77
	33.63	32.16d	0.38b	1.01	1.08	0.95	0.97
3	35.27	34.71		0.82	0.79	0.51	0.64
	35.31	33.21	33.56cd	0.76a	0.66	0.54	0.97
4	35.03	36.20	34.64		0.56	0.81	0.60
	38.20	39.08	36.46	36.34abc	0.64a	0.73	1.00
5	36.40	34.20	33.93	35.92		0.65	0.75
	37.18	34.16	36.73	36.55	34.79bcd	0.54ab	0.65
6	35.50	39.31	36.68	39.55	39.30		0.63
	38.37	36.43	38.26	39.92	39.38	38.08ab	0.44b
7	35.39	35.44	33.60	37.12	35.97	39.81	
	35.95	36.77	36.70	39.06	38.35	40.44	39.55a

Item	MMD	PRI
1	36.19	0.53
2	36.00	0.81
3	37.15	0.65
4	± 1.251	±0.094
5	± 1.769	± 0.135
6+		

* MMD and PRI calculated from the date of the first boll split, PRI in g/plant/day.

Items 1-6 see bottom of Table A26.

Table A30: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross for July sown trial in 1976

Parents	1	2	3	4	5	6	7
1	69.73d	68.17	69.10	71.47	71.23	72.00	69.40
		69.17	69.77	73.00	72.43	72.27	74.53
2	4.70b	69.70cd	67.53	67.92	71.23	70.20	71.13
	4.60		68.03	71.33	68.97	70.87	71.43
3	4.83	4.63b	68.40d	67.83	67.67	69.30	68.10
	4.63	5.00		71.27	69.67	72.00	72.30
4	4.90	5.13	4.67b	71.33c	71.10	74.97	73.27
	4.83	4.83	5.03		73.10	71.70	75.40
5	4.93	5.00	5.20	5.00b	71.63c	71.47	71.80
	4.80	5.07	4.83	5.13		71.67	73.83
6	4.77	4.77	5.17	5.17	4.87b	74.23b	75.23
	4.70	4.93	5.07	5.13	5.03		74.87
7	4.57	5.00	5.00	5.00	4.83	4.87b	80.43a
	4.90	5.23	4.87	5.37	4.97	5.40	
	4.93	5.07	5.27	5.63	5.43	5.17	5.57a

Item	NFB	DFF
1	4.90	71.92
2	4.97	70.40
3	5.04	71.83
4	± 0.136	± 0.843
5	± 0.193	± 1.193
6+		

Items 1 - 6 see bottom of Table A26.

Table A31: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for Yield (bottom left half) and TFP (top right half) of a seven parent diallel cross for July sown trial in 1976.

Parents	1	2	3	4	5	6	7
1	24.77	28.23	25.40	20.97	26.77	27.80	29.77
		25.80	29.17	24.33	25.20	24.03	23.40
	15.67ba	25.90	26.13	28.30	24.57	27.63	30.90
2	24.87		26.83	21.47	26.57	25.60	27.00
	26.03	15.93bc	22.83	29.97	29.70	24.30	28.93
3	22.97	17.10		26.70	28.37	26.30	23.33
	17.77	16.63	12.07c	23.00	25.50	24.43	27.97
4	26.73	32.23	33.33		21.10	28.40	26.43
	25.13	20.50	28.67	26.63a	23.97	28.80	35.13
5	27.07	30.00	35.47	23.90		25.75	28.97
	21.77	26.97	27.77	19.17	22.17ab	22.90	25.30
6	26.40	24.03	33.40	20.83	27.37		22.50
	19.70	21.37	18.40	31.10	24.10	19.53ab	22.07NS
7	28.37	31.73	31.97	34.70	34.50	25.23	
	20.47	27.40	22.57	23.00	27.50	25.17	16.63bc

Items	Yield	TFP
1	18.38	23.63
2	28.20	27.36
3	23.29	25.28
4	± 3.056	± 2.460
5	± 4.432	± 3.479
6[+]		

Items 1 - 6 see bottom of Table A24.

Table A32: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for July sown trial in 1976

Parents	1	2	3	4	5	6	7
1	101.93e	87.87	84.53	101.03	108.97	110.23	103.80
		95.20	90.67	103.63	97.07	118.27	100.07
	16.00	77.73d	78.33	100.07	94.50	113.80	94.73
2	16.83		74.77	104.17	101.73	100.63	93.87
	17.07	14.63	68.00d	92.70	92.60	93.37	82.50
3	16.47	16.17		95.30	110.20	88.90	86.30
	18.30	13.67	13.83	116.23b	112.70	113.20	115.07
4	14.60	17.10	17.03		111.57	139.57	111.53
	16.30	16.27	17.47	15.87	109.70bc	128.03	118.53
5	16.90	14.53	17.83	15.17		126.30	117.10
	13.93	16.83	17.67	16.67	16.63	138.60a	117.30
6	16.93	17.57	16.20	14.93	19.97		115.30
	16.33	16.03	17.57	18.57	16.90	17.13	98.20c
7	17.50	14.20	18.40	16.57	20.43	16.00	
	14.07	15.93	15.30	17.43	19.87	16.47	14.83NS

Items	NSB	PHT
1	15.56	101.49
2	16.73	102.11
3	16.60	104.34
4	± 1.379	± 4.969
5	± 1.950	± 7.027
6[+]		

Items 1 - 6 see bottom of Table A24.

Table A33: General combining ability effects in the F_1 (top half) and F_2 (bottom half) generations of a seven-parent diallel cross for June-sown trial in 1977

Parents	E1%	E2%	MMD(1)	PRI	NFB	DFF	Yield	TFP	NSB	PHT
For F1										
1	2.85	-0.19	-0.41	0.03	-0.15	0.05	0.53	-1.40	-1.14	-4.62
2	10.20	3.38	-2.03	0.05	-0.11	-0.93	-0.97	-1.84	-1.00	-11.25
3	11.98	3.86	-2.37	-0.15	-0.02	-1.55	-7.50	-2.65	-1.73	-13.87
4	2.25	-0.67	0.69	0.18	-0.02	-0.19	6.54	3.66	1.80	7.17
5	-3.99	2.13	-0.65	0.13	-0.02	-0.88	3.85	1.76	0.71	4.61
6	-9.62	-4.10	2.67	-0.12	0.28	2.57	-0.82	1.50	0.87	5.37
7	-13.67	-4.39	2.10	-0.11	0.04	1.92	-1.64	-1.04	0.52	12.60
s.e.+	3.977	2.004	0.762	0.104	0.119	0.702	3.600	1.611	0.753	2.290
For F_2										
1	10.76	11.59	3.29	0.11	-0.14	0.44	3.89	-0.26	-0.64	-0.33
2	15.79	12.56	2.33	0.39	-0.08	-0.91	11.07	0.40	-0.97	-10.24
3	16.93	14.85	1.89	0.18	-0.09	-1.89	4.03	-1.44	-0.19	-11.67
4	-16.40	-25.86	-10.21	-0.13	-0.09	-0.41	-4.74	1.83	1.19	6.00
5	-4.37	-9.24	-2.95	-0.31	0.07	-0.30	-10.60	-2.67	-0.53	-0.32
6	-7.13	7.00	6.64	0.21	0.23	2.49	3.26	2.02	2.29	5.32
7	-15.57	-10.90	-0.99	-0.26	0.11	1.57	-6.90	0.13	0.85	11.24
s.e.+	3.977	2.004	0.762	0.104	0.119	0.702	3.600	1.611	0.753	2.290

(1) MMD (and consequently PRI) are calculated from the date of sowing.

\+ s.e. of the difference between two effects.

Table A34: Means of parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven parent diallel cross for June sown trial in 1977.

Parents	1	2	3	4	5	6	7
1	97.99a	95.93	99.38	98.14	89.52	84.65	86.02
		98.52	98.76	99.66	91.93	89.50	87.84
	72.62bc	98.75a	97.33	98.82	98.26	89.72	91.45
2	66.96		98.49	96.54	94.55	89.42	91.96
	84.14	91.23a	97.84	92.46	95.27	94.37	94.99
3	88.02	81.69		96.12	97.36	96.31	94.58
	71.24	82.90	76.78ab	96.25a	91.22	93.22	91.41
4	74.93	86.20	69.40		89.88	86.89	84.48
	80.51	72.00	69.85	67.65bc	90.75ab	88.73	88.28
5	59.96	84.47	68.45	48.79		93.11	92.72
	59.45	74.71	70.60	63.62	55.82c	76.06c	81.98
6	56.65	55.49	63.63	60.01	51.38		91.63
	50.73	48.60	71.58	42.53	58.94	25.12d	82.10bc
7	46.78	55.26	67.80	51.00	46.08	43.78	
	43.63	55.86	58.19	48.27	49.69	44.67	33.71d

Items	E1%	E2%
1	60.42	91.39
2	63.18	92.44
3	61.99	93.35
4	± 6.288	± 3.168
5	± 8.892	± 4.481
6[+]		

Items 1 - 6 see bottom of Table A26.

Table A35: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for MMD* (bottom left half) and PRI (top right half) of a seven diallel cross for June sown trial in 1977

Parents	1	2	3	4	5	6	7
1	1.19a	1.49	1.34	1.13	1.08	1.04	1.33
		1.16	1.34	0.87	1.20	1.04	1.09
2	32.12c	0.91ab	0.94	1.47	1.65	0.97	0.98
	33.20		1.19	1.05	1.60	1.08	1.14
3	30.43	29.40c	1.04ab	0.90	1.19	1.19	0.92
	29.77	30.94		0.89	1.14	0.85	0.08
4	32.20	30.61	31.55c	0.93ab	1.74	1.48	1.19
	31.77	30.10	33.34		0.98	0.90	0.89
5	30.78	32.40	32.77	33.03bc	1.02ab	1.17	1.38
	35.04	30.42	33.08	36.40		1.15	1.10
6	34.81	32.00	32.49	34.48	35.48b	0.64b	0.89
	36.20	35.67	33.88	34.55	36.37		0.96
7	36.37	36.64	32.50	37.88	34.71	41.78a	0.92ab
	37.41	35.46	33.21	36.06	37.19	38.38	
	37.55	35.25	34.61	37.41	36.06	36.88	39.74a

Items	MMD	PRI
1	34.73	0.95
2	34.21	1.21
3	34.23	1.07
4	± 1.205	± 0.164
5	± 1.704	± 0.232
6+		

* MMD and PRI (g/pl/day) calculated from the date of first boll split.

Items 1 - 6 see bottom of Table A26.

Table A36: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures generations for NFB (bottom left half) and DFF (top right half) of a seven parent diallel cross for June sown trial in 1977

Parents	1	2	3	4	5	6	7
1	60.90bc	59.57	57.97	59.50	60.73	63.07	63.57
		59.00	60.20	60.73	62.60	64.97	65.87
	4.00c	59.90bc	57.43	56.30	56.10	62.90	62.23
2	4.27		58.23	59.03	59.90	62.40	63.07
	2.37	4.13bc	58.47c	58.83	59.57	60.30	62.33
3	4.27	4.27		60.20	59.40	62.17	61.50
	4.27	4.23	4.27ab	61.93b	62.27	60.73	62.13
4	4.25	4.53	4.43		61.37	63.47	64.87
	4.47	4.37	4.57	4.53abc	62.87b	62.30	62.27
5	4.53	4.33	4.53	4.50		61.77	64.10
	4.30	4.37	4.47	4.67	4.63ab	68.40a	64.47
6	4.40	4.50	4.07	4.53	4.53		64.23
	4.77	4.80	4.70	4.83	4.30	4.87a	86.73a
7	4.80	4.80	4.77	4.90	4.73	4.63	
	4.57	4.90	4.77	4.87	4.87	4.60	5.03a

Item	NFB	DFF
1	4.50	62.74
2	4.54	60.69
3	4.57	61.86
4	± 0.188	± 1.111
5	± 0.266	± 1.571
6+		

Items 1 - 6 see bottom of Table A26.

Table A37: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generation for yield (bottom left half) and TPP (top right half) of a seven parent diallel cross for June sown trial in 1977

Parents	1	2	3	4	5	6	7
	27.00ab	30.37	26.97	23.37	21.57	21.33	24.80
		20.73	24.77	20.80	23.67	23.77	28.93
	39.00	22.40b	19.07	23.90	26.60	22.03	23.27
2	49.30		20.87	22.93	24.50	27.17	29.12
	35.50	26.53	23.57b	19.87	25.17	27.50	23.17
3	40.33	29.00		21.30	27.47	21.00	24.40
	43.33	36.37	32.60	22.53b	37.17	29.97	29.03
4	35.93	44.33	29.63		23.60	22.23	21.07
	27.07	33.23	29.80	30.83	26.30ab	23.80	38.83
5	37.07	49.47	39.10	60.93		27.83	27.77
	42.13	50.63	37.13	33.47	36.13	19.10b	24.27
6	37.27	34.17	39.73	51.07	41.17		22.37
	38.37	39.37	27.47	33.03	39.40	26.43	31.57a
7	48.53	34.63	30.47	43.13	50.73	34.17	
	39.77	39.93	36.60	32.77	39.97	33.97	35.63NS

Items	Yield	TFP
1	32.45	24.68
2	40.96	25.87
3	36.63	23.89
4	± 5.692	± 2.548
5	± 8.050	± 3.603
6+		

Items 1 - 6 see bottom of Table A24.

Table A38: Means of parental[+] (main diagonal) F_1 (upper figures) and F_2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for June sown trial in 1977

Parents	1	2	3	4	5	6	7
1	68.93b	57.50	55.80	73.87	69.03	77.87	71.00
		54.80	54.70	61.57	74.60	86.33	78.17
	13.97b	46.53c	42.50	62.73	67.33	78.50	63.33
2	15.30		44.93	57.63	62.63	71.13	69.47
	10.53	11.47b	45.27c	58.23	68.60	73.17	60.50
3	13.57	11.37		62.17	61.70	63.20	66.77
	15.13	12.27	13.93b	77.00ab	89.10	90.17	77.10
4	12.60	13.17	11.77		76.53	81.67	70.63
	12.30	12.47	13.10	13.30b	80.93a	79.17	90.77
5	12.43	14.27	13.60	18.30		89.33	77.00
	13.53	13.83	14.10	14.57	14.20b	82.87a	92.30
6	13.20	13.33	14.43	18.07	15.57		76.37
	14.00	15.00	12.57	14.37	16.17	12.47b	77.90ab
7	13.30	13.67	12.70	15.77	20.93	14.10	
	13.47	13.20	14.03	12.70	15.90	14.30	17.73a

Items	NSB	PHT
1	13.87	68.49
2	14.35	71.36
3	13.69	68.63
4	± 1.191	± 3.779
5	± 1.684	± 5.344
6[+]		

Items 1 - 6 see bottom of Table A26.

Table A39: General combining ability effects in the F_1 (top half) and F_2 (bottom half) generations of a seven-parent diallel cross for July sown trial in 1977.

Parents	E1%	E2%	MMD	PRI	NFB	DFF	Yield	TFP	NSB	PHT
For F1										
1	7.14	9.40	-2.10	0.04	-0.20	-1.62	5.11	0.63	0.13	-1.17
2	10.23	6.54	-2.24	0.02	-0.22	-1.76	3.15	1.70	-0.25	-6.30
3	5.12	3.90	-1.36	-0.03	0.12	-0.64	-4.40	-1.97	-0.73	-6.19
4	-1.88	-3.29	0.00	0.01	0.04	0.42	0.82	-0.04	0.33	2.60
5	-4.13	-2.90	0.98	-0.02	-0.01	-0.14	-1.75	-1.42	0.07	0.78
6	-5.67	-3.73	1.37	-0.01	0.10	-1.31	1.38	1.76	0.09	1.84
7	-10.81	-9.91	2.71	-0.01	-0.01	2.42	-1.55	-0.65	0.37	8.44
s.e.+	4.855	4.393	1.187	0.053	0.102	0.797	2.207	1.590	0.672	3.661
For F_2										
1	1.48	-3.87	0.31	-0.00	-0.13	0.65	-0.56	-0.87	-0.84	-1.01
2	13.61	10.56	-3.22	0.01	-0.16	-2.36	0.30	-2.22	-1.04	-7.70
3	0.85	1.28	-0.11	0.01	-0.08	-1.58	1.76	1.92	0.43	-1.04
4	1.71	2.96	-0.73	-0.00	-0.06	-0.83	0.09	2.56	1.14	4.90
5	-3.75	-0.35	0.55	0.01	0.02	0.40	1.57	0.35	0.53	4.64
6	-13.06	-9.12	2.93	-0.01	0.17	2.59	-0.92	-0.98	-0.43	-3.48
7	-0.85	-1.46	0.27	-0.01	0.25	1.12	-2.24	-0.76	0.20	3.67
s.e.+	4.855	4.393	1.187	0.053	0.102	0.797	2.207	1.590	0.672	3.661

MMD (and consequently PRI) are calculated from the date of sowing.

\+ s.e. of the difference between two effects.

Table A40: Means of the parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for E1% (bottom left half) and E2% (top right half) of a seven-parent diallel cross for July-sown trial in 1977

Parents	1	2	3	4	5	6	7
1	73.24ab	81.83	83.04	81.05	65.74	64.07	76.64
		67.40	53.06	62.20	65.80	61.10	51.09
2	63.65a	82.22a	82.10	65.55	76.87	68.56	63.20
	62.88		74.27	82.39	95.46	55.83	67.41
3	53.95	59.30a	70.03ab	75.10	62.31	66.95	55.35
	52.65	63.59		64.25	66.75	77.67	50.37
4	35.24	53.07	57.63a	65.72ab	56.01	44.37	68.80
	64.52	46.63	54.37		53.50	63.15	52.75
5	39.28	55.00	41.99	42.45ab	70.83ab	58.52	69.47
	46.15	65.12	42.32	25.99		62.72	60.57
6	47.18	64.30	32.28	26.00	46.68ab	57.08bc	53.34
	39.60	47.21	48.30	21.42	39.21		53.23
7	46.34	39.79	48.35	38.05	39.74	33.99bc	39.08c
	46.59	42.35	41.00	43.11	48.47	26.83	
	22.35	41.88	30.22	17.86	35.94	23.41	18.33c

Items	E1%	E2%
1	46.01	65.46
2	46.11	67.56
3	39.49	63.33
4	± 7.676	± 6.946
5	±10.855	± 7.982
6+		

Items 1 - 6, see bottom of Table A26.

Table A41: Means of the parental[+] (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for MMD (bottom left half) and PRI (top right half) of a seven-parent diallel cross for July-sown trial in 1977

Parents	1	2	3	4	5	6	7
1	0.60ab	1.01	0.60	0.63	0.77	0.59	0.65
		0.48	0.39	0.58	0.52	0.44	0.43
	36.84bc	0.50abc	0.46	0.55	0.61	0.62	0.72
2	35.74		0.48	0.72	0.60	0.41	0.50
	38.51	36.19c	0.42abc	0.56	0.52	0.52	0.32
3	36.98	35.06		0.55	0.58	0.57	0.56
	43.20	37.95	37.91c	0.55ab	0.47	0.46	0.45
4	35.60	40.17	37.83		0.37	0.45	0.40
	41.61	36.79	41.00	40.85bc	0.65a	0.49	0.59
5	40.29	36.12	40.95	44.14		0.46	0.44
	39.96	35.03	41.85	43.22	39.55bc	0.25c	0.42
6	41.28	39.66	39.64	46.03	41.98		0.30
	40.71	42.77	38.27	41.76	41.31	42.40ab	0.37bc
7	38.75	41.18	41.88	40.26	39.34	44.07	
	44.97	40.33	44.61	45.82	42.40	43.98	47.39a

* MMD and PRI are calculated from the date of first boll split; PRI in g/pl/day.

Items	MMD	PRI
1	41.03	0.47
2	40.70	0.56
3	42.18	0.48
4	± 1.077	± 0.083
5	± 2.654	± 0.117
6+		

Items 1 - 6; see bottom of Table A26.

Table A42: Means of the parental[+] (main diagonal), F_2 (upper figures) and F_2 (lower figures) generations for NFB (bottom left half) and DFF (top right half) of a seven-parent diallel cross for July-sown trial in 1977

Parents	1	2	3	4	5	6	7
1	69.10bc	65.60	68.63	67.17	68.86	71.07	70.27
		70.03	73.00	71.53	73.33	71.30	74.77
2	4.57b	70.17bc	67.63	68.57	68.30	72.03	68.80
	4.37		66.47	69.17	68.17	70.90	73.00
3	4.67	4.47b	67.30c	68.90	68.97	70.00	72.37
	4.87	4.63		69.47	69.00	71.80	71.07
4	4.60	4.40	4.53b	71.17a	73.17	72.13	69.10
	4.50	4.60	4.97		73.80	72.80	74.77
5	4.80	4.73	4.63	5.10a	70.10bc	71.70	70.83
	4.87	4.70	5.07	5.07		71.27	73.70
6	4.67	4.67	4.83	4.80	4.60b	76.37a	74.90
	4.73	4.87	4.93	5.03	4.97		75.17
7	4.97	4.90	5.13	5.33	5.07	5.14a	77.13a
	4.73	4.80	5.23	4.87	4.63	5.33	
	4.87	5.07	5.20	5.00	5.13	4.80	5.43a

Item	NFB	DFF
1	4.83	71.62
2	4.85	69.95
3	4.87	71.59
4	± 0.161	± 1.261
5	± 0.228	±11.783
6+		

Items 1 - 6, see bottom of Table A26.

Table A43: Means of parental (main diagonal), F_1 (upper figures) and F_2 (lower figures) generations for yiedl (bottom left half) and TFP (top right half) of a seven parent.

Parents	1	2	3	4	5	6	7
1	18.93 22.93	23.10 14.53	14.73 14.93	16.27 19.73	19.97 18.73	18.40 15.53	19.43 14.90
2	35.87 18.10	13.20 18.60	14.57 16.20	17.17 15.57	14.77 17.27	18.30 14.07	30.03 14.83
3	21.77 16.77	15.77 17.90	18.03 15.93	17.17 19.00	18.17 24.93	15.87 17.67	15.63 20.60
4	23.60 24.17	22.23 26.47	21.83 22.23	17.57 22.70	15.57 16.53	17.40 18.47	16.53 15.00
5	31.03 19.80	23.50 20.63	20.90 24.47	21.03 16.47	20.60 26.17	18.77 18.83	19.37 18.30
6	24.27 17.53	24.37 17.17	20.50 21.53	20.63 19.10	20.60 19.20	12.83 10.77	15.73 14.60
7	25.43 19.47	30.37 19.87	13.67 24.53	18.27 18.40	23.47 18.87	18.33 12.87	17.03NS 17.50NS

Items	Yield	TFP
1	19.11	16.80
2	22.74	17.82
3	19.77	17.09
4	± 3.490	± 2.514
5	± 4.936	± 3.556
6+		

Items 1 - 6, see bottom of Table A24.

Table A44: Means of parental (main diagonal), F_1 (upper figures) and F2 (lower figures) generations for NSB (bottom left half) and PHT (top right half) of a seven parent diallel cross for July sown trial in 1977

Parents	1	2	3	4	5	6	7
1	51.20b	53.90	41.50	53.30	65.60	66.57	59.97
	11.37a	44.40	47.23	61.07	61.57	55.83	51.07
2	11.23	33.50c	38.03	55.60	49.47	59.93	57.47
	9.77	8.23b	48.87	52.43	50.30	48.13	43.60
3	9.87	9.30	43.67bc	59.87	60.63	66.57	48.33
	9.17	10.27	11.10a	58.20	61.27	51.63	53.83
4	10.00	10.93	10.93	61.77ab	55.47	67.33	59.00
	11.57	10.03	11.80	12.00a	55.97	66.00	55.73
5	11.87	9.50	11.60	10.27	69.90a	62.93	65.57
	10.83	11.33	13.23	11.37	12.80a	70.00	54.00
6	11.00	10.77	10.27	12.07	11.80	54.80ab	65.57
	10.63	10.13	10.80	12.57	12.77	9.03b	50.60
7	11.43	11.77	9.10	10.93	11.30	10.70	55.83ab
	9.50	8.93	12.53	10.97	11.40	10.17	10.70ab

Item	NSB	PHT
1	10.75	52.95
2	10.80	57.78
3	10.94	54.37
4	± 1.063	± 5.789
5	± 1.503	± 8.189
6		

Items 1 - 6 see bottom of Table A26.

Table A45: Means of lint quality test results for the parental (main diagonal) F1 (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for June-sown trial in 1976

Parents	Traits	1	2	3	4	5	6	7
1	Mic.	3.50	3.40	3.20	2.90	3.10	3.30	3.10
	EL	34.00	38.00	37.00	39.00	39.00	39.00	38.00
	BS	19.90	22.30	20.90	22.50	22.30	21.10	21.30
2	Mic	3.00	3.20	3.10	2.90	3.00	2.90	2.90
	EL	37.00	36.00	37.00	37.00	39.00	39.00	38.00
	BS	20.00	21.10	20.71	21.80	22.70	22.90	22.00
3	Mic.	3.60	2.80	3.10	2.80	3.00	2.80	3.10
	EL	37.00	36.00	34.00	36.00	38.00	38.00	37.00
	BS	20.10	20.50	20.70	21.90	22.70	21.80	22.00
4	Mic.	3.20	2.70	3.00	3.00	2.90	3.00	3.10
	EL	38.00	38.00	37.00	39.00	41.00	41.00	40.00
	BS	22.90	21.80	21.30	24.60	23.80	23.30	22.80
5	Mic	3.00	2.90	2.90	2.80	3.00	2.80	3.40
	EL	39.00	39.00	38.00	41.00	42.00	40.00	40.00
	BS	22.30	22.50	22.10	23.90	24.90	22.80	22.50
6	Mic	3.10	3.00	2.80	2.90	2.90	2.90	2.90
	EL	39.00	39.00	37.00	41.00	41.00	39.00	39.00
	BS	22.70	21.40	20.30	23.30	22.80	23.10	23.40
7	Mic	3.10	2.90	3.00	3.00	2.90	3.00	3.20
	EL	38.00	38.00	37.00	41.00	42.00	40.00	38.00
	BS	22.60	22.20	20.30	23.80	24.10	23.80	24.00

Data not analysed but only means given.

Table A46: Means of lint quality test results for the parental (main diagonal) F_1 (bottom left half) and F_2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for July-sown trial in 1976

Parents	Traits	1	2	3	4	5	6	7
1	Mic	3.73	3.87	3.78	3.53	3.75	3.68	3.55
	EL	35.33	36.67	34.67	39.00	38.17	37.33	36.50
	BS	20.37	21.53	21.83	22.30	22.78	21.22	21.18
2	Mic	4.02	3.63	3.42	3.77	3.30	3.27	3.57
	EL	35.67	36.50	34.00	37.00	37.83	37.00	37.67
	BS	21.13	21.22	22.20	22.42	22.23	21.62	22.20
3	Mic	3.92	3.78	3.48	3.82	3.93	3.42	3.80
	EL	36.50	37.34	33.33	36.83	36.87	37.33	35.33
	BS	21.87	23.02	21.32	23.08	22.25	21.05	21.37
4	Mic	3.43	3.45	3.37	3.52	3.50	3.17	3.55
	EL	38.00	37.17	35.84	39.83	39.67	39.00	39.00
	BS	23.23	21.13	21.47	22.65	21.92	22.42	23.00
5	Mic	3.18	3.33	3.95	3.23	3.17	3.13	3.38
	EL	38.17	38.67	37.17	39.17	40.00	39.50	38.17
	BS	21.02	21.43	31.42	22.55	23.32	22.83	23.03
6	Mic	3.67	3.45	3.68	3.20	3.03	3.12	3.08
	EL	38.33	37.50	36.50	39.00	39.67	39.67	39.67
	BS	21.65	21.68	20.20	21.55	21.25	21.67	22.90
7	Mic	3.58	3.65	3.38	3.13	3.25	3.48	3.02
	EL	37.50	36.17	36.00	39.17	39.50	38.83	37.67
	BS	22.27	20.92	22.03	23.68	22.93	22.23	23.00

	Mic	EL	BS
s.e. of the mean	± 0.211	± 0.838	± 0.649

Table A47: Means of lint quality test results for the parental (main diagonal), F1 (bottom left half) and F2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for June-sown trial in 1977

Parents	Traits	1	2	3	4	5	6	7
1	Mic	3.42	3.00	3.37	3.02	3.40	3.30	3.85
	EL	35.50	37.00	34.67	37.67	38.67	36.83	37.17
	BS	23.00	24.03	22.03	23.45	24.48	21.95	21.43
2	Mic	3.20	2.65	3.40	3.43	2.95	3.52	3.00
	EL	35.17	35.00	35.67	37.33	38.00	36.67	37.00
	BS	22.08	21.98	22.57	22.92	23.87	23.17	22.68
3	Mic	2.85	3.23	3.23	3.08	3.30	2.95	3.12
	EL	35.50	34.67	33.83	36.83	37.17	37.17	37.50
	BS	21.88	21.87	21.32	23.85	23.17	23.40	24.07
4	Mic	3.55	3.42	3.13	3.27	3.27	3.25	3.13
	EL	38.50	39.50	37.83	39.67	39.50	39.17	38.83
	BS	22.15	23.78	23.20	22.93	25.75	23.10	24.83
5	Mic	2.97	3.02	2.80	3.15	3.28	2.73	3.27
	El	37.50	39.00	36.67	39.67	41.17	40.00	39.17
	BS	24.40	23.07	22.37	23.90	24.73	24.67	23.52
6	Mic	3.22	3.22	3.25	3.67	2.98	3.47	3.00
	EL	39.00	38.17	37.50	38.50	38.83	40.33	37.00
	BS	22.00	22.93	22.08	22.27	24.03	22.93	21.92
7	Mic	3.53	2.90	3.35	3.40	3.67	2.82	3.48
	EL	38.00	36.17	36.17	39.83	38.67	39.83	38.17
	BS	22.35	23.67	22.30	24.28	23.65	23.27	24.08

		Mic	EL	BS
s.e. of the mean	±	0.251	± 0.772	± 1.180

EL and BS as in Table A45.

Table **A48:** Means of lint quality test results for the parental (main diagonal), F1 (bottom left half) and F2 (top right half) generations for Mic., EL and BS of a seven-parent diallel cross for July-sown trial in 1977

Parents	Traits	1	2	3	4	5	6	7
1	Mic	3.85	4.09	4.67	3.72	4.15	3.75	4.07
	EL	38.50	37.83	34.33	39.00	36.83	38.67	36.17
	BS	22.60	22.50	24.08	24.95	24.10	24.22	22.55
2	Mic	4.12	3.50	4.07	2.92	4.07	3.85	3.17
	EL	36.67	36.83	36.17	37.33	39.00	35.83	36.33
	BS	22.43	23.77	22.18	25.23	24.97	22.68	23.27
3	Mic	4.25	3.63	3.51	3.87	3.18	3.95	3.92
	EL	36.00	34.67	35.83	36.17	36.83	36.33	35.17
	BS	23.47	23.05	23.80	23.43	24.50	23.88	23.52
4	Mic	3.52	3.65	4.42	3.82	3.68	3.32	3.68
	EL	39.00	37.83	37.50	39.17	40.50	39.67	38.33
	BS	24.25	24.75	24.50	24.28	25.35	24.58	26.65
5	Mic	3.52	4.51	3.92	4.07	3.73	3.93	3.35
	EL	38.83	37.33	38.50	38.50	40.67	42.17	40.17
	BS	23.70	24.43	24.32	25.25	26.23	24.53	25.62
6	Mic	4.03	4.00	4.22	4.07	4.09	4.00	2.29
	EL	40.33	39.33	37.50	39.17	40.83	39.00	38.50
	BS	24.05	24.13	23.43	24.47	25.18	25.48	23.08
7	Mic	3.42	3.90	2.42	3.55	3.33	2.33	3.83
	EL	38.83	38.67	36.50	40.83	40.33	37.33	36.50
	BS	22.70	24.17	23.83	25.52	27.23	26.10	23.52

	Mic	EL	BS
s.e. of the mean	± 0.449	± 0.855	± 0.977

Table A49: Mean squares[1] from an analysis of variance from a log transformed data of the cross Stripper x UK66; and also the mean squares for the generations (bottom), grown in 1976

Sources	d.f.	Earliness characters						Productivity characters				PHT
		E2%	MMD(2)	PRI g/pl/d	NFB	DFF	BP	Yield g/pl	TFP	NSB	NSB/PHT	
Replications	3	9.15	3.68	151.51	0.53	0.77	4.84	1333.94	164.28	2.60	40.04	58.51
Generations	5	40.09**	23.36**	169.34**	66.65**	21.28**	3.54**	1697.11**	157.72**	36.50**	108.33**	217.66**
R x G	15	5.09*	3.17**	34.89**	57.64**	1.60**	0.77	310.23**	25.41	11.78*	8.38	136.41**
Error	28	2.32	1.18	11.18	4.46	0.49	0.65	100.13	14.90	5.15	6.49	9.95
Plots/reps/BC_1	8	0.94	0.51	16.00	7.65	0.29	0.70	138.19	24.30	6.48	1.76	7.19
Plots/reps/F_2	12	3.89	2.03	13.35	3.66	0.30	0.89	117.05	11.58	4.62	11.91	14.07
Plots/reps/BC_2	8	1.36	0.58	3.08	2.45	0.96	0.23	36.68	10.49	4.63	3.10	6.51
Plants/plots	468	1.61	0.84	3.13	3.39	0.38	0.39	29.01	7.68	3.33	4.06	5.01
Plants/plots/P_1	36	0.40	0.20	0.66	2.20	0.06	0.16	7.30	6.53	1.59	1.70	1.15
BC_1	108	0.94	0.61	4.60	2.40	0.34	0.42	34.33	8.91	3.01	3.99	5.08
F_1	36	0.43	0.32	0.30	1.39	0.06	0.22	5.31	10.80	2.75	2.52	1.72
F_2	144	3.19	1.31	4.34	5.78	0.69	0.53	42.50	8.81	4.68	6.39	8.17
BC_2	108	1.24	0.55	2.83	2.96	0.31	0.37	28.71	5.49	3.34	3.38	3.09
P_2	36	0.94	0.50	0.35	1.24	0.06	0.19	5.86	4.08	1.09	0.89	1.70

*, ** significant at the 0.05, 0.01 levels of probability respectively.

(1) Mean squares for each character except MMD and yield are multiplied by 10^2

(2) Mean square for MMD is multiplied by 10^4

Table A50: Means, standard errors, mid-parents values and the A,B,C, scales for the additive dominance model, and also the D,H,E components of phenotypic variance from a log transformed data of the cross Stripper x UK 66, grown in 1976

Generations	Total no. of plants	Earliness characters					
		E2%	MMD	PRI g/pl/d	NFB	DFF	BP
P_1	40	4.54±0.024	5.036±0.0017	-0.43±0.053	1.45±0.033	4.12±0.111	3.90±0.013
BC_1	120	4.52±0.014	5.037±0.0010	-0.60±0.031	1.45±0.019	4.13±0.064	3.92±0.008
F_1	40	4.46±0.024	5.042±0.0017	-0.18±0.053	1.54±0.033	4.16±0.111	3.93±0.013
F_2	160	4.44±0.012	5.043±0.0008	-0.41±0.026	1.58±0.016	4.19±0.055	3.93±0.006
BC_2	120	4.43±0.014	5.044±0.0010	-0.36±0.031	1.62±0.019	4.22±0.064	3.95±0.008
P_2	40	4.28±0.024	5.055±0.0017	-0.20±0.053	1.76±0.033	4.29±0.111	3.98±0.013
$\overline{P_1P_2}$		4.41±0.017	5.046±0.0012	-0.32±0.037	1.61±0.023	4.21±0.078	3.94±0.009
Scales							
A		0.04±0.023	-0.004±0.002	-0.59±0.042	-0.09±0.041	-0.02±0.012	0.01±0.015
B		0.12±0.028	-0.009±0.002	-0.34±0.033	-0.06±0.041	-0.01±0.006	-0.01±0.015
C		0.02±0.063	-0.003±0.007	-0.65±0.070	0.03±0.090	0.03±0.028	-0.02±0.029
Variance comp(1)							
D		8.40	2.92	2.50	12.40	1.46	0.54
H(1)		-6.40	-1.96	10.61	- 8.12	-0.04	0.28
E		0.59	0.34	0.44	1.61	0.06	0.19
$\sqrt{(H/D)}$		-	-	2.060	-	-	0.720
h^2(narrow sense)		93.44	89.57	18.45	88.51	96.05	53.47

cont'd next page.

Table A50 (cont'd)

Generations	Total no. of plants	Productivity characters				
		Yield g/pl	TFP	NSB	NSB/PHT	PHT
P_1	40	3.30±0.158	3.53±0.061	2.70±0.036	-1.60±0.040	4.30±0.050
BC_1	120	2.88±0.091	3.57±0.035	2.65±0.021	-1.60±0.023	4.24±0.029
F_1	40	4.22±0.158	3.96±0.061	2.85±0.036	-1.68±0.040	4.53±0.050
F_2	160	3.45±0.079	3.62±0.031	2.71±0.018	-1.77±0.020	4.48±0.025
BC_2	120	3.56±0.091	3.50±0.035	2.74±0.021	-1.86±0.023	4.59±0.029
P_2	40	4.16±0.158	3.85±0.061	2.85±0.036	-1.88±0.040	4.74±0.050
$\overline{P_1P_2}$		3.73±0.112	3.69±0.043	2.78±0.028	-1.74±0.028	4.52±0.035
Scales A		-1.76±0.121	-0.35±0.085	-0.25±0.046	-0.08±0.049	-0.35±0.049
B		-1.26±0.111	-0.65±0.074	-0.22±0.046	-0.16±0.044	-0.09±0.049
C		-2.1 ±0.226	-0.82±0.149	-0.41±0.090	0.24±0.180	-0.18±0.103
Variance comp(1) D		43.92	6.44	6.02	10.82	16.34
$H^{(1)}$		57.53	-6.19	-0.56	- 1.89	6.09
E		6.16	7.14	1.81	1.70	1.52
$\sqrt{(H/D)}$		1.145	-	-	-	-
h^2(narrow sense)		40.81	47.42	76.88	86.42	68.23

(1) Negative values of H are regarded as zero.

le A51: Mean squares (1) from an analysis of variance from the log transformed data of the cross 2421 x Samaru 71; and also the mean squares for the generations (bottom), grown in 1976

rces	d.f.	Earliness characters						Productivity characters				PHT
		E2%	$x10^{-4}$ MMD (2)	PRI	NFB	DFF	BP	Yield g/pl	TFP	NSB	NSB/PHT	
plications	3	4.63	2.70**	42.38**	1.39	0.11	1.30**	381.09**	128.45**	56.41**	50.18**	2.45
nerations	5	31.56**	19.53**	121.29**	14.12**	1.39**	11.85**	1145.97**	97.88**	39.28**	16.22*	107.71**
x G	15	3.89	2.41*	17.04*	1.47	0.19	0.85	141.43	8.93	6.61	6.44	9.44
rror	28	2.37	1.07	7.45	1.86	0.14	0.48	70.62	15.14	5.39	3.86	6.81
Plots/reps/BC_1	8	2.91	1.13	7.96	0.61	0.15	0.28	60.90	12.59	6.31	3.54	2.73
Plots/reps/F_2	12	2.79	1.32	6.46	2.28	0.11	0.42	70.34	14.99	3.46	4.49	6.73
Plots/reps BC_2	8	1.18	0.63	8.42	2.47	0.17	0.78	80.76	17.92	7.37	3.24	11.02
lants/plots	468	2.24	1.19	4.45	2.20	0.15	0.34	38.15	6.47	4.05	3.09	4.06
within P_1	36	0.69	0.37	0.66	0.11	0.08	0.29	5.28	3.62	2.74	2.06	1.54
within BC_1	108	1.45	0.90	4.92	1.68	0.13	0.24	36.19	5.93	2.80	2.44	3.52
within F_1	36	1.15	0.61	4.29	1.99	0.11	0.23	36.45	10.79	3.47	3.92	2.92
within F_2	144	3.06	1.56	5.98	3.12	0.20	0.44	50.75	7.01	4.88	4.88	6.23
within BC_2	108	2.80	1.50	3.78	2.02	0.14	0.37	37.40	4.59	4.40	1.73	3.73
within P_2	36	2.22	1.18	3.40	1.48	0.09	0.32	30.40	10.06	5.26	2.21	1.65

*, ** Significant at the .05, .01 levels of probability respectively.

(1) Mean squares for all characters except MMD are multiplied by 10^2

(2) Mean square for MMD is multiplied by 10^4

Table A52: Means, standard errors, mid-parent values and the A,B,C, scales for the additive-dominance model; and also the D,H,E components of phenotypic variance from a log transformed data of the cross 2421 x Samaru 71, grown in 1976

Generations	Total no. of plants	Earliness characters					
		E2%	MMD	PRI	NFB	DFF	BP
P_1	40	4.55±0.024	5.034±0.0016	-0.69±0.043	1.40±0.022	4.14±0.006	3.90±0.011
BC_1	120	4.51±0.014	5.038±0.0009	-0.55±0.025	1.46±0.012	4.13±0.003	3.91±0.006
F_1	40	4.51±0.024	5.038±0.0016	-0.33±0.043	1.49±0.022	4.15±0.006	3.96±0.011
F_2	160	4.46±0.012	5.041±0.0008	-0.45±0.022	1.50±0.011	4.15±0.003	3.94±0.005
BC_2	120	4.48±0.014	5.040±0.0009	-0.40±0.025	1.53±0.012	4.13±0.003	3.99±0.006
P_2	40	4.30±0.024	5.054±0.0016	-0.24±0.043	1.56±0.022	4.16±0.006	4.02±0.011
$\overline{P_1P_2}$		4.43±0.017	5.044±0.0012	-0.47±0.031	1.48±0.015	4.15±0.004	3.96±0.008
Scales							
A		-0.04±0.031	0.004±0.0023	0.08±0.054	0.03±0.033	-0.03±0.010	-0.04±0.028
B		0.15±0.042	-0.012±0.0036	0.23±0.056	0.01±0.039	-0.05±0.010	0.00±0.014
C		0.53±0.070	0.000±0.0040	0.21±0.106	0.06±0.074	0.00±0.0188	-0.08±0.049
Variance comp(1)							
D		3.74	1.44	6.52	5.08	0.26	0.54
H		0.64	0.48	-0.24	-2.45	-0.09	-0.44
E		1.35	0.72	2.78	1.19	0.09	0.28
$\sqrt{(H/D)}$		0.414	0.333	-	-	-	-
h^2(narrow sense)		65.27	54.55	70.11	81.02	74.29	65.85

cont'd next page.

Table A52 (cont'd)

Generations	Total no. of plants	Productivity characters				
		Yield g/pl	TFP	NSB	NSB/PHT	PHT
P_1	40	2.62±0.133	3.27±0.062	2.62±0.037	-1.86±0.031	4.49±0.041
BC_1	120	2.98±0.077	3.51±0.036	2.69±0.021	-1.86±0.018	4.54±0.024
F_1	40	3.67±0.133	3.63±0.062	2.77±0.037	-1.90±0.031	4.67±0.041
F_2	160	3.31±0.066	3.48±0.031	2.72±0.018	-1.88±0.016	4.60±0.021
BC_2	120	3.45±0.077	3.60±0.036	2.78±0.021	-1.94±0.018	4.73±0.024
P_2	40	4.01±0.133	3.68±0.062	2.88±0.037	-1.99±0.031	4.87±0.041
$\overline{P_1P_2}$		3.32±0.094	3.48±0.044	2.75±0.026	-1.93±0.022	4.68±0.029
Scales A		-0.33±0.150	0.12±0.073	-0.01±0.054	-0.04±0.043	-0.08±0.048
B		-0.78±0.151	-0.11±0.082	-0.09±0.060	-0.01±0.046	-0.08±0.049
C		-0.73±0.310	-0.29±0.146	-0.16±0.102	-0.13±0.099	-0.30±0.100
Variance comp(1)						
D		55.82	7.00	5.12	11.18	10.42
H		- 4.81	-18.51	-6.01	- 13.56	- 4.07
E		24.04	8.16	3.82	2.73	2.04
$\sqrt{(H/D)}$		-	-	-	-	-
h^2(narrow sense)		69.90	46.17	57.27	80.37	83.63

(1) negative values for H are regarded as zero.