GENETIC ANALYSIS OF GRAIN YIELD COMPONENTS IN RICE (*Oryza sativa* L.)

THESIS SUBMITTED IN PART FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PLANT BREEDING AND GENETICS TO THE TAMIL NADU AGRICULTURAL UNIVERSITY COIMBATORE

LIBRARY
TNAU, Coimbatore - 3
000113918

By

SUKANYA SUBRAMANIAN, M. Sc. (Ag.)

SCHOOL OF GENETICS
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE - 641 003

1981

Certificate

This is to certify that the thesis entitled "GENETIC ANALYSIS OF GRAIN YIELD COMPONENTS IN RICE (*Oryza sativa* L.)" submitted in part fulfilment of the requirements for the degree of DOCTOR OF PHILOSOPHY IN PLANT BREEDING AND GENETICS to the Tamil Nadu Agricultural University, Coimbatore, is a record of **bona fide** research work carried out by Smt. SUKANYA SUBRAMANIAN under my supervision and guidance and that no part of this thesis has been submitted for the award of any other degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

Date April 6 1981

(Dr. M. Rathinam)
Chairman

Place : Coimbatore-3

Approved by

Chairman :

(Dr. M. Rathinam)

Members :

(Dr. K. R. Ramaswamy)

(Mr G. Purushothaman)

(Prof. V. S. Raman)

(Dr. Y. B. Morachan)

ABSTRACT

GENETIC ANALYSIS OF GRAIN YIELD COMPONENTS IN RICE (*Oryza sativa* L.)

by

SUKANYA SUBRAMANIAN

DEGREE: DOCTOR OF PHILOSOPHY IN PLANT BREEDING AND GENETICS

CHAIRMAN: Dr.M.RATHINAM, Associate Professor (Breeding)
Department of Forestry
Tamil Nadu Agricultural University,
Coimbatore - 641 003

1991

With the object of identifying potential parents and superior cross combinations and evolving breeding strategies for improvement of yield coupled with grain quality in rice (*Oryza sativa*), a set of 10 x 10 diallel crosses was attempted. A comparative performance of hybrids and their parents was made in three seasons. Analysis of combining ability, genetical and graphical were done to bring out the information needed.

Grain yield and straw yield were under the influence of dominance gene action predominantly in addition to additive gene action. The heritability estimate was moderate. Plant height, number of grains per panicle, hundred grain weight, harvest index (grain-straw ratio), length, width and

length-width ratio of grain were found to be governed by additive gene action mainly, having high heritability estimates. Filler number was controlled by dominance gene action with low heritability while panicle length was influenced by both additive and dominance gene action, with high heritability. Under the above situation, a reciprocal recurrent selection may be profitable to evolve high yielding short stature strains with fine quality.

The relative stability of GCA variances was higher over seasons than that of SCA variances for grain yield and most of its components suggesting the need for the evaluation of the hybrids in more than one season.

Of the 50 combinations between semi- dwarf and tall parents, 26, involving the parents P_1, P_2, P_3, P_4 and P_5 with P_7, P_8 and P_9 were found to be shorter than the general mean height. Of these, four combinations namely, P_9 x P_3 (TKM 4 x Dgwg), P_1 x P_8 (Jaya x Rasmati-370) and their reciprocals were identified to be superior from the point of view of realising recombinants with short stature and high yield of grain with fine quality, in the subsequent generations.

CONTENTS

	PAGE NO.
INTRODUCTION	1
REVIEW OF LITERATURE	4
MATERIALS AND METHODS	30
EXPERIMENTAL RESULTS	47
A. Analyses of variances ...	47
B. Evaluation of the parental varieties	47
C. Evaluation of the hybrids ...	95
1. Characters and the expression of heterosis	95
2. Combining ability analysis ...	132
a. General combining ability variances (GCA)	132
b. Specific combining ability variances (SCA) ...	136
c. The ratio of GCA to SCA variances	136
d. The combining ability effects	137
e. The seasonal effects ...	183
f. Reciprocal effects ...	183
3. Graphic analysis	202

4. Genetic analysis 211

a. Tests of hypotheses ... 211

(1) t^2 test 212

(2) Test of homogeneity of (Wr+Vr) values 212

(3) Test of homogeneity of (Wr-Vr) values 212

b. Estimates of genetic parameters 212

5. Correlation studies ... 229

DISCUSSION 233

SUMMARY 272

ACKNOWLEDGEMENT 279

REFERENCES

LIST OF TABLES

Table No.	Title
1.	Analysis of variance
2.	Pooled analysis of variance
3.	Plant height - Mean expression
4.	Earbearing tillers per plant - Mean expression
5.	Panicle length - Mean expression
6.	Number of grains per panicle - Mean expression
7.	100 grain weight - Mean expression
8.	Grain yield per plant - Mean expression
9.	Straw yield per plant - Mean expression
10.	Grain-straw ratio - Mean expression
11.	Grain length - Mean expression
12.	Grain width - Mean expression
13.	Length-width ratio of grain - Mean expression
14.	Plant height - Estimates of heterosis
15.	Earbearing tillers per plant - Estimates of heterosis
16.	Panicle length - Estimates of heterosis
17.	Number of grains per panicle - Estimates of heterosis
18.	100 grain weight - Estimates of heterosis
19.	Grain yield per plant - Estimates of heterosis
20.	Straw yield per plant - Estimates of heterosis
21.	Grain-straw ratio - Estimates of heterosis
22.	Grain length - Estimates of heterosis

LIST OF TABLES (CONTD.)

Table No.	Title
23.	Grain width - Estimates of heterosis
24.	Length-width ratio of grain - Estimates of heterosis
25.	Analysis of variance due to combining ability
26.	Pooled analysis of variance due to combining ability
27.	Plant height and earbearing tillers per plant - General combining ability effects
28.	Panicle length and number of grains per panicle - General combining ability effects
29.	100 grain weight and grain yield per plant - General combining ability effects
30.	Straw yield per plant and grain-straw ratio - General combining ability effects
31.	Grain length and grain width - General combining ability effects
32.	Length-width ratio of grain - General combining ability effects
33.	GCA x Season effects of the parents (for 5 traits)
34.	GCA x Season effects of the parents (for 6 traits)
35.	Plant height and earbearing tillers per plant - Specific combining ability effects
36.	Panicle length and Number of grains per panicle - Specific combining ability effects
37.	100 grain weight and Grain yield per plant - Specific combining ability effects
38.	Straw yield per plant and Grain-straw ratio - Specific combining ability effects
39.	Grain length and Grain width - Specific combining ability effects
40.	Length-width ratio of grain - Specific combining ability effects

LIST OF TABLES (CONTD.)

Table No.	Title
41.	SCA x Season effect of the combinations (for five traits)
42.	SCA x Season effect of the combinations (for six traits)
43.	Seasonal effects
44.	Plant height and Earbearing tillers per plant - Reciprocal effects
45.	Panicle length and Number of grains per panicle - Reciprocal effects
46.	100 grain weight and Grain yield per plant - Reciprocal effects
47.	Straw yield per plant and Grain-straw ratio - Reciprocal effects
48.	Grain length and Grain width - Reciprocal effects
49.	Length-width ratio of grain - Reciprocal effects
50.	Test of the Wr-Vr slope for unity 'b' value
51.	Test of Wr-Vr' slope for b= 0.5
52.	Significance of Wr-Vr regression
53.	The variances of (Wr-Vr) and (Wr-Vr) values
54a.	Estimates of genetic parameters (D, F, H_1)
b.	Estimates of genetic parameters (H_2, h^2, E)
c.	Ratios involving different genetic parameters
55.	Estimates of mean variance and covariance
56.	The genotypic associations among nine characters

LIST OF FIGURES

Figure No.	Title
1.	Wr,Vr, Wr-Wr' and standardised deviation graphs for plant height
2.	Wr,Vr, Wr,Wr' and standardised deviation graphs for earbearing tillers per plant
3.	Wr,Vr, Wr,Wr' and standardised deviation graphs for panicle length
4.	Wr,Vr, Wr,Wr' and standardised deviation graphs for number of grains per panicle
5.	Wr,Vr, Wr,Wr' and standardised deviation graphs for 100 grain weight
6.	Wr,Vr, Wr,Wr' and standardised deviation graphs for grain yield per plant
7.	Wr,Vr, Wr,Wr' and standardised deviation graphs for straw yield per plant
8.	Wr,Vr, Wr,Wr' and standardised deviation graphs for grain-straw ratio
9.	Wr,Vr, Wr,Wr' and standardised deviation graphs for grain length
10.	Wr,Vr, Wr,Wr' and standardised deviation graphs for grain width
11.	Wr,Vr, Wr,Wr' and standardised deviation graphs for length-width ratio of grain

LIST OF PLATES

Plate No.	Title
1.	Intervarietal hybrids
2.	Grain size variation in the hybrids

INTRODUCTION

INTRODUCTION

A knowledge of the genetic architecture of the varieties and the nature of gene action for the traits has led to refinement in breeding procedures for crop improvement in general. Systematic genetic analysis of the available plant resources have resulted in isolation of genetically potential plants. Of the different biometrical methods, the diallel technique in particular gives a precise and comparable estimate of the genetic make up of different genotypes.

The diallel analysis has been extensively employed in recent times to determine the genetic architecture in rice varieties for their better utility in the breeding programmes (Sivasubramanian, 1970; Shanlax *et al.*, 1977a and Chandramohan, 1979).

The recent concept of an ideal 'plant type' has brought into sharp focus the implications of plant height which invariably is being considered as a necessary criterion for achieving high yield in rice crop. Considerable increase in grain yield has been achieved by utilising the dwarf donors (*Dgwg*, T(N)1, IR.8 etc.) in the breeding programmes. The dwarf varieties released so far possess, no doubt, the dwarf plant type but in most cases do not possess the desirable fine grain quality. With the attainment of self-sufficiency

in rice production, the demand for quality grain depending upon the consumer preferences, is increasingly felt. Evaluation of rice varieties with fine grain quality thus becomes necessary for the isolation of desirable lines. Information on genetic variability, heritability, correlation and selection criteria and mode of gene action for the grain quality viz., length and width determining the shape of grain (length-width ratio) are necessary to isolate fine grained lines coupled with high grain yield. Such studies on grain quality aspects are very few (Singh and Richharia, 1977 and Goomrith et al., 1979).

Seasonal variation exists in the yielding potential of rice and it is therefore necessary to identify genotypes which might be suitable for different seasons. An evaluation of the available dwarf varieties and fine grained varieties for their genetic potentialities may be useful for isolating suitable parents for producing hybrid combinations possessing high yield potential coupled with short stature and fine quality of grain.

With the above background, investigations in ten varieties of rice and their ninety combinations were undertaken with the following objectives using diallel mating design in three seasons.

1. to obtain information on the genetic make up of the parents, nature of gene action and heritability for grain yield attributes and grain quality aspects as well as character association for grain yield,

2. to study the extent of seasonal influence on the expression of these characters, and

3. to indicate the scope of further improvement of the parents by appropriate breeding methods.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The rice plant with its wide range of adaptability and enormous variation with regard to morphological and physiological characters, offers a wealth of material for genetical studies. Success of any plant breeding programme depends largely on the choice of suitable parents which on crossing would throw desirable segregants. The impact of biometrical genetics in agriculture has been in the establishment of the concepts and their utilisation in improving the efficiency of experimentation in breeding programmes, particularly ordering parents for combining ability, improvement of selection criteria and genotype-environment interaction in space and time. Diallel technique of analysis provides genetic information on the inheritance and behaviour of major quantitative characters associated with yield or the economic trait of concern to the breeder.

Diallel design

Yates (1947) was the first to develop the concept of diallel crosses in Trifolium hybridum. The theory and analysis of diallel crosses were originally developed by Jinks and Hayman (1953). Later Hayman (1954a, 1954b, 1957 and 1960a) described the utilisation of diallel crosses in self-pollinated crop. Jinks (1954 and 1956) and Griffing (1956b) used this technique in understanding the quantitative inheritance. Allard (1956b) defined a complete diallel cross

as n^2 possible matings using 'n' genotypes and explained the utility of Wr, Vr and br, Wr' graphs in identifying the non-allelic interactions and dominance of the genotypes. Jinks (1956) and Hayman (1953 and 1960b) extended the scope of diallel analysis to cover later generations like F_2 and backcrosses also.

Griffing (1956a) classified the diallel technique into definite groups for the purpose of analysis to estimate the combining ability and provided expectations for different methods. Mckinnon and Jinks (1956) and Kempthorne (1957) discussed the conditions under which the diallel technique would be more effective. The use of diallel cross in the estimation of genotype-environment interaction had been considered by Hatsinger and Kempthorne (1956), Allard (1956b) and Hatsinger et al. (1959). Johnson and Askel (1959) used the standardized deviation graph to support the information on graphic analysis. Askel and Johnson (1962) provided a complete working model for diallel analysis.

The diallel technique was widely used in different crops by different investigators like Jinks (1955) in flax, maize and tobacco, Allard (1956a) in lima bean, Loffel and Hanson (1961) in soybean and Whitehouse et al. (1958), Crumpacker and Allard (1962) in wheat, Liang et al. (1965) and Vasudeva Rao and Goud (1977) in sorghum and Wu (1968), Ramanathan (1972), Hester (1976) and Khan and Khan (1980) in rice.

The diallel technique was not out of criticism. Gilbert (1958) felt that the utility of diallel technique was exaggerated. Tandon et al. (1970) opined that the combining ability analysis was found to be better than graphic analysis in predicting the prepotency of cultures especially in the later generations when the expression of dominance effects was reduced. Daniel (1975) appreciated the technique since a complete analysis is obtained from the parents and F_1 generation. Arunachalam (1976) compared the efficiency of the combining ability analysis of diallel with that of graphic and genetic analyses and concluded that the combining ability analysis could be more reliable since it was not restricted to one gene model and it operated with feasible assumptions. Recently Baker (1978) reviewed the critical issues in the use of diallel analysis. He opined that the assumption concerning the independent distribution of genes in the parents to be least acceptable in actual practice and the assumption that there is no epistasis, frequently be incorrect. Still, this method has been widely adopted with a view to get results in a short time which is highly valued in breeding programmes.

A brief review of the results obtained through the use of diallel crossing designs and other techniques in rice with reference to heterosis, combining ability, gene action, heritability and genotypic-environmental interactions in F_1 generation and correlation of yield components on the yield

of grain is presented below:

Heterosis

Positive expression of hybrid vigour in plant height, tiller number, panicle length, 1000 grain weight and grain yield per plant had been reported by many workers since 1908 (Vander Stok, 1960). The study of F_1 progenies among tall and semi-dwarf varieties revealed high heterosis in plant height, tiller number, panicle length, number of grains per panicle and grain yield (Anon., 1970). Majority of the crosses between tall and dwarf varieties in a diallel system exhibited heterosis in grain yield and panicle length (Sivasubramanian, 1970). The manifestation of heterosis in F_1 hybrids over better parents was reported by Purohit (1972) for grain yield, ear-bearing tillers, panicle length, number of grains per panicle and plant height. Heterosis was observed in the characters height, panicle number and length and grain yield by Chang et al. (1973). Saini and Ishkumar (1973) noted heterosis over mid parent for ear bearing tillers, panicle length, spikelet number, 1000 grain weight and grain yield.

Maximum positive heterosis was observed for tiller number, grain yield, height and panicle length by Bardhan Roy et al. (1975) in the F_1 progenies of crosses between a tall and five semi-dwarf rice lines. Reyuba (1975) reported heterosis for plant height, panicle length and number of

spikelets per panicle in the F_1 hybrids of crosses between tall and dwarf varieties. Yield showed positive heterosis in most of the hybrids in a diallel involving eight varieties of rice according to Singh et al. (1977). Gupta and Singh (1977) proposed a possible model for heterosis in grain weight on the basis of the dominance theory of heterosis. He identified four esterase loci G_1, G_2, G_3, G_4 corresponding to bands G_1, G_2, G_3 and G_4 respectively which appeared to be associated with grain weight and to complement each other in an additive manner.

In the hybrids between a Russian variety and six foreign varieties, heterosis for yield, plant height and number of grains per panicle was observed by Singil'I-in and Shilovskii (1977). Heterosis in desirable direction for plant height, number of productive tillers, number of grains per plant and grain yield per plant was observed by Singh and Singh (1978). Chandramohan (1979) recorded heterosis for panicle length while Singh and Singh (1979) registered heterosis for panicle length and 100 grain weight.

Heterosis was not exhibited in grain yield per plant in many of the hybrids studied by Jennings (1967). Negative heterosis was recorded for panicle length and 100 grain weight by Singh and Singh (1978). Absence of heterosis for panicle length and dwarfness was reported by Rajagopalan et al. (1979) from a study of the hybrids of dwarf and tall indica varieties.

Negative heterosis in plant height was also observed by Kumaran (1974) in intra-racial hybrids involving different varieties including tall and dwarf indicas.

In one out of the four crosses studied by Nambodiri (1963), the value of the F_1 exceeded that of the means of the parents for grain length and in all the four crosses for grain breadth. Heterosis was observed for grain width in 15 hybrids involving nine varieties by Karunakaran (1968). Katayama (1976) observed heterosis over parental means in several cases in a diallel cross of 14 Sikkimese, indica and japonica rice strains for grain length, width and length/width ratios.

Combining ability

The information on the nature of combining ability in respect of parents and hybrids will facilitate the breeder to plan the breeding programme effectively for improvement of crop plants. The concept of combining ability in terms of genetic variation was put forth by Sprague and Tatum (1942) using the single crosses of maize and attributed additive effects of genes to gca and dominant deviation and epistatic interaction to sca. Henderson (1952) further dilated the expression of specific combining ability. Rojas and Sprague (1952) and Sprague and Federer (1952) studied combining ability over years and found out that specific combining ability not only included dominance and epistasis, but a

considerable amount of genotype x environment interaction also. Griffing (1956b) expressed that general combining ability included both additive effects as well as additive x additive interaction. Carnham et al. (1960) confirmed the above findings. Kempthorne (1957) precisely defined the general combining ability and specific combining ability variance in terms of covariance of half sibs (HS) and full sibs (F.S) in random mating population where GCA variance is Cov. HS and SCA variance is Cov. F.S. - 2 Cov. H.S. Combining ability as genetic parameter has been reported in many crops to evaluate the gene pleom and their cross combination for rapid crop improvement but has not yet largely been reported in rice.

Maximum general combining ability and specific combining ability effects were observed for grain yield and six yield components viz., panicle length, panicle weight, number of grains and number of empty spikelets per panicle, plant height and number of productive tillers by Sivasubramanian (1970). Additive gene action appeared to be predominant, governing the expression of grain yield, though non-allelic gene interaction was also indicated.

GCA and SCA variances were significant for grain yield per plant, 1000 grain weight, number of panicles per plant and number of spikelets in the leading panicle (Ishkumar et al., 1975). The high SCA for yield appeared to be related to the high SCA for yield components.

Singh and Nanda (1976a) found significant GCA and SCA variances for grain yield, panicle length and number of grains per panicle. The high magnitude of analytical estimates due to GCA variance than SCA variance and high degree of dominance with low Hg values for grain yield, panicle length, grains per panicle and 100 grain weight indicated the presence of non-additive gene action while additive gene action was more important for panicle number.

In a diallel cross involving seven varieties Maurya and Singh (1977) got higher GCA variances than SCA variances for grain yield. A diallel analysis with six varieties revealed significant GCA and SCA variances for panicle length, spikelet number, 100 grain weight and grain yield (Singh, 1977).

For grain dimensions (length and width), grain shape (L/W ratio), plant height and panicle bearing tillers, the GCA and SCA variances were highly significant, the GCA:SCA ratio being considerably high in a 6 x 6 diallel analysis (Singh and Richharia, 1978).

In a diallel involving eight varieties, combining ability and component of variance analysis indicated predominant non-additive gene action for yield (Singh et al., 1977). In a six parent diallel cross Chandramohan (1979) found significant GCA and SCA variances, the former being

higher than the latter for plant height, tiller number, panicle length, number of grains per panicle and grain yield.

In a 6 x 6 half diallel cross, the analysis for combining ability was significant for panicle length and number of grains per panicle indicating the importance of both additive and non-additive gene actions. The variances due to SCA were higher than those due to GCA revealing the predominance of non-additive gene action (dominance and epistasis) for the above characters in addition to 100 grain weight (Singh et al., 1979a). Rao et al. (1980) found significant GCA and SCA variances for grain yield, plant height, panicle length, grains per panicle and 100 grain weight.

Gene action

The inheritance of plant height in rice proved to be highly complex under different dwarf backgrounds as evidenced from numerous reports by different rice workers from very early times (Akemine, 1925; Yamaguti, 1931; Kadam, 1937; Kamiah, 1959). Although the plant height for dwarfness was taken as less than 100 cm (Anon., 1969; Cheng and Tagumpay, 1970), the dwarf varieties differed widely in respect of plant height. Seetharaman and Srivastava (1969) classified the gene systems of height into four categories such as (1) those involving major genes, (2) a recessive gene of the type of DgNg (3) presence of suppressor genes and (4) presence of

genes di, dii etc. which control the typical dwarf habit. They have also grouped the dwarfs into "semi-dwarfs" (71 to 100 cm) and dwarfs (70 cm and below).

Wu (1968) in a diallel analysis of plant height in the F_1 progenies of five parental varieties found dominance to be in the direction of greater height and the ratio of the total number of dominant to recessive genes in the parents was 1.2. The regression analysis showed a relatively simple genetic mechanism and atleast three gene groups were thought to be involved. Sivasubramanian (1970) in a 4 x 4 diallel analysis reported the short stature to be controlled by the interaction of three recessive genes; the presence of any two of them led to the production of shorts. Plant height had a predominance of additive genes with partial dominance in the 6 x 6 diallel cross studied by Vijayan (1971). In a diallel analysis of six parental varieties Ranganathan (1972) found overdominance and dominant gene action for plant height and presence of non-allelic interaction by graphical analysis.

Plant height in T(N)1, IR 8 and DgWg appeared to be controlled by two pairs of additive genes with cumulative effect by Ram (1973). In the study of F_1 progenies of tall x dwarf varieties, Sukanya Subramanian and Madhava Menon (1973b) inferred partial dominance or overdominance for plant stature inheritance and found the major dwarfing genes influenced by the action of modifier complex. Short straw was reported to be

controlled mainly by a recessive gene and other genes with minor effects (Anon., 1973; Lee, 1974; Seshu et al., 1974). Semi-dwarfness was found to be controlled by a single recessive gene by Woo et al. (1974) in the crosses between the induced mutants and the parental variety. Ganeshan and Whittington (1975) detected incomplete dominance for tallness in the diallel crosses between four dwarf mutants of H_4 and the parent H_4 and also evidence for four separate loci with various degrees of dominance determining dwarfism.

The diallel analysis by Li (1975) showed dominance generally to be towards tallness, that both additive and dominance were important in determining plant height, though dominance component was higher than additive component, and that the additive effects of genes controlling plant height were more or less consistent over environments. Foster and Rutger (1975, 1976) proposed a three gene model with additive effects and partial to complete dominance for increased height at each locus. Kim and New (1977) in an evaluation of a diallel cross between nine semi-dwarf varieties reported that one major gene controlled culm length and additive effects were the main source of variation which was highly heritable.

Additive, dominance, additive x additive and additive x dominance gene effects were significant for plant height in the crosses between tall and dwarf varieties studied by

Shealan and Aly (1977a, b). Yein (1977) reported significant dominance and additive gene effects for height and that at least one gene pair controlled the trait. Data from parental, F_1, F_2 and F_3 generations of a 10 x 10 diallel involving two tall japonica lines and eight semi-dwarfs indicated that most of the height variation among the parents could be accounted for by three major genes with additive effects. Foster and Rutger (1978) also observed a preponderance of dominant alleles with partial dominance of increased plant height. A major gene controlled semi-dwarfism in [illegible] in the 55 half diallel crosses involving 11 dwarf, semi-dwarf and tall varieties studied by Loresto and Chang (1970). Quantitative genetic analysis conducted by Singh et al. (1979b) involving crosses between 14 dwarfs and a common tall variety IARI 11124 showed that the degree of dominance in the hybrids varied with the cross. In another study Singh et al. (1979c) showed the 33 spontaneous and induced dwarfs to fall into ten different clusters irrespective of their allelic relationships and geographical area of collection.

Complete dominance of high tillering over low tillering and partial dominance of high panicle number were indicated in the study of F_1 hybrids between tall and semi-dwarf lines (Anon., 1970). Jivaubramanian (1970) reported tiller number to be under additive gene action as well as dominance.

Dominant genes had a preponderant role in the case of ear number (Vijayan, 1971). In the diallel crosses of six parental varieties handled by Ranganathan (1972), the over all genetic position and partitioning of the genetic components brought out dominant gene action for number of productive tillers and the graphic analysis showed the presence of non-allelic interaction. Additive nature of the genes controlling the number of earbearing tillers was reported by Rao et al. (1973). Overdominance or dominance for high tillering capacity was displayed by the hybrids studied by Sukanya Subramanian and Madhava Menon (1973b). In a six parent half diallel, both additive and dominant genes were important for panicles per plant as reported by Ranchariah et al. (1974). Besides, there was partial dominance and locus-lined epistasis for the trait. The diallel analysis conducted by Ganeshan and Whittington (1975) showed additivity of various degrees of dominance with no evidence of gene interaction. Partial dominance was suggested and additive gene effects and recessive genes were found to be important by Singh and Narda (1976b) in the F_1 of a diallel cross involving six varieties. Shanlan and Aly (1977a, b) reported significant additive, dominance gene effects, additive x additive and additive x dominance epistasis in the crosses studied. Both additive and non-additive effects were observed for earbearing tillers besides overdominance by Singh and Richharia (1980).

Studies of diallel crosses largely attributed additive effect to panicle length while dominance played a small part and the parental difference was found to be controlled by four genes (Anon., 1967). Partial dominance was reported by Sivasubramanian (1970). Vijayan (1971) found mainly dominant gene action besides additive gene for panicle length. Partial dominance and dominant gene action were reported by Ranganathan (1972). Overdominance was reported by Sukanya Subramanian and Madhava Menon (1973b). Dominance towards longer panicles in addition to additive and dominance inheritance were reported by Li (1975). Over dominance was suggested for panicle length by Singh and Nanda (1976b). Besides additive genes, dominant genes were also reported to be important for the trait. Significant additive, dominance, additive x additive, additive x dominance and dominance x dominance epistasis were reported by Shaalan and Aly (1977a, b). Overdominance besides additive and non-additive effects were observed by Singh and Richharia (1980).

Chang (1971) reported significant dominant variances for grain number per panicle. Ranganathan (1972) reported overdominance on an over all genetic position, dominant gene action by partitioning of genetic components and non-allelic interaction by graphic analysis for number of grains per panicle in a diallel cross involving six parents. Additive genes controlled the trait according to Balakrishna Rao et al. (1973). Number of grains per panicle exhibited mainly

overdominance in the crosses between tall and dwarf varieties studied by Sukanya Subramanian and Madhava Menon (1973b). In contrast, partial dominance together with additive and dominant genes were important for grain number in a six parent half diallel cross progenies handled by Manchareiah et al. (1974). In a diallel analysis, Ganeshan and Whittington (1975) showed additivity and various degrees of dominance. Number of spikelets per panicle was found to be governed by additive genetic variance by Lohkumar et al. (1975) in a diallel cross involving six parents. Dominance was reported to be generally towards more spikelets per panicle by Li (1975) in a diallel analysis and both additive and dominance inheritance were important in determining the trait. Presence of non-additive gene action was reported by Singh and Nanda (1976a).

The weight of grain is of highly economic importance. Hutchinson and Ranlah (1938) prescribed 1000 grain weight while Cheng and Nordenas (1965) advocated 100 grain weight for classification. A diallel crossing study at Central Rice Research Institute, Cuttack (Anon., 1972b) showed that most of the variance was due to additive effects and that dominance was only partial for 1000 grain weight. The overall genetic position brought out overdominance and the partitioning of the genetic components indicated equal additive and dominant gene effects while the graphical analysis showed the presence of non-allelic interaction for 100 grain weight (Ranganathan, 1972).

Sukanya Subramanian and Madhava Menon (1973c) detected partial dominance and explained the inheritance of weight of grain on a basic multifactor hypothesis having more additive action. Partial dominance besides both additive and dominant genes were shown to be important for grain weight by Manoharaiah et al. (1974). Ishkumar et al. (1975) and Singh and Panda (1976b) found the 1000 grain weight to be governed by non-additive genetic variance. Additive, dominance, additive x additive and dominance x dominance gene effects were reported by Shaalan and Aly (1977a) for the trait. The variation in 100 grain weight was reported to be predominantly due to additive gene effect by Soomith et al. (1979).

Knowledge accumulated so far has convincingly shown that yield is a complex character related to specific morphological characteristics determined by the plant type. Sivasubramanian (1970) in a diallel analysis with two tall and two dwarf varieties inferred that additive genetic component was more important for grain yield. Both additive and non-additive genetic complements played a significant role, the former being of a higher magnitude, according to Vijayan (1971). In the 6 x 6 diallel analysis conducted by Rangaswamy (1972) the overall genetic position brought out partial dominance for grain yield while dominant gene action was indicated in the partitioning of the genetic components and non-allelic interaction by graphic analysis. Overdominance

or partial dominance was expressed by the hybrids between tall x dwarf varieties and polygenes with both positive and negative effect were found operating for the trait by Sukanya Subramanian and Madhava Menon (1973b). The hybrids of six parent half diallel cross with dwarf varieties exhibited overdominance for grain yield while both additive and dominant genes were found important for the trait by Kancheraiah et al. (1974). Ishkumar et al. (1975) reported both additive and non-additive gene effects to be important for grain yield in a diallel cross involving six tall and dwarf varieties. The results from a 6 x 6 diallel cross suggest overdominance for yield per plant while additive and dominant genes were also important (Singh and Nanda, 1976b). Additive, dominance, additive x additive, additive x dominance and dominance x dominance gene effects were revealed in the hybrids of tall and dwarf varieties studied by Shaalan and Aly (1977a). Predominant non-additive gene effects, dominant component of genetic variation in the overdominance range, non-allelic interaction of the additive x additive and dominance x dominance type and high heritability were reported for grain yield by Khaleque et al. (1978). Both non-additive and dominance effects were found important for yield per plant by Singh et al. (1980) in a six parent diallel analysis.

For weight of straw higher non-additive component than the additive and partial dominant nature of inheritance

were reported by Vijayan (1971). Overdominance or partial dominance was exhibited by the hybrids between tall and dwarf varieties for straw yield (Sukanya Subramanian and Madhava Menon, 1973b).

Poonai (1966) detected both additive and dominance effects in polygenic inheritance though the direction of dominance varied from one cross to another for grain length. A diallel crossing study showed that most of the variance for grain dimensions was due to additive effects and that dominance was only partial (Anon., 1972a). Length of grain was found to be governed by one major gene pair with incomplete dominance, influenced by modifiers with enhancing effect to a higher degree by Sukanya Subramanian and Madhava Menon (1973c). Polygenic inheritance was reported by Chang (1974). In a 4 x 4 diallel cross, genetic variation in grain length was found to be controlled by a major gene and several minor genes by Enkedo and Seito (1977). Soosaith et al. (1979) detected both additive and dominance effects as major contributors to the variation in grain length.

Murty and Govindaswamy (1967) reported polygenic system controlling the grain width. Rollich (1957) reported polymeric (3 to 5 genes) inheritance and partial dominance of narrow spikelets over broad spikelets. Sukanya Subramanian and Madhava Menon (1973c) identified width of grain to be controlled by a polygenic system of simple nature consisting of fewer genes

with more or less of some effect. Singh and Richharia (1977) observed additive genetic variance for grain width.

There is considerable variation in the size and shape of the rice grain. The shape is governed by the length/width ratio and the length of the grain (Maniah and Parthasarathy, 1933). Various classifications were advocated by different authors and Murty and Govindaswami (1967) adopted the following classification based on length/width ratio which has been followed in the present study.

Above 4 = Very fine

3 to 4 = Fine

2 to 3 = Coarse

Less than 2 = Round.

Chullen (1966) and Murty and Govindaswami (1967) observed polygenic nature of inheritance for grain shape. Sukanya Subramanian and Madhava Menon (1973c) observed partial dominance for L/W ratio, which was governed by one major gene pair with incomplete dominance, influenced by modifiers with enhancing effect to a higher degree. The diallel analysis showed additivity and various degrees of dominance with no evidence of gene interaction for grain size (Ganeshan and Whittington, 1975). Results at Central Rice Research Institute, Cuttack (Anon., 1972b) and Singh and Richharia (1977) attributed additive genetic variance to grain shape index while Soomith et al. (1979) attributed additive as well as dominance variance.

Heritability

High heritability estimates were recorded for plant height by Lin and Huang (1973), Singh (1973), Dayuba and Shilovskii (1976), Maurya (1976) and Shanlan and Aly (1977b) while Sivasubramanian (1970) and Li (1975) reported low heritability estimates.

Sivasubramanian (1970), Singh (1973), Li (1975), Singh and Nanda (1976a) and Shanlan et al. (1977a) reported high estimates of heritability while Perez Ponce and Martin Jimenez (1974) and Maurya (1976) reported low estimate for number of tillers per plant.

For panicle length high heritability estimate was registered by Reddy and Goud (1972), Singh (1973), Shanlan et al. (1975), Dayuba and Shilovskii (1976) and Chandramohan (1979) while low estimate was registered by Sivasubramanian (1970) and Perez Ponce and Martin Jimenez (1974).

High values of heritability were observed by Sivasubramanian (1970), Singh (1973), Li (1975), Dayuba and Shilovskii (1976) and Maurya (1976) for number of grains per panicle.

Moderate estimate of heritability was reported by Chandraratna and Sakai (1960), Govindaswamy et al. (1973), Mancephong (1973) and Soomrith et al. (1979) for 100 grain weight while high estimates were recorded by Maurya (1976).

Grain yield per plant expressed high values of heritability in the materials studied by Sivasubramanian (1970) and Liu (1977); moderate estimate by Govindaswamy et al. (1973) and low estimate by Li (1975) and Maurya (1976).

The grain-straw ratio showed lower heritability than stem length but higher estimate than grain yield in the F_3 and F_5 hybrids studied by Ito (1975). Mohan and Saini (1979) reported high heritability for grain-straw ratio.

Grain length and grain shape were found to be highly heritable traits (Poonai, 1966; Nakatat, 1972). Caraus (1970) reported high heritability values for length-breadth ratio of spikelets. Spikelet length and width exhibited high heritability values according to Lin and Huang (1973). Chang and Parker (1976) reported low to very high heritability for grain size and shape. Estimates of heritability for grain length and L-B ratio ranged from moderately high to high (Soomrith et al., 1979).

Correlation

Grain yield was found to be positively correlated with plant height by Yamamoto and Toriyama (1972), Chaudhury et al. (1976), Liu (1977), Veeramanivan (1977), Agarwal et al. (1978) and Yadav and Singh (1979) while negative correlation was reported by Chang and Tagumpay (1970), Raul (1972) and Lunus et al. (1976).

Significant positive correlation of grain yield with tiller number was reported by U-San-Kho (1974), Singh and Nanda (1975), Nakayama and Saito (1978) and Aly (1979) while negative or poor correlation was recorded by Yanamoto and Toriyama (1972), Saini and Gagneja (1975) and Khaleque et al. (1977).

Singh and Nanda (1975), Brar and Saini (1976) and Paramasivam (1977) registered positive correlation of panicle length with grain yield while negative correlation was reported by Mallick et al. (1978).

In the case of number of grains per panicle, positive correlation with grain yield was recorded by Singh and Nanda (1975), Satpathy and Nanda (1978) and Yadav and Singh (1979).

Grain yield was reported to be positively associated with 100 grain weight by Talwar and Goud (1974); Singh and Nanda (1975), Brar and Saini (1976) and Anon. (1978) while negative or poor association was found by Khaleque et al. (1977) and no correlation by Lyalkovkin (1977).

Swaminathan (1972) opined that in many high yielding dwarf indicas, the total biological yield does not appear to be higher than in the tall indicas and that the higher grain yield really arises from a higher harvest index i.e., grain/straw ratio. Chandramohan and Narayanaswamy (1973) reported significant positive correlation of straw yield with grain yield. Ito (1975) and Mohan and Saini (1979) found positive

correlation of grain-straw ratio with grain yield. In traditional variation the grain weight per plant increased with harvest index (the ratio of panicle weight : total dry matter) while in improved varieties (ASD1 and Ghiannon 3) no significant correlation was found between the two traits (Anon., 1976).

Shastry (1972) and Seetharaman and Shobha Rani (1979) reported that grain size and yielding ability showed no clear association. In contrary Sulanya Subramanian and Madhava Menon (1979a) and Paramasivam (1977) reported positive association of grain yield with L/B ratio of grain.

Plant height was positively correlated with tiller number (Sree Rangasamy and Murugesan, 1973), with panicle length (Foster, 1976), with number of grains per panicle (Rucks, 1973), with 100 grain weight (Chang, 1974) and with straw yield (Patel, 1967), while negative correlation with tiller number was reported by Majumder et al. (1971) and Govindaswamy et al. (1973) and no significant correlation with panicle length by Jain (1977).

Forbearing tillers were reported to be positively correlated with grain number per panicle and 100 grain weight (Morales et al., 1974), with straw yield (Vijayan, 1971), negatively correlated with panicle length (Majumder et al., 1971), with grain number per panicle (Mishra et al., 1973),

with 100 grain weight (Chaudhury et al., 1975) and no correlation with number of grains per panicle (Katayama, 1975).

Manivannan (1979) reported positive correlation of panicle length with number of grains per panicle, Saini and Cagnoje (1975), with plant height and Ito (1975), with grain-straw ratio.

L/W ratio of grain and 100 grain weight were found to be positively correlated by Sukanya Subramanian and Madhava Menon (1973a). Grain number per panicle and 100 grain weight were reported to be positively associated by Morales et al. (1974). Chaudhury et al. (1976) reported that 100 grain weight was positively correlated with plant height, tillers and panicle length. Soosmith et al. (1979) found negative correlation of L/W ratio of grain with 100 grain weight and positive correlation of L/W ratio of grain with plant height.

Genotype-environment interaction

The importance of interaction of genotype with environment needs no emphasis in the breeding experiments (Comstock and Robinson, 1952). Studies most often centred on estimation of variety x year, variety x location components of variance (Comstock and Moll, 1963). These reports have rarely offered measure of stability but have confirmed that performance of characters varied with environment (Anand, 1968)

and that the variety x location component would be expected to increase as the reference base of location is expanded (Abou-El-Fittouh et al., 1969). Sutjihno and Gomez (1968) using six rice varieties at four and 16 locations during the 1966 dry and wet seasons respectively, found that when a combined analysis over both location and season was made, varieties responded differently when grown in different environments, but that there were no consistent effects of location or season on differential varietal response.

The yield reduction was mostly due to rice sterility at lower light intensities of the wet season, Kharif (Togari and Koshiwakura, 1958) and increased yield during the rabi might be ascribed to the prevalent high light intensity (Stoessel et al., 1965; Tanaka and Yamazaki, 1967). The correlation between grain yield and solar radiation is particularly significant during the period of flowering and ripening (De Datta and Zarate, 1970; Murty et al., 1975; Yoshida and Parao, 1976). The grain yield was reduced during kharif than in rabi and the reduction was reported to be due to reduction in leaf area index, grain number per square meter and grain number per panicle while 1000 grain weight was least affected (Murty and Murty, 1970).

Morishima et al. (1967) found the variance due to genotype-season interactions to be significantly large, indicating the response to growing seasons to be genetically

controlled. Differences among forms including japonica x indica types and linear component of genotype x environmental interactions were found significant by Ram et al. (1970). Sahu et al. (1980) reported that harvest-index was liable for changing under different seasons.

The parental order of dominance for genetic control of panicle number and grain yield appeared to alter drastically with environmental changes, but the additive effects of gene controlling plant height, panicle length, panicle weight and spikelet number were more or less consistent over environments (Li, 1975). Chorol et al. (1975) suggested that heading duration and culm length could be used for selection for yield in the wet season as could grain weight in the dry season and grains per panicle was suitable for selection in either season.

MATERIALS AND METHODS

MATERIALS AND METHODS

MATERIALS

Ten varieties of rice (*Oryza sativa* L.) were chosen for the study. The parentage, source and the distinguishing characters of the ten varieties are furnished below:

Table 1A. Particulars of the varieties studied

Variety	Parentage	Source	Plant stature	Shape of grain
Jaya	A derivative from T(N)1 x T.141 (Seetharaman and Shobha Rani, 1979)	AICRIP Hydorabad	Semi-dwarf	Coarse
Taichung Native 1	A derivative from DgWg x Tsai-yuan Chung (Chang, 1961 and Huang *et al.*, 1972)	Taiwan	Semi-dwarf	Coarse
Dee-geo-woo-gen	A spontaneous mutant from Wu-Chien (Hu, 1973)	Taiwan	Semi-dwarf	Coarse
I-geo-tse	A spontaneous mutant (Lu Yung Ken, 1979)	Taiwan	Semi-dwarf	Coarse
TNAU 13613	A mutant from TKM 6 by treatment with 0.1% DES (Sree Rangaswamy *et al.*, 1973)	Coimbatore	Semi-dwarf	Coarse
TKM 6 Sanna Swarnavari	A derivative from CRF 24 x Co.18 (Anon., 1954b)	Tirurkuppam	Tall	Fine

Variety	Parentage	Source	Plant stature	Shape of grain
SLO 16 (Kasi-pichodi)	Pureline selection (Anon., 1954a)	Samalkota	Tall	Fine
Lanmati	Pureline selection (Ghose et al., 1956)	Punjab	Tall	Fine
TKM 6 Yerrasanna vadlu	Pureline selection (Anon., 1954c)	Tirurkuppam	Tall	Fine
Co.20 Sellasanna vadlu	Pureline selection (Anon., 1954d)	Coimbatore	Tall	Fine

METHODS

The investigations were carried out at the Paddy Breeding Station, Department of Agricultural Botany, Tamil Nadu Agricultural University, Coimbatore during 1976-78. Hybridisation was carried out by hand emasculation and artificial pollination by the "wet cloth method" (Chiang et al., 1967). The parents were raised by staggered sowing and planting for getting synchrony in flowering. Both direct and reciprocal crosses were effected among the ten varieties. Thus ninety combinations were obtained for diallel analysis.

1. Field lay-out

Ninety hybrids along with the ten parents were tested on three seasons nacely 1976 kar season (June to September),

1977 summer season (January to April) and 1978 samba season (August to November), in a randomised blocks design replicated twice. Each variant was raised in two rows of two metres length, each containing 21 plants. A spacing of 20 cm between the successive rows and 10 cm between the plants in the row was adopted. Border rows were grown around the experimental blocks in all the cases. The field was uniformly fertilised at the rate of 100 kg N, 50 kg P_2O_5 and 50 kg K_2O per hectare. Recommended cultural and plant protection measures were followed as and when necessary.

2. Observations on quantitative characters

The following eleven characters were studied in twenty plants chosen at random in each variant from each replication.

a. Plant height: The height of plant at maturity was measured from the ground level to the top of the panicle of the tallest tiller to the nearest millimetre.

b. Earbearing tillers per plant: Number of tillers bearing mature panicles was counted in each plant at the time of harvest.

c. Panicle length: This was measured from the panicle base to the tip on the primary tiller to the nearest millimetre.

d. Number of grains per panicle: The number of well filled grains in the primary panicle was counted.

e. 100 grain weight: A random sample of 100 grains taken from single plant was weighed to the nearest milligram.

f. Grain yield per plant: The grains from individual plants were gathered in paper bags separately. After drying to constant weight, the produce was weighed in grams.

g. Straw yield per plant: After removing the panicles from each plant, the remaining straw was dried to constant weight and weighed in grams.

h. Grain-straw ratio: The ratio of grain yield to straw yield was calculated for each plant.

i. Grain length: The longitudinal dimension measured from well-developed grains as the distance from the base of the lower most sterile lemma to the tip (apiculus) of the lemma or palea, whichever is longer was determined. The measurement was taken for ten grains at random in each plant and average calculated.

j. Grain width: This is the dorsiventral diameter measured as the distance across the lemma and palea at the widest point. The measurement was taken in the same ten grains in which length was measured and average calculated.

k. Length-width ratio of grain: The ratio of length to width indicating the size of grain was calculated for the ten grains and average calculated.

3. Statistical analysis - Diallel analysis

The data collected in each of the three seasons were analysed individually as well as after pooling.

a. Analysis of variance: The assumption of 'null hypothesis' was tested as detailed by Panse and Sukhatme (1961)

b. Estimation of heterosis: The magnitude of heterosis was estimated utilising the mid-parental value. Deviation of F_1 from the mid parent

$$di = \frac{\bar{F}_1 - MP}{MP} \times 100$$

where

$\bar{F}_1$ = the mean value of F_1 hybrid

MP = mid-parental value = $\frac{\bar{P}_1 + \bar{P}_2}{2}$

$\bar{P}_1$ and $\bar{P}_2$ = the mean values of first and second parents.

c. Combining ability analysis:

(1) Individual season analysis

(2) Pooled analysis over seasons

(1) Individual season analysis: The procedure outlined by Griffing (1956a) for Method I and Model I was considered appropriate for this study as variety and block effects were assumed to be constant.

(a) Variances: The analysis of variance table with the expectations of mean squares was carried out as follows:

Source	D.F.	Sum of squares	Mean squares	Expectation of mean squares
GCA	$p-1$	S_g	M_g	$\sigma^2 + 2p\left(\frac{1}{p-1}\right)\sum g_i^2$
SCA	$p(p-1)/2$	S_s	M_s	$\sigma^2 + \frac{2}{p(p-1)}\sum_{i}\sum_{j} s_{ij}^2$
RCA	$p(p-1)/2$	S_r	M_r	$\sigma^2 + 2\left(\frac{2}{p(p-1)}\right)\sum_{i<j}\sum r_{ij}^2$
Error	n	S_e	M_e'	σ^2

where

$$S_g = \frac{1}{2p}\sum_i (X_{i.} + X_{.i}) - \frac{2}{p^2} X_{..}^2$$

$$S_s = \frac{1}{2}\sum_i\sum_j (x_{ij} + x_{ji}) - \frac{1}{2p}\sum_i (X_{.i} + X_{i.})^2 + \frac{1}{p^2} X_{..}^2$$

$$S_r = \frac{1}{2}\sum_{i<j}\sum (x_{ij} - x_{ji})^2$$

p = number of parents involved

$M_e' = \frac{M_e}{b}$ where M_e is the error mean square for the randomized blocks design and 'b' is the number of blocks.

(b) Effects: The general and specific combining ability and reciprocal effects were estimated as follows:-

$$\mu = \frac{1}{p^2} X_{..},$$

$$g_i = \frac{1}{2p}(X_{i.} + X_{.i}) - \frac{1}{p^2} X_{..},$$

$$s_{ij} = \frac{1}{2}(x_{ij} + x_{ji}) - \frac{1}{2p}(X_{i.} + X_{.i} + X_{j.} + X_{.j}) + \frac{1}{p^2} X_{..}$$

and

$$r_{ij} = \frac{1}{2}(x_{ij} - x_{ji})$$

The variances of effects were estimated as follows:

$$\text{Var.}(g_i) = \frac{(p-1)}{2p^2}\ \sigma^2$$

$$\text{Var.}(s_{ij}) = \frac{1}{2p^2}(p^2 - 2p + 2)\ \sigma^2$$

$$\text{Var.}(r_{ij}) = \frac{1}{2}\sigma^2$$

By taking square root of the variances, the corresponding standard errors required for testing were obtained.

(2) Pooled analysis over seasons: Since the experiment was conducted for three seasons, the combining ability analysis of the diallel data over different environments as developed by Kaljit Singh (1973) for Method I - Model I was adopted for the calculation of pooled general combining ability, specific combining ability, reciprocal and interaction variances and effects. For the purpose of this analysis, only those data from the seasons which proved significant in the individual season analysis were utilised. The model used for this analysis was

$$x_{ijkm} = \mu + v_i + l_j + (vl)_{ij} + (lb)_{jk} + (vlb)_{ijk} + e_{ijkm}$$

where

μ = population mean

v_i = the effect of i^{th} variety

l_j = the effect of j^{th} environment

$(vl)_{ij}$ = the interaction of i^{th} variety with j^{th} environment

$(lb)_{jk}$ = the effect of k^{th} block within j^{th} environment

$(vlb)_{ijk}$ = the interaction of i^{th} variety in the k^{th} block of j^{th} environment

e_{ijkm} = the effect of i^{th} variety, k^{th} block in j^{th} environment associated with m^{th} individual

(a) Variances: The expectations of the mean squares in the pooled analysis of variance are given below:

Source	D.F.	S.S.	Expectation of mean squares
Seasons (l)	(l-1)	M_l	$\sigma e^2 + vr\left[\leq l_j^2/(l-1)\right]$
Blocks within seasons (lr)	l(r-1)	M_{lr}	$\sigma e^2 + v\left[\leq_k \leq_j r_{jk}^2/l(r-1)\right]$
Varieties (v)	(v-1)	M_v	$\sigma e^2 + lr\left[\leq_i v_i^2/(v-1)\right]$
Interaction (v x l)	(v-1)(l-1)	M_{vl}	$\sigma e^2 + r\left[\leq_i \leq_j (vl)_{ij}^2/(v-1)(l-1)\right]$
Error	l(v-1)(l-1)	M_e	σe^2

Notation is similar to the one used by Griffing (1956)

The form of analysis of variance for combining ability and expectations of mean squares are detailed below:

Source	D.F.	S.S.	Mean squares	Expectation of mean squares
GCA (G)	$(p-1)$	$SS(g)$	A_g	$\sigma^2 + \left(\frac{2pl}{p-1}\right) \sum_i g_i^2$
SCA (S)	$\frac{p(p-1)}{2}$	$SS(s)$	A_s	$\sigma^2 + \frac{2l}{p(p-1)} \sum_i \sum_j s_{ij}^2$
RGA (R)	$\frac{p(p-1)}{2}$	$SS(r)$	A_r	$\sigma^2 + \frac{4l}{p(p-1)} \sum_i \sum_{j<i} r_{ij}^2$
Season(ω)	$(l-1)$	$SS(l)$	A_l	$\sigma^2 + \frac{p^2}{l-1} \sum_k l_k^2$
Interaction G x L	$(p-1)(l-1)$	$SS(gl)$	A_{gl}	$\sigma^2 + \frac{2p}{p(p-1)(l-1)} \sum_k \sum_i (gl)_{ik}^2$
Interaction S x L	$\frac{p(p-1)(l-1)}{2}$	$SS(sl)$	A_{sl}	$\sigma^2 + \frac{2}{p(p-1)(l-1)} \sum_k \sum_i \sum_j (sl)_{ijk}^2$
Interaction R x L	$\frac{p(p-1)(l-1)}{2}$	$SS(rl)$	A_{rl}	$\sigma^2 + \frac{4}{p(p-1)(l-1)} \sum_k \sum_i \sum_j (rl)_{ijk}^2$
Error			A_e	σ^2

Where

$$SS(\omega) = \frac{X_{....}^2}{p^2 l},$$

$$SS(g) = \frac{\sum_i (X_{i..} + X_{.i.})^2}{2pl} - \frac{2X_{....}^2}{p^2 l},$$

$$SS(s) = \frac{\sum_i \sum_j (X_{ij.} + X_{ji.}) X_{ij.}}{2l} - \frac{\sum_i (X_{i..} + X_{.i.})^2}{2pl} + \frac{X_{....}^2}{p^2 l},$$

$$SS(r) = \frac{\sum_i \sum_j (X_{ij.} - X_{ji.})^2}{2l},$$

$$SS(1) = \frac{\sum_k X^2_{..k}}{2} - \frac{X^2_{...}}{p^2 l},$$

$$SS(\rho l) = \frac{\sum_k \sum_i (X_{i.k} + X_{.ik})^2}{2p} - \frac{\sum_i (X_{i..} + X_{.i.})^2}{2pl} - \frac{2\sum_k X^2_{..k}}{p^2} + \frac{2 X^2_{...}}{p^2 l},$$

$$SS(\alpha l) = \frac{\sum_k \sum_j \sum_i (X_{iik} + X_{jjk})}{2} - \frac{\sum_i \sum_j (X_{ii.} + X_{jj.}) X_{ij.}}{2l} - \frac{\sum_k \sum_i (X_{i.k} + X_{.ik})^2}{2p} + \frac{\sum_i (X_{i..} + X_{.i.})^2}{2pl} + \frac{\sum_k X^2_{..k}}{p^2} - \frac{X^2_{...}}{p2l}$$

$$SS(\tau l) = \frac{\sum_k \sum_i \sum_j (X_{iik} - X_{jjk})^2}{2} - \frac{\sum_i \sum_j (X_{ii.} - X_{jj.})^2}{2l}$$

$\Delta_e = M_e/b$ where M_e is the error variance for the pooled analysis of variance and b is the number of blocks.

(b) Effects: The models for calculation of effects are as follows:

$$\mu = \frac{X_{...}}{p^2 l}$$

$$\beta_i = \frac{(X_{i..} + X_{.i.})}{2pl} - \frac{X_{...}}{p^2 l}$$

$$\alpha_{ij} = \frac{(X_{ii.} + X_{jj.})}{2l} - \frac{(X_{i..} + X_{.i.} + X_{j..} + X_{.j.})}{2pl} + \frac{X_{...}}{p^2 l}$$

$$\tau_{ij} = \frac{(X_{ii.} - X_{jj.})}{2l}$$

$$l_k = \frac{X_{..k}}{p^2} - \frac{X_{...}}{p^2 l}$$

$$(gl)_{ik} = \frac{(X_{i.k} + X_{.ik})}{2p} - \frac{(X_{i..} + X_{.j.})}{2pl} - \frac{X_{..k}}{p^2} + \frac{X_{...}}{p^2 l}$$

$$(sl)_{ijk} = \frac{(x_{ijk} + x_{jik})}{2} - \frac{(X_{ij.} + X_{ji.})}{2l} -$$

$$\frac{(X_{i.k} + X_{.ik} + X_{j.k} + X_{.jk})}{2p} +$$

$$\frac{(X_{i..} + X_{.i.} + X_{j..} + X_{.j.})}{2pl} + \frac{X_{..k}}{p^2} - \frac{X_{...}}{p^2 l}$$

The variances of effects and their interactions with seasons were worked out based on the following formulae.

$$\text{Var.}u = \frac{1}{p^2 l}\ \sigma^2$$

$$\text{Var.}g_i = \frac{p-1}{2p^2}\ \sigma^2$$

$$\text{Var.}s_{ij} = \frac{(p^2 - 2p + 2)}{2p^2 l}\ \sigma^2$$

$$\text{Var.}r_{ij} = \left(\frac{1}{2l}\right)\ \sigma^2$$

$$\text{Var.}(gl)_{ik} = \frac{(p-1)(l-1)}{2p^2 l}\ \sigma^2$$

$$\text{Var.}(sl)_{ijk} = \frac{(p-1)^2(l-1)}{p^2 l}\ \sigma^2$$

$$\text{Var.}l_k = \frac{(l-1)}{lp^2}\ \sigma^2$$

The effects were tested for their significance with the standard errors obtained by taking square root of the corresponding variances.

d. Relative stability: The relative stability of GCA and SCA variances was worked out as suggested by Ambal and Webster (1965).

$$\text{Relative stability of GCA over seasons} = \frac{\text{GCA variance}}{\text{GCA variance} + \text{GCA x season interaction component of variance}}$$

$$\text{Relative stability of SCA over seasons} = \frac{\text{SCA variance}}{\text{SCA variance} + \text{SCA x season interaction component of variance}}$$

e. Partitioning of variance

(1) Tests of hypotheses: The validity of the assumptions for graphic and genetic analyses as postulated by Hayman (1954a) was tested by

$$(a)\ t^2 = \frac{n-2}{4} \times \frac{(\text{Var. Vr} - \text{Var. Wr})^2}{(\text{Var. Vr} \times \text{Var. Wr}) - \text{Cov}^2 (\text{Wr.Vr})}$$

with n - 2 degrees of freedom. Significant t^2 indicated failure of atleast one of the assumptions postulated.

(b) Tests of significance of the differences between arrays in Wr + Vr were performed by analysis of variance (Rather and Jinks, 1971). The variances for arrays and blocks were compared with their respective error variances.

(c) The differences between arrays in Wr - Vr was tested for their significance by analysis of variance (Mather & Jinks, 1971). The array and block variances of Wr - Vr were compared with their respective error variances.

(d) Heterogeneity of regression of Vr and Wr was tested for their significance with the error variances (Mather and Jinks, 1971).

(2) Graphic analysis: The graphic analysis as proposed by Jinks and Hayman (1953) and Hayman (1954a) was adopted. The variances and covariances listed below were calculated.

Vr = The variance of r^{th} array

Wr = The covariance between the non-recurring parent and the offspring of the r^{th} array

Wr' = The covariance between the array mean and the offspring of the r^{th} array.

V_0L_0 = The variance of the parent

V_0L_{01} = The variance of the means of the arrays

V_1L_1 = The mean variance of the arrays

W_0L_{01} = The mean covariance between the parents and the arrays

$ML_1 - ML_0$ = The difference between the mean of the parents and the mean of their n^2 progeny

E = Expected environmental component of variation.

With Wr, Vr and Wr, Wr' thus calculated, the graphs were drawn for all the characters studied.

The limiting parabola for the Wr - Vr graph was drawn with the formula $Wr^2 = V_r V_p$.

Standardised deviations of Yr were computed using the formula $(X_i - X)/\sigma$ where X_i is the value of the individual parent, X, the mean of the parents and σ, the standard deviation of the parents. The standardised deviations of Wr + Vr were similarly calculated. The standardised deviation graphs were drawn, utilising these data as proposed by Johnson and Askel (1959).

(5) Genetic analysis: The total variance was partitioned by a genetic analysis (Hayman, 1954a and b). The different genetic parameters, D, H_1, H_2, F and h^2 were estimated from the data, where

D = Component of variation due to additive effects of the genes

H_1 = Component of variation due to dominance effects of genes

H_2 = $\sum (1-(u - v)^2)$ where u = proportion of positive alleles while v = proportion of negative alleles, u + v = 1.

h^2 = Dominance effects (as the algebraic sum over all loci in heterozygous phase in all crosses).

F = the mean value of F_r over arrays, F_r being covariance of additive and non-additive effects in the r^{th} array.

(D) = $V_0 L_0 - E$

(F) = $2 V_0 L_0 - 4 V_0 L_{01} - 2(n-2) E/n$

$(H_1) = V_0L_0 - 4\ V_0L_{01} + V_1L_1 - (3n-2)\ E/n$

$(H_2) = 4\ V_1L_1 - 4\ V_0L_1 - 2E$

$(h^2) = 4\ (VL_1 - VL_0)^2 - 4\ (n-1)\ E/n^2$

(L) = The expected environmental variation obtained as sums of squares for blocks + sum of squares for block interaction divided by number of replications (Singh and Chaudhary, 1979).

The significance of each of these genetic parameters was tested using the standard errors calculated by using the equation $\frac{1}{n}\left[\text{Var}\ (Vr - Vr)\right] = s^2$ as the common multiplier and terms of the main diagonal of the covariance matrix given by Hayman (1954a) as corresponding multipliers.

The genetic parameters thus calculated were used for the computation of proportional values as indicated below.

$(H_1/D)^{\frac{1}{2}}$ = mean degree of dominance over all loci

$H_2/4H_1$ = the proportion of genes with positive and negative effects in the parents

$K_D/K_R = \dfrac{4(VH_1)^{\frac{1}{2}} + F}{4(VH_1)^{\frac{1}{2}} - F}$ the proportion of dominant and recessive genes in the parents

h^2/H_2 = the number of groups of factors controlling the characters and exhibit dominance.

$$\frac{\frac{1}{4}D + h(H_1) - g(H_2) - \frac{1}{2}F}{\frac{1}{4}D + h(H_1) - \frac{1}{2}(H_2) - \frac{1}{2}F + E}$$ heritability in the narrow sense.

The correlation between parental order of dominance (Wr + Vr) and parental measurements (Yr) was computed. A significant positive correlation indicates that the negative genes are mostly dominant while significant negative value indicates that most of the dominant genes have positive effects.

f. Correlations: Genotypic correlations between the characters for each season were computed using diallel cross data as per the method of Johnson et al. (1955).

The statistical analysis of the data pertaining to this study was carried out through the Electronic Computer IBM - 512 at the PSG College of Technology, Coimbatore, Tamil Nadu.

Abbreviations adopted

The ten parents were designated as P_1, P_2 etc., as detailed below:

Jaya	P_1
Taichung Native 1	P_2 T(N) 1
Dee-geo-woo-gen	P_3, DgWg
I-geo-tze	P_4, Igt

ZHAU 13613	P_5
ZRM 6	P_6
SIO 16	P_7
Basmati-370	P_8
ZRM 4	P_9
Co 20	P_{10}

The following abbreviations are followed for the different characters throughout the text.

Plant height	Plant height
Earbearing tillers per plant	Tiller number
Panicle length	Panicle length
Number of grains per panicle	Number of grains
100 grain weight	100 grain weight
Grain yield per plant	Grain yield
Straw yield per plant	Straw yield
Grain-straw ratio	Grain-straw ratio
Grain length	Grain length
Grain width	Grain width
Length-width ratio of grain	Length-width ratio or Grain shape
Kar season, 1976	S_1
Kaveral season, 1977	S_2
Pooled season, 1978	S_3

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

A total of ten rice varieties was evaluated for their potentiality for their combining ability in different possible combinations. The hybrids along with their parents, were studied in the diallel design for three seasons. Observations recorded were analysed and the results are presented below.

A. Analysis of Variances

The eleven characters studied showed significant differences among the entries in the three seasons (Table 1). The genotype and season interactions were significant for the characters studied (Table 2).

B. Evaluation of the Parental Varieties

The height of the parents P_{10}, P_6, P_9 and P_8 in the three seasons (Table 3) ranged from 119.7 cm to 162.35 cm (P_8 in S_3 and P_{10} in S_2). The parents P_3, P_2, P_5, P_1 and P_4 were shorter recording a height ranging from 70.50 to 93.45 cm (P_4 in S_3 and P_3 in S_2). The parent P_{10} was the tallest (153.73 cm) and the parent P_4, the shortest (73.87 cm).

In the tillering habit, P_{10}, P_5, P_6 and P_4 produced the largest number of tillers, the number being 14.10, 13.72, 13.55 and 13.52 respectively (Table 4).

TABLE 1

Analysis of variance

Character	Season	Variance due to	
		Hybrids	Error
Plant height	S_1	1001.053**	0.792
	S_2	990.281**	0.170
	S_3	768.230**	1.966
Bearing tillers per plant	S_1	2.178**	0.144
	S_2	2.051**	0.220
	S_3	1.971**	0.295
Panicle length	S_1	9.522**	0.213
	S_2	9.181**	0.054
	S_3	9.954**	0.377
Number of grains per panicle	S_1	96.962**	1.380
	S_2	53.091**	0.060
	S_3	52.105**	1.856
100 grain weight	S_1	0.120768**	0.000083
	S_2	0.114729**	0.000093
	S_3	0.121717**	0.000061
Grain yield per plant	S_1	27.386**	0.155
	S_2	23.291**	0.095
	S_3	21.261**	0.272
Straw yield per plant	S_1	262.335**	1.031
	S_2	224.074**	0.117
	S_3	267.155**	0.460
Grain-straw ratio	S_1	0.05344**	0.00016
	S_2	0.05056**	0.00002
	S_3	0.05767**	0.00053
Grain length	S_1	0.487828**	0.000535
	S_2	0.470667**	0.002071
	S_3	0.445102**	0.011242
Grain width	S_1	0.080545**	0.001161
	S_2	0.076979**	0.000929
	S_3	0.083313**	0.000763
Length-width ratio of grain	S_1	0.529444**	0.002939
	S_2	0.495081**	0.001303
	S_3	0.484606**	0.000697

* Significant at 5% level
** Significant at 1% level

TABLE 2

Pooled Analysis of Variance

Characters	Variance due to			
	Season	Hybrids	Seasons x Hybrids	Error
Plant Height	5815.000**	2724.918**	17.318**	0.966
Earbearing tillers per plant	417.476**	4.597**	0.302**	0.220
Panicle length	257.718**	17.981**	1.338**	0.215
Number of grains per panicle	6637.000**	169.363**	16.393**	1.101
100 grain weight	1.308**	0.354**	0.002**	0.000024
Grain yield per plant	1800.812**	65.328**	5.605**	0.174
Straw yield per plant	3575.070**	732.989**	10.288**	0.2267
Grain-straw ratio	0.817**	0.150**	0.001**	0.00024
Grain length	0.937**	1.371**	0.015**	0.0046
Grain width	0.449**	0.235**	0.002**	0.00095
Length-width ratio of grain	7.306**	1.479**	0.015**	0.0013

* Significant at 5% level

** Significant at 1% level

The panicle length of the parents P_{10}, P_9 and P_8 was consistently higher (Table 5) ranging from 23.49 to 29.34 cm (P_8 in S_3 and P_{10} in S_1). The parent P_5 expressed the lowest value (19.03 to 21.70 cm).

The parent P_{10} consistently possessed the highest number of grains per panicle ranging from 111.25 to 125.75 (Table 6), while the parent P_8 recorded the lowest (91.35 to 100.55).

The 100 grain weight of the parents P_1, P_3 and P_4 was consistently higher ranging from 2.231 to 2.641 g (P_4 in S_3 and P_1 in S_2), while it was low in the parent P_7, the value ranging from 1.326 to 1.521 g (Table 7).

The parent P_{10} in S_1 and S_3 seasons and P_1 in S_2 season (Table 8) recorded the maximum grain yield per plant (27.5, 22.9 and 29.9 g respectively). The parent P_7 recorded the minimum grain yield (10.2 to 15.0 g) per plant.

Straw yield per plant was the highest in parent P_{10} (Table 9), the yield ranging from 47.52 to 58.42 g. The parent P_2 recorded the minimum straw yield (19.79 g to 27.34 g).

The parent P_3 in S_1 and S_3 seasons and P_2 in S_2 season registered the highest grain-straw ratio (0.920, 0.933 and 0.934), while P_9 recorded the least ratios ranging from 0.403 to 0.461 (Table 10).

TAMIL NADU AGRICULTURAL UNIVERSITY LIBRARY
—113918—

TABLE 3

Plant height (cm)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	78.05	79.30	74.25	77.20
2.	P_2	84.40	85.50	80.25	83.38
3.	P_3	91.25	93.45	85.25	89.98
4.	P_4	74.50	76.60	70.50	73.87
5.	P_5	78.70	80.35	74.80	77.95
6.	P_6	134.00	136.25	129.15	133.13
7.	P_7	108.75	110.75	102.15	107.22
8.	P_8	127.75	129.55	119.70	125.67
9.	P_9	135.65	136.60	121.65	131.30
10.	P_{10}	160.00	162.35	138.65	153.75
11.	$P_1 \times P_2$	82.95	84.40	76.35	81.23
12.	$P_2 \times P_1$	83.65	84.35	77.35	81.78
13.	$P_1 \times P_3$	86.20	88.20	79.15	84.52
14.	$P_3 \times P_1$	85.80	91.60	80.10	85.83
15.	$P_1 \times P_4$	79.95	82.65	75.65	79.42
16.	$P_4 \times P_1$	80.35	87.15	77.25	81.58
17.	$P_1 \times P_5$	78.85	78.20	75.50	77.52
18.	$P_5 \times P_1$	76.75	78.15	74.80	76.57
19.	$P_1 \times P_6$	126.35	129.30	119.80	125.12
20.	$P_6 \times P_1$	125.50	129.20	121.10	125.27
21.	$P_1 \times P_7$	96.95	98.70	91.90	95.72
22.	$P_7 \times P_1$	98.30	101.00	93.80	97.70
23.	$P_1 \times P_8$	111.45	117.50	105.40	111.45
24.	$P_8 \times P_1$	111.20	110.45	104.15	108.60
25.	$P_1 \times P_9$	115.70	121.55	112.45	116.57
26.	$P_9 \times P_1$	116.40	118.25	114.75	116.47

TABLE 3 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	132.70	138.75	124.90	132.12
28.	$P_{10} \times P_1$	132.75	135.15	126.50	131.47
29.	$P_2 \times P_3$	90.15	94.75	88.10	91.00
30.	$P_3 \times P_2$	89.55	98.15	88.80	92.17
31.	$P_2 \times P_4$	82.50	87.95	77.40	82.62
32.	$P_4 \times P_2$	83.40	85.95	79.45	82.93
33.	$P_2 \times P_5$	81.25	82.75	77.55	80.52
34.	$P_5 \times P_2$	81.80	86.90	79.45	82.72
35.	$P_2 \times P_6$	126.80	129.80	121.50	125.92
36.	$P_6 \times P_2$	126.00	127.90	124.70	126.20
37.	$P_2 \times P_7$	99.20	100.25	99.10	99.52
38.	$P_7 \times P_2$	98.15	105.45	95.45	99.68
39.	$P_2 \times P_8$	126.60	130.60	113.40	123.53
40.	$P_8 \times P_2$	125.25	126.95	113.60	121.93
41.	$P_2 \times P_9$	112.90	120.50	119.75	117.72
42.	$P_9 \times P_2$	111.35	116.05	120.50	115.97
43.	$P_2 \times P_{10}$	130.20	140.50	129.40	133.07
44.	$P_{10} \times P_2$	137.95	134.45	130.35	134.25
45.	$P_3 \times P_4$	83.10	86.30	79.70	83.03
46.	$P_4 \times P_3$	84.40	91.45	82.65	86.17
47.	$P_3 \times P_5$	84.90	87.50	80.20	84.13
48.	$P_5 \times P_3$	84.55	88.05	82.05	84.88
49.	$P_3 \times P_6$	119.80	130.45	119.80	123.35
50.	$P_6 \times P_3$	119.85	129.05	112.55	120.48
51.	$P_3 \times P_7$	100.40	103.20	97.30	100.30
52.	$P_7 \times P_3$	100.55	104.45	93.65	99.55
53.	$P_3 \times P_8$	120.50	131.05	117.00	125.52
54.	$P_8 \times P_3$	128.20	130.10	117.25	125.18

TABLE 3 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	118.10	125.90	110.85	118.28
56.	$P_9 \times P_3$	117.50	119.10	108.60	115.07
57.	$P_3 \times P_{10}$	136.20	139.85	125.25	133.77
58.	$P_{10} \times P_3$	135.70	130.90	126.10	133.57
59.	$P_4 \times P_5$	74.40	79.25	71.45	75.03
60.	$P_5 \times P_4$	76.05	87.70	74.40	79.38
61.	$P_4 \times P_6$	125.40	129.05	110.00	121.48
62.	$P_6 \times P_4$	125.45	130.30	114.20	123.32
63.	$P_4 \times P_7$	104.25	111.45	94.15	103.28
64.	$P_7 \times P_4$	104.50	109.15	96.25	103.30
65.	$P_4 \times P_8$	119.60	123.70	106.40	115.23
66.	$P_8 \times P_4$	115.10	124.20	108.75	116.02
67.	$P_4 \times P_9$	113.05	119.50	106.15	113.17
68.	$P_9 \times P_4$	111.70	115.55	103.10	110.12
69.	$P_4 \times P_{10}$	133.00	137.95	125.50	132.15
70.	$P_{10} \times P_4$	132.20	131.70	121.75	128.55
71.	$P_5 \times P_6$	124.45	130.35	115.90	123.57
72.	$P_6 \times P_5$	122.75	129.00	120.05	123.80
73.	$P_5 \times P_7$	100.00	104.60	96.75	101.12
74.	$P_7 \times P_5$	100.05	108.05	95.50	101.20
75.	$P_5 \times P_8$	112.80	118.40	105.25	112.15
76.	$P_8 \times P_5$	112.60	116.40	107.55	112.18
77.	$P_5 \times P_9$	113.00	118.30	106.45	112.58
78.	$P_9 \times P_5$	113.90	115.40	109.95	112.75
79.	$P_5 \times P_{10}$	125.45	128.60	117.20	123.75
80.	$P_{10} \times P_5$	126.85	127.40	119.70	124.65

TABLE 5 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	126.35	130.45	120.10	125.63
82.	$P_7 \times P_6$	127.90	130.15	118.20	125.42
83.	$P_6 \times P_8$	144.55	149.40	133.10	142.35
84.	$P_8 \times P_6$	144.70	147.75	130.10	140.85
85.	$P_6 \times P_9$	139.85	147.75	133.05	140.21
86.	$P_9 \times P_6$	143.00	147.35	130.90	140.62
87.	$P_6 \times P_{10}$	144.80	149.05	136.25	143.36
88.	$P_{10} \times P_6$	145.20	140.95	134.40	142.85
89.	$P_7 \times P_8$	124.60	129.95	116.65	123.73
90.	$P_8 \times P_7$	123.40	129.35	118.75	123.83
91.	$P_7 \times P_9$	125.85	127.65	115.50	123.00
92.	$P_9 \times P_7$	125.70	127.95	113.75	122.45
93.	$P_7 \times P_{10}$	128.70	130.25	120.35	126.43
94.	$P_{10} \times P_7$	128.10	130.30	119.25	125.88
95.	$P_8 \times P_9$	140.50	143.60	126.80	136.97
96.	$P_9 \times P_8$	140.10	141.95	128.95	137.00
97.	$P_8 \times P_{10}$	147.65	149.80	129.65	142.37
98.	$P_{10} \times P_8$	147.45	147.70	131.10	142.08
99.	$P_9 \times P_{10}$	150.90	152.95	133.30	145.72
100.	$P_{10} \times P_9$	152.80	156.45	135.50	148.25
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.613	0.292	0.992	0.695
	Parent	107.31	109.07	99.65	105.34
	Combination	114.56	118.47	107.72	113.58

TABLE 4

Harbearing tillers per plant

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	13.05	14.30	10.70	12.68
2.	P_2	12.85	14.05	10.95	12.62
3.	P_3	12.45	14.05	11.70	12.73
4.	P_4	13.65	15.25	11.65	13.52
5.	P_5	14.90	14.85	11.40	13.72
6.	P_6	13.40	15.25	12.00	13.55
7.	P_7	10.90	11.55	10.00	10.82
8.	P_8	10.75	11.75	10.15	10.88
9.	P_9	11.70	12.20	10.20	11.37
10.	P_{10}	14.00	15.00	13.30	14.10
11.	$P_1 \times P_2$	16.05	15.70	12.25	14.67
12.	$P_2 \times P_1$	15.90	15.75	12.55	14.73
13.	$P_1 \times P_3$	13.05	14.45	12.75	13.42
14.	$P_3 \times P_1$	12.60	15.75	13.75	14.03
15.	$P_1 \times P_4$	14.20	14.64	12.70	13.85
16.	$P_4 \times P_1$	14.45	15.85	12.90	14.40
17.	$P_1 \times P_5$	16.10	16.15	13.10	15.12
18.	$P_5 \times P_1$	15.25	15.40	13.05	14.57
19.	$P_1 \times P_6$	14.50	16.15	11.90	14.18
20.	$P_6 \times P_1$	15.95	16.35	14.15	15.38
21.	$P_1 \times P_7$	12.55	15.15	12.10	13.27
22.	$P_7 \times P_1$	12.45	14.90	12.00	13.12
23.	$P_1 \times P_8$	12.90	14.80	11.95	13.22
24.	$P_8 \times P_1$	13.50	15.00	12.10	13.53
25.	$P_1 \times P_9$	14.05	15.35	12.10	13.83
26.	$P_9 \times P_1$	14.20	14.45	11.75	13.47

TABLE 4 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	13.45	15.35	13.25	14.02
28.	$P_{10} \times P_1$	13.40	14.15	12.60	13.38
29.	$P_2 \times P_3$	13.45	14.45	12.25	13.38
30.	$P_3 \times P_2$	13.90	15.05	12.65	13.95
31.	$P_2 \times P_4$	15.00	16.05	12.65	14.57
32.	$P_4 \times P_2$	15.30	16.55	12.35	14.73
33.	$P_2 \times P_5$	13.45	15.85	11.00	13.43
34.	$P_5 \times P_2$	13.40	15.15	11.30	13.35
35.	$P_2 \times P_6$	15.00	18.15	13.05	15.40
36.	$P_6 \times P_2$	15.05	16.30	14.00	15.11
37.	$P_2 \times P_7$	15.45	16.30	11.70	14.48
38.	$P_7 \times P_2$	15.30	15.10	11.80	14.07
39.	$P_2 \times P_8$	15.40	16.30	12.55	14.75
40.	$P_8 \times P_2$	13.20	14.80	11.90	13.97
41.	$P_2 \times P_9$	16.05	15.55	12.30	14.63
42.	$P_9 \times P_2$	15.45	14.75	11.95	14.05
43.	$P_2 \times P_{10}$	14.75	15.85	12.70	14.43
44.	$P_{10} \times P_2$	14.75	15.20	13.35	14.43
45.	$P_5 \times P_4$	15.45	16.55	13.90	15.30
46.	$P_4 \times P_3$	14.55	16.25	12.70	14.50
47.	$P_3 \times P_5$	15.00	16.35	12.85	14.73
48.	$P_5 \times P_3$	15.30	15.75	12.90	14.65
49.	$P_3 \times P_6$	14.85	16.00	13.80	14.88
50.	$P_6 \times P_3$	15.30	17.00	14.90	15.73
51.	$P_3 \times P_7$	14.35	15.55	12.20	14.03
52.	$P_7 \times P_3$	14.85	14.70	13.20	14.25
53.	$P_3 \times P_8$	15.65	17.10	13.90	15.55
54.	$P_8 \times P_3$	15.45	15.25	13.20	14.63

TABLE 4 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	14.45	16.40	12.95	14.60
56.	$P_9 \times P_3$	14.85	15.30	13.20	14.48
57.	$P_3 \times P_{10}$	15.45	17.45	14.05	15.59
58.	$P_{10} \times P_3$	15.00	14.95	13.35	14.43
59.	$P_4 \times P_5$	14.25	16.65	12.10	14.33
60.	$P_5 \times P_4$	14.25	15.95	11.40	13.87
61.	$P_4 \times P_6$	15.60	16.30	14.10	15.33
62.	$P_6 \times P_4$	15.15	16.0[illegible]	13.25	15.10
63.	$P_4 \times P_7$	14.90	16.85	12.75	14.83
64.	$P_7 \times P_4$	14.85	15.30	12.45	14.20
65.	$P_4 \times P_8$	14.00	16.25	12.85	14.37
66.	$P_8 \times P_4$	14.95	14.70	12.35	13.87
67.	$P_4 \times P_9$	14.35	15.20	11.95	13.83
68.	$P_9 \times P_4$	14.20	14.85	12.70	13.92
69.	$P_4 \times P_{10}$	13.85	15.15	13.15	14.05
70.	$P_{10} \times P_4$	14.45	14.50	12.65	13.87
71.	$P_5 \times P_6$	15.25	16.30	12.75	14.77
72.	$P_6 \times P_5$	15.20	16.15	13.00	14.78
73.	$P_5 \times P_7$	14.10	15.50	11.20	13.60
74.	$P_7 \times P_5$	13.65	16.05	10.95	13.55
75.	$P_5 \times P_8$	14.65	15.85	11.50	14.00
76.	$P_8 \times P_5$	14.95	14.20	10.75	13.53
77.	$P_5 \times P_9$	14.15	16.10	11.75	14.00
78.	$P_9 \times P_5$	14.50	14.10	10.30	12.97
79.	$P_5 \times P_{10}$	15.70	16.85	13.70	15.42
80.	$P_{10} \times P_5$	15.60	15.90	13.50	15.00

TABLE 4 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	14.00	15.40	13.95	14.72
82.	$P_7 \times P_6$	14.10	15.30	12.65	14.02
83.	$P_6 \times P_8$	15.35	16.30	13.75	15.13
84.	$P_8 \times P_6$	15.50	15.75	13.20	14.82
85.	$P_6 \times P_9$	14.60	16.25	13.95	14.93
86.	$P_9 \times P_6$	14.00	15.20	13.15	14.58
87.	$P_6 \times P_{10}$	14.25	15.90	13.55	14.57
88.	$P_{10} \times P_6$	14.40	15.90	13.45	14.58
89.	$P_7 \times P_8$	14.35	14.60	13.25	14.07
90.	$P_8 \times P_7$	14.45	15.40	12.55	14.13
91.	$P_7 \times P_9$	15.25	15.20	13.50	14.65
92.	$P_9 \times P_7$	15.10	15.40	12.65	14.38
93.	$P_7 \times P_{10}$	15.35	15.00	12.85	14.67
94.	$P_{10} \times P_7$	15.05	14.85	12.95	14.28
95.	$P_8 \times P_9$	14.95	16.05	14.10	15.03
96.	$P_9 \times P_8$	15.45	15.40	13.50	14.78
97.	$P_8 \times P_{10}$	15.65	16.05	13.90	15.20
98.	$P_{10} \times P_8$	14.95	14.95	13.15	14.35
99.	$P_9 \times P_{10}$	15.10	15.70	13.45	14.75
100.	$P_{10} \times P_9$	14.45	14.50	13.10	14.02
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SL	0.263	0.352	0.305	0.332
	Parent	12.76	13.82	11.20	12.59
	Combination	14.69	15.64	12.77	14.37

TABLE 5

Panicle length (cm)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	20.87	25.18	20.92	21.65
2.	P_2	20.98	23.60	20.21	21.59
3.	P_3	21.45	24.49	21.63	22.52
4.	P_4	20.68	22.64	20.13	21.14
5.	P_5	19.26	21.70	19.03	19.99
6.	P_6	24.43	25.30	23.01	24.24
7.	P_7	20.99	21.38	19.94	20.89
8.	P_8	24.67	25.61	23.46	24.59
9.	P_9	25.93	26.77	25.98	25.56
10.	P_{10}	29.34	28.32	26.28	27.98
11.	$P_1 \times P_2$	20.62	21.23	21.10	20.98
12.	$P_2 \times P_1$	20.60	22.35	19.80	20.92
13.	$P_1 \times P_3$	20.65	23.93	21.85	22.14
14.	$P_3 \times P_1$	19.29	21.71	21.03	20.68
15.	$P_1 \times P_4$	20.93	24.30	21.13	22.12
16.	$P_4 \times P_1$	21.44	22.83	19.91	21.39
17.	$P_1 \times P_5$	18.76	22.40	20.68	20.68
18.	$P_5 \times P_1$	19.05	20.75	20.02	20.14
19.	$P_1 \times P_6$	22.50	24.73	23.21	23.49
20.	$P_6 \times P_1$	22.69	24.40	23.41	23.53
21.	$P_1 \times P_7$	20.29	23.69	19.91	21.29
22.	$P_7 \times P_1$	20.12	22.75	20.54	21.13
23.	$P_1 \times P_8$	21.74	23.54	21.05	22.11
24.	$P_8 \times P_1$	22.01	23.07	20.94	22.00
25.	$P_1 \times P_9$	22.39	24.55	22.21	23.05
26.	$P_9 \times P_1$	22.98	24.50	21.94	23.14

TABLE 5 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	24.53	28.13	22.93	25.19
28.	$P_{10} \times P_1$	24.25	24.78	22.97	23.99
29.	$P_2 \times P_3$	21.83	23.66	20.90	22.13
30.	$P_3 \times P_2$	21.26	22.78	21.23	21.75
31.	$P_2 \times P_4$	20.90	23.44	19.99	21.44
32.	$P_4 \times P_2$	20.16	22.20	21.00	21.14
33.	$P_2 \times P_5$	18.89	22.54	19.61	20.34
34.	$P_5 \times P_2$	19.14	21.06	20.40	19.86
35.	$P_2 \times P_6$	23.71	25.73	22.71	24.05
36.	$P_6 \times P_2$	23.40	25.55	23.44	24.13
37.	$P_2 \times P_7$	23.01	24.33	19.95	22.43
38.	$P_7 \times P_2$	23.12	24.09	19.98	22.39
39.	$P_2 \times P_8$	24.13	26.20	22.70	24.34
40.	$P_8 \times P_2$	24.24	23.84	23.50	23.86
41.	$P_2 \times P_9$	24.43	26.77	22.83	24.67
42.	$P_9 \times P_2$	25.10	24.76	23.14	24.33
43.	$P_2 \times P_{10}$	24.33	26.20	23.43	24.65
44.	$P_{10} \times P_2$	24.55	24.91	23.75	24.40
45.	$P_3 \times P_4$	22.20	23.38	20.99	22.19
46.	$P_4 \times P_3$	25.50	24.67	22.69	24.31
47.	$P_3 \times P_5$	19.70	21.63	19.12	20.15
48.	$P_5 \times P_3$	20.70	22.74	20.40	21.28
49.	$P_3 \times P_6$	24.75	26.20	24.00	24.98
50.	$P_6 \times P_3$	24.59	25.96	23.82	24.99
51.	$P_3 \times P_7$	23.75	25.73	21.77	23.75
52.	$P_7 \times P_3$	23.50	25.04	20.24	22.92
53.	$P_3 \times P_8$	26.21	27.26	24.93	26.13
54.	$P_8 \times P_3$	26.38	26.78	24.54	25.96

TABLE 5 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	23.99	26.28	24.56	24.93
56.	$P_9 \times P_3$	24.30	24.42	24.42	24.38
57.	$P_3 \times P_{10}$	24.79	27.12	23.46	25.12
58.	$P_{10} \times P_3$	25.29	24.79	24.06	24.71
59.	$P_4 \times P_5$	20.12	22.86	19.62	20.86
60.	$P_5 \times P_4$	20.44	22.11	20.05	20.86
61.	$P_4 \times P_6$	23.63	26.58	22.80	24.34
62.	$P_6 \times P_4$	24.44	25.55	23.40	24.46
63.	$P_4 \times P_7$	21.42	24.46	20.59	22.15
64.	$P_7 \times P_4$	21.52	24.78	20.93	22.40
65.	$P_4 \times P_8$	22.55	23.94	21.64	22.71
66.	$P_8 \times P_4$	23.36	24.38	23.39	23.70
67.	$P_4 \times P_9$	24.00	24.31	23.06	23.79
68.	$P_9 \times P_4$	24.53	24.52	22.06	23.70
69.	$P_4 \times P_{10}$	24.61	25.47	24.15	24.74
70.	$P_{10} \times P_4$	24.30	24.51	22.20	23.67
71.	$P_5 \times P_6$	24.43	25.84	21.37	23.88
72.	$P_6 \times P_5$	23.95	25.36	22.49	23.93
73.	$P_5 \times P_7$	21.15	23.57	20.97	21.87
74.	$P_7 \times P_5$	22.13	24.27	20.08	22.16
75.	$P_5 \times P_8$	24.10	25.90	22.02	24.00
76.	$P_8 \times P_5$	23.84	24.72	22.43	23.66
77.	$P_5 \times P_9$	23.38	24.81	20.68	22.95
78.	$P_9 \times P_5$	23.22	24.74	23.39	23.78
79.	$P_5 \times P_{10}$	24.73	25.57	22.97	24.42
80.	$P_{10} \times P_5$	25.07	24.53	23.29	24.30

TABLE 5 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	21.99	23.14	21.64	22.26
82.	$P_7 \times P_6$	22.04	23.37	20.81	22.07
83.	$P_6 \times P_8$	25.41	26.28	23.52	25.07
84.	$P_8 \times P_6$	25.24	26.59	22.82	24.88
85.	$P_6 \times P_9$	25.39	26.41	24.05	22.95
86.	$P_9 \times P_6$	25.63	25.68	23.45	24.92
87.	$P_6 \times P_{10}$	26.96	27.00	25.06	24.42
88.	$P_{10} \times P_6$	27.40	26.81	24.70	26.30
89.	$P_7 \times P_8$	23.61	25.40	23.82	24.27
90.	$P_8 \times P_7$	23.93	26.03	23.15	25.05
91.	$P_7 \times P_9$	25.32	24.90	22.30	24.17
92.	$P_9 \times P_7$	23.70	24.24	22.99	23.64
93.	$P_7 \times P_{10}$	25.48	25.27	23.57	24.77
94.	$P_{10} \times P_7$	24.91	24.55	24.11	24.52
95.	$P_8 \times P_9$	23.29	23.47	23.95	23.56
96.	$P_9 \times P_8$	23.09	23.43	23.61	23.38
97.	$P_8 \times P_{10}$	26.24	26.31	24.71	25.75
98.	$P_{10} \times P_8$	26.37	25.73	25.53	25.87
99.	$P_9 \times P_{10}$	26.47	25.85	25.21	25.84
100.	$P_{10} \times P_9$	25.29	26.25	25.73	25.75
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.326	0.165	0.434	0.328
	Parent	22.96	24.32	21.86	23.01
	Combination	23.23	24.59	22.36	23.39

TABLE 6

Number of grains per panicle

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	104.55	111.25	95.95	103.92
2.	P_2	102.95	107.70	97.20	102.62
3.	P_3	103.95	109.00	91.55	101.50
4.	P_4	111.85	113.35	103.25	109.48
5	P_5	106.65	111.25	99.80	105.97
6.	P_6	116.65	119.05	105.05	113.58
7.	P_7	100.30	102.50	93.15	98.65
8.	P_8	97.60	100.85	91.35	96.60
9.	P_9	124.20	114.10	103.70	114.00
10.	P_{10}	125.75	122.65	111.25	119.55
11.	$P_1 \times P_2$	102.95	108.00	97.60	102.85
12.	$P_2 \times P_1$	104.90	110.50	96.15	103.85
13.	$P_1 \times P_3$	103.15	110.35	92.95	102.15
14.	$P_3 \times P_1$	97.75	102.00	96.35	98.70
15.	$P_1 \times P_4$	111.35	113.60	105.70	110.22
16.	$P_4 \times P_1$	116.20	116.25	101.45	111.30
17.	$P_1 \times P_5$	100.55	105.44	95.00	100.33
18.	$P_5 \times P_1$	100.35	109.95	93.75	101.22
19.	$P_1 \times P_6$	103.80	107.55	96.10	102.48
20.	$P_6 \times P_1$	106.70	111.80	102.50	107.00
21.	$P_1 \times P_7$	103.60	104.20	91.10	99.63
22.	$P_7 \times P_1$	103.25	109.15	92.90	101.77
23.	$P_1 \times P_8$	101.05	106.65	94.95	100.88
24.	$P_8 \times P_1$	103.50	105.10	93.55	100.72
25.	$P_1 \times P_9$	108.60	116.10	97.00	107.23
26.	$P_9 \times P_1$	109.60	111.85	99.75	106.07

TABLE 6 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	101.30	108.80	100.10	103.40
28.	$P_{10} \times P_1$	102.65	106.85	100.60	103.37
29.	$P_2 \times P_3$	104.65	112.35	95.35	104.12
30.	$P_3 \times P_2$	103.40	106.05	95.25	101.57
31.	$P_2 \times P_4$	107.80	112.65	99.55	106.47
32.	$P_4 \times P_2$	103.15	112.40	103.50	108.02
33.	$P_2 \times P_5$	90.00	104.40	93.25	95.88
34.	$P_5 \times P_2$	90.15	103.00	95.80	97.08
35.	$P_2 \times P_6$	110.40	115.80	101.10	109.07
36.	$P_6 \times P_2$	110.45	113.00	102.30	108.58
37.	$P_2 \times P_7$	93.30	103.40	93.55	96.75
38.	$P_7 \times P_2$	95.75	104.90	95.50	98.05
39.	$P_2 \times P_8$	101.55	104.90	93.40	99.95
40.	$P_8 \times P_2$	102.85	105.40	97.50	101.92
41.	$P_2 \times P_9$	108.35	113.30	100.55	107.40
42.	$P_9 \times P_2$	106.95	109.20	102.05	106.07
43.	$P_2 \times P_{10}$	103.95	111.65	101.10	105.57
44.	$P_{10} \times P_2$	102.00	105.40	101.40	102.93
45.	$P_3 \times P_4$	104.45	110.45	97.45	104.12
46.	$P_4 \times P_3$	105.45	111.75	98.25	105.15
47.	$P_3 \times P_5$	104.25	108.75	95.30	102.77
48.	$P_5 \times P_3$	104.50	108.20	97.60	103.43
49.	$P_3 \times P_6$	111.65	112.80	101.45	108.63
50.	$P_6 \times P_3$	112.30	113.40	100.35	110.35
51.	$P_3 \times P_7$	103.60	106.65	94.65	102.30
52.	$P_7 \times P_3$	105.85	108.05	90.85	100.92
53.	$P_3 \times P_8$	103.20	110.20	92.45	101.95
54.	$P_8 \times P_3$	102.65	100.10	92.40	101.05

TABLE 6 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	111.50	112.20	99.25	107.32
56.	$P_9 \times P_3$	111.60	110.30	98.30	106.73
57.	$P_3 \times P_{10}$	112.25	114.44	100.75	109.12
58.	$P_{10} \times P_3$	111.05	107.60	102.85	107.17
59.	$P_4 \times P_5$	106.80	112.80	101.70	107.15
60.	$P_5 \times P_4$	106.35	114.00	102.05	107.47
61.	$P_4 \times P_6$	120.35	120.30	105.40	115.35
62.	$P_6 \times P_4$	121.15	123.45	110.25	118.28
63.	$P_4 \times P_7$	97.50	103.85	95.60	98.98
64.	$P_7 \times P_4$	98.10	104.05	95.15	99.10
65.	$P_4 \times P_8$	101.45	105.35	94.70	100.50
66.	$P_8 \times P_4$	102.20	104.70	96.05	100.98
67.	$P_4 \times P_9$	110.25	113.65	103.50	109.13
68.	$P_9 \times P_4$	108.75	110.75	102.45	107.32
69.	$P_4 \times P_{10}$	120.35	120.25	109.60	116.73
70.	$P_{10} \times P_4$	120.20	116.20	105.55	113.98
71.	$P_5 \times P_6$	111.90	117.00	102.20	110.37
72.	$P_6 \times P_5$	112.60	105.80	103.75	107.38
73.	$P_5 \times P_7$	95.45	100.75	92.20	96.13
74.	$P_7 \times P_5$	94.85	101.25	89.95	95.35
75.	$P_5 \times P_8$	94.15	102.05	90.25	95.48
76.	$P_8 \times P_5$	95.40	98.80	91.55	95.25
77.	$P_5 \times P_9$	110.70	114.50	100.55	108.43
78.	$P_9 \times P_5$	110.30	110.45	101.05	107.27
79.	$P_5 \times P_{10}$	115.00	115.05	105.30	111.78
80.	$P_{10} \times P_5$	115.95	111.60	105.95	111.17

TABLE 6 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	107.45	112.60	100.10	106.71
82.	$P_7 \times P_6$	107.55	103.85	95.45	102.28
83.	$P_6 \times P_8$	104.35	109.30	100.50	104.88
84.	$P_8 \times P_6$	104.80	113.65	99.10	105.85
85.	$P_6 \times P_9$	109.15	114.85	104.55	109.52
86.	$P_9 \times P_6$	106.80	110.55	104.25	101.20
87.	$P_6 \times P_{10}$	106.60	121.15	110.00	112.58
88.	$P_{10} \times P_6$	107.95	117.75	108.10	111.27
89.	$P_7 \times P_8$	100.45	104.15	91.15	98.58
90.	$P_8 \times P_7$	102.20	107.20	93.75	101.05
91.	$P_7 \times P_9$	109.85	108.20	96.25	104.77
92.	$P_9 \times P_7$	109.60	105.10	100.15	104.95
93.	$P_7 \times P_{10}$	111.60	106.75	99.60	105.98
94.	$P_{10} \times P_7$	112.05	108.90	97.15	106.03
95.	$P_8 \times P_9$	100.90	110.40	100.85	107.05
96.	$P_9 \times P_8$	108.90	103.35	99.65	105.63
97.	$P_8 \times P_{10}$	116.45	112.65	99.75	109.62
98.	$P_{10} \times P_8$	115.90	113.65	102.95	110.83
99.	$P_9 \times P_{10}$	105.50	117.60	107.70	113.60
100.	$P_{10} \times P_9$	114.40	117.55	110.20	114.05
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.831	0.173	0.963	0.742
	Parent	109.46	111.17	99.22	106.62
	Combination	106.37	110.07	98.99	105.11

TABLE 7

100 grain weight (g)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	2.595	2.641	2.558	2.598
2.	P_2	2.247	2.273	2.136	2.219
3.	P_3	2.539	2.567	2.426	2.511
4.	P_4	2.313	2.370	2.231	2.305
5.	P_5	2.036	2.067	1.932	2.011
6.	P_6	1.779	1.833	1.683	1.783
7.	P_7	1.437	1.521	1.326	1.428
8.	P_8	1.889	1.902	1.772	1.854
9.	P_9	1.868	1.903	1.771	1.849
10.	P_{10}	2.163	2.194	2.065	2.141
11.	$P_1 \times P_2$	2.499	2.613	2.446	2.520
12.	$P_2 \times P_1$	2.503	2.591	2.422	2.506
13.	$P_1 \times P_3$	2.644	2.655	2.527	2.609
14.	$P_3 \times P_1$	2.650	2.694	2.526	2.623
15.	$P_1 \times P_4$	2.434	2.552	2.329	2.458
16.	$P_4 \times P_1$	2.415	2.488	2.351	2.411
17.	$P_1 \times P_5$	2.306	2.388	2.226	2.307
18.	$P_5 \times P_1$	2.325	2.436	2.212	2.324
19.	$P_1 \times P_6$	2.233	2.294	2.138	2.222
20.	$P_6 \times P_1$	2.227	2.301	2.133	2.220
21.	$P_1 \times P_7$	2.107	2.210	2.043	2.120
22.	$P_7 \times P_1$	2.133	2.157	2.039	2.110
23.	$P_1 \times P_8$	2.388	2.415	2.256	2.353
24.	$P_8 \times P_1$	2.369	2.426	2.265	2.353
25.	$P_1 \times P_9$	2.537	2.607	2.413	2.519
26.	$P_9 \times P_1$	2.444	2.561	2.410	2.471

TABLE 7 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	2.464	2.514	2.374	2.451
28.	$P_{10} \times P_1$	2.449	2.439	2.386	2.441
29.	$P_2 \times P_3$	2.462	2.518	2.368	2.449
30.	$P_3 \times P_2$	2.542	2.652	2.334	2.509
31.	$P_2 \times P_4$	2.342	2.430	2.235	2.335
32.	$P_4 \times P_2$	2.332	2.433	2.257	2.357
33.	$P_2 \times P_5$	2.101	2.198	2.075	2.152
34.	$P_5 \times P_2$	2.124	2.148	2.069	2.114
35.	$P_2 \times P_6$	2.152	2.221	2.047	2.140
36.	$P_6 \times P_2$	2.135	2.193	2.020	2.118
37.	$P_2 \times P_7$	2.163	2.190	2.022	2.124
38.	$P_7 \times P_2$	2.125	2.193	2.014	2.113
39.	$P_2 \times P_8$	2.315	2.373	2.207	2.289
40.	$P_8 \times P_2$	2.325	2.398	2.211	2.311
41.	$P_2 \times P_9$	2.040	2.096	1.936	2.024
42.	$P_9 \times P_2$	2.038	2.099	1.937	2.024
43.	$P_2 \times P_{10}$	2.270	2.282	2.181	2.244
44.	$P_{10} \times P_2$	2.277	2.293	2.172	2.247
45.	$P_3 \times P_4$	2.516	2.547	2.333	2.482
46.	$P_4 \times P_3$	2.450	2.550	2.391	2.460
47.	$P_3 \times P_5$	2.243	2.273	2.188	2.235
48.	$P_5 \times P_3$	2.240	2.325	2.192	2.254
49.	$P_3 \times P_6$	2.161	2.182	2.086	2.143
50.	$P_6 \times P_3$	2.183	2.256	2.077	2.172
51.	$P_3 \times P_7$	2.217	2.254	1.902	2.126
52.	$P_7 \times P_3$	2.279	2.286	1.882	2.148
53.	$P_3 \times P_8$	2.273	2.310	2.152	2.245
54.	$P_8 \times P_3$	2.224	2.309	2.152	2.228

TABLE 7 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	2.284	2.314	2.712	2.257
56.	$P_9 \times P_3$	2.275	2.311	2.189	2.258
57.	$P_3 \times P_{10}$	2.360	2.381	2.274	2.338
58.	$P_{10} \times P_3$	2.348	2.392	2.269	2.336
59.	$P_4 \times P_5$	2.216	2.300	2.145	2.221
60.	$P_5 \times P_4$	2.209	2.276	2.135	2.207
61.	$P_4 \times P_6$	2.127	2.228	2.061	2.139
62.	$P_6 \times P_4$	2.166	2.259	2.044	2.156
63.	$P_4 \times P_7$	2.038	2.094	1.908	2.133
64.	$P_7 \times P_4$	2.006	2.110	1.920	2.012
65.	$P_4 \times P_8$	2.161	2.233	2.130	2.174
66.	$P_8 \times P_4$	2.165	2.194	2.118	2.159
67.	$P_4 \times P_9$	2.170	2.213	2.056	2.147
68.	$P_9 \times P_4$	2.134	2.162	2.065	2.120
69.	$P_4 \times P_{10}$	2.225	2.273	2.135	2.211
70.	$P_{10} \times P_4$	2.244	2.231	2.142	2.220
71.	$P_5 \times P_6$	2.060	2.122	1.960	2.047
72.	$P_6 \times P_5$	2.086	2.144	1.946	2.059
73.	$P_5 \times P_7$	1.859	1.918	1.750	1.843
74.	$P_7 \times P_5$	1.830	1.904	1.762	1.832
75.	$P_5 \times P_8$	1.959	2.040	1.889	1.963
76.	$P_8 \times P_5$	1.987	2.063	1.885	1.978
77.	$P_5 \times P_9$	2.179	2.227	2.070	2.161
78.	$P_9 \times P_5$	2.200	2.237	2.058	2.168
79.	$P_5 \times P_{10}$	2.160	2.199	2.066	2.142
80.	$P_{10} \times P_5$	2.151	2.204	2.065	2.140

TABLE 7 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	1.671	1.737	1.553	1.654
82.	$P_7 \times P_6$	1.652	1.760	1.558	1.657
83.	$P_6 \times P_8$	1.855	1.946	1.749	1.850
84.	$P_8 \times P_6$	1.863	1.962	1.763	1.863
85.	$P_6 \times P_9$	1.836	1.859	1.730	1.808
86.	$P_9 \times P_6$	1.756	1.860	1.731	1.783
87.	$P_6 \times P_{10}$	2.006	2.090	1.892	1.996
88.	$P_{10} \times P_6$	1.987	2.064	1.872	1.974
89.	$P_7 \times P_8$	1.688	1.749	1.569	1.669
90.	$P_8 \times P_7$	1.694	1.769	1.555	1.673
91.	$P_7 \times P_9$	1.773	1.873	1.672	1.773
92.	$P_9 \times P_7$	1.773	1.847	1.660	1.760
93.	$P_7 \times P_{10}$	1.799	1.890	1.679	1.789
94.	$P_{10} \times P_7$	1.773	1.877	1.691	1.780
95.	$P_8 \times P_9$	2.010	2.073	1.878	1.987
96.	$P_9 \times P_8$	1.991	2.029	1.898	1.972
97.	$P_8 \times P_{10}$	1.876	1.963	1.979	1.939
98.	$P_{10} \times P_8$	1.990	2.021	1.958	1.989
99.	$P_9 \times P_{10}$	2.007	2.098	1.958	2.021
100.	$P_{10} \times P_9$	2.012	2.095	1.940	2.016
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.0064	0.0068	0.0055	0.0035
	Parent	2.087	2.133	1.990	2.070
	Combination	2.160	2.209	2.061	2.143

TABLE 8

Grain yield per plant (g)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	26.8	29.9	21.5	26.04
2.	P_2	23.0	25.5	17.3	21.94
3.	P_3	23.4	26.4	18.9	22.92
4.	P_4	25.3	28.1	21.6	24.81
5.	P_5	23.4	26.0	19.2	22.86
6.	P_6	22.6	25.5	20.0	22.69
7.	P_7	13.0	15.0	10.2	12.74
8.	P_8	15.3	16.9	12.5	14.92
9.	P_9	19.5	21.0	17.0	19.17
10.	P_{10}	27.5	27.4	22.9	25.94
11.	$P_1 \times P_2$	21.9	32.1	19.9	24.64
12.	$P_2 \times P_1$	22.1	31.7	20.9	24.88
13.	$P_1 \times P_3$	25.3	31.4	21.6	26.16
14.	$P_3 \times P_1$	24.7	32.1	19.3	25.37
15.	$P_1 \times P_4$	26.1	31.5	21.2	26.23
16.	$P_4 \times P_1$	26.4	31.6	21.9	26.66
17.	$P_1 \times P_5$	24.6	28.5	19.9	24.33
18.	$P_5 \times P_1$	23.9	28.1	20.0	23.98
19.	$P_1 \times P_6$	26.3	29.4	22.0	25.91
20.	$P_6 \times P_1$	26.3	29.1	22.0	25.80
21.	$P_1 \times P_7$	22.2	24.8	19.3	22.08
22.	$P_7 \times P_1$	22.5	24.3	19.3	22.02
23.	$P_1 \times P_8$	28.3	26.0	24.2	26.82
24.	$P_8 \times P_1$	28.7	29.1	25.0	27.59
25.	$P_1 \times P_9$	24.1	27.9	20.2	24.09
26.	$P_9 \times P_1$	24.4	27.4	24.5	24.07

TABLE 8 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	27.3	28.5	22.7	26.15
28.	$P_{10} \times P_1$	27.2	28.6	23.9	26.55
29.	$P_2 \times P_3$	26.3	27.5	21.5	25.08
30.	$P_3 \times P_2$	26.5	29.7	21.2	25.82
31.	$P_2 \times P_4$	24.3	30.3	20.5	25.02
32.	$P_4 \times P_2$	25.2	30.7	22.0	25.95
33.	$P_2 \times P_5$	20.0	24.3	15.1	19.80
34.	$P_5 \times P_2$	20.5	23.0	15.9	19.80
35.	$P_2 \times P_6$	28.4	30.1	24.9	27.84
36.	$P_6 \times P_2$	28.3	29.7	25.0	27.66
37.	$P_2 \times P_7$	18.5	21.5	15.0	18.37
38.	$P_7 \times P_2$	19.2	22.6	15.0	18.78
39.	$P_2 \times P_8$	26.9	27.5	19.7	24.60
40.	$P_8 \times P_2$	26.6	27.8	20.4	24.95
41.	$P_2 \times P_9$	22.3	26.4	19.0	22.53
42.	$P_9 \times P_2$	22.3	25.6	19.0	22.31
43.	$P_2 \times P_{10}$	25.4	28.8	21.7	25.28
44.	$P_{10} \times P_2$	25.8	27.9	22.3	25.33
45.	$P_3 \times P_4$	29.3	29.7	24.0	27.66
46.	$P_4 \times P_3$	29.3	30.6	24.8	28.25
47.	$P_3 \times P_5$	28.7	28.8	23.2	26.91
48.	$P_5 \times P_3$	29.1	29.9	23.9	27.63
49.	$P_3 \times P_6$	31.2	30.2	26.7	29.34
50.	$P_6 \times P_3$	31.6	30.9	26.3	29.60
51.	$P_3 \times P_7$	24.9	25.0	20.0	23.16
52.	$P_7 \times P_3$	24.9	25.3	20.2	24.46
53.	$P_3 \times P_8$	25.4	25.9	21.3	24.22
54.	$P_8 \times P_3$	25.9	26.6	20.9	24.48

TABLE 8 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	28.7	31.8	24.2	28.21
56.	$P_9 \times P_3$	30.0	30.6	25.3	28.64
57.	$P_3 \times P_{10}$	30.7	31.0	26.9	29.55
58.	$P_{10} \times P_3$	30.5	29.3	27.1	28.97
59.	$P_4 \times P_5$	30.3	30.6	24.7	28.53
60.	$P_5 \times P_4$	30.6	30.6	24.1	28.45
61.	$P_4 \times P_6$	29.6	30.9	25.7	28.71
62.	$P_6 \times P_4$	30.5	31.3	25.5	29.10
63.	$P_4 \times P_7$	22.5	22.6	18.4	21.14
64.	$P_7 \times P_4$	22.7	22.2	18.7	21.26
65.	$P_4 \times P_8$	24.6	26.3	20.8	23.89
66.	$P_8 \times P_4$	24.9	25.1	20.9	23.65
67.	$P_4 \times P_9$	24.9	26.5	20.8	24.05
68.	$P_9 \times P_4$	25.5	25.6	21.0	24.01
69.	$P_4 \times P_{10}$	28.4	29.4	24.9	27.57
70.	$P_{10} \times P_4$	28.6	28.7	25.1	27.47
71.	$P_5 \times P_6$	26.2	27.1	22.9	25.40
72.	$P_6 \times P_5$	26.7	27.6	22.9	25.43
73.	$P_5 \times P_7$	19.8	21.3	16.2	19.09
74.	$P_7 \times P_5$	20.3	22.3	17.2	19.92
75.	$P_5 \times P_8$	21.6	22.6	18.6	20.70
76.	$P_8 \times P_5$	21.8	21.8	18.0	20.51
77.	$P_5 \times P_9$	23.3	25.5	19.4	22.71
78.	$P_9 \times P_5$	23.0	25.0	18.9	22.27
79.	$P_5 \times P_{10}$	26.6	29.3	22.4	26.04
80.	$P_{10} \times P_5$	26.3	29.1	22.5	25.97

TABLE 8 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	21.1	22.5	19.2	20.91
82.	$P_7 \times P_6$	21.4	22.1	18.2	20.59
83.	$P_6 \times P_8$	30.4	30.3	21.0	27.25
84.	$P_8 \times P_6$	30.9	30.3	20.9	27.34
85.	$P_6 \times P_9$	21.9	24.6	22.1	22.92
86.	$P_9 \times P_6$	20.6	22.9	21.6	21.70
87.	$P_6 \times P_{10}$	28.7	30.2	27.0	28.64
88.	$P_{10} \times P_6$	30.0	29.3	27.1	28.68
89.	$P_7 \times P_8$	17.2	20.9	15.5	17.88
90.	$P_8 \times P_7$	17.6	21.2	14.9	17.94
91.	$P_7 \times P_9$	21.5	23.6	19.0	21.38
92.	$P_9 \times P_7$	21.5	23.9	18.6	21.34
93.	$P_7 \times P_{10}$	22.4	24.5	19.4	22.10
94.	$P_{10} \times P_7$	22.8	23.4	20.0	22.07
95.	$P_8 \times P_9$	25.4	26.1	22.0	24.51
96.	$P_9 \times P_8$	24.9	25.3	21.9	24.07
97.	$P_8 \times P_{10}$	27.3	29.0	24.9	27.07
98.	$P_{10} \times P_8$	28.5	29.2	25.5	27.74
99.	$P_9 \times P_{10}$	25.2	26.9	22.7	24.90
100.	$P_{10} \times P_9$	25.5	27.4	23.0	25.51
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.278	0.218	0.369	0.295
	Parent	21.98	24.17	18.05	21.40
	Combination	25.35	27.31	21.44	24.70

TABLE 9

Straw yield per plant (g)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	30.59	33.05	25.37	29.67
2	P_2	25.11	27.34	19.79	24.08
3.	P_3	25.42	28.51	20.31	24.74
4.	P_4	28.03	31.38	23.38	27.60
5.	P_5	27.46	30.42	22.01	26.89
6.	P_6	45.17	51.75	39.93	45.62
7.	P_7	26.77	32.13	21.10	26.66
8.	P_8	32.56	37.65	27.05	32.42
9.	P_9	46.70	48.89	42.15	45.91
10.	P_{10}	53.35	58.42	47.52	53.09
11.	$P_1 \times P_2$	28.04	37.44	22.95	29.47
12.	$P_2 \times P_1$	28.66	38.90	23.25	30.27
13.	$P_1 \times P_3$	27.06	37.63	22.87	29.48
14.	$P_3 \times P_1$	28.22	38.61	23.35	30.05
15.	$P_1 \times P_4$	29.42	39.81	24.57	31.26
16.	$P_4 \times P_1$	31.07	40.28	24.96	32.10
17.	$P_1 \times P_5$	26.42	32.11	23.23	27.25
18.	$P_5 \times P_1$	25.65	32.72	22.92	27.09
19.	$P_1 \times P_6$	36.73	37.04	31.05	34.94
20.	$P_6 \times P_1$	36.52	37.61	30.91	35.01
21.	$P_1 \times P_7$	32.73	35.00	27.90	31.87
22.	$P_7 \times P_1$	33.16	34.34	27.56	31.69
23.	$P_1 \times P_8$	58.18	58.73	52.23	56.39
24.	$P_8 \times P_1$	56.40	59.33	51.43	55.72
25.	$P_1 \times P_9$	58.49	58.61	53.08	56.72
26.	$P_9 \times P_1$	58.69	61.94	52.73	57.79

TABLE 9 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	54.45	58.13	49.00	53.86
28.	$P_{10} \times P_1$	55.11	57.92	49.63	54.22
29.	$P_2 \times P_3$	29.57	34.13	24.93	29.54
30.	$P_3 \times P_2$	30.27	33.92	25.12	29.77
31.	$P_2 \times P_4$	29.55	36.21	24.12	29.96
32.	$P_4 \times P_2$	30.57	37.22	24.52	30.77
33.	$P_2 \times P_5$	29.27	34.56	23.92	29.25
34.	$P_5 \times P_2$	29.04	34.76	24.03	29.27
35.	$P_2 \times P_6$	43.45	46.44	38.11	42.66
36.	$P_6 \times P_2$	44.10	45.20	38.00	42.47
37.	$P_2 \times P_7$	32.15	37.57	27.11	32.27
38.	$P_7 \times P_2$	32.42	36.36	25.99	32.25
39.	$P_2 \times P_8$	44.79	48.45	39.60	44.27
40.	$P_8 \times P_2$	46.37	49.32	39.76	45.31
41.	$P_2 \times P_9$	45.08	52.24	39.98	46.30
42.	$P_9 \times P_2$	44.03	53.38	37.92	45.10
43.	$P_2 \times P_{10}$	49.28	48.04	40.05	44.72
44.	$P_{10} \times P_2$	45.20	48.53	40.55	44.75
45.	$P_3 \times P_4$	32.40	33.91	29.57	31.95
46.	$P_4 \times P_3$	33.73	33.93	30.95	32.93
47.	$P_5 \times P_5$	30.60	30.78	25.94	29.11
48.	$P_5 \times P_3$	30.27	31.75	25.63	29.22
49.	$P_3 \times P_6$	55.58	54.30	49.26	53.05
50.	$P_6 \times P_3$	57.90	60.31	50.41	56.21
51.	$P_3 \times P_7$	37.55	38.53	31.48	35.85
52.	$P_7 \times P_3$	37.24	38.29	31.03	35.51
53.	$P_3 \times P_8$	45.95	48.97	40.29	45.03
54.	$P_8 \times P_3$	46.27	48.53	39.31	44.70

TABLE 9 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	42.42	47.83	37.59	42.61
56.	$P_9 \times P_3$	42.49	46.47	37.52	42.16
57.	$P_3 \times P_{10}$	57.90	59.58	52.54	56.47
58.	$P_{10} \times P_3$	58.17	59.22	52.85	56.74
59.	$P_4 \times P_5$	41.10	42.86	32.93	38.94
60.	$P_5 \times P_4$	41.43	41.98	34.41	39.29
61.	$P_4 \times P_6$	35.60	36.68	35.93	36.07
62.	$P_6 \times P_4$	41.04	42.73	35.28	39.68
63.	$P_4 \times P_7$	30.35	32.69	25.78	29.60
64.	$P_7 \times P_4$	31.60	32.05	26.01	29.88
65.	$P_4 \times P_8$	49.93	53.74	45.10	49.59
66.	$P_8 \times P_4$	50.15	52.14	44.42	48.90
67.	$P_4 \times P_9$	40.00	43.25	34.02	39.09
68.	$P_9 \times P_4$	41.16	42.02	35.68	39.62
69.	$P_4 \times P_{10}$	54.12	56.38	48.93	53.14
70.	$P_{10} \times P_4$	54.13	53.95	48.67	52.25
71.	$P_5 \times P_6$	52.79	57.11	45.04	51.64
72.	$P_6 \times P_5$	54.33	55.17	46.44	51.98
73.	$P_5 \times P_7$	29.90	33.36	24.94	29.39
74.	$P_7 \times P_5$	30.97	33.96	24.21	29.04
75.	$P_5 \times P_8$	42.77	46.22	35.94	41.64
76.	$P_8 \times P_5$	43.05	43.71	36.35	41.03
77.	$P_5 \times P_9$	51.07	56.86	45.02	50.98
78.	$P_9 \times P_5$	49.23	55.05	43.05	49.10
79.	$P_5 \times P_{10}$	53.56	60.93	46.94	53.78
80.	$P_{10} \times P_5$	55.33	58.76	48.04	54.04

TABLE 9 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	42.36	44.67	36.97	41.33
82.	$P_7 \times P_6$	42.07	44.71	36.02	40.93
83.	$P_6 \times P_8$	60.50	61.23	54.88	58.86
84.	$P_8 \times P_6$	60.61	61.41	54.46	58.82
85.	$P_6 \times P_9$	44.50	50.51	59.27	51.43
86.	$P_9 \times P_6$	44.86	48.76	58.90	50.84
87.	$P_6 \times P_{10}$	57.04	60.84	53.04	56.98
88.	$P_{10} \times P_6$	58.71	59.14	52.62	56.82
89.	$P_7 \times P_8$	34.26	41.22	27.85	34.44
90.	$P_8 \times P_7$	34.97	42.65	28.04	35.49
91.	$P_7 \times P_9$	48.05	50.73	44.13	47.94
92.	$P_9 \times P_7$	47.91	51.91	43.41	47.74
93.	$P_7 \times P_{10}$	45.92	49.68	40.04	45.20
94.	$P_{10} \times P_7$	44.97	47.43	39.50	43.96
95.	$P_8 \times P_9$	58.50	60.57	52.63	57.23
96.	$P_9 \times P_8$	57.80	59.47	52.57	56.61
97.	$P_8 \times P_{10}$	65.59	65.50	59.61	63.56
98.	$P_{10} \times P_8$	65.61	66.18	60.09	63.94
99.	$P_9 \times P_{10}$	63.22	62.43	57.72	61.12
100.	$P_{10} \times P_9$	63.76	65.36	58.67	62.59
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.718	0.242	0.420	0.518
	Parent	34.12	37.95	28.94	33.67
	Combination	43.65	47.07	34.40	41.71

TABLE 10

Grain-straw ratio

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	0.875	0.905	0.846	0.875
2.	P_2	0.914	0.934	0.902	0.916
3.	P_3	0.920	0.927	0.935	0.927
4.	P_4	0.902	0.895	0.901	0.899
5.	P_5	0.843	0.854	0.843	0.847
6.	P_6	0.500	0.493	0.502	0.498
7.	P_7	0.487	0.497	0.485	0.489
8.	P_8	0.468	0.502	0.464	0.478
9.	P_9	0.418	0.461	0.403	0.427
10.	P_{10}	0.488	0.503	0.483	0.491
11.	$P_1 \times P_2$	0.702	0.858	0.866	0.835
12.	$P_2 \times P_1$	0.770	0.814	0.898	0.828
13.	$P_1 \times P_3$	0.905	0.835	0.951	0.897
14.	$P_3 \times P_1$	0.874	0.832	0.846	0.851
15.	$P_1 \times P_4$	0.886	0.790	0.862	0.846
16.	$P_4 \times P_1$	0.853	0.786	0.877	0.838
17.	$P_1 \times P_5$	0.932	0.896	0.856	0.895
18.	$P_5 \times P_1$	0.929	0.858	0.872	0.886
19.	$P_1 \times P_6$	0.717	0.795	0.709	0.739
20.	$P_6 \times P_1$	0.719	0.774	0.713	0.735
21.	$P_1 \times P_7$	0.677	0.708	0.691	0.692
22.	$P_7 \times P_1$	0.677	0.709	0.699	0.695
23.	$P_1 \times P_8$	0.486	0.478	0.462	0.475
24.	$P_8 \times P_1$	0.510	0.490	0.486	0.495
25.	$P_1 \times P_9$	0.413	0.477	0.381	0.423
26.	$P_9 \times P_1$	0.415	0.443	0.386	0.415

TABLE 10 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	0.501	0.491	0.463	0.485
28.	$P_{10} \times P_1$	0.494	0.493	0.481	0.489
29.	$P_2 \times P_3$	0.885	0.865	0.860	0.871
30.	$P_3 \times P_2$	0.877	0.874	0.846	0.865
31.	$P_2 \times P_4$	0.822	0.836	0.850	0.835
32.	$P_4 \times P_2$	0.823	0.824	0.897	0.848
33.	$P_2 \times P_5$	0.683	0.704	0.630	0.672
34.	$P_5 \times P_2$	0.705	0.662	0.661	0.676
35.	$P_2 \times P_6$	0.654	0.649	0.654	0.652
36.	$P_6 \times P_2$	0.643	0.655	0.656	0.651
37.	$P_2 \times P_7$	0.577	0.573	0.553	0.568
38.	$P_7 \times P_2$	0.579	0.588	0.577	0.581
39.	$P_2 \times P_8$	0.599	0.567	0.497	0.554
40.	$P_8 \times P_2$	0.576	0.557	0.515	0.549
41.	$P_2 \times P_9$	0.494	0.486	0.431	0.470
42.	$P_9 \times P_2$	0.507	0.480	0.500	0.496
43.	$P_2 \times P_{10}$	0.562	0.589	0.541	0.564
44.	$P_{10} \times P_2$	0.571	0.576	0.549	0.565
45.	$P_3 \times P_4$	0.905	0.876	0.811	0.863
46.	$P_4 \times P_3$	0.869	0.902	0.802	0.858
47.	$P_3 \times P_5$	0.938	0.935	0.895	0.923
48.	$P_5 \times P_3$	0.960	0.941	0.936	0.946
49.	$P_3 \times P_6$	0.561	0.555	0.542	0.553
50.	$P_6 \times P_3$	0.547	0.513	0.523	0.527
51.	$P_3 \times P_7$	0.651	0.650	0.635	0.645
52.	$P_7 \times P_3$	0.669	0.661	0.650	0.660
53.	$P_3 \times P_8$	0.555	0.528	0.529	0.537
54.	$P_8 \times P_3$	0.561	0.549	0.532	0.547

TABLE 10 (Contd.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	0.676	0.604	0.643	0.661
56.	$P_9 \times P_3$	0.706	0.659	0.674	0.679
57.	$P_3 \times P_{10}$	0.584	0.520	0.514	0.525
58.	$P_{10} \times P_3$	0.524	0.495	0.513	0.510
59.	$P_4 \times P_5$	0.740	0.714	0.752	0.735
60.	$P_5 \times P_4$	0.738	0.729	0.701	0.723
61.	$P_4 \times P_6$	0.832	0.842	0.715	0.796
62.	$P_6 \times P_4$	0.744	0.732	0.723	0.733
63.	$P_4 \times P_7$	0.740	0.691	0.714	0.715
64.	$P_7 \times P_4$	0.718	0.693	0.725	0.712
65.	$P_4 \times P_8$	0.493	0.489	0.462	0.481
66.	$P_8 \times P_4$	0.497	0.481	0.472	0.483
67.	$P_4 \times P_9$	0.622	0.612	0.611	0.615
68.	$P_9 \times P_4$	0.610	0.600	0.597	0.605
69.	$P_4 \times P_{10}$	0.526	0.521	0.457	0.501
70.	$P_{10} \times P_4$	0.528	0.532	0.516	0.525
71.	$P_5 \times P_6$	0.497	0.475	0.508	0.493
72.	$P_6 \times P_5$	0.491	0.500	0.474	0.488
73.	$P_5 \times P_7$	0.661	0.639	0.650	0.650
74.	$P_7 \times P_5$	0.703	0.656	0.709	0.689
75.	$P_5 \times P_8$	0.510	0.488	0.500	0.499
76.	$P_8 \times P_5$	0.507	0.500	0.493	0.499
77.	$P_5 \times P_9$	0.454	0.449	0.430	0.444
78.	$P_9 \times P_5$	0.466	0.454	0.444	0.454
79.	$P_5 \times P_{10}$	0.490	0.481	0.477	0.485
80.	$P_{10} \times P_5$	0.476	0.496	0.467	0.479

TABLE 10 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	0.498	0.503	0.518	0.506
82.	$P_7 \times P_6$	0.510	0.495	0.506	0.503
83.	$P_6 \times P_8$	0.502	0.480	0.384	0.455
84.	$P_8 \times P_6$	0.509	0.493	0.384	0.462
85.	$P_6 \times P_9$	0.493	0.491	0.372	0.452
86.	$P_9 \times P_6$	0.459	0.470	0.367	0.432
87.	$P_6 \times P_{10}$	0.504	0.496	0.509	0.502
88.	$P_{10} \times P_6$	0.505	0.496	0.515	0.505
89.	$P_7 \times P_8$	0.503	0.507	0.557	0.522
90.	$P_8 \times P_7$	0.506	0.493	0.541	0.515
91.	$P_7 \times P_9$	0.440	0.466	0.430	0.445
92.	$P_9 \times P_7$	0.450	0.460	0.430	0.446
93.	$P_7 \times P_{10}$	0.488	0.496	0.485	0.489
94.	$P_{10} \times P_7$	0.507	0.494	0.503	0.502
95.	$P_8 \times P_9$	0.456	0.431	0.420	0.428
96.	$P_9 \times P_8$	0.432	0.427	0.417	0.425
97.	$P_8 \times P_{10}$	0.417	0.442	0.418	0.426
98.	$P_{10} \times P_8$	0.435	0.441	0.426	0.433
99.	$P_9 \times P_{10}$	0.402	0.431	0.393	0.408
100.	$P_{10} \times P_9$	0.401	0.421	0.392	0.404
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.0089	0.0092	0.0162	0.0109
	Parent	0.6815	0.6974	0.6762	0.6850
	Combination	0.6135	0.6075	0.5943	0.6051

TABLE 11

Grain length (mm)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	9.05	9.11	8.93	9.03
2.	P_2	7.60	7.71	7.59	7.62
3.	P_3	8.24	8.32	8.20	8.25
4.	P_4	7.28	7.40	7.26	7.31
5.	P_5	7.00	7.07	6.93	7.00
6.	P_6	8.31	8.40	8.20	8.30
7.	P_7	9.11	9.13	8.93	9.06
8.	P_8	9.80	9.93	9.67	9.80
9.	P_9	9.25	9.33	9.17	9.25
10.	P_{10}	9.22	9.28	9.11	9.20
11.	$P_1 \times P_2$	7.89	8.09	8.03	8.00
12.	$P_2 \times P_1$	7.93	8.13	8.04	8.03
13.	$P_1 \times P_3$	8.65	8.75	9.25	8.97
14.	$P_3 \times P_1$	8.63	8.73	8.47	8.61
15.	$P_1 \times P_4$	8.20	8.33	8.80	8.44
16.	$P_4 \times P_1$	8.10	8.21	7.91	8.10
17.	$P_1 \times P_5$	7.89	7.93	8.18	8.00
18.	$P_5 \times P_1$	7.98	8.03	8.01	8.01
19.	$P_1 \times P_6$	8.45	8.68	8.74	8.61
20.	$P_6 \times P_1$	8.51	8.76	8.61	8.63
21.	$P_1 \times P_7$	9.14	9.12	9.04	9.10
22.	$P_7 \times P_1$	9.11	9.03	9.01	9.07
23.	$P_1 \times P_8$	9.55	9.65	9.35	9.52
24.	$P_8 \times P_1$	9.67	8.77	9.46	9.63
25.	$P_1 \times P_9$	9.35	9.39	9.28	9.34
26.	$P_9 \times P_1$	9.43	9.45	9.29	9.37

TABLE 11 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	9.41	9.48	9.23	9.37
28.	$P_{10} \times P_1$	9.42	9.47	9.30	9.40
29.	$P_2 \times P_3$	8.03	8.20	7.89	8.04
30.	$P_3 \times P_2$	8.05	8.21	7.85	8.04
31.	$P_2 \times P_4$	7.55	8.72	7.54	7.94
32.	$P_4 \times P_2$	7.63	7.75	7.52	7.65
33.	$P_2 \times P_5$	7.35	7.45	6.91	7.24
34.	$P_5 \times P_2$	7.28	7.40	6.95	7.21
35.	$P_2 \times P_6$	8.45	8.48	8.25	8.39
36.	$P_6 \times P_2$	8.40	8.49	8.11	8.36
37.	$P_2 \times P_7$	8.72	8.76	8.67	8.72
38.	$P_7 \times P_2$	8.71	8.69	8.63	8.68
39.	$P_2 \times P_8$	9.31	9.33	8.97	9.20
40.	$P_8 \times P_2$	9.27	9.23	9.03	9.18
41.	$P_2 \times P_9$	8.75	8.79	8.76	8.77
42.	$P_9 \times P_2$	8.83	8.84	8.71	8.79
43.	$P_2 \times P_{10}$	8.94	8.97	8.91	8.94
44.	$P_{10} \times P_2$	8.95	8.99	8.90	8.95
45.	$P_3 \times P_4$	7.75	7.87	7.83	7.82
46.	$P_4 \times P_3$	7.85	7.72	7.80	7.79
47.	$P_3 \times P_5$	7.81	7.94	7.70	7.81
48.	$P_5 \times P_3$	7.91	7.94	7.73	7.83
49.	$P_3 \times P_6$	9.27	8.71	8.49	8.82
50.	$P_6 \times P_3$	8.55	8.45	8.42	8.47
51.	$P_3 \times P_7$	8.85	8.96	8.83	8.88
52	$P_7 \times P_3$	8.93	8.99	8.79	8.90
53.	$P_3 \times P_8$	9.32	9.40	9.14	9.29
54.	$P_8 \times P_3$	9.31	9.40	9.14	9.21

TABLE 11 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	8.96	9.07	8.82	8.95
56.	$P_9 \times P_3$	8.96	9.03	8.92	8.97
57.	$P_3 \times P_{10}$	9.02	9.79	8.91	9.24
58.	$P_{10} \times P_3$	9.04	9.08	8.87	9.00
59.	$P_4 \times P_5$	6.83	6.90	7.14	6.98
60.	$P_5 \times P_4$	6.87	7.05	7.09	7.00
61.	$P_4 \times P_6$	8.21	8.27	8.09	8.19
62.	$P_6 \times P_4$	8.24	8.33	8.05	8.21
63.	$P_4 \times P_7$	8.54	8.52	8.37	8.48
64.	$P_7 \times P_4$	8.49	8.63	8.41	8.51
65.	$P_4 \times P_8$	8.85	8.97	8.85	8.89
66.	$P_8 \times P_4$	8.81	9.03	8.73	8.86
67.	$P_4 \times P_9$	8.63	8.65	8.35	8.54
68.	$P_9 \times P_4$	8.63	8.77	8.43	8.61
69.	$P_4 \times P_{10}$	8.56	8.59	8.45	8.53
70.	$P_{10} \times P_4$	8.57	8.60	8.61	8.59
71.	$P_5 \times P_6$	8.14	8.24	8.07	8.15
72.	$P_6 \times P_5$	8.12	8.25	7.95	8.11
73.	$P_5 \times P_7$	8.35	8.43	8.18	8.31
74.	$P_7 \times P_5$	7.99	8.60	8.25	8.08
75.	$P_5 \times P_8$	8.78	8.91	8.63	8.77
76.	$P_8 \times P_5$	8.81	8.95	8.63	8.79
77.	$P_5 \times P_9$	8.39	8.49	8.35	8.41
78.	$P_9 \times P_5$	8.44	8.56	8.31	8.44
79.	$P_5 \times P_{10}$	8.48	8.55	8.39	8.45
80.	$P_{10} \times P_5$	8.55	8.64	8.39	8.51

TABLE 11 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	8.73	8.83	8.73	8.76
82.	$P_7 \times P_6$	8.69	8.91	8.76	8.79
83.	$P_6 \times P_8$	9.16	9.15	9.10	9.10
84.	$P_8 \times P_6$	9.16	9.33	9.15	9.21
85.	$P_6 \times P_9$	8.87	8.99	8.75	8.87
86.	$P_9 \times P_6$	8.88	9.04	8.75	8.89
87.	$P_6 \times P_{10}$	9.13	9.21	9.05	9.13
88.	$P_{10} \times P_6$	9.13	9.25	9.00	9.13
89.	$P_7 \times P_8$	9.41	9.50	9.38	9.45
90.	$P_8 \times P_7$	9.39	9.67	9.35	9.47
91.	$P_7 \times P_9$	9.20	9.39	9.15	9.25
92.	$P_9 \times P_7$	9.15	9.31	9.11	9.19
93.	$P_7 \times P_{10}$	9.14	9.19	9.09	9.14
94.	$P_{10} \times P_7$	9.12	9.13	9.11	9.12
95.	$P_8 \times P_9$	9.55	9.67	9.46	9.56
96.	$P_9 \times P_8$	9.53	9.63	9.39	9.52
97.	$P_8 \times P_{10}$	9.50	9.64	9.43	9.52
98.	$P_{10} \times P_8$	9.53	9.69	9.37	9.56
99.	$P_9 \times P_{10}$	9.29	9.28	9.18	9.25
100.	$P_{10} \times P_9$	9.23	9.53	9.15	9.14
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.0164	0.0322	0.0749	0.0447
	Parent	8.486	8.568	8.395	8.483
	Combination	8.691	8.752	8.572	8.672

TABLE 12

Grain width (mm)

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	3.05	3.08	3.00	3.04
2.	P_2	3.07	3.13	3.04	3.08
3.	P_3	3.03	3.12	2.93	3.03
4.	P_4	3.33	3.31	3.13	3.26
5.	P_5	2.87	2.93	2.73	2.84
6.	P_6	2.39	2.48	2.33	2.40
7.	P_7	2.17	2.17	2.12	2.15
8.	P_8	2.37	2.44	2.24	2.35
9.	P_9	2.43	2.53	2.37	2.44
10.	P_{10}	2.35	2.40	2.33	2.36
11.	$P_1 \times P_2$	2.89	3.03	2.75	2.89
12.	$P_2 \times P_1$	2.86	2.97	2.67	2.84
13.	$P_1 \times P_3$	2.85	3.03	2.84	2.90
14.	$P_3 \times P_1$	2.81	3.02	2.80	2.88
15.	$P_1 \times P_4$	3.20	3.25	3.03	3.16
16.	$P_4 \times P_1$	3.09	3.19	2.97	3.08
17.	$P_1 \times P_5$	2.93	2.99	2.91	2.94
18.	$P_5 \times P_1$	2.89	3.02	2.80	2.90
19.	$P_1 \times P_6$	2.80	2.89	2.76	2.82
20.	$P_6 \times P_1$	2.85	2.96	2.73	2.85
21.	$P_1 \times P_7$	2.61	2.60	2.57	2.59
22.	$P_7 \times P_1$	2.52	2.56	2.56	2.55
23.	$P_1 \times P_8$	2.75	2.81	2.65	2.74
24.	$P_8 \times P_1$	2.68	2.89	2.69	2.75
25.	$P_1 \times P_9$	2.82	2.87	2.75	2.81
26.	$P_9 \times P_1$	2.75	2.77	2.75	2.76

TABLE 12 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	2.72	2.80	2.68	2.73
28.	$P_{10} \times P_1$	2.75	2.77	2.75	2.76
29.	$P_2 \times P_3$	3.10	3.09	3.08	3.09
30.	$P_3 \times P_2$	3.09	3.11	3.07	3.09
31.	$P_2 \times P_4$	3.29	3.27	3.32	3.29
32.	$P_4 \times P_2$	3.25	3.23	3.31	3.26
33.	$P_2 \times P_5$	3.00	3.11	2.95	3.02
34.	$P_5 \times P_2$	3.00	3.08	2.96	3.01
35.	$P_2 \times P_6$	2.87	2.91	2.89	2.89
36.	$P_6 \times P_2$	2.86	2.87	2.85	2.86
37.	$P_2 \times P_7$	2.85	2.87	2.73	2.82
38.	$P_7 \times P_2$	2.82	2.87	2.73	2.81
39.	$P_2 \times P_8$	2.71	2.77	2.64	2.71
40.	$P_8 \times P_2$	2.72	2.73	2.72	2.72
41.	$P_2 \times P_9$	2.92	2.85	2.73	2.80
42.	$P_9 \times P_2$	2.75	2.79	2.72	2.75
43.	$P_2 \times P_{10}$	2.77	2.79	2.75	2.77
44.	$P_{10} \times P_2$	2.71	2.79	2.69	2.73
45.	$P_3 \times P_4$	3.11	3.19	3.12	3.14
46.	$P_4 \times P_3$	3.09	3.11	3.12	3.10
47.	$P_3 \times P_5$	2.91	3.04	2.88	2.94
48.	$P_5 \times P_3$	2.99	3.07	2.91	2.99
49.	$P_3 \times P_6$	2.72	2.79	2.72	2.74
50.	$P_6 \times P_3$	2.76	2.68	2.68	2.71
51.	$P_3 \times P_7$	2.57	2.59	2.56	2.57
52.	$P_7 \times P_3$	2.62	2.65	2.51	2.59
53.	$P_3 \times P_8$	2.66	2.69	2.60	2.65
54.	$P_8 \times P_3$	2.65	2.68	2.59	2.64

TABLE 12 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	2.83	2.89	2.69	2.80
56.	$P_9 \times P_3$	2.79	2.88	2.79	2.82
57.	$P_3 \times P_{10}$	2.65	2.80	2.67	2.71
58.	$P_{10} \times P_3$	2.65	2.76	2.61	2.67
59.	$P_4 \times P_5$	3.05	3.15	3.08	3.09
60.	$P_5 \times P_4$	3.16	3.17	3.04	3.12
61.	$P_4 \times P_6$	2.85	2.91	2.91	2.89
62.	$P_6 \times P_4$	2.81	2.93	2.87	2.87
63.	$P_4 \times P_7$	2.82	2.87	2.80	2.83
64.	$P_7 \times P_4$	2.81	2.92	2.81	2.85
65.	$P_4 \times P_8$	2.83	2.92	2.83	2.86
66.	$P_8 \times P_4$	2.83	2.93	2.79	2.85
67.	$P_4 \times P_9$	2.95	3.01	2.80	2.92
68.	$P_9 \times P_4$	2.94	3.03	2.77	2.91
69.	$P_4 \times P_{10}$	2.85	2.88	2.80	2.87
70.	$P_{10} \times P_4$	2.90	2.89	2.83	2.87
71.	$P_5 \times P_6$	2.77	2.91	2.68	2.79
72.	$P_6 \times P_5$	2.72	2.93	2.64	2.76
73.	$P_5 \times P_7$	2.51	2.63	2.41	2.52
74.	$P_7 \times P_5$	2.49	2.64	2.43	2.52
75.	$P_5 \times P_8$	2.62	2.76	2.49	2.62
76.	$P_8 \times P_5$	2.59	2.80	2.40	2.63
77.	$P_5 \times P_9$	2.74	2.80	2.73	2.76
78.	$P_9 \times P_5$	2.83	2.92	2.69	2.81
79.	$P_5 \times P_{10}$	2.57	2.65	2.57	2.60
80.	$P_{10} \times P_5$	2.65	2.71	2.57	2.64

TABLE 12 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	2.27	2.37	2.23	2.29
82.	$P_7 \times P_6$	2.29	2.44	2.23	2.32
83.	$P_6 \times P_8$	2.19	2.36	2.29	2.28
84.	$P_8 \times P_6$	2.20	2.44	2.33	2.32
85.	$P_6 \times P_9$	2.52	2.57	2.35	2.48
86.	$P_9 \times P_6$	2.53	2.60	2.35	2.49
87.	$P_6 \times P_{10}$	2.41	2.40	2.36	2.39
88.	$P_{10} \times P_6$	2.38	2.40	2.31	2.36
89.	$P_7 \times P_8$	2.27	2.35	2.24	2.29
90.	$P_8 \times P_7$	2.30	2.37	2.21	2.29
91.	$P_7 \times P_9$	2.41	2.51	2.35	2.42
92.	$P_9 \times P_7$	2.37	2.44	2.29	2.37
93.	$P_7 \times P_{10}$	2.21	2.33	2.23	2.26
94.	$P_{10} \times P_7$	2.19	2.37	2.25	2.27
95.	$P_8 \times P_9$	2.54	2.49	2.32	2.45
96.	$P_9 \times P_8$	2.53	2.44	2.37	2.45
97.	$P_8 \times P_{10}$	2.39	2.43	2.29	2.37
98.	$P_{10} \times P_8$	2.38	2.44	2.24	2.35
99.	$P_9 \times P_{10}$	2.52	2.52	2.39	2.48
100.	$P_{10} \times P_9$	2.52	2.53	2.36	2.47
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.0235	0.0215	0.0196	0.0218
	Parent	2.706	2.759	2.622	2.696
	Combination	2.722	2.791	2.666	2.726

TABLE 13

Length-width ratio of grain

Mean expression

Sl.No.	Parent/Combination	S_1	S_2	S_3	Pooled
1.	P_1	2.96	2.96	2.79	2.904
2.	P_2	2.51	2.46	2.14	2.370
3.	P_3	2.72	2.67	2.41	2.600
4.	P_4	2.10	2.24	1.98	2.134
5.	P_5	2.44	2.41	2.08	2.312
6.	P_6	3.40	3.39	3.10	3.323
7.	P_7	4.21	4.20	4.00	4.136
8.	P_8	4.14	4.03	3.67	3.969
9.	P_9	3.81	3.69	3.38	3.628
10.	P_{10}	3.93	3.88	3.57	3.794
11.	$P_1 \times P_2$	2.73	2.68	2.20	2.537
12.	$P_2 \times P_1$	2.75	2.73	2.21	2.567
13.	$P_1 \times P_3$	3.03	2.89	2.58	2.835
14.	$P_3 \times P_1$	3.07	2.86	2.60	2.851
15.	$P_1 \times P_4$	2.56	2.56	2.32	2.492
16.	$P_4 \times P_1$	2.65	2.58	2.32	2.516
17.	$P_1 \times P_5$	2.67	2.66	2.50	2.618
18.	$P_5 \times P_1$	2.76	2.66	2.49	2.635
19.	$P_1 \times P_6$	3.01	3.00	2.89	2.971
20.	$P_6 \times P_1$	2.98	2.96	2.92	2.955
21.	$P_1 \times P_7$	3.50	3.52	3.15	3.386
22.	$P_7 \times P_1$	3.61	3.56	3.15	3.436
23.	$P_1 \times P_8$	3.48	3.43	2.92	3.277
24.	$P_8 \times P_1$	3.61	3.50	2.92	3.303
25.	$P_1 \times P_9$	3.51	3.36	3.06	3.244
26.	$P_9 \times P_1$	3.50	3.41	3.09	3.334

TABLE 13 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
27.	$P_1 \times P_{10}$	3.46	3.39	3.19	3.348
28.	$P_{10} \times P_1$	3.43	3.41	3.15	3.329
29.	$P_2 \times P_3$	2.59	2.66	2.29	2.511
30.	$P_3 \times P_2$	2.60	2.65	2.28	2.514
31.	$P_2 \times P_4$	2.29	2.37	2.10	2.251
32.	$P_4 \times P_2$	2.35	2.40	2.06	2.271
33.	$P_2 \times P_5$	2.45	2.40	2.14	2.328
34.	$P_5 \times P_2$	2.43	2.40	2.15	2.319
35.	$P_2 \times P_6$	2.95	2.92	2.61	2.824
36.	$P_6 \times P_2$	2.96	2.96	2.63	2.853
37.	$P_2 \times P_7$	3.04	3.06	3.02	3.040
38.	$P_7 \times P_2$	3.09	3.04	3.03	3.051
39.	$P_2 \times P_8$	3.44	3.37	3.02	3.279
40.	$P_8 \times P_2$	3.42	3.37	2.96	3.248
41.	$P_2 \times P_9$	3.10	3.08	2.71	2.964
42.	$P_9 \times P_2$	3.22	3.18	2.75	3.050
43.	$P_2 \times P_{10}$	3.24	3.23	2.75	3.072
44.	$P_{10} \times P_2$	3.31	3.23	2.85	3.129
45.	$P_3 \times P_4$	2.49	2.47	2.14	2.365
46.	$P_4 \times P_3$	2.55	2.47	2.15	2.383
47.	$P_3 \times P_5$	2.72	2.61	2.19	2.508
48.	$P_5 \times P_3$	2.61	2.60	2.19	2.465
49.	$P_3 \times P_6$	3.15	3.12	2.85	3.041
50.	$P_6 \times P_3$	3.10	3.10	2.97	3.022
51.	$P_3 \times P_7$	3.45	3.46	3.15	3.355
52.	$P_7 \times P_3$	3.41	3.45	3.17	3.340
53.	$P_3 \times P_8$	3.50	3.51	2.98	3.332
54.	$P_8 \times P_3$	3.50	3.47	2.98	3.315

TABLE 15 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
55.	$P_3 \times P_9$	3.17	3.14	2.97	3.095
56.	$P_9 \times P_3$	3.21	3.14	2.97	3.104
57.	$P_3 \times P_{10}$	3.40	3.24	3.00	3.214
58.	$P_{10} \times P_3$	3.42	3.24	3.03	3.226
59.	$P_4 \times P_5$	2.24	2.22	2.03	2.161
60.	$P_5 \times P_4$	2.17	2.24	2.07	2.165
61.	$P_4 \times P_6$	2.88	2.84	2.42	2.714
62.	$P_6 \times P_4$	2.94	2.84	2.46	2.745
63.	$P_4 \times P_7$	3.03	2.98	2.83	2.947
64.	$P_7 \times P_4$	3.02	2.96	2.83	2.940
65.	$P_4 \times P_8$	3.12	3.07	2.76	2.983
66.	$P_8 \times P_4$	3.04	3.08	2.80	2.975
67.	$P_4 \times P_9$	2.93	2.88	2.40	2.734
68.	$P_9 \times P_4$	2.94	2.91	2.45	2.764
69.	$P_4 \times P_{10}$	3.01	2.98	2.63	2.873
70.	$P_{10} \times P_4$	2.96	2.97	2.71	2.878
71.	$P_5 \times P_6$	2.94	2.83	2.59	2.787
72.	$P_6 \times P_5$	2.99	2.82	2.62	2.809
73.	$P_5 \times P_7$	3.32	3.27	2.90	3.160
74.	$P_7 \times P_5$	3.36	3.27	2.86	3.165
75.	$P_5 \times P_8$	3.35	3.23	2.74	3.109
76.	$P_8 \times P_5$	3.41	3.20	2.79	3.118
77.	$P_5 \times P_9$	3.06	3.04	2.67	2.921
78.	$P_9 \times P_5$	2.97	2.94	2.67	2.858
79.	$P_5 \times P_{10}$	3.30	3.25	2.61	3.046
80.	$P_{10} \times P_5$	3.25	3.19	2.56	3.002

TABLE 13 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
81.	$P_6 \times P_7$	3.84	3.72	3.30	3.624
82.	$P_7 \times P_6$	3.80	3.66	3.33	3.596
83.	$P_6 \times P_8$	4.18	3.68	3.39	3.816
84.	$P_8 \times P_6$	4.16	3.82	3.39	3.793
85.	$P_6 \times P_9$	3.52	3.49	3.34	3.452
86.	$P_9 \times P_6$	3.50	3.49	3.33	3.442
87.	$P_6 \times P_{10}$	3.78	3.85	3.37	3.670
88.	$P_{10} \times P_6$	3.82	3.85	3.38	3.684
89.	$P_7 \times P_8$	4.14	4.08	3.67	3.963
90.	$P_8 \times P_7$	4.08	4.07	3.70	3.950
91.	$P_7 \times P_9$	3.82	3.74	3.66	3.742
92.	$P_9 \times P_7$	3.86	3.82	3.69	3.792
93.	$P_7 \times P_{10}$	4.13	3.96	3.80	3.963
94.	$P_{10} \times P_7$	4.16	4.02	3.75	3.974
95.	$P_8 \times P_9$	3.76	3.88	3.54	3.724
96.	$P_9 \times P_8$	3.76	3.91	3.51	3.730
97.	$P_8 \times P_{10}$	3.97	3.97	3.57	3.836
98.	$P_{10} \times P_8$	4.00	3.97	3.54	3.838
99.	$P_9 \times P_{10}$	3.69	3.69	3.37	3.585
100.	$P_{10} \times P_9$	3.66	3.69	3.47	3.609
	Significance by				
	F test	Yes	Yes	Yes	Yes
	SE	0.0383	0.0255	0.0187	0.0224
	Parent	3.323	3.198	2.912	3.146
	Combination	3.214	3.177	2.857	3.083

The parent P_8 possessed the longest grain in the seasons (9.67 to 9.93 mm) followed by P_9 and P_{10} while P_5 had the shortest grain, the length being 6.93 to 7.07 mm (Table 11).

The parent P_4 recorded the maximum grain width with an average of 3.26 mm followed by P_2, P_1 and P_3 while P_7, the narrowest grain of 2.15 mm (Table 12).

The parent P_7 recorded the highest length-width ratio of grain (4.136) followed by P_8 and P_{10} while P_4, the lowest ratio of 2.134 (Table 13).

C. Evaluation of the Hybrids

1. Characters and the expression of heterosis

a. Plant height: Among the ninety combinations studied, the combinations $P_9 \times P_{10}$ and its reciprocal were taller than the rest, the height being 145.72 and 148.25 cm respectively, while the combination $P_4 \times P_5$ recorded the shortest height of 75.09 cm (Table 3).

The heterosis of the F_1s ranged from -0.19 to 21.02 per cent, the combination $P_2 \times P_6$ recording the maximum and $P_2 \times P_5$, the minimum (Table 14).

b. Bearing tillers per plant: The combinations $P_6 \times P_3$, $P_3 \times P_{10}$ and $P_3 \times P_8$ produced more number of tillers per plant

TABLE 14

Plant height

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	2.12	2.40	-1.17	1.12
2.	$P_2 \times P_1$	3.05	2.34	1.29	2.23
3.	$P_1 \times P_3$	1.03	2.11	-0.75	1.06
4.	$P_3 \times P_1$	1.36	6.05	0.44	2.62
5.	$P_1 \times P_4$	4.75	6.03	4.53	5.10
6.	$P_4 \times P_1$	5.27	11.80	6.74	7.94
7.	$P_1 \times P_5$	7.39	-2.04	1.31	2.22
8.	$P_5 \times P_1$	4.53	-2.10	0.37	0.93
9.	$P_1 \times P_6$	23.38	19.38	17.80	20.35
10.	$P_6 \times P_1$	18.31	19.80	19.68	19.09
11.	$P_1 \times P_7$	3.75	3.87	3.74	3.79
12.	$P_7 \times P_1$	5.19	6.29	6.35	5.94
13.	$P_1 \times P_8$	8.26	12.52	8.69	9.82
14.	$P_8 \times P_1$	8.01	7.06	7.40	7.49
15.	$P_1 \times P_9$	8.23	12.60	14.80	11.88
16.	$P_9 \times P_1$	8.89	9.54	17.15	11.86
17.	$P_1 \times P_{10}$	11.44	14.84	17.22	14.50
18.	$P_{10} \times P_1$	11.48	11.86	18.72	14.02
19.	$P_2 \times P_3$	2.62	5.87	6.47	4.90
20.	$P_3 \times P_2$	1.94	9.66	7.31	6.30
21.	$P_2 \times P_4$	3.84	8.48	2.69	5.00
22.	$P_4 \times P_2$	4.97	6.01	5.41	5.46
23.	$P_2 \times P_5$	-0.37	-0.24	0.03	-0.19
24.	$P_5 \times P_2$	0.31	4.76	2.49	2.52
25.	$P_2 \times P_6$	16.12	17.04	29.90	21.02
26.	$P_6 \times P_2$	15.38	15.35	19.10	16.60
27.	$P_2 \times P_7$	2.72	2.14	8.66	4.51
28.	$P_7 \times P_2$	1.63	7.44	4.66	4.58

TABLE 14 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	20.89	21.43	13.43	18.58
30.	$P_8 \times P_2$	18.08	18.04	13.63	16.58
31.	$P_2 \times P_9$	1.91	8.49	18.62	9.67
32.	$P_9 \times P_2$	1.20	4.48	19.37	8.35
33.	$P_2 \times P_{10}$	13.09	13.19	16.12	14.80
34.	$P_{10} \times P_2$	12.89	0.47	18.99	13.45
35.	$P_3 \times P_4$	0.27	1.50	2.34	1.37
36.	$P_4 \times P_3$	1.84	7.56	6.13	5.17
37.	$P_3 \times P_5$	-0.09	0.46	0.22	0.20
38.	$P_5 \times P_3$	-0.50	1.32	2.53	1.12
39.	$P_3 \times P_6$	6.37	13.58	11.75	10.57
40.	$P_6 \times P_3$	6.42	12.36	4.09	7.92
41.	$P_3 \times P_7$	0.40	1.68	3.84	1.77
42.	$P_7 \times P_3$	0.55	2.30	0.05	0.93
43.	$P_3 \times P_8$	17.35	17.53	14.17	16.35
44.	$P_8 \times P_3$	17.08	16.68	14.42	16.06
45.	$P_3 \times P_9$	3.94	9.45	7.15	5.85
46.	$P_9 \times P_3$	3.57	3.54	4.98	4.03
47.	$P_3 \times P_{10}$	8.42	9.34	11.78	9.85
48.	$P_{10} \times P_3$	8.02	8.60	12.54	9.72
49.	$P_4 \times P_5$	-2.87	0.09	-1.65	-1.18
50.	$P_5 \times P_4$	-0.72	11.76	2.41	4.48
51.	$P_4 \times P_6$	20.29	21.26	10.19	17.25
52.	$P_6 \times P_4$	20.34	22.43	14.40	19.06
53.	$P_4 \times P_7$	13.78	18.98	9.06	13.94
54.	$P_7 \times P_4$	14.05	16.52	11.50	14.02
55.	$P_4 \times P_8$	14.31	19.41	11.88	15.20
56.	$P_8 \times P_4$	13.82	20.49	14.35	16.22
57.	$P_4 \times P_9$	8.35	12.10	10.49	10.31
58.	$P_9 \times P_4$	6.31	8.40	7.31	7.34
59.	$P_4 \times P_{10}$	19.09	15.46	19.90	18.15
60.	$P_{10} \times P_4$	12.75	10.23	16.31	13.10

TABLE 14 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	17.02	20.36	13.66	17.01
62.	$P_6 \times P_5$	15.42	19.11	17.72	17.42
63.	$P_5 \times P_7$	6.10	9.47	11.61	9.06
64.	$P_7 \times P_5$	6.75	13.70	7.94	9.46
65.	$P_5 \times P_8$	9.28	12.82	8.23	10.11
66.	$P_8 \times P_5$	9.00	10.91	10.59	10.19
67.	$P_5 \times P_9$	5.44	9.06	8.37	7.62
68.	$P_9 \times P_5$	5.27	6.38	10.92	7.52
69.	$P_5 \times P_{10}$	5.11	5.97	9.71	6.93
70.	$P_{10} \times P_5$	6.28	4.99	12.05	7.77
71.	$P_6 \times P_7$	4.10	5.63	3.85	4.53
72.	$P_7 \times P_6$	5.38	5.38	2.20	4.32
73.	$P_6 \times P_8$	10.45	12.42	6.97	9.95
74.	$P_8 \times P_6$	10.56	11.17	4.56	8.76
75.	$P_6 \times P_9$	3.73	8.30	6.10	6.04
76.	$P_9 \times P_6$	6.51	8.00	4.39	6.30
77.	$P_6 \times P_{10}$	-1.50	-0.17	1.68	0.003
78.	$P_{10} \times P_6$	-1.22	0.23	0.30	-0.23
79.	$P_7 \times P_8$	5.37	8.16	5.16	6.23
80.	$P_8 \times P_7$	4.36	7.66	7.05	6.36
81.	$P_7 \times P_9$	2.99	3.21	3.22	3.14
82.	$P_9 \times P_7$	2.86	3.38	1.65	2.63
83.	$P_7 \times P_{10}$	-4.22	-4.61	-0.12	-2.98
84.	$P_{10} \times P_7$	-4.67	-4.58	-1.04	-3.43
85.	$P_8 \times P_9$	6.68	7.91	5.00	6.56
86.	$P_9 \times P_8$	6.38	6.67	6.86	6.46
87.	$P_8 \times P_{10}$	2.54	2.64	0.29	1.82
88.	$P_{10} \times P_8$	2.48	1.20	1.41	1.70
89.	$P_9 \times P_{10}$	2.08	2.32	2.34	1.56
90.	$P_{10} \times P_9$	3.37	4.67	4.03	4.02

TABLE 15

Earbearing tillers per plant

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	23.94	10.76	13.16	15.95
2.	$P_2 \times P_1$	22.78	11.11	15.94	16.61
3.	$P_1 \times P_3$	2.35	1.94	13.84	6.04
4.	$P_3 \times P_1$	1.18	11.1	22.77	11.68
5.	$P_1 \times P_4$	6.37	-0.85	13.65	6.39
6.	$P_4 \times P_1$	7.49	7.23	15.44	10.07
7.	$P_1 \times P_5$	8.35	10.81	18.55	12.74
8.	$P_5 \times P_1$	9.12	5.66	18.10	10.96
9.	$P_1 \times P_6$	9.64	9.31	4.85	7.93
10.	$P_6 \times P_1$	26.60	16.66	24.67	16.64
11.	$P_1 \times P_7$	4.80	17.21	16.91	12.97
12.	$P_7 \times P_1$	3.97	15.28	15.94	11.72
13.	$P_1 \times P_8$	8.40	13.63	14.63	12.22
14.	$P_8 \times P_1$	13.45	15.16	16.07	14.89
15.	$P_1 \times P_9$	13.55	15.85	15.79	15.06
16.	$P_9 \times P_1$	14.75	9.06	12.44	12.08
17.	$P_1 \times P_{10}$	-0.55	4.78	10.42	4.88
18.	$P_{10} \times P_1$	-0.02	3.41	5.00	2.50
19.	$P_2 \times P_3$	6.52	2.85	8.17	5.78
20.	$P_3 \times P_2$	9.88	7.12	13.47	10.16
21.	$P_2 \times P_4$	10.21	9.56	11.95	11.57
22.	$P_4 \times P_2$	13.40	12.97	9.29	11.09
23.	$P_2 \times P_5$	-3.06	9.69	-1.57	1.57
24.	$P_5 \times P_2$	-3.42	4.84	2.91	1.44
25.	$P_2 \times P_6$	14.29	23.89	13.73	17.30
26.	$P_6 \times P_2$	14.67	11.26	22.00	15.98
27.	$P_2 \times P_7$	30.10	27.34	11.69	23.04
28.	$P_7 \times P_2$	28.84	11.97	12.65	17.82

TABLE 15 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	30.51	26.36	18.96	25.28
30.	$P_8 \times P_2$	11.36	14.73	12.80	12.96
31.	$P_2 \times P_9$	30.75	18.48	16.31	21.85
32.	$P_9 \times P_2$	25.87	12.38	13.00	17.08
33.	$P_2 \times P_{10}$	9.46	9.12	4.74	7.77
34.	$P_{10} \times P_2$	9.46	4.65	10.10	8.07
35.	$P_3 \times P_4$	18.39	12.97	19.06	16.81
36.	$P_4 \times P_3$	11.49	10.92	8.79	10.40
37.	$P_3 \times P_5$	9.69	13.15	11.26	11.37
38.	$P_5 \times P_3$	11.88	9.00	11.69	10.86
39.	$P_3 \times P_6$	14.89	9.22	16.46	13.52
40.	$P_6 \times P_3$	18.38	16.04	25.74	20.05
41.	$P_3 \times P_7$	23.34	23.41	12.44	19.73
42.	$P_7 \times P_3$	27.62	16.67	21.66	21.98
43.	$P_3 \times P_8$	34.91	33.59	27.23	31.91
44.	$P_8 \times P_3$	33.19	19.14	20.82	24.38
45.	$P_3 \times P_9$	19.67	24.95	18.26	20.96
46.	$P_9 \times P_3$	22.98	16.37	20.55	20.03
47.	$P_3 \times P_{10}$	16.82	20.14	12.40	16.45
48.	$P_{10} \times P_3$	13.42	2.93	6.80	7.72
49.	$P_4 \times P_5$	-0.17	10.63	4.99	5.15
50.	$P_5 \times P_4$	-0.17	5.98	-1.08	1.57
51.	$P_4 \times P_6$	15.54	6.39	19.23	13.82
52.	$P_6 \times P_4$	12.02	10.82	12.05	11.63
53.	$P_4 \times P_7$	21.39	25.75	17.78	21.64
54.	$P_7 \times P_4$	21.34	14.18	15.01	16.84
55.	$P_4 \times P_8$	14.75	20.37	17.89	17.67
56.	$P_8 \times P_4$	22.54	8.89	13.30	14.91
57.	$P_4 \times P_9$	13.21	10.75	9.38	11.11
58.	$P_9 \times P_4$	13.10	8.20	16.25	12.52
59.	$P_4 \times P_{10}$	0.18	0.16	5.41	1.92
60.	$P_{10} \times P_4$	4.52	-4.13	1.40	0.60

TAMIL NADU Agricultural University LIBRARY 113918

TABLE 13 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	7.77	8.31	8.97	8.35
62.	$P_6 \times P_5$	7.42	7.31	11.11	8.61
63.	$P_5 \times P_7$	4.30	17.42	4.67	8.80
64.	$P_7 \times P_5$	5.81	14.02	2.34	7.38
65.	$P_5 \times P_8$	14.23	19.17	6.73	13.38
66.	$P_8 \times P_5$	16.57	12.03	-0.23	9.46
67.	$P_5 \times P_9$	6.39	19.04	8.80	11.41
68.	$P_9 \times P_5$	9.02	4.25	-4.62	2.88
69.	$P_5 \times P_{10}$	8.65	12.90	10.93	10.82
70.	$P_{10} \times P_5$	7.96	6.53	9.31	7.93
71.	$P_6 \times P_7$	21.81	14.93	26.82	21.19
72.	$P_7 \times P_6$	15.64	14.18	15.00	14.94
73.	$P_6 \times P_8$	27.12	20.74	24.15	24.00
74.	$P_8 \times P_6$	27.25	16.67	19.19	21.04
75.	$P_6 \times P_9$	16.33	18.40	25.68	20.14
76.	$P_9 \times P_6$	17.93	10.75	18.47	15.72
77.	$P_6 \times P_{10}$	4.01	5.12	7.11	5.41
78.	$P_{10} \times P_6$	5.11	5.12	6.32	5.52
79.	$P_7 \times P_8$	32.56	25.32	31.51	29.80
80.	$P_8 \times P_7$	33.49	32.19	24.51	30.06
81.	$P_7 \times P_9$	34.96	28.00	33.66	32.21
82.	$P_9 \times P_7$	33.63	29.60	25.25	29.52
83.	$P_7 \times P_{10}$	23.29	19.02	10.30	17.54
84.	$P_{10} \times P_7$	20.88	11.86	11.16	14.63
85.	$P_8 \times P_9$	33.18	34.03	38.57	35.26
86.	$P_9 \times P_8$	37.64	28.60	32.68	32.96
87.	$P_8 \times P_{10}$	26.46	20.00	18.55	21.67
88.	$P_{10} \times P_8$	20.81	11.78	12.15	14.91
89.	$P_9 \times P_{10}$	17.51	15.44	14.47	15.81
90.	$P_{10} \times P_9$	12.45	6.62	11.89	10.32

TABLE 16

Panicle length

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-1.43	-9.26	2.49	-2.71
2.	$P_2 \times P_1$	1.53	-4.41	-3.82	-2.23
3.	$P_1 \times P_3$	-2.40	0.40	2.70	0.23
4.	$P_3 \times P_1$	-6.83	-8.88	-1.15	-6.29
5.	$P_1 \times P_4$	0.77	6.09	2.96	3.27
6.	$P_4 \times P_1$	3.23	-0.37	-2.97	-0.04
7.	$P_1 \times P_5$	-6.25	-0.16	4.53	-0.71
8.	$P_5 \times P_1$	-2.00	-7.51	0.25	-3.09
9.	$P_1 \times P_6$	-0.64	2.57	5.58	2.50
10.	$P_6 \times P_1$	0.18	1.58	6.47	2.74
11.	$P_1 \times P_7$	-3.07	4.96	-2.55	-0.22
12.	$P_7 \times P_1$	-3.88	0.80	6.56	-0.84
13.	$P_1 \times P_8$	-4.49	3.49	-5.18	-2.06
14.	$P_8 \times P_1$	-3.31	-5.41	5.65	-1.02
15.	$P_1 \times P_9$	-4.30	-1.68	-1.06	-2.35
16.	$P_9 \times P_1$	-1.80	-1.38	-2.28	-1.99
17.	$P_1 \times P_{10}$	-2.20	9.26	-2.85	1.38
18.	$P_{10} \times P_1$	3.39	-3.75	-2.65	-1.00
19.	$P_2 \times P_3$	2.89	-1.56	-0.20	0.38
20.	$P_3 \times P_2$	0.20	-3.22	1.37	-1.22
21.	$P_2 \times P_4$	0.36	3.64	-1.02	0.99
22.	$P_4 \times P_2$	-3.22	-1.48	4.01	-0.23
23.	$P_2 \times P_5$	-6.13	-0.46	-0.16	-2.25
24.	$P_5 \times P_2$	-9.03	-6.99	3.86	-4.32
25.	$P_2 \times P_6$	4.45	5.80	4.87	5.04
26.	$P_6 \times P_2$	3.06	5.06	8.27	5.46
27.	$P_2 \times P_7$	9.64	6.80	-0.71	5.24
28.	$P_7 \times P_2$	10.16	5.75	-0.56	5.12

TABLE 16 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	5.75	6.90	3.81	5.35
30.	$P_8 \times P_2$	6.24	-3.09	7.49	3.55
31.	$P_2 \times P_9$	4.16	6.31	3.21	4.56
32.	$P_9 \times P_2$	7.02	-1.67	4.63	3.33
33.	$P_2 \times P_{10}$	-3.31	0.94	0.71	-0.55
34.	$P_{10} \times P_2$	-2.41	-4.03	2.06	-1.46
35.	$P_3 \times P_4$	5.40	-0.76	0.54	1.73
36.	$P_4 \times P_3$	21.45	4.71	8.68	11.61
37.	$P_3 \times P_5$	3.22	-6.32	-5.93	-3.01
38.	$P_5 \times P_3$	1.67	-1.52	0.37	0.17
39.	$P_3 \times P_6$	7.90	5.79	-7.53	2.05
40.	$P_6 \times P_3$	4.25	4.83	6.64	5.24
41.	$P_3 \times P_7$	11.92	10.78	4.74	9.15
42.	$P_7 \times P_3$	10.72	7.81	-2.60	5.31
43.	$P_3 \times P_8$	13.69	8.84	10.55	11.03
44.	$P_8 \times P_3$	14.43	6.93	8.82	10.06
45.	$P_3 \times P_9$	1.09	2.56	7.71	3.79
46.	$P_9 \times P_3$	2.59	-4.70	7.07	1.65
47.	$P_3 \times P_{10}$	-2.38	2.73	-2.06	-0.57
48.	$P_{10} \times P_3$	-0.43	-6.10	0.45	-2.03
49.	$P_4 \times P_5$	0.74	3.11	0.19	1.35
50.	$P_5 \times P_4$	2.37	-0.27	2.41	1.50
51.	$P_4 \times P_6$	4.79	11.47	5.60	7.29
52.	$P_6 \times P_4$	8.36	7.15	8.38	7.96
53.	$P_4 \times P_7$	2.00	9.66	2.79	4.81
54.	$P_7 \times P_4$	3.17	11.10	4.46	6.24
55.	$P_4 \times P_8$	-0.50	-0.81	-0.77	-0.69
56.	$P_8 \times P_4$	3.06	1.06	7.26	3.79
57.	$P_4 \times P_9$	3.00	-1.60	4.56	1.99
58.	$P_9 \times P_4$	3.26	-0.75	0.00	1.50
59.	$P_4 \times P_{10}$	-1.59	-0.04	4.05	0.81
60.	$P_{10} \times P_4$	-2.85	-3.81	-4.33	-3.66

TABLE 16 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	11.62	10.54	1.38	7.98
62.	$P_6 \times P_5$	9.63	8.49	6.90	8.34
63.	$P_5 \times P_7$	5.09	7.95	7.62	6.89
64.	$P_7 \times P_5$	9.96	11.19	3.09	8.05
65.	$P_5 \times P_8$	9.75	9.49	3.60	7.61
66.	$P_8 \times P_5$	8.56	4.50	5.53	6.20
67.	$P_5 \times P_9$	3.49	2.31	-3.83	0.90
68.	$P_9 \times P_5$	2.76	2.08	8.75	4.53
69.	$P_5 \times P_{10}$	1.77	2.24	1.41	1.81
70.	$P_{10} \times P_5$	3.19	-1.92	2.79	1.39
71.	$P_6 \times P_7$	-3.13	-1.57	0.69	-1.34
72.	$P_7 \times P_6$	-2.93	-0.59	-3.20	-2.24
73.	$P_6 \times P_8$	0.54	3.75	1.11	1.80
74.	$P_8 \times P_6$	2.87	4.97	-1.92	1.97
75.	$P_6 \times P_9$	0.85	1.93	2.27	1.68
76.	$P_9 \times P_6$	1.79	0.80	-0.28	0.80
77.	$P_6 \times P_{10}$	0.27	1.18	1.60	1.02
78.	$P_{10} \times P_6$	1.93	0.62	0.14	0.90
79.	$P_7 \times P_8$	3.44	6.72	9.74	6.63
80.	$P_8 \times P_7$	4.86	9.62	15.87	10.12
81.	$P_7 \times P_9$	7.04	2.17	1.54	3.88
82.	$P_9 \times P_7$	1.05	-0.53	4.70	1.57
83.	$P_7 \times P_{10}$	1.23	0.46	0.92	0.87
84.	$P_{10} \times P_7$	-1.03	-2.37	4.37	0.32
85.	$P_8 \times P_9$	-7.92	-10.39	0.92	-5.80
86.	$P_9 \times P_8$	-3.69	-10.54	-0.51	-6.58
87.	$P_8 \times P_{10}$	-2.82	-2.43	-0.67	-1.97
88.	$P_{10} \times P_8$	-2.32	-4.56	2.60	-1.43
89.	$P_9 \times P_{10}$	-4.21	-6.15	0.32	-3.35
90.	$P_{10} \times P_9$	-3.50	-4.77	2.39	-3.63

TABLE 17

Number of grains per panicle

Estimates of heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-0.77	-1.35	1.06	-0.35
2.	$P_2 \times P_1$	1.11	0.94	-0.43	0.54
3.	$P_1 \times P_3$	-1.06	0.20	-0.85	-0.57
4.	$P_3 \times P_1$	-6.24	-7.38	2.77	-3.62
5.	$P_1 \times P_4$	2.91	1.16	6.12	3.40
6.	$P_4 \times P_1$	7.39	3.52	1.80	4.24
7.	$P_1 \times P_5$	-4.87	-5.21	2.94	-2.38
8.	$P_5 \times P_1$	-5.06	-1.53	-4.16	-3.58
9.	$P_1 \times P_6$	-6.15	-6.60	-4.38	-5.71
10.	$P_6 \times P_1$	-3.66	-2.91	1.99	-1.53
11.	$P_1 \times P_7$	0.10	-2.50	-3.64	-2.01
12.	$P_7 \times P_1$	0.81	2.13	-1.75	0.39
13.	$P_1 \times P_8$	-0.03	0.57	1.39	0.64
14.	$P_8 \times P_1$	2.40	-0.90	-0.11	0.54
15.	$P_1 \times P_9$	-5.05	-3.04	-2.83	-1.61
16.	$P_9 \times P_1$	-4.17	-0.73	-3.08	-2.66
17.	$P_1 \times P_{10}$	-13.18	-6.97	-3.38	-7.84
18.	$P_{10} \times P_1$	-10.47	-3.64	-2.89	-7.33
19.	$P_2 \times P_3$	1.16	3.69	1.03	1.96
20.	$P_3 \times P_2$	0.19	-2.12	0.93	-0.33
21.	$P_2 \times P_4$	0.37	1.38	-0.67	0.36
22.	$P_4 \times P_2$	0.70	1.70	3.27	1.89
23.	$P_2 \times P_5$	-14.20	-4.64	-5.33	-8.06
24.	$P_5 \times P_2$	-16.36	-1.35	-2.74	-6.82
25.	$P_2 \times P_6$	0.56	2.14	-0.12	0.79
26.	$P_6 \times P_2$	0.41	-0.33	1.16	0.41
27.	$P_2 \times P_7$	-0.19	-1.62	-1.71	-1.17
28.	$P_7 \times P_2$	-5.78	-0.19	-1.76	-2.58

TABLE 17 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	1.27	0.60	0.95	0.93
30.	$P_8 \times P_2$	2.57	1.03	3.42	2.56
31.	$P_2 \times P_9$	-4.60	2.16	0.10	-0.78
32.	$P_9 \times P_2$	-5.33	-1.53	1.59	-1.92
33.	$P_2 \times P_{10}$	-8.70	-3.06	-3.00	-4.92
34.	$P_{10} \times P_2$	-10.41	-8.49	-2.71	-7.20
35.	$P_3 \times P_4$	-3.20	-0.65	0.05	-1.27
36.	$P_4 \times P_3$	-2.27	0.52	0.87	-0.29
37.	$P_3 \times P_5$	-1.09	-1.25	-0.39	-0.91
38.	$P_5 \times P_3$	-1.33	-1.75	2.01	-0.36
39.	$P_3 \times P_6$	1.22	-1.07	3.20	1.12
40.	$P_6 \times P_3$	1.81	3.84	2.09	2.58
41.	$P_3 \times P_7$	1.44	2.74	2.49	2.22
42.	$P_7 \times P_3$	1.69	2.17	-1.62	0.75
43.	$P_3 \times P_8$	2.41	5.03	1.09	2.84
44.	$P_8 \times P_3$	1.86	3.03	1.04	1.98
45.	$P_3 \times P_9$	-2.26	0.58	-0.64	-0.77
46.	$P_9 \times P_3$	-2.17	-1.12	0.69	-0.87
47.	$P_3 \times P_{10}$	-1.40	1.20	0.64	0.15
48.	$P_{10} \times P_3$	-2.89	-7.10	1.45	-2.85
49.	$P_4 \times P_5$	-0.64	0.58	0.17	-0.63
50.	$P_5 \times P_4$	-2.74	1.51	1.20	-0.01
51.	$P_4 \times P_6$	3.34	3.55	1.20	3.36
52.	$P_6 \times P_4$	6.21	6.24	5.86	6.10
53.	$P_4 \times P_7$	-3.03	-3.78	-2.65	-4.84
54.	$P_7 \times P_4$	-7.52	-3.59	-1.55	-4.22
55.	$P_4 \times P_8$	-3.13	-2.39	-2.67	-2.73
56.	$P_8 \times P_4$	-2.41	-2.99	-1.28	-2.23
57.	$P_4 \times P_9$	-6.59	-0.66	0.01	-2.41
58.	$P_9 \times P_4$	-7.84	-2.62	-1.02	-3.83
59.	$P_4 \times P_{10}$	1.73	1.91	2.19	1.94
60.	$P_{10} \times P_4$	1.04	-1.53	-1.59	-0.69

TABLE 17 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	0.13	1.60	-0.22	0.50
62.	$P_6 \times P_5$	0.76	-3.12	1.29	-2.02
63.	$P_5 \times P_7$	-7.94	-5.73	-4.43	-6.00
64.	$P_7 \times P_5$	-3.42	-5.26	-3.38	-5.69
65.	$P_5 \times P_8$	-7.96	-3.77	-5.57	-5.75
66.	$P_8 \times P_5$	7.65	-6.84	4.20	1.64
67.	$P_5 \times P_9$	-4.18	1.22	-1.18	-1.38
68.	$P_9 \times P_5$	-3.83	-1.97	-0.69	-2.16
69.	$P_5 \times P_{10}$	-0.69	-1.62	3.49	0.39
70.	$P_{10} \times P_5$	0.13	-4.57	0.40	-1.35
71.	$P_6 \times P_7$	-0.94	1.65	1.00	0.57
72.	$P_7 \times P_6$	-0.85	-6.25	-3.68	-3.59
73.	$P_6 \times P_8$	-2.59	-0.14	2.34	-0.13
74.	$P_8 \times P_6$	-2.17	3.37	10.92	4.04
75.	$P_6 \times P_9$	-3.36	-1.48	0.17	-3.56
76.	$P_9 \times P_6$	-11.31	-5.17	-0.12	-5.55
77.	$P_6 \times P_{10}$	-11.68	0.25	1.71	-3.24
78.	$P_{10} \times P_6$	-10.56	-2.57	3.05	-4.36
79.	$P_7 \times P_8$	1.52	2.43	7.19	3.71
80.	$P_8 \times P_7$	3.28	5.43	1.63	3.45
81.	$P_7 \times P_9$	2.14	0.09	-2.21	-1.48
82.	$P_9 \times P_7$	-2.36	-2.95	1.75	-1.18
83.	$P_7 \times P_{10}$	-0.82	-5.17	-1.27	-2.42
84.	$P_{10} \times P_7$	-0.42	-3.26	-4.94	-2.87
85.	$P_8 \times P_9$	-0.90	2.72	3.41	1.74
86.	$P_9 \times P_8$	-1.80	-1.05	2.18	-0.22
87.	$P_8 \times P_{10}$	4.74	0.81	-1.53	1.34
88.	$P_{10} \times P_8$	4.25	1.70	1.63	2.53
89.	$P_9 \times P_{10}$	7.21	-0.65	0.21	2.55
90.	$P_{10} \times P_9$	-8.09	-0.70	-6.77	-5.19

TABLE 18

100 grain weight (g)

Estimates of heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	3.23	6.34	4.26	4.61
2.	$P_2 \times P_1$	3.44	5.46	4.05	4.32
3.	$P_1 \times P_3$	2.99	0.02	1.24	1.42
4.	$P_3 \times P_1$	3.24	1.51	1.24	1.99
5.	$P_1 \times P_4$	-0.84	1.85	-2.75	-0.58
6.	$P_4 \times P_1$	-1.61	-0.70	-2.67	-1.66
7.	$P_1 \times P_5$	-0.39	1.45	0.87	0.64
8.	$P_5 \times P_1$	0.41	3.49	1.45	1.78
9.	$P_1 \times P_6$	2.11	1.50	2.03	1.81
10.	$P_6 \times P_1$	1.84	1.61	1.79	1.75
11.	$P_1 \times P_7$	4.50	8.82	-2.50	3.61
12.	$P_7 \times P_1$	5.82	6.19	-2.70	3.10
13.	$P_1 \times P_8$	6.50	6.72	4.18	5.67
14.	$P_8 \times P_1$	5.65	6.80	4.64	5.70
15.	$P_1 \times P_9$	13.68	14.59	11.45	13.24
16.	$P_9 \times P_1$	9.53	10.53	11.52	10.46
17.	$P_1 \times P_{10}$	3.57	4.00	2.72	3.43
18.	$P_{10} \times P_1$	2.92	2.97	3.20	3.03
19.	$P_2 \times P_3$	2.86	1.93	3.63	2.81
20.	$P_3 \times P_2$	6.43	7.36	2.10	5.30
21.	$P_2 \times P_4$	2.60	4.67	2.34	3.23
22.	$P_4 \times P_2$	4.44	4.80	3.34	4.19
23.	$P_2 \times P_5$	1.86	1.31	2.04	1.74
24.	$P_5 \times P_2$	-0.83	-0.99	1.69	-0.04
25.	$P_2 \times P_6$	6.88	6.76	8.68	7.44
26.	$P_6 \times P_2$	6.06	5.63	7.19	6.29
27.	$P_2 \times P_7$	17.39	15.59	16.78	16.52
28.	$P_7 \times P_2$	15.33	15.95	16.32	15.87

TABLE 18 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	11.94	13.69	12.97	12.87
30.	$P_8 \times P_2$	12.40	14.88	13.17	13.48
31.	$P_2 \times P_9$	-0.90	0.25	0.87	0.07
32.	$P_9 \times P_2$	-1.00	0.42	0.87	0.10
33.	$P_2 \times P_{10}$	2.94	2.19	3.81	2.99
34.	$P_{10} \times P_2$	3.23	2.66	3.43	3.11
35.	$P_3 \times P_4$	3.70	1.14	2.10	2.31
36.	$P_4 \times P_3$	0.99	1.24	2.01	1.41
37.	$P_3 \times P_5$	-1.95	-3.98	0.16	-1.92
38.	$P_5 \times P_3$	-1.74	-1.83	0.34	-1.08
39.	$P_3 \times P_6$	0.95	-4.19	2.58	-0.23
40.	$P_6 \times P_3$	1.11	-0.94	2.14	0.77
41.	$P_3 \times P_7$	11.54	7.63	1.14	6.77
42.	$P_7 \times P_3$	14.44	9.16	0.08	7.89
43.	$P_3 \times P_8$	2.76	1.09	2.26	2.04
44.	$P_8 \times P_3$	0.45	1.05	2.30	1.27
45.	$P_3 \times P_9$	3.65	1.14	3.28	2.69
46.	$P_9 \times P_3$	3.24	1.01	4.04	2.76
47.	$P_3 \times P_{10}$	0.37	-2.03	1.02	-0.21
48.	$P_{10} \times P_3$	0.13	-1.57	0.80	-0.21
49.	$P_4 \times P_5$	1.93	3.70	3.05	2.89
50.	$P_5 \times P_4$	1.61	2.82	2.57	2.33
51.	$P_4 \times P_6$	3.93	4.66	6.69	5.09
52.	$P_6 \times P_4$	5.25	6.09	5.77	5.90
53.	$P_4 \times P_7$	8.68	7.66	-1.27	5.02
54.	$P_7 \times P_4$	6.97	8.48	-0.65	4.93
55.	$P_4 \times P_8$	2.42	4.55	6.37	4.44
56.	$P_8 \times P_4$	3.03	2.70	5.77	3.83
57.	$P_4 \times P_9$	3.81	3.47	2.72	3.33
58.	$P_9 \times P_4$	2.06	1.06	3.12	2.08
59.	$P_4 \times P_{10}$	-0.58	-0.37	-0.65	-0.53
60.	$P_{10} \times_4$	0.25	-0.04	-0.33	-0.04

TABLE 18 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	8.01	7.79	7.98	8.43
62.	$P_6 \times P_5$	9.40	8.45	9.20	9.01
63.	$P_5 \times P_7$	7.10	6.94	7.42	7.15
64.	$P_7 \times P_5$	5.45	6.16	8.16	6.58
65.	$P_5 \times P_8$	-0.17	2.83	1.94	1.53
66.	$P_8 \times P_5$	1.26	3.97	1.78	2.34
67.	$P_5 \times P_9$	11.64	12.04	12.23	11.97
68.	$P_9 \times P_5$	13.13	12.56	11.15	12.28
69.	$P_5 \times P_{10}$	2.91	3.22	3.38	3.17
70.	$P_{10} \times P_5$	2.48	3.45	3.53	3.09
71.	$P_6 \times P_7$	3.92	1.92	5.00	3.61
72.	$P_7 \times P_6$	2.77	5.27	5.27	5.77
73.	$P_6 \times P_8$	1.15	2.67	2.70	2.18
74.	$P_8 \times P_6$	1.61	3.46	3.58	2.88
75.	$P_6 \times P_9$	0.69	-2.08	1.67	0.09
76.	$P_9 \times P_6$	-3.59	-2.08	1.67	-1.32
77.	$P_6 \times P_{10}$	1.81	2.41	2.35	2.19
78.	$P_{10} \times P_6$	0.82	1.14	1.22	1.06
79.	$P_7 \times P_8$	1.53	2.12	1.23	1.63
80.	$P_8 \times P_7$	1.69	3.28	0.52	1.87
81.	$P_7 \times P_9$	7.39	9.26	7.91	8.17
82.	$P_9 \times P_7$	7.32	7.71	7.20	7.41
83.	$P_7 \times P_{10}$	0.07	1.74	-1.03	0.21
84.	$P_{10} \times P_7$	-1.49	1.05	-0.32	-0.25
85.	$P_8 \times P_9$	7.00	8.79	6.01	6.93
86.	$P_9 \times P_8$	5.99	6.48	7.08	6.52
87.	$P_8 \times P_{10}$	-7.09	-4.16	3.10	-2.82
88.	$P_{10} \times P_8$	-1.76	-1.53	2.06	-0.34
89.	$P_9 \times P_{10}$	-0.46	2.90	2.08	1.51
90.	$P_{10} \times P_9$	0.18	2.16	1.15	1.16

TABLE 19

Grain yield per plant (g)

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-11.06	13.87	1.17	1.06
2.	$P_2 \times P_1$	-11.24	11.39	6.31	2.15
3.	$P_1 \times P_3$	0.86	11.68	7.67	6.74
4.	$P_3 \times P_1$	-1.65	14.14	-4.31	2.73
5.	$P_1 \times P_4$	0.13	8.49	-0.38	2.75
6.	$P_4 \times P_1$	1.52	9.12	3.11	4.58
7.	$P_1 \times P_5$	-1.82	1.84	2.21	0.74
8.	$P_5 \times P_1$	-4.69	0.45	-1.77	-2.00
9.	$P_1 \times P_6$	6.63	6.10	6.17	6.30
10.	$P_6 \times P_1$	6.39	5.14	6.22	5.92
11.	$P_1 \times P_7$	11.35	10.61	21.64	14.53
12.	$P_7 \times P_1$	12.53	8.67	21.51	14.24
13.	$P_1 \times P_8$	34.20	10.83	6.21	20.08
14.	$P_8 \times P_1$	36.40	24.17	3.54	21.39
15.	$P_1 \times P_9$	4.29	9.67	5.23	6.40
16.	$P_9 \times P_1$	5.32	7.57	27.50	13.46
17.	$P_1 \times P_{10}$	3.22	-0.47	2.32	1.69
18.	$P_{10} \times P_1$	2.53	-0.21	7.69	3.47
19.	$P_2 \times P_3$	13.51	13.77	16.69	14.59
20.	$P_3 \times P_2$	14.54	14.33	15.50	14.79
21.	$P_2 \times P_4$	0.64	12.92	5.45	6.34
22.	$P_4 \times P_2$	4.35	14.84	13.07	10.75
23.	$P_2 \times P_5$	13.65	-5.56	-18.62	-3.51
24.	$P_5 \times P_2$	11.62	-10.59	-14.25	-4.41
25.	$P_2 \times P_6$	24.97	18.13	31.70	24.93
26.	$P_6 \times P_2$	24.48	16.19	31.96	24.21
27.	$P_2 \times P_7$	3.06	6.53	6.98	5.52
28.	$P_7 \times P_2$	4.28	11.55	6.98	7.60

TABLE 19 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	40.53	29.52	29.52	33.19
30.	$P_8 \times P_2$	39.22	30.84	34.52	34.86
31.	$P_2 \times P_9$	4.87	23.49	8.99	12.45
32.	$P_9 \times P_2$	5.17	10.05	8.99	8.07
33.	$P_2 \times P_{10}$	3.76	8.72	6.36	6.28
34.	$P_{10} \times P_2$	5.43	5.53	9.20	6.72
35.	$P_3 \times P_4$	20.44	9.06	19.86	16.45
36.	$P_4 \times P_3$	20.48	12.38	24.16	19.01
37.	$P_3 \times P_5$	22.75	9.96	21.80	18.17
38.	$P_5 \times P_3$	24.36	14.14	25.00	21.17
39.	$P_3 \times P_6$	35.81	16.22	37.11	29.71
40.	$P_6 \times P_3$	37.71	19.09	35.27	30.69
41.	$P_3 \times P_7$	34.33	21.16	37.08	30.86
42.	$P_7 \times P_3$	36.86	25.38	38.31	33.52
43.	$P_3 \times P_8$	31.69	19.65	35.22	28.85
44.	$P_8 \times P_3$	33.96	23.00	32.68	29.88
45.	$P_3 \times P_9$	33.73	34.12	34.61	34.15
46.	$P_9 \times P_3$	39.00	29.12	40.85	36.62
47.	$P_3 \times P_{10}$	24.38	15.42	28.51	22.77
48.	$P_{10} \times P_3$	25.33	9.11	29.41	20.62
49.	$P_4 \times P_5$	24.55	13.11	22.75	20.14
50.	$P_5 \times P_4$	25.72	14.22	19.87	19.94
51.	$P_4 \times P_6$	21.45	15.28	25.13	20.62
52.	$P_6 \times P_4$	27.62	16.66	24.26	22.84
53.	$P_4 \times P_7$	17.14	4.96	17.17	13.27
54.	$P_7 \times P_4$	18.50	3.24	20.59	14.11
55.	$P_4 \times P_8$	21.13	16.72	23.90	20.58
56.	$P_8 \times P_4$	22.71	11.58	24.62	19.64
57.	$P_4 \times P_9$	11.04	7.87	9.39	9.43
58.	$P_9 \times P_4$	13.69	4.25	10.44	9.46
59.	$P_4 \times P_{10}$	10.67	6.09	13.22	9.99
60.	$P_{10} \times P_4$	11.32	3.55	14.36	9.74

TABLE 19 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	14.13	5.24	16.67	12.01
62.	$P_6 \times P_5$	16.20	7.12	12.23	11.85
63.	$P_5 \times P_7$	8.61	4.09	10.05	7.58
64.	$P_7 \times P_5$	11.83	8.78	16.50	12.37
65.	$P_5 \times P_8$	11.98	5.17	13.06	9.94
66.	$P_8 \times P_5$	12.64	1.82	13.38	9.28
67.	$P_5 \times P_9$	8.63	3.58	6.94	6.38
68.	$P_9 \times P_5$	7.09	2.03	4.50	4.54
69.	$P_5 \times P_{10}$	7.76	9.72	6.10	7.86
70.	$P_{10} \times P_5$	6.37	9.14	6.76	7.42
71.	$P_6 \times P_7$	18.52	11.17	26.70	8.90
72.	$P_7 \times P_6$	23.22	9.41	20.36	17.66
73.	$P_6 \times P_8$	60.31	38.40	29.20	42.64
74.	$P_8 \times P_6$	62.95	42.71	28.28	44.65
75.	$P_6 \times P_9$	4.23	6.48	19.22	9.98
76.	$P_9 \times P_6$	-2.16	-1.56	16.90	4.39
77.	$P_6 \times P_{10}$	10.20	14.20	25.33	10.41
78.	$P_{10} \times P_6$	25.45	10.89	26.16	20.17
79.	$P_7 \times P_8$	21.53	30.79	36.11	29.48
80.	$P_8 \times P_7$	24.42	33.45	31.20	29.69
81.	$P_7 \times P_9$	32.16	31.48	39.58	34.41
82.	$P_9 \times P_7$	32.35	32.79	36.93	34.02
83.	$P_7 \times P_{10}$	14.51	15.07	17.10	15.86
84.	$P_{10} \times P_7$	16.56	10.72	20.90	16.06
85.	$P_8 \times P_9$	46.14	37.50	49.12	44.25
86.	$P_9 \times P_8$	43.21	33.65	48.51	41.79
87.	$P_8 \times P_{10}$	32.16	30.99	40.38	34.51
88.	$P_{10} \times P_8$	37.73	31.81	44.05	37.86
89.	$P_9 \times P_{10}$	10.46	11.12	13.64	11.74
90.	$P_{10} \times P_9$	12.13	13.29	15.25	13.56

TABLE 20

Straw yield per plant

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	0.67	24.00	2.78	9.15
2.	$P_2 \times P_1$	2.90	12.29	4.12	6.44
3.	$P_1 \times P_3$	-0.15	22.27	0.09	7.40
4.	$P_3 \times P_1$	0.01	25.46	2.23	9.23
5.	$P_1 \times P_4$	0.34	23.57	0.76	8.22
6.	$P_4 \times P_1$	5.99	29.03	2.40	11.14
7.	$P_1 \times P_5$	-9.34	1.17	-3.57	-3.91
8.	$P_5 \times P_1$	-12.00	3.10	-4.36	-4.59
9.	$P_1 \times P_6$	-3.05	-12.67	-4.90	6.87
10.	$P_6 \times P_1$	-3.59	-11.20	-5.33	6.74
11.	$P_1 \times P_7$	14.09	7.40	20.15	13.88
12.	$P_7 \times P_1$	15.61	5.39	10.64	13.21
13.	$P_1 \times P_8$	84.28	66.14	99.46	83.29
14.	$P_8 \times P_1$	72.62	67.85	96.22	80.89
15.	$P_1 \times P_9$	51.14	43.06	57.23	50.48
16.	$P_9 \times P_1$	51.67	51.18	56.19	53.01
17.	$P_1 \times P_{10}$	29.72	27.13	34.45	30.43
18.	$P_{10} \times P_1$	31.30	26.66	36.20	31.39
19.	$P_2 \times P_3$	17.02	22.22	25.90	21.71
20.	$P_3 \times P_2$	19.81	21.48	26.86	22.72
21.	$P_2 \times P_4$	11.16	23.31	13.05	15.84
22.	$P_4 \times P_2$	15.02	26.75	14.93	18.90
23.	$P_2 \times P_5$	10.79	19.66	13.03	14.69
24.	$P_5 \times P_2$	9.93	20.37	14.16	14.84
25.	$P_2 \times P_6$	23.63	17.44	28.71	23.26
26.	$P_6 \times P_2$	25.49	14.45	29.61	23.18
27.	$P_2 \times P_7$	23.92	26.38	34.27	28.18
28.	$P_7 \times P_2$	24.96	29.03	28.73	27.57

TABLE 20 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	55.34	49.09	70.87	58.43
30.	$P_8 \times P_2$	60.32	53.31	70.87	61.67
31.	$P_2 \times P_9$	25.36	37.05	29.82	30.74
32.	$P_9 \times P_2$	22.44	40.06	23.43	28.64
33.	$P_2 \times P_{10}$	15.41	19.91	19.89	16.40
34.	$P_{10} \times P_2$	15.22	15.98	21.39	16.60
35.	$P_3 \times P_4$	23.49	13.22	35.31	24.01
36.	$P_4 \times P_3$	28.54	13.31	41.68	27.84
37.	$P_3 \times P_5$	15.19	4.47	20.36	13.34
38.	$P_5 \times P_3$	13.05	7.78	18.92	13.55
39.	$P_3 \times P_6$	57.46	55.32	63.58	52.12
40.	$P_6 \times P_3$	64.03	50.29	67.36	60.56
41.	$P_3 \times P_7$	43.87	27.08	52.12	41.02
42.	$P_7 \times P_3$	42.66	26.29	49.95	39.63
43.	$P_5 \times P_8$	58.14	48.05	70.10	58.76
44.	$P_8 \times P_5$	59.59	46.72	66.00	57.44
45.	$P_5 \times P_9$	17.45	25.59	20.36	20.47
46.	$P_9 \times P_5$	17.66	20.08	20.14	19.29
47.	$P_5 \times P_{10}$	45.99	37.09	54.33	45.80
48.	$P_{10} \times P_5$	47.69	36.26	55.80	46.58
49.	$P_4 \times P_5$	47.43	38.76	42.15	42.75
50.	$P_5 \times P_4$	48.79	38.85	48.99	44.54
51.	$P_4 \times P_6$	-2.76	-11.76	15.50	-0.34
52.	$P_6 \times P_4$	12.09	2.80	11.45	8.78
53.	$P_4 \times P_7$	10.72	2.93	15.99	9.89
54.	$P_7 \times P_4$	15.29	0.91	16.98	11.06
55.	$P_4 \times P_8$	67.74	55.70	78.86	67.43
56.	$P_8 \times P_4$	65.47	51.07	76.16	64.23
57.	$P_4 \times P_9$	6.38	7.75	5.83	6.15
58.	$P_9 \times P_4$	9.93	4.67	8.96	7.55
59.	$P_4 \times P_{10}$	32.98	25.56	30.03	30.39
60.	$P_{10} \times P_4$	32.99	26.14	28.03	30.39

TABLE 26 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$F_5 \times P_6$	44.89	39.00	43.59	42.49
62.	$P_6 \times P_5$	49.09	34.28	48.04	43.80
63.	$P_5 \times P_7$	9.73	6.66	13.62	10.02
64.	$P_7 \times P_5$	6.37	8.58	10.34	8.43
65.	$P_5 \times P_8$	41.94	35.84	44.16	40.65
66.	$P_8 \times P_5$	42.85	28.42	45.81	39.03
67.	$P_5 \times P_9$	37.10	43.38	38.64	39.71
68.	$P_9 \times P_5$	32.15	36.81	32.48	34.48
69.	$P_5 \times P_{10}$	32.01	37.19	33.49	34.23
70.	$P_{10} \times P_5$	36.53	32.30	36.64	35.16
71.	$P_6 \times P_7$	17.77	6.53	21.17	15.16
72.	$P_7 \times P_6$	16.95	6.60	18.03	13.86
73.	$P_6 \times P_8$	55.65	36.98	63.87	52.98
74.	$P_8 \times P_6$	55.94	37.39	62.62	51.98
75.	$P_6 \times P_9$	3.23	0.37	44.42	16.01
76.	$P_9 \times P_6$	2.45	-3.11	43.52	14.28
77.	$P_6 \times P_{10}$	15.79	10.46	21.30	15.85
78.	$P_{10} \times P_6$	19.18	7.37	20.36	15.64
79.	$P_7 \times P_8$	15.48	18.15	15.70	16.44
80.	$P_8 \times P_7$	17.54	22.25	20.23	20.01
81.	$P_7 \times P_9$	33.08	25.23	39.60	32.64
82.	$P_9 \times P_7$	30.23	28.14	37.29	31.89
83.	$P_7 \times P_{10}$	14.62	9.74	16.69	13.68
84.	$P_{10} \times P_7$	12.26	4.78	15.11	10.72
85.	$P_8 \times P_9$	47.42	39.97	52.14	46.51
86.	$P_9 \times P_8$	45.67	37.42	51.97	45.02
87.	$P_8 \times P_{10}$	52.67	25.95	60.03	46.22
88.	$P_{10} \times P_8$	52.72	37.76	61.19	50.56
89.	$P_9 \times P_{10}$	25.64	16.36	14.37	18.79
90.	$P_{10} \times P_9$	27.51	21.65	20.73	25.96

TABLE 21

Grain-straw ratio

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-12.60	-6.63	0.92	-6.10
2.	$P_2 \times P_1$	-13.39	-11.42	2.86	-7.48
3.	$P_1 \times P_3$	0.01	-0.79	6.61	-0.46
4.	$P_3 \times P_1$	-2.59	-9.17	-5.16	-5.64
5.	$P_1 \times P_4$	-0.25	-12.20	-1.20	-4.55
6.	$P_4 \times P_1$	-9.65	-12.72	0.52	-7.28
7.	$P_1 \times P_5$	-0.44	1.87	1.48	-1.69
8.	$P_5 \times P_1$	-9.38	-2.47	3.26	-2.86
9.	$P_1 \times P_6$	4.29	13.56	5.19	7.66
10.	$P_6 \times P_1$	4.59	10.77	5.79	7.05
11.	$P_1 \times P_7$	-0.55	1.07	3.98	1.50
12.	$P_7 \times P_1$	-0.62	1.14	5.03	1.85
13.	$P_1 \times P_8$	-27.81	-32.13	-29.31	-29.75
14.	$P_8 \times P_1$	-24.17	-30.42	-25.80	-26.79
15.	$P_1 \times P_9$	-36.19	-30.21	-38.99	-35.13
16.	$P_9 \times P_1$	-64.19	-35.19	-37.37	-45.75
17.	$P_1 \times P_{10}$	-26.24	-30.30	-30.32	-28.95
18.	$P_{10} \times P_1$	-27.35	-29.95	-27.46	-28.25
19.	$P_2 \times P_3$	-5.11	-7.04	-6.41	-5.52
20.	$P_3 \times P_2$	-4.36	-6.02	-8.04	-4.14
21.	$P_2 \times P_4$	-9.47	-8.58	-5.71	-7.92
22.	$P_4 \times P_2$	-3.31	-3.84	-0.39	-6.51
23.	$P_2 \times P_5$	-22.22	-21.27	-27.68	-23.72
24.	$P_5 \times P_2$	-19.77	-25.92	-24.24	-25.31
25.	$P_2 \times P_6$	-7.39	-9.01	-6.84	-7.75
26.	$P_6 \times P_2$	-3.62	-8.17	-6.55	-7.91
27.	$P_2 \times P_7$	-17.56	-19.85	-20.11	-19.17
28.	$P_7 \times P_2$	-17.27	-17.82	-16.65	-17.25

TABLE 21 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	-14.22	-21.03	-27.23	-20.83
30.	$P_8 \times P_2$	-17.55	-22.35	-24.60	-21.50
31.	$P_2 \times P_9$	-25.80	-30.30	-49.53	-35.21
32.	$P_9 \times P_2$	-23.65	-31.16	-41.35	-32.11
33.	$P_2 \times P_{10}$	-18.54	-18.13	-21.88	-19.52
34.	$P_{10} \times P_2$	-18.18	-19.73	-20.72	-19.54
35.	$P_3 \times P_4$	-0.66	-3.84	-11.80	-5.41
36.	$P_4 \times P_3$	-4.55	-0.99	-12.78	-6.11
37.	$P_3 \times P_5$	6.38	5.02	-2.55	2.95
38.	$P_5 \times P_3$	8.93	5.64	1.79	5.45
39.	$P_3 \times P_6$	-21.03	-21.73	-24.58	-22.45
40.	$P_6 \times P_3$	-22.95	-27.79	-27.36	-26.03
41.	$P_3 \times P_7$	-7.39	-8.78	-10.61	-8.93
42.	$P_7 \times P_3$	-4.83	-7.20	-6.51	-6.85
43.	$P_3 \times P_8$	-20.13	-26.03	-24.54	-23.57
44.	$P_8 \times P_3$	-19.34	-23.23	-24.11	-22.23
45.	$P_3 \times P_9$	1.38	-4.22	-3.95	-2.36
46.	$P_9 \times P_3$	3.57	-5.01	0.52	0.36
47.	$P_3 \times P_{10}$	-16.68	-27.18	-27.66	-23.84
48.	$P_{10} \times P_3$	-25.30	-30.75	-27.80	-27.95
49.	$P_4 \times P_5$	-16.13	-18.39	-13.65	-16.05
50.	$P_5 \times P_4$	-15.44	-16.60	-19.49	-17.18
51.	$P_4 \times P_6$	18.80	21.44	1.92	14.05
52.	$P_6 \times P_4$	6.17	5.44	3.06	4.89
53.	$P_4 \times P_7$	6.55	-0.72	3.03	2.95
54.	$P_7 \times P_4$	9.46	-0.43	4.62	2.55
55.	$P_4 \times P_8$	-28.19	-30.06	-32.21	-30.15
56.	$P_8 \times P_4$	-27.60	-31.14	-30.74	-29.83
57.	$P_4 \times P_9$	-5.72	-9.63	-6.29	-7.21
58.	$P_9 \times P_4$	-6.18	-10.20	-9.97	-5.49
59.	$P_4 \times P_{10}$	-24.12	-25.37	-23.50	-24.33
60.	$P_{10} \times P_4$	-23.75	-25.86	-25.29	-24.30

TABLE 21 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	-25.99	-29.55	-24.31	-26.62
62.	$P_6 \times P_5$	-26.98	-25.76	-29.52	-27.37
63.	$P_5 \times P_7$	-0.64	-5.44	-2.11	-2.73
64.	$P_7 \times P_5$	5.67	-2.92	6.78	3.08
65.	$P_5 \times P_8$	-22.48	-28.05	-23.49	-24.67
66.	$P_8 \times P_5$	-22.94	-26.35	-24.56	-24.62
67.	$P_5 \times P_9$	-28.63	-31.79	-31.14	-30.52
68.	$P_9 \times P_5$	-26.09	-31.03	-28.73	-28.62
69.	$P_5 \times P_{10}$	-24.92	-29.18	-28.05	-27.38
70.	$P_{10} \times P_5$	-28.31	-26.97	-29.56	-28.28
71.	$P_6 \times P_7$	0.96	1.67	5.17	2.60
72.	$P_7 \times P_6$	3.29	-0.05	2.53	1.92
73.	$P_6 \times P_8$	3.45	-3.57	-20.50	-6.87
74.	$P_8 \times P_6$	4.89	-0.96	-20.50	-5.52
75.	$P_6 \times P_9$	7.42	3.04	-17.79	-2.44
76.	$P_9 \times P_6$	0.11	1.36	-18.89	-5.81
77.	$P_6 \times P_{10}$	2.60	-0.30	3.35	1.88
78.	$P_{10} \times P_6$	2.70	-0.40	4.57	2.29
79.	$P_7 \times P_8$	5.01	1.90	17.39	7.96
80.	$P_8 \times P_7$	5.64	-0.30	14.01	6.45
81.	$P_7 \times P_9$	-2.82	-2.66	-2.93	-2.80
82.	$P_9 \times P_7$	-0.61	-4.02	-3.38	-2.67
83.	$P_7 \times P_{10}$	0.52	-0.75	0.21	-0.01
84.	$P_{10} \times P_7$	0.49	-1.25	4.96	1.40
85.	$P_8 \times P_9$	-1.97	-10.54	-5.34	-5.28
86.	$P_9 \times P_8$	-2.67	-11.26	-3.80	-5.95
87.	$P_8 \times P_{10}$	-12.58	-11.89	-11.72	-12.06
88.	$P_{10} \times P_8$	-8.91	-12.19	-10.03	-10.38
89.	$P_9 \times P_{10}$	-10.72	-10.49	-11.29	-10.83
90.	$P_{10} \times P_9$	-11.05	-12.56	-11.51	-11.71

TABLE 22

Grain length

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-5.24	-3.73	-2.59	-3.85
2.	$P_2 \times P_1$	-4.84	-3.25	-2.51	-3.53
3.	$P_1 \times P_3$	0.12	0.38	7.38	2.63
4.	$P_3 \times P_1$	-0.19	0.23	-1.17	-0.38
5.	$P_1 \times P_4$	0.55	0.97	8.64	3.58
6.	$P_4 \times P_1$	8.70	-0.48	-2.30	1.97
7.	$P_1 \times P_5$	-1.70	-1.90	3.11	-0.86
8.	$P_5 \times P_1$	-0.54	-0.74	1.01	-0.09
9.	$P_1 \times P_6$	-2.57	-0.84	2.02	-0.46
10.	$P_6 \times P_1$	-1.96	0.76	0.47	-0.24
11.	$P_1 \times P_7$	0.66	0.00	1.19	-0.62
12.	$P_7 \times P_1$	0.37	-0.44	0.90	-0.22
13.	$P_1 \times P_8$	1.38	1.40	0.50	2.59
14.	$P_8 \times P_1$	2.58	2.66	1.72	2.32
15.	$P_1 \times P_9$	2.15	1.81	2.54	2.17
16.	$P_9 \times P_1$	3.10	2.53	2.69	2.77
17.	$P_1 \times P_{10}$	3.07	3.12	2.33	2.84
18.	$P_{10} \times P_1$	3.14	2.97	3.07	3.06
19.	$P_2 \times P_3$	1.43	2.33	0.25	1.34
20.	$P_3 \times P_2$	1.68	2.50	-0.34	1.28
21.	$P_2 \times P_4$	1.52	2.21	1.86	1.84
22.	$P_4 \times P_2$	2.51	2.56	1.53	2.20
23.	$P_2 \times P_5$	0.73	0.90	4.60	1.89
24.	$P_5 \times P_2$	0.27	0.18	4.05	1.50
25.	$P_2 \times P_6$	6.29	5.30	4.83	5.47
26.	$P_6 \times P_2$	6.62	5.46	3.05	5.04
27.	$P_2 \times P_7$	4.35	4.04	5.13	4.52
28.	$P_7 \times P_2$	4.19	5.25	4.69	4.04

TABLE 22 (CONCD.)

Cl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	7.05	5.82	4.10	5.68
30.	$P_8 \times P_2$	6.59	4.61	4.95	5.38
31.	$P_2 \times P_9$	3.88	3.13	4.85	3.95
32.	$P_9 \times P_2$	4.75	3.76	4.19	4.23
33.	$P_2 \times P_{10}$	6.30	5.65	7.00	6.32
34.	$P_{10} \times P_2$	6.38	5.81	6.84	6.34
35.	$P_3 \times P_4$	-0.17	0.85	1.65	0.78
36.	$P_4 \times P_3$	1.20	-1.78	1.30	0.24
37.	$P_3 \times P_5$	2.36	3.29	1.76	2.47
38.	$P_5 \times P_3$	2.54	3.29	2.11	2.65
39.	$P_3 \times P_6$	3.46	4.15	3.50	3.70
40.	$P_6 \times P_3$	3.30	1.12	2.68	2.37
41.	$P_3 \times P_7$	2.04	2.67	3.04	2.58
42.	$P_7 \times P_3$	2.88	2.98	2.65	2.84
43.	$P_3 \times P_8$	3.33	2.99	2.31	2.88
44.	$P_8 \times P_3$	3.18	2.99	2.31	2.83
45.	$P_3 \times P_9$	2.44	2.72	1.57	2.24
46.	$P_9 \times P_3$	2.44	2.27	2.73	2.48
47.	$P_3 \times P_{10}$	3.32	2.72	2.89	2.98
48.	$P_{10} \times P_3$	3.55	3.18	2.43	3.05
49.	$P_4 \times P_5$	-4.39	-3.41	0.56	-2.41
50.	$P_5 \times P_4$	3.83	-2.49	-0.09	0.42
51.	$P_4 \times P_6$	5.30	4.64	4.57	4.84
52.	$P_6 \times P_4$	5.73	5.49	4.14	5.12
53.	$P_4 \times P_7$	4.19	3.06	3.37	3.51
54.	$P_7 \times P_4$	3.54	4.35	3.79	3.89
55.	$P_4 \times P_8$	3.67	3.54	4.49	3.90
56.	$P_8 \times P_4$	3.12	4.15	3.07	3.48
57.	$P_4 \times P_9$	4.43	3.43	1.58	3.19
58.	$P_9 \times P_4$	4.43	4.86	2.56	3.95
59.	$P_4 \times P_{10}$	3.76	2.96	3.17	3.30
60.	$P_{10} \times P_4$	3.92	3.12	5.09	4.04

TABLE 22 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	6.36	6.55	6.61	6.51
62.	$P_6 \times P_5$	6.10	6.72	5.02	5.95
63.	$P_5 \times P_7$	3.43	4.03	3.11	3.52
64.	$P_7 \times P_5$	4.10	6.17	3.95	4.74
65.	$P_5 \times P_8$	4.52	4.78	4.02	4.44
66.	$P_8 \times P_5$	4.92	5.10	4.02	4.68
67.	$P_5 \times P_9$	3.20	3.58	3.69	3.49
68.	$P_9 \times P_5$	3.86	4.39	3.27	3.84
69.	$P_5 \times P_{10}$	4.56	4.57	3.86	4.33
70.	$P_{10} \times P_5$	5.38	5.71	3.78	4.96
71.	$P_6 \times P_7$	0.26	0.68	1.87	0.94
72.	$P_7 \times P_6$	-0.19	1.60	2.26	1.22
73.	$P_6 \times P_8$	1.18	-0.22	1.87	0.94
74.	$P_8 \times P_6$	1.18	1.82	2.39	1.80
75.	$P_6 \times P_9$	0.99	1.35	0.81	1.05
76.	$P_9 \times P_6$	0.23	1.95	0.81	1.00
77.	$P_6 \times P_{10}$	4.15	4.22	4.58	4.36
78.	$P_{10} \times P_6$	4.15	4.83	3.97	4.32
79.	$P_7 \times P_8$	-0.53	0.28	0.86	0.20
80.	$P_8 \times P_7$	-0.74	1.40	0.57	0.41
81.	$P_7 \times P_9$	0.18	1.66	1.07	0.97
82.	$P_9 \times P_7$	0.53	0.79	0.63	0.68
83.	$P_7 \times P_{10}$	0.22	0.22	0.70	0.38
84.	$P_{10} \times P_7$	0.51	0.80	1.00	0.77
85.	$P_8 \times P_9$	0.28	0.35	-0.46	0.06
86.	$P_9 \times P_8$	0.00	-0.07	0.25	0.06
87.	$P_8 \times P_{10}$	0.11	0.55	0.39	0.28
88.	$P_{10} \times P_8$	0.18	0.90	-0.18	0.30
89.	$P_9 \times P_{10}$	0.61	-0.29	0.44	0.25
90.	$P_{10} \times P_9$	0.04	0.29	0.15	0.16

TABLE 25

Grain width

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-5.45	-2.58	-9.05	-5.69
2.	$P_2 \times P_1$	-5.88	-4.30	-11.70	-7.29
3.	$P_1 \times P_3$	-5.92	-2.37	-4.27	-4.19
4.	$P_3 \times P_1$	-7.46	-2.37	-5.62	-5.15
5.	$P_1 \times P_4$	0.21	1.68	-1.30	0.26
6.	$P_4 \times P_1$	3.13	-0.21	-3.04	-0.04
7.	$P_1 \times P_5$	-0.90	-0.67	1.40	-0.06
8.	$P_5 \times P_1$	-2.25	0.67	-2.33	-1.30
9.	$P_1 \times P_6$	2.94	4.08	3.50	3.51
10.	$P_6 \times P_1$	4.90	6.47	2.80	4.62
11.	$P_1 \times P_7$	0.13	-1.02	1.00	0.04
12.	$P_7 \times P_1$	-3.32	-2.54	0.00	1.75
13.	$P_1 \times P_8$	1.35	1.93	1.27	1.52
14.	$P_8 \times P_1$	-1.10	4.83	2.80	2.18
15.	$P_1 \times P_9$	2.92	2.14	2.23	2.43
16.	$P_9 \times P_1$	0.49	-1.19	2.23	0.51
17.	$P_1 \times P_{10}$	0.74	2.19	0.50	1.14
18.	$P_{10} \times P_1$	1.73	1.22	3.00	1.98
19.	$P_2 \times P_3$	1.75	-1.07	3.13	1.27
20.	$P_3 \times P_2$	1.53	-0.64	2.68	1.19
21.	$P_2 \times P_4$	2.92	1.45	7.56	3.98
22.	$P_4 \times P_2$	1.46	0.21	7.13	2.93
23.	$P_2 \times P_5$	1.12	2.42	7.08	5.54
24.	$P_5 \times P_2$	1.12	1.54	2.54	1.73
25.	$P_2 \times P_6$	5.13	5.56	7.20	5.30
26.	$P_6 \times P_2$	4.89	2.14	6.20	4.41
27.	$P_2 \times P_7$	9.04	8.04	5.94	7.67
28.	$P_7 \times P_2$	7.77	6.04	5.94	7.25

TABLE 23 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	-0.37	0.48	0.00	0.37
30.	$P_8 \times P_2$	-0.12	-1.91	3.03	0.33
31.	$P_2 \times P_9$	2.67	0.71	0.98	1.45
32.	$P_9 \times P_2$	0.24	-1.65	0.49	-0.30
33.	$P_2 \times P_{10}$	1.97	0.72	2.23	1.64
34.	$P_{10} \times P_2$	0.00	0.72	0.25	0.32
35.	$P_3 \times P_4$	-2.31	-0.83	2.86	-0.09
36.	$P_4 \times P_3$	-3.14	-3.32	2.86	-1.20
37.	$P_3 \times P_5$	-1.13	0.44	1.65	0.32
38.	$P_5 \times P_3$	1.58	1.32	2.59	1.83
39.	$P_3 \times P_6$	0.49	-0.48	3.29	1.10
40.	$P_6 \times P_3$	1.97	-4.29	1.77	-0.18
41.	$P_3 \times P_7$	-1.17	-2.27	1.32	-0.71
42.	$P_7 \times P_3$	0.89	-1.26	-0.79	-0.39
43.	$P_3 \times P_8$	-1.24	-3.12	0.51	-1.28
44.	$P_8 \times P_3$	-1.61	-2.64	0.00	-1.42
45.	$P_3 \times P_9$	3.67	2.36	1.51	2.51
46.	$P_9 \times P_3$	2.44	1.89	5.09	3.45
47.	$P_3 \times P_{10}$	-1.24	1.45	1.27	0.49
48.	$P_{10} \times P_3$	-1.49	0.00	-0.76	0.75
49.	$P_4 \times P_5$	-1.51	0.85	5.00	1.45
50.	$P_5 \times P_4$	1.94	1.71	3.64	2.43
51.	$P_4 \times P_6$	-0.47	0.46	6.34	2.11
52.	$P_6 \times P_4$	-1.06	1.38	4.88	1.47
53.	$P_4 \times P_7$	2.55	4.62	6.00	4.39
54.	$P_7 \times P_4$	2.00	6.57	7.11	5.25
55.	$P_4 \times P_8$	0.58	1.62	5.21	2.47
56.	$P_8 \times P_4$	0.58	2.03	3.72	2.13
57.	$P_4 \times P_9$	2.31	3.20	1.69	2.40
58.	$P_9 \times P_4$	2.06	3.65	0.73	2.15
59.	$P_4 \times P_{10}$	0.23	1.37	5.65	2.48
60.	$P_{10} \times P_4$	2.11	0.91	5.41	2.14

TABLE 23 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	5.29	7.39	5.79	6.16
62.	$P_6 \times P_5$	3.55	8.37	4.21	5.38
63.	$P_5 \times P_7$	-0.13	2.87	-6.22	-1.16
64.	$P_7 \times P_5$	-0.93	3.40	-5.70	-1.08
65.	$P_5 \times P_8$	0.13	2.75	0.27	1.04
66.	$P_8 \times P_5$	-1.14	4.23	0.27	1.12
67.	$P_5 \times P_9$	3.53	2.44	7.05	4.34
68.	$P_9 \times P_5$	6.59	6.83	5.48	6.30
69.	$P_5 \times P_{10}$	-1.29	0.50	1.58	-0.07
70.	$P_{10} \times P_5$	1.53	1.50	1.58	1.54
71.	$P_6 \times P_7$	-0.15	2.01	0.00	0.62
72.	$P_7 \times P_6$	0.43	4.87	0.00	1.77
73.	$P_6 \times P_8$	-7.71	-4.07	0.29	-3.83
74.	$P_8 \times P_6$	-7.43	0.81	2.05	-1.52
75.	$P_6 \times P_9$	4.71	2.66	-0.28	2.36
76.	$P_9 \times P_6$	5.26	3.72	-0.28	2.90
77.	$P_6 \times P_{10}$	1.07	-1.64	1.14	0.49
78.	$P_{10} \times P_6$	0.56	-1.64	-1.14	-0.74
79.	$P_7 \times P_8$	0.29	1.73	2.75	1.59
80.	$P_8 \times P_7$	1.47	2.99	1.53	1.96
81.	$P_7 \times P_9$	4.79	6.52	4.45	5.25
82.	$P_9 \times P_7$	3.34	3.68	2.08	3.03
83.	$P_7 \times P_{10}$	-1.92	2.04	0.00	0.04
84.	$P_{10} \times P_7$	-2.81	3.79	1.20	0.73
85.	$P_8 \times P_9$	5.98	0.27	0.58	2.28
86.	$P_9 \times P_8$	5.70	-1.88	2.39	2.24
87.	$P_8 \times P_{10}$	1.56	0.28	-0.58	0.42
88.	$P_{10} \times P_8$	0.99	0.83	2.89	1.54
89.	$P_9 \times P_{10}$	5.59	2.16	1.42	3.06
90.	$P_{10} \times P_9$	5.59	2.70	0.38	2.86

TABLE 24

Length-width ratio of grain

Estimates of Heterosis - (Percentage of deviation from mid-parent)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
1.	$P_1 \times P_2$	-0.24	-1.16	-10.53	-3.98
2.	$P_2 \times P_1$	0.65	0.73	-10.12	-2.92
3.	$P_1 \times P_3$	6.66	2.93	-0.77	2.94
4.	$P_3 \times P_1$	7.86	2.65	0.00	3.50
5.	$P_1 \times P_4$	-0.35	1.44	-2.73	-1.51
6.	$P_4 \times P_1$	2.80	-0.69	-2.73	-0.19
7.	$P_1 \times P_5$	-0.53	-0.88	-2.87	-0.49
8.	$P_5 \times P_1$	2.06	-1.02	2.05	1.03
9.	$P_1 \times P_6$	-6.31	-5.32	-1.87	-4.50
10.	$P_6 \times P_1$	-7.45	-6.74	0.85	-4.45
11.	$P_1 \times P_7$	-2.34	-1.80	-7.22	-3.79
12.	$P_7 \times P_1$	0.61	-0.71	-7.22	-2.44
13.	$P_1 \times P_8$	-20.76	-2.58	-9.60	-10.98
14.	$P_8 \times P_1$	1.53	-4.15	-9.20	-5.97
15.	$P_1 \times P_9$	-2.18	1.04	0.81	0.65
16.	$P_9 \times P_1$	5.43	2.57	0.16	2.05
17.	$P_1 \times P_{10}$	5.40	-0.98	0.16	1.53
18.	$P_{10} \times P_1$	-0.46	-0.16	-1.10	0.57
19.	$P_2 \times P_3$	0.91	3.79	0.44	1.71
20.	$P_3 \times P_2$	0.43	3.52	0.00	1.32
21.	$P_2 \times P_4$	2.23	0.77	1.69	1.56
22.	$P_4 \times P_2$	0.14	2.17	-0.24	0.69
23.	$P_2 \times P_5$	-0.95	-1.50	0.94	0.50
24.	$P_5 \times P_2$	-1.94	-1.29	0.47	0.92
25.	$P_2 \times P_6$	-1.20	-0.15	0.57	-0.26
26.	$P_6 \times P_2$	-1.00	1.32	-0.57	-0.08
27.	$P_2 \times P_7$	9.58	-8.08	-1.79	-0.10
28.	$P_7 \times P_2$	0.02	-2.80	-1.46	-0.75

TABLE 24 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
29.	$P_2 \times P_8$	0.58	3.20	3.78	2.52
30.	$P_8 \times P_2$	2.90	3.15	1.72	2.55
31.	$P_2 \times P_9$	-1.77	0.42	-1.99	-1.11
32.	$P_9 \times P_2$	1.93	3.45	-0.16	1.73
33.	$P_2 \times P_{10}$	0.69	1.83	-4.01	-0.50
34.	$P_{10} \times P_2$	2.71	2.02	-0.52	1.40
35.	$P_3 \times P_4$	1.65	0.69	-2.50	-0.05
36.	$P_4 \times P_3$	3.05	0.78	-2.96	0.59
37.	$P_3 \times P_5$	5.18	3.00	-2.67	1.84
38.	$P_5 \times P_3$	1.05	2.41	-2.67	0.26
39.	$P_3 \times P_6$	0.15	3.32	3.45	2.31
40.	$P_6 \times P_3$	-0.15	2.46	4.17	2.16
41.	$P_3 \times P_7$	-0.45	0.96	-1.72	-0.40
42.	$P_7 \times P_3$	-1.67	0.30	-1.09	-0.75
43.	$P_3 \times P_8$	-2.67	4.17	-1.97	0.04
44.	$P_8 \times P_3$	1.93	2.92	-1.97	0.96
45.	$P_3 \times P_9$	-3.01	-1.04	2.59	0.49
46.	$P_9 \times P_3$	-1.87	-1.10	2.59	-0.13
47.	$P_3 \times P_{10}$	2.22	-1.04	0.17	0.45
48.	$P_{10} \times P_3$	2.72	-1.04	1.17	0.95
49.	$P_4 \times P_5$	3.34	-4.56	-0.25	-0.49
50.	$P_5 \times P_4$	6.06	-3.53	1.72	1.40
51.	$P_4 \times P_6$	17.50	1.12	-4.72	4.63
52.	$P_6 \times P_4$	3.69	0.94	-3.15	0.47
53.	$P_4 \times P_7$	5.18	7.55	-5.39	2.46
54.	$P_7 \times P_4$	5.37	8.04	-5.55	2.69
55.	$P_4 \times P_8$	1.22	-2.83	-2.30	-1.30
56.	$P_8 \times P_4$	3.74	-2.48	-0.88	0.13
57.	$P_4 \times P_9$	2.29	-2.84	-10.45	-3.67
58.	$P_9 \times P_4$	2.00	-1.89	-8.58	-2.79
59.	$P_4 \times P_{10}$	1.62	-2.49	-5.39	-2.09
60.	$P_{10} \times P_4$	3.29	-2.65	-2.52	-0.63

TABLE 24 (CONTD.)

Sl.No.	Combination	S_1	S_2	S_3	Pooled
61.	$P_5 \times P_6$	-0.03	-2.17	-0.19	-1.09
62.	$P_6 \times P_5$	0.79	-2.78	1.55	-1.73
63.	$P_5 \times P_7$	-0.26	-1.21	-4.76	-2.08
64.	$P_7 \times P_5$	11.65	-1.21	-6.68	1.45
65.	$P_5 \times P_8$	10.07	-0.35	-4.86	4.29
66.	$P_8 \times P_5$	3.49	-1.49	-4.51	-0.84
67.	$P_5 \times P_9$	2.15	-0.33	-2.38	-0.19
68.	$P_9 \times P_5$	4.92	-3.67	-2.39	-0.38
69.	$P_5 \times P_{10}$	3.46	2.64	-7.58	-0.49
70.	$P_{10} \times P_5$	2.16	1.53	-9.70	-2.00
71.	$P_6 \times P_7$	0.06	1-78	-7.04	-2.94
72.	$P_7 \times P_6$	1.10	-3.60	-6.20	-2.90
73.	$P_6 \times P_8$	0.95	-3.45	0.15	-2.45
74.	$P_8 \times P_6$	0.92	-4.75	0.15	-2.89
75.	$P_6 \times P_9$	-3.57	1.26	3.40	0.43
76.	$P_9 \times P_6$	3.92	1.43	3.09	2.81
77.	$P_6 \times P_{10}$	2.01	5.99	0.90	2.97
78.	$P_{10} \times P_6$	3.10	6.07	1.20	3.46
79.	$P_7 \times P_8$	0.88	-1.44	-4.30	-1.62
80.	$P_8 \times P_7$	2.25	-1.73	-5.52	-1.00
81.	$P_7 \times P_9$	6.21	-5.07	-0.01	0.11
82.	$P_9 \times P_7$	3.32	-5.07	0.27	0.16
83.	$P_7 \times P_{10}$	1.47	-1.83	0.26	-0.05
84.	$P_{10} \times P_7$	2.22	-1.62	-1.06	0.18
85.	$P_8 \times P_9$	5.44	-0.19	0.43	1.89
86.	$P_9 \times P_8$	5.42	0.73	-0.43	1.91
87.	$P_8 \times P_{10}$	-1.64	-0.26	-1.52	-1.14
88.	$P_{10} \times P_8$	0.81	-0.19	-2.34	-1.11
89.	$P_9 \times P_{10}$	-4.70	-2.33	-3.16	3.41
90.	$P_{10} \times P_9$	-3.35	-2.41	0.29	-2.49

(15.73, 15.59 and 15.55 respectively) than the rest (Table 4), while the combination $P_7 \times P_1$ produced the minimum number (13.12).

The hybrids showed positive heterosis. The expression of heterosis was maximum (35.26 per cent) in the combination $P_8 \times P_9$ (Table 15) and minimum in the combination $P_{10} \times P_4$ (0.60 per cent)

c. Panicle length: The combinations $P_{10} \times P_6$ and $P_3 \times P_8$ had longer panicles (26.30 and 26.13 cm) than others (Table 5) while in the combinations $P_2 \times P_9$ and its reciprocal, the panicle length was low (20.34 and 19.86 cm).

The expression of heterosis (Table 16) was the highest in the combination $P_4 \times P_3$ (11.61 per cent) and lowest in $P_9 \times P_8$ (-6.98 per cent).

d. Number of grains per panicle: The combinations $P_6 \times P_4$ and $P_4 \times P_{10}$ produced more number of grains per panicle (116.20 and 116.73) whereon the combination $P_7 \times P_5$ produced the lowest number of 89.95 (Table 6).

The heterosis was maximum (6.10 per cent) in the combination $P_6 \times P_4$ (Table 17) and minimum in the combination $P_2 \times P_5$ (-3.06 per cent).

e. 100 grain weight: The 100 grain weight was more in the combinations $P_3 \times P_1$ and its reciprocal (2.623 and 2.609 g)

(Table 7) while it was low in the combinations $P_6 \times P_7$ and its reciprocal (1.654 and 1.657).

The heterosis of the hybrids (Table 18) ranged from -2.32 per cent ($P_0 \times P_{10}$) to 16.52 per cent ($P_2 \times P_7$).

f. Grain yield per plant: The combinations $P_6 \times P_3$, $P_5 \times P_{10}$, $P_3 \times P_6$ and $P_6 \times P_4$ recorded high grain yield ranging from 29.1 to 29.60 g per plant (Table 8) while the combinations $P_7 \times P_8$ and its reciprocal recorded the minimum of 17.88 and 17.94 g respectively.

The hybrids expressed positive heterosis for grain yield. A maximum heterosis of 44.65 per cent was recorded in $P_8 \times P_6$, and a minimum of -4.41 per cent in $P_5 \times P_2$ (Table 19).

g. Straw yield per plant: Combinations $P_{10} \times P_8$ and its reciprocal produced more straw per plant (63.94 and 63.56 g) while the combination $P_5 \times P_1$ produced the minimum (27.09 g) (Table 9).

Maximum heterosis of 83.29 and 80.89 per cent was recorded in combinations $P_1 \times P_8$ and its reciprocal (Table 20) while the combinations $P_1 \times P_5$ and its reciprocal recorded the minimum of -3.91 and -4.59 per cent respectively.

h. Grain-straw ratio: The combinations $P_5 \times P_3$ and its reciprocal possessed higher grain-straw ratio (0.946 and

0.925) whereas the combinations $P_9 \times P_{10}$ and its reciprocal had lower ratios (0.408 and 0.404).

Only 19 combinations expressed positive heterosis while the others expressed negative heterosis (Table 21). The maximum value of 14.05 per cent was recorded by $P_4 \times P_6$ and the minimum of -45.75 per cent by $P_9 \times P_1$.

i. Grain length: The grain length (Table 11) was maximum in the combinations $P_8 \times P_1$, its reciprocal, $P_8 \times P_9$ and $P_{10} \times P_8$ ranging from 9.52 to 9.03 mm while it was minimum in the combinations $P_4 \times P_5$ and its reciprocal (6.90 and 7.00 mm).

The maximum heterosis observed was 6.32 and 6.34 per cent in the combinations $P_2 \times P_{10}$ and its reciprocal respectively (Table 22) and the minimum was observed in $P_1 \times P_5$ (-5.86 per cent).

j. Grain width: The grain width was maximum in the combinations $P_2 \times P_4$ and its reciprocal (3.29 and 3.26 mm) (Table 12), while it was minimum in the combinations $P_7 \times P_{10}$ and its reciprocal and $P_7 \times P_8$ and its reciprocal (2.26 and 2.29 mm).

The maximum heterosis was observed in the combinations $P_2 \times P_7$ and its reciprocal (7.67 and 7.25 per cent) while the combinations $P_1 \times P_2$ and its reciprocal had minimum heterosis of -5.69 and -7.29 per cent (Table 23).

k. Length-width ratio of grain: The combinations $P_7 \times P_{10}$, its reciprocal, $P_7 \times P_8$ and its reciprocal recorded the maximum length-width ratio ranging from 3.950 to 3.974(Table 13) while in the combinations $P_4 \times P_5$ and its reciprocal the ratios were minimum being 2.161 and 2.163 respectively.

The heterosis (Table 24) was maximum in the combination $P_4 \times P_6$ (4.63 per cent) and minimum in the combination $P_6 \times P_1$ (-4.45 per cent).

2. Combining ability analysis

a. General combining ability variances (GCA): The characters exhibited significant GCA variances in each of the seasons as well as in pooled analysis (Tables 25, 26). The GCA variances were enhanced for plant height, panicle length, number of grains per panicle, grain length, and length-width ratio of grain in the S_1 season, for grain yield per plant in the S_2 season and for tiller number, 100 grain weight, straw yield per plant, grain-straw ratio and grain width in the S_3 season. The GCA variances for the characters studied showed significant interactions with the seasons (Table 26).

The relative stability estimates of GCA variances for the different characters ranged from 0.7639 to 0.9986, the maximum value being recorded by 100 grain weight and the minimum by tiller number (Table 26).

TABLE 25

Analysis of variance due to combining ability

Character	Season	GCA	SCA	RCA	$\frac{GCA}{SCA}$
Plant height	S_1	5123.50**	75.577**	0.607**	67.79
	S_2	4995.78**	84.266**	5.669**	59.28
	S_3	3011.83**	79.235**	5.109**	40.11
Earbearing tillers per plant	S_1	1.355**	2.027**	0.092	0.663
	S_2	2.042**	1.210**	0.525**	2.098
	S_3	4.250**	1.046**	0.263**	4.063
Panicle length	S_1	40.704**	2.037**	0.293**	20.03
	S_2	15.125**	1.796**	0.671**	9.03
	S_3	25.792**	0.945**	0.434**	27.33
Number of grains per panicle	S_1	313.222**	42.555**	1.298**	7.36
	S_2	131.944**	15.711**	0.003**	13.27
	S_3	242.166**	5.583**	3.094**	43.38
100 grain weight	S_1	0.595**	0.012**	0.000009**	49.58
	S_2	0.569**	0.012**	0.000067**	47.42
	S_3	0.619**	0.009**	0.000053**	68.77
Grain yield per plant	S_1	91.883**	11.554**	0.143**	7.95
	S_2	92.059**	7.511**	0.532**	12.26
	S_3	76.571**	7.923**	0.257**	9.79
Straw yield per plant	S_1	1007.465**	86.261**	0.779*	11.68
	S_2	865.145**	71.706**	1.693**	12.07
	S_3	1009.423**	73.612**	0.342*	14.94
Grain-straw ratio	S_1	0.229*	0.012**	0.000222**	19.00
	S_2	0.309**	0.013**	0.000289**	16.08
	S_3	0.243**	0.014**	0.000422**	17.36
Grain length	S_1	2.400**	0.049**	0.005**	48.90
	S_2	2.369**	0.037**	0.00244**	64.41
	S_3	2.164**	0.040**	0.015**	54.10
Grain width	S_1	0.412**	0.005**	0.000022	82.40
	S_2	0.398**	0.004	0.000711*	99.50
	S_3	0.423**	0.006**	0.000511	70.50
Length-width ratio of grain	S_1	2.304**	0.010**	0.001.66	147.53
	S_2	2.657**	0.012**	0.000088	221.42
	S_3	2.561**	0.015**	0.000047**	170.67

* Significant at 5% level
** Significant at 1% level

TABLE 26

Pooled Analysis of Variance due to Combining Ability

Variances due to	Plant Height	Earbearing tillers per plant	Paniele length	Number of grains per paniele	100 grain weight
General combining ability (GCA)	13944.556**	5.069**	78.715**	693.888**	1.779**
Specific combining ability (SCA)	223.555**	3.586**	3.436**	41.800**	0.032**
Reciprocal effects (RCA)	4.023**	0.442**	0.557**	4.965**	0.00062**
GCA x Season	43.166**	1.567**	1.944**	21.777**	0.0025**
SCA x Season	7.760**	0.349**	0.661**	10.000**	0.0013**
RCA x Season	2.691**	0.219**	0.421**	3.676**	0.0004**
GCA/SCA	61.929	1.413	22.909	16.600	55.594
Relative Stability Estimates					
a) GCA	0.9968	0.7639	0.9759	0.9696	0.9986
b) SCA	0.9664	0.9113	0.8387	0.8009	0.9610

* Significant at 5% level

** Significant at 1% level

TABLE 26 (CONTD.)

Variances due to	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
General combining ability (GCA)	242.868**	2949.25**	0.680**	6.914**	1.227**	8.005**
Specific combining ability (SCA)	22.948**	177.49**	0.038**	0.112**	0.011**	0.023**
Reciprocal effects (RCA)	0.299**	1.44**	0.00042**	0.009**	—	—
GCA x Season	8.922**	592.78**	0.001166**	0.016**	0.003**	0.019**
SCA x Season	1.964**	27.05**	0.001044**	0.00677**	0.002**	0.011**
RCA x Season	0.215**	0.7148**	0.000256**	0.00766**	-	-
GCA/SCA	10.583	16.616	17.895	61.732	111.545	348.04
Relative Stability Estimates						
a) GCA	0.9649	0.8326	0.9983	0.9977	0.9976	0.9976
b) SCA	0.9204	0.8677	0.9733	0.9450	0.8462	0.6765

* Significant at 5% level

** Significant at 1% level

b. Specific combining ability variances (SCA): The characters showed significant specific combining ability variances in the individual seasons and in the pooled analysis. Enhanced SCA variances were observed for the tiller number, panicle length, number of grains per panicle, 100 grain weight, grain yield, straw yield, grain length and length-width ratio of grain during the S_1 season, for plant height during the S_2 season and for grain-straw ratio and grain width during the S_3 season (Table 25). The SCA variances for the characters exhibited significant interactions with the seasons (Table 26).

The relative stability estimates of SCA variances ranged from 0.6765 to 0.9753, the grain-straw ratio and length-width ratio of grain recording the maximum and minimum estimates respectively (Table 26).

c. The ratio of GCA to SCA variances: The ratio of GCA to SCA variances ranged from 0.668 to 221.42 for the various characters among the seasons (Table 25). Tiller number, panicle length, grain yield, straw yield and grain-straw ratio showed relatively low ratio (0.668 to 27.28) as compared to other characters. The maximum ratio was recorded by the length-width ratio of grain (147.58 to 221.42).

In the pooled analysis (Table 26) the length-width ratio of grain recorded relatively a high ratio (348.04) as compared to other characters. The ratios of GCA/SCA variances obtained

were more for plant height and grain-straw ratio during the S_1 season, for grain yield, grain length, grain width and length-width ratio of grain during the S_2 season and for other characters during the S_3 season.

d. The combining ability effects: The general combining ability effects (gca), specific combining ability effects (sca) and their interaction with seasons are presented below characterwise.

(1) Plant height: The parents P_{10}, P_6, P_8 and P_9 showed significant positive gca effects consistently over the seasons (Table 27) whereas, the other six parents exhibited significant negative gca effects. The parents P_8, P_9 and P_{10} had positive interaction while the parents P_1, P_2 and P_3 had negative interaction with the S_1 as well as the S_2 seasons (Table 33). But the parents P_6, P_8, P_9 and P_{10} had negative interaction and the rest of the six parents, positive interaction with the S_3 season.

Seventeen combinations exhibited significant positive sca effects in the seasons consistently (Table 35) while nineteen combinations showed significant negative sca effects. Four combinations $P_1 \times P_6$, $P_1 \times P_{10}$, $P_2 \times P_{10}$ and $P_3 \times P_8$ exhibited high positive sca effects (9.014 to 9.653) while $P_6 \times P_{10}$, $P_7 \times P_{10}$ and $P_8 \times P_{10}$ showed high negative effects (-7.362 to -11.166). Significant positive sca x season interaction was noticed in nine, fourteen and ten combinations

TABLE 27

Plant height and bearing tillers per plant
General combining ability effects

Parent	Plant height				Bearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
P_1	-14.94**	-15.88**	-12.96**	-14.59**	-0.476**	-0.260**	-0.199**	-0.312**
P_2	-11.51**	-12.10**	-9.29**	-10.64**	0.253**	0.039	-0.386**	-0.021
P_3	-10.04**	-9.30**	-8.93**	-9.42**	-0.073	0.162**	0.488**	0.192**
P_4	-15.13**	-13.83**	-14.65**	-14.53**	0.041	0.292**	-0.006	0.109
P_5	-16.45**	-16.28**	-13.90**	-15.54**	0.233**	0.274**	-0.611**	-0.034
P_6	17.52**	18.33**	16.77**	17.54**	0.313**	0.647**	0.710**	0.557**
P_7	-2.31**	-2.35**	-1.79**	-2.15**	-0.356**	-0.435**	-0.381**	-0.391**
P_8	13.95**	13.86**	10.75**	12.86**	-0.073	-0.310**	-0.079	-0.154**
P_9	12.91**	12.91**	11.72**	12.51**	-0.026	-0.450**	-0.179**	-0.218**
P_{10}	25.99**	24.65**	21.30**	23.97**	0.186**	-0.007	0.648**	0.275**
SE	0.1300	0.0618	0.2105	0.1474	0.0569	0.0703	0.0815	0.0704

* Significant at 5% level
** Significant at 1% level

TABLE 28

Panicle length and Number of grains per panicle

General combining ability effects

Parent	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
P_1	-1.837**	-1.060**	-0.980**	-1.293**	-2.153**	-0.871**	-2.106**	-1.713**
P_2	-0.977**	-0.619**	-0.819**	-0.805**	-4.008**	-1.379**	-1.066**	-2.151**
P_3	-0.114	0.036**	0.050	0.007	-0.728**	-0.256**	-2.731**	-1.237**
P_4	-0.821**	-0.583**	-0.819**	-0.741**	2.346**	2.450**	2.793**	2.696**
P_5	-1.649**	-1.125**	-1.420**	-1.398**	-3.033**	-1.654**	-1.086**	-1.924**
P_6	1.154**	1.027**	0.823**	1.001**	5.781**	4.225**	3.946**	3.984**
P_7	-0.547**	-0.425**	-0.851**	-0.607**	-4.150**	-4.684**	-4.458**	-4.431**
P_8	1.057**	0.641**	1.047**	0.915**	-3.373**	-3.544**	-3.566**	-3.494**
P_9	1.219**	0.604**	1.064**	0.963**	4.774**	1.948**	2.646**	3.122**
P_{10}	2.516**	1.454**	1.907**	1.959**	6.051**	3.768**	5.631**	5.150**
SD	0.0692	0.0348	0.0921	0.0695	0.1762	0.0967	0.2043	0.1574

* Significant at 5% level
** Significant at 1% level

TABLE 29

100 grain weight and Grain yield per plant
General combining ability effects

Parent	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
P_1	0.263**	0.269**	0.275**	0.269**	0.274**	2.195**	0.235**	0.902**
P_2	0.115**	0.109**	0.107**	0.111**	-1.204**	0.410**	-1.425**	-0.739**
P_3	0.218**	0.203**	0.191**	0.204**	2.457**	1.963**	1.724**	2.040**
P_4	0.098**	0.104**	0.108**	0.103**	1.701**	1.510**	1.262**	1.490**
P_5	-0.032**	-0.037**	-0.025**	-0.032**	-0.516**	-0.629**	-0.972**	-0.706**
P_6	-0.166**	-0.150**	-0.167**	-0.161**	1.734**	0.261**	1.909**	1.540**
P_7	-0.280**	-0.270**	-0.312**	-0.287**	-4.600**	-4.799**	-3.862**	-4.420**
P_8	-0.107**	-0.110**	-0.095**	-0.104**	-0.518**	-1.664**	-1.056**	-1.110**
P_9	-0.092**	-0.095**	-0.087**	-0.092**	-1.310**	-1.234**	-0.454**	-1.000**
P_{10}	-0.016**	-0.024	0.004**	-0.012**	2.084**	1.265**	2.638**	1.990**
SE	0.001367	0.0266	0.001171	0.000735	0.0590	0.0462	0.0782	0.0626

* Significant at 5% level
** Significant at 1% level

TABLE 30

Straw yield per plant and Grain-straw ratio

General combining ability effects

Parent	Straw yield per plant				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
P_1	-4.344**	-3.045**	-4.431**	-3.940**	0.094**	0.100**	0.107**	0.100**
P_2	-7.294**	-5.524**	-7.630**	-6.833**	0.076**	0.084**	0.086**	0.082**
P_3	-3.956**	-4.472**	-4.099**	-4.176**	0.131**	0.118**	0.126**	0.125**
P_4	-5.023**	-5.427**	-5.026**	-5.159**	0.117**	0.106**	0.114**	0.112**
P_5	-4.212**	-3.982**	-4.927**	-4.375**	0.058**	0.047**	0.054**	0.053**
P_6	5.252**	4.214**	6.673**	5.381**	-0.059**	-0.046**	-0.063**	-0.056**
P_7	-6.651**	-6.588**	-7.098**	-6.780**	-0.043**	-0.042**	-0.024**	-0.037**
P_8	6.631**	6.000**	5.32[illegible]**	6.153**	-0.121**	-0.124**	-0.131**	-0.125**
P_9	7.070**	7.201**	8.751**	7.678**	-0.134**	-0.124**	-0.146**	-0.135**
P_{10}	12.518**	11.624**	12.012**	12.052**	-0.127**	-0.120**	-0.123**	-0.123**
SE	0.1523	0.0515	0.1017	0.1078	0.0019	0.00067	0.00345	0.00701

* Significant at 5% level

** Significant at 1% level

TABLE 31

Grain length and Grain width

General combining ability effects

Parent	Grain length				Grain width			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
P_1	0.103**	0.092**	0.177**	0.124**	0.093**	0.103**	0.098**	0.095**
P_2	-0.292**	-0.293**	-0.317**	-0.301**	0.152**	0.133**	0.162**	0.149**
P_3	-0.096**	-0.097**	-0.071**	-0.088**	0.092**	0.094**	0.103**	0.096**
P_4	-0.454**	-0.442**	-0.399**	-0.432**	0.225**	0.211**	0.234**	0.223**
P_5	-0.560**	-0.536**	-0.545**	-0.547**	0.065**	0.090**	0.052**	0.0692**
P_6	0.036**	-0.023**	-0.027**	-0.005	-0.106**	-0.092*	-0.093**	-0.098**
P_7	0.135**	0.191**	0.209**	0.194**	-0.192**	-0.192**	-0.185**	-0.190**
P_8	0.498**	0.525**	0.433**	0.485**	-0.144**	-0.135**	-0.150**	-0.143**
P_9	0.278**	0.279**	0.255**	0.271**	-0.053**	-0.069**	-0.089**	-0.071**
P_{10}	0.303**	0.303**	0.286**	0.297**	-0.152**	-0.140**	-0.120**	-0.131**
SE	0.0035	0.0068	0.0159	0.0095	0.0049	0.0046	0.0042	0.0046

* Significant at 5% level
** Significant at 1% level

TABLE 32

Length-width ratio of grain

General combining ability effects

Parent	Season			
	S_1	S_2	S_3	Pooled
P_1	-0.122**	-0.129**	-0.099**	-0.117**
P_2	-0.376**	-0.347**	-0.360**	-0.361**
P_3	-0.205**	-0.207**	-0.203**	-0.205**
P_4	-0.548**	-0.514**	-0.491**	-0.518**
P_5	-0.381**	-0.398**	-0.417**	-0.399**
P_6	-0.148**	0.117**	0.133**	0.133**
P_7	0.427**	0.422**	0.487**	0.445**
P_8	0.485**	0.464**	0.361**	0.437**
P_9	0.205**	0.228**	0.259**	0.231**
P_{10}	0.366**	0.363**	0.332**	0.354**
SE	0.0081	0.0054	0.0059	0.0047

* Significant at 5% level
** Significant at 1% level

TABLE 33

GCA x Season effects of the parents

GCA x Season (gl)	Plant height	Earbearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight
1.1	-0.340**	-0.164**	-0.545**	-0.470**	-0.0065**
1.2	-1.280**	0.050	0.232**	0.840**	0.0002
1.3	1.630**	0.110	0.312**	-0.405**	0.0061**
2.1	-0.880**	0.365**	-0.173**	-1.862**	0.0047**
2.2	-1.467**	0.052	0.185**	0.770**	-0.1201**
2.3	2.357**	-0.368**	-0.014	1.080**	-0.0011
3.1	-0.625**	-0.262**	-0.125**	0.500**	0.0142**
3.2	0.127	-0.032	0.079	0.980**	-0.0012**
3.3	0.502**	0.293**	0.043	-1.510**	-0.0130**
4.1	-1.096**	-0.063	-0.080	0.130	0.0056**
4.2	0.711**	0.182**	0.157**	-0.250	0.0002
4.3	5.860**	-0.118**	-0.079	0.085	0.0040**
5.1	-0.910**	0.272**	-0.252**	1.110**	0.0011
5.2	-0.745**	0.307**	0.273**	0.270**	0.0054**
5.3	1.655**	-0.580**	-0.022	0.830**	0.0065**
6.1	-0.015	-0.239**	0.152**	-0.210	0.0053**
6.2	0.790**	0.088	0.026	0.240	0.0109**
6.3	-0.760**	0.151**	-0.178**	-0.050	0.0057**
7.1	-0.440**	0.039	0.060	0.115	0.0074**
7.2	-0.185	-0.046	0.182**	-0.025	0.0175**
7.3	0.375**	0.007	-0.243**	-0.045	-0.0245**
8.1	1.097**	0.085	0.141**	-4.190**	0.0029**
8.2	1.015**	0.157**	-0.274**	-0.050	0.0057**
8.3	-2.090**	0.093	0.131**	-0.085	0.0089**
9.1	0.400**	0.197**	0.256**	1.645**	0.0011
9.2	0.400**	0.757**	-0.358**	-1.180**	0.0021**
9.3	-0.785**	0.037	0.099	-0.490**	0.0042**
10.1	2.020**	-0.085	0.556**	0.900**	-0.0628**
10.2	0.655**	-0.285**	-0.505**	-1.380**	-0.0703**
10.3	-0.695**	0.370**	-0.053	0.480**	-0.0417**
SE	0.1204	0.0574	0.0568	0.1285	0.0006

* Significant at 5% level
** Significant at 1% level
(gl) 1.2 First digit denotes parent, Second digit denotes season

TABLE 34

GCA x Season effects of the parents

GCA & Season (gl)	Grain yield per plant	Straw yield per plant	Grain - straw ratio	Grain length	Grain width	Length - width ratio of grain
1.1	-0.6262**	-0.4026**	0.0063**	-0.0210**	-0.0012	-0.0049
1.2	1.3023**	0.8963**	-0.0004	-0.0312**	0.0084**	-0.0125**
1.3	-0.6662**	-0.4089**	0.0068**	0.0220**	-0.0069	0.0174**
2.1	-0.4635**	-0.4597**	-0.0060**	0.0084	0.0037	-0.0151**
2.2	1.1585**	1.3110**	0.0021	0.0075	-0.0159**	0.0144**
2.3	-0.6855**	-0.8447**	0.0041**	-0.0159**	0.0150**	0.0009
3.1	0.4100**	0.2226**	0.0063**	0.0070	-0.0047	0.0001
3.2	-0.0770*	-0.2940**	-0.0066**	0.0088	-0.0023	-0.0019
3.3	-0.3240**	0.0788	-0.0005	0.0166**	0.0071	0.0019
4.1	0.2110**	0.1373	0.0050**	-0.0225**	0.0022	-0.0301**
4.2	0.0275	-0.2668**	-0.0067**	-0.0100	-0.0124**	0.0037
4.3	-0.2385**	0.1345	0.0018	0.0327**	0.0103**	0.0265**
5.1	0.1902**	0.1728	0.0047**	-0.0129	-0.0035	-0.0130**
5.2	0.0852	0.4032**	-0.0058**	0.0106	0.0211**	0.0008
5.3	-0.2638**	-0.5425**	0.0012	0.0023	-0.0172**	-0.0187**
6.1	0.1935**	-0.1264	0.0028	0.0412**	0.0090**	0.0150**
6.2	-0.5525**	-1.1650**	0.0072**	-0.0187**	0.0049	-0.0153**
6.3	0.3680**	1.2948**	-0.0098**	-0.0226**	0.0041	0.0004
7.1	-0.1870**	0.1313	-0.0067**	-0.0110	-0.0025	-0.0100**
7.2	-0.3795**	0.1937**	0.0054**	-0.0030	-0.0023	-0.5397**
7.3	0.5505**	-0.3155**	0.0122**	0.0142	0.0048	0.0449**
8.1	0.4958**	0.4808**	0.0040**	0.0127	-0.0021	0.0482**
8.2	-0.5432**	-0.1503	0.0018	0.0397**	0.0061	0.0275**
8.3	0.0568	-0.3245**	-0.0056**	-0.0526**	-0.0090**	-0.0756**
9.1	-0.3100**	-0.5966**	0.0006	0.0075	0.0176**	-0.0253**
9.2	-0.2265**	-0.4737**	0.0110**	0.0083	0.0010	-0.0025
9.3	0.5460**	1.0761**	-0.0116**	-0.0600**	-0.0185**	0.0279**
10.1	0.0887**	0.4629**	-0.0041**	0.0059	-0.0010	0.0126**
10.2	-0.7223**	-0.4247**	0.0032	0.0037	-0.0098	0.0094**
10.3	-0.6427**	-0.0374	0.0009	-0.0114**	0.0108	-0.0219**
SE	0.0511	0.0897	0.0019	0.0077	0.0038	0.0039

* Significant at 5% level
** Significant at 1% level

(gl) 1.2 First digit (1) denotes parent, second digit (2) denotes season.

TABLE 35

Plant height and Earbearing tillers per plant
Specific combining ability effects

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	-4.080**	-5.171**	-8.805**	-6.019**	1.723**	0.437**	0.369	0.843**
$P_1 \times P_3$	-2.855**	-2.457**	-5.395**	-3.568**	-1.118**	-0.259	0.344	-0.344**
$P_1 \times P_4$	-3.618**	-2.929**	-2.848**	-3.131**	0.256	-0.239	0.389	0.138
$P_1 \times P_5$	-4.647**	-7.199**	-4.903**	-5.583**	1.423**	0.303	1.269**	-0.998**
$P_1 \times P_6$	9.502**	9.218**	9.729**	9.435**	0.743**	0.405	-0.103	0.348**
$P_1 \times P_7$	1.044**	0.542**	0.496	0.694	-1.160**	0.265	0.014	-0.294
$P_1 \times P_8$	-1.520**	-1.542**	0.074	-0.996**	-0.743**	0.013	-0.313	-0.347**
$P_1 \times P_9$	4.242**	5.337**	7.931**	5.837**	0.134	0.153	-0.315	-0.008
$P_1 \times P_{10}$	7.837**	10.670**	10.454**	9.655**	-0.778**	-0.439**	-0.140	-0.452**
$P_2 \times P_3$	-2.452**	0.317	-1.235	-1.116**	-0.978**	-0.959**	-0.167	-0.702**
$P_2 \times P_4$	-4.245**	-4.651**	-5.540**	-4.812**	0.381**	0.460**	0.276	-0.372**
$P_2 \times P_5$	-4.350**	-4.324**	-6.220**	-4.965**	-1.535**	-0.322	-0.368	-0.742**
$P_2 \times P_6$	6.549**	5.093**	7.536**	6.393**	-0.016	1.030**	0.584**	0.532**
$P_2 \times P_7$	-1.332**	-0.232	0.454	-0.370	1.003**	0.588**	-0.008	0.497**
$P_2 \times P_8$	9.652**	9.483**	4.131**	7.755**	0.646**	0.313	0.074	0.344**
$P_2 \times P_9$	-3.110**	-0.062	9.789**	2.205**	1.049	0.055	0.074	0.392**
$P_2 \times P_{10}$	9.759**	7.320**	9.962**	9.014**	-0.163	-0.014	0.146	-0.010

TABLE 35 (CONTD.)

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	-4.920**	-5.536**	-2.153**	-4.203**	0.539**	0.438**	0.201	0.409**
$P_3 \times P_5$	-2.625**	-4.284**	-2.958**	-3.289**	0.496**	0.115	0.381	0.344**
$P_3 \times P_6$	-1.500**	3.183**	1.424**	1.035**	0.341**	0.233	0.534**	0.369**
$P_3 \times P_7$	-1.007**	-2.067**	-0.708	-1.261**	0.536	-0.059	-0.023	0.151
$P_3 \times P_8$	10.602**	8.472**	8.394**	9.156**	1.204**	0.865**	0.524**	0.864**
$P_3 \times P_9$	1.009**	1.352**	0.026	0.823**	0.256	0.680**	0.149	0.362**
$P_3 \times P_{10}$	6.159**	6.510**	6.399**	6.356**	0.619**	0.588**	-0.053	0.384**
$P_4 \times P_5$	-7.038**	-3.954**	-5.438**	-5.476**	-0.518**	0.275	-0.248	-0.163
$P_4 \times P_6$	9.186**	7.638**	3.069**	6.631**	0.526**	0.203	0.354	0.361**
$P_4 \times P_7$	7.979**	8.938**	4.756**	7.218**	0.721**	0.760**	0.371	0.617**
$P_4 \times P_8$	2.689**	6.377**	4.564**	4.543**	-0.185	0.035	0.069	-0.027
$P_4 \times P_9$	1.151**	0.908**	0.646	0.902**	-0.233	-0.274	-0.165	-0.204
$P_4 \times P_{10}$	7.897**	6.490**	10.069**	8.152**	-0.570**	-0.917**	-0.357	-0.615**
$P_5 \times P_6$	8.681**	9.890**	8.189**	8.920**	0.104**	-0.154	0.159	0.062
$P_5 \times P_7$	4.949**	7.415**	5.906**	6.090**	-0.496**	0.477**	-0.548**	-0.188

TABLE 35 (CONTD.)

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	1.359**	2.280**	2.634**	2.091**	0.146	-0.047	-0.800**	-0.235
$P_5 \times P_9$	3.147**	2.685**	2.966**	2.933**	-0.375**	-0.181	-0.850**	-0.452**
$P_5 \times P_{10}$	2.767**	2.118**	4.139**	3.008**	0.736**	0.650**	0.946**	0.777**
$P_6 \times P_7$	-1.925**	-5.216**	-2.735**	-2.626**	-0.001	-0.319	0.354	0.011
$P_6 \times P_8$	-0.690	-1.152**	-2.832**	-1.558**	0.601**	0.230	0.227	0.382**
$P_6 \times P_9$	-2.552**	-1.221**	-3.425**	-2.400**	-0.081	0.070	0.402	0.130
$P_6 \times P_{10}$	-12.357**	-11.489**	-9.653**	-11.166**	-0.668**	-0.197	-0.475	-0.447**
$P_7 \times P_8$	-1.470**	0.598**	1.834**	0.319	0.536	0.287	0.744**	0.456**
$P_7 \times P_9$	-1.339**	-0.346	-2.208**	-0.405	1.063**	0.728**	1.019**	0.937**
$P_7 \times P_{10}$	-9.115**	-9.539**	-6.610**	-8.421**	0.876**	0.310	0.016	0.401**
$P_8 \times P_9$	-0.400	-1.532**	-1.505**	-1.145**	0.806	1.028**	1.441**	1.092**
$P_8 \times P_{10}$	-6.230**	-7.274**	-9.582**	-7.362**	0.694**	0.360	0.339	0.464**
$P_9 \times P_{10}$	0.892**	-0.369	-5.525**	-2.262**	0.121	0.100	0.189	0.137
SE	0.3926	0.1867	0.6348	0.3611	0.1718	0.2124	0.2459	0.1723

* Significant at 5% level
** Significant at 1% level

TABLE 36

Panicle length and Number of grains per panicle
Specific combining ability effects

Combination	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	0.231	-1.092**	-0.064	-0.308	3.416**	1.316**	1.121	1.951**
$P_1 \times P_3$	-1.270**	-0.771**	0.054	-0.662**	-3.344**	-2.980**	0.561	-1.987**
$P_1 \times P_4$	0.650**	0.643**	0.007	0.434**	6.410**	3.161**	3.961**	4.511**
$P_1 \times P_5$	-0.503**	-0.804**	0.558	-0.256	-1.033	-0.157	-1.358**	-0.850
$P_1 \times P_6$	0.082	0.077	1.151**	0.437**	-3.048**	-3.863**	-1.466**	-2.792**
$P_1 \times P_7$	-0.608**	0.140	-0.255	-0.241	5.058**	2.046**	-0.361	1.581**
$P_1 \times P_8$	-0.543**	-0.858**	-1.384**	-0.921**	1.150**	0.106	0.096	0.744
$P_1 \times P_9$	0.164	0.417**	-0.321	0.086	-0.191	2.714**	-2.991**	-0.022
$P_1 \times P_{10}$	0.510**	1.493**	-0.294	0.569**	-8.594**	-5.255**	-2.100**	-5.316**
$P_2 \times P_3$	-0.560**	-0.812**	-0.481	-0.618**	2.075**	0.652**	0.171	0.966**
$P_2 \times P_4$	-0.866**	-0.504**	-0.180	-0.517**	2.435**	0.969**	0.871	1.452**
$P_2 \times P_5$	-2.053**	-1.020**	-0.069	-1.047**	-9.564**	-0.950**	-2.268**	-4.254**
$P_2 \times P_6$	0.182	0.665**	0.758	0.536**	3.970**	1.369**	-0.156	1.728**
$P_2 \times P_7$	1.391**	0.609**	-0.674**	0.460**	-3.906**	0.029	0.123	-1.291**
$P_2 \times P_8$	0.907**	0.432**	0.559**	0.633**	2.901**	-0.110	1.156	1.315**
$P_2 \times P_9$	1.324**	1.211**	0.427	0.987**	0.203	0.490**	0.795	0.493
$P_2 \times P_{10}$	-0.294	0.156	0.182	0.017	-5.749**	-4.047	-2.240**	-4.012**

TABLE 36 (CONTD.)

Combination	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	1.655**	-0.043	0.296	0.628**	-3.854**	-1.278**	-1.138	-2.090**
$P_3 \times P_5$	-1.233**	-1.342**	-1.180**	-1.251**	1.450**	0.202	1.341**	0.998**
$P_3 \times P_6$	0.432**	0.397**	0.722**	0.517**	2.235**	1.440**	0.758	1.480**
$P_3 \times P_7$	1.091**	1.155**	-0.507	0.580**	1.910**	3.106**	1.013	2.013**
$P_3 \times P_8$	2.154**	1.726**	1.326**	1.735**	0.341	2.766**	-0.203	0.968**
$P_3 \times P_9$	-0.175	0.090	1.061	0.325	0.818	-0.625**	-0.566	-0.124
$P_3 \times P_{10}$	-0.559**	-0.149	-0.508	-0.405**	-0.359	-2.720**	-0.026	-1.035**
$P_4 \times P_5$	-0.447**	-0.374**	-0.257	-0.352**	0.081	2.494**	1.241**	1.272**
$P_4 \times P_6$	0.506**	1.052**	0.785**	0.781**	7.440**	5.014**	2.158**	4.871**
$P_4 \times P_7$	-0.359	1.063**	0.113	0.274	-7.576**	-4.000**	-1.886**	-4.487**
$P_4 \times P_8$	-0.476**	0.463**	-0.027	-0.322	-4.329**	-4.065**	-2.778**	-3.724**
$P_4 \times P_9$	0.670**	-0.171	0.002	0.167	-4.801**	-2.393**	-1.591**	-2.859**
$P_4 \times P_{10}$	-0.435**	-0.446**	-0.225	-0.369**	4.695**	1.821**	0.223	2.247**
$P_5 \times P_6$	1.487**	1.134**	0.216	0.946**	4.820**	-1.355**	1.188	1.551**
$P_5 \times P_7$	0.645**	0.907**	0.401	0.677**	-4.346**	-2.845**	-2.306**	-3.165**

TABLE 36 (CONCD.)

Combination	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	1.364**	1.227**	0.283	0.958**	-5.498**	-4.560**	-3.373**	-4.477**
$P_5 \times P_9$	0.534**	0.729**	0.078	0.447**	2.078**	1.771**	0.318	1.388**
$P_5 \times P_{10}$	0.840**	0.154	0.330	0.442**	5.775**	1.027**	2.153**	2.985**
$P_6 \times P_7$	-1.785**	-1.915**	-1.060**	-1.587**	1.188**	-1.500**	-0.638	-0.316
$P_6 \times P_8$	-0.082	0.199	-1.013	-0.208	-2.513**	0.859**	0.493	-0.386
$P_6 \times P_9$	-0.059	-0.153**	-0.448	-0.220	-7.261**	-3.658**	-1.118	-4.012**
$P_6 \times P_{10}$	0.313	-0.142	-0.161	0.003	-9.238**	1.272**	0.546	-2.473**
$P_7 \times P_8$	0.064	0.955**	1.978**	0.999**	2.168**	3.719**	1.548**	2.479**
$P_7 \times P_9$	0.641**	-0.172	0.118	0.196	2.420**	-0.798**	1.086	0.903**
$P_7 \times P_{10}$	0.027	-0.685**	0.471	-0.061	3.243**	-1.442**	-1.723**	0.025
$P_8 \times P_9$	-2.282**	-2.362**	-0.647**	-1.763**	1.318**	0.786**	2.243**	1.449**
$P_8 \times P_{10}$	-0.464**	-0.641**	-0.147	-0.417**	6.816**	2.742**	0.358	3.305**
$P_9 \times P_{10}$	-1.057**	-0.587**	0.187	-0.483**	-2.556**	1.674**	1.746**	0.288
SE	0.2090	0.1052	0.2780	0.1704	0.5319	0.1145	0.5168	0.3855

* Significant at 5% level
** Significant at 1% level

TABLE 37

100 grain weight and Grain yield per plant

Specific combining ability effects

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	-0.029**	0.008	-0.003	-0.008**	-2.078**	2.293**	0.470**	0.228
$P_1 \times P_3$	0.012	-0.012**	0.005	0.002	-2.763**	0.612**	-2.520**	-1.550**
$P_1 \times P_4$	-0.090**	-0.067**	-0.107**	-0.089**	-0.726**	0.838**	-1.055**	-0.314**
$P_1 \times P_5$	-0.067**	-0.034**	-0.085**	-0.062**	-0.508**	-0.294**	-0.425	-0.409**
$P_1 \times P_6$	-0.018**	-0.035**	-0.026**	-0.027**	-0.734**	-0.917**	-1.223**	-0.959**
$P_1 \times P_7$	-0.015**	-0.029**	-0.023**	-0.007**	1.627**	0.173	1.796**	1.190**
$P_1 \times P_8$	0.069**	0.047**	0.026**	0.048**	3.832**	1.012**	4.290**	3.040**
$P_1 \times P_9$	0.167**	0.195**	0.169**	0.177**	0.285	-0.296**	-0.543**	-0.185
$P_1 \times P_{10}$	0.057**	0.042**	0.045**	0.048**	-0.142	-1.927**	-0.677**	-0.915**
$P_2 \times P_3$	0.014**	0.057**	-0.001	0.023**	0.133	-0.769**	-0.046	-0.227
$P_2 \times P_4$	-0.005	-0.043	-0.023**	-0.008**	-0.775**	1.558**	0.300	0.361**
$P_2 \times P_5$	-0.083**	-0.113**	-0.063**	-0.087**	-3.059**	-3.091**	-3.221**	-3.120**
$P_2 \times P_6$	0.041**	0.036**	-0.039**	0.039**	2.949**	1.507**	3.370**	2.570**
$P_2 \times P_7$	0.155**	0.140**	0.168**	0.015**	-0.550**	-0.555**	-0.796**	-0.634**
$P_2 \times P_8$	0.158**	0.171**	0.143**	0.016**	3.586**	1.870**	1.439**	2.290**
$P_2 \times P_9$	-0.137**	-0.131**	-0.137**	-0.135**	-0.198	-0.183	-0.249	-0.210
$P_2 \times P_{10}$	0.021**	-0.012**	0.019**	0.007**	-0.265	-0.341**	-0.353	-0.320**

TABLE 37 (CONTD.)

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	0.012**	0.026**	0.028**	-0.023**	0.150	-0.319**	0.302	-0.044
$P_3 \times P_5$	-0.093**	-0.081**	-0.030**	-0.069**	1.026**	1.015**	1.738**	1.550**
$P_3 \times P_6$	-0.032**	-0.047**	0.003	-0.025**	2.194**	0.579**	1.790**	1.520**
$P_3 \times P_7$	0.154**	0.125**	-0.040**	0.080**	1.817**	0.990**	1.127**	1.310**
$P_3 \times P_8$	-0.015*	0.001	0.002	-0.004**	-1.144**	-1.044**	-0.673**	-0.954**
$P_3 \times P_9$	0.000	-0.009**	0.022**	0.004**	3.179**	3.480**	2.362**	3.000**
$P_3 \times P_{10}$	-0.001	-0.006	0.021**	0.004**	1.052**	-0.049	1.526**	0.843**
$P_4 \times P_5$	-0.005	0.006	0.003	0.002	4.252**	2.728**	3.029**	3.530**
$P_4 \times P_6$	0.062**	0.076**	0.057**	0.065**	1.605**	1.585**	1.324**	1.500**
$P_4 \times P_7$	0.050**	0.054**	0.064**	0.056**	0.468**	-1.323**	0.134	-0.240
$P_4 \times P_8$	0.018**	0.005	0.057**	0.027**	-1.328**	-1.171**	-0.439	-0.979**
$P_4 \times P_9$	-0.006	-0.035**	-0.013**	-0.018**	-0.228*	-1.248**	-1.015	-0.831**
$P_4 \times P_{10}$	0.000	-0.016**	-0.027**	-0.015**	-0.303	-0.711**	0.003	-0.337**
$P_5 \times P_6$	0.119**	0.107**	0.092**	0.106**	0.219	-0.002	0.415	0.210
$P_5 \times P_7$	0.004	0.004	0.039**	0.016**	0.164	0.211	0.419	0.265

TABLE 37 (CONTD.)

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	-0.040**	-0.014**	-0.045**	-0.033**	-2.188**	-2.504**	-1.138**	-1.940**
$P_5 \times P_9$	0.165**	0.150**	0.127**	0.147**	-0.063	0.006	-0.540**	-0.169
$P_5 \times P_{10}$	0.051**	0.048**	0.032**	0.044**	-0.130	1.575**	-0.341	0.867**
$P_6 \times P_7$	-0.044**	-0.043**	-0.018**	-0.035**	-0.892**	-0.886**	-0.457	-0.742**
$P_6 \times P_8$	-0.019**	0.001	0.034**	-0.017**	4.493**	5.982**	-0.986**	2.490**
$P_6 \times P_9$	-0.096**	-0.108**	-0.060**	-0.091**	-4.181**	-2.899**	-0.722**	-2.600**
$P_6 \times P_{10}$	0.027**	0.038**	-0.008**	0.019**	0.350	0.507**	1.393**	0.750**
$P_7 \times P_8$	-0.074**	-0.074**	-0.083**	-0.077**	-2.356**	0.533**	-0.950**	-0.926**
$P_7 \times P_9$	-0.006	0.011**	0.011**	0.006**	2.415**	2.794**	2.026**	2.410**
$P_7 \times P_{10}$	-0.069**	-0.035**	-0.061**	-0.055**	0.075	0.501**	-0.154	0.140
$P_8 \times P_9$	0.047**	0.041**	0.017**	0.036**	2.113**	1.615**	2.373**	2.030**
$P_8 \times P_{10}$	-0.095**	-0.087**	0.005	-0.059**	1.440**	2.480**	2.534**	2.150**
$P_9 \times P_{10}$	-0.034**	0.002	-0.021**	-0.018**	-0.438**	0.130	-0.464	-0.257
SE	0.0041	0.0043	0.0035	0.0013	0.1782	0.1396	0.2361	0.1533

* Significant at 5% level
** Significant at 1% level

TABLE 38

Straw yield per plant and Grain-straw ratio
Specific combining ability effects

Combination	Straw yield per plant				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	-2.709**	0.580**	-2.440**	-1.522**	-0.015**	0.054**	0.085**	0.034**
$P_1 \times P_3$	-6.307**	-0.518**	-6.015**	-4.282**	0.043**	-0.002	0.063**	0.034**
$P_1 \times P_4$	-3.082**	2.361**	-3.428**	-1.385**	0.037**	-0.034**	0.045**	0.016**
$P_1 \times P_5$	-3.103**	-6.710**	-5.217**	-6.680**	0.157**	0.112**	0.099**	0.123**
$P_1 \times P_6$	-6.983**	-10.060**	-8.916**	-8.633**	0.054**	0.113**	0.065**	0.077**
$P_1 \times P_7$	1.239**	-1.854**	1.610**	0.332	0.006	0.034**	0.010	0.017**
$P_1 \times P_8$	12.306**	9.915**	12.200**	11.677**	-0.094**	0.109**	-0.104**	-0.102**
$P_1 \times P_9$	13.154**	9.962**	10.935**	11.351**	-0.166**	-0.133**	-0.178**	-0.159**
$P_1 \times P_{10}$	3.905**	3.291**	4.084**	3.762**	-0.089**	-0.104**	-0.114**	-0.102**
$P_2 \times P_3$	-1.525**	-2.137**	-0.948**	-1.532**	0.053**	0.049**	0.037**	0.046**
$P_2 \times P_4$	-0.318	1.504**	-0.624**	0.187	0.007	0.022**	0.069**	0.033**
$P_2 \times P_5$	-2.033**	-1.992**	-1.068**	-1.699**	-0.061**	-0.065**	-0.098**	-0.075**
$P_2 \times P_6$	3.115**	1.000**	1.445**	1.854**	0.002	-0.002	0.029**	0.009
$P_2 \times P_7$	3.531**	3.918**	3.676**	3.710**	-0.074**	-0.078**	-0.098**	-0.083**
$P_2 \times P_8$	3.548**	2.496**	3.879**	3.307**	0.012**	-0.015**	-0.052**	-0.018**
$P_2 \times P_9$	2.066**	5.975**	0.172	2.260**	-0.062**	-0.094**	-0.077**	-0.077**
$P_2 \times P_{10}$	-2.680**	-3.574**	-1.685**	-2.647**	-0.002	0.001	0.021**	-0.007

TABLE 38 (CONTD.)

Combination	Straw yield per plant				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	-0.656	-2.339**	1.732**	-0.358	0.017**	0.047**	-0.036**	0.009
$P_3 \times P_5$	-4.094**	-6.434**	-2.853**	-4.454**	0.138**	0.155**	0.132**	0.142**
$P_3 \times P_6$	12.745**	11.406**	9.612**	11.256**	-0.147**	-0.154**	-0.132**	-0.144**
$P_3 \times P_7$	5.301**	3.309**	4.806**	4.472**	-0.047**	-0.037**	-0.060**	-0.048**
$P_3 \times P_8$	0.686	1.064**	0.416	0.725**	-0.072**	-0.072**	-0.066**	-0.070**
$P_3 \times P_9$	-3.368**	-1.735**	-4.750**	-3.284**	0.073**	0.050**	0.076**	0.066**
$P_3 \times P_{10}$	6.579**	6.090**	7.028**	6.567**	-0.094**	-0.107**	-0.092**	-0.098**
$P_4 \times P_5$	7.827**	5.632**	5.920**	6.478**	-0.058**	-0.048**	-0.044**	-0.050**
$P_4 \times P_6$	-4.609**	-5.238**	-3.696**	-4.515**	0.101**	0.111**	0.065**	0.092**
$P_4 \times P_7$	0.046	-1.775**	0.370	-0.488*	0.035**	0.012**	0.027**	0.024**
$P_4 \times P_8$	5.728**	6.214**	6.308**	6.082**	-0.121**	-0.113**	-0.118**	-0.117**
$P_4 \times P_9$	-4.173**	-5.239**	-6.529**	-5.334**	0.017**	0.012**	0.029**	0.019**
$P_4 \times P_{10}$	3.954**	2.803**	4.165**	3.637**	-0.083**	-0.075**	-0.107**	-0.088**
$P_5 \times P_6$	9.822**	9.751**	6.340**	8.637**	-0.153**	-0.130**	-0.102**	-0.122**
$P_5 \times P_7$	-2.394**	-1.930**	-1.048**	0.614*	0.047**	0.025**	0.047**	0.040**

TABLE 38 (CONTD.)

Combination	Straw yield per plant				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	-2.209**	-3.213**	-2.407**	-2.610**	-0.040**	-0.046**	-0.029**	-0.041**
$P_5 \times P_9$	4.588**	6.578**	2.552**	4.574**	-0.084**	-0.089**	-0.075**	-0.082**
$P_5 \times P_{10}$	3.416**	6.050**	2.754**	4.071**	-0.063**	-0.055**	-0.061**	-0.060**
$P_6 \times P_7$	0.917**	0.907**	-0.734**	0.363	-0.021**	-0.023**	-0.001	-0.017**
$P_6 \times P_8$	5.967**	4.950**	4.515**	5.139**	0.058**	0.040**	-0.023**	0.024**
$P_6 \times P_9$	-10.349**	-7.940**	6.008**	-4.093**	0.041**	0.034**	-0.022**	0.017**
$P_6 \times P_{10}$	-2.591**	-2.003**	-3.504**	-2.699**	0.063**	0.046**	0.096**	0.068**
$P_7 \times P_8$	-0.114**	-3.633**	-7.984**	-6.575**	0.049**	0.052**	0.103**	0.068**
$P_7 \times P_9$	5.305**	4.590**	4.464**	4.774**	0.002	0.012**	0.000	0.004
$P_7 \times P_{10}$	-3.120**	-2.637**	-2.800**	-2.855**	0.048**	0.041**	0.041**	0.043**
$P_8 \times P_9$	1.740**	0.658**	0.375**	0.924**	0.069**	0.060**	0.093**	0.074**
$P_8 \times P_{10}$	3.746**	2.054**	4.342**	3.382**	0.055**	0.070**	0.073**	0.066**
$P_9 \times P_{10}$	1.191**	-1.085**	-0.222	-0.039	0.043**	0.054**	0.059**	0.052**
SE	0.4597	0.1549	0.3071	0.2690	0.0057	0.0020	0.0104	0.0057

* Significant at 5% level

** Significant at 1% level

TABLE 39

Grain length and Grain width

Specific combining ability effects

Combination	Grain length				Grain width			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	-0.380**	-0.272**	-0.255**	-0.302**	-0.121**	-0.080**	-0.216**	-0.139**
$P_1 \times P_3$	-0.030**	0.003	0.119**	0.031*	-0.101**	-0.021	-0.073**	-0.065**
$P_1 \times P_4$	-0.006	0.001	0.072	0.022	0.000	0.006	-0.068**	-0.021
$P_1 \times P_5$	-0.095**	-0.124**	0.022	-0.066**	-0.015	-0.035**	0.000	-0.016
$P_1 \times P_6$	-0.024**	-0.084**	-0.062	-0.057**	0.092**	0.090**	0.064**	0.082**
$P_1 \times P_7$	0.054**	-0.012	-0.033	0.003	-0.014	-0.072**	0.023	-0.021
$P_1 \times P_8$	0.097**	0.110**	0.024	0.078**	0.044**	0.081**	0.066**	0.064**
$P_1 \times P_9$	0.157**	0.136**	0.114**	0.136**	0.008	-0.012	0.059**	0.018
$P_1 \times P_{10}$	0.152**	0.155**	0.068	0.125**	0.047**	0.036**	0.058**	0.051**
$P_2 \times P_3$	-0.081**	0.017	-0.126**	-0.063**	0.037**	0.001	0.037**	0.025**
$P_2 \times P_4$	-0.062**	-0.022	-0.053	-0.046**	0.033**	-0.006	0.089**	0.040**
$P_2 \times P_5$	-0.162**	-0.154**	-0.360**	-0.225**	-0.008	0.005	0.001	-0.001
$P_2 \times P_6$	0.203**	0.127**	0.039	0.123**	0.061**	0.033**	0.082**	0.059**
$P_2 \times P_7$	0.141**	0.088**	0.175**	0.135**	0.127**	0.113**	0.071**	0.104**
$P_2 \times P_8$	0.261**	0.172**	0.216**	0.216**	-0.016	-0.026	0.000	0.014
$P_2 \times P_9$	0.103**	0.066**	0.193**	0.121**	-0.055**	-0.044**	-0.024	-0.041**
$P_2 \times P_{10}$	0.193**	0.167**	0.293**	0.217**	-0.011	0.008	0.000	-0.001

TABLE 39 (CONTD.)

Combination	Grain length				Grain width			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	-0.102**	-0.171**	-0.086	-0.119**	-0.049**	-0.036**	0.003	-0.027**
$P_3 \times P_5$	0.006	0.038	-0.015	0.010	0.016	0.014	0.013	0.014
$P_3 \times P_6$	0.082**	0.000	0.021	0.035	0.020	-0.042**	0.014	0.000
$P_3 \times P_7$	0.076**	0.082**	0.052	0.071**	0.004	-0.027	-0.019	-0.014
$P_3 \times P_8$	0.079**	0.065**	0.075	0.074**	0.005	-0.036**	-0.006	-0.012
$P_3 \times P_9$	0.034**	0.046**	0.050	0.044	0.027	0.051**	0.039**	0.039**
$P_3 \times P_{10}$	0.061**	0.035	0.032	0.043	-0.013	0.037**	-0.001	-0.007
$P_4 \times P_5$	-0.352**	-0.311**	0.135**	-0.266**	-0.002	-0.025	0.007	-0.007
$P_4 \times P_6$	0.208**	0.135**	0.061	0.135**	-0.040**	-0.019	0.025**	-0.011
$P_4 \times P_7$	0.152**	0.124**	0.065	0.114**	0.035**	0.035**	0.057**	0.049**
$P_4 \times P_8$	0.075**	0.108**	0.138**	0.107**	0.002	0.025	0.022	0.017
$P_4 \times P_9$	0.147**	0.144**	0.015	0.102**	-0.006	0.027	-0.053**	-0.011
$P_4 \times P_{10}$	0.072**	0.110**	0.090	0.091**	0.020	0.003	0.029**	0.018
$P_5 \times P_6$	0.191**	0.190**	0.160**	0.180**	0.060**	0.038**	0.035**	0.065**
$P_5 \times P_7$	0.143**	0.176**	0.078	0.133**	-0.036**	-0.018	-0.050**	-0.035**

TABLE 39 (CONTD.)

Combination	Grain length				Grain width			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	0.151**	0.148**	0.169**	0.156**	-0.010	0.037**	-0.027**	-0.002
$P_5 \times P_9$	0.083**	0.094**	0.119**	0.099**	0.036**	0.028**	0.073**	0.046**
$P_5 \times P_{10}$	0.163**	0.122**	0.088	0.124**	-0.017	-0.032**	-0.003	-0.018
$P_6 \times P_7$	-0.172**	-0.076**	-0.041	-0.097**	-0.031**	-0.002	-0.052**	-0.029**
$P_6 \times P_8$	-0.082**	-0.127**	0.019	-0.063**	-0.142**	-0.062**	-0.019	-0.075**
$P_6 \times P_9$	-0.060**	-0.048**	-0.080	-0.063**	0.013	0.008	-0.058**	-0.012
$P_6 \times P_{10}$	0.000	0.039**	0.093	0.061**	-0.004	-0.059**	-0.052**	-0.032**
$P_7 \times P_8$	-0.137**	-0.065**	-0.034	-0.079**	0.010	0.004	0.005	0.007
$P_7 \times P_9$	-0.083**	-0.044**	-0.037	-0.055**	-0.002	0.018	0.015	-0.011
$P_7 \times P_{10}$	-0.140**	-0.186**	-0.088	-0.138**	-0.063**	0.005	-0.015	-0.025**
$P_8 \times P_9$	-0.125**	-0.123**	-0.236**	-0.161**	0.058**	0.035**	0.003	0.009
$P_8 \times P_{10}$	-0.170**	-0.134**	-0.337**	-0.214**	0.025	0.005	-0.025**	0.002
$P_9 \times P_{10}$	-0.138**	-0.158**	-0.084	-0.127**	0.034**	0.009	-0.012	0.010
SE	0.0104	0.0206	0.0480	0.0232	0.015	0.0318	0.0125	0.0113

* Significant at 5% level
** Significant at 1% level

TABLE 40

Length-width ratio of grain
Specific combining ability effects

Combination	Season			
	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	0.013	0.005	-0.192**	0.058**
$P_1 \times P_3$	0.151**	0.047**	0.030**	0.076**
$P_1 \times P_4$	0.049**	0.037**	0.049**	0.045**
$P_1 \times P_5$	0.001	0.000	0.152**	0.054**
$P_1 \times P_6$	-0.250**	-0.185**	0.011	-0.141**
$P_1 \times P_7$	0.020	0.065**	-0.165**	-0.006
$P_1 \times P_8$	-0.045	-0.110**	-0.201**	-0.119**
$P_1 \times P_9$	0.100**	0.105**	0.053**	0.086**
$P_1 \times P_{10}$	-0.022	-0.013	-0.075**	0.013
$P_2 \times P_3$	-0.046	0.028	-0.011	-0.010
$P_2 \times P_4$	0.020	0.064**	0.069**	0.052**
$P_2 \times P_5$	-0.028	-0.033**	0.048**	-0.005
$P_2 \times P_6$	-0.040	-0.011	-0.015	-0.022
$P_2 \times P_7$	-0.215**	-0.205**	0.037**	-0.013
$P_2 \times P_8$	0.095**	0.077**	0.124**	0.099**
$P_2 \times P_9$	0.168	0.070**	-0.031**	0.049**
$P_2 \times P_{10}$	0.057**	0.035**	-0.034**	0.019

TABLE 40 (CONTD.)

Combination	Season			
	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	0.050**	0.010	-0.034**	0.009
$P_3 \times P_5$	0.023	0.030	-0.048**	0.002
$P_3 \times P_6$	-0.045	0.021	0.067**	0.014
$P_3 \times P_7$	-0.019	0.062**	0.010	0.018
$P_3 \times P_8$	-0.004	0.055**	-0.043**	0.003
$P_3 \times P_9$	-0.037	-0.060**	0.051**	-0.015
$P_3 \times P_{10}$	0.021	-0.093**	0.023**	-0.018
$P_4 \times P_5$	-0.091**	-0.036**	0.039**	-0.009
$P_4 \times P_6$	0.083**	0.058**	-0.066**	0.025**
$P_4 \times P_7$	-0.077**	-0.117**	-0.023**	-0.073**
$P_4 \times P_8$	-0.077**	-0.052**	0.045**	-0.028**
$P_4 \times P_9$	0.050**	-0.001	-0.204**	-0.052**
$P_4 \times P_{10}$	-0.062**	-0.051**	-0.035**	-0.050**
$P_5 \times P_6$	-0.052	-0.072**	-0.029**	-0.025**
$P_5 \times P_7$	0.067**	0.062**	-0.049**	0.027**

TABLE 40 (CONCD.)

Combination	Season			
	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	0.049**	-0.023	-0.061**	-0.013
$P_5 \times P_9$	-0.032	-0.022	-0.038**	-0.031**
$P_5 \times P_{10}$	0.063**	0.065**	-0.189**	-0.020
$P_6 \times P_7$	0.020	-0.027	-0.166**	-0.058**
$P_6 \times P_8$	0.310**	0.097**	0.037**	0.145**
$P_6 \times P_9$	-0.067**	-0.036**	0.034**	-0.006
$P_6 \times P_{10}$	0.060**	0.192**	0.049**	0.100**
$P_7 \times P_8$	-0.029	0.010	-0.026**	-0.015
$P_7 \times P_9$	-0.019	-0.046**	0.068**	0.001
$P_7 \times P_{10}$	0.125**	0.015	0.092**	0.078**
$P_8 \times P_9$	-0.154**	-0.022	0.041**	-0.030**
$P_8 \times P_{10}$	-0.091**	-0.035**	-0.001	-0.043
$P_9 \times P_{10}$	-0.122**	-0.079**	-0.028**	-0.077**
SE	0.0245	0.0163	0.0119	0.0116

* Significant at 5% level

** Significant at 1% level

TABLE 41

SCA x season effect of the combinations

SCA & season (91)	Plant height	Bearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight
12.1	1.9389**	0.7798**	0.8655**	1.2960**	-0.0218**
12.2	0.8490	-0.5062**	-0.7830**	-0.8490**	0.0161**
12.3	-2.7865**	-2.5747**	0.2390	-0.9690	0.0049**
13.1	0.7131	-0.7743**	-0.1923	-1.4523**	0.0107**
13.2	1.1132**	0.0847	-0.0148	-0.9975	-0.0148**
13.3	-1.8250**	0.6887**	0.8032**	2.4027**	0.0033
14.1	-0.4879	0.1273	0.5413**	1.8977**	-0.0017
14.2	0.2057	-0.3787	0.2078	-1.3573**	0.0207**
14.3	0.2827	0.2503	-0.4232	-0.5173	-0.0198**
15.1	0.9345	0.4248	0.0782	-0.1807	-0.0056**
15.2	-1.6144**	-0.6962**	-0.5493**	0.6893	0.0279**
15.3	0.6801	0.2703	0.7987**	-0.4807	-0.0226**
16.1	0.0189	0.3948	-0.0502	-0.2523	0.0081**
16.2	-0.2635	0.0563	-0.3567	-1.0773**	-0.0090**
16.3	0.2465	-0.4522	0.7098**	1.3327**	0.0001
17.1	0.6303	-0.8668**	-0.9018**	1.4577**	-0.0083**
17.2	-0.1501	0.5572**	0.3852	0.4927	-0.0230**
17.3	-0.1981	0.3087	-0.0163	-1.9373**	0.0310**
18.1	-0.5244	-0.3960	-0.1547	0.4143	0.0216**
18.2	-0.0443	0.3605	0.0798	-0.6107	-0.0015*
18.3	1.0707**	0.0345	-0.4632	0.2043	-0.0215**
19.1	1.5983**	0.1423	-0.3462	-0.1673	-0.0102**
19.2	-0.9527	0.1613	0.3473	2.6627**	0.0173**
19.3	2.0953**	-0.3047	-0.3897	-2.5373**	-0.0080**
110.1	-1.8175**	-0.3260	-0.5943**	0.3279	0.0082**
110.2	1.0181**	0.1855	0.9242**	0.0360	-0.0072**
110.3	0.8006	0.3120	-0.8658**	0.3171	-0.0025
25.1	-1.3151**	-0.2769	0.3838	1.0877**	0.0008**

TABLE 41 (CONTD.)

SCA & season (S1)	Plant height	Earbearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight
23.2	1.4365**	-0.2578	-0.1902	-0.3123	0.0332**
23.3	-0.1190	0.5337**	0.1378	-0.7923	-0.0253**
24.1	0.5672	0.0915	-0.0225	1.0510	0.0026
24.2	0.9123	0.1705	0.0075	-0.4890	0.0115**
24.3	-0.7282	-0.0130	0.3365	-0.5790	-0.0156**
25.1	0.6147	0.2057	-0.6827	-5.2823**	0.0030
25.2	0.6423	1.4197**	0.0303	3.3027**	-0.0269**
25.3	-1.2557**	0.3737	0.9788**	1.9927**	0.0228**
26.1	0.3574	-0.5493**	-0.0325	2.2293**	0.0022
26.2	-1.2985**	0.4972**	0.1315	-0.3507	-0.0033
26.3	-0.0415	0.0512	0.2105	-1.9207**	-0.0001
27.1	-0.6813	0.5057**	1.2488**	-2.7357**	-0.0101**
27.2	0.1398	0.1122	0.2248	1.2643**	-0.0243**
27.3	0.8243	-0.5965**	-1.1467**	1.3943**	-0.0031
28.1	1.8974**	0.3015	0.5995**	1.5877**	0.0006
28.2	2.2290**	0.6955**	-0.1972	-1.4723**	0.0131**
28.3	-3.6235**	-0.2705	-0.0702	-0.2073	-0.0146**
29.1	-5.3146**	0.6865**	0.6678**	-0.3440	-0.0022
29.2	4.0207**	-0.3395	0.2253	-0.0490	0.0037
29.3	13.8697**	-0.3180	-0.5612**	0.3010	-0.0022
210.1	0.7461	-0.1535	0.1827	-1.7090**	-0.0156**
210.2	1.6918**	-0.0045	0.3022	-0.0599	-0.0494**
210.3	0.9482	-0.1570	0.3427	1.7260**	-0.0264**
34.1	-0.7169	0.1290	1.3297**	-1.7607**	-0.0101**
34.2	-1.5318**	0.0780	-0.6723**	0.8093	0.0038
34.3	2.0502**	-0.2080	-0.3323	0.9593	0.0050**
35.1	0.6639	0.1515	0.3445	0.4810	-0.0252**
35.2	-0.9935	-0.1895	-0.0895	-0.7740	-0.0136**

TABLE 41 (CONTD.)

SCA & season (S1)	Plant height	Earbearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight
35.3	0.3310	0.0370	0.0625	0.3460	0.0386**
36.1	-2.5351**	-0.0285	0.2412	0.7843	-0.0080
36.2	2.1490**	-0.1370	-0.1188	-0.0357	-0.0220**
36.3	0.3890	0.1645	0.2057	-0.7157	0.0286**
37.1	0.5346	0.4182	0.8363**	-0.1140	0.0751**
37.2	-0.8043	-0.1778	0.5763**	1.0460	0.0455**
37.3	0.5527	-0.1413	-0.0892	-1.0440	-0.1208**
38.1	4.4466**	0.3590	0.7448**	-0.6490	-0.0116**
38.2	-0.1618	-0.0005	-0.0087	1.7510**	0.0054**
38.3	-0.7618	-0.3105	-0.4077	-1.1940**	0.0061**
39.1	0.2669	-0.1055	-0.1763	0.9027	0.0040
39.2	0.5315	0.3185	-0.2348	-0.5423	-0.1145**
39.3	-0.7955	-0.2125	1.2362**	-0.4023	0.0179**
310.1	-0.1365	0.2340	0.1715	0.6877	0.0065**
310.2	0.2156	0.2030	0.2570	-1.6523**	-0.0118**
310.3	0.1031	-0.4380	-0.1020	1.0227	-0.2083**
45.1	-1.5580**	-0.3554	0.2315	-1.1640**	-0.0082**
45.2	1.5281**	0.4388	-0.0205	1.2410**	-0.0053**
45.3	0.0426	-0.0847	0.1145	0.0010	0.0019**
46.1	2.5556**	0.1648	0.3382	2.5227**	-0.0035
46.2	1.0082**	-0.1587	5.2722	0.1627	0.0104**
46.3	2.2872**	-0.0072	0.0057	-2.7273**	-0.0076**
47.1	1.0429**	0.0032	-0.3087	-2.9090**	-0.0025
47.2	1.7215**	0.1422	0.7923**	0.6110	-0.0055**
47.3	-2.4815**	-0.2463	-0.1522	2.8110**	-0.0023
48.1	-1.8544**	-0.1593	0.1705	-0.6223	0.0091**
48.2	2.3357**	0.0622	-0.1380	-0.3673	-0.0225**
48.3	0.0207	0.0962	0.2960	0.9777	0.0299**
49.1	0.2492	-0.0293	0.8290**	-1.9423**	0.0122**
49.2	0.0073	-0.0703	-0.3405	-4.3941**	0.1083**

TABLE 41 (CONTD.)

GCA & season (S1)	Plant height	Earbearing tillers per plant	Paniole length	Number of grains per paniole	100 grain weight
49.3	5.5943**	0.0987	-0.1605	1.5027**	0.0047
410.1	0.2558	0.0773	0.2588	2.4760**	-0.0145**
410.2	-1.6552**	-0.2687	0.0263	-0.4540	-0.0019
410.3	1.9173**	0.2903	-0.1433	-1.9890**	-0.0131**
56.1	-0.2386	0.1207	0.5663	3.2270**	0.0135**
56.2	0.9715	0.2178	0.1883	-2.9123**	0.0005
56.3	-0.7310	-0.0962	-0.7292	0.3323	-0.0145**
57.1	-2.3606**	-0.3077	0.3062	-1.2257**	-0.0124**
57.2	1.3265**	0.6663	0.2302	0.3193	-0.0120**
57.3	-0.1840	-0.3597	-0.1953	1.4393**	0.0231**
58.1	-0.7329	2.0465**	0.7417**	-0.9940	-0.0073**
58.2	0.6906	1.9330**	0.2732	-0.1090	0.0187**
58.3	0.5431	1.0995**	-0.6738**	1.1060**	-0.0122**
59.1	0.2134	0.0765	0.4122	0.6910	0.0180**
59.2	-0.2460	0.2705	0.2807	0.3310	0.0025
59.3	0.0345	-0.3480	-0.3703	-1.0690**	-0.0207**
510.1	-0.2416	0.0418	0.7233	2.8177**	0.0072**
510.2	-0.0885	-0.1278	-0.2042	-1.9873**	0.0039
510.3	1.1315**	0.1687	-0.1082	-0.8523	-0.0123**
67.1	0.9821	-0.0127	0.1208	1.5110**	-0.0059**
67.2	-0.5893	-0.3312	-0.3262	-1.2090**	-0.0091**
67.3	-0.1093	0.3428	0.5268	-0.2390	0.0164**
68.1	0.8691	0.3082	0.5420**	-2.0990**	-0.0019
68.2	-3.8638**	-0.1529	0.4975**	1.2210**	0.0815**
68.3	-1.2738**	-0.1563	-0.7110**	0.8560	-0.0170
69.1	-0.1523	-0.2118	0.5455**	-3.2223**	-0.0058**
69.2	1.1798**	-0.0603	0.0034	0.3527	-0.0179**
69.3	-1.0242**	0.2712	-0.2275	2.9027**	0.0723**

TABLE 41 (CONTD.)

SCA & season (S1)	Plant height	Tarbearing tillers per plant	Panicle length	Number of grains per panicle	100 grain weight
610.1	-1.1906**	-0.2210	0.8783**	-6.7373**	-0.0081**
610.2	-0.3210	0.2497	-0.1482	3.4927**	-0.0808**
610.3	1.5145**	-0.5288**	-0.1637	-5.2223**	-0.1238**
78.1	-1.5132**	-0.1202	-0.6068**	-7.3340**	0.0033
78.2	0.7799	-0.1687	-0.0473	-5.7340**	0.0021
78.3	1.5149**	0.2878	0.7862**	-7.9790**	-0.0063**
79.1	2.0257**	0.6265**	0.7733**	1.4360**	-0.0124**
79.2	0.0598	0.2905	-0.3682	-1.8090**	0.0058**
79.3	-1.8022**	0.5820**	-0.0787	0.0069	0.0062**
710.1	-0.4126	0.4748	0.4148	3.1977**	-0.0199
710.2	-1.1168**	0.0912	-0.6197**	-1.4927**	0.0191**
710.3	1.8115**	-0.3847	0.5368**	-1.7173**	-0.1056**
89.1	0.7461	-0.2860	-0.1912	-0.1307	0.0177
89.2	0.1157	-0.0645	-0.5952**	0.6557**	0.0066**
89.3	-0.3583	0.3495	1.1238**	0.7495	-0.0189**
810.1	1.1327**	0.2423	0.1150	3.5377**	-0.0366
810.2	0.5598	-0.0912	-0.2200	-0.6123	-0.0295**
810.3	-1.2197**	-0.1122	0.2750	-2.9923**	0.0648**
910.1	1.3698**	0.0840	-0.2395	-2.8940**	-0.0165**
910.2	1.1049**	0.0630	-0.0975	1.256**	0.0193**
910.3	-3.2616**	0.1520	0.6735**	1.416**	-0.0037
S.E.	0.5167	0.2437	0.2409	0.5452	0.0025

Note: 12.1 The first two digits denote hybrid combination, third digit, the season.

* Significant at 5% level
** Significant at 1% level

TABLE 42

SCA x season effect of the combinations

SCA & season (Sl)	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
12.1	-2.3086**	13.7544**	-0.0503**	-0.0778**	0.0162*	0.0717**
12.2	2.0614**	17.0430**	-0.0005	0.0304	0.0598**	0.0613**
12.3	0.2434	14.0177**	0.0503**	0.2785**	-0.0761**	-0.1345**
13.1	-1.2071**	12.8644**	0.0131	-0.0615	-0.0373**	0.0743**
13.2	2.1619**	18.6450**	-0.0371**	-0.0273	0.0439**	-0.0295
13.3	-0.9631**	13.1427**	0.0276**	0.3198**	-0.0080	-0.0468**
14.1	-0.4131	14.1527**	0.0210**	0.0067	0.0197	0.0037
14.2	1.1424**	19.5813**	-0.0514**	0.0144	0.0278	-0.0081
14.3	-0.7456**	13.7910**	0.0339**	0.3170**	-0.0460**	0.0025
15.1	-0.0990	12.1727**	0.0341**	-0.0370	0.0004	-0.0533**
15.2	0.1080	13.5463**	-0.0104	-0.0656**	-0.0190	-0.0492**
15.3	-0.0125	15.0410**	-0.0236**	0.0313	0.0177	0.0982**
16.1	0.2177	19.1411**	-0.0229**	0.0327	0.0090	-0.1098**
16.2	0.0357	14.7844**	0.0355**	-0.0271	0.0086	-0.0444**
16.3	-0.2668	17.2040**	-0.0126	0.2295**	-0.0187	0.1525**
17.1	0.4349**	16.8094**	-0.0106	0.0519	0.0064	0.0272
17.2	-1.0206**	13.7020**	0.0169**	-0.0150	-0.1015**	0.0710**
17.3	0.6074**	10.4527**	-0.0063	0.1942**	0.0447**	-0.0999**
18.1	1.7486**	28.6677**	0.0091	0.0199	-0.0191	0.0734**
18.2	-1.0804**	26.2703**	0.0067	0.0336	0.0170	0.0082
18.3	2.2076**	29.1510**	-0.0025	0.1782**	0.0022	-0.0829**
19.1	0.4712**	30.4477**	-0.0075	0.0329	-0.0106	0.0135
19.2	-0.1203	27.2513**	0.0360**	0.0011	-0.0310	0.0187
19.3	2.9152**	28.2160**	-0.0195**	0.2092**	0.0407**	-0.0034**
110.1	0.7738**	27.1794**	0.0133	0.0270	-0.0045	-0.0359**
110.2	-1.0212**	26.5530**	0.0080	0.0297	0.0147	-0.0266
110.3	3.5118**	27.3423**	-0.0118	0.1738**	0.0175	0.0613**
23.1	6.3635**	14.8061**	0.0063	-0.0536	0.0109	-0.0378**

TABLE 42 (CONTD.)

SCA & season (S1)	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
23.2	5.4485**	14.1897**	0.0019	0.0806**	-0.0245	0.037**
23.3	6.1795**	15.4744**	-0.0092	0.0623	0.0122	-0.0017
24.1	5.2608**	14.6677**	-0.0261**	-0.0161	-0.0071	-0.0312
24.2	-2.9293**	16.4863**	-0.0107	0.0256	-0.0425**	0.0123
24.3	-4.1793**	14.3460**	0.0358**	-0.0073	0.0502**	0.0170
25.1	0.0650	14.3411**	0.0139	-0.0639	-0.0095	-0.1787**
25.2	0.0280	14.3747**	0.0092	0.0710**	0.0056	-0.0289
25.3	-0.0965	15.2794**	-0.0238**	-0.1549**	0.0028	0.0528**
26.1	0.2753	22.5827**	-0.0075	0.0805**	0.0014	-0.0188
26.2	-2.5721**	20.3863**	-0.0122	0.0037	-0.0255	0.0104
26.3	0.7908	20.8860**	0.0197	-0.0842	0.0237	0.0059
27.1	0.0972	15.9761**	0.0009	0.0060	0.0224	-0.0881**
27.2	-1.8423**	16.3747**	0.0053	-0.0468	-0.0360**	-0.0785**
27.3	-0.1585	9.334**	-0.0155	0.0538	-0.0313**	0.165**
28.1	1.2827**	22.6577**	0.0204**	0.0444	-0.0050	-0.0032
28.2	-0.4403**	21.5563**	0.0033	0.0439	-0.0114	-0.0226
28.3	-0.8548**	22.9860**	-0.0342**	-0.0008	0.0145	0.0247
29.1	0.0152	22.1694**	0.0154	-0.0175	-0.0146	0.0586**
29.2	0.0197	25.6080**	-0.0162**	-0.0553	-0.0035	0.0207
29.3	-0.0309	20.3227**	0.00035	0.0723**	0.0177	-0.3309**
210.1	0.0598	23.3044**	0.0194**	-0.0238	-0.0108	0.0475**
210.2	-0.0312	21.4630**	0.0039	-0.0511	0.0103	0.0147
210.3	-0.0322	23.3327**	-0.0138	0.0745**	0.0000	-0.0538**
34.1	0.1057	16.0061**	0.0079	0.0177	-0.0370**	0.0415**
34.2	-0.3738	14.2547**	0.0373**	-0.0516	-0.0249	0.0012
34.3	0.2592	18.3894**	-0.0463**	0.0355	0.0163	-0.0240
35.1	-4.4435**	12.4961**	-0.0033	-0.0023	0.0012	0.0219
35.2	-5.3615**	10.2097**	0.0129	0.0279	-0.0012	0.0286

TABLE 42 (CONTD.)

SOA & season (S1)	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
35.3	-1.3630**	13.7694**	-0.0102	-0.0860**	-0.0015	-0.0511**
36.1	0.6765**	28.7694**	-0.0032	-0.1193**	0.0290	-0.0609**
36.2	-0.9505**	27.4530**	0.0241**	-0.2011**	-0.0424**	0.0069
36.3	0.2660	25.6277**	0.0119	-0.1800**	-0.0192	0.0519**
37.1	0.4283**	18.6977**	0.0006	0.0097	0.0184	-0.0379**
37.2	-0.4052	16.6763**	0.0450**	0.0109	-0.0648**	0.0383**
37.3	-0.2582	11.5110**	-0.0057	-0.0175	-0.0388**	-0.0076
38.1	-0.1928	22.4462**	-0.0018	0.0054	0.0177	-0.0020
38.2	-0.1028	22.7248**	0.0311**	-0.0079	-0.0252	0.0572**
38.3	0.2772	22.1295**	0.0033	0.0022	0.0060	-0.0409**
39.1	0.1750	21.0744**	0.0058	-0.0105	0.0927**	-0.0226
39.2	-1.5115**	22.6930**	0.0171**	0.0029	0.1163**	-0.0449**
39.3	-0.6470**	19.6827**	0.0096	0.0075	0.1050**	0.0664**
310.1	0.2046	28.2727**	0.0031	0.0189	-0.0213	0.0391**
310.2	-0.8974**	27.0313**	-0.0038	-0.0124	0.0303	-0.0910**
310.3	0.6946**	28.7760**	0.0035	-0.0108	0.0095	0.0409**
45.1	0.9188**	20.9294**	-0.0075	-0.0868**	-0.0040	-0.0823**
45.2	0.6127**	18.7330**	-0.0015	-0.0451	0.0184	-0.0275
45.3	-0.4579**	18.9827**	-0.0050	0.1315**	-0.0143	0.1086**
46.1	0.0985	18.8311**	0.0036	0.0735**	-0.0290	0.0584**
46.2	0.0693	18.2047**	0.0177**	0.0020	0.0084	0.0333**
46.3	-0.1762	23.0150**	0.0278**	-0.0732**	-0.0373**	-0.0927**
47.1	0.7160**	15.3477**	-0.0102	0.0365	-0.0138	-0.0056
47.2	-1.0390**	13.6163**	-0.0126	0.0102	0.0718**	-0.0453**
47.3	0.3780	9.0210**	-0.0023	-0.0487	0.0085	-0.4865**
48.1	-0.2961	24.2461	-0.0029	0.0318	0.0148	-0.0499**
48.2	-0.1456	24.7147**	0.0038	0.0004	0.0095	-0.0245
48.3	0.6024**	24.8894**	-0.0135	0.0310	0.0085	0.0732**

TABLE 42 (CONTD.)

30A & season (S1)	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
49.1	0.5990**	20.8744**	-0.0027	0.0454	0.0052	0.1021**
49.2	-0.4310**	19.6830**	-0.0076	0.0421	0.0378**	0.0499**
49.3	-0.1875	18.4427**	0.0094	0.0898**	-0.0425**	-0.1539
410.1	0.0320	26.6261**	0.0045	-0.0186	0.0019	-0.0132
410.2	-0.3839	25.5547**	0.0128	0.0187	-0.0145	-0.0023
410.3	0.3375	18.8694**	-0.0194**	-0.0012	0.0117	0.0135
56.1	0.0113	27.1427**	-0.0111	0.0105	-0.0050	-0.0075
56.2	-0.2177	26.9813**	-0.0082	0.0097	0.0341**	-0.0476**
56.3	0.2033	23.5710**	0.0197**	-0.0207	-0.0297	0.0539**
57.1	-0.0899	13.9711**	0.0074	0.0102	-0.0010	0.0400**
57.2	-0.0524	14.4047**	-0.0145	0.0434	-0.0344**	0.0354**
57.3	0.1591	8.6544**	0.0069	-0.0545	-0.0147	-0.0770**
58.1	-0.2420	21.0694**	-0.0072	-0.0051	-0.0095	0.0628**
58.2	-0.5670**	20.1030**	-0.0056	-0.0084	0.0071	-0.0159
58.3	0.8045**	20.8227**	0.0117	0.0132	-0.0272	-0.0485**
59.1	0.1065	24.9977**	-0.0015	-0.0163	-0.0096	-0.0018
59.2	0.2580	26.9713**	-0.0064	-0.0051	-0.0185	0.0079
59.3	-0.3730	22.9760**	0.0090	0.0210	0.0277	-0.0082
510.1	-0.4955**	26.8994**	-0.0040**	0.0382	0.0005	0.0840**
510.2	1.2005**	29.4930**	0.0051**	-0.0021	-0.0154	-0.0287
510.3	-0.7130**	26.2527**	-0.0016**	-0.0360	0.0143	-0.1696**
67.1	-0.1332	21.1111**	-0.0049	-0.0760**	-0.0028	0.0782**
67.2	-0.1447	21.1147**	-0.0118	0.0202	-0.0242	0.0297
67.3	0.2948	12.7594**	0.0159	0.0553	-0.0235	-0.1090**
68.1	1.9957**	30.2094**	0.3270**	-0.0195	-0.0675**	0.1646**
68.2	1.4807**	29.2130**	0.0154	-0.0636	0.0121	-0.0579**
68.3	-3.4798**	28.8277**	-0.0495**	0.0830**	0.0958**	-0.1087**
69.1	-1.5818**	19.3371**	0.0227**	0.0030	0.1929**	-0.0610**
69.2	-0.3093	21.6813**	0.0167**	0.0142	0.1880**	-0.0301
69.3	1.8627**	35.6800**	-0.0407**	-0.0177	0.1202**	0.0904**
610.1	1.4622**	88.5894**	-0.0057	-0.0608	0.1947**	-0.0400**

TABLE 42 (CONTD.)

SCA & season (S1)	Grain yield per plant	Straw yield per plant	Grain-straw ratio	Grain length	Grain width	Length-width ratio of grain
610.2	-0.2535	29.1530**	-0.0225**	0.0289	0.1398**	0.0919**
610.3	0.6260**	13.4777**	0.0283**	0.0320	0.1665**	-0.0519**
78.1	-1.4221**	15.9871**	-0.0101**	0.0904**	0.0039	0.5551**
78.2	1.4644**	20.4163**	-0.0164**	0.0099	-0.0455**	0.5945**
78.3	-0.0256	18.4006**	0.0343**	0.2012**	-0.0018	0.5569**
79.1	-0.1058	29.4327**	0.0140	-0.0281	-0.0128	-0.0210
79.2	0.2732	23.6913**	0.0241**	0.0101	-0.0422**	-0.0476**
79.3	-0.4893**	16.9310**	0.0111	0.0177	0.0055	0.0669**
710.1	-3.1363**	12.0440**	-0.0140	-0.0025	-0.0590**	0.0470**
710.2	-2.7278**	14.5097**	-0.0030	-0.0478	-0.0204	-0.0626**
710.3	-3.3678**	15.6744**	0.0013	0.0498	0.0088	0.0136
89.1	0.0742	29.3311**	0.0054	0.0355	0.0504**	-0.1255**
89.2	-0.4303**	23.3697**	0.0352**	0.0382	-0.0490**	0.0518**
89.3	0.3372	27.8994**	0.0192**	-0.0757**	0.0000	0.0716**
810.1	-0.7095**	38.2494**	-0.0116	0.0434	0.0223	-0.0487**
810.2	0.3205	36.5080**	0.0032	0.0796**	0.0448**	0.0067
810.3	0.3855	38.7927**	0.0060	-0.1233**	-0.0273	0.0407**
910.1	-0.1870	32.2827**	-0.0091	-0.0110	-0.0233	-0.0441**
910.2	-0.3805	29.9813**	0.0020	-0.0313	-0.0017	0.0032
910.3	-0.2070	30.2510**	0.0069	0.0423	-0.0230	0.0472**
SE	0.2167	0.3805	0.0080	0.0329	0.0160	0.0164

Note: 12.1 The first two digits denote hybrid combination, third digit, the season

* Significant at 5% level
** Significant at 1% level

in the S_1, S_2 and S_3 seasons respectively (Table 41).

(2) Harbearing tillers per plant: Significant positive gca effects in the parent P_6 and negative effects in the parents P_1 and P_7 were observed consistently in the seasons (Table 27). The interaction between gca x season was significant and positive for the parents P_2, P_5 and P_9 in the S_1 season, for the parents P_4, P_5, P_8 and P_9 in the S_2 season and for the parents P_3, P_6 and P_{10} in the S_3 season while it was significant and negative for three (P_1, P_3 and P_6), one (P_{10}) and three (P_2, P_4 and P_5) parents in the S_1, S_2 and S_3 seasons respectively (Table 33).

Of the four combinations which exhibited significant positive sca effects in the seasons, $P_8 \times P_9$ was superior (Table 35). Significant positive sca x season interaction was noticed for five combinations in the S_1 season, for another five combinations in the S_2 season and for four combinations in the S_3 season while negative interaction was noticed for three, two and three combinations in the S_1, S_2 and S_3 seasons respectively (Table 41).

(3) Panicle length: The parents P_6, P_8, P_9 and P_{10} showed significant positive gca effects consistently in the seasons while the parents P_1, P_2, P_4, P_5 and P_7 exhibited significant negative effects (Table 28). During the S_1 season the parents P_6, P_8 and P_9 interacted positively with the season while the parents, P_1, P_2, P_3 and P_5 interacted negatively

(Table 33). In the S_2 season the interaction of the parents P_1, P_2, P_4, P_5 and P_7 with the season was positive and for the parents P_8, P_9 and P_{10}, it was negative. In the S_3 season, positive interaction was observed in the parents P_1, P_8 and P_{10} and negative interaction in the parents P_6 and P_7.

The specific combining ability effects were significant and positive for the combinations $P_3 \times P_8$, $P_4 \times P_6$, $P_2 \times P_8$ and $P_3 \times P_6$, the values being 1.733, 0.781, 0.653 and 0.517 respectively. The effects were negative for four other combinations (Table 36). The gca x season interaction was significant and positive for 16 combinations and significant and negative for four combinations in the S_1 season (Table 41). In the S_2 season, four combinations showed positive interaction and five combinations, negative interaction. Ten and six combinations showed positive and negative interactions respectively in the S_3 season.

(4) Number of grains per panicle: The parents P_4, P_6, P_9 and P_{10} showed significant positive gca effects and the others exhibited significant negative gca effects consistently in the seasons (Table 28). Among the parents with positive effects, P_{10} was markedly superior, the value ranging from 3.768 to 6.651. The gca x season interaction was significant and positive for the parents P_3, P_5, P_9 and P_{10} in the S_1 season, for the parents P_1, P_2, P_3 and P_5 in the S_2 season and for the parents P_2 and P_5 in the S_3 season (Table 33). Negative

interaction was noticed for the parents P_1, P_2 and P_8, for the parents P_9 and P_{10} and for the parents P_1, P_3, P_9 and P_{10} in the S_1, S_2 and S_3 seasons respectively.

Five combinations showed positive gca effects in the seasons, while nine combinations showed negative effects (Table 36). Among the combinations showing positive effects, $P_4 \times P_6$ and $P_1 \times P_4$ were markedly superior, the value being 4.371 and 4.511 respectively. The gca x season interaction effect was significant and positive for 14 combinations and negative for 13 combinations in the S_1 season (Table 41). During the S_2 season, eight combinations exhibited significant positive interaction and 13 combinations negative interaction. Eleven combinations showed significant positive interaction and another 11 combinations, negative interaction in the S_3 season.

(5) <u>100 grain weight</u>: Four parents P_1, P_2, P_3 and P_4 were observed to be good general combiners with positive effect, among which P_1, was superior with the value ranging from 0.263 to 0.275 (Table 29). Five parents P_5, P_6, P_7, P_8 and P_9 showed significant negative gca effect in the seasons, P_7 recording the maximum negative effect of -0.267. In the S_1 season, the gca x season interaction was positive for all the parents except P_1, P_5 and P_9, while the interaction was negative for the parent P_1 (Table 33). In the S_2 season, the parents P_5, P_6, P_7, P_8 and P_9 showed positive interaction and the parents P_2, P_3 and P_{10}, negative interaction. The parents P_1,

P_4, P_5, P_6, P_8 and P_9 showed positive interaction and the parents P_3, P_7 and P_{10}, negative interaction in the S_3 season The parents P_3, P_7 and P_8 were superior in showing positive interaction during the S_1, S_2 and S_3 seasons respectively and their values were 0.0142, 0.0173 and 0.0089.

Significant positive sca effects were observed for 19, 17 and 19 combinations in the S_1, S_2 and S_3 seasons respectively (Table 37). The combination P_1 x P_9 was superior in showing the highest positive sca effect of 0.177 followed by P_5 x P_9 with a value of 0.147. Eleven combinations showed positive sca effects in all the seasons while 13, negative effects. The sca x season interaction was significant and positive for 14 combinations in the S_1 season, for 17 combinations in the S_2 season and 13 combinations in the S_3 season (Table 41).

(6) Grain yield per plant: The gca effects of the parents P_1, P_3, P_4, P_6 and P_{10} were significant and positive in the seasons and among the parents, P_3 was superior to others (2.04). The rest of the parents, recorded negative effects of which P_7 had the maximum negative effect of -4.42 (Table 39). The gca x season interaction effect was found to be significant and positive in the parents P_3, P_4, P_5, P_6, P_8 and P_{10} while the interaction was negative in the parents P_1, P_2, P_7 and P_9 in the S_1 season (Table 34). In the S_2 season, the parents P_1, P_2 and P_5 showed significant positive interaction and the

other parents showed negative interaction except P_4. Significant positive interaction was shown by the parents P_6, P_7 and P_9 and significant negative interaction by the other parents in the S_3 season except P_8.

Twelve combinations exhibited significant positive gca effects in the seasons, the combinations $P_4 \times P_5$, $P_1 \times P_8$ and $P_3 \times P_9$ being superior with values of 3.33, 3.04 and 3.00 respectively (Table 37). Eight combinations had significant negative effects in the seasons, with the combination $P_2 \times P_5$ recording the highest value of -3.12. The sca x season interaction effects were significant and positive in 13 combinations and negative in ten combinations during the S_1 season (Table 42). In the S_2 season, seven combinations showed significant positive interaction with the season and 16 showed negative interaction. Eleven combinations exhibited significant positive interaction while another eleven combinations registered negative interaction in the S_3 season.

(7) Straw yield per plant: The parents P_6, P_8, P_9 and P_{10} exhibited significant positive gca effects in the seasons, P_{10} recording the highest value of 12.052 (Table 30). The remaining parents showed negative effects with the parent P_2 having the maximum negative effect of -6.333. The gca x season interaction was positive in the parents P_3, P_8 and P_{10} and negative for the parents P_1, P_2 and P_9 in the S_1 season (Table 34). During the S_2 season the interaction was

significant and positive in the parents P_1, P_2, P_5 and P_7 and negative in the others except P_8. The parents P_6 and P_9 exhibited significant positive interaction with the S_3 season while P_1, P_2, P_7 and P_8 exhibited negative interaction. The parents P_8, P_2 and P_6 were superior with positive effects of 0.4808, 1.3110 and 1.2948 respectively in the S_1, S_2 and S_3 seasons.

Eighteen combinations exhibited significant positive sca effects in the seasons while 15 combinations exhibited negative effects (Table 38.. The combination P_1 x P_8 showed the maximum positive effect of 11.0777 and the combination P_1 x P_6, the maximum negative effect of -8.6330. The sca x season interaction was significant and positive for the combinations in the three seasons (Table 42).

(8) Grain-straw ratio: Significant and positive gca effects were registered by the parents P_1, P_2, P_3, P_4 and P_5 with the maximum value ranging from 0.118 to 0.131 for the parent P_3 in the seasons (Table 30). The parent P_9 registered the maximum negative value of -0.135 among the other parents. The gca x season effects were significant and positive for five, three and three parents in the S_1, S_2 and S_3 seasons respectively (Table 34). The parents exhibiting maximum interactions were P_1 and P_3 (0.0063), P_9 (0.0110 and P_7 (0.0122) in the S_1, S_2 and S_3 seasons respectively.

Fifteen combinations exhibited positive gca effects and 17 negative effects in the seasons (Table 38). The combination $P_3 \times P_5$ was superior with positive effect ranging from 0.132 to 0.155. The gca x season interaction was significant and positive for six, fourteen and nine combinations in the S_1, S_2 and S_3 seasons respectively (Table 42). Negative interaction was noted for four, three and nine combinations during the S_1, S_2 and S_3 seasons respectively.

(9) Grain length: The parents P_1, P_7, P_8, P_9 and P_{10} showed significant positive gca effects consistently in the seasons while the parents P_2, P_3, P_4 and P_5 exhibited negative effects (Table 31). Parent P_8 registered the maximum positive effect (0.485) and P_5, the maximum negative effect (-0.547). During the S_1 season, the parent P_6 interacted positively with the season while the parents P_1 and P_4 interacted negatively (Table 34). The interaction of the parent P_8 with the season was positive while for the parents P_1 and P_6, it was negative in the S_2 season. In the S_3 season, positive interaction was observed in the parents P_1, P_3 and P_4 and negative interaction in P_2, P_6, P_9 and P_{10}.

The specific combining ability effects were significant and positive for nine combinations and negative for five combinations in the seasons (Table 39). Among the combinations showing positive effects, $P_2 \times P_{10}$ and $P_2 \times P_8$ were superior, their pooled values being 0.217 and 0.216 respectively.

Among the combinations showing negative effects, $P_1 \times P_2$ was markedly superior, the value ranging from -0.255 to -0.300. The gca effects were significant and positive for 24, 22 and 11 combinations and negative for 18, 13 and five combinations in the S_1, S_2 and S_3 seasons respectively.

The gca x season interaction effect was significant and positive for three, three and thirteen combinations and negative for three, two and nine combinations in the S_1, S_2 and S_3 seasons respectively (Table 42). During the S_1, S_2 and S_3 seasons the combinations $P_7 \times P_8$, $P_2 \times P_3$ and $P_1 \times P_3$ respectively had the maximum positive interaction.

(10) Grain width: Five parents P_1, P_2, P_3, P_4 and P_5 recorded significant positive effects, the parent P_4 recording the maximum values ranging from 0.211 to 0.234 (Table 31). The parent P_7 registered the maximum negative effect ranging from -0.185 to -0.192 among the other parents. The gca x season interaction was positive for the parents, P_6 and P_9, for the parents P_1 and P_5 and for the parents, P_2 and P_4 during the S_1, S_2 and S_3 seasons respectively (Table 34). The parental P_5 and P_2 were superior to others in the S_1, S_2 and S_3 seasons respectively.

Significant positive gca effects were observed for 12, 11 and 14 combinations in the S_1, S_2 and S_3 seasons respectively (Table 39). Eight combinations showed positive gca effect in the seasons while two showed negative effects. The combination

$P_2 \times P_7$ had high positive effect and $P_1 \times P_2$, high negative effect. The gca x season interaction was significant and positive for four, ten and six combinations and negative for four, eight and seven combinations in the S_1, S_2 and S_3 seasons respectively (Table 42). The combinations $P_6 \times P_{10}$ (0.1947), $P_6 \times P_9$ (0.1880) and $P_8 \times P_{10}$ (0.1665) exhibited highest positive effect in the S_1, S_2 and S_3 seasons respectively.

(11) Length-width ratio of grain: The gca effects of the parents P_1, P_2, P_3, P_4 and P_5 were significant and negative while the remaining parents showed positive effects (Table 32). Parent P_7 registered the maximum positive effect (0.445) while P_4 registered the maximum negative effect (-0.518). The gca x seasons interaction effect was found to be significant and positive in the parents P_6, P_8 and P_{10} and negative in the parents P_2, P_4, P_5, P_7 and P_9 in the S_1 season (Table 34). In the S_2 season, the parents P_2, P_8 and P_{10} showed significant positive interaction, while the parents P_1, P_6 and P_7 exhibited significant negative interaction. Significant positive interaction was shown by the parents P_1, P_4, P_7 and P_9 and negative interaction by the parents P_5, P_8 and P_{10} in the S_3 season. The parents P_3, P_8 and P_7 registered the maximum positive interaction effects in the S_1, S_2 and S_3 seasons respectively.

Nine combinations exhibited significant positive sca effects (Table 40) in the seasons, the combinations $P_6 \times P_8$ and

P_6 x P_{10} being superior. The gca x season interaction effects were significant and positive in 16 combinations while in 14 combinations, the effects were significant and negative in the S_1 season (Table 42). In the S_2 season, 11 combinations showed significant and positive interaction with the season and ten showed significant and negative interaction. Seventeen combinations exhibited significant and positive interaction while 15 combinations registered significant and negative interaction effect in the S_3 season. In all the three seasons the combination P_7 x P_8 registered the maximum interaction effect consistently.

e. The seasonal effects: All the characters recorded significant seasonal effects (Table 43) except the grain width in the 1976 kar season. The panicle length showed significant and negative effect, while the other characters except grain width showed positive effects in the 1976 kar season. During 1977 mavorai season, the characters showed significant and positive effect while in the 1978 samba season, it was negative.

f. Reciprocal effects: The variances due to reciprocal differences among the combinations were significant for all the characters in the seasons except for tiller number in the S_1 season, for grain width in the S_1 and S_3 seasons and for length-width ratio of grain in the S_1 and S_2 seasons (Table 25). The interaction of the variances with the seasons for the

TABLE 43

Seasonal effects

Character	Season			SE
	S_1	S_2	S_3	
Plant height	1.0754**	4.7720**	-5.8490**	0.0567
Earbearing tillers per plant	0.3040**	1.2680**	-1.5730**	0.0271
Panicle length	-0.1620**	1.2080**	-1.0450**	0.0268
Number of grains per panicle	1.4160**	4.9160**	-6.3340**	0.0606
100 grain weight	0.0127**	0.0738**	-0.0864**	0.0003
Grain yield per plant	0.6400**	2.6200**	-3.2700**	0.0237
Straw yield per plant	0.5294**	3.9880**	-4.5170**	0.0423
Grain-straw ratio	0.0072**	0.0034**	-0.0106**	0.0009
Grain length	0.0117**	0.0619**	-0.0735**	0.0037
Grain width	-0.0018	0.0483**	-0.0465**	0.0018
Length-width ratio of grain	0.1365**	0.0900**	-0.2266**	0.0018

* Significant at 5% level
** Significant at 1% level

TABLE 44

Plant height and Earbearing tillers per plant

Reciprocal effects

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	0.350	-0.025	0.500	0.274	-0.075	0.024	0.150	0.033
$P_1 \times P_3$	-0.199	1.100**	0.474	0.650**	-0.224	0.649**	0.500	0.308**
$P_1 \times P_4$	0.200	2.250**	0.799	1.083**	0.125	0.600**	0.099	0.275**
$P_1 \times P_5$	-1.050**	-0.025	-0.349	-0.475	-0.425	-0.375	-0.024	-0.275**
$P_1 \times P_6$	-0.425	0.000	0.650	0.075	0.575	0.100	1.125**	0.600**
$P_1 \times P_7$	0.675	1.149**	1.150	0.991**	-0.049	-0.125	-0.050	-0.075
$P_1 \times P_8$	-0.125	-3.525**	0.625	-1.424**	0.299	0.099	0.014	0.158
$P_1 \times P_9$	0.349	-1.650**	1.149	-0.050	0.074	-0.449	-0.175	-0.183
$P_1 \times P_{10}$	0.024	-1.799**	0.799	-0.324	0.025	-0.599**	0.324	-0.316**
$P_2 \times P_3$	-0.300	1.700**	0.349	0.583**	-0.225	0.300	0.300	0.275**
$P_2 \times P_4$	0.450	-1.000**	1.025	0.158	0.150	0.250	-0.150	0.083
$P_2 \times P_5$	0.275	2.075**	0.950	1.100**	-0.024	-0.350	-0.250	-0.041
$P_2 \times P_6$	-0.400	-0.949**	1.775**	0.141	-0.025	-0.925**	0.474	-0.141
$P_2 \times P_7$	-0.524	2.599**	-1.825**	0.083	-0.074	-0.600**	0.050	-0.208
$P_2 \times P_8$	-0.675	-1.825**	0.099	-0.799**	-0.099	-0.750**	-0.324	-0.391**
$P_2 \times P_9$	-0.775	-2.224**	0.375	-0.875**	-0.300	-0.400	-0.174	-0.291**
$P_2 \times P_{10}$	-0.125	-2.924**	0.475	-0.858**	0.000	-0.324	0.324	0.000

TABLE 44 (CONTD.)

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	0.649	2.574**	1.474**	1.566**	-0.449**	-0.150	-0.599**	-0.399**
$P_3 \times P_5$	-0.174	0.375	0.925	0.375	0.150	-0.300	0.025	-0.041
$P_3 \times P_6$	0.025	-0.699**	-3.625**	-1.433**	0.225	0.500**	0.550**	0.425**
$P_3 \times P_7$	0.074	0.625**	-1.825**	-0.375	0.250	-0.425	0.499	0.105
$P_3 \times P_8$	-0.149	-0.474**	0.125	-0.166	-0.100	-0.925**	-0.350	-0.458**
$P_3 \times P_9$	-0.300	-3.400**	-1.125	-1.608**	0.199	-0.550**	0.124	-0.075
$P_3 \times P_{10}$	-0.250	-0.474**	0.425	-0.099	-0.225	-1.250**	-0.350	-0.608**
$P_4 \times P_5$	0.824	4.225**	1.475**	2.175**	0.000	-0.349	-0.350	-0.233
$P_4 \times P_6$	0.024	0.625**	2.100**	0.916**	-0.224	0.300	-0.425	-0.116
$P_4 \times P_7$	0.125	-1.150**	1.049	0.008	-0.050	-0.775**	-0.199	-0.325**
$P_4 \times P_8$	-0.250	0.250	1.174	0.391	0.275	-0.774**	-0.250	-0.250
$P_4 \times P_9$	-1.075**	-1.974**	-1.525**	-1.525**	-0.074	-0.175	0.374	0.041
$P_4 \times P_{10}$	-0.399	-3.125**	-1.875**	-1.799**	0.300	-0.325	-0.250	-0.091
$P_5 \times P_6$	-0.850	-0.875**	2.074**	0.116	-0.024	-0.075	0.125	0.008
$P_5 \times P_7$	0.025	1.724**	-1.625**	0.041	-0.225	0.275	-0.125	-0.024

TABLE 44 (CONTD.)

Combination	Plant height				Earbearing tillers per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	-0.099	-1.000**	1.150	0.016	0.490	-0.475**	-0.375	-0.235
$P_5 \times P_9$	0.450	-1.449**	1.250	0.083	0.175	-1.000**	-0.724**	-0.516**
$P_5 \times P_{10}$	0.699	-0.600**	1.250	0.449	-0.050	-0.475**	-0.100	-0.208
$P_6 \times P_7$	0.775	-0.150	-0.950	-0.108	-0.350	-0.050	-0.649**	-0.349**
$P_6 \times P_8$	0.074	-0.825**	-1.500**	-0.750**	0.074	-0.275	-0.274	-0.158
$P_6 \times P_9$	1.875**	-0.199	-1.075	0.200	0.100	-0.524**	-0.399	-0.274**
$P_6 \times P_{10}$	0.199	-0.049	-0.924	-0.258	0.074	0.000	-0.050	0.008
$P_7 \times P_8$	-0.599	-0.300	1.049	0.049	0.050	0.399	-0.349	0.033
$P_7 \times P_9$	-0.075	0.100	-0.875	-0.283	-0.074	0.099	-0.424	-0.133
$P_7 \times P_{10}$	-0.300	0.025	-0.550	-0.274	-0.149	-0.475**	0.049	-0.191
$P_8 \times P_9$	-0.199	-0.824**	1.075	0.016	0.250	-0.325	0.300	-0.125
$P_8 \times P_{10}$	-0.099	-1.050**	0.725	-0.141	-0.350	-0.550**	-0.374	-0.424**
$P_9 \times P_{10}$	0.949**	1.750**	1.099	1.266	-0.324	-0.600**	-0.175	-0.366**
SE	0.4336	0.2062	0.7011	0.2837	NS	0.2345	0.2716	0.1354

* Significant at 5% level
** Significant at 1% level

TABLE 45

Panicle length and Number of grains per panicle

Reciprocal effects

Combination	Panicle length				Number of grains per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	-0.009	0.559**	-0.649**	-0.033	0.974	1.250**	-0.724	0.500
$P_1 \times P_3$	-0.679**	-1.107**	-0.409	-0.732**	-2.700**	-4.175**	1.700**	-1.725**
$P_1 \times P_4$	0.254	-0.737**	-0.612**	-0.364**	2.425**	1.324**	-2.125**	0.541
$P_1 \times P_5$	0.447	-0.827**	-0.427	-0.269**	-0.099	2.050**	-0.625	0.441
$P_1 \times P_6$	0.092	-0.117	0.099	0.024	1.450**	2.125**	3.199**	2.258**
$P_1 \times P_7$	-0.085	-0.467**	0.317	-0.078	-0.175	2.474**	0.900	1.066**
$P_1 \times P_8$	0.135	-0.234**	0.052	-0.050	1.224**	-0.775**	-0.699	-0.083
$P_1 \times P_9$	0.295	-0.025	-0.137	0.044	0.500	-2.125**	-0.125	-0.583
$P_1 \times P_{10}$	-0.147	-1.674**	0.017	-0.601	0.674	-0.974**	0.250	-0.016
$P_2 \times P_3$	-0.284	-0.442	0.165	-0.187	-0.625	-3.150**	-0.050	-1.274**
$P_2 \times P_4$	-0.372	-0.580**	0.504	-0.149	0.175	0.175	1.974**	0.774**
$P_2 \times P_5$	-0.372	-0.742**	0.395	-0.240	0.075	1.799**	1.275	1.050
$P_2 \times P_6$	-0.157	-0.090	0.367	0.040	0.025	-1.400**	0.650	-0.241
$P_2 \times P_7$	0.055	-0.122	0.014	-0.017	1.224**	0.750**	-0.025	0.649**
$P_2 \times P_8$	0.055	-1.182**	0.402	-0.241	0.650	0.250**	2.049**	0.983**
$P_2 \times P_9$	0.335	-1.004	0.157	-0.170	-0.700	-2.049**	0.749	-0.666**
$P_2 \times P_{10}$	0.112	0.644**	0.157	-0.125	-0.975**	-3.125**	0.149	-1.316**

TABLE 45 (CONTD.)

Combination	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	1.690**	0.647**	0.852**	1.063**	0.500	0.650**	0.399	0.516
$P_3 \times P_5$	0.500**	0.552**	0.640**	0.564**	0.125	-0.274**	1.150	0.333
$P_3 \times P_6$	-0.079	-0.120	-0.087	-0.095	0.324	2.800**	-0.549	0.858**
$P_3 \times P_7$	-0.127	-0.345**	-0.762**	-0.411**	0.125	-0.300**	-1.900**	-0.691**
$P_3 \times P_8$	0.084	-0.237**	-0.194	-0.115	-0.275	-1.049**	-0.024	-0.449
$P_3 \times P_9$	0.177	-0.930**	-0.072	-0.274**	0.050	-0.949**	0.025	-0.291
$P_3 \times P_{10}$	0.250	-1.165**	0.300	-0.204	-0.599	-3.375**	1.050	-0.974**
$P_4 \times P_5$	0.159	-0.375**	0.217	0.000	-0.224	0.524**	0.175	0.158
$P_4 \times P_6$	0.402	-0.514**	0.300	0.062	0.400	1.575**	2.424**	1.466**
$P_4 \times P_7$	0.049	0.157	0.167	0.125	0.300	0.099	-0.225	0.058
$P_4 \times P_8$	0.402	0.222	0.874**	0.500	0.375	-0.325**	0.675	0.241
$P_4 \times P_9$	0.262	0.107	-0.502	-0.044	-0.750	-1.450**	-0.524	-0.908**
$P_4 \times P_{10}$	-0.157	-0.482**	-0.972**	-0.537**	-0.074	-2.024**	-2.025**	-1.375**
$P_5 \times P_6$	-0.239	-0.259**	0.560	0.026	0.349	-5.599**	0.774	-1.491**
$P_5 \times P_7$	0.489**	0.350**	-0.444	0.131	-0.299	0.250**	-1.124	-0.391

TABLE 45 (CONTD.)

Combination	Panicle length				Number of grains per panicle			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	-0.130	-0.592**	0.204	-0.172	0.624	1.624**	0.650	-0.116
$P_5 \times P_9$	-0.082	-0.032	1.352**	0.412**	-0.200	-1.799**	0.250	-0.583
$P_5 \times P_{10}$	0.170	-0.517**	0.157	-0.063	0.475	-1.724**	0.324	-0.308
$P_6 \times P_7$	0.020	0.114	-0.417	-0.094	0.049	-4.375**	-2.325**	-2.216**
$P_6 \times P_8$	-0.082	0.157	-0.352	-0.092	0.224	1.925**	-0.699	0.483
$P_6 \times P_9$	0.117	-0.367**	-0.299	-0.183	-1.175**	-2.150**	-0.150	-1.158**
$P_6 \times P_{10}$	0.222	-0.097	-0.180	-0.018	0.675	-1.700**	-0.949	-0.658**
$P_7 \times P_8$	0.162	0.340**	0.665**	0.389**	0.874	1.525**	1.299	1.233**
$P_7 \times P_9$	-0.807**	-0.330**	0.347	-0.263**	-0.125	-1.549**	1.950**	0.091
$P_7 \times P_{10}$	-0.284	-0.357**	0.272	-0.123	0.224	1.075**	-1.225	0.024
$P_8 \times P_9$	-0.097	-0.017	-0.170	-0.095	-0.500	-1.025**	-0.599	-0.708**
$P_8 \times P_{10}$	0.067	-0.292**	0.407	0.060	-0.274	0.500*	1.600**	0.608**
$P_9 \times P_{10}$	-0.592**	0.190	0.259	0.047	-0.549	-0.025	1.250	0.225
SE	0.2308	0.1162	0.3070	0.1704	0.5874	0.3507	0.6812	0.3029

* Significant at 5% level
** Significant at 1% level

TABLE 46

100 grain weight and grain yield per plant
Reciprocal effects

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	0.002	-0.010**	-0.012**	-0.007**	0.077	-0.227	0.504	0.118
$P_1 \times P_3$	0.003	0.019**	0.000	0.007**	-0.310	0.345**	-1.214**	-0.393**
$P_1 \times P_4$	-0.009**	-0.031**	0.000	0.013**	0.179	0.092	0.372	0.214
$P_1 \times P_5$	0.009**	0.024**	-0.006	0.009**	-0.360	-0.195	0.042	-0.170
$P_1 \times P_6$	-0.005	0.003	-0.002	-0.007**	-0.029	-0.132	0.007	-0.052
$P_1 \times P_7$	0.013**	-0.026**	-0.001	-0.005**	0.142	-0.217	-0.010	-0.028
$P_1 \times P_8$	-0.009**	0.005	0.004	0.000	0.239	0.507**	0.409	0.385**
$P_1 \times P_9$	-0.046**	-0.023**	-0.001	-0.024**	0.120	-0.267	0.122	-0.008
$P_1 \times P_{10}$	-0.007	-0.012**	0.005	-0.005**	-0.037	-0.037	-0.597**	0.199
$P_2 \times P_3$	0.040**	0.066**	-0.017**	0.030**	0.142	1.072**	-0.107	0.369**
$P_2 \times P_4$	0.019**	0.001	0.010**	0.011**	0.447**	0.207	0.737**	0.464**
$P_2 \times P_5$	-0.028**	-0.025**	-0.002	-0.019**	0.229	-0.647**	0.405	-0.004
$P_2 \times P_6$	-0.008	-0.011**	-0.013**	-0.011**	-0.055	-0.247	0.030	-0.091
$P_2 \times P_7$	-0.018**	0.005	-0.003	-0.006**	0.110	0.507**	0.000	0.205
$P_2 \times P_8$	0.004	0.012**	0.002	0.006**	-0.125	0.139	0.382	0.132
$P_2 \times P_9$	-0.001	0.001	0.000	0.000	0.032	-0.364**	0.000	-0.110
$P_2 \times P_{10}$	0.003	0.005	-0.004	0.001	0.205	-0.422**	0.290	0.024

TABLE 46 (CONTD.)

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	-0.033**	0.001	-0.001	-0.011**	0.004	0.452**	0.425	0.294**
$P_3 \times P_5$	0.002	0.025**	0.001	0.010**	0.187	0.547**	0.354	0.363**
$P_3 \times P_6$	0.010**	0.037**	-0.004	0.014**	0.237	0.372**	-0.180	0.143
$P_3 \times P_7$	0.028**	0.013**	-0.009	0.011**	0.229	0.132	0.090	0.150
$P_3 \times P_8$	-0.025**	0.000	0.000	-0.009**	0.219	0.362**	-0.200	0.127
$P_3 \times P_9$	-0.004	-0.001	0.008**	0.001	0.662**	-0.592**	0.562**	0.210
$P_3 \times P_{10}$	-0.006	0.005	-0.002	-0.001	-0.130	-0.887**	0.094	-0.290**
$P_4 \times P_5$	-0.003	-0.012**	-0.005	-0.007**	0.142	0.017	-0.290	-0.043
$P_4 \times P_6$	0.019**	0.015**	-0.008**	0.009**	0.487**	0.185	-0.092	0.193
$P_4 \times P_7$	-0.016**	0.008**	0.006	-0.007**	0.129	-0.184	0.224	0.056
$P_4 \times P_8$	0.001	-0.019**	-0.006	-0.008**	0.159	-0.577**	0.062	-0.118
$P_4 \times P_9$	-0.018**	-0.025**	0.004	-0.013**	0.277	-0.470**	0.102	-0.023
$P_4 \times P_{10}$	0.009**	0.003	0.003	0.005**	0.082	-0.352**	0.125	-0.048
$P_5 \times P_6$	0.013**	-0.011**	-0.006	0.006**	0.237	0.242	-0.432	0.016
$P_5 \times P_7$	-0.014**	-0.007**	0.006	-0.005**	0.292	0.479**	0.474	0.415**

TABLE 46 (CONTD.)

Combination	100 grain weight				Grain yield per plant			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	0.014**	0.011**	-0.002	0.008**	0.102	-0.360**	-0.027	-0.095
$P_5 \times P_9$	0.014**	0.005	-0.010**	0.003**	-0.164	-0.275	-0.222	-0.220
$P_5 \times P_{10}$	-0.004	0.002	0.000	-0.001	-0.172	-0.069	0.070	-0.057
$P_6 \times P_7$	-0.009**	0.011**	0.002	0.001	0.167	-0.177	-0.473	-0.163
$P_6 \times P_8$	0.004	0.007**	0.007	0.006**	0.250	-0.042	-0.072	0.045
$P_6 \times P_9$	-0.038**	0.000	0.000	-0.013**	-0.672**	-0.935**	-0.217	-0.608**
$P_6 \times P_{10}$	-0.009**	-0.013**	-0.010**	-0.011**	0.455**	-0.437**	0.037	0.018
$P_7 \times P_8$	0.002	0.009**	-0.007	-0.002	0.204	0.162	-0.280	0.029
$P_7 \times P_9$	0.000	-0.013**	-0.005	-0.006**	0.014	0.117	-0.184	-0.017
$P_7 \times P_{10}$	-0.012**	-0.007**	0.005	-0.005**	0.200	-0.555**	0.312	-0.014
$P_8 \times P_9$	-0.009**	-0.021**	0.009**	0.007**	-0.254	-0.364**	-0.042	-0.220
$P_8 \times P_{10}$	0.056**	0.029**	-0.010**	0.025**	0.582**	0.090	0.322	0.331**
$P_9 \times P_{10}$	0.002	-0.001	-0.008**	-0.003**	0.189	0.259	0.164	0.204
SE	0.0045	0.0048	0.0039	0.0014	0.1968	0.1541	0.2608	0.1204

* Significant at 5% level
** Significant at 1% level

TABLE 47

Straw yield per plant and Grain-straw ratio
Reciprocal effects

Combination	Straw yield per plant				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_1 \times P_2$	0.309	0.732**	0.150	0.398	-0.005	-0.021**	0.016	-0.003
$P_1 \times P_3$	0.125	0.489**	0.239	0.285	-0.015**	-0.001	-0.052**	-0.023**
$P_1 \times P_4$	0.327	0.255	0.199	0.420**	-0.016**	-0.002	0.007	-0.003
$P_1 \times P_5$	-0.387	0.305	-0.154	-0.078	-0.001	-0.019**	0.007	-0.004
$P_1 \times P_6$	-0.102	0.285	-0.072	0.035	0.000	-0.009**	0.001	-0.002
$P_1 \times P_7$	0.217	-0.327	-0.172	-0.092	0.000	0.000	0.003	0.001
$P_1 \times P_8$	-0.892	0.302	-0.424	-0.537	-0.012	0.006**	0.011**	0.009
$P_1 \times P_9$	0.102	1.665**	-0.177	0.532**	0.001	-0.016**	0.003	-0.004
$P_1 \times P_{10}$	0.332	-0.107	0.317	0.180	-0.003	0.001	0.009	0.002
$P_2 \times P_3$	0.352	-0.102	0.092	0.113	-0.005	0.004	-0.007	-0.002
$P_2 \times P_4$	0.512	0.505**	0.200	0.405	0.000	-0.005**	0.023**	0.006
$P_2 \times P_5$	-0.112	0.102	0.050	0.013	0.010	-0.020**	0.015	0.001
$P_2 \times P_6$	0.327	-0.592**	-0.014	0.095	-0.005	0.003	0.000	0.000
$P_2 \times P_7$	0.135	0.397**	-0.555	-0.007	0.000	0.007**	0.011	0.006
$P_2 \times P_8$	0.790	0.685**	0.082	0.520*	-0.011	-0.004	0.008	-0.002
$P_2 \times P_9$	0.525	-0.425**	-0.980	-0.064	0.006	-0.003	0.034**	0.012
$P_2 \times P_{10}$	-0.087	-0.157	0.247	0.015	0.004	-0.006**	0.004	0.000

TABLE 47 (CONTD.)

Combination	Straw yield per panicle				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_3 \times P_4$	0.662	0.012	0.692**	0.490**	-0.017**	0.012**	-0.004	-0.003
$P_3 \times P_5$	-0.165	0.487**	-0.154	0.055	0.011	0.002	0.020	0.011**
$P_3 \times P_6$	1.159**	3.005**	0.572	1.580**	-0.006	-0.021**	-0.009	-0.012**
$P_3 \times P_7$	-0.157	-0.119	-0.225	-0.168	0.009	0.005**	0.007	0.007
$P_3 \times P_8$	0.207	-0.219	-0.490	-0.167	0.002	0.010**	0.001	0.004
$P_3 \times P_9$	0.037	-0.680**	-0.032	-0.223	0.015**	-0.002	0.015	0.009*
$P_3 \times P_{10}$	0.334	-0.180	0.252	0.135	-0.005	-0.012**	0.000	-0.006
$P_4 \times P_5$	0.189	-0.449**	0.787**	0.175	0.000	0.007**	-0.025**	-0.005
$P_4 \times P_6$	2.717**	3.024**	-0.322	1.807**	-0.044**	-0.055**	0.004	-0.031**
$P_4 \times P_7$	0.627	-0.320	0.112	0.140	-0.010	0.000	0.005	-0.001
$P_4 \times P_8$	0.109	-0.799**	-0.340	-0.343	0.002	-0.003	0.004	0.001
$P_4 \times P_9$	-0.580	-0.617**	0.832**	0.265	-0.001	-0.002	-0.011	-0.004
$P_4 \times P_{10}$	-0.002	-1.214**	-0.127	-0.447**	0.001	0.005**	0.029**	0.012**
$P_5 \times P_6$	0.765	-0.970**	0.702**	0.167	-0.002	0.012**	-0.017	-0.002
$P_5 \times P_7$	0.465	0.299	-0.362	-0.177	0.021**	0.003**	0.029**	0.019**

TABLE 47 (CONTD.)

Combination	Straw yield per panicle				Grain-straw ratio			
	Season				Season			
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3	Pooled
$P_5 \times P_8$	0.137	-1.252**	0.202	-0.305	-0.001	0.005**	-0.003	0.000
$P_5 \times P_9$	-0.922	-0.904**	-0.997**	-0.940**	0.006	0.002	0.007	0.005
$P_5 \times P_{10}$	0.914	-1.084**	0.554	0.128	-0.011	0.007**	-0.004	-0.002
$P_6 \times P_7$	-0.147	0.015	-0.472	-0.200	0.005	-0.004	-0.006	-0.001
$P_6 \times P_8$	0.055	0.092	-0.207	-0.020	0.003	0.006**	0.000	0.003
$P_6 \times P_9$	0.180	-0.877**	-0.184	-0.295	-0.016**	-0.010**	-0.002	-0.009**
$P_6 \times P_{10}$	0.832	-0.852**	-0.207	-0.077	0.000	0.000	0.002	0.000
$P_7 \times P_8$	0.305	0.714**	0.544	0.522**	0.001	-0.004	-0.007	-0.003
$P_7 \times P_9$	-0.522	0.590**	-0.364	-0.098	0.004	-0.003	0.000	0.000
$P_7 \times P_{10}$	-0.470	-1.120**	-0.270	-0.620**	0.009	-0.001	0.011	0.006
$P_8 \times P_9$	-0.349	-0.552**	-0.030	-0.312	-0.002	-0.001	-0.001	-0.001
$P_8 \times P_{10}$	0.009	0.342**	0.217	0.190	0.008	0.000	0.003	0.003
$P_9 \times P_{10}$	-0.267	1.462**	0.472	-0.733**	-0.000	-0.004	0.000	-0.002
SE	0.5077	0.1710	0.3391	0.2114	0.0063	0.0022	0.0115	0.0045

* Significant at 5% level
** Significant at 1% level

TABLE 48

Grain length and Grain width
Reciprocal effects

Combination	Grain length				Grain width		
	Season				Season		
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3
$P_1 \times P_2$	0.012	0.014	0.002	0.010	-0.121	-0.017	-0.030
$P_1 \times P_3$	-0.010	-0.002	-0.292**	0.101**	-0.101	0.002	-0.014
$P_1 \times P_4$	-0.009	-0.045**	-0.352**	-0.129**	0.000	-0.027	-0.020
$P_1 \times P_5$	-0.034**	0.034	-0.062	0.002	-0.015	0.014	-0.037
$P_1 \times P_6$	-0.237**	0.032	-0.050	-0.085**	0.092	0.027	-0.009
$P_1 \times P_7$	-0.009	-0.014	-0.009	-0.012	-0.014	-0.015	-0.007
$P_1 \times P_8$	0.037**	0.042	0.042	0.041**	0.044	0.029	0.014
$P_1 \times P_9$	0.032**	0.027	0.005	0.022	0.008	-0.032**	0.000
$P_1 \times P_{10}$	0.002	-0.004	0.025	0.007	0.047	-0.009	0.022
$P_2 \times P_3$	0.007	0.029	-0.017	0.006	0.037	0.005	-0.005
$P_2 \times P_4$	0.027**	0.009	-0.007	0.010	0.033	-0.012	-0.002
$P_2 \times P_5$	-0.027**	-0.017	-0.015	-0.010	-0.008	-0.009	0.002
$P_2 \times P_6$	-0.009	0.002	-0.027	-0.038**	0.061	-0.015	-0.007
$P_2 \times P_7$	-0.004	-0.025	-0.014	-0.015	0.127	0.000	0.000
$P_2 \times P_8$	-0.015*	-0.042	0.024	-0.011	-0.016	-0.012	0.027
$P_2 \times P_9$	0.027**	0.019	-0.019	0.009	-0.055	-0.024	0.005
$P_2 \times P_{10}$	0.002	0.004	-0.005	0.001	-0.011	-0.007	-0.017

TABLE 48 (CONTD.)

Combination	Grain length				Grain width		
	Season				Season		
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3
$P_3 \times P_4$	0.039**	-0.052**	-0.009	-0.007	-0.049	-0.029	-0.002
$P_3 \times P_5$	0.005	0.002	0.009	0.006	0.016	0.009	0.009
$P_3 \times P_6$	-0.114**	-0.097**	-0.024	-0.079**	0.028	-0.039**	-0.015
$P_3 \times P_7$	0.027**	0.010	-0.012	0.008	0.004	0.025	-0.020
$P_3 \times P_8$	-0.004	-0.002	0.000	-0.002	0.005	-0.002	-0.007
$P_3 \times P_9$	0.000	-0.017	0.037	0.007	0.027	0.002	0.034
$P_3 \times P_{10}$	0.007	0.014	-0.014	0.002	-0.013	-0.012	-0.022
$P_4 \times P_5$	0.014**	0.027	-0.017	0.008	-0.002	0.007	-0.015
$P_4 \times P_6$	-0.112**	0.022	-0.012	-0.034	-0.040	0.010	-0.017
$P_4 \times P_7$	-0.019	0.042	0.012	0.012	0.035	0.019	0.002
$P_4 \times P_8$	-0.017	0.020	-0.045	-0.014	0.002	0.002	-0.017
$P_4 \times P_9$	0.000	0.044	0.029	0.025	-0.006	0.005	-0.012
$P_4 \times P_{10}$	0.004	0.084**	0.060	0.050**	0.029	0.004	-0.024
$P_5 \times P_6$	-0.079**	0.002	-0.045	-0.041**	0.060	0.007	0.015
$P_5 \times P_7$	0.019	0.064**	0.025	0.037**	-0.036	0.004	0.017

TABLE 43 (CONTD.)

Combination	Grain length				Grain width		
	Season				Season		
	S_1	S_2	S_3	Pooled	S_1	S_2	S_3
$P_5 \times P_8$	0.007	0.010	0.000	0.006	-0.010	0.017	0.000
$P_5 \times P_9$	0.014	0.024	-0.012	0.009	0.036	0.044	-0.012
$P_5 \times P_{10}$	0.050**	0.037	-0.002	0.028	-0.017	0.022	0.000
$P_6 \times P_7$	0.000	0.029	0.012	0.014	-0.031	0.027	0.000
$P_6 \times P_8$	0.085**	0.067**	0.017	0.057**	-0.142	0.030	0.012
$P_6 \times P_9$	0.107**	0.020	0.000	0.042**	0.013	0.007	0.000
$P_6 \times P_{10}$	-0.002	0.012	-0.019	-0.003	-0.024	0.002	-0.019
$P_7 \times P_8$	-0.007	0.039	-0.009	0.007	0.010	0.012	-0.010
$P_7 \times P_9$	-0.017	-0.054**	-0.015	-0.029*	-0.002	-0.032**	-0.022
$P_7 \times P_{10}$	-0.010	-0.017	0.009	-0.006	-0.063	0.017	0.009
$P_8 \times P_9$	-0.009	-0.015	-0.225**	-0.083**	0.053	-0.019	0.019
$P_8 \times P_{10}$	0.010	0.022	-0.270**	-0.079**	0.025	0.000	-0.019
$P_9 \times P_{10}$	-0.022	0.017	-0.009	-0.005	0.034	0.004	-0.010
SE	0.0116	0.0227	0.0530	0.0183	NS	0.0152	NS

* Significant at 5% level
** Significant at 1% level

TABLE 49

Length-width ratio of grain

Reciprocal effects

Combination	Season		
	S_1	S_2	S_3
$P_1 \times P_2$	0.012	0.027	0.005
$P_1 \times P_3$	0.016	-0.003	0.009
$P_1 \times P_4$	0.040	0.010	0.000
$P_1 \times P_5$	0.035	-0.002	-0.007
$P_1 \times P_6$	-0.013	-0.022	0.017
$P_1 \times P_7$	0.054	0.019	0.000
$P_1 \times P_8$	0.064	-0.020	0.002
$P_1 \times P_9$	0.094	0.025	0.014
$P_1 \times P_{10}$	-0.017	0.014	-0.025
$P_2 \times P_3$	0.006	-0.003	0.002
$P_2 \times P_4$	0.027	0.016	-0.014
$P_2 \times P_5$	-0.012	0.002	-0.002
$P_2 \times P_6$	0.007	0.021	0.015
$P_2 \times P_7$	0.026	-0.011	0.002
$P_2 \times P_8$	-0.012	0.000	-0.032**
$P_2 \times P_9$	0.050	0.046**	0.025
$P_2 \times P_{10}$	0.032	0.003	0.049**
$P_3 \times P_4$	0.028	0.001	-0.002
$P_3 \times P_5$	-0.053	-0.007	-0.002
$P_3 \times P_6$	-0.025	-0.013	0.009
$P_3 \times P_7$	-0.021	-0.008	0.007
$P_3 \times P_8$	-0.002	-0.021	-0.002
$P_3 \times P_9$	0.018	0.000	-0.014
$P_3 \times P_{10}$	0.008	0.000	0.010

TABLE 49 (CONTD.)

Combination	Season		
	S_1	S_2	S_3
$P_4 \times P_5$	-0.031	0.011	0.022
$P_4 \times P_6$	0.026	-0.002	0.022
$P_4 \times P_7$	-0.003	-0.008	0.000
$P_4 \times P_8$	-0.030	0.005	0.022
$P_4 \times P_9$	0.003	0.013	0.025
$P_4 \times P_{10}$	-0.025	-0.004	0.037**
$P_5 \times P_6$	0.025	-0.008	0.017
$P_5 \times P_7$	0.025	0.000	-0.017
$P_5 \times P_8$	0.027	-0.018	0.004
$P_5 \times P_9$	-0.043	-0.050	0.000
$P_5 \times P_{10}$	-0.020	-0.017	-0.027**
$P_6 \times P_7$	-0.020	-0.033	0.012
$P_6 \times P_8$	-0.006	-0.027	0.000
$P_6 \times P_9$	-0.007	-0.003	-0.005
$P_6 \times P_{10}$	0.019	0.000	0.002
$P_7 \times P_8$	-0.028	-0.006	0.014
$P_7 \times P_9$	0.016	0.039**	0.017
$P_7 \times P_{10}$	0.012	0.034	-0.025
$P_8 \times P_9$	0.000	0.018	-0.009
$P_8 \times P_{10}$	0.016	0.001	-0.015
$P_9 \times P_{10}$	-0.012	0.000	-0.049
SE	0.0271 NS	0.0180 NS	0.0132

* Significant at 5% level

** Significant at 1% level

characters was significant except for grain width and length-width ratio of grain (Table 26). The reciprocal effects (rca) were estimated for the characters and presented in Tables 44 to 49.

5. Graphic analysis

The assumptions of the diallel design and the nature of gene action were verified by the (Wr, Vr) and (Wr, Vr') graphs. The array variances (Vr), covariances between the parent and their progenies in each array (Wr) and the covariance between the array means and off-spring in each array (Wr') were computed from the diallel table with the reciprocal averaged.

The deviation of the regression slope of Wr on Vr from unity as well as from zero was tested. These results (Table 50) showed that the characters viz., plant height, panicle length, number of grains per panicle, 100 grain weight, grain yield per plant, grain-straw ratio, grain length, width and length-width ratio satisfied both the tests namely (i) significant deviation from zero and (ii) no deviation from unity. The rest of the characters satisfied the tests in one or two seasons. The deviation of Wr, Wr' regression from zero as well as from half was tested for their significance (Table 51). The characters showed regression not significantly different from half, in one or more seasons. Thus all the characters satisfied the tests. The graphic analysis was carried out for eleven characters for the three seasons. Standardised deviation graphs were also drawn for the characters studied.

TABLE 50

Test of the Wr-Vr slope for unity 'b' value

Character	Season	b	b-0/sb	1-b/sb
Plant height	S_1	0.939 ± 0.043	23.0000**	0.2558
	S_1S_2	1.000 ± 0.032	30.9890**	0.0000
	S_2	0.967 ± 0.041	23.3100**	0.7955
Earbearing tillers per plant	S_1	0.323 ± 0.195	2.6890*	2.4933*
	S_1S_2	0.650 ± 0.103	6.3168**	3.4014**
	S_2	0.334 ± 0.144	4[illegible].2417	4.4697**
Panicle length	S_1	[illegible] ± 0.172	4.9100**	[illegible]
	S_1S_2	0.742 ± 0.226	2.5928*	0.3019
	S_2	0.819 ± 0.194	4.1700**	0.0899
Number of grains per panicle	S_1	0.759 ± 0.239	3.1700*	1.0100
	S_1S_2	0.945 ± 0.124	7.6395**	0.4446
	S_2	0.866 ± 0.094	9.2128**	1.4255
100 grain weight	S_1	0.924 ± 0.071	13.0525**	1.0746
	S_1S_2	0.918 ± 0.106	8.6749**	0.7727
	S_2	0.963 ± 0.089	11.3873**	0.1917
Grain yield per plant	S_1	0.718 ± 0.159	4.5243**	1.7769
	S_1S_2	0.701 ± 0.158	4.4400**	1.8950
	S_2	0.972 ± 0.131	7.4312**	0.2141
Straw yield per plant	S_1	0.608 ± 0.153	3.9800*	2.5686
	S_1S_2	0.780 ± 0.173	4.5100**	1.2744
	S_2	0.492 ± 0.136	3.6500*	3.7229*
Grain-straw ratio	S_1	0.883 ± 0.074	11.9939**	1.5892
	S_1S_2	0.926 ± 0.077	12.0249**	0.9609
	S_2	0.935 ± 0.059	16.0351**	1.1147
Grain length	S_1	0.896 ± 0.046	19.6461**	2.2803
	S_1S_2	0.930 ± 0.033	27.7990**	2.0916
	S_2	0.955 ± 0.063	15.1587**	0.7143
Grain width	S_1	0.962 ± 0.094	10.4092**	0.1908
	S_1S_2	0.944 ± 0.079	12.0002**	0.7123
	S_2	1.200 ± 0.172	6.9867**	-1.1644
Length-width ratio of grain	S_1	0.989 ± 0.071	12.4607**	1.5558
	S_1S_2	0.919 ± 0.054	16.8900**	1.4888
	S_2	1.030 ± 0.042	24.2100**	-0.7050

* Significant at 5% level
** Significant at 1% level

TABLE 51

Test of Wr-Kr' slope for b=0.5

Character	Season	b	b-0/sb	0.5-b/sb
Plant height	S_1	0.533 ± 0.033	16.0998**	0.9969
	S_2	0.525 ± 0.040	12.9323**	0.6158
	S_3	0.523 ± 0.045	11.4990**	0.5056
Earbearing tillers per plant	S_1	0.221 ± 0.147	1.5000	1.8992
	S_2	0.141 ± 0.111	1.2650	0.3269
	S_3	0.436 ± 0.033	13.1517**	1.9309
Panicle length	S_1	0.446 ± 0.117	3.7900**	0.4593
	S_2	0.444 ± 0.291	1.5252	0.1924
	S_3	0.516 ± 0.069	7.4095**	-0.2522
Number of grains per panicle	S_1	0.375 ± 0.094	3.9900*	1.3300
	S_2	0.393 ± 0.093	4.2276**	1.1188
	S_3	0.487 ± 0.078	6.2109**	0.1658
100 grain weight	S_1	0.503 ± 0.035	14.1679**	-0.0845
	S_2	0.342 ± 0.095	3.6400	1.1650
	S_3	0.499 ± 0.045	11.1136**	0.0223
Grain yield per plant	S_1	0.252 ± 0.203	1.2406	1.2209
	S_2	0.549 ± 0.157	2.2100	0.9581
	S_3	0.311 ± 0.191	1.6257	0.9880
Straw yield per plant	S_1	0.532 ± 0.299	1.7737	0.1067
	S_2	0.464 ± 0.221	2.0951	0.2425
	S_3	0.568 ± 0.380	1.4959	-0.1791
Grain-straw ratio	S_1	0.491 ± 0.076	6.4350**	0.0090
	S_2	0.474 ± 0.097	4.8600**	0.2666
	S_3	0.511 ± 0.062	8.2047**	-0.1766
Grain length	S_1	0.521 ± 0.038	13.7263**	-0.5533
	S_2	0.508 ± 0.031	16.3945**	-0.2302
	S_3	0.489 ± 0.142	3.4500*	0.0776
Grain width	S_1	0.492 ± 0.072	6.8305**	0.1111
	S_2	0.489 ± 0.057	8.5789**	0.1925
	S_3	0.489 ± 0.079	6.2024**	0.1395
Length-width ratio of grain	S_1	0.519 ± 0.046	11.1464**	-0.4081
	S_2	0.483 ± 0.062	7.8260**	0.2754
	S_3	0.505 ± 0.025	19.9200**	-0.1972

* Significant at 5% level
** Significant at 1% level

a. Plant height: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.1. The y-intercept of the regression line in the three seasons was above the origin. The parents P_6, P_7, P_8, P_9 and P_{10} were located near the origin in all the seasons while others consistently occupied the extreme right position on the regression line away from the origin. The parent P_9 was located near the parabola, while the parents P_8 and P_{10} were near the regression line. Interchange of position of all the parental arrays except l_3 was observed in Wr, Wr' graph in one or more seasons.

The parents P_1, P_2, P_3, P_4 and P_5 which are shorter in stature, consistently occupied the 'recessive-low' quadrant of the standardised deviation graphs in the seasons while the tall parents occupied the 'dominant high' quadrant.

b. Earbearing tillers per plant: The (Wr, Vr) and (Wr, Wr') graphs are presented in Fig.2. The Wr, Vr regression line crossed the Y-ordinate below the origin in the S_1 and S_2 seasons and above the origin in the S_3 season. The parents P_4, P_6 and P_{10} were located near the origin of the regression line while the parents P_7 and P_8 occupied the extreme right position away from the origin. The array points were well distributed along the regression line. Interchange of position of the parental arrays was observed in Wr, Wr' graphs in one or more seasons.

FIG 1 PLANT HEIGHT

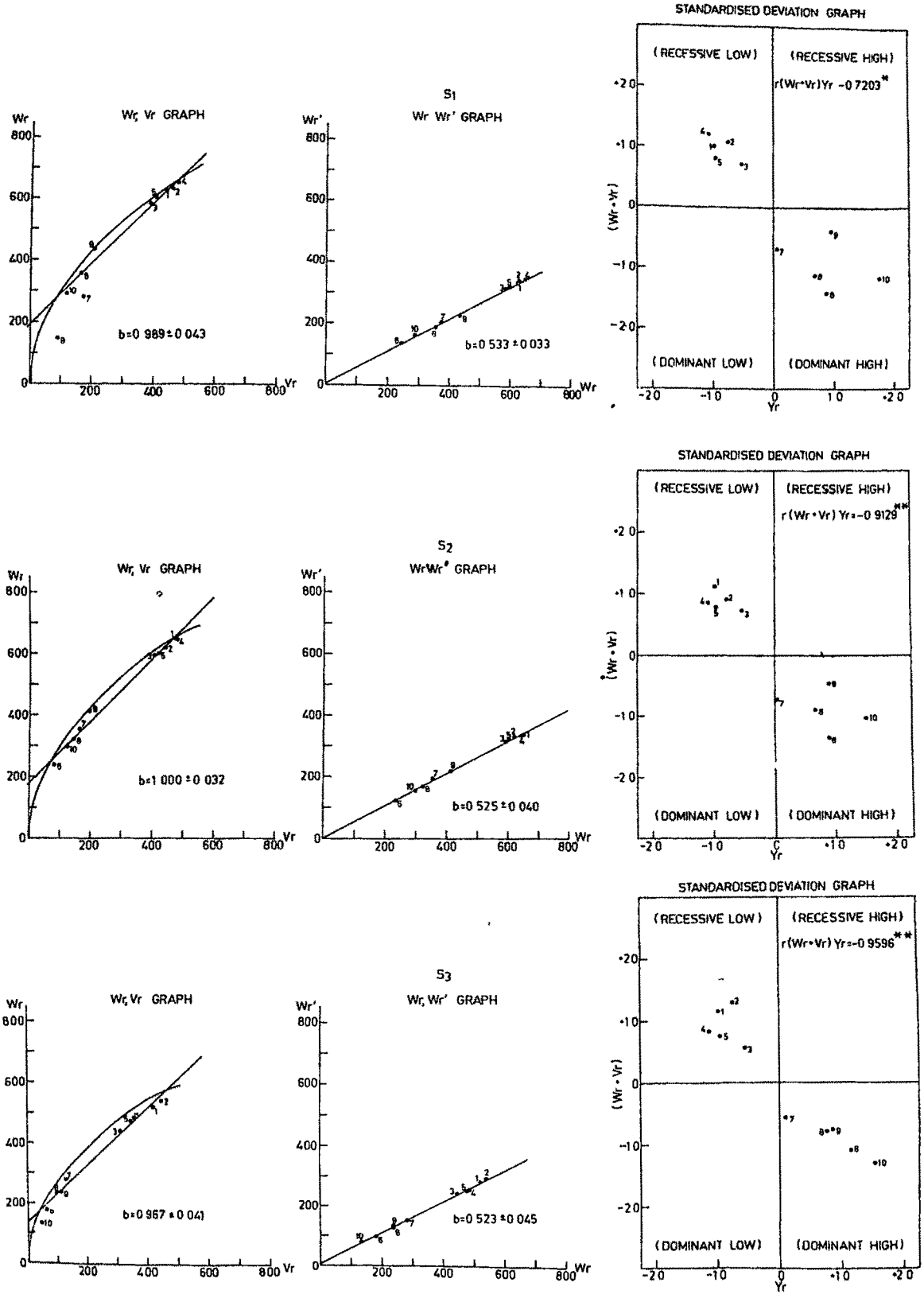
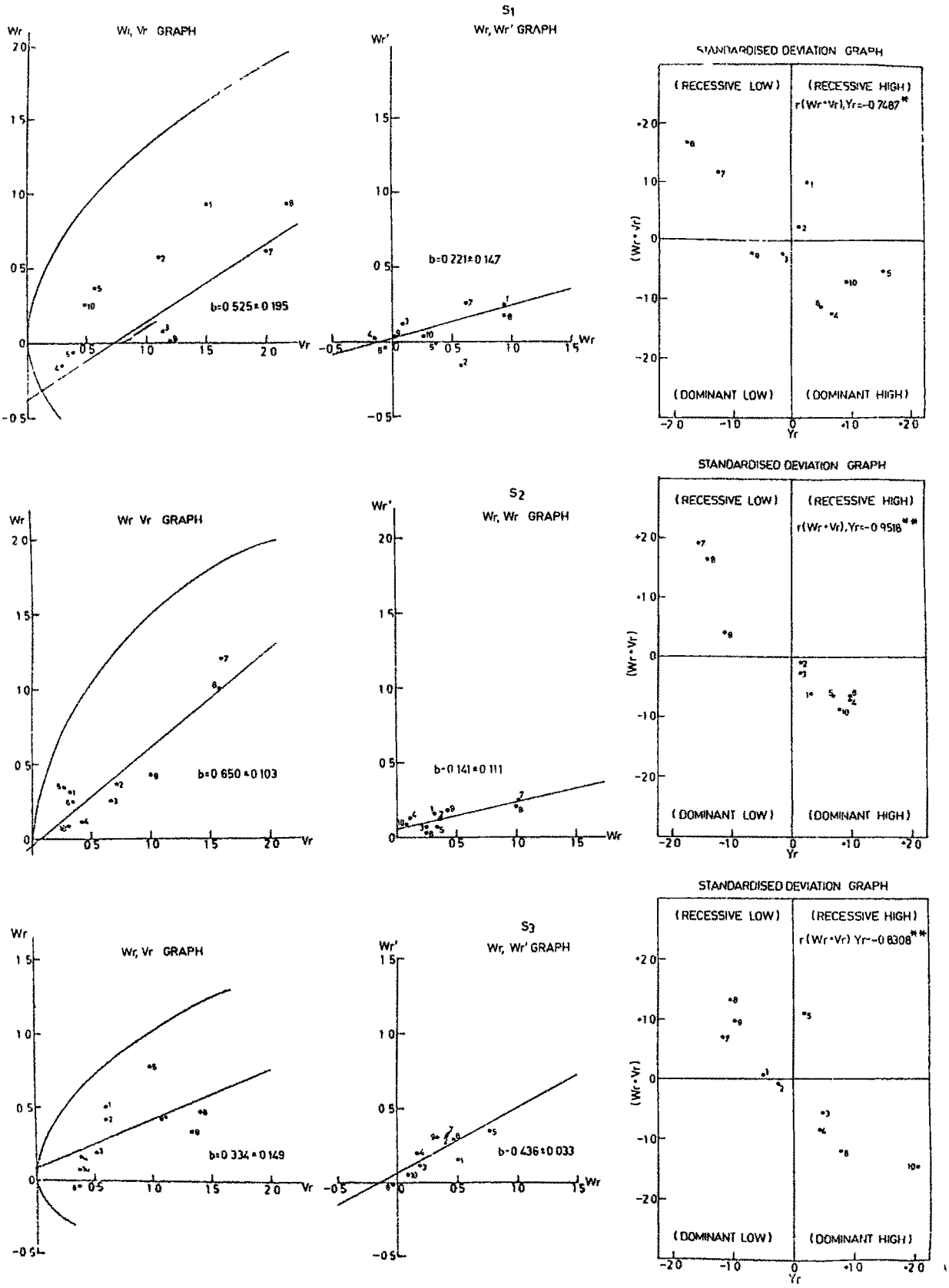


FIG 2 EARBEARING TILLERS PER PLANT



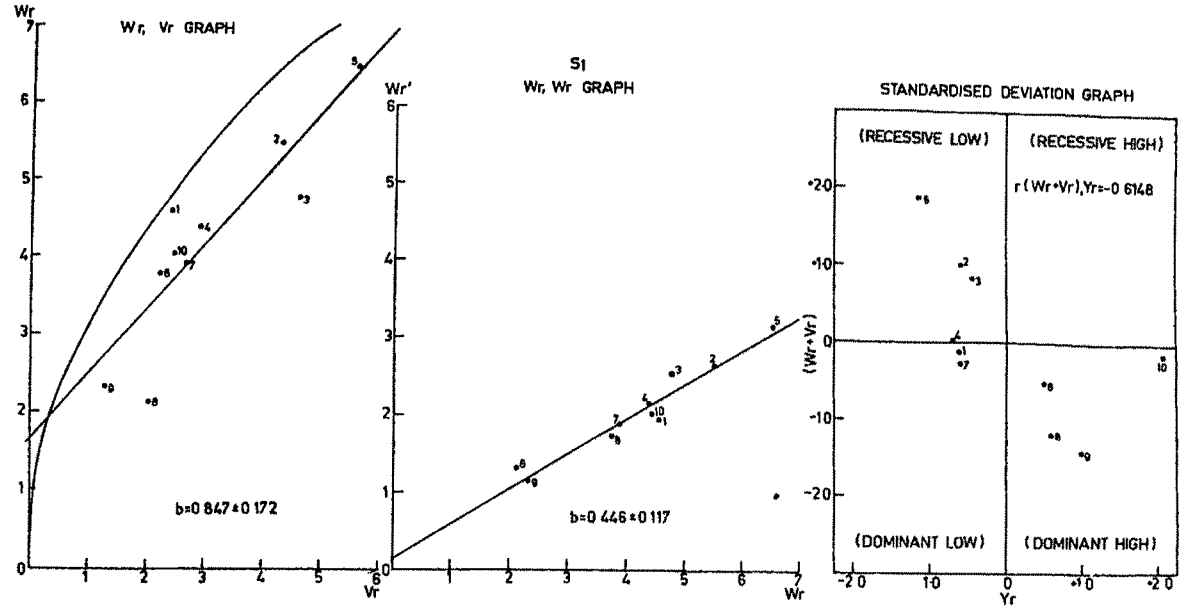
The parents P_7 and P_8 occupied the 'recessive-low' quadrant consistently in the standardised deviation graph. The parents P_4, P_6 and P_{10} consistently occupied the 'dominant-high' quadrant in the seasons. The parent P_9 occupied the 'recessive low' quadrant in the S_2 and S_3 seasons, the parent P_5, the 'dominant-high' quadrant in the S_1 and S_2 seasons and the parent P_3, the 'dominant-high' quadrant in the S_2 and S_3 seasons.

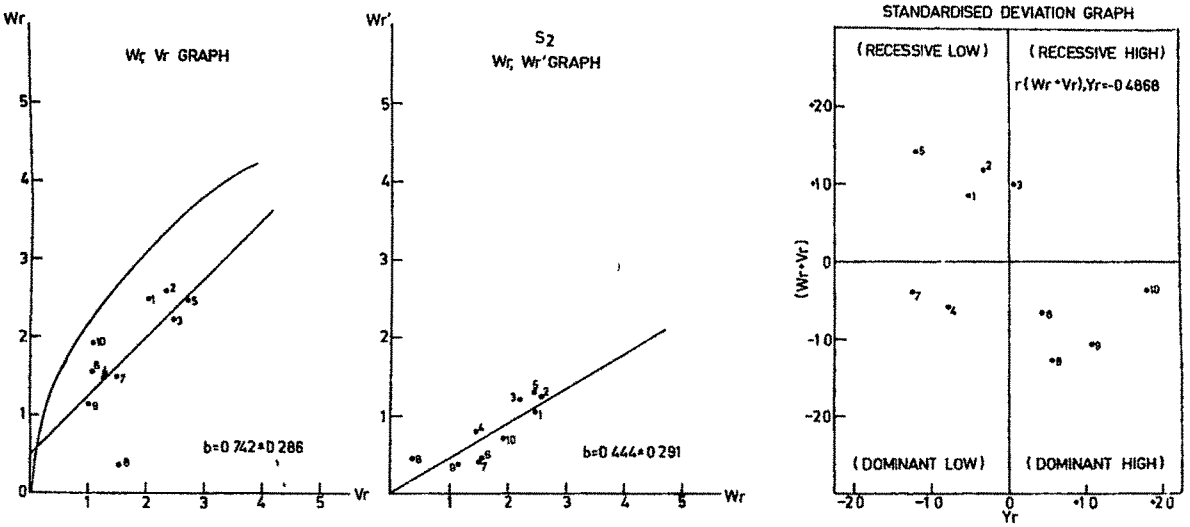
c. Panicle length: The (Vr, Vr) and (Vr, Vr') graphs are illustrated in Fig.3. The regression line in all the seasons crossed the y-axis above the origin. The parents P_8 and P_9 occupied the position near the origin while P_2, P_3 and P_5 were away from the point of origin of the regression line. Interchange of position of the parental arrays except P_2, P_4 and P_9 was noted in Vr, Vr' graph in one or more seasons.

In the standardised deviation graph, the parents P_2 and P_5 consistently occupied the 'recessive-low' quadrant while P_6, P_8, P_9 and P_{10}, the 'dominant-high' quadrant in the seasons. The parents P_3 and P_4 occupied the 'recessive-low' quadrant during the S_1 and S_3 seasons.

d. Number of grains per panicle: The (Vr, Vr) and (Vr, Vr' graphs are illustrated in Fig.4. The y-intercept of the regression line was above the origin. The array points of the parent P_4, P_5 and P_{10} consistently occupied the extreme right position

FIG 3 PANICLE LENGTH





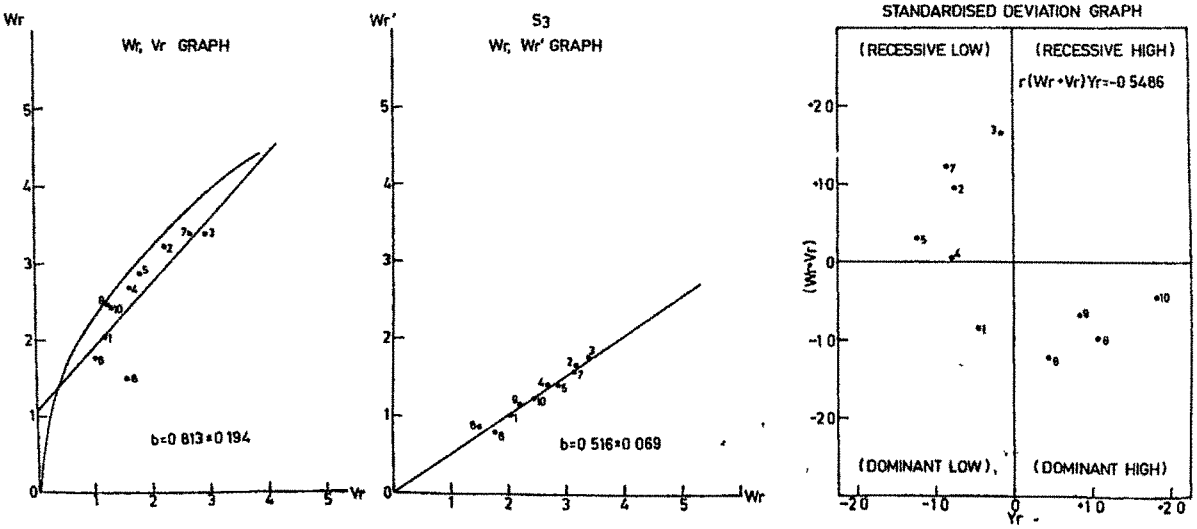
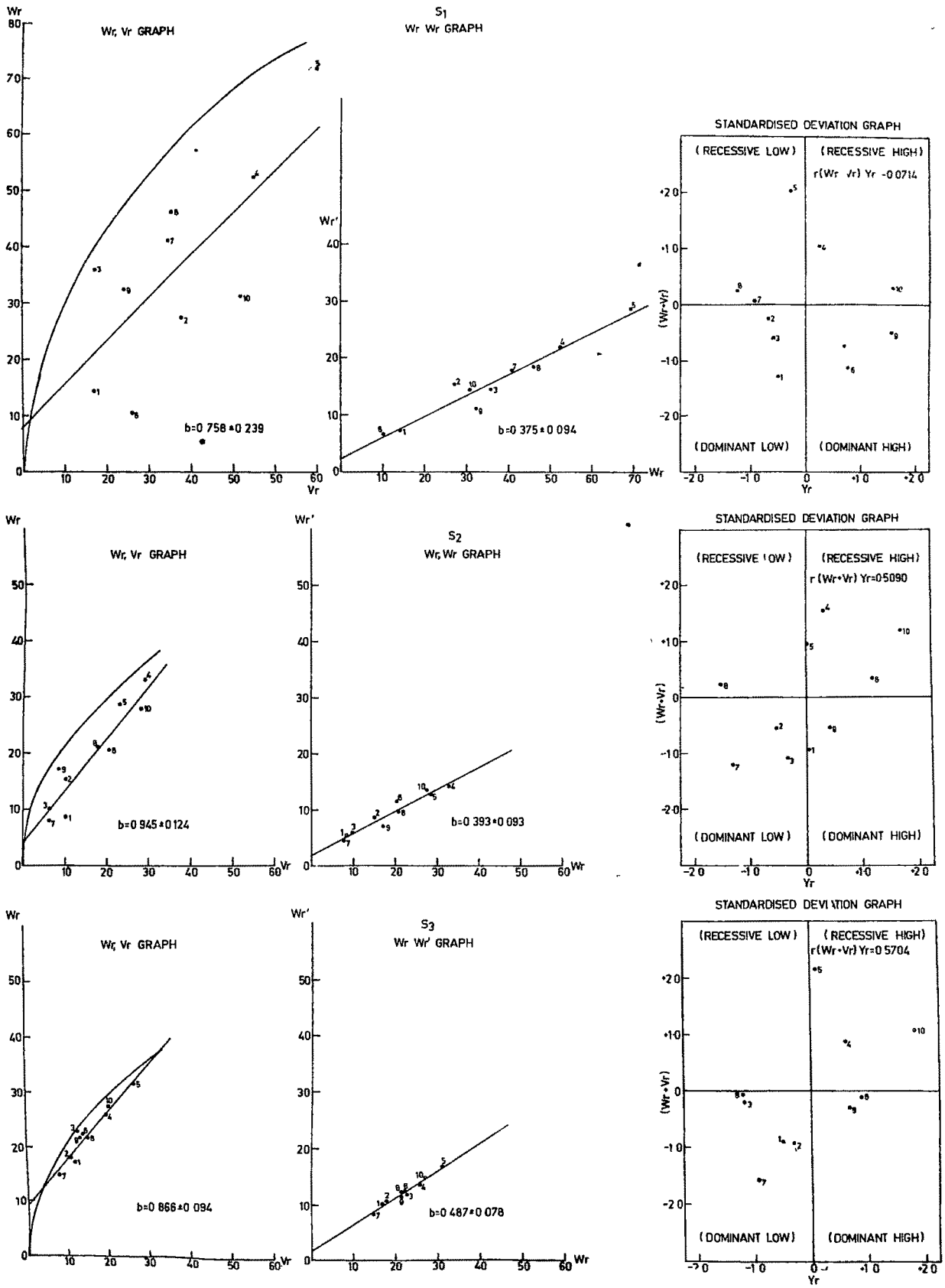


FIG 4 NUMBER OF GRAINS PER PANICLE



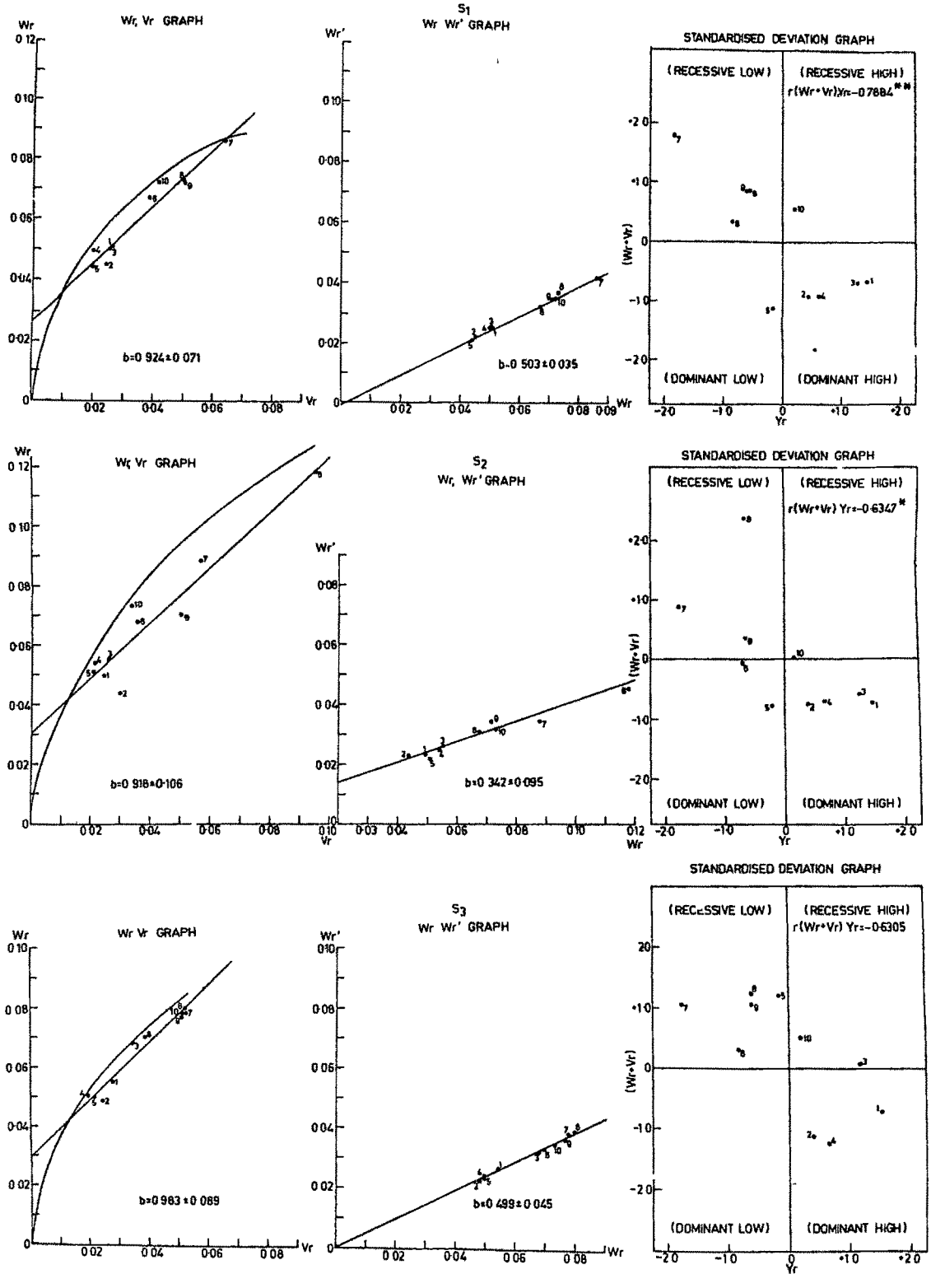
away from the origin. The parents P_1 and P_7 were located near the origin. Interchange of position of the parental arrays was noted in the Wr, Wr' graphs in one or the other season.

The parents P_4 and P_{10} consistently occupied the 'recessive-high' quadrant while P_2 and P_3, the 'dominant-low' quadrant in the seasons. The parent P_5 occupied the 'recessive-high' quadrant and P_7, the 'dominant-high' quadrant in the S_2 and S_3 seasons. The parent P_8 occupied the 'recessive-low' quadrant in the S_1 and S_2 seasons. The parents P_6 and P_9 occupied the 'dominant-high' quadrant while P_1 occupied 'dominant-low' quadrant in the S_1 and S_3 seasons.

c. 100 grain weight: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.5. The regression line crossed the y-axis above the origin. The array points of the parents P_7, P_8 and P_9 consistently occupied the extreme right position away from the origin. The parent P_2 was located near the origin. Interchange of position of the parental arrays except P_7 was observed in Wr, Wr' graph in one or the other season.

In the standardised deviation graph, the parental arrays P_7, P_8 and P_9 consistently occupied the 'recessive-low' quadrant, P_{10} the 'recessive-high' quadrant and P_1, P_2 and P_4 the 'dominant-high' quadrant. The parent P_6 occupied the 'recessive-low' quadrant in the S_1 and S_3 seasons, P_5, the

FIG 5 100 GRAIN WEIGHT



'dominant-low' quadrant and P_3, the 'dominant-high' quadrant in the S_1 and S_2 seasons.

f. Grain yield per plant: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.6. The regression line crossed the Y-ordinate above the origin in the S_1 and S_2 seasons and below the origin in the S_3 season. The array points for the parents P_1, P_9 and P_{10} were located near the origin consistently in the seasons. The parent P_8 consistently occupied extreme right position on the regression line away from the origin. Interchange of position of all parental arrays except P_1 and P_7 was noted in Wr, Wr' graph in one or more seasons.

In the standardised deviation graph, the parents P_7 and P_8 occupied the 'recessive-low' quadrant in the seasons, parents P_5 and P_6, the 'recessive-high' quadrant, the parent P_9, the 'dominant-low' quadrant, and the parents P_1 and P_3, the 'dominant-high' quadrant. The parent P_4 occupied the 'dominant-high' quadrant in the S_1 and S_2 seasons and P_{10}, the 'dominant-high' quadrant in the S_1 and S_2 seasons.

6. Straw yield per plant: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.7. The Wr - Vr regression line in the three seasons crossed the Y-ordinate above the origin. The parents P_{10}, P_9 and P_6 consistently were located near the origin. The parents P_1, P_3 and P_5 occupied the extreme right

FIG 6 GRAIN YIELD PER PLANT

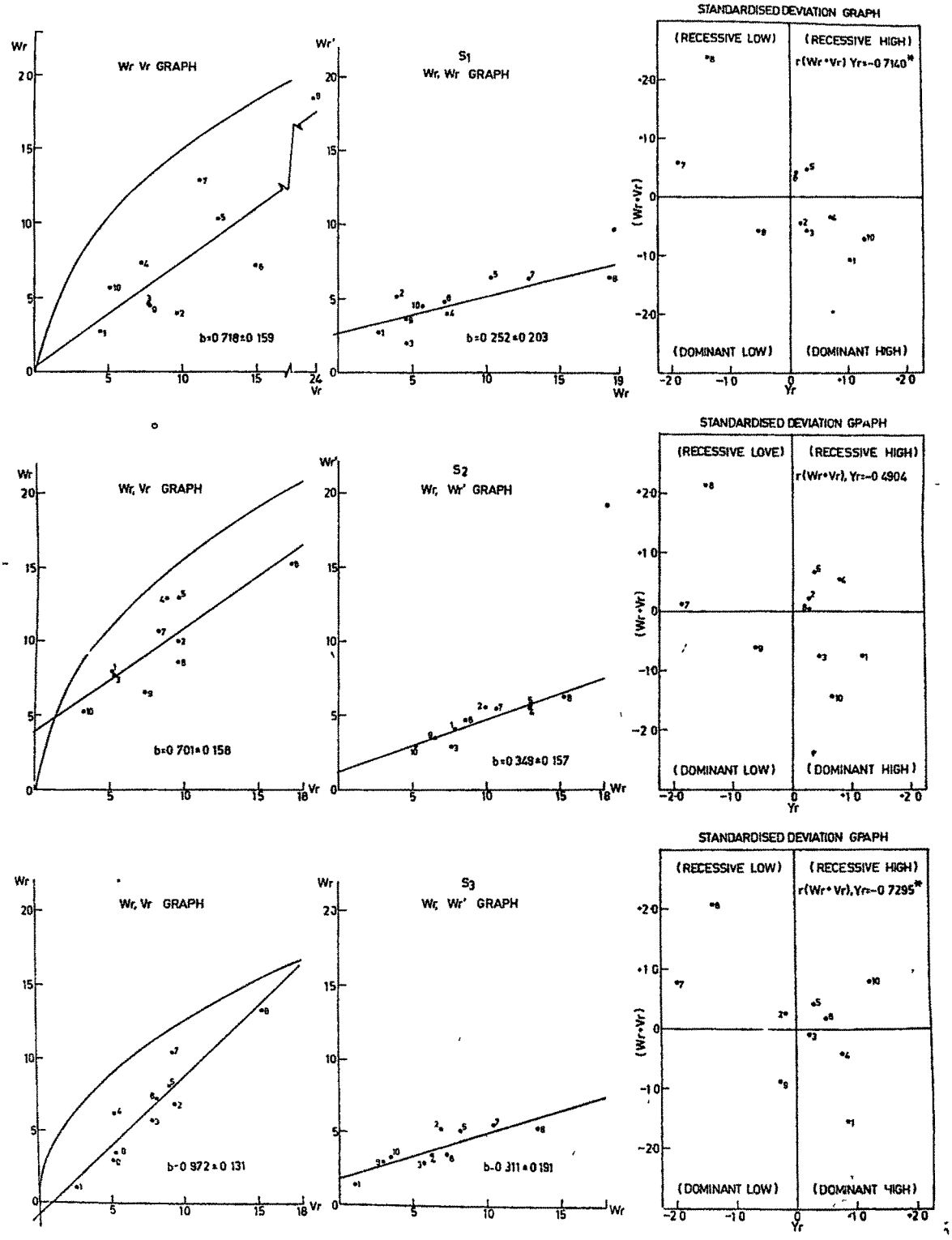
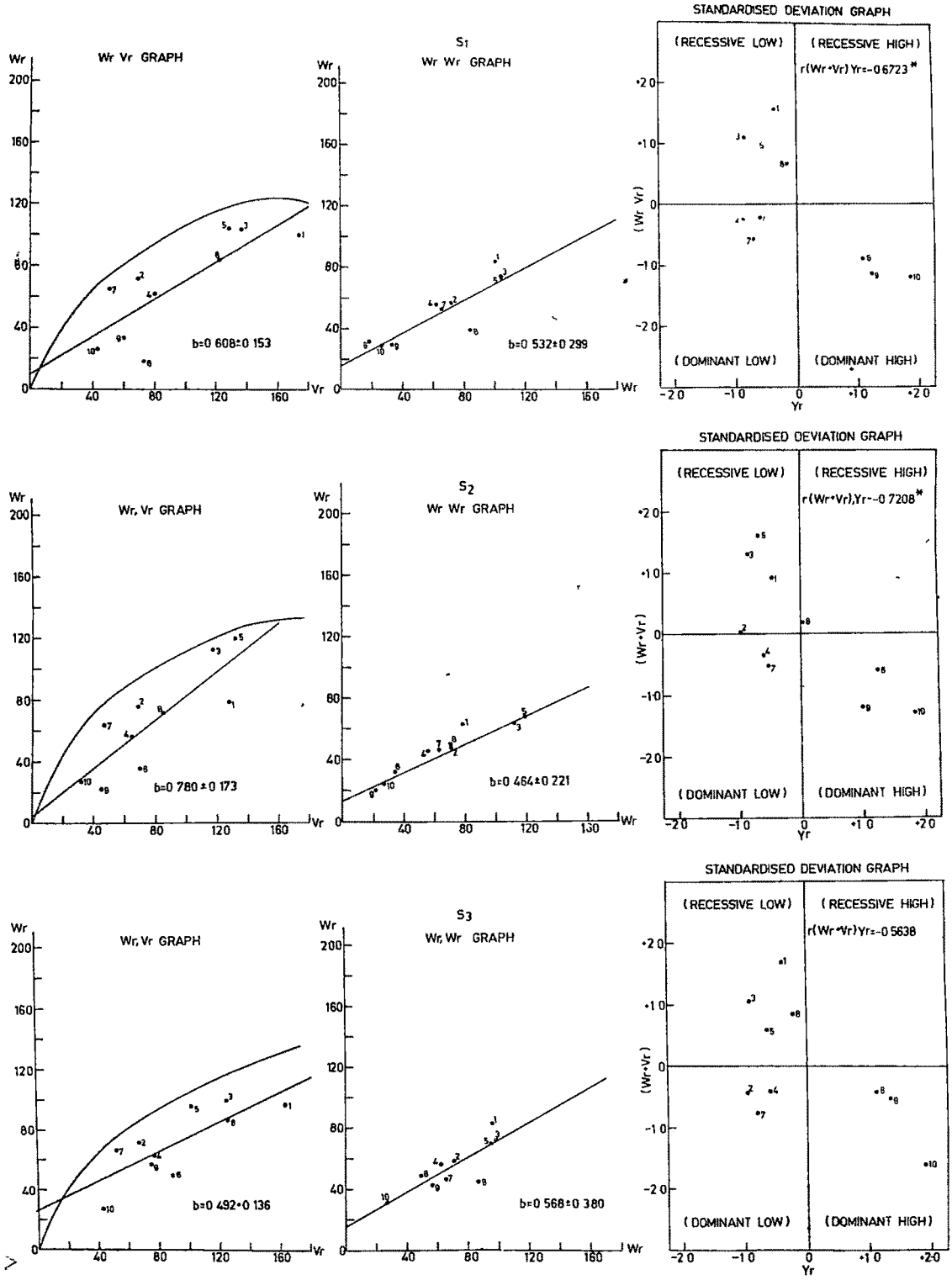


FIG 7 STRAW YIELD PER PLANT



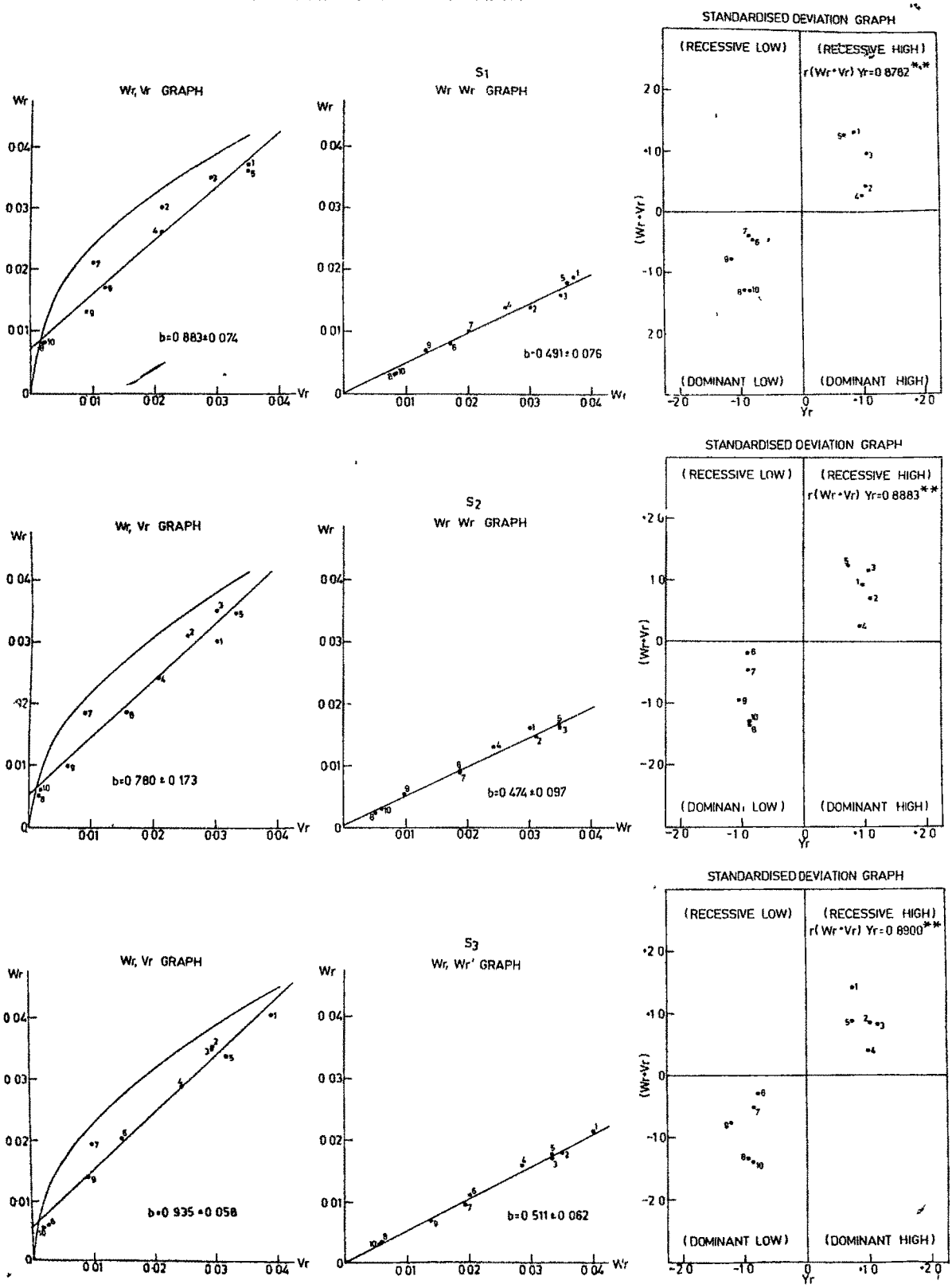
position away from the origin of the regression line. The array points were scattered on both sides of the regression line. Interchange of position of the parental arrays except P_2, P_7, P_8 and P_9 was noticed in Wr, Vr' graph in one or more seasons.

In the standardised deviation graph, the parents P_1, P_3 and P_5 occupied the 'recessive-low' quadrant consistently in the seasons. The parents P_4 and P_7 occupied the 'dominant-low' quadrant and P_6, P_9 and P_{10}, the 'dominant-high' quadrant. The parent P_2 occupied the 'dominant-low' quadrant and P_8, the 'recessive-low' quadrant in the S_1 and S_3 seasons.

h. Grain-straw ratio: The (Wr, Vr) and (Ur, Ur') graphs are illustrated in Fig.8. The Wr, Vr, regression line crossed the y-axis above the point of origin. The parents P_1 and P_5 occupied the extreme right position on the regression line away from the origin. The parents P_8 and P_{10} were located near the origin. The array points were well distributed along the regression line. Interchange of position of the array points except P_6 was noted in Wr, Wr' graph in one or the other season.

The parents P_1, P_2, P_3, P_4 and P_5 consistently occupied the 'recessive-high' quadrant and the remaining parents, the 'dominant-low' quadrant in the seasons.

FIG 8 GRAIN-STRAW RATIO



i. Grain length: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.9. The regression line in all the seasons crossed the y-axis above the origin. The parents P_8 and P_{10} occupied position near the origin and P_4 and P_5, away from the point of origin of the regression line. The array point of the parent P_3 was located mid way on the regression line. Interchange of position of the parental arrays was noted in the Wr, Wr' graph.

In the standardised deviation graph, the parents P_2, P_3, P_4 and P_5 consistently occupied the 'recessive-low' quadrant, the parent P_1, the 'recessive-high' quadrant, P_7, P_8, P_9 and P_{10}, the 'dominant-high' quadrant and P_6, the 'dominant-low' quadrant in the three seasons.

j. Grain width: The (Wr, Vr) and (Wr, Wr') graphs are illustrated in Fig.10. The regression line in the seasons crossed the y-axis above the origin. The array points of the parents P_6 and P_7 consistently occupied the extreme right position away from the origin. The parents P_1 and P_2 were located near the origin. Interchange of position of the parental arrays except P_1 and P_5 was observed in Wr, Wr' graph.

In the standardised deviation graph, the parental arrays P_6, P_7, P_8 and P_{10} consistently occupied the 'recessive-low' quadrant and P_1, P_2 and P_4, the 'dominant-high' quadrant. The parent P_9 occupied the 'dominant-high' quadrant in the

FIG 9 GRAIN LENGTH

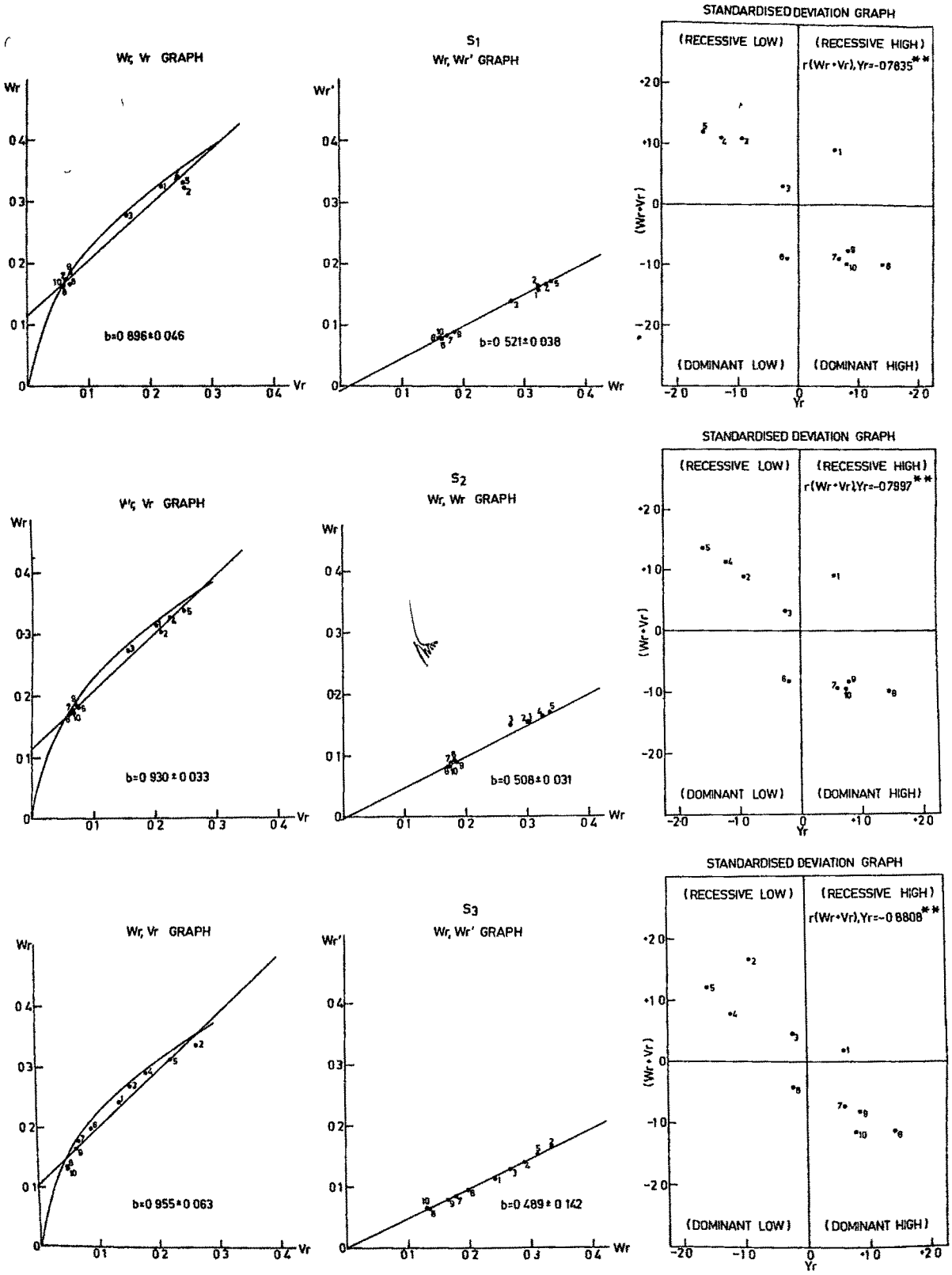
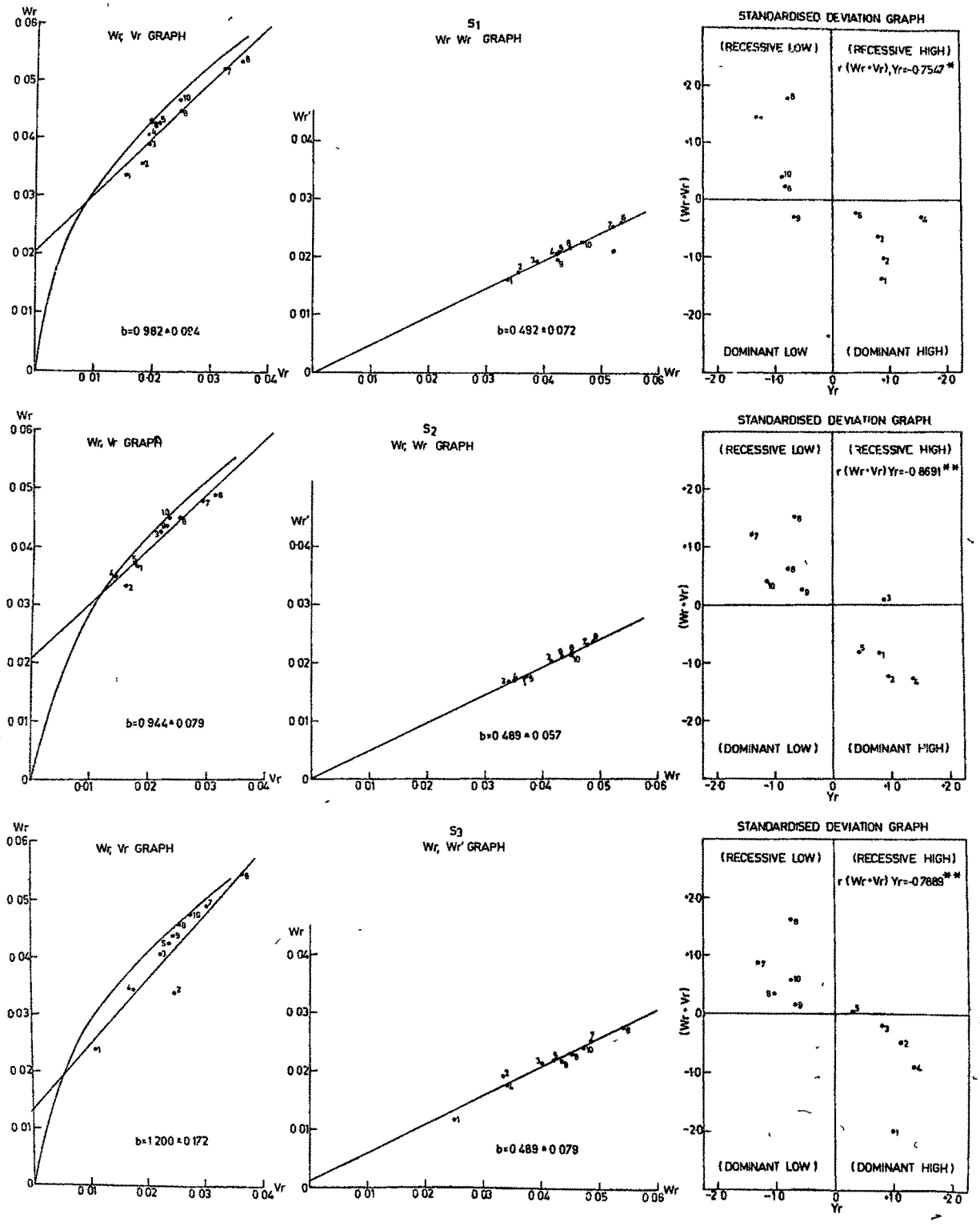


FIG 10 GRAIN WIDTH



S_1 and S_2 seasons and P_3, the same quadrant in the S_1 and S_3 seasons while P_9 occupied the 'recessive-low' quadrant during the S_2 and S_3 seasons.

k. Length-width ratio: The (Wr, Vr) and (Vr, Vr') graphs are illustrated in Fig.11. The regression line crossed the Y-ordinate above the origin in the seasons. The array points for the parents P_6 and P_7 were located away from the origin. The parent P_4 was located near the origin. Interchange of position of the parental arrays was noted in Wr, Vr' graph in one or more seasons.

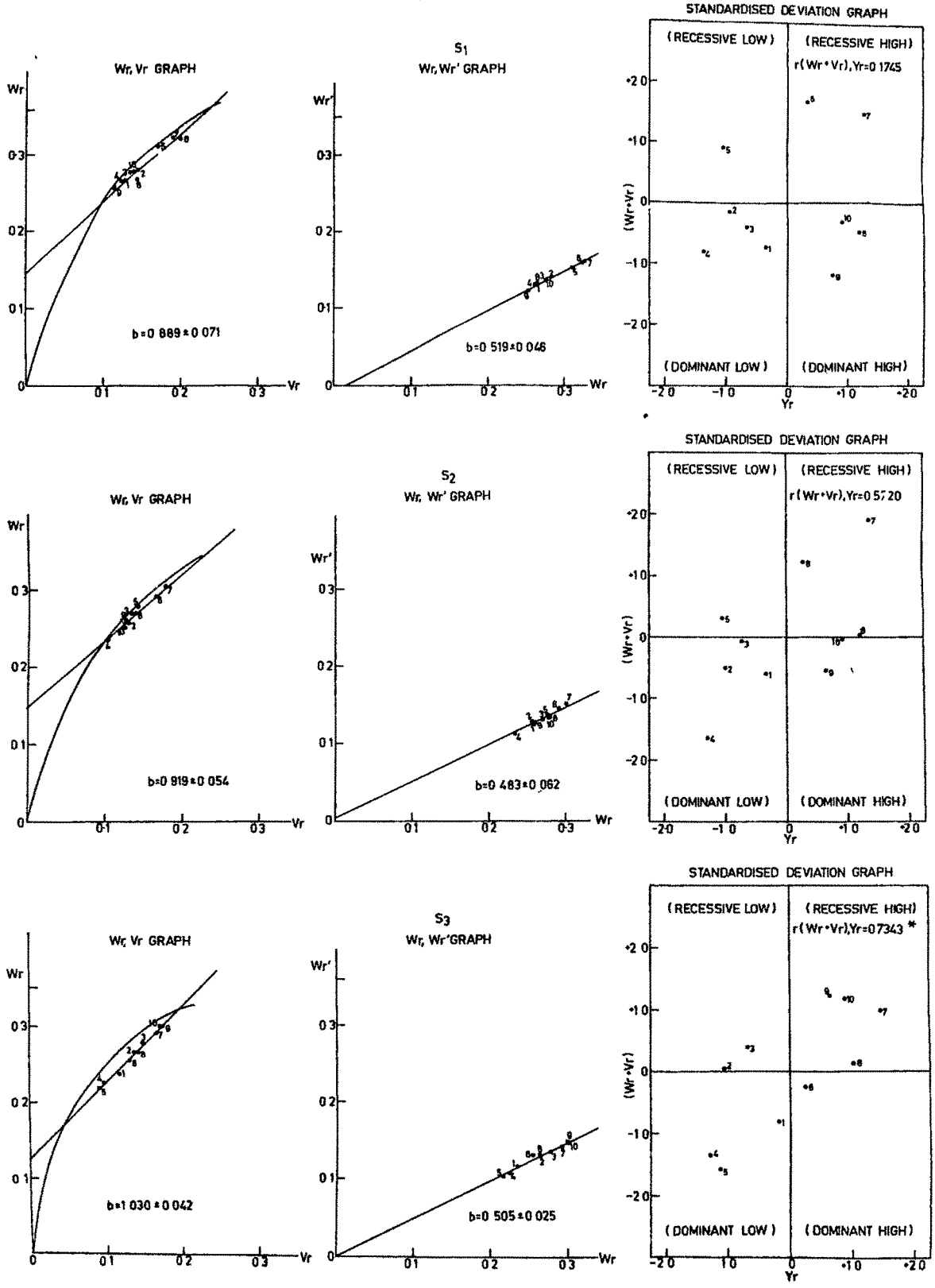
The parents P_1 and P_4 occupied the 'dominant low' quadrant and P_7, the 'recessive-high' quadrant in the seasons. ParentP_5 occupied the 'recessive-low' quadrant, P_2 and P_3, the 'dominant-low' quadrant, P_6 the 'recessive-high' quadrant and P_9 and P_{10}, the 'dominant-high' quadrant in the S_1 and S_2 seasons.

4. Genetic analysis

The nature of gene action for the various characters was studied by the diallel technique (Hayman, 1954a). The results of the genetic analysis for the characters are presented below.

a. Tests of hypotheses: The t^2 test and the test of homogeneity of the (Wr+Vr) and (Wr-Vr) value over blocks were carried out.

FIG. 11 LENGTH-WIDTH RATIO OF GRAIN



(1) t^2 test: The t^2 was not significant for most of the characters in the seasons except for the character tiller number in the S_2 and S_3 seasons, for grain length in the S_1 and S_2 seasons and for grain width in the S_3 season, indicating the homogeneity of the (Wr-Vr) values over the arrays (Table 52).

(2) Test of homogeneity of (Wr+Vr) values: The array variances of (Wr + Vr) values are presented in Table 53. The array variances of (Wr + Vr) values were not significant for three characters in one season each, while it was significant for other seasons and other characters. Thus, the array variances of (Wr + Vr) values were uniform.

(3) Test of homogeneity of (Wr-Vr) values: The array variances of (Wr-Vr) values are presented in Table 53. The array variances of (Wr-Vr) values were not significant for four characters either in one or two seasons, while it was significant for other characters, thereby revealing their consistency.

Thus all the three tests satisfied the assumptions needed for a diallel analysis.

b. Estimates of genetic parameters

(1) Plant height: The genetic components D, H_1 and H_2 were highly significant and positive in the seasons with the additive component D being nearly thrice as that of dominance

TABLE 32

Significance of Vr-Vr regression

Character	t^2 in season		
	S_1	S_2	S_3
Plant height	0.6093	0.0167	0.3960
Bearing tillers per plant	1.1040	5.6320**	5.6660**
Panicle length	0.0194	0.1372	0.0038
Number of grains per panicle	0.0039	0.0024	0.9099
100 grain weight	0.5634	0.1009	0.0225
Grain yield per plant	0.7905	0.9453	0.1339
Straw yield per plant	2.0192	0.1916	2.0394
Grain-straw ratio	1.7400	0.3038	0.6667
Grain length	3.8100*	3.7455*	0.1823
Grain width	0.0386	0.1424	3.9511*
Length-width ratio of grain	1.3466	1.6322	0.9579

* Significant at 5% level

** Significant at 1% level

TABLE 53

The Variances of (Vr+Vr) and (Vr-Vr) values

Character	Season	Mean sum squares	
		Vr+Vr differences	Vr-Vr differences
Plant height	S_1	88942.82**	171224.80**
	S_2	113934.51**	152009.97**
	S_1+S_2	80636.51**	107639.86**
Earbearing tillers per plant	S_1	1.5393**	0.4619NS
	S_2	1.9594**	1.0865**
	S_1+S_2	0.8804NS	0.2958NS
Panicle length	S_1	6.3010NS	10.1880**
	S_2	2.2379**	2.5346**
	S_1+S_2	6.4963**	8.3957**
Number of grains per penicle	S_1	3259.90**	2457.57**
	S_2	409.72**	264.10NS
	S_1+S_2	669.59**	330.12**
100 grain weight	S_1	-	-
	S_2	-	-
	S_1+S_2	0.0026**	0.0006**
Grain yield per plant	S_1	304.58**	135.01**
	S_2	237.89**	76.47**
	S_1+S_2	178.62**	84.00NS
Straw yield per plant	S_1	6543.66**	3299.09**
	S_2	4833.00**	2356.74**
	S_1+S_2	5925.75**	3043.41**
Grain-straw ratio	S_1	0.00040**	0.00034NS
	S_2	0.00035**	0.00027**
	S_1+S_2	0.00069**	0.00023**
Grain length	S_1	0.0615**	0.0576**
	S_2	0.0636**	0.0451**
	S_1+S_2	0.0462**	0.0345**
Grain width	S_1	0.00070**	0.00045**
	S_2	0.00051**	0.00039**
	S_1+S_2	0.00037NS	0.00052**
Length-width ratio of grain	S_1	0.0282**	0.0338**
	S_2	0.0222**	0.0253**
	S_1+S_2	0.0232**	0.0224**

* Significant at 5% level
** Significant at 1% level
NS Not significant

TABLE 54a

Estimates of genetic parameters

Character	Season	D	F	H_1
Plant height	S_1	915.75** ± 13.65	85.79** ± 31.49	173.43** ± 29.05
	S_1S_2	924.26** ± 11.79	-46.89 ± 27.19	196.09** ± 25.09
	S_3	665.14** ± 15.52	86.92** ± 35.81	166.59** ± 33.04
Earbearing tillers per plant	S_1	1.724** ± 0.358	2.713** ± 0.827	5.165** ± 0.763
	S_1S_2	1.980** ± 0.174	2.271** ± 0.402	2.959** ± 0.371
	S_3	0.907** ± 0.256	0.551 ± 0.590	2.287** ± 0.545
Panicle length	S_1	9.659** ± 0.512	2.386 ± 1.181	4.702** ± 1.090
	S_1S_2	4.826** ± 0.163	2.592** ± 0.933	4.495** ± 0.860
	S_3	4.971** ± 0.280	0.638 ± 0.646	1.615** ± 0.596
Number of grains per panicle	S_1	92.27** ± 9.17	40.99 ± 21.16	94.97** ± 19.53
	S_1S_2	44.96** ± 2.29	14.25** ± 5.30	32.75** ± 4.89
	S_3	42.17** ± 1.43	3.46 ± 2.76	11.98** ± 2.55
100 grain weight	S_1	0.128** ± 0.002	0.0119 ± 0.005	0.0285** ± 0.005
	S_1S_2	0.169** ± 0.027	0.1124 ± 0.062	0.1011 ± 0.0570
	S_3	0.137** ± 0.002	0.0146* ± 0.005	0.0212** ± 0.0049
Grain yield per plant	S_1	22.21** ± 2.24	13.49** ± 5.18	32.66** ± 4.78
	S_1S_2	24.17** ± 1.52	9.31** ± 3.51	18.47** ± 3.24
	S_3	15.79** ± 0.95	5.38** ± 2.20	20.27** ± 1.85

TABLE 54a (CONTD.)

Character	Season	D	F	H_1
Straw yield per plant	S_1	103.65** ± 18.68	54.93 ± 43.10	212.14** ± 39.76
	S_2	120.90** ± 14.21	21.68 ± 32.79	175.69** ± 30.25
	$S_1 + S_2$	104.79** ± 17.51	73.21 ± 40.40	186.62** ± 37.27
Grain-straw ratio	S_1	0.0496** ± 0.0022	0.0072 ± 0.0051	0.0236** ± 0.0047
	S_2	0.0477** ± 0.0021	0.0102 ± 0.0048	0.0312** ± 0.0044
	$S_1 + S_2$	0.0496** ± 0.0017	0.0047 ± 0.0039	0.0317** ± 0.0037
Grain length	S_1	0.5058** ± 0.0110	0.0371 ± 0.0254	0.1087** ± 0.0234
	S_2	0.5001** ± 0.0067	0.0290 ± 0.0155	0.0778** ± 0.0143
	$S_1 + S_2$	0.4640** ± 0.0103	0.0309 ± 0.0238	0.0682** ± 0.0220
Grain width	S_1	0.0925** ± 0.0012	0.0123** ± 0.0023	0.0119** ± 0.0026
	S_2	0.0877** ± 0.0009	0.0095** ± 0.0021	0.0088** ± 0.0020
	$S_1 + S_2$	0.0820** ± 0.0026	0.0006 ± 0.0061	0.0137** ± 0.0056
Length-width ratio of grain	S_1	0.5812** ± 0.0049	0.0265** ± 0.0113	0.0417** ± 0.0104
	S_2	0.5498** ± 0.0027	0.0239** ± 0.0063	0.0284** ± 0.0059
	$S_1 + S_2$	0.5401** ± 0.0026	0.0283** ± 0.0061	0.0354** ± 0.0056

* Significant at 5% level
** Significant at 1% level

D - Component of variation due to additive effects of the genes
F - Covariance of additive and dominance effects
H_1 - Component of variation due to dominance effects of the genes

TABLE 54b

Estimates of genetic parameters

Character	Season	H_2	h^2	E
Plant height	S_1	150.31** ± 24.69	170.51** ± 16.58	0.461 ± 4.11
	S_2	168.15** ± 21.32	236.07** ± 14.26	0.256 ± 12.63
	S_3	156.49** ± 23.09	210.29** ± 18.77	1.088 ± 4.68
Earbearing tillers per plant	S_1	3.918** ± 0.648	11.93** ± 0.434	0.074 ± 0.108
	S_2	2.171** ± 0.315	10.62** ± 0.211	0.134** ± 0.053
	S_3	1.821** ± 0.465	7.93** ± 0.310	0.148** ± 0.006
Panicle length	S_1	3.855** ± 0.926	0.4150 ± 0.620	0.1098 ± 0.1543
	S_2	3.509** ± 0.731	0.2312 ± 0.489	0.034 ± 0.1219
	S_3	1.530** ± 0.507	0.7550** ± 0.339	0.195** ± 0.0845
Number of grains per panicle	S_1	89.75** ± 16.59	28.56** ± 11.11	0.756** ± 2.766
	S_2	27.00** ± 4.16	3.81 ± 2.78	0.235 ± 0.693
	S_3	9.35** ± 2.16	0.027 ± 1.65	0.986** ± 0.292
100 grain weight	S_1	0.0253** ± 0.004	0.0175** ± 0.0029	0.00004 ± 0.007
	S_2	0.0384 ± 0.048	0.063 ± 0.032	0.00005 ± 0.008
	S_3	0.0193** ± 0.004	0.016** ± 0.003	0.00007 ± 0.0007
Grain yield per plant	S_1	23.02** ± 4.06	36.86** ± 2.72	0.0824 ± 0.677
	S_2	14.93** ± 2.75	31.95** ± 1.84	0.0530 ± 0.459
	S_3	15.39** ± 1.73	36.76** ± 1.15	0.1398 ± 0.288

TABLE 54b (CONTD.)

Character	Season	H_2	h^2	E
Straw yield per plant	S_1	171.54** ± 33.79	294.20** ± 22.62	0.539 ± 5.632
	S_2	143.27** ± 25.71	269.22** ± 17.21	0.0062 ± 4.284
	S_3	146.78** ± 31.68	303.59** ± 21.20	0.2441 ± 5.280
Grain-straw ratio	S_1	0.0251** ± 0.0040	0.0149** ± 0.0027	0.000089 ± 0.00066
	S_2	0.0263** ± 0.0037	0.0259** ± 0.0025	0.000017 ± 0.00062
	S_3	0.0280** ± 0.0031	0.0216** ± 0.0021	0.00027 ± 0.00052
Grain length	S_1	0.0971** ± 0.0190	0.0765** ± 0.0133	0.00062 ± 0.0033
	S_2	0.0716** ± 0.0122	0.0636** ± 0.0082	0.00151 ± 0.0020
	S_3	0.0696** ± 0.0187	0.0563** ± 0.0125	0.00598 ± 0.0031
Grain width	S_1	0.0098** ± 0.0026	0.00049 ± 0.0015	0.00059 ± 0.00057
	S_2	0.0075** ± 0.0017	0.0019 ± 0.0011	0.00051 ± 0.00028
	S_3	0.0117** ± 0.0048	0.0034 ± 0.0032	0.00047 ± 0.0008
Length-width ratio of grain	S_1	0.03574** ± 0.0089	0.00023 ± 0.0059	0.0015 ± 0.0015
	S_2	0.02293** ± 0.0049	0.00104 ± 0.0033	0.00074 ± 0.00082
	S_3	0.03101** ± 0.0048	0.0104** ± 0.0032	0.00042 ± 0.0009

* Significant at 5% level
** Significant at 1% level

H_2 - Dominance indicating asymmetry of positive and negative effects of genes

h^2 - The sum of dominance effects over all loci

E - Environmental component of variance

TABLE 54c

Ratios involving different genetic parameters

Character	Season	$(H_1/D)^{\frac{1}{2}}$	$H_2/4H_1$	K_D/K_R	h^2/H_2	Heritability (Percentage)	r(Wr+Vr),Yr
Plant height	S_1	0.4352	0.2167	0.3056	1.1344	93.09	-0.7203*
	S_2	0.4606	0.2144	0.8956	1.7013	92.20	-0.9129**
	S_3	0.5005	0.2348	0.7690	1.3438	90.47	-0.9596**
Harbearing tillers per panicle	S_1	1.7310	0.1896	2.6675	3.0456	40.93	-0.7487*
	S_2	1.2225	0.1835	2.7684	4.8917	27.07	-0.9518**
	S_3	1.5877	0.1990	1.4732	4.3532	41.00	-0.8308**
Panicle length	S_1	0.6977	0.2056	1.4302	0.1076	79.21	-0.6148
	S_2	0.9651	0.1952	1.7712	0.0659	63.91	-0.4868
	S_3	0.5701	0.2367	0.9777	0.4937	81.96	-0.5486
Number of grains per panicle	S_1	1.0145	0.2205	1.5606	0.3410	59.09	-0.0714
	S_2	0.8543	0.2061	1.4566	0.1410	72.29	+0.5090
	S_3	0.5331	0.1957	0.8571	0.0029	89.09	+0.5784
100 grain weight	S_1	0.4719	0.2222	1.2199	0.6918	95.99	-0.7884**
	S_2	0.7727	0.0950	2.5033	1.6421	91.99	-0.6347**
	S_3	0.3939	0.2274	1.3152	0.8367	92.69	-0.6305
Grain yield per plant	S_1	1.2127	0.1762	1.6685	1.6016	61.16	-0.7140*
	S_2	0.8742	0.2021	1.5650	2.1400	70.87	-0.4904
	S_3	1.1330	0.1898	1.3541	2.3885	65.78	-0.7295*
Straw yield per plant	S_1	1.4157	0.2021	0.6902	1.7151	69.89	-0.6723*
	S_2	1.1986	0.2062	0.8608	1.8701	70.67	-0.7208*
	S_3	1.3417	0.1945	0.5868	2.0683	74.85	-0.5638

TABLE 54c (CONTD.)

Character	Season	$(H_1/D)^{\frac{1}{2}}$	$H_2/4H_1$	K_D/K_R	h^2/H_2	Heritability (Percentage)	r(Wr+Vr), Yr
Grain-straw ratio	S_1	0.7593	0.2197	1.2102	0.5954	78.28	0.8782**
	S_2	0.8078	0.2150	1.3052	0.9679	75.73	0.8983**
	S_3	0.7999	0.2201	1.1262	0.7720	77.07	0.8900**
Grain length	S_1	0.4636	0.2233	1.1172	0.7883	90.62	-0.7855**
	S_2	0.3945	0.2299	1.1585	0.8893	92.59	-0.7997**
	S_3	0.3833	0.2553	1.1902	0.8088	90.39	-0.8808**
Grain width	S_1	0.3586	0.2054	1.4547	0.0508	93.23	-0.7547*
	S_2	0.3170	0.2118	1.4137	0.2544	94.44	-0.8691**
	S_3	0.4086	0.2131	0.9818	0.2950	92.66	-0.7889**
Length-width ratio of grain	S_1	0.2678	0.2144	1.1862	0.0066	96.43	0.1745
	S_2	0.2272	0.2017	1.2114	0.0452	97.64	0.5720
	S_3	0.2561	0.2189	1.2279	0.3355	96.94	0.7343*

* Significant at 5% level
** Significant at 1% level

$(H_1/D)^{\frac{1}{2}}$ - Mean degree of dominance over all loci

$H_2/4H_1$ - Estimate of average frequency of positive and negative alleles in the parents

K_D/K_R - Ratio of total number of dominant to recessive genes in the parents

h^2/H_2 - The number of groups of genes controlling the character

r(Wr+Vr), Yr - Coefficient of correlation between parental order of dominance and parental measurements

TABLE 55

Estimates of mean variance and covariance

Character	V_1L_1/V_0L_{01} in season		
	S_1	S_2	S_3
Plant height	0.6133	0.6161	0.6496
Harboaring tillers per plant	3.0443	1.6926	2.4862
Panicle length	0.7187	0.9613	0.6994
Number of grains per panicle	1.0276	0.8448	0.6763
100 grain weight	0.9926	1.1900	0.9541
Grain yield per plant	1.3422	0.8965	1.1795
Straw yield per plant	1.4017	1.2009	1.2978
Grain-straw ratio	0.7734	0.8057	0.8159
Grain length	0.5937	0.5676	0.5709
Grain width	0.5399	0.5300	0.5502
Length-width ratio of grain	0.5275	0.5165	0.5209

V_1L_1 - Mean variance of the arrays

V_0L_{01} - Mean covariance between parents and arrays

components (Tables 54a and b). The ratio of the mean variance of arrays to the mean covariance was less than unity (Table 55) in the seasons. The covariance component F was found to be significant and positive in the S_1 and S_3 seasons. The dominance component h^2 was significant in the seasons.

The value for the mean degree of dominance as indicated by the ratio $(H_1/D)^{\frac{1}{2}}$ was less than unity (Table 54c). The estimate of $H_2/4H_1$ was varying from 0.2167 to 0.2348 in the different seasons. The ratio of K_1/K_2 was less than unity in the seasons. The h^2/H_2 estimates ranged from 1.1344 to 1.7013. The heritability estimates were very high ranging from 90.47 to 93.09 per cent. The correlation between parental order of dominance and parental values was negative and significant in the seasons with the r values ranging from -0.7203 to -0.9596.

(2) Earbearing tillers per plant: The genetic components D, H_1 and H_2 were highly significant and positive in the seasons (Tables 54a and b). The dominance components H_1 and H_2 were of a higher order. The ratio of the mean variance of arrays to the mean covariance was more than one (1.6926 to 3.0443) in the seasons (Table 55). The covariance component F was found to be positive and significant in the S_1 and S_2 seasons. The parameter h^2 was significant in the seasons.

The values of mean degree of dominance as indicated by the ratio $(H_1/D)^{\frac{1}{2}}$ were 1.7310, 1.2225 and 1.9877 during the S_1, S_2 and S_3 seasons respectively (Table 54a).

The estimates of $H_2/4H_1$ ranged from 0.1835 to 0.1990 in the seasons. The ratio of K_D/K_R was more than unity in all the seasons. The h^2/H_2 estimates were 3.0456, 4.8917 and 4.3532 in the S_1, S_2 and S_3 seasons respectively. The estimates of heritability were low ranging from 27.07 to 41.00 per cent. The association between the parental order of dominance and parental measurements was significant and negative in the three seasons.

(3) Panicle length: The components of genetic variation D, H_1 and H_2 were significant and positive in the seasons (Tables 54a and b). The ratio of the mean variance of arrays to the mean covariance was less than unity (Table 55). The covariance component F was found to be positive and significant in the S_2 season. The parameter h^2 was significant in the S_3 season.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was less than unity in the seasons (Table 54c). The estimates of $H_2/4H_1$ varied from 0.1952 to 0.2367 in the seasons. The ratio of K_D/K_R was more than unity in the S_1 and S_2 seasons and less than unity in the S_3 season. The value of h^2/H_2 ranged from 0.0659 to 0.4937. The heritability estimates were high and ranged from 69.91 to 81.96 per cent in the seasons. The correlation between the

parental order of dominance and the parental measurements was negative and non-significant in the seasons.

(4) Number of grains per panicle: The genetic components D, H_1 and H_2 were significant and positive in the seasons (Tables 54a and b). The additive component was slightly greater than the dominance components. The value of $\sqrt{Vr}/\sqrt{r}$ was slightly more than unity in the S_1 season and less than unity in the S_2 and S_3 seasons (Table 55). The covariance component F was positive and significant in the S_2 season.

The value of $(H_1/D)^{\frac{1}{2}}$ was slightly more than unity in the S_1 season and less than unity in the S_2 and S_3 seasons (Table 54c). The ratio of $H_2/4H_1$ was varying from 0.1957 to 0.2205 in the different seasons. The estimates of K_D/K_R were more than one in the S_1 and S_2 seasons and less than one in the S_3 season. The h^2/H_2 estimates ranged from 0.0029 to 0.3410. The heritability estimates were high ranging from 59.09 to 68.09 per cent. The association of parental order of dominance and parental measurements was significant and positive in the S_2 and S_3 seasons and negative and non-significant in the S_1 season.

(5) 100 grain weight: The component of variation D was significant and positive in the seasons while the dominance components H_1 and H_2 and the parameter h^2 were significant and

positive in the S_1 and S_3 seasons (Tables 54a and b). The ratio of the mean variance of arrays to the mean covariance was less than unity in the S_1 and S_3 seasons and more than unity in the S_2 season (Table 55). The F value was positive and significant in the S_2 season.

The $(H_1/D)^{\frac{1}{2}}$ was less than unity (0.3939 to 0.7727) in the seasons (Table 54c). The estimates of $H_2/4H_1$ were varying from 0.0950 to 0.2274 in the different seasons. The ratio of K_D/K_R was more than one (1.2197 to 2.5033) in the seasons. The h^2/H_2 estimates ranged from 0.6918 to 1.6421. The heritability estimates were 93.99, 91.99 and 92.69 per cent in the S_1, S_2 and S_3 seasons. The correlation between parental order of dominance and the parental measurements was significant and negative in the S_1 and S_2 seasons and non-significant and negative in the S_3 season.

(6) <u>Grain yield per plant</u>: The genetic components of variation D, H_1 and H_2 were significant and positive in the seasons with relatively high value of the non-additive genetic portion of H_1 and H_2 (Tables 54a and b). The parameter h^2 was significant in the seasons and was found to be nearly one and a half to two times more than the additive component D. The ratio of the mean variance of arrays to the mean covariance was more than unity in the S_1 and S_3 seasons and less than unity in the S_2 season (Table 55). The covariance component F was positive and significant in the seasons.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was more than unity in the S_1 and S_3 seasons and less than unity in the S_2 season (Table 54c). The values of $H_2/4H_1$ varied from 0.1762 to 0.2021 in the different seasons. The ratio of K_D/K_R was more than unity (1.3541 to 1.6685) in the seasons. The h^2/H_2 ratio ranged from 1.6016 to 2.3089. The heritability estimates varied from 61.16 to 70.37 per cent in the different seasons. The correlation between the parental order of dominance and parental measurements was significant and negative in the S_1 and S_3 seasons.

(7) Straw yield per plant: The genetic components D, H_1 and H_2 were significant and positive in the seasons (Tables 54a and b). The dominance components H_1 and H_2 had high values when compared to the additive component D. The ratio of $\overline{Vr}/\overline{Wr}$ was more than unity ranging from 1.2009 to 1.4017 in the different seasons (Table 55). The covariance component F was found to be non-significant and positive. The parameter h^2 was significant and was found to be two to three times more than the additive component D.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was more than unity in the seasons (Table 54c). The value of $H_2/4H_1$ varied from 0.1945 to 0.2062 in the different seasons. The ratio of K_D/K_R was less than unity. The estimates of h^2/H_2 ranged from 1.7151 to 2.0683 in the different seasons. The heritability estimates varied from 60.89 to 74.85 per cent. The correlation between parental order of dominance and the parental measurements was significant

and negative in the S_1 and S_2 seasons.

(8) Grain-straw ratio: The genetic components D, H_1 and H_2 were significant and positive (Tables 54a and b). The dominance components H_1 and H_2 had high values compared to the additive component D. The parameter h^2 was significant and ranged from 0.0149 to 0.0259. The ratio of $\overline{Vr}/\overline{Wr}$ was less than unity (Table 55) in the seasons (0.7734 to 0.8159). The covariance component F was positive and non-significant in the seasons.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was less than unity (Table 54c) in the seasons. The values of $H_2/4H_1$ varied from 0.2150 to 0.2201 in the different seasons. The ratio of K_D/K_R was more than unity ranging from 1.1262 to 1.3052. The h^2/H_2 estimates ranged from 0.5954 to 0.9679. The heritability estimates ranged from 75.73 to 78.20 per cent in the different seasons. The correlation of parental order of dominance to the parental measurements was positive and significant.

(9) Grain length: The components of genetic variation D, H_1 and H_2 were significant and positive in the different seasons with relatively low estimates of the non-additive genetic parameters, H_1 and H_2 (Tables 54a and b). The estimate of h^2 was significant and positive ranging from 0.0563 to 0.0765. The ratio of the mean variance of arrays to the mean covariance was less than unity in the seasons (Table 55).

The covariance component F was found to be positive and non-significant.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was less than unity in the different seasons (Table 54c). The estimates of $H_2/4H_1$ varied from 0.2233 to 0.2553. The ratio of K_D/K_R was more than unity in the seasons ranging from 1.1172 to 1.1902. The value of h^2/H_2 ranged from 0.7983 to 0.8983. The heritability estimates were high ranging from 90.39 to 92.59 per cent. The correlation between the parental order of dominance and the parental measurements was significant and positive in the seasons.

(10) Grain width: The components of variation D, H_1 and H_2 were significant and positive (Tables 54a and b). The additive component (D) was notably greater than the dominance components (H_1 and H_2). The parameter h^2 was not significant in the seasons. The ratio of $\overline{Vr}/\overline{Wr}$ was less than unity in the seasons (Table 55). The F value was significant and positive in the S_1 and S_2 seasons.

The value of $(H_1/D)^{\frac{1}{2}}$ was less than unity (0.3170 to 0.4036) in the seasons (Table 54c). The estimates of $H_2/4H_1$ were varying from 0.2054 to 0.2131. The ratio of K_D/K_R was more than unity in the S_1 and S_2 seasons and less than unity in the S_3 season. The h^2/H_2 estimates ranged from 0.0508 to 0.2950. The heritability estimates ranged from 92.66 to 94.44 per cent. The association between the parental order of

dominance and the parental measurements was significant and negative in the seasons.

(11) Length-width ratio of grain: The genetic components of variation D, H_1 and H_2 were significant and positive with relatively higher value of additive genetic portion, D (Tables 54a and b). The h^2 was significant and positive in the S_3 season. The ratio of the mean variance of arrays to the mean covariance was less than unity in the seasons (Table 55). The F value was positive and significant.

The ratio of $(H_1/D)^{\frac{1}{2}}$ was less than unity in the seasons (Table 54c). The values of $H_2/4H_1$ ranged from 0.2017 to 0.2109 in the different seasons. The ratio of K_D/K_R was more than unity with a range of 1.1862 to 1.2279. The h^2/H_2 estimates ranged from 0.0066 to 0.3355. The heritability estimates ranged from 96.43 to 97.64 per cent. The correlation between parental order of dominance and parental measurements was significant and positive in the S_3 season.

5. Correlation studies

The genotypic correlation coefficients of grain yield per plant with 100 grain weight, tiller number and grain-straw ratio were significant and positive (Table 56). With plant height, panicle length and length-width ratio of grain, the correlations of grain yield were significant and negative. Plant height showed a significant and positive correlation with panicle length, length-width ratio of grain and straw yield

TABLE 56

The genotypic associations among nine characters

Character	Season	Plant height X_1	Tiller number X_2	Panicle length X_3	Number of grains per panicle X_4	100 grain weight X_5	Length-width ratio of grain X_6	Straw yield X_7	Grain-straw ratio X_8
Y	S_1	-0.6606**	1.0961**	-0.3447**	0.3117**	0.8297**	-0.3490**	0.1835	0.4560**
	S_2	-1.3320**	0.3304**	-2.3969**	0.1132	1.1914**	-0.8600**	-0.3136**	0.7714**
	S_3	-0.6638**	0.8011**	-0.4683**	0.0945	0.8078**	-0.3614**	0.3907**	0.1900
X_1	S_1	X	-0.2640**	0.8902**	0.2971**	-1.1958**	1.0178**	0.3384**	-1.1561**
	S_2	X	-0.9571**	1.1032**	-1.1208**	-1.3271**	1.0727**	1.0046**	-1.2816**
	S_3	X	-0.1690	0.7734**	0.2160*	-1.3421**	1.2523**	0.8905**	-1.1684**
X_2	S_1		X	0.8333**	-0.5515**	0.4751**	-0.2189**	-0.3356**	0.3610**
	S_2		X	0.8746**	-2.0186**	0.6523**	-0.9083**	-1.0512**	0.8963**
	S_3		X	0.5981**	-3.0867**	0.0409	-0.1311	0.0587	0.0015
X_3	S_1			X	0.3421**	-0.9718**	0.8781**	0.9792**	-1.0739**
	S_2			X	2.4597**	-0.4425**	2.0891**	2.5016**	-2.3776**
	S_3			X	-0.5102**	-0.8971**	1.0169**	0.3295**	-1.2744**
X_4	S_1				X	-0.0374	-0.0364	0.9996**	-0.7483**
	S_2				X	1.2109**	-2.0417**	0.8610**	-0.4988**
	S_3				X	-0.0915	-0.0883	0.7495**	-0.8400**

TABLE 56 (CONTD.)

Character	Season	Plant Height X_1	Tiller number X_2	Panicle length X_3	Number of grains per panicle X_4	100 grain weight X_5	Length-width ratio of grain X_6	Straw yield X_7	Grain-straw ratio X_8
X_5	S_1					X	-0.8740**	-0.8383**	1.3765**
	S_2					X	-0.8825**	-0.8527**	1.2810**
	S_3					X	-0.9048**	-0.6878**	1.3017**
X_6	S_1						X	0.7745**	-0.9665**
	S_2						X	0.7406**	-1.0267**
	S_3						X	0.8473**	-1.1678**
X_7	S_1							X	-0.8267**
	S_2							X	-0.8755**
	S_3							X	-0.9837**

* Significant at 5% level
** Significant at 1% level

Y - Grain yield
X_1 - Plant height
X_2 - Tiller number
X_3 - Panicle length
X_4 - Number of grains per panicle
X_5 - 100 grain weight
X_6 - Length-width ratio of grain
X_7 - Straw yield
X_8 - Grain-straw ratio

and a negative correlation with tiller number, 100 grain weight and grain-straw ratio in the different seasons. The number of earbearing tillers was positively associated with panicle length, 100 grain weight and grain-straw ratio while negatively associated with number of grains per panicle, length-width ratio of grain and straw yield. The genotypic association of panicle length with number of grains, length-width ratio of grain and straw yield was significant and positive while it was negative with 100 grain weight and grain-straw ratio. The number of grains had significant positive correlation with straw yield and negative correlation with grain-straw ratio. The 100 grain weight showed a significant and positive correlation with grain-straw ratio and a negative correlation with length-width ratio of grain and straw yield. The genotypic association of length-width ratio of grain with the straw yield was significant and positive and was negative with grain-straw ratio. The straw yield showed a significant and negative correlation with grain-straw ratio.

DISCUSSION

INTRODUCTION

In rice, adoption of systematic plant breeding programmes involving techniques as and when developed have resulted in the evolution of strains, meeting the needs of the local requirements (environment). In this respect, new genetic lines resulting out of rare combinations of yield components have hastened the realisation of breeding objectives. It is the building up of desirable plant types through most suitable combination of parents that has been responsible for the development of the desirable varieties. Hence, the need for an understanding of the basic genetic architecture of the component characters related to yield in rice cannot be over-emphasised. The diallel technique has been utilised extensively to furnish the required information for a larger and intensive application in the breeding programmes.

The discovery of a single dwarfing gene in an indica variety of rice (Dee-geo-woo-gen) from Taiwan and its (Dee-geo-woo-gen) subsequent use in developing new varieties like Taichung Native 1, IR 8, IR 20 etc., at the International Rice Research Institute, Philippines, have resulted in a major breakthrough in tropical rice yields (Athwal, 1968). Beginning with the development of Jaya in 1963, 158 high yielding varieties have been released so far in the country (Seetharaman and Shekhawat, 1979 and 1980) with improvement in the grain yield and

specific characters. Among the released varieties, 76 are characterised by coarse grains. Coarse grains (length-width ratio less than 3) admittedly are not favoured by the consuming public. It would therefore, be desirable to transfer the 'fine-grain' character of the tall varieties to the dwarf, indica types without altering either their stature or high yielding potential. Semi-dwarf rices have been mostly used as parents in the breeding programme for improving yield, fertilizer response and non-lodging complex while tall varieties, as donors of preferred grain quality and maturity duration (Hargrove, 1978) . Association between grain size and yielding ability has not been found to be definite (Shastry, 1972). An understanding of the nature of gene action in the parents influencing different stature and grain size and their genotypic association with grain yield will be useful in the breeding programme for the evolution of high yielding varieties particularly with those of fine grain quality. Investigations on the stability of different grain yield attributes and genotypes over the seasons were undertaken by subjecting the hybrids and parents to diallel test over three seasons.

The rice varieties chosen are diploids (2n=24). The inheritance is mostly disomic. The parents chosen are maintained pure through selfing for many generations. The above features satisfy the requirements for subjecting these

varieties to diallel analysis, which as a biometrical tool has been employed by different workers for getting information on the nature of gene action and ultimately fix up the parents in breeding programme in rice (Sivasubramanian, 1970; Ganeshan and Whittington, 1975; Loresto and Chang, 1978).

The graphic analysis was carried out further as the characters studied satisfied the test of non-significant deviation from unity in one or more seasons. The t^2 values were also non-significant for the characters in either one or two of the three seasons, revealing the consistency of Wr-Vr over arrays. The consistency of (Wr+Vr) and (Wr-Vr) over arrays between blocks and joint regression was satisfied for six characters in one or two seasons. Thus, the data permitted further genetic analysis. The genetic parameters estimated through diallel analysis over three seasons and the data obtained in graphic analysis were utilised to ascertain the breeding value of the chosen parents for the different characters studied. The character-wise discussion is presented below.

The high proportion of the variances observed due to progenies in respect of the characters studied as compared to the corresponding error variances indicate wide diversity among the parents (Table 1). The varied expression of mean and the significant seasonal effects (Table 43) in the seasons

indicate the influence of the seasons on the expression of the characters studied. The significant interaction of the seasons with the hybrids for the characters in the pooled analysis (Table 2) confirms the above indication and suggests the need for evaluation of the seasonal influence on the genotypes.

1. Plant height

The high ratios of GCA/SCA obtained in the three seasons (Table 25) as well as from the pooled data (Table 26) reveal the predominance of additive gene action for plant height in the parental genotypes. Singh and Richharia (1978) have reported significant GCA and SCA variances and high GCA: SCA ratio for plant height. Additive gene action is also revealed by the significant values of D component in the different seasons (Table 54a) and the high heritability estimates (Table 54c). However, partial dominance is indicated for this trait by the interception of Y axis above the origin in the Wr, Vr graph (Fig.1). The partial dominance is also indicated by the low dominance ratio of $(H_1/D)^{\frac{1}{2}}$ and K_D/K_R being less than unity (Table 54c). This is further supported by the ratio of $\frac{V_1 L_1}{W_0 L_{01}}$ being less than one (Table 55). It would therefore appear that besides additive gene action for plant height, presence of partial dominance for its expression is also discernible. Such a situation has been met with in the rice varieties by earlier workers (Kim and Rew, 1977; Foster and Rutger, 1978; Singh et al., 1979b and Khan and Khan, 1980). Complementary gene interaction

is indicated by the position of the parents except P_3 in the Wr, Wr' graphs.

The parameters F, H_1 and H_2 (Tables 54a and b) suggest the presence of dominant genes in the genotypes. Clustering of five array points near the origin of the regression line and the remaining five array points away from the line in Wr, Vr graph gives evidence for the presence of both dominant and recessive genes. The $H_2/4H_1$ ratio being less than 0.25 reveals the asymmetrical distribution of positive and negative genes among the parents. Singh and Mehharia (1980) have reported similar observations. The trait is found to have high heritability values (Table 54c). High heritability estimates for plant height have been reported by Li (1975), Maurya (1976) and Chandramohan (1979). One or two blocks of genes are found to control the inheritance of plant height. Three blocks of genes have been found to control the inheritance of height by Chandramohan (1979).

The negative correlation between the mean values of the parents and order of dominance suggests that the dominant genes are positive. This observation is also supported by the consistent negative relationship observed between Yr and Wr + Vr measurement, as well as the location of parents with high mean expression namely P_6, P_7, P_8, P_9 and P_{10} near the origin of the regression line in the Wr, Vr graph. Consistent

location of the semi-dwarf parents P_1, P_2, P_3, P_4 and P_5 in 'recessive-low' quadrant and the remaining five tall parents in the 'dominant-high' quadrant of the standardised deviation graph lends further support for the above observations.

The GCA variance exhibits significant interaction with seasons (Table 26), the proportion of which however, is low as compared to GCA component. This indicates that the seasonal influence on GCA is not considerable enough to affect its estimate. This is supported by the high stability value (0.9960) of GCA variance. The significant difference in the estimates of SCA variance among the seasons (Table 26), the significant interaction of the SCA variance with the seasons and the comparatively low stability value clearly indicate that SCA variance for plant height is less stable over seasons and further the heterotic phenomenon also seems to vary with seasons. Li (1975) has observed similar significant interactions of GCA and SCA variances with the environment.

The parents P_1, P_2, P_3, P_4 and P_5 are semi-dwarfs with low mean expression (Table 3) and negative gca effects (Table 27 The hybrids involving the above parents and also with that of P_7 fall under semi-dwarf group. Out of 90 combinations studied, 50 are between semi-dwarf and tall varieties. Out of the latter, 26 combinations involving the parents P_1, P_2, P_3, P_4

and P_5, with P_7, P_8 and P_9 are found to be shorter in height than the general mean of the 50 combinations (117.4 cm). For the isolation of semi-dwarf types, these combinations might offer scope for selection of desirable segregants in the subsequent generations.

Preponderance of additive gene action, high heritability estimates and greater stability of GCA variances for plant height indicate the suitability of the material for pedigree selection in developing desirable semi-dwarf varieties.

2. Earbearing tillers per plant

The major role of dominant gene action for the expression of this character is revealed by the low values of variance ratio GCA/SCA obtained in the three seasons as well as pooled data (Tables 25 and 26). In the genetic analysis, the additive (D) and dominance (H_1 and H_2) components are significant, the latter being of a higher order (Tables 54a and b). The estimates of $(H_1/D)^{\frac{1}{2}}$ and $\overline{Vr}/\overline{Wr}$ (Tables 54c and 55) being more than unity and the interception of Y-axis by the regression line below the origin (in two seasons) indicate over-dominance. Non-allelic interactions of the complementary type observed in the 'r, Vr and 'r, Vr' graphs (Fig.2) may be responsible for the overdominant trend. Both additive and dominance components appear to govern the inheritance of tiller number, with the preponderance of the latter.

Ranganathan (1972), Nancharaiah et al. (1974), Shaalan et al. (1977b) and Singh and Richharia (1980) have reported similar situations.

Low heritability estimates (Table 54c) are observed in the present study. Manoophong (1973), Jeres Ponce and Martin Jimenez (1974) and Maurya (1976) have observed low heritability estimates for tiller number. However, higher heritability has also been observed by Majumder et al. (1971) and Singh and Nanda (1976a).

The location of the parents P_5 and P_{10} with high mean expression towards the origin and the parents P_7 and P_8 with low mean value away from the origin of the regression line in the Wr, Vr graph suggests that high mean expression is associated with dominance. The location of the high mean parents P_5 and P_{10} in the 'dominant-high' quadrant and the low mean parents P_7 and P_8 in the 'recessive-low' quadrant of the standardised deviation graph supports the above indication. The consistent positive values of the parameter F, significant values of h^2 and higher estimates of K_D/K_R (more than unity) reveal the preponderance of dominant alleles (Tables 54a, b and c) in the genotypes under study. The low-ratio of $H_2/4H_1$ (less than 0.25) indicates the asymmetrical distribution of positive and negative alleles in the parents. The number of blocks of genes controlling tiller number is found to vary from three to five.

The low stability value for GCA variance (Table 26) indicates relative unstability of the parents over seasons. The relative stability value for SCA variance is high indicating that SCA variance is relatively more stable than GCA variance for tiller number. Significant variance of GCA and SCA have been reported by Rao et al. (1980) for earbearing tillers.

Of the 50 combinations between semi-dwarf and tall varieties, 24 have produced more number of tillers than the general mean (14.3). Of the combinations shorter than the general mean, five combinations involving the parents, P_2, P_3 and P_4 with P_7, P_8 and P_9 are not only shorter but also promising for better production of earbearing tillers. As such, for the isolation of semi-dwarf lines with high tillering habit, these combinations may offer scope for selection of desirable recombinants in the subsequent generations.

In view of both additive and non-additive gene effects with predominance of the latter being responsible for this trait, reciprocal recurrent selection programme may be useful in stepping up tiller number.

3. Panicle-length

The high GCA/SCA ratios in the combining ability analysis of the individual seasons and in the pooled data indicate the major role of additive gene effects in the expression of panicle length (Tables 25 and 26). Additive gene action is revealed by the significant values of D component in the seasons (Table 34a). The high heritability estimate as well as the close correspondence between parents and hybrids in the expression of panicle length corroborate the above finding. Ranganathan (1972), Singh and Nanda (1976b) and Chandramohan (1979) have reported additive gene action to be predominant in the expression of this trait.

The values of mean degree of dominance as indicated by the ratios $(H_1/D)^{\frac{1}{2}}$ and $\overline{Vr}/\overline{Wr}$ are less than one (Tables 34c and 35) showing partial dominance for this character. Partial dominance of the genes determining the panicle length is also evident from the position of the regression line above the origin in the graphic analysis (Fig.3). Sivasubramanian (1970) and Ranganathan (1972) have observed partial dominance for this character. Presence of non-allelic interaction is also inferred by the interchange in the position of array points in Wr, Vr and Wr, Wr' graphs (Fig.3). The parents P_3, P_5, P_8 and P_{10} by their position in the Wr, Wr' graph suggest complementary interaction.

The magnitude of the estimates H_1 and H_2 being equal to D component (Tables 54a and b) reveals dominant gene action also. The parameters F and h^2 show low dominance and the ratio K_D/K_R being more than unity shows high dominance. The parents P_6, P_8, P_9 and P_{10} exhibiting high mean values for this character (Table 5) have more of dominant alleles as revealed by the standardised deviation graph. The location of the high mean parents towards the origin and low mean parent P_5 away from the origin in the Wr, Vr graph (Fig.3) suggests that dominance is associated with longer panicles. The location of high mean parents in the 'dominant-high' quadrant and the low mean parents P_2, P_3, P_4 and P_5 in the 'recessive-low' quadrant of the standardised deviation graph also supports the above indication. The $H_2/4H_1$ ratio being less than 0.25, reveals the unequal distribution of positive and negative genes among the parents. Single block of genes is found to control the inheritance of panicle length. The heritability estimates are found to be high. Dayuba and Shilovskii (1976) and Liu (1977) have observed high heritability estimates for panicle length.

The GCA variance shows significant interaction with seasons (Table 26), the magnitude of which, however, is low as compared to GCA component, revealing the high relative stability of the GCA variance. There is significant interaction between GCA variance and the seasons. But the

relative stability estimate of SCA is low compared to that of GCA variance, thus indicating the relative unstable nature of the SCA variance. Maurya and Singh (1977) have found GCA variance higher than SCA variance.

Of the 50 combinations between semi-dwarf and tall varieties, 33 have produced longer panicles than the general mean value (23.7 cm). Of the combinations with plant height less than the general mean, ten combinations involving the parents P_2, P_3, P_4 and P_5 with P_8 and P_9 are not only shorter but also promising for the production of longer panicles. As such, for the isolation of semi-dwarf lines with longer panicles, these combinations may offer scope for the selection of desirable recombinants in the subsequent generations. The combinations $P_9 \times P_3$ and its reciprocal are not only shorter and higher tillering but also promising in the production of longer panicles.

The part played by the additive as well as dominant components, high heritability estimate and wide diversity among the parents for panicle length may render it possible for selection of homozygous lines with longer panicles by reciprocal recurrent selection programme.

4. Number of grains per panicle

The significant GCA variance, the high proportion of GCA variance to SCA variance (Table 25) and the significant additive component of variance, (Table 64a) recorded in the

seasons reveal a major role of additive gene action. Additive gene action has been reported by Mohanty and Mahapatra (1973), Rao et al. (1973) and Ishkumar et al. (1975). Partial dominance of the genes determining the number of grains an evident from the position of regression line in the graphic analysis (Fig.4) also indicates the predominance of additive component. The high heritability estimates observed (Table 54c) support the above indication. Li (1975), Verma et al. (1977) and Chandramohan (1979) have reported high heritability estimates. The genetic analysis shows partial dominance as indicated by the lower value (less than one in two seasons) and overdominance by the higher value (more than one in one season) of the ratios $(H_1/D)^{\frac{1}{2}}$ and $\sqrt{Vr}/\sqrt{Wr}$ (Tables 54c and 55). Partial dominance has been observed by Ranganathan (1972) and Nancharaiah et al. (1974) and overdominance by Sukanya Subramanian and Madhava Menon (1975b) and Khan and Khan (1980). Epistatic influence is indicated by the graphic analysis. Singh and Richharia (1980) have found a similar influence in their study.

The positive value of F (Table 54a) denotes the presence of more dominant genes and this is supported by the high K_D/K_R values (more than one in two seasons). The $H_2/4H_1$ ratio being less than 0.25 reveals the unequal distribution of positive and negative genes among the parents. Single group of genes is found to control the inheritance of this character.

Though the parents P_6, P_9 and P_{10} exhibit high mean expression for this character, the parent P_{10} possesses recessive alleles in addition to dominant alleles while parents P_6 and P_9 have more of dominant alleles as revealed by the standardised deviation graph. The location of high mean parent P_9 towards the origin in the Wr, Vr graph suggests that dominance is associated with more number of grains. On the other hand, among the parents P_3, P_7 and P_8 exhibiting low mean, the parents P_3 and P_7 possess dominant alleles in addition to recessive alleles while P_8 has more of recessive alleles as revealed by their position in the standardised deviation graph. The location of low mean parents P_3 and P_7 towards the origin in the Wr, Vr graph suggests that dominance is also associated with low number of grains. Thus non-allelic interaction is revealed by the above behaviour. The positive correlation between the parental order of dominance and the mean parental measurements, suggests that high mean expression is associated with recessiveness.

The proportion of interaction of GCA x Season component is low as compared to GCA component (Table 26), which indicates that the GCA is not influenced by the season to a large extent. The high estimates of relative stability observed support this finding. The large difference in the estimates of SCA variance among the seasons, the significant interaction of the SCA variance with the seasons and the

low relative stability value obtained, indicate that SCA variance for number of grains per panicle is comparatively unstable over seasons.

Among the 50 combinations between semi-dwarf and tall parents, 26 have recorded more number of grains per panicle over the general mean (105). Of the combinations which are shorter than the general mean in height, ten hybrids besides being shorter, produced more number of grains than the general mean. As such these combinations may offer scope for isolation of desirable recombinants in the subsequent generations. For the selection of shorter plants with more number of grains per panicle, the combinations involving the parents P_1, P_2, P_3, P_4 and P_5 with P_9 appear to be promising. The combinations $P_9 \times P_3$ and its reciprocal are not only shorter and higher tillering with longer panicles but also possess more number of grains per panicle.

Preponderance of additive gene action coupled with dominance gene action, high heritability estimates and greater stability of GCA variance for number of grains indicate the suitability of the material for reciprocal recurrent selection, for developing desirable varieties with high number of grains. The possession of recessive genes with dominant gene action is an advantage in breeding programme as it might facilitate fixation of the trait in the early generations.

5. 100 grain weight

High GCA/SCA ratios in the combining ability analysis in the different seasons and also in the pooled data (Tables 25 and 26) suggest the major role of additive gene action in the expression of this character. Additive gene action is also revealed by the significant value of D component (Table 54a) in all the seasons. Workers at Central Rice Research Institute, Cuttack (Anon., 1972b) and Seemrith et al. (1979) have reported additive gene action for the trait. The high heritability estimate observed supports the above finding. Maurya (1976), Bhattacherya (1978), Singh and Richharia (1980) have also reported high heritability estimates for 100 grain weight.

The value of $(H_1/D)^{\frac{1}{2}}$ being less than unity (Table 54a) reveals the partial dominance for this character. Partial dominance is indicated by the low value (less than one in two seasons) and over dominance by the higher value (more than one in one season) of the ratio $\sqrt{Vr}/\sqrt{Vr}$ (Table 55). The position of regression line in the Y intercept in the graphic analysis further indicates the partial dominance of this character. Partial dominance has been reported by Sukanya Subramanian and Madhava Menon (1973a) and Nanchariah et al. (1974) and overdominance by Singh and Richharia (1980). Non-allelic interaction is also inferred by the interchange in the position of array points in the Wr, Vr and Wr, Vr'

graphs (Fig.3). Except the parent P_7, all the other parents by their position in the Wr, Wr' graph suggest complementary gene interaction. Gupta and Singh (1977) have reported that four esterase loci appeared to be associated with grain weight and to complement each other in an additive manner. The dominance components have also reached statistical significance (in two seasons). The findings of Ichkumar et al. (1975) and Singh and Panda (1976b) have revealed dominance inheritance for the trait. Both additive and non-additive factors seem to govern this character as indicated by the significant levels of GCA and SCA variances in the combining ability analysis (Table 25). Ranganathan (1972), Shaalan et al. (1977a), Rao et al. (1980) and Singh and Richharia (1980) have also reported both additive and dominant gene action for the trait.

The gene distribution among the parents is observed to be unequal with greater frequencies of dominant alleles as indicated by the covariance component 'F' and the ratio of K_D/K_R (Tables 54a and c). Asymmetrical distribution of positive and negative alleles is indicated by the $H_2/4H_1$ ratio by being less than 0.25 in the seasons. Significant negative correlation (in two seasons) between the parental values and the order of dominance suggests that high mean expression is associated with dominance. The position of the parents with high mean expression towards the origin of the

regression line in Vr,Vr graph and in the 'dominant-high' quadrant in the standardised deviation graph and the low mean expression parents away from the origin and their position in the 'recessive-low' quadrant exemplify the above inference. The number of blocks of genes governing this trait varies from one to two.

The GCA variance exhibits significant interaction with seasons, but the proportion of interaction component is low as compared to GCA variance (Table 26), thus indicating the greater stability of GCA variance over the seasons. The high estimates of relative stability further supports the above finding. The significant interaction component of SCA x season and the low relative stability value reveal the relative unstability of SCA variance to seasonal effects.

Out of the 50 combinations between semi-dwarf and tall parents, 20 have heavier grain weight than the general mean (2.10 g). Of the combinations shorter in height, six possessed higher grain weight in addition. The combinations involving the parents P_1 and P_3 with P_8 and P_9 may offer scope for the isolation of desirable recombinants possessing short stature and heavy grains in the subsequent generations. The combinations $P_9 \times P_3$ and its reciprocal appear to maintain their desirability in respect of the weight of grains besides other characteristics.

Preponderance of additive gene action, high heritability estimates and greater stability of GCA variance for 100 grain weight indicate the suitability of the varieties for pedigree selection for developing desirable homozygous lines with greater grain weight. The presence of significant dominance component of variance, epistasis and genetic diversity among the parents, would favour a successful exploitation of heterosis. In view of both additive and dominant gene effects being responsible for this trait, reciprocal recurrent selection programme may be useful in securing lines with high grain weight.

6. Grain yield per plant

A high degree of heterosis is observed for this character (Table 19). The presence of epistasis observed in the parents by the graphic analysis (Fig.6) may contribute for such high heterosis.

The combining ability analysis brings out the role of both additive and dominance components, since both the GCA and SCA variances are significant (Table 25). However, the GCA variances are of higher value than SCA variances in the seasons which revealed the significant role of additive gene action. In the genetic analysis, both additive (D) and dominance (H_1 and H_2) components (Tables 34a and b) are significant and positive with relatively higher value of the latter component. The value of h^2 being nearly twice that of

D component confirms the dominance gene action involved in the character. Additive gene action has been reported by Sivasubramanian (1970) and Chandramohan (1979) and dominance gene action by Ranganathan (1972). Both additive and dominant gene effects have been reported by Ishkumar et al. (1975) and Shaalan et al. (1977a).

The estimates of $(H_1/D)^{\frac{1}{2}}$ and $\overline{Vr}/\overline{Wr}$ (Tables 54c and 55) being more than unity (in two seasons) and the interception of Y-axis by the regression line below the origin (in one season) suggest overdominance. Non-allelic interactions of the complementary type observed in the Wr, Vr and Wr, Wr' graphs may be responsible for the overdominant trend. The parents P_2, P_4 and P_6 by their position in the Wr, Wr' graph suggest complementary gene interaction. Such overdominance has been reported by Sukanya Subramanian and Madhava Menon (1973b) and Hanchariah et al. (1974). From the above indications it appears that both additive and dominance components govern the inheritance of grain yield, with the preponderance of the latter. Singh and Nanda (1976b), Khaleque et al. (1978) and Singh et al. (1980) have opined that dominance was more important for the expression of grain yield.

Moderate heritability estimates (Table 54c) are observed in the present study. Li (1975) and Maurya (1976) have observed low heritability estimates. Idu (1977) and

Bhattacharya (1978), high estimates and Govindaswamy et al. (1973), moderate estimates.

The location of the parents P_1 and P_{10} with high mean expression towards the origin and the parents P_7 and P_8 with low mean value away from the origin of the regression line in the Wr, Vr graph suggests that high mean expression is associated with dominance. The location of the high mean parents P_1 and P_{10} in the 'dominant-high' quadrant and low mean parents P_7 and P_8 in the 'recessive-low' quadrant of the standardised deviation graph supports the above inference. The consistent positive values of the parameter 'F' and higher estimates of F_D/F_R (more than unity) reveal the preponderance of dominant alleles in the genotypes under study. The significant negative correlation of Wr + Vr with Vr reveals predominance of dominant genes. The low ratio of $H_2/4H_1$ (less than 0.25) indicates the asymmetrical distribution of positive and negative alleles in the parents. The number of blocks of genes controlling grain yield is found to vary from two to three.

The increased mean expression in the neverai season 1977 (Table 8) reveals the considerable influence of the season on the expression of grain yield. Stansel et al. (1965), Tanaka and Vergara (1967) and Murty and Murty (1973) have reported better yield in rabi than in kharif. The

significant interaction with seasons observed in the pooled analysis (Table 2) reveals appreciable influence of the season. A significant variance due to genotype x season interaction has been reported by Morishima et al. (1967) and Han et al. (1978). The GCA variance of the parents is stable over seasons as revealed by the high relative stability value (Table 26). The relative stability value for SCA variance is comparatively low indicating that GCA variance is more stable than SCA variance for grain yield.

Twenty six combinations are found to record higher grain yield than the general mean (24.7 g) out of the 50 combinations between semi-dwarf and tall parents. Of these, four combinations viz., $P_1 \times P_8$, its reciprocal and $P_9 \times P_5$ and its reciprocal besides being high yielders, are found to be shorter in addition. In the subsequent generations, these combinations may develve desirable recombinants with high yield and shorter stature. It is interesting to note that the combinations $P_9 \times P_5$ and its reciprocal are outstanding in the grain yield besides possessing the other desirable yield attributes.

The heterosis observed is found to vary with seasons. The relative unstability of SCA variance results in the variable nature of heterotic expression in the different seasons. The maximum mean value is expressed by the combination $P_6 \times P_5$, the high x high general combiners (Table 29)

showing moderate heterotic effect and low sca effect in the grain yield. The sca effect (Table 57) is maximum in the combination $P_4 \times P_5$ having high x low combiners whose mean is moderate and heterotic effect, low. In contrast, the highly heterotic combination $P_8 \times P_6$ involving low x high combiners expresses high mean and sca effect. The combinations $P_1 \times P_8$, its reciprocal, $P_3 \times P_9$ and its reciprocal (high x low combiners) are high yielders with moderate to high heterotic effect and significant positive high sca effects. Thus, the heterotic phenomenon observed in the present investigations may be due to epistasis or dominance. Ishkumar et al. (1975) have also reported such variable heterosis. This suggests the need for evaluation of genotypes in more than one season.

In view of both additive and non-additive gene effects with preponderance of the latter being responsible for grain yield, reciprocal recurrent selection programme may be useful in stepping up the grain yield per plant.

7. Straw yield per plant

A high degree of heterosis is observed for this character (Table 20). The presence of epistasis is observed in the parents by the graphic analysis (Fig.7).

Both additive and non-additive factors seem to govern this character as indicated by the significant levels of GCA and SCA variances in the combining ability analysis (Table 25).

The predominance of additive gene action is revealed by the ratio of GCA to SCA exceeding unity in the seasons. The partial dominance exhibited in the graphic analysis by the interception of Y axis above the origin also lends further support to the importance of additive gene action. The moderate heritability estimates (Table 54c) observed also favour the above indication.

In the genetic analysis both additive (D) and dominance (H_1 and H_2) components (Tables 54a and b) are highly significant in the different seasons, the magnitude of the latter component being higher than the former. The parameter h^2 which is two to three times greater than the additive component indicates the greater involvement of dominance component in the trait. The estimates of $(H_1/D)^{\frac{1}{2}}$ (Table 64c) and $\overline{Vr}/\overline{Wr}$ (Table 55) indicate overdominance. Non-allelic interactions of the complementary type observed in Wr, Vr and Wr, Wr' graphs (Fig.7) may contribute to the overdominant trend. According to Mayman (1954a) the apparent overdominance may be due to epistasis. Sukanya Subramanian and Madhava Menon (1975b) have reported overdominance as well as partial dominance in the inheritance of straw yield. Thus, it appears that both additive and non-additive components with preponderance of the latter, are involved in the expression of straw yield.

The position of the parents P_6, P_9 and P_{10} with high mean value towards the origin and the parents P_1, P_3 and P_5 with low mean away from the origin in the Wr, Vr graph suggests that dominance is associated with high expression. The consistent location of the high mean parents in the 'dominant-high' quadrant and the low mean parents in the 'recessive-low' quadrant of the standardised deviation graph also support the above finding. The consistent positive values of covariance parameter 'F' and negative correlation of Wr+Vr, Vr reveal the presence of dominant alleles while the lower estimates of K_D/K_R (less than one) reveal the presence of recessive alleles. The low ratio of $H_2/4H_1$ (less than 0.25) indicates the distribution of the positive and negative alleles to be asymmetrical. The number of blocks of genes influencing this character appears to vary from two to three.

The comparatively lower relative stability value of GCA variance than that of SCA (Table 26), indicates the relative low stability of the parents over seasons. The heterosis observed is found to vary with the seasons. Higher heterotic expression is observed in the navarai season, 1977 than in the other seasons. The heterotic phenomenon observed may be due to epistasis or dominance. This suggests the need for evaluation of genotypes in more than one season to get valid information.

A reciprocal recurrent selection programme could utilise the considerable degree of additive as well as non-additive influence with the predominance of the latter, present in the varieties under study, for reduction of straw yield.

8. Grain-straw ratio

The high proportion of GCA variance to SCA variance (Table 25) and the significant additive variance (Table 54a) observed in the seasons reveal the major role of additive gene action. The dominant components H_1 and H_2 and the parameter h^2 are also significant indicating the role of dominance gene action (Table 54b). Partial dominance of genes determining grain-straw ratio as evident from the position of regression line in the graphic analysis (Fig.8) also gives indication of the predominance of additive component. High heritability estimates (Table 54c) as well as the close correspondence between the parents and the hybrids support the above indication. High heritability estimates have been reported by Ito (1975) and Mehon and Saini (1979). The genetic analysis under diallel technique shows partial dominance as indicated by the less than unity $(H_1/D)^{\frac{1}{2}}$ and $\overline{Vr}/\overline{Wr}$ ratios in the seasons (Tables 54c and 55). Complementary type of epistasis is indicated by the graphic analysis (Fig. 8) The parents P_1, P_2, P_3 and P_5 possess complementary genes by their interchange of position in the Wr, Vr' graph. From the above findings it

would appear that both additive and dominance components govern the grain-straw ratio with the preponderance of the former.

The location of the parents P_1, P_2, P_3, P_4 and P_5 with high mean ratios away from the origin in the Wr, Vr graph and in the 'recessive-high' quadrant in the standardised deviation graph suggests that the high mean expression may be associated with recessiveness. Significant positive correlation between the parental measurements and order of dominance in all the seasons favours the above observation. The positive value of r and more than unity estimates of K_D/K_R reveal the preponderance of dominant alleles in the genotypes under study. High genetic differences exist among the parents as seen from the wide spread of the array points (Fig.6). The low ratio of $H_2/4H_1$ (less than 0.25) indicates the distribution of the positive and negative alleles to be asymmetrical.

The mean (Table 10) and the variance vary widely among the seasons indicating the need for evaluating the material in more than one season. The hybrid x season interaction in the pooled analysis is significant (Table 2). Sahu et al. (1980) have reported that harvest index is prone to change under different seasons. The relative stability estimate of GCA variance is more than that of SCA (Table 26), indicating the relative greater stability of the former than the latter.

Out of the 90 combinations involving semi-dwarf and tall parents, 20 combinations are found to record higher harvest index i.e., grain-straw ratio than the general mean (0.569). Of these, 14 combinations involving the parents P_1, P_2, P_3, P_4 and P_5 with P_7 and P_9 besides being higher harvest index are shorter in height than the general mean. The combinations $P_9 \times P_3$ and its reciprocal are promising, possessing all desirable features of high grain yield including high harvest index.

The heterosis observed is found to vary widely (Table 21). The combination $P_3 \times P_5$ having high mean expression (0.946) is between two high general combiners (Table 30) but expresses low heterotic vigour and high sca effect. The combination $P_4 \times P_6$ expressing maximum heterosis is between high and low general combiners and has moderate mean expression and sca effect (Table 28). The combination $P_9 \times P_3$ (low x high gca) has moderate mean expression and sca effect with low heterosis. Thus, the heterotic phenomenon observed may be due to dominant or epistatic interaction.

In view of both additive and non-additive gene effects with the preponderance of the former being responsible for the harvest index, ~~reciprocal recurrent~~ pedigree selection programme may be useful in improving the same.

9. Grain length

The high values of the variance ratio of GCA/SCA ranging from 46.98 to 64.40 (Table 25) in the individual seasons and 61.75 in the pooled analysis (Table 26) reveal the predominance of additive gene action for grain length in the parental genotypes. Such significant GCA and SCA variances and high GCA to SCA ratios have been reported by Singh and Richharia (1977). Predominance of additive gene action is also revealed by the phenomenally high values of D component compared to those of H_1, H_2 and h^2 components (Table 54a and b). The high heritability estimates (Table 54c) observed for this character support the major role of additive gene action. Poonai (1966), Nakatat (1972) and Seemrith et al. (1979) have reported high heritability for this character. Predominance of additive gene action for grain length has been reported by Poonai (1966) and workers at Central Rice Research Institute, Cuttack (Anon., 1972b).

Partial dominance is indicated by the interception of Y axis above the origin in the Wr, Vr graph (Fig. 9). The partial dominance is also indicated by the low dominance ratio $(H_1/D)^{0.5}$ being less than unity (Table 54c). This is further supported by the ratio of $\frac{V_1 L_1}{V_0 L_{01}}$ being less than one (Table 55). Partial dominance has been reported by

Sukanya Subramanian and Madhava Menon (1973c). Non-allelic interaction is also inferred by the interchange in the position of array points in Wr, Vr and wr, Wr' graphs. The position of the parents in the Wr, Vr' graph suggests complementary gene interaction.

The parameters F (positive value) and H_D/H_R (more than unity) suggest preponderance of dominant genes in the genotypes (Tables 54a and c). Clustering of five array points (parents with high mean expression) near the origin and the others away from the origin of the regression line in Wr, Vr graph gives evidence for the presence of both dominant and recessive genes. The $H_2/4H_1$ ratio being less than 0.25 (in two seasons) reveals the asymmetrical distribution of positive and negative genes among the parents. A single group of genes is found to control the inheritance of this character. The negative correlation between the mean values of the parents and order of dominance suggests that the dominant genes are positive. Consistent location of the shorter grained parents P_2, P_3, P_4 and P_5 in the 'recessive-low' quadrant and longer grained parents P_7, P_8, P_9 and P_{10} in the 'dominant-high' quadrant of the standardised deviation graph lend further support for the above observation.

The GCA variance exhibits significant interaction with seasons (Table 26), the proportion of which is low as compared to GCA component. This indicates that the seasonal influence on GCA is not considerable enough to affect its

estimate, which in turn is confirmed by the high stability value of GCA variance. The comparative low stability value of SCA variance to that of GCA variance clearly indicate that SCA variance for grain length is relatively less stable over seasons.

The combinations $P_1 \times P_8$, its reciprocal, $P_8 \times P_9$ and $P_{10} \times P_8$ having longest grain and average x high and high x high gca (Table 31) express low heterotic effect and low sca effect (Table 39). In contrary, the combination $P_2 \times P_{10}$, having low x high combiners, possesses high heterotic effect and sca effect. The heterotic effect seems to be due to dominance or epistatic interaction of genes.

The greater part played by the additive component, high heritability estimate and wide diversity among the parents for grain length may render it possible for selection of homozygous lines with longer grains by pedigree breeding following a crossing programme. The presence of significant dominance component of variance, epistasis and genetic diversity among the parents, would favour a successful exploitation of heterosis in the breeding programme.

10. Grain width

Consistently high GCA/SCA ratios in the combining ability analyses of the individual seasons and the pooled data (Tables 25 and 26) indicate the major role of additive

gene effects in the expression of grain width. Additive gene action is also revealed by the significant values of D component in the seasons (Table 54a). Singh and Richharia (1977) have reported additive genetic variance for grain width.

Partial dominance of the genes determining grain width as evident from the position of regression line above the origin in the graphic analysis (Fig. 10) further supports the influence of the predominance of additive gene action. Partial dominance of narrow spikelets over broad spikelets has been reported by Ralich (1957). The high heritability estimates (Table 54c) as well as the close correspondence between parents and hybrids in the expression of this character (Table 12) corroborate the above finding. High heritability estimate has been reported by Lin and Huang (1973). The genetic analysis also shown partial dominance as indicated by the less than unity ratios of $(H_1/D)^{\frac{1}{2}}$ and $\frac{V_1 L_1}{V_0 L_0}$ in the seasons. Non-allelic interaction is inferred by the interchange in the position of array points, in the Wr, Vr and Vr, Wr' graphs. All the parents except P_1 by their position in the Wr, Vr' graph in one or other seasons suggest complementary gene interaction. The significant values of H_1 and H_2 indicate the role of dominance also, the magnitude of which, however, is smaller than D component. From the above results, it may be inferred that both additive and non-additive components govern this trait with the preponderance of the former.

The location of the parents, P_1, P_2, P_3, P_4 and P_5 with high mean expression towards the origin in the Wr, Vr graph suggests that the high mean expression is associated with dominance. The significant negative correlation between the parental measurements and order of dominance and the location of the high mean parental array points in 'dominant-high' quadrant support the above finding. The consistent positive values of covariance parameter 'r' and more than unity estimates of K_D/K_R in the different seasons reveal the presence of dominant alleles in the genotypes under study. The low ratio of $H_2/4H_1$ (less than 0.25) indicates that the distribution of the positive and negative alleles is asymmetrical. Minimum of one group of genes appears to influence the expression of grain width.

The GCA and SCA variances showed significant interaction with seasons (Table 26). However, the relative stability estimate of SCA is low compared to that of GCA variance, thus indicating the relatively unstable nature of the SCA variance.

In view of the predominant additive gene effects being responsible for the grain width, pedigree breeding following a crossing programme may be useful in securing progenies with narrow spikelets.

11. Length-width ratio of grain

High GCA/SCA ratios in the combining ability analyses in the different seasons and also in the pooled data (Tables 25 and 26) suggest the major role of additive gene action in the expression of grain shape. Singh and Richharia (1977) have also found high GCA/SCA ratio for grain shape. Additive gene action is also revealed by the significant value of a component in the different seasons (Table 54a). The high heritability estimate (Table 54c), as well as the close correspondence between the expression of the parents and the hybrids support the above conclusion. Caraus (1970), Nakatat (1972) and Soomrith et al. (1979) have also reported high heritability estimates for grain shape. Additive gene action has been reported by Ganeson and Whittington (1975) and Singh and Richharia (1977).

The values of $(H_1/D)^{\frac{1}{2}}$ and $(\overline{Vr}/\overline{Wr})$ being less than unity (Tables 54c and 55) indicate the partial dominance. The position of regression line in the Y-intercept in the graphic analysis (Fig.11) further reveals the partial dominance. Non-allelic interaction is also inferred by the interchange in the position of array points in Wr, Vr and Wr, Vr' graphs. All the parents by their position in the Wr, Vr' graph in one or more seasons suggest complementary gene interaction. The dominance components have also reached statistical significance, the magnitude of which,

however, is very low compared to the additive component. Both additive and non-additive factors seem to govern the grain shape as indicated by the significant levels of dGA and SCA variances in the combining ability analyses of the different seasons. Similar results have been observed for the grain shape by Soomrith et al. (1979). From the above indications it would appear that both additive and non-additive components govern the grain shape with the preponderance of the former.

The gene distribution among the parents is observed to be unequal with greater frequencies of dominant alleles as indicated by the positive co-variance component 'F' and the high ratio of K_D/K_R (Tables 54a and c). Asymmetrical distribution of positive and negative alleles is indicated by the $H_2/4H_1$ ratio, being less than 0.25 in the seasons. However, significant positive correlation between the parental values and order of dominance in the S_3 season suggests that high mean expression may be associated with recessiveness. The greater frequency of recessive genes in the parents P_6, P_7, P_8, P_9 and P_{10} with high mean expression, and preponderance of dominant alleles in the other five parents with low mean expression by their position in the standardised deviation graph (Fig. 11) in one or more seasons exemplify the above conclusion.

The GCA variance exhibits significant interaction with seasons, but the proportion of interaction component is low as compared to GCA variance (Table 26), thus indicating the greater stability of GCA variance over the seasons. The high estimates of relative stability further supports the above indication. The significant interaction component of GCA x season and the low relative stability value reveal the relative unstability of SCA variance to seasonal effects. Singh and Nichharia (1977) have also observed such significant GCA and SCA variances for grain shape.

The number of combinations possessing finer grains than the general mean (3.07) out of the 50 combinations between semi-dwarf and tall variation, is 24. Of these, 14 combinations are shorter in stature besides possessing finer grains. These combinations involving the parents P_1, P_3 and P_5 with P_7, P_8 and P_9 offer scope for isolating segregants combining short stature and fine grain quality in the subsequent generations. The only combinations that have desirable yield attributes, short stature, high harvest index and fine grain quality emerge to be $P_9 \times P_5$ and its reciprocal.

Preponderance of additive gene action, high heritability estimates and greater stability of GCA variances for the fineness of grain indicate the suitability of the material for pedigree selection in developing fine grained lines.

Breeding value of the parents

The studies undertaken envisage to bring out the genetic architecture of the selected parents, particularly, the factors influencing the grain yield, its attributes and the grain quality in respect of size and shape, and to explore the possibility of improving them through recombination breeding. The foregoing discussion on the potentialities and combining ability of the parents for the various grain yield attributes has brought out the possibility of realising the objectives. The following general inferences are indicated.

Among the parents studied, the parents P_3 and P_4 possessed high mean expression and gca effects for grain yield, and other yield attributes, nacely, number of tillers and 100 grain weight. The parent P_4 has high gca for number of grains per panicle in addition. The parents P_6 and P_{10} have high mean expression and gca effects for grain yield, tiller number, panicle length and number of grains per panicle. The parents P_3 and P_4 by their short stature possess high harvest index (grain-straw ratio) which is lacking in P_6 and P_{10}. On the other hand, the parents P_6 and P_{10} possess fine quality of grain while P_3 and P_4 have coarse grains. The parents P_1 and P_2, besides being short statured, possess high 100 grain weight. Except for greater number of recessive alleles for short stature, P_5 has the lowest expression for most of the economic traits. The parents P_7, P_8 and P_9 possess high gca effects for length-width ratio of grain, besides the latter two parents for panicle length in addition.

Of the fifty combinations between semi-dwarf and tall varieties under study, twenty six are found to be shorter than the general mean arising out of the combination of the parents P_1, P_2, P_3, P_4 and P_5 with P_7, P_8 and P_9. From a consideration of better tillering habit, larger number of grains per panicle, more 100 grain weight, shorter stature, higher grain yield and fine quality of grain, the combinations of the parents P_1 and P_3 with P_8 and P_9 appear to be promising. The combinations $P_9 \times P_3$ and its reciprocal are outstanding from the point of view of realising the most desirable recombinants in the subsequent generations in respect of short stature, higher yield of grain with fine quality (Plates 1 and 2).

Most of the desirable grain yield attributes are found to be controlled by both additive and non-additive gene actions. However, plant height, number of grains, 100 grain weight and harvest index are predominantly governed by additive factors while tiller number, grain yield and straw yield are influenced mostly by non-additive factors. Panicle length is controlled by both additive and dominance gene action. Among the grain quality factors, grain length, width and length-width ratio are controlled by additive gene action predominantly. In such a situation, where there is predominance of non-additive components or influence of both additive and non-additive components, simple pedigree selection method may not be adequate since it will not yield

PLATE 1

Intervarietal Hybrids

1a

P_1 - Jaya

$P_1 \times P_8$ - Jaya x Basmati

P_8 - Basmati

1b

P_8 - Basmati

$P_8 \times P_1$ - Basmati x Jaya

P_1 - Jaya

1c

P_3 - DgWg

$P_3 \times P_9$ - DgWg x TKM 4

P_9 - TKM 4

1d

P_9 - TKM 4

$P_9 \times P_3$ - TKM 4 x DgWg

P_3 - DgWg

PLATE 1.



1a



1b



1c



1d

PLATE 2

PLATE 2

Grain size variation in the hybrids

2a

P_1 - Jaya

P_8 - Basmati

$P_1 \times P_8$ - Jaya x Basmati

$P_8 \times P_1$ - Basmati x Jaya

2b

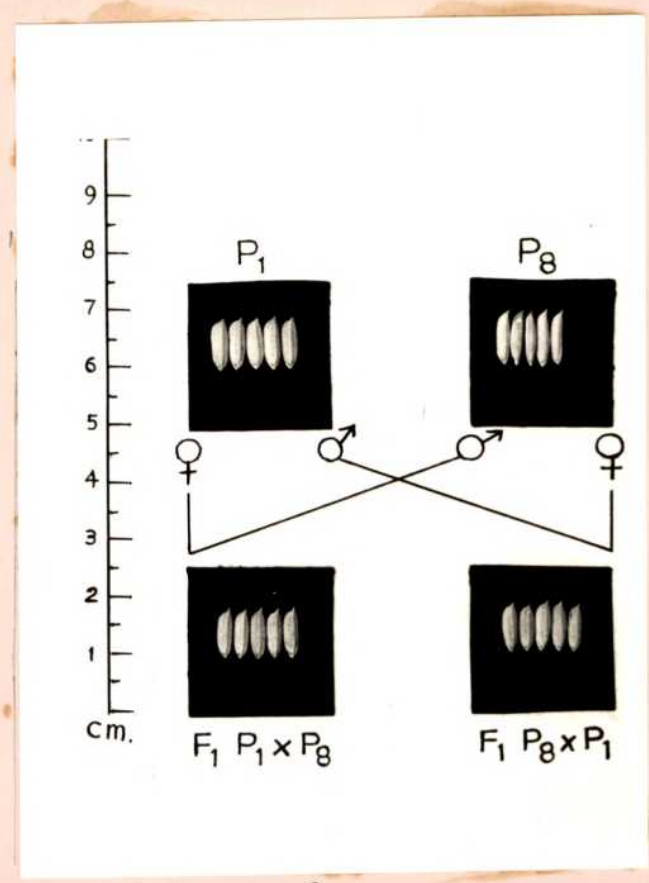
P_3 - DgWg

P_9 - TKM 4

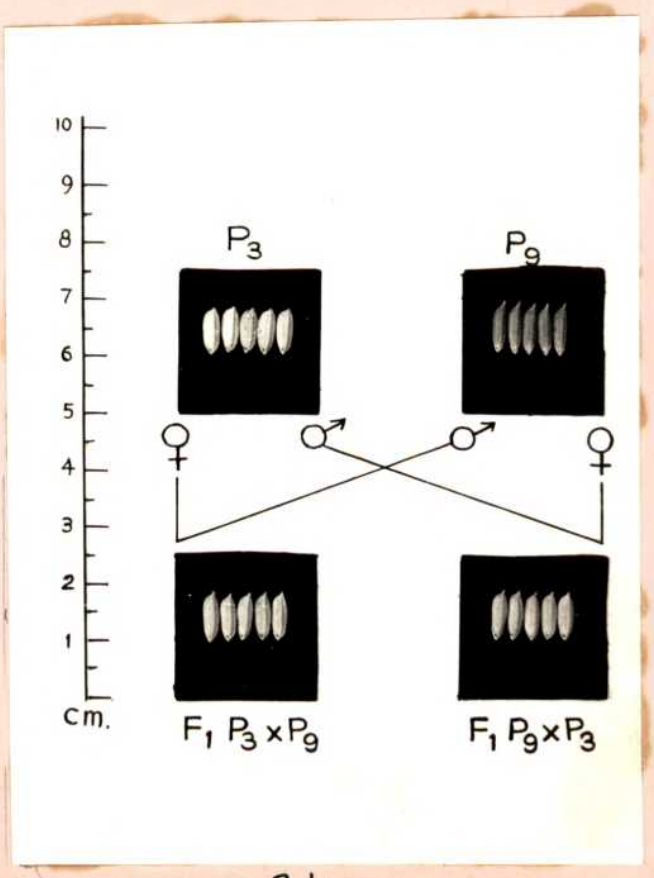
$P_3 \times P_9$ - DgWg x TKM 4

$P_9 \times P_3$ - TKM 4 x DgWg

PLATE 2.


9
8
7
6
5
4
3
2
1
cm.
P1
P8
F1 P1 x P8
F1 P8 x P1

2 a


10
9
8
7
6
5
4
3
2
1
cm.
P3
P9
F1 P3 x P9
F1 P9 x P3

2 b

a desirable level of improvement. Probably this may be the reason for the slow progress in combining high yield and fine quality of grain. Considering the high genetic variance for the above desirable characters, further improvement among the parents can be effected through a programme of reciprocal recurrent selection.

In the present investigation, the genotypic correlation of eight traits with grain yield as well as their inter relationships were studied. The grain yield is correlated with 100 grain weight, tiller number and grain-straw ratio significantly and positively. Among themselves, the latter three traits are positively correlated. Negative correlation of grain yield is found with plant height, panicle length and length-width ratio of grain. The latter three components are correlated positively among themselves. The inter-relationship viz., the negative association of length-width ratio of grain with grain yield and 100 grain weight and the positive association between the latter two traits, may be the reason for the rare combination of fine grain quality (high length-width ratio) with high yield. In order to get recombinants combining high yield with fine grain quality, either modified backcrossing technique or recurrent selection may have to be resorted to.

SUMMARY

SUMMARY

Ten varieties of rice were evaluated for their utility as parents, as well as their combinations through a diallel technique over three seasons with a view to identify the potential parents and superior combinations, their genetic architecture and their interaction with seasons. The ten varieties were crossed among themselves in all possible combinations and 90 hybrids were tested along with their parents.

Plant height, number of earbearing tillers per plant, panicle length, number of grains per panicle, 100 grain weight and straw yield per plant were considered as the grain yield attributes along with grain quality aspects viz., length and width of grain.

The characters varied widely among the parents and their combinations. The plant height was governed predominantly by additive gene action with high heritability estimates. The parents evaluated possessed unequal distribution of dominant and recessive genes. The distribution of positive alleles and negative alleles was asymmetrical, with the positive alleles being associated with high mean expression. One or two blocks of genes controlled the plant height. The genotypic association of plant height with grain yield was significant and negative and with length-width ratio, significant and positive.

Number of earbearing tillers was governed by both additive and non-additive factors with the preponderance of the latter. The heritability estimates were low. Non-allelic interaction of the complementary type was observed for this character. Dominant and recessive genes were unequally distributed with high frequency of the former. Asymmetry in the distribution of positive and negative alleles was noticed in the parents. Three to five blocks of genes conditioned this character. Significant positive genotypic association was observed between tiller number and grain yield.

Additive and non-additive factors controlled the inheritance of panicle length. Non-allelic interaction has also influenced this character. The heritability estimates were high. The parents had unequal distribution of dominant and recessive genes as well as positive and negative alleles. This character was controlled by a single block of genes.

A major role of additive gene action with high heritability was observed to control the inheritance of the number of grains per panicle along with non-additive gene action. Non-allelic interaction was observed. The gene distribution was unequal with greater frequency of dominant genes. The positive and negative alleles were asymmetrically distributed in the parents. Higher mean expression was associated with

recessiveness. This character was controlled by a single group of genes.

The predominant role of additive gene action with high heritability estimates was noticed in the inheritance of the 100 grain weight. Asymmetrical distribution of positive and negative alleles, as well as dominant and recessive genes in the parents were noticed. Dominant genes were associated with high grain weight. Non-allelic interaction was observed. One or two blocks of genes controlled this character. Significant positive genotypic association was observed between the 100 grain weight and grain yield and negative association with length-width ratio of grain.

Dominance gene action predominantly, with appreciable heterosis was observed for grain yield per plant. Additive factors also governed the inheritance of this character. Moderate heritability estimates were noted. The genetic analysis revealed a preponderance of dominant genes with asymmetrical distribution of positive and negative alleles in the parents. Non-allelic interaction of complementary type was noticed. High mean expression was associated with dominance. One to two blocks of genes controlled this character. Significant negative genotypic association between grain yield and length-width ratio of grain existed.

A high degree of heterosis with complementary type of epistasis was observed for straw yield per plant. Both

additive and dominance components controlled the inheritance with the preponderance of the latter. Excess of dominant genes with unequal proportion of positive and negative alleles was observed in the genotypes. Dominance was associated with high straw yield. Moderate heritability was noted for this character. The number of blocks of genes governing this trait was two to three.

Grain-straw ratio was governed by both additive and non-additive factors with the preponderance of the former. Complementary type of epistasis interaction was noticed. The parents possessed a preponderance of dominant genes with asymmetrical distribution of increasing and decreasing alleles. High mean expression was associated with recessiveness. One block of genes controlled the expression of grain-straw ratio.

The preponderance of additive gene action with high heritability estimates was noticed in the inheritance of grain length. Asymmetrical distribution of positive and negative alleles, as well as dominant and recessive genes with the preponderance of dominant genes in the parents were noticed. Dominant genes were associated with longer grains. Non-allelic interaction of complementary type was observed. One block of genes controlled this character.

Additive and non-additive factors controlled the inheritance of grain width with the preponderance of the former and high heritability estimates. Non-allelic interaction

also influenced this character. The parents had an excess of dominant alleles with unequal distribution of dominant and recessive genes, as well as positive and recessive alleles. Greater width of grain was associated with dominance. This character was controlled by one block of genes.

Length-width ratio of grain was governed by both additive and non-additive factors with the preponderance of the former. High heritability was noticed. Complementary type of epistasis influenced the ratio. The parents possessed a preponderance of dominant genes with asymmetrical distribution of increasing and decreasing alleles. Higher mean expression was associated with recessiveness. One block of genes controlled the expression of length-width ratio of grain. The genotypic association of length-width ratio of grain with grain yield was negative and with plant height, positive.

The overall genetic position brought out partial dominance for plant height, panicle length and length and width of grain, over dominance for tiller number and both partial dominance and over dominance for number of grains per panicle, 100 grain weight and grain yield and straw yield per plant.

The characters, plant height, tiller number, panicle length, number of grains per panicle, 100 grain weight, grain yield and straw yield per plant and length and width of grain

interacted significantly with seasons. To obtain precise information on these characters, it is desirable to evaluate them in different seasons.

The GCA variances were generally more stable over seasons than SCA variances for the characters. A single season testing could give sufficient inference for the utilisation of the additive variance available in the materials studied in a breeding programme. The differential behaviour of SCA variances to seasons suggested the need for evaluation of the hybrids in more than one season.

Among the parents, P_1, P_3, P_8 and P_9, in particular have been identified as the appropriate parents for use in the crossing programme for further accumulation of favourable genes through recombination and selection. The other parents possessed one or more favourable features of yield attributes with fine grain quality and they could be used in a recurrent selection programme, for securing high yielding, short stature lines possessing fine grain quality.

Twenty four combinations involving the parents P_1, P_2, P_3, P_4 and P_5 with P_7, P_8 and P_9 were found to be shorter than the general mean height of the 50 combinations between semi-dwarf and tall varieties studied. Of these, the combinations of the parents P_1 and P_3 with P_8 and P_9 were promising recording high yield besides possessing the various yield

attributes with fine grain quality. The combinations $P_9 \times P_3$ and its reciprocal offer scope for realising the most desirable recombinants in respect of shorter stature, high yield potential and fine quality of grain, in the subsequent generations.

ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

I express my deep sense of gratitude to Dr.K.Rathinam, Associate Professor (Breeding), Department of Forestry, Tamil Nadu Agricultural University and Chairman of my advisory committee for suggesting the problem and for his keen interest, constant guidance and encouragement throughout the investigation.

I am highly thankful to Dr.P.V.Marappan, Director, School of Genetics, Prof.A.Subramanian, Prof.S.Kamalanathan, and Dr.R.Appadurai, the then heads of Department of Agricultural Botany, for their helpful suggestions and encouragement. My grateful thanks are also due to the other members of the advisory committee, Dr.K.R.Ramaswamy, Professor and Head, Department of Seed Technology, Mr.G.Purushothaman, Associate Professor (Sunflower), Prof.V.S.Raman, Professor (Oilseeds) and Dr.Y.B.Morachan, Director of Extension Education for their encouragement during the course of investigation. I am also grateful to Dr.J.Chandramohan, Professor (Rice), Dr.S.Sankaran, Professor and Head, Department of Agronomy, Dr.M.Balasubramanian, Professor and Head, University Research Centre, Aduthurai and Dr.T.V.Kariyarathnaraju, Associate Professor, Agricultural Research Station, Bhavanisagar the then members of the advisory committee for their helpful suggestions.

I am thankful to all the members of the Paddy Breeding Station, for the help rendered by them. I am indebted to my family members, Mrs.Rukmini Sarma, Mr.T.L.Subramanian, Master T.S.Ramanarayanan and Sri V.Veeraswamy for the moral support rendered by them.

I am grateful to the authorities of the Tamil Nadu Agricultural University for permitting me to carry out the Doctoral work as part-time student under the trimester system.

Coimbatore SUKANYA SUBRAMANIAN

REFERENCES

REFERENCES

Abou-El-Fittouh, H.A., J.O.Rawlings and P.A.Miller. 1969. Genotype by environment interactions in cotton - their nature and related environmental variables. Crop Sci., 9: 377-381.

Agarwal, R.K., J.P.Lal and A.K.Richharia. 1978. Note on selection indices and path coefficient in semi-dwarf rice varieties. Indian J. agric. Sci., 48: 58-60.

*Akemine, M. 1925. On the inheritance of dwarf habit in rice (In Japanese). Report Jap. Assoc. Adv. Sci., 1: 308-314.

Allard, R.W. 1956a. Estimation of prepotency from Lima bean diallel cross data. Agron. J. 48: 537-543.

Allard, R.W. 1956b. Biometrical approach to plant breeding. Proc. Symp. on Genetics and Plant Breeding. Brookhaven Nat. Laboratory. 69-86.

Aly, A.M. 1979. Correlation and path coefficient analysis in some short statured rice cultivars and strains. Int. Rice Comm. Newsl., 28: 19-21.

Anand, S.C. 1968. Variety into environment interactions in wheat. J. Res. Punjab Agric. Univ., Ludhiana, 5: 63-66.

Anonymous. 1967. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp. 71-73.

Anonymous. 1969. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp. 266.

Anonymous. 1970. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp. 220.

Anonymous. 1972a. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp. 193.

Anonymous. 1973. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp. 161.

Anonymous. 1976. Internatl. Rice Res. Inst. Ann. Rpt. Los Banos, Philippines. pp.18-19, 21-22.

Anonymous. 1954a. Memoirs of the Department of Agriculture, Madras. 2. pp. 106.

Anonymous. 1954b. Memoirs of the Department of Agriculture, Madras. 2. pp. 121.

Anonymous. 1954c. Memoirs of the Department of Agriculture, Madras 2. pp. 122.

Anonymous. 1954d. Memoirs of the Department of Agriculture, Madras 2. pp. 123.

Anonymous. 1972b. Technical Report for the year 1971, Centl. Rice Res. Inst., Cuttack, ICAR. New Delhi. India. pp.242.

Arunachalam, V. 1976. Evaluation of diallel crosses by graphical and combining ability methods. Indian J. Genet., 36: 358-66.

Askel, R. and L.P.V.Johnson. 1962. Analysis of diallel cross. A worked example. Adv. Front. Pl. Sci., 2:37-54

Athwal, D.S. 1963. Concepts of plant type and disease resistance in rice breeding. Indian J. Genet., 23: 1-11.

*Bal, S.H. 1973. Studies on inheritance and ecological variation of culm length and related characters in short rice varieties. Research Reports of the Office of Rural Development Crop, 15: 129-166. Pl. Breed. Abstr., 44: 5964. 1974.

Baker, R.J. 1976. Issues in diallel analysis. Crop Sci., 18: 533-536.

Bardhan Roy, S.K., A.K.Mitra and D.K.Mukherji. 1975. Hybrid vigour in five cross combinations in rice. Oryza sativa L. Sci. and Cult., 41: 118-119.

Bollich, C.N. 1957. Inheritance of several economic quantitative characters in rice. Diss. Abstr., 17: 1638.

Brar, G.S. and S.S.Saini. 1976. Association of grain yield and some economic characters in segregating population of two crosses between tall and dwarf varieties of rice. Indian J. agric. Sci., 46: 305-307.

*Carnus, V. 1970. Studies on the combining ability of some varieties and lines of rice. Lucrari Stiintifice Institutue Agronimic, Timisoara, Agronomie. 13:559-567. Pl. Breed. Abstr., 44: 5969. 1974.

Carnham, H.L., A.W.Hovin., H.O.Graumann., W.R.Kehr., R.L.Davis. L.J.elling and G.H.Hanson. 1960. General versus specific combining ability in alfalfa for seedling vigour and growth habit in the year of establishment. Agron. J., 52: 511-515.

Chaisang, K., P.U.T.Ponnaiya and K.M.Palasubramaniam. 1967. Studies on anthesis, pollination and hybridisation techniques in rice (O.sativa L.). Madras agric. J., 54: 118-123.

Chandramohan, P. 1979. Inheritance of earliness and yield components in a six parent diallel cross of rice (Oryza sativa L.). M.Sc.(Ag.)., Diss. Tamil Nadu Agrl. Univ., Coimbatore.

Chandramohan, J. and P.Narayanaswamy. 1975. Correlation of yield components and other metric traits with yield in tall and dwarf indica rice. Madras agric. J., 60: 1162-1163.

Chandraratna, M.F. and A.A.Sahai. 1960. A biometrical analysis of matroclinous inheritance of grain weight in rice. Heredity. 14: 365-379.

Chang, T.T. 1971. Studies on the quantitative genetics of rice. I. A diallel cross involving semi-dwarf rice varieties. J. Taiwan Agric. Res., 20: 9-26.

Chang, T.T. 1974. Studies on the genetics of grain type in rice. J. Taiwan Agric. Res., 23: 9-15.

Chang, T.T. 1961. Recent advances in rice breeding in Taiwan. In Crop and seed improvement in Taiwan, Republic of China. Chin. Am. Joint-Comm. Rur. Reconstr. Plant Ind. Ser., 22: 53-58.

Chang, T.T. and E.A.Jardiene. 1965. The morphology and varietal characteristics of the rice plant. Internatl. Rice Res. Inst. Los Banos, Philippines. Tech. Bull., 4: pp.40.

Chang, T.T., C.C.Li and O.Tagumpay. 1973. Genotypic correlation, heterosis, inbreeding depression and transgressive segregation of agronomic traits in a diallel cross of rice (Oryza sativa L.). Bot. Bull. Acad. Sinica. 14: 85-89.

Chang, T.T. and K.B.Parker. 1976. Characteristics of rice cultivars. Riso. 25: 195-201.

Chang, T.T. and O.Tagumpay. 1970. Genotypic association between grain yield and six agronomic traits in a cross between rice varieties of contrasting plant type. Euphytica. 19: 356-63.

Chaudhury, D., S.N.Ratho., R.N.Misra and N.J.Balakrishna Rao. 1976. Variability and correlation studies in the F_2 generation of two inter-varietal crosses in rice. Riso. 25: 103-111.

Chaudhury, L., D.P.Srivastava, A.K.Ghosh and R.Seetharamen. 1973. Genetic variability and correlation for yield components in rice. Indian J. agric. Sci., 43: 181-184.

Comstock, R.E. and R.H.Moll. 1963. Genotype - environment interactions. Symp. on Statistical Genetics and Plant Breeding. NAS.-NAS. Pub. 982. pp. 164-196.

Comstock, R.E. and H.F.Robinson. 1952. Estimation of average dominance of genes. In 'Heterosis'. Ed. J.W.Gowen. Iowa State College Press, Ames.

Crumpacker, D.W. and R.W.Allard. 1962. A diallel analysis of heading date in wheat. Hilgardia. 32: 275-318.

Daljit Singh. 1973. Diallel analysis over different environments. Indian J. Genet., 33: 127-136.

*Daniel, L. 1973. Methods of diallel analysis of quantitative characters and properties of plants. Acta. Univ. Agric. Fac. Agron., Brno, 21: 413-426. Genetics Abstr., 7: 76. 2564.

De Datta, S.K. and D.M.Zarate. 1970. Environmental conditions affecting the growth characteristics, nitrogen response and grain yield of tropical rice. Biometeorol., 4:75-89.

Dickinson, A.G. and J.L.Jinks. 1956. A generalised analysis of diallel cross. Genetics. 41: 65-78.

*Dzyuba, V.A. 1975. A study of heterosis in rice hybrids. Byul. nauch-tekhn. inform. VNII. risa. 1975. 15: 3-7. Referativnyi Zhurnal. 5: 138. Pl. Breed. Abstr., 47: 11529. 1977.

*Dayuba, V.A. and V.N.Shilovskii. 1976. Inheritance of several characters in rice. Byul. nauch-tekhn. inform. VNII. risa. 1975. 18: 3-8. Referativnyi Zhurnal. 5:108. Pl. Breed. Abstr., 48: 5511 (1978).

Dunus, N., I.N.Atkins and J.W.Stansel. 1976. Inter-relationship among quantitative characters in rice. Indian J. agric. Sci., 44: 673-75.

Foster, K.W. 1976. Inheritance of plant height in rice (Oryza sativa L.) and its relationships with agronomic characters. Diss. abstr. Internatl. B. The Sciences and Engineering. 1977. 37: 4514-B.

Foster, K.W. and J.N.Rutger. 1975. Evidence of non-allelic short stature genes in rice (Oryza sativa L.). Agronomy Abstr., 51.

Foster, K.W. and J.N.Rutger. 1976. Additional semi-dwarfing genes in rice (Oryza sativa L.). Pl. Breed. Abstr., 49: 4730. 1979.

Foster, K.W. and J.N.Rutger. 1978. Inheritance of semi-dwarfism in rice (Oryza sativa L.). Genetics. 89: 559-574.

*Fuchs, A. 1975. Biometrical studies on normal and semi-dwarf varieties of rice (O. sativa L.). Correlations between yield determining characters. Beitrage Zur. Tropischen Landwirtschaft und Veterinarmedicin: 11: 537-546. Pl. Breed. Abstr., 45: 2071. 1975.

Ganeshan, P. and W.J.Whittington. 1975. Inheritance of dwarfism and other characters in rice. Euphytica. 24: 775-784.

Ghorai, D.P., N.K.Sinha and R.N.De. 1975. Quantitative studies on genetic variability and seasonal influence in rice. Indian Agric., 19: 325-332.

Ghose, R.L.M., M.B.Ghatge and V.Subrahmanyan. 1956. Rice in India. I.C.A.R Pub. New Delhi. pp.100.

Gilbert, N.E. 1958. Diallel cross in plant breeding. Heredity. 12: 477-492.

Govindaswamy, S., A.K.Ghosh., M.J.Mohamm and A.B.Desh. 1975. Genetic variability and correlation studies in protein content and some quantitative characters of rice (Oryza sativa L.). Oryza. 10: 1-8.

Griffing, B. 1956a. Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci., 9: 463-493.

Griffing, B. 1956b. A generalised treatment of the diallel cross in quantitative inheritance. Heredity, 10:31-50.

Gupta, V.A. and S.S.Singh. 1977. Biochemical basis of hybrid vigour. The genetics of grain weight of rice (Oryza sativa L.). Theor. Appl. Genet., 49: 259-264.

Hargrove, T.R. 1978. The diffusion of genetic materials and the objectives for their use among rice breeding programmes in India. Field Crops Res., 1: 197-213.

Hayman, B.I. 1954a. The theory and analysis of diallel crosses. Genetics. 39: 789-809.

Hayman, B.I. 1954b. The analysis of variance of diallel tables. Biometrics. 10: 235-244.

Hayman, B.I. 1957. Interaction, heterosis and diallel cross Genetics. 42: 336-355.

Hayman, B.I. 1958. The theory and analysis of diallel crosses. II. Genetics. 43: 63-85.

Hayman, B.I. 1960a. The theory and analysis of diallel crosses. III. Genetics. 45: 155-172.

Hayman, B.I. 1960b. Heterosis and quantitative inheritance. Heredity. 15: 323-327.

Henderson, C.R. 1952. Specific and general combining ability. In 'Heterosis'. Ed. J.W.Gowen. Iowa State College Press, Ames.

Hu, C.H. 1973. Evaluation of breeding semi-dwarf rice by induced mutation and hybridization. Euphytica. 22: 562-574.

Huang, C.H., C.L.Chang and L.T.Chang. 1972. Penlai varieties and Taichung Native 1. Rice Breeding. Internatl. Rice Res. Inst. Los Banos, Philippines. pp. 31-46.

Hutchinson, J.B. and K.Ramiah. 1954. Description of crop plant characters and their ranges of variation. II. Variability in rice. Indian J. agric. Sci., 8: 592-616.

Ishkumar, S.S.Saini and K.N.Gagnoja. 1975. Combining ability analysis for yield and yield components in rice (Oryza sativa L.). Crop Improv., 2: 55-59.

Ito, K. 1975. Significance of grain/straw ratio in rice breeding. JARQ. 9: 181-190.

Jennings, P.R. 1967. Rice heterosis at different growth stages in a tropical environment. Int. Rice Comm. Newsl., 16: 24-26.

Jinks, J.L. 1954. The analysis of continuous variations in diallel crosses of Nicotiana rustica varieties. Genetics. 39: 767-788.

Jinks, J.L. 1955. A survey of the genetical basis of heterosis in a variety of diallel crosses. Heredity. 9: 223-238.

Jinks, J.L. 1956. The F_2 and backcross generations from a set of diallel crosses. Heredity. 10: 1-30.

Jinks, J.L. and B.I.Hayman. 1953. The analysis of diallel crosses. Maize Genetic Coop. Newsletter. 27: 48-54.

Johnson, L.P.V. and D.Askel. 1959. Inheritance of yielding capacity in a fifteen parent diallel cross of barley. Can. J. Genet. Cytol., 1: 209-255.

Johnson, H.W., H.F.Robinson and R.E.Comstock. 1955. Genotypic and phenotypic correlations in soybeans and their implications in selection. Agron. J., 47:477-483.

Kadam, D.S. 1937. Cohen for dwarfing in rice. Nature. 139: 1070.

Kambal, A.E.K. and O.J.Webster. 1965. Estimates of general and specific combining ability in grain sorghum Sorghum vulgare Pers. Crop Sci., 5: 521-523.

Karunakaran, V. 1968. Expression of heterosis in some inter-varietal hybrids of Oryza sativa L. Agric. Res. J. Kerala. 6: 9-14.

*Katayama, T.C. 1975. Diallel cross experiment among Sikkimese varieties, indica and japonica testers of rice, Oryza sativa L. III. Morphological characters. Memoirs of the Faculty of Agriculture, Kagoshima Univ. Kagoshima Daigaku Nogakubu Ihyo. 11: 1-55.
21. Breed. Abstr., 46: 1445. 1976.

*Katayama, T.C. 1976. Diallel cross experiment among Sikkimese varieties, indica and japonica testers of rice, Oryza sativa L. IV. Unhusked grains. Memoirs of the Faculty of Agriculture, Kagoshima Daigoku Nogakubu Ihyo. 12: 1-39. Pl. Breed. Abstr., 47: 553. 1977.

Paul, N.L.R. 1972. Performance, inter-relationships and heritability estimates of certain morphological traits of Oryza sativa L. J. Indian Bot. Soc., 51: 286-290.

Kempthorne, O. 1957. An Introduction to Genetic Statistics. John Wiley and Sons, Inc., New Delhi.

Khaleque, M.A., O.I.Joarder and A.R.Kunus. 1977. Correlation studies and the application of discriminant function selection in rice breeding. Genetica Agraria. 31: 335-345.

Khaleque, M.A., O.I.Joarder, A.R.Kunus and A.K.M.A.Islam. 1978. Nature of gene interaction in the inheritance of yield and yield components in some rice crosses. Oryza 15: 157-172.

Khan, M.R. and M.A.Chen. 1960. Diallel analysis of plant height, tiller number and panicle length in rice. IRRI. 9:4.

*Kim, K.H. and H.H.Hew. 1977. Genetic segregation of plant height in intervarietal rice crosses. V. Crosses between semi-dwarf varieties. Korean J. Breed. 9: 127-134. Pl. Breed. Abstr., 49: 202693. 1979.

Kumaran, S. 1974. Investigations on intra-racial (indica x indica) hybrid sterility in rice (Oryza sativa L.). Ph.D. Thesis. Tamil Nadu Agrl. Univ., Coimbatore.

Leffel, R.C. and D.Hanson. 1961. Early generation testing of diallel crosses of soybean. Crop Sci., 1: 169-174.

*Li, C.C. 1975. Diallel analysis of yield and its component traits in rice (Oryza sativa L.). J. Agric. Assoc. China. 92: 41-56. Pl. Breed. Abstr., 47: 376. 1977.

Liang, G.H.L., W.G.Hayes, J.N.Chung and V.G.Koh. 1969. The analysis of heritable variation for 5 agronomic traits in 6 variety diallel of grain sorghum. Canad. J. Genet. Cytol., 10: 460-65.

*Lin, C.T. and C.S.Kuang. 1975. Cytoplasmic male sterility in rice and the genetics of related plant characters. J. Agric. Assoc. China. 89: 9-27. Pl. Breed. Abstr., 45: 1266. 1975.

Liu, T.M. 1977. Studies on the inheritence of quantitative characters in F_2 progeny of crosses between tall and dwarf indica rice. Agricultural Quarterly 13: 149-160.

Loresto, G.C. and T.T.Chang. 1978. Half diallel and F_2 analysis of culm length in dwarf, semi-dwarf and tall strains of rice (Oryza sativa L.). Bot. Bull. Acad. Sinica. 19: 97-106.

Lu Yung-Kan. 1979. The origin of semi-dwarf genes. IRRI. 4:1.

*Lyakhovkin, A.S. 1977. Initial material for breeding high yielding rice cultivars with improved technological qualities. Trudy po Prikladnoi Botanike, Genetike i Selektsii. 59: 66-68. Field Crop Abstr. 32: 3791.

Majumder, M.K., A.K.Roy and S.K.Banerjee. 1971. Studies on genetic variability and correlation in some rice varieties. Indian agric., 15: 191-198.

Mallick, R.K., U.C.Majra and P.Kalyagi. 1978. Heterosis in indica rice. Indian J. agric. Sci., 48: 384-387.

Maneephong, C. 1975. Genetic studies of plant type in rice. Diss. Abstr. Internatl. B. The Sciences and Engineering. 1975. 35: 6370.

Manivannan, K. 1979. Studies on the relationship of grain yield with grain characters and causal schemes on components of yield in genotypes of rice (Oryza sativa L.). M.Sc.(Ag.) Diss. Tamil Nadu Agri. Univ., Coimbatore.

Mather, K. and J.L.Jinks. 1971. Biometrical Genetics. Chapman and Hall Ltd., London. 382 p.

Hatzinger, D.F. and O.Kempthorne. 1956. The modified diallel table with partial inbreeding and interaction with environment. Genetics. 41: 822-833.

Hatzinger, D.F., G.F.Sprague and C.C.Cockerham. 1959. Diallel crosses of maize in experiments repeated over locations and years. Agron. J., 51: 346-350.

Maurya, D.M. 1976. Heritability and genetic advance in rice. Oryza. 13: 97-100.

Maurya, D.M. and D.P.Singh. 1977. Combining ability in rice for yield and fitness. Indian J. agric. Sci., 47:65-70.

Mehan, D.K. and S.S.Saini. 1979. Importance of flag leaf area and grain-straw ratio in rice improvement. IRRN. 4: 6.

Mishra, P.N., J.S.Nanda and P.C.Chaudhary. 1975. Correlation, path coefficient and selection indices in dwarf rice. Indian J. agric. Sci., 45: 306-311.

Mohanty, N.K. and [illegible].C.Mahapatra. 1973. Diallel analysis of yield and yield components in rice. Indian J. Genet., 33: 264-270.

*Morales, A., V.Guerra, G.Perea, P.Fuentes, R.Alfonso and R.Milian. 1974. An investigation of some yield components and their correlations in three varieties of rice, Oryza sativa L., Revista Agrotecnia de Cuba. 6: 93-94. Field Crop Abstr., 31: 6006. 1978.

Morishima, H., H.I.Oka and T.T.Chang. 1967. Analysis of genetic variations in plant type of rice. 2. Seasonal change in genetic plant type. Jap. J. Breed., 17:251-61.

Murty, K.S., S.K.Nayak and G.Sahu. 1975. Effect of low light stress on rice crop. Symp. 'Crop plant response to environmental stress'. Vivekananda Lab. for Hill Agric. Almora. 1975. pp. 76-84.

Murty, P.S.N. and S.Govindaswami. 1967. Inheritance of grain size and its correlation with the hulling and cooking qualities. Oryza. 4: 12-21.

Murty, P.S.S. and M.S.Murty. 1970. Seasonal influence on production efficiency and nitrogen response of high yielding early rice cultures. Oryza. 15: 47-51.

Nakatat, S. 1972. Heritability estimates concerning some physical characteristics of the rice grain. M.Sc.Thesis. Kasetsomt Univ., Bangkok.

*Nakayama, K. and K.Saito. 1978. Variability of rice characteristics in particular within plant variability. II. Bulletin of the Faculty of Agriculture., Hirosaki Univ. 29: 50-63. Pl. Breed. Abstr., 49: 7064. 1979.

Namboodiri, K.M.N. 1963. Hybrid vigour in rice. Rice News Letter. 11: 92-96.

Nanchariah, D., J.S.Kanda and K.C.Chaudhary. 1974. Genetics of yield and yield components in dwarf rice. Indian J. agric. Sci. 44: 437-443.

Panse, V.G. and P.V.Sukhatme. 1961. Statistical methods for Agricultural Research Workers. I.C.A.R. New Delhi.

Paramasivam, K.S. 1977. Correlation studies in tall and dwarf Indica rice. Madras agric. J., 64: 836-38.

Patel, J.P. 1967. Relationships of the plant characters attributing to the yield of rice. Indian J. Agron., 12: 407-10.

*Perez Ponce, J. and R.Martin Jimenez. 1974. Estimation of heritability coefficients in rice (O. sativa L.). Centro Agricola. 1: 25-29. Pl. Breed. Abstr., 46:4947, 1976.

Poonai, P. 1966. Genetic behaviour of spikelet length, spikelet breadth and plant height in cultivated rice in the F_2 population. Diss. Abstr. 27: 1350B.

Purohit, A.G. 1972. Heterosis in rice. Madras agric. J., 59: 355-358.

Rajagopalan, P., J.Chandrasekhan and P.Ponnuswamy. 1973. Studies on crosses between dwarf and tall Indica rice varieties. Madras agric. J., 60: 104-110.

*Ram, C., Ajeet Singh, L.S.Jatasra and L.V.S.Panwar. 1978. Stability analysis for grain yield in rice. Cereal Research Communication. 6: 279-284. Pl. Breed. Abstr., 50: 1967.

Ram, H. 1973. Utility of induced mutations in rice breeding. Indian J. agric. Sci., 43: 1087-1091.

Ramiah, K. 1953. Rice Breeding and Genetics. Scientific Monograph No.19. I.C.A.R., New Delhi.

Ramiah, K. and N.Parthasarathy. 1933. Inheritance of grain length in rice. Indian J. agric. Sci., 3: 905-917.

Ranganathan, T.B. 1972. Genetic investigations on duration to flowering and yield in semi-dwarf varieties of rice (Oryza sativa L.) M.Sc.(Ag.) Diss. Tamil Nadu Agri. Univ., Coimbatore.

Rao, A.V., C.Sai Krishna and A.S.N.Prasad. 1980. Combining ability analysis in rice. Indian J. Agric. Sci., 50: 193-197.

Rao, M.J.D., D.Choudhary, S.N. Ratho and R.K.Mishra. 1973. Variability and correlation studies in upland rice. Oryza. 10: 19-21.

Reddy, T.S. and J.V.Goud. 1972. Variability in selection of two rice crosses. Andhra agric. J., 17: 131-134.

Roe, J.R. 1974. Inheritance of culm length in a cross of mutant rice variety Milyang 10. RARDA J., 6: 33-35.

Rojas, B.A. and G.F. Sprague. 1952. A comparison of variance components in corn yield trials. III. General and specific combining ability and their interactions with locations and years. Agron. J., 44: 462-466.

Sahu, G., K.S.Murty and B.C.Vinay Rai. 1980. Effect of season, nitrogen rate and planting density on harvest index in rice. Oryza 17: 28-33.

Saini, S.S. and H.R.Gagneja. 1975. Interrelationship between yield and some agronomic characters in short statured rice cultures. Indian J. Genet., 35: 441-445.

Saini, S.S. and Ishkumar. 1973. Hybrid vigour for yield and yield components in rice. Indian J. Genet., 33: 197-200.

Satpathy, P. and A.V.Nande. 1976. Interrelationship between yield and some associated characters in upland rice grown under rainfed conditions. Oryza. 15: 12-19.

Seetharaman, K. and K.Shobha Rani. 1979. High yielding varieties in India, their impact and our changing concepts. Indian J. agric. Sci., 49: 141-150.

Seetharaman, K. and K.Shobha Rani. 1980. Note on some new rice varieties released in India. Indian J. agric. Sci., 50: 178-181.

Seetharaman, R. and L.P.Srivastava. 1969. Inheritance of semi-dwarf stature and cigar shaped panicle in rice. Indian J. Genet., 29: 220-226.

Seshu, D.V., D.Pracheda Rao, T.E.Srinivasan and S.V.S.Shastry. 1974. New source of dwarfism in the Assam rice collections. Indian J. Genet., 34: 390-394.

Shanlan, M.I. and A.E. Aly. 1977a. Studies on types of gene effects in some crosses of rice (Oryza sativa L.). Libyan J. Agric., 6: 229-233.

Shanlan, M.I. and A.E.Aly. 1977b. Studies on type of gene action in some crosses in rice (Oryza sativa L.) in Egypt. Libyan J. Agric., 6: 235-243.

Shanlan, M.I., A.M. Gad, A.E.Aly, M.A. El-Fawal and A.A.Alshishan. 1975. Breeding studies on some crosses of rice (Oryza sativa L.). XI. Inheritance of yield and its components. Egyptian J. Genet and Cytol., 4: 474.

Shastry, S.V.S. 1972. Toward rice revolution. Indian Frs., 22: 95-112.

Singh, D.P. and J.S.Nanda. 1975. Correlation and path analysis of yield and yield components and incidence of bacterial leaf blight in rice. Int. Rice Comm. Newsl., 24: 23-27.

Singh, D.P. and J.S.Nanda. 1976a. Combining ability and heritability in rice. Indian J. Genet., 36: 10-15.

Singh, D.P. and J.S.Nanda. 1976b. Inheritance of yield and yield contributing characters in rice. Indian J. agric. Sci., 46: 323-326.

Singh, I.D. and H.C.Stapkopf. 1971. Harvest index in cereals. Agron. J., 63: 224-26.

Singh, N.B., H.G.Singh and P.Singh. 1977. Heterosis and combining ability for quality components in rice. Indian J. Genet., 37: 347-352.

Singh, R.K. and B.D.Chaudhary. 1979. Biometrical Methods in Quantitative Genetic Analysis (revised) Kalyani Publishers, New Delhi.

Singh, R.P. and P.P.Singh. 1979. Heterosis in rice. Oryza. 16: 119-22.

Singh, R.P., R.R.Singh, S.P.Singh and R.V.Singh. 1979a. Combining ability for yield components in rice. Oryza. 16: 115-18.

Singh, R.P., R.R.Singh, S.P.Singh and R.V.Singh. 1980. Estimation of genetic component on variation in rice. Oryza. 17: 24-27.

Singh, R.S. 1973. Diallel and path coefficient analysis for certain quantitative characters in Oryza sativa L. Ph.D. Thesis. Banaras Hindu University.

Singh, R.S. 1977. Combining ability for grain yield and panicle characters in rice. Indian J. Genet., 37: 584-587.

Singh, R.S. and A.K.Richharia. 1977. Combining ability for grain dimensions and shape in unhulled rice. Indian J. agric. Sci., 47: 54-57.

Singh, R.S. and A.K.Richharia. 1978. Combining ability for certain quantitative characters in rice. Oryza. 15: 34-38.

Singh, R.S. and A.K.Richharia. 1980. Diallel analysis for grain yield and its components in rice. Indian J. Agric. Sci., 50: 1-5.

Singh, S.P. and K.G.Singh. 1978. Heterosis in rice. Oryza. 15: 173-175.

Singh, V.P., E.A. Siddiq and M.S.Swaminathan. 1979b. Mode of inheritance of dwarf stature and allelic relationships among various spontaneous and induced dwarfs of cultivated rice. (Oryza sativa L.) Theor. Appl. Genet., 55: 169-176.

Singh, V.P., M.S.Swaminathan, B.Mehra and E.A.Siddiq. 1979c. Divergence among dwarfs of cultivated rice. Indian J. Genet., 39: 319-322.

*Singil 'L-in G.A. and V.N.Shilovskii. 1977. Heterosis in rice. Byul NII VNII ris. 22: 3-6 (Ru-en) From Referati nyi Zhurnal. 1978. 6: 65-99. Fl. Agroed. Abstr., 49: 9142. 1979.

Alvasubramanian, S. 1970. Genetic analysis of height and components of yield in rice (Oryza sativa L.) by diallel analysis. M.Sc.(Ag.) Diss. Univ., Madras.

Beachell, H., T.T.Chang and S.H.Jackson. 1979. Genetic analysis of traits related to grain characteristics and quality in two crosses of rice. IRRI. Res. Paper Series. 25.

Sprague, G.F. and W.T.Federer. 1952. A comparison of variance components in corn yield trials. II. Error, year x variety, location x variety and variety components. Agron. J., 44: 535-554.

Sprague, G.F. and L.A.Tatum. 1942. General versus specific combining ability in single crosses in corn. J. Amer. Soc. Agron., 34: 923-932.

Sree Ranganwami, S.A. and M.Muruganan. 1973. Genotypic association and path analysis in diploid and tetraploid in rice. Madras agric. J., 60: 1107-112

Sree Ranganwami, S.N., A.Subramanian and C.B.Ranganathen. 1979. Recent achievements in mutation breeding in rice at Coimbatore. Madras agric. J., 60: 1783-1783.

Stansel, J.W., C.N.Bollich, J.R.Thysell and V.L. Hall. 1965. The influence of light intensity and nitrogen fertility on rice yield and components of yield. Rice J., 68: 34-35.

Sukanya Subramanian and P.Madhava Menon. 1979a. Correlation studies of plant stature, grain shape and yield in the hybrids of rice (Oryza sativa L.). Madras agric. J., 60: 1113-1117.

Sukanya Subramanian and P. Madhava Menon. 1979b. Pattern of variation in yield attributes and yield in the hybrids of rice (Oryza sativa L.). Madras agric. J. 60: 1118-1124.

Sukanya Subramanian and P.Madhava Menon. 1979c. Pattern of variation in grain quality in the hybrids of rice (Oryza sativa L.). Madras agric. J., 60: 1123-1128.

Sutjihuo and K.A.Gomez. 1968. Analysis of experimental data from several locations and seasons. The Philipp. Agric., 52: 161-174.

Swaminathan, M.S. 1972. Genetic reconstruction of crop idiotypes. Adv. Fl. Morph., pp. 205-210.

*Tahodo, K. and K.Saito. 1977. Genetics and character expression of the gene controlling small grain derived from the rice tester line 'Minute'. Bull. Fac. Agric., Hirosaki Univ., 27: 1-29.

Talwar, S.N. and J.V.Goud. 1974. Pattern of association between yield and yield attributes in rice. Indian J. agric. Sci., 44: 712-717.

Tandon, J.P., A.P.Joshi and R.u.L.Jain. 1970. Comparison of graphic and combining ability analysis of diallel crosses in wheat. Indian J. Genet., 30: 91-105.

Tanaka, A. and B.J.Vergara. 1967. Growth habit and ripening of rice plants in relation to the environmental conditions in the far-east. Int. Rice Comm. Newsl., 26: 42.

*Thallon, N. 1966. Genetic behaviour of length and breadth of spikelets in cultivated rice. Diss. Abstr., 26: 4158-59.

Togari, Y. and Y.Koshiyahara. 1958. Studies on the sterility in rice plant induced by super abundant nitrogen supply and insufficient light intensity. Proc. Crop Sci. Soc., Japan. 27: 3-5.

*U-Son-Kho. 1974. Tillering and productivity of samples of different geographical groups of rice. Sy ulletin Vsesoyuznogo Ordena Lenina Institute Rastenievodstva Imeni N.I.Vavilov. 1974. 37: 39-43. VIR Leningrad USSR. Fl. Breed. Abstr., 44: 8673. 1974.

*Vander Stok, J.S. 1968. On the inheritance of grain colour in rice. Zeyenenrin. 12: 65-75. Quoted by Ramiah, K. 1953.

Vasudeva Rao, N.J. and J.V.Goud. 1977. Inheritance of grain yield and its components in sorghum. Indian J. Genet., 37: 31-39.

Verma, A.K., J.L.Chandra and Haque. 1977. Genotypic and phenotypic variability of quantitative characters in rice (Oryza sativa L.). Proc. Bihar Acad. Agric. Sci., Silver Jubilee issue. 25: 8-15.

Vijayan, P.K. 1971. Biometrical studies on components of yield in rice (Oryza sativa L.) varieties, hybrids and their derivatives. Ph.D. Thesis. Tamil Nadu Agrl. Univ., Coimbatore.

Whitehouse, R.N.H., J.B.Thomson and M.A.M. Valle Ribeiro. 1950. Studies on the breeding of self pollinated cereals. 2. The use of a diallel cross analysis in yield prediction. Euphytica. 7: 147-169.

Woo, S.C., W.P. Wu and I.L.Tung. 1974. Two semi-dwarf genes induced from japonica rice, Chianung 242 and Tainan 5. Bot. Bull. Acad. Sinica. 15: 54-56.

Wu, H.P. 1968. Studies on the quantitative inheritance of Oryza sativa L. I. A diallel analysis of heading time and plant height in F_1 progeny. Bot. Bull. Acad. Sinica. 9 1-9.

Yadav, B. and H.G. Singh. 1979. Correlated response and path analysis in semi-dwarf rice varieties. Indian J. agric. Sci., 49: 756-758.

*Yamaguti, K. 1931. Crossing investigations on rice plants. III. Genetics of the colour character of various parts of the plant, the growth habit and the time of heading. Ber. Ohara Inst., 5: 1-56.

Yamamoto, T. and K.Toriyama. 1972. Contribution of traits to yield improvement under different seedling densities in rice selection experiments. Jap. J. Breed., 22: 20-24.

Yates, F. 1947. The analysis of data from all possible reciprocal crosses between a set of parental lines. Heredity. 1: 287-301.

Yoshida, S. and Parao, F.A. 1976. Climatic influence on yield and yield components of low-land rice in the tropics. Climate and rice. IRRI., Philippines, 471-94.

*Yoin, C.P. 1977. Genetic studies on the semi-dwarf rice plant. A biometric-genetic and anatomical exploration of the histological structure of rice culm tissue. J. Agrl. Assoc. China. 100: 60-77. Field Crop Abstr., 32: 4535. 1979.

TAMIL NADU AGRICULTURAL UNIVERSITY LIBRARY 113918 COIMBATORE-3

* Original not seen