

BIOMETRICAL STUDIES IN RICE (*Oryza sativa* L.) - BREEDING
VALUE OF DIFFERENT DWARF SOURCES

By

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THESIS
SUBMITTED IN FULFILMENT OF THE REQUIREMENTS
(PART II - THESIS)
FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY
OF
THE TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE, INDIA

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AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
TAMIL NADU AGRICULTURAL UNIVERSITY
COIMBATORE
1976

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ACKNOWLEDGEMENT

ACKNOWLEDGEMENT

The author is deeply grateful to Dr. D.Jagathesan, Senior Geneticist, Sugarcane Breeding Institute, Coimbatore for his expert guidance, sustained interest, constructive criticism and invaluable help during the investigation and in the preparation of the thesis.

The author also wishes to place on record his respectful appreciation and humble indebtedness to his revered Vice-Chancellor, Dr. G.Rangaswami, whose genius, soaring ideals and dynamism have always been an abundant source of inspiration and whose magnanimity enabled the author to successfully complete this piece of investigation.

The author is grateful to the members of the Doctoral Committee Dr. S.R.Sree Rangaswami, formerly Professor of Biology and Dr. R.Appadurai, Professor of Agricultural Botany, Agricultural College and Research Institute, Coimbatore for their keen interest in the progress of this work.

The author is greatly indebted to Prof. A.Subramanian, Head of the Department of Agricultural Botany for his valuable advice, continued interest and constant encouragement throughout the course of the study and preparation of this thesis and also for kindly providing the necessary physical facilities at the Paddy Breeding Station, Coimbatore for the successful completion of the investigation.

The author wishes to extend his sincere thanks to Dr. V.Sivasubramanian, Associate Professor of Agricultural Botany for his unstinted help and inestimable guidance in the critical interpretation of the results and in the preparation of the thesis.

His thanks are also due to Mr. K.M.Palaniswamy, Associate Professor of Agricultural Statistics for his help in the statistical analysis of the data and to Dr. G.Ramanathan, Associate Professor of Soil Science and Agricultural Chemistry for a careful reading of the manuscript.

The author is deeply conscious of his debt to many staff members of the Rice Unit of the Department of Agricultural Botany for their kind assistance extended at one stage or other during the course of this investigation.

INTRODUCTION

INTRODUCTION

The yield per unit area of rice has increased substantially in India in recent years. This increase in rice production has been possible mainly due to the wide acceptance and large scale cultivation of dwarf, non-lodging, fertiliser responsive, high yielding varieties which have been developed during the past decade. These varieties had a spontaneous and natural rapid spread in the areas once occupied by the traditional tall varieties. In the earlier years research on rice improvement was directed towards evolving tall indica varieties suited for conditions of a more or less low-investment and low-reward rice culture that involved minimal levels of fertiliser use, plant protection, water management and other inputs. During the fifties, there was emphasis on fertiliser-responsiveness and attempts to improve production through indica x japonica breeding programmes produced a few varieties that at best were only marginally better than those that previously existed. Plant type, the key to the problem, had at that time not been recognised (Freeman and Shastri, 1972).

Susceptibility to lodging at high fertility levels was recognised by rice breeders in the early sixties as a major constraint which stood in the way of a break-through in rice yields. The tall indica varieties grown in India as well as in the other tropical countries since time immemorial possessed many desirable attributes but were prone to lodging with an

attendant limitation on yield, as lodging susceptibility is known to be largely a function of height (Anon., 1964). Such plant type defects in these varieties became more serious under conditions of good management (Shastri and Freeman, 1971).

The introduction of the Taiwan dwarf variety Taichung (Native)1 in 1965 revolutionised the concept of rice breeding in India (Chandra Mohan et al., 1973 a) and short stature along with stiffness of straw was considered an essential criterion to eliminate the possible loss due to lodging at higher levels of fertiliser application (Shastri, 1969). This change in the architecture of the plant which is now known as the dwarf plant type or the improved plant type has been described by many workers including Jennings (1964), Beachell and Jennings (1965), Tsumoda (1965), Beachell (1966), Seetharaman (1966), Shastri (1969), Beachell et al. (1972), Chandler (1972), Seetharaman et al. (1972), Osamu Kamijima (1973) and Rajagopalan et al. (1973). In their views, the concept of development of a new plant type should include dwarf stature (below 100 cm tall), sturdy stem, moderate tillering, lodging resistance, erect leaves and nitrogen-responsiveness. New vistas for rice development were thrown open with the recognition of this dwarf plant type and India soon recognised new horizons for increasing rice yield (Anon., 1973 a).

The impact of the improved dwarf plant type on rice yields in South and Southeast Asia according to Chandler (1972) is reflected in the increase of 1 to 2 metric tonnes per hectare by the farmers in tropical Asian countries simply by replacing

the traditional tall varieties with the new short ones. Even within the short period of less than a decade between 1966 and 1974, 16 dwarf rice varieties were released by the Central Variety Release Committee, while 63 others were released by the different States of India (Shastri and Freeman, 1971; Seshu, 1976). The task is not yet completed by any means. But only a beginning has been made. The dwarf varieties released so far possess, no doubt, the dwarf plant type but in most cases do not combine yield attributes with a wide range of other traits like quality including kernel size, kernel texture, milling and cooking quality, range of duration, resistance to pests and diseases, sustenance under stress conditions and other economic characters. There is also scope for further increase in yield.

While the dwarf indica breeding programmes in India today have been relying mainly on the single source of Taiwan dwarf gene found in Dee-gee-wee-gen, Taichung (Native) 1 and other dwarf derivatives like IR 8, it is considered desirable to look for new sources of dwarfism in order to achieve a more effective combination of traits and thereby broaden the genetic base for development of improved varieties. The dangers of genetic uniformity are now well recognised (Wilkes and Wilkes, 1972) and the wide usage of the same dwarf gene may pose serious hazards to crop production in the long run (Verma and Kumar, 1974). The new sources of dwarfism should offer rice breeders the opportunity to diversify the genetic backgrounds in dwarf breeding programmes. Difference in genotype among

dwarf mutants had been reported (Anon., 1972) and evaluation of short cultivars from Assam for grain yield and other traits had been made in India (Sinha *et al.*, 1974). The possibility of using some japonicas also as a source of dwarf gene in breeding programmes had been indicated by Balakrishna Rao and Nagarajan (1974). Utilisation of different sources of dwarf plant type like the indigenous dwarf indicas, dwarf artificial mutants and dwarf hybrid derivatives may be useful. While attempting to combine the dwarf plant type of the exotic and indigenous dwarf sources of rice with the specific desirable attributes of local indigenous tall varieties, there is bound to be disturbance in the genetic architecture of the varieties, which makes the process difficult for the identification of derivatives with high yield potential without a proper assessment of the genetic bases of yield and its components in the particular dwarf background.

In order to make suitable choices of alternate dwarf sources for providing a broad genetic base, an evaluation on the available dwarf genotypes would be a prerequisite in rice breeding programmes. The objectives of this investigation are to assess the breeding value of the various dwarf sources by eliciting information on the following:

1. Genetic background of the dwarf sources.
2. Biometrical traits of these sources in relation to their breeding value.

3. The genetic relationship of various economic traits under different dwarf backgrounds.
4. The ability of the different dwarf sources to bring about useful recombination of economic traits with plant height in the progenies.

The recently perfected procedures and techniques of biometrical analysis of quantitative traits like yield and its component characters developed over the last decade or more have been utilised. For the evaluation of the parents, first generation hybrids and second generation progenies, the genetic parameters like variability, heritability, genetic advance, heterosis, maternal inheritance and magnitude and direction of association of different plant traits were assessed to distinguish the different dwarf sources with respect to their breeding values and to identify desirable alternate sources of dwarfism for use in rice breeding programmes.

MATERIALS AND METHODS

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Materials

Six dwarf indica varieties with different dwarf backgrounds were chosen as parents for crosses with four other tester varieties as given below.

Dwarf indica varieties

Referred to in the text of the thesis as

1. Dee-geo-woo-gen	DGWG
2. ARC 5824	5824
3. Taichung (Native) 1	T(N)1
4. CO 29-M-40	CO 29-M-40
5. TKN 6-10-12	TKN 6-10-12
6. CO 33-9	CO 33-9

Tester varieties

1. CO 29	CO 29
2. TKN 6	TKN 6
3. CO 33	CO 33
4. CO 13	CO 13

For purposes of this study, only two classes were recognised based on the criterion of plant height, one with a height of below 100 cm as dwarf and the other with a height of 100 cm and above as tall. More information about the varieties are given below:

1. DGWG is a dwarf variety from Taiwan. It was obtained

from a cross between two indica varieties

Wu-chien (Hu, 1973). It grows to a height of about 98 cm (PLATE I-1). It is one of the parents in the crosses from which the best yielders like T(N)1 and IR 8 were evolved. To these varieties it has contributed its short stature (Sastry et al., 1967)

2. 5824 is a variety from the hills of Assam and is locally known as Theki. It is a dwarf indica from Assam Rice Collection and is a natural dwarf, indigenous to India. It attains a height of 80 cm (PLATE I-2) and has a tendency to slightly spread during the ripening stage. It is a new source of dwarfism (Seshu et al., 1974).

3. T(N)1 is a high yielding selection made at the Taichung District Agricultural Improvement Station, Taiwan from a cross between DGWG, a dwarf that tillers profusely and Tsai-yuan-chung a tall disease resistant variety, both of them being indica parents (Chang, 1961 and Huang et al., 1972). The mean height of the variety is 87 cm (PLATE I-3).

4. GO 29-M-40 is a pure breeding dwarf mutant from the popular and early tall indica variety GO 29. It was obtained as a mutant by the treatment with nitroso methyl urea. This has a very short stature of about 57 cm height (PLATE I-4) and erect habit and is another new source of dwarfism (Gopinathan Nair, 1971)

5. IKN 6-10-12 is a dwarf mutant obtained by gamma irradiation (10 Kr) of the tall indica variety IKN 6. It has good plant type and grows to a height of 81 cm (PLATE I-5).

6. CO 33-9 is a mutant obtained from the dwarf variety CO 33 (Karuna) by treatment with ethyl methane sulphonate. It has short stature with a height of 76 cm (PLATE I-6) and is similar to that of the parental variety.

7. CO 29 is one of the early tall selections resulted from the crossing of tall indica varieties CO 13 and CO 4, developed at the Paddy Breeding Station, Coimbatore. It is insensitive to photoperiod and has wide adaptability. It grows to a height of 131 cm (PLATE I-7) and is susceptible to lodging (Anon., 1952).

8. TKM 6, locally known as Sanna Swarnavari is a progeny of a cross between GRB 24 and CO 18 and this was selected in 1953 at the Rice Research Station, Tirurkuppam in the State of Tamil Nadu, India (Anon., 1966 b). It is noted for its earliness, non-sensitivity to photoperiod, wide adaptability, quality grain and high yield potential. It grows to a height of 135 cm (PLATE I-8). It has been recognised as a potential tall indica donor parent in the breeding programmes on varietal improvement in rice all over the world (Chandra Mohan and Subramanian, 1971). It is a source of resistance to tungro virus, bacterial blight and stem borers and also possesses the hidden gene for resistance to brown plant hoppers (Anon., 1968; Pathak, 1972; Breth and Hargrove, 1973).

9. CO 33 locally known as Karuna is a progeny of a cross between IR 8 and ADT 27 developed in 1970 at the Paddy Breeding Station, Coimbatore. It is a dwarf high yielding variety possessing lodging resistance and fertilizer responsiveness

(Manamohan Lal and Srinivasan, 1970). It has good plant type and grows to a height of 76 cm.

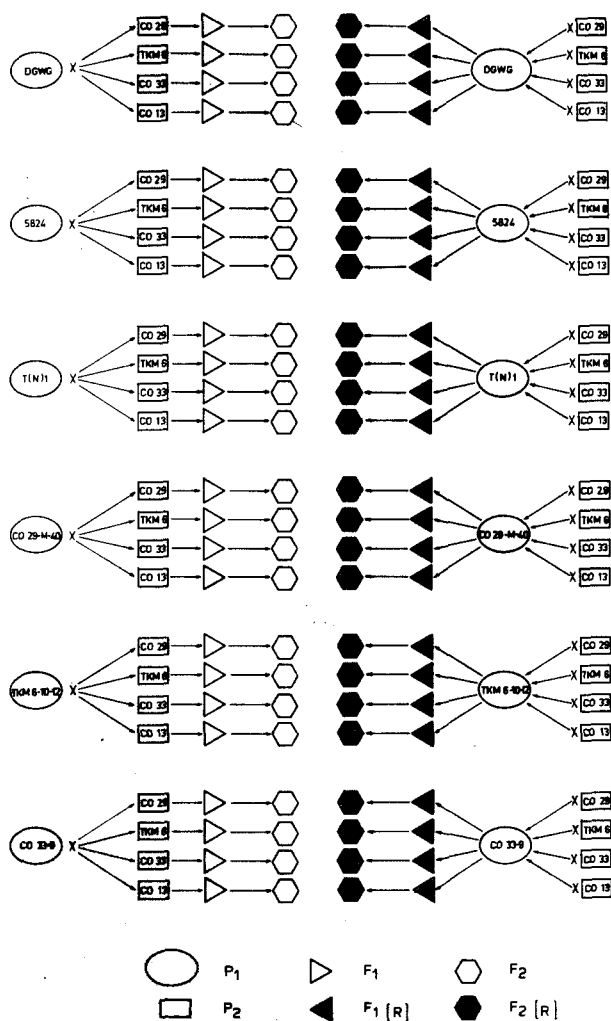
10. CO 13 is a tall indica variety which has been isolated through pure line selection from a early variety Arupathamkodai of Madurai district in Tamil Nadu, India. The mean height of this variety is 151 cm. It has white kernels and possesses photo-insensitivity (Anon., 1941) (PLATE I-9).

Two varieties DGWG and 5824 were obtained from All India Co-ordinated Rice Improvement Project, Hyderabad and Indian Agricultural Research Institute, New Delhi respectively. The other eight varieties were obtained from the Paddy Breeding Station, Coimbatore.

A total number of 48 crosses including reciprocals was made from the six dwarf donor parents DGWG, 5824, T(W)1, CO 29-M-40, TKM 6-10-12 and CO 33-9 on the one hand and the other four tester varieties CO 29, TKM 6, CO 33 and CO 13 on the other. The crosses made and the different generations studied are schematically represented in Fig. 1. A total of about 2400 hybrid seeds at the rate of over 50 seeds for each set of crosses including reciprocals was obtained for growing the F_1 plants as also for the production of seeds for raising F_2 plants. A net total number of 960 F_1 plants including reciprocals and 3840 F_2 plants including progenies of reciprocal hybrids were available for study and for recording of the biometrical data.

The parents and progenies of the different generations were assigned the following symbols and the same will be adopted

FIG.1 SCHEMATIC REPRESENTATION OF GENERATIONS STUDIED



throughout the text of the thesis.

S.No.	Generation	Symbol assigned
1.	Parent 1 refers to one of the dwarf donor parents DGWG, 5824, T(N)1, CO 29-M-40, TKM 6-10-12 or CO 33-9	P_1
2.	Parent 2 refers to one of the tester parents CO 29, TKM 6, CO 33 or CO 13	P_2
3.	First generation $P_1 (\varphi) \times P_2 (\sigma)$	F_1
4.	First generation - reciprocal $P_2 (\varphi) \times P_1 (\sigma)$	$F_{1(R)}$
5.	Second generation from F_1	F_2
6.	Second generation from $F_{1(R)}$	$F_{2(R)}$

Methods

1. Raising of parent varieties

Seed samples obtained from the three sources were raised during Kharif 1973 in small plots of uniform size by planting single seedlings. The plant characters were studied following Chang and Bardenas (1963) and later compared with the standard descriptions. Seed materials for further sowings were collected from selfed panicles of ten plants in each of the varieties.

2. Hybridisation programme and crossing techniques

Four fortnightly sowings of all the varieties were made during Babi 1974 in small seedbeds to synchronise blooming of the varieties to facilitate hybridisation. Twenty two day old seedlings were transplanted in double rows of each variety leaving a spacing of 80 cm between varieties and 20 cm between rows in each variety and 10 cm between the plants within rows. For hybridisation, the 'wet cloth method' for emasculation and pollination (Chaisang et al., 1967) was followed. Anthesis in all the varieties was observed between 9.00 a.m. and 10.45 a.m. and florets remained open for a period of 50 to 60 minutes. In each cross 85 to 100 spikelets from four to five panicles of the female parent were emasculated two hours before anthesis. After emasculation and pollination, the panicles were properly labelled and individually covered with specially made butter paper bags supported by thin bamboo stakes to avoid contamination. Mature seeds were carefully collected from each cross, sun-dried and stored separately in brown paper bags. On an average 45 to 50 hybrid seeds were collected in each cross.

3. Growing of parents and hybrids in F_1 generation

During Kharif 1974 a part of the hybrid seeds (about ten) collected from each cross was sown separately in specially prepared square seed beds. A thin short peg of the size of a match stick was inserted in the bed close to every seed to make sure that the seedlings which come out after germination are

from the hybrid seeds. On the seventh day other seedlings when found were carefully removed. Parents were also raised in small beds. In the field, the hybrids were planted in between respective parents in lines spaced 20 x 10 cm apart. Hybrid plants were identified and mature seeds were collected from two selfed hybrid plants in each cross, sun dried and stored separately in brown paper bags.

4. Lay out

Seeds of P_1 , P_2 , F_1 , $F_{1(R)}$, F_2 and $F_{2(R)}$ were sown in small seed beds. In the case of F_1 special care was taken as described elsewhere for identifying the seedlings in the seed bed. Twenty two day old seedlings were transplanted in the field and grown adopting a design similar to the compact family block model as described by Panse and Sukhatme (1957) with four replications. The P_1 , P_2 , F_1 , $F_{1(R)}$, F_2 and $F_{2(R)}$ of each cross were grown together in one block. The generations were randomised within each block. Single seedlings were planted in single rows measuring 2 metre length spaced 20 x 10 cm apart. The same planting method was maintained in other crosses in the same replication. Border rows of the parent material were planted around, which were discarded for purposes of experiment. For recording biometrical data, 5 single plants were selected at random for the generations P_1 , P_2 , F_1 and $F_{1(R)}$ and all the 20 plants for F_2 and $F_{2(R)}$ in each cross and replication. The F_1 plants selected were identified as true hybrids before recording the data.

5. Character studied

The following nine traits were studied.

- a) Plant height,
- b) Tiller number,
- c) Number of internodes,
- d) Leaf area,
- e) Panicle length,
- f) Number of grains per panicle,
- g) Weight of grains per panicle,
- h) 1000 grain weight and
- i) Grain yield per plant.

These terms will be adopted throughout the text of the thesis.

6. Collection of data

Data on the above traits were recorded for the selected plants in each generation.

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

b) Tiller number: Number of tillers bearing mature panicle was counted in each plant at the time of harvest.

c) Number of internodes: Number of internodes was counted for the top ten tillers and was expressed as number of internodes

per tiller. In case where number of tillers was less than ten the mean number was computed from all the available tillers.

d) Leaf area: The leaf length and the maximum leaf width (taken at the widest point perpendicular to the length measurement) of the flag leaf of ten tillers or the available tillers in the plant were measured nearest to the millimeter after panicle emergence. Leaf area was computed by multiplying length and width with a constant factor 0.75 (Gomes, 1972; Palanisamy and Gomes, 1974).

e) Panicle length: The length of the panicles of the top ten tillers or the available tillers was measured and mean panicle length arrived at. The panicle length was measured from the junction of the peduncle with the main inflorescence axis to the tip of the panicle to the nearest millimeter.

f) Number of grains per panicle: The total number of fully developed grains from each of the ten top panicles or the actual available panicles was counted individually and average calculated.

g) Weight of grains per panicle: The fully developed grains from each of the ten top panicles or the available panicles were weighed to the nearest milligram and average weight of grain per panicle arrived at.

h) 1000 grain weight: Five random samples, each consisting of 100 fully developed grains collected from all the panicles

of the single plant were weighed to the nearest milligram and the mean 100 grain weight was worked out. This was expressed as 1000 grain weight.

1) Grain yield per plant: The fully developed grains collected from all the panicles of the single plant were pooled and weighed to the nearest milligram.

7. Statistical analysis

i. Unit analysis: Mean, variance, standard error and coefficient of variation were computed for P_1 , P_2 , F_1 , $F_{1(R)}$, F_2 and $F_{2(R)}$ of each cross in respect of all the plant traits studied following the procedure outlined by Steel and Torrie (1960). The differences among the means of P_1 , P_2 , F_1 and F_2 , F_1 and $F_{1(R)}$ and F_2 and $F_{2(R)}$ were tested statistically for all traits as outlined by Snedecor and Cochran (1967).

ii. Genetic analysis:

a) Partitioning of variance: Phenotypic variance (V_{ph}), genotypic variance (V_g), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) (broad sense) and genetic advance (GA) were estimated following the method adopted by Johnson et al. (1955) and described by Allard (1966).

The variance of pooled values of the progenies of F_2 generation was considered as total phenotypic variance (V_{ph}). The environmental variance (V_e) was estimated as the mean

variance of the non-segregating generations viz., variance of P_1 , variance of P_2 and variance of F_1 adopting the formula given below:

$$V_E = \frac{V_{P_1} + V_{P_2} + V_{F_1}}{3}$$

where

V_E = Environmental variance

V_{P_1} = Variance of parent 1

V_{P_2} = Variance of parent 2

V_{F_1} = Variance of F_1

The genotypic variance (V_G) was estimated as the difference between the total phenotypic variance (V_{ph}) and environmental variance (V_E) i.e., $V_G = V_{ph} - V_E$.

The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated as under.

$$PCV = \frac{\sqrt{V_{ph}} \times 100}{\text{General mean}}$$

$$GCV = \frac{\sqrt{V_G} \times 100}{\text{General mean}}$$

b) Heritability and genetic advance: These parameters were estimated for each trait and cross combination.

The heritability (h^2) in the broad sense was calculated as $\frac{V_G}{V_{ph}}$ and expressed in terms of percentage.

The expected genetic advance (GA) was calculated as

$$GA = 2.06 \times \frac{V_g}{\sqrt{V_{ph}}}$$
 where 2.06 is a constant (selection differential) at 5 per cent selection intensity.

c) Heterosis and heterobeltiosis: Heterosis and heterobeltiosis were worked out for F_1 and $F_{1(R)}$ hybrids using the criteria in relation to (i) the mid-parental value and (ii) the better parent respectively as followed by Williams and Gilbert (1960) and Fonseca and Patterson (1968). In the case of plant height heterobeltiosis for both tallness and dwarfness were computed.

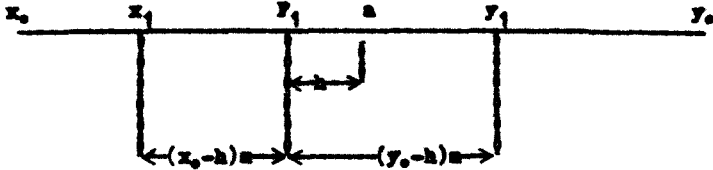
$$d_i = \bar{F}_1 - \frac{(\bar{F}_1 + \bar{F}_2)}{2}$$

$$d_{ii} = \bar{F}_1 - \bar{F}_1 \text{ or } \bar{F}_2 \quad (\text{whichever is better})$$

$$d_{iii} = \bar{F}_1 - \bar{F}_1 \text{ or } \bar{F}_2 \quad (\text{whichever is shorter for plant height only})$$

d) Matroclinous inheritance: The manifestation of matroclinous inheritance of the nine traits chosen for this study was assessed by employing the biometrical analysis as per the model adopted in rice by Chandraratna and Sakai (1960).

Genetic model: The following genetic model has been constructed to fit the results. It assumes that the phenotype of the hybrid is determined primarily by its genotype, but is affected by cytoplasmic factors contributed by the female parent. It is also assumed that the genotype of the female parent influences the nature of these cytoplasmic factors.



Genetic model of inheritance in reciprocal hybrids:
 x_0 and y_0 are the parents, a is the mid-parental value,
 h is the deviation due to dominance and n is a constant
 that provides a measure of the magnitude of the maternal
 effect.

The above figure gives a diagram of the model. On the
 basis of this model, the average phenotypic value of the
 various hybrid populations will be:

$$\begin{aligned}
 x_1 &= a + h + \left| (x_0 - a) - h \right| n \\
 x_2 &= a + \frac{h}{2} + \left| (x_1 - a) - \frac{h}{2} \right| n \\
 &\vdots \\
 x_n &= a + \frac{h}{2^{n-1}} + \left| (x_{n-1} - a) - \frac{h}{2^{n-1}} \right| n
 \end{aligned} \quad (1)$$

and

$$\begin{aligned}
 y_1 &= a + h + \left| (y_0 - a) - h \right| n \\
 y_2 &= a + \frac{h}{2} + \left| (y_1 - a) - \frac{h}{2} \right| n \\
 &\vdots \\
 y_n &= a + \frac{h}{2^{n-1}} + \left| (y_{n-1} - a) - \frac{h}{2^{n-1}} \right| n
 \end{aligned} \quad (2)$$

x_n and y_n can be re-written in the following form:

$$x_n = a(1-n) + \frac{h}{2^{n-1}} (1-n) + nx_{n-1} \quad (3)$$

and

$$y_n = a(1-m) + \frac{h}{2^{n-1}} (1-m) + ny_{n-1} \quad (4)$$

The following two formulae which are derived from (3) and (4) are functions of parental values:

$$x_n = a(1-m^n) + \frac{h(1-m)}{2^{n-1}} \frac{(1-2^{n-1}m^n)}{(1-2m)} + m^n x_0 \quad (5)$$

$$y_n = a(1-m^n) + \frac{h(1-m)}{2^{n-1}} \frac{(1-2^{n-1}m^n)}{(1-2m)} + m^n y_0 \quad (6)$$

Substituting p for $a(1-m)$ and q for $h(1-m)$, the estimates of a , m and h were obtained.

The mean for each character was computed utilising the mean values of P_1 , P_2 , F_1 and $F_{1(R)}$. The expected values as per the genetic model adopted were calculated and compared with the observed values. The deviation of the expected values with the observed values was tested for the agreement using the chi-square statistic and also adequacy of the genetic model. The m values were compared among different crosses and different traits.

c) Scaling test: The scaling test suggested by Mather and Jinks (1971) based on means was carried out to test the adequacy of the data for additive dominance model. The following formula was adopted.

$G = 4P_2 - (2F_1 + F_1 + F_2)$ and variance for G value was calculated with the formula.

$$V_0 = 16V_{F_2} + 4V_{F_1} + V_{F_1} + V_{F_2}$$

r) Persistence of dominance: The persistence of dominance was computed for F_1 , $F_{1(R)}$, F_2 and $F_{2(R)}$ for each cross combination involving dwarf donor parents in respect of each trait separately. It was expressed as percentage over respective mid-parental values.

iii. Association analysis

a. Simple correlation: Simple correlation was worked out to study the extent of relationship between:

- 1) grain yield per plant and other eight traits under study and
- 2) plant height and other eight traits.

Correlation coefficients were calculated as described by Panse and Sukhatme (1957).

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 \times \sum (y - \bar{y})^2}}$$

where

r = Correlation coefficient

$\sum$ = Summation

y = Yield of grain per plant or plant height

x = Value for the corresponding trait to be correlated to y .

b. Phenotypic and genotypic correlation: For estimation of phenotypic and genotypic correlation, the method adopted by Al-Jibouri et al. (1958) was utilized and the following expectations were utilized.

ANOVA

Source of variation	df	MS	Expectations
Between crosses	3	M_1	$V_e + 80 V_g$
Within crosses	316	M_2	V_e
Total	319		

The covariance estimates were also done similarly using sum of products.

$$V_e = \text{Environmental variance} = M_2$$

$$V_g = \text{Genotypic variance} = \frac{M_1 - M_2}{80}$$

$$V_p = V_e + V_g$$

The genotypic correlation between grain yield per plant and other plant traits as well as plant height and other traits were computed using the formula.

$$\text{Genotypic 'r'} = \frac{\text{COV. } G.X \text{ } G.Y}{\sqrt{V_{G.X} V_{G.Y}}}$$

where

$Cov_{g.x.y}$ = Genotypic covariance between y
(yield per plant/plant height) and
x (other traits)

$V_{g.x}$ = Genotypic variance in x (other traits)

$V_{g.y}$ = Genotypic variance in y (yield per plant/
plant height)

Similarly the phenotypic and environmental correlation coefficients were also computed.

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

I. Evaluation of Parents

1. Mean performance: The mean performance of parents recorded with respect to the nine traits studied is represented in Table 1.

With regard to plant height among the dwarf donor parents CO 29-M-40 was the shortest while DOWG recorded the maximum height of 98.59 cm. Among the tester parents CO 13 was the tallest. T(N)1 and CO 29 recorded the highest tiller number among the dwarf donor and tester parents respectively, while DOWG had the least number. The dwarf parents registered a lower mean number of internodes than the tall parents. The same trend was seen in the case of panicle length also. There was no difference in the leaf area among the dwarf donor parents except CO 29-M-40 which had the smallest leaf area. There was a marked difference between the parental varieties irrespective of their height in the expression of the character, number of grains per panicle. The dwarf donor parent CO 33-9 had the highest number of grains per panicle (104.56). DOWG among the dwarf parents and CO 13 among the tester parents recorded significantly higher weight of grains per panicle than the other parents. There was significant difference in 1000 grain weight among different parents irrespective of their height. The dwarf donor parent 3824 possessed the heaviest grain, while CO 33 had the lightest. With regard to grain yield per plant, T(N)1 among the dwarf donors and CO 29 among the testers recorded the highest yields.

The dwarf donor parent OO 29-M-40 recorded the lowest values in respect of the characters, plant height, leaf area, panicle length, number of grains per panicle, weight of grains per panicle and grain yield per plant.

2. Variability of the parents: The coefficients of variation per cent in the different traits computed for each one of the parents are given in Table 2.

Among the parents, there was no marked difference in the values of coefficients of variation except in the case of OO 29-M-40 which had the lowest expression in respect of the traits, leaf area and 1000 grain weight. Among the characters studied the expression of variation was highest in the traits, grain yield per plant and tiller number, while the least expression was observed in 1000 grain weight and panicle length.

II. Evaluation of F_1 and $F_{1(R)}$ Hybrids

1. Mean performance: The mean values observed in respect of the different characters in the F_1 and $F_{1(R)}$ hybrids along with the parental values in respect of each cross are presented in Tables 3 a to 3 i.

The parents differed significantly for plant height in all cross combinations. F_1 and $F_{1(R)}$ plants, in general, differed significantly from those of the respective parents. The tendency of the F_1 plants was to lean towards the height of the dwarf parents with a few exceptions. $F_{1(R)}$ hybrids recorded higher

values for plant height as compared to F_1 hybrids. The highest reciprocal difference was observed in the cross CO 33-9 x CO 13 (Table 3 a). With regard to tiller number a relatively high expression was observed in the F_1 and $F_{1(R)}$ of the crosses involving dwarf donor parents CO 29-M-40, TKN 6-10-12 and CO 33-9 on the one hand and all tester parents on the other, except the cross TKN 6-10-12 x TKN 6 (Table 3 b). The F_1 and $F_{1(R)}$ of the crosses involving CO 33 as tester parent exhibited the least number of internodes (Table 3 c). In respect of leaf area the F_1 and $F_{1(R)}$ values were either intermediate or tended to approach towards the lower parental value (Table 3 d). In the crosses involving CO 29-M-40 and TKN 6-10-12 the panicle lengths of F_1 and $F_{1(R)}$ were higher than the dwarf donor parents and lower than the respective testers (Table 3 e). In the case of the number of grains per panicle, the crosses involving CO 29-M-40, F_1 and $F_{1(R)}$ performed better than the dwarf donor parents (Table 3 f).

The parents differed significantly with regard to the weight of grains per panicle in crosses with CO 29-M-40 as dwarf donor or CO 33 as tester parent in most cases. The crosses involving DOWG gave the highest value, while TKN 6-10-12 gave the lowest among the donor parents and those of CO 33 recorded the least among the tester parents (Table 3 g). In respect of the character, 1000 grain weight, the tester parents mostly differed from dwarf donor parents. The highest degree of expression for 1000 grain weight was contributed by DOWG in the F_1 and $F_{1(R)}$ generations and the least by dwarf donor parent CO 33-9 and tester parent CO 33 (Table 3 h). The grain yield

per plant of the dwarf donor parents in the crosses involving CO 29-M-40 and TKM 6-10-12 was lesser than the corresponding tester parents. The performance of F_1 and $F_{1(R)}$ was intermediate between parents in the crosses involving T(N)1 while in others, this trend was not observed to be constant. The maximum expression of grain yield per plant was observed in $F_{1(R)}$ of the cross TKM 6-10-12 x CO 29 while the minimum expression was noticed in general in the crosses involving the tester parent CO 33 (Table 3 i).

2. Variability of F_1 and $F_{1(R)}$ hybrids: The values on the coefficient of variation per cent in F_1 and $F_{1(R)}$ in respect of the different traits studied are given in Tables 4 a to 4 i.

In respect of plant height the hybrids of dwarf donors 5824 and TKM 6-10-12 exceeded the parental variation (Table 4 a). Lesser variability was observed in respect of the characters number of internodes (Table 4 c) and leaf area (Table 4 d) in the F_1 and $F_{1(R)}$ involving T(N)1 and CO 33-9 than in other cases. With respect to panicle length high magnitude of variation was observed in F_1 and $F_{1(R)}$ of the crosses involving TKM 6-10-12 and CO 29-M-4 even to the extent of exceeding the parental variation (Table 4 e). In the case of weight of grains per panicle, the variation of F_1 and $F_{1(R)}$ of the crosses involving TKM 6-10-12 markedly exceeded the parental variation (Table 4 g). With regard to 1000 grain weight the variability tended to increase in $F_{1(R)}$ generation as compared to the corresponding F_1 , with some exceptions involving the crosses with 5824 (Table 4 h). The magnitude of variation of parents in grain yield per plant was widely different, the

range being 19.9 per cent (GO 33) to 48.1 per cent (TKN 6-10-12). In crosses with DGV8 and 5824 the F_1 and $F_{1(R)}$ exhibited increased variability as compared to the corresponding parents. Among the characters studied highest variability (21.8 per cent to 53.1 per cent) in F_1 and $F_{1(R)}$ generations was found in the trait grain yield per plant followed by tiller number (17.8 per cent to 47.6 per cent) (Tables 4 i and 4 b) and the least variability (2.8 per cent to 14.5 per cent) was observed in 1000 grain weight and panicle length (3.4 per cent to 9.4 per cent (Tables 4 h and 4 e).

3. Heterosis and Heterobeltiosis: The heterosis and heterobeltiosis in respect of the nine traits worked out as deviations from the mid-parent and better parent respectively for the different cross combinations involved in this study are presented in Tables 5 a to 5 i. In the case of plant height, heterobeltiosis for tallness and dwarfness were computed and they are presented in Table 5 a.

There was reciprocal differences in the hybrids in the expression of heterosis and heterobeltiosis for plant height. Significant and positive heterosis for tallness was observed in F_1 progenies of all the crosses involving GO 29-M-40 and crosses 5824 x TKN 6, T(W)1 x TKN 6 and GO 33-9 x GO 29. Heterobeltiosis for tallness was present in the F_1 of the cross GO 29-M-40 x GO 33 and $F_{1(R)}$ of the cross DGV8 x GO 29. The GO 33 tester parent exhibited high heterobeltiosis for dwarfness in F_1 and $F_{1(R)}$ except in the F_1 of the cross with DGV8 and in both the generation

of CO 29-M-40 (Table 5 a). In respect of tiller number extent of heterosis and heterobeltiosis was greater in F_1 and $F_{1(R)}$ of the crosses involving CO 29-M-40, TKM 6-10-12 and CO 33-9 than with others (Table 5 b). For the trait number of internodes, crosses involving DGWG, 5824 and T(N)1 exhibited in general low magnitude for positive heterosis in F_1 and negative deviation over the mid and better parents in F_1 and $F_{1(R)}$ of the crosses involving the other dwarf donor parents (Table 5 c).

In the case of leaf area, heterobeltiotic influence was negative with varying magnitudes but with a solitary exception of the cross 5824 x TKM 6, where positive though feeble, expression of heterosis and heterobeltiosis was observed (Table 5). With regard to panicle length, highest heterotic influence was observed in both F_1 and $F_{1(R)}$ of the crosses involving CO 29-M-40. Heterobeltiosis was absent in most of the crosses (Table 5 e). In the character number of grains per panicle, positive heterosis of high magnitude was seen in F_1 and $F_{1(R)}$ hybrids of the crosses involving CO 29-M-40. In all crosses where CO 33 formed the tester parent except with CO 29-M-40, the heterosis and heterobeltiosis were negative and high in magnitude (Table 5 f). The highest heterosis in respect of weight of grains per panicle was observed in F_1 and $F_{1(R)}$ of all the crosses involving CO 29-M-40 and in the crosses of 5824 or T(N)1 with TKM 6. In all other instances, the heterosis and heterobeltiosis were negative with varying degrees of magnitude. In this trait also CO 33 tester parent had a striking influence towards the negative direction

of heterosis and heterobeltiosis (Table 5 g).

The highest expression of heterosis in the trait 1000 grain weight was observed in the F_1 of the crosses involving T(N)1. Heterobeltiosis was absent or negative in most of the other crosses (Table 5 h). In the case of grain yield per plant a relatively high magnitude of heterosis and heterobeltiosis was observed in F_1 and $F_{1(R)}$ hybrids of the crosses 5824 x TKN 6, CO 29-M-40 x TKN 6 and CO 33-9 with CO 29 and CO 13. In this character, heterosis and heterobeltiosis were high and negative in most of the other instances and T(N)1 crosses were worth mentioning in this respect (Table 5 i).

III. Evaluation of Segregating Generations:

1. Mean performance of F_2 and $F_{2(R)}$: The performance of F_2 and $F_{2(R)}$ progenies in respect of the nine characters studied is indicated in Tables 6 a to 6 i.

The maximum expression of plant height was observed in $F_{2(R)}$ of the cross CO 33-9 x CO 13. The highest expression of dwarfness was in evidence in both F_2 and $F_{2(R)}$ of the cross 5824 x CO 33. The reciprocal differences were significantly higher in all crosses involving CO 29-M-40, TKN 6-10-12 and CO 33-9 as dwarf donor parents and CO 29, TKN 6 and CO 33 as tester parents (Table 6 a). In general better expression for tiller number was observed in the crosses involving DSW6 and 5824. The reciprocal differences were absent in most of the

cross combinations particularly in all crosses involving CO 13 as tester parent (Table 6 b).

The range of expression of the character, number of internodes was within narrow limits with the highest value of 6.00 in the cross DGWG x TKM 6 and the lowest expression of 3.78 in the cross 5824 x TKM 6. The reciprocal differences were absent in all the crosses involving CO 29-M-40 (Table 6 c). Comparatively higher degree of expression of leaf area was in evidence in the crosses involving DGWG, while there was considerable reduction in leaf area in crosses involving CO 33-9 or CO 33. Reciprocal differences were absent in most cases especially in all crosses involving T(N)1 as dwarf donor parent (Table 6 d). The mean expression of panicle length was relatively high in the crosses involving T(N)1 and DGWG (Table 6 e).

As compared to other traits, number of grains per panicle varied considerably in F_2 and $F_{2(R)}$ progenies. The highest number (103.10) was found in $F_{2(R)}$ of the cross CO 33-9 x CO 33 and the lowest (57.17) in the F_2 of the cross 5824 x CO 29. In general, 5824 and CO 29-M-40 among the dwarf donor parents and CO 29 among the tester parents tended to reduce the number of grains per panicle in the F_2 means in all crosses. Significant reciprocal differences were evident in all crosses involving T(N)1 and absence of reciprocal effect was indicated in all cross combinations involving 5824 (Table 6 f).

Higher weight of grains per panicle was recorded in the crosses with DOW or CO 13 as one of the parents while the lowest expression of this trait was seen in the F_2 and $F_{2(R)}$ progenies of the cross CO 29-M-40 x CO 33. The reciprocal differences were high in the crosses involving Z(N)1 (Table 6 g). Relatively low 1000 grain weight was observed in the crosses involving CO 33 as tester parent or CO 33-9 as dwarf donor parent. The magnitude of reciprocal difference for this trait was inconsistent among the crosses (Table 6 h). With regard to grain yield per plant, it was generally observed that DOW imparted high grain yield in the progenies. Among the testers, the crosses involving CO 33 exhibited relatively low values. The reciprocal difference in this trait was not significantly felt in the crosses involving 5824, CO 29-M-40 and TIM 6-10-12 as dwarf donor parents with the single exception of TIM 6-10-12 x CO 29 (Table 6 i).

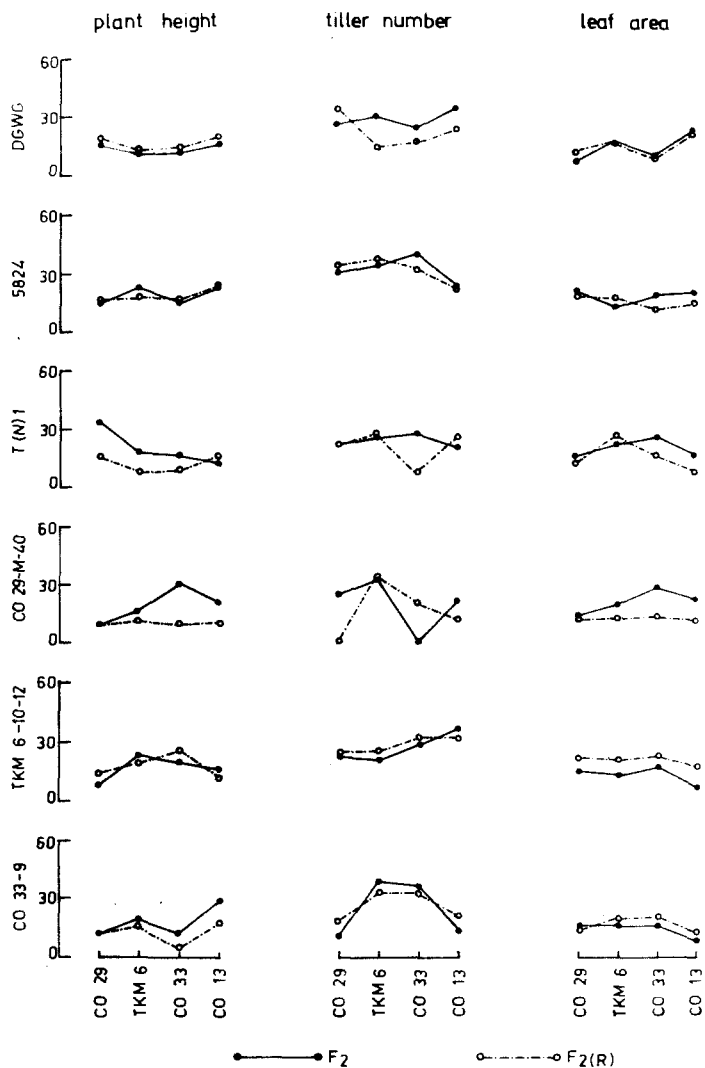
2. Variability of F_2 and $F_{2(R)}$: The variability of the segregating population was estimated as genotypic and phenotypic variances and corresponding coefficients of variation were also computed and presented in Tables 7 a to 7 i.

The difference between the phenotypic and genotypic variances for plant height was considerable in all hybrid combinations. The highest genotypic variance was observed in the F_2 of Z(N)1 x CO 29 (1255.09) and the lowest in the $F_{2(R)}$ of the cross CO 33-9 x CO 33 (13.96). The estimate of genotypic coefficient of variation for plant height indicated that

the variability of the crosses was wider in F_2 generation (8.5 to 34.2) than that of $F_{2(R)}$ (5.2 to 25.9) (Table 7 a and Fig. 2). In the case of tiller number the differences between genotypic and phenotypic variances were very high. The reciprocal difference was not much barring a few cases. The genotypic coefficient of variation was maximum in the crosses involving 5824 as donor parent (Table 7 b and Fig. 2). The variability for the number of internodes was the least among the characters. The differences between genotypic and phenotypic variances were moderate. The estimates of genotypic coefficient of variation were nearly equal in F_2 and $F_{2(R)}$ except in the cross DGWG x CO 29, T(N)1 x CO 29, TKN 6-10-12 x TKN 6 and CO 33-9 x CO 13 (Table 7 c). High magnitudes of differences in leaf area between genotypic and phenotypic variances were noticed in the crosses involving DGWG. The highest genotypic variance was observed in the $F_{2(R)}$ of the cross T(N)1 x TKN 6. The trend of variation in the GCV estimates were mostly uniform among the crosses as well as between generations (Table 7 d and Fig. 2).

The trend of variability in panicle length for genotypic and phenotypic variances in the different crosses were similar and the differences between these estimates were not high. The GCV estimates were found to be higher in F_2 than in $F_{2(R)}$ (Table 7 e). In the case of number of grains per panicle, there were wide differences between the phenotypic and genotypic variances in all the crosses. The genotypic coefficient of variation was found to be higher in F_2 than $F_{2(R)}$

GENOTYPIC COEFFICIENT OF VARIATION IN F_2 AND $F_{2(R)}$ GENERATIONS



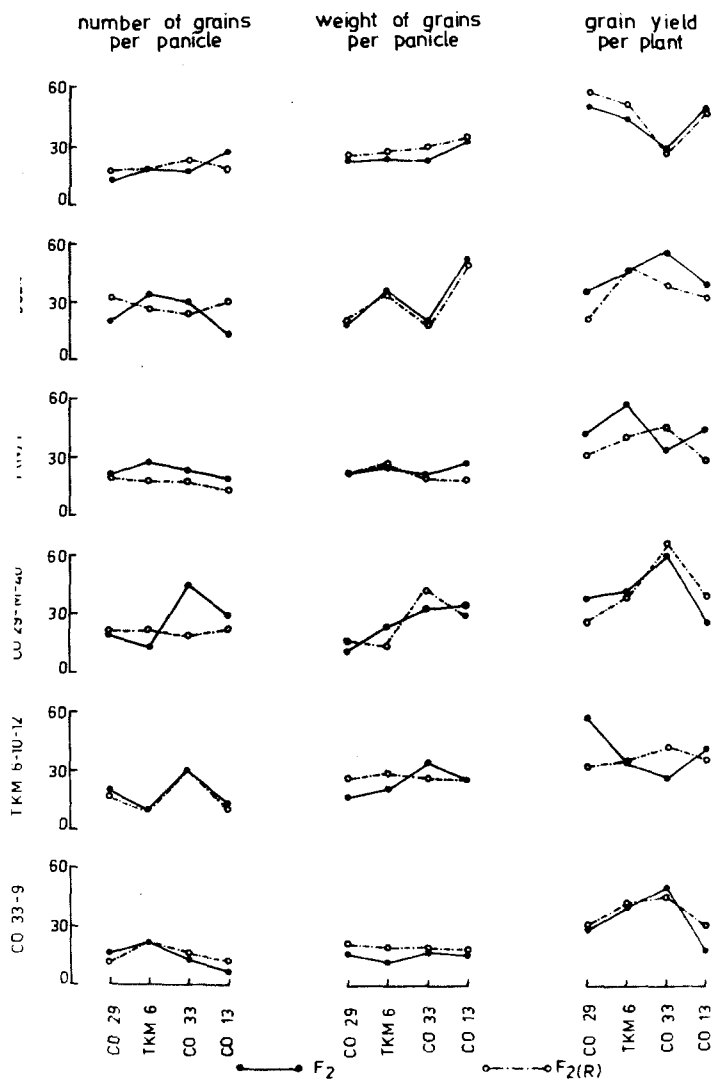
(Table 7 f and Fig. 3). The differences in the phenotypic and genotypic variances in the second generation were also high with respect to weight of grains per panicle. F_2 and $F_{2(R)}$ did not vary much with regard to the genotypic coefficient of variation (Table 7 g and Fig. 3).

In the case of 1000 grain weight, the differences between genotypic and phenotypic variances were relatively low as compared to other traits. High genotypic variance was observed in all crosses involving GO 33 as a tester parent with the exception of the crosses with TKM 6-10-12 and GO 33-9. The highest GCV estimate was observed in the cross TKM 6-10-12 x GO 13 (Table 7 h). Grain yield per plant exhibited wide range of differences between genotypic and phenotypic variances in F_2 and $F_{2(R)}$ of all cross combinations. The magnitudes of differences were also varied. The values of GCV estimates were high as compared to other characters. In general, $F_{2(R)}$ generation had lower GCV estimates in the crosses with 5824, T(N)1 and TKM 6-10-12 than the F_2 generation (Table 7 i and Fig. 3).

IV. Genetic Analysis

1. Scaling test: The mean performance of F_2 and $F_{2(R)}$ generations was subjected to Mather's scaling test to assess the adequacy of the additive model. The results of scaling test are furnished in Tables 8 a to 8 i.

GENOTYPIC COEFFICIENT OF VARIATION IN F_2 AND $F_{2(R)}$ GENERATIONS



In general, the results were not very much consistent among different crosses with regard to the adequacy of the additive model.

As regards plant height the dwarf donors CO 29-M-40, TKM 6-10-12 and CO 33-9 failed to satisfy the adequacy in the test while the other dwarf parents DONG, 5824 and T(N)1 gave a good fit for scaling test in crosses with CO 29 and TKM 6 as tester parents (Table 8 a). In the case of tiller number, crosses involving TKM 6 as tester parent failed to fit in the additive model while all other crosses proved adequate for scaling test (Table 8 b). In the case of number of internodes, inadequacy of the scale was observed in crosses involving DONG, 5824, CO 29-M-40 and CO 33-9 with most other tester parents (Table 8 c). In cases of leaf area and number of grains per panicle, crosses involving CO 29 tester parent exhibited adequacy of the additive model. In the other crosses the results were inconsistent (Tables 8 d and 8 f).

As regards panicle length the additive model was adequate for crosses involving TKM 6 on the one hand and DONG, T(N)1, CO 29-M-40 and TKM 6-10-12 on the other (Table 8 e). Crosses involving TKM 6 as tester parent or CO 33-9 as dwarf parent showed a good fit for the adequacy of scaling test in respect of weight of grains per panicle (Table 8 g). The additive model was inadequate for all crosses involving TKM 6 and CO 33 as tester parents or CO 29-M-40, and TKM 6-10-12 and DONG as dwarf parents in respect of 1000 grain weight (Table 8 h). As for as grain

yield per plant was concerned the crosses involving CO 29-M-40 as dwarf parent showed a good fit for the adequacy of the scaling test (Table 8 i).

2. Persistence of heterosis: An estimate of the persistence of heterosis in the F_2 and $F_{2(R)}$ generations was obtained based on the percentage on mean performance on the mid-parental value and compared with the corresponding F_1 and $F_{1(R)}$. Results are presented in Tables 9 a to 9 i.

The persistence of heterosis was present in the F_2 and $F_{2(R)}$ generations of crosses involving CO 29-M-40 as donor parent in respect of plant height, leaf area, panicle length and number of grains per panicle (Tables 9 a, 9 d, 9 e and 9 f). The heterotic influence was completely absent in the segregating generations in respect of the two traits, number of internodes and 1000 grain weight while in the case of weight of grains per panicle it was negligible even if present (Tables 9 c, 9 h and 9 g). In the case of tiller number heterosis persisted in varying magnitudes in the F_2 and $F_{2(R)}$ generations and the influence was relatively less in crosses involving T(W)1 (Table 9 b). With regard to grain yield per plant, the influence of heterosis was evident in certain crosses involving IO 29-M-40, IKM 6-10-12 and CO 33-9 as dwarf donor parents or IKM 6, CO 33 and CO 13 as tester parents (Table 9 i).

3. Matrocytic inheritance: Based on the genetic model, suggested by Chandraratna and Sakai (1960) for assessing the

maternal effect in the F_1 and F_2 generations, the expected values were estimated and compared with the observed values which are presented in Annexure I. The coefficient of the maternal effect, deviation due to dominance and the mid-parental values were estimated on the above mentioned hypothetical model and the results are given in Table 10 a to 10 i.

The adequacy of the hypothetical genetic model for matroclinal was demonstrated by the agreement between the observed and expected values for all the characters due to non-significance of calculated chi-square statistic values.

In respect of plant height, moderately high values for the coefficient of maternal effect was observed in all crosses involving DQWG, 5824 and T(N)1 while it varied considerably in the other dwarf backgrounds. Matroclinal effect was negligible for plant height in crosses involving CO 29-M-40. The deviation effect due to dominance was positive and considerable in crosses involving DQWG, 5824 and T(N)1 but it was negative or negligible in the case of the other dwarf donor parents (Table 10 a). In the case of tiller number, highest coefficient of maternal effect was observed in the cross DQWG x CO 29 (76.4 per cent). The maternal effect was absent in all the crosses involving DQWG, 5824 and T(N)1 (except the single case mentioned above). In the case of other dwarf donor parents the maternal effect was seen in most crosses and to an extent of 63.7 per cent.

In general, tiller number had least values for deviation due to dominance (Table 10 b). With respect to number of internodes, matroclinous effect was seen at a higher degree in the crosses involving CO 29-M-40, TKN 6-10-12 and CO 33-9 with the exception of TKN 6-10-12 x CO 13 and CO 29-M-40 x CO 29. In general, deviation effects due to dominance were low in all crosses (Table 10 c).

In relation to leaf area the crosses between TKN 6-10-12 and TKN 6 or CO 33 expressed high matroclinous effect among all crosses. The other crosses which showed very high coefficient of maternal effect were T(H)1 x CO 29 (89.7 per cent) and CO 33-9 x CO 33 (93.0 per cent) (Table 10 d). As regards panicle length, the magnitude and direction of maternal effect were varying and highest value of 126.7 per cent was recorded by the cross CO 33-9 x TKN 6. The matroclinous effect was observed in more number of crosses involving TKN 6-10-12 and CO 33-9 than others. Estimates of the deviation due to dominance effect were also inconsistent among the crosses (Table 10 e).

In respect of number of grains per panicle the influence of matroclinous effect was highly expressive in crosses involving T(H)1 (Table 10 f). The maternal effect was negligible in all crosses with respect to weight of grains per panicle. The crosses involving CO 29 tester parent were unique as they had recorded high coefficient of maternal effect, particularly in crosses with dwarf parents 5824 and TKN 6-10-12 (Table 10 g). The maternal effect was complete for 1000 grain weight in crosses

3824 x CO 13, TKN 6-10-12 x CO 33 and CO 33-9 x TKN 6. There was evidence of maternal effect in general in most of the crosses with varying magnitudes (Table 10 h). The matroclinous effect for the trait, grain yield per plant in general was not considerable except in crosses DONG x CO 29, T(N)1 x CO 33, TKN 6-10-12 x CO 29, TKN 6-10-12 x TKN 6 and CO 33-9 x CO 13. The values for deviation due to dominance were moderate and of varying magnitudes (Table 10 i).

4. Heritability and genetic advance: The estimates of heritability, genetic advance and genetic advance as per cent on mean were determined in the F_2 and $F_{2(R)}$ generations for all the nine traits and the results are furnished in Tables 11 a to 11 i.

In respect of plant height, the heritability estimates were high in all the crosses particularly in those cases of crosses involving T(N)1 and the highest value of 96.2 per cent was observed in F_2 of T(N)1 x CO 29. The genetic advance as per cent on mean was highly variable among crosses and the highest genetic progress was seen in the cross T(N)1 x CO 29 (Table 11 a and Fig. 7). Widely variable heritability estimates were observed in the case of tiller number. High expression of heritability was evident in the crosses involving 3824 while the least was noticed in the crosses with CO 29-M-40. The genetic progress for tiller number was higher in the F_2 and $F_{2(R)}$ of the crosses involving 3824 than in other crosses and the same trend was observed in all the three estimates (Table 11 b

and Fig. 8). With respect to number of internodes, the crosses involving dwarf donor parent CO 33-9 exhibited higher values for estimates of heritability, genetic advance and genetic advance as per cent on mean (Table 11 c). With regard to leaf area, the highest heritability estimates as well as genetic advance as per cent on mean were observed in the crosses involving 5824, T(W)1 and CO 29-M-40 (Table 11 d). In panicle length, all the crosses with 5824 and CO 29-M-40 as dwarf donor parents showed relatively high values for heritability estimates, genetic advance as well as genetic advance as per cent on mean (Table 11 e).

Number of grains per panicle was observed to be highly heritable in most of the crosses particularly in the crosses involving CO 29-M-40. The genetic advance per cent on mean was highly variable from 5.6 per cent to 88.6 per cent (Table 11 f and Fig. 9). The heritability estimates for weight of grains per panicle were moderate to high in both F_2 and $F_{2(R)}$ generations for all crosses. Comparatively higher estimates of heritability were obtained in both generations in the crosses involving DGWG, 5824 or CO 29-M-40 as dwarf parent with CO 13 or CO 33 as tester parents. The genetic progress in this character was found to be moderate to high in all crosses and the highest estimates were obtained in the F_2 and $F_{2(R)}$ generations of the cross 5824 x CO 13 (Table 11 g and Fig. 10). Very high estimates of heritability were in evidence for 1000 grain weight in both in F_2 and $F_{2(R)}$ generations of all the

crosses. The genetic advance percentage was found to be low to medium for this trait (Table 11 h). In general, high heritability estimates were observed in respect of grain yield per plant among the crosses as well as F_2 and $F_{2(R)}$ generations. The expression of genetic advance per cent was also high for grain yield per plant. The maximum estimates for genetic progress were registered by the cross CO 29-M-40 x CO 33 (Table 11 i and Fig. 11).

V. Association Analysis

1. Simple correlation

a) Grain yield per plant vs other traits: In order to understand the relationship of various characters with the grain yield per plant and at the same time to assess the change in the pattern of association of these traits with yield in the non-segregating and segregating populations, simple correlation coefficients were worked out for each generation separately. The results are presented in Tables 12 a to 12 h.

Positive and significant relationship between grain yield per plant and plant height were observed in the parents T(N)1 and CO 33-9 among the dwarf donors and in all tester parents except CO 33. Correlation was observed in the F_2 generation of all the four crosses involving CO 29-M-40 as dwarf donor parent but such association was absent in the parent CO 29-M-40 and its F_1 generation. Consistent trend of relationship was not observed in the different generations (Table 12 a). Tiller number was highly correlated to the grain yield per plant in

respect of all the dwarf donor parents except TKM 6-10-12 and all tester parents. The same trend of relationships was maintained in F_2 and $F_{2(R)}$ generations as well as in the F_1 and $F_{1(R)}$ generations with a few exceptions in the crosses with GO 33 and GO 13 as tester parents (Table 12 b). No correlation was observed between number of internodes and grain yield per plant in parental, hybrid and segregating population of different crosses except in a few instances (Table 12 c).

Leaf area possessed correlation with yield in all the dwarf donor parents and only in two tester parents TKM 6 and GO 29 but this association was not evident in the F_1 and $F_{1(R)}$ generations. In the crosses involving T(N)1 the dwarf donor parent, the association was absent in F_1 and $F_{1(R)}$ while it was present in F_2 and $F_{2(R)}$ generations (Table 12 d). Association between grain yield per plant and panicle length was indicated in the dwarf donor parents TKM 6-10-12 and GO 33-9 and the tester parents GO 29, TKM 6 and GO 33. This trend was also noticed in F_2 and $F_{2(R)}$ generations of all crosses involving these parents (Table 12 e). Positive correlation between number of grains per panicle and grain yield per plant was observed in all dwarf donor and tester parents and this relationship was maintained in the first and second generations of all crosses with a few exceptions (Table 12 f). There was relationship between yield and weight of grains per panicle in all parents except T(N)1. The same trend was maintained in the first and second generations of different crosses (Table 12 g).

Significant negative association was indicated between 1000 grain weight and grain yield per plant in dwarf donor parent GO 29-M-40 and tester parent:GO 29 and GO 33. The direction of the association was not consistently the same in other generations (Table 12 h).

b) Plant height vs other traits: With a view to understand the association of plant height with other traits in the parents, the first and second generations and to study the trend of continuance of the association in the different generations, simple correlation coefficients were worked out for each generation separately. The results are given in Tables 13 a to 13 g.

Negative association of plant height with tiller number was observed in DSWG and 3824 and positive association in T(N)1 and TKM 6-10-12 among the dwarf donor parents and positive association in all the tester parents except GO 33. The relationship between these two traits was not uniformly consistent in the different generations (Table 13 a). The dwarf donor parents DSWG and T(N)1 exhibited positive relationship between plant height and number of internodes, while among the tester parents GO 33 (dwarf) showed positive correlation and TKM 6 exhibited significant negative association. Positive association between these two traits was observed uniformly in all crosses involving dwarf donor parents except GO 29-M-40 (Table 13 b). Leaf area was observed to be associated with plant height positively under all dwarf backgrounds except

5824 and CO 29-M-40 and in all tester parents except CO 33. Among the F_2 and $F_{2(R)}$ generations, the segregants of all crosses involving dwarf donor parents except CO 29-M-40 exhibited positive association between these traits barring a few exceptions (Table 13 c).

Plant height was positively correlated with panicle length in DSWG, 5824, CO 29-M-40 and CO 33-9 among the dwarf donor parents and CO 29 and CO 33 among tester parents and in majority of the cases in each of the F_1 , $F_{1(R)}$, F_2 and $F_{2(R)}$ generations (Table 13 d). Negative association between plant height and number of grains per panicle was observed in the case of the dwarf donor parent T(N)1, while it was positive in the case of other dwarf donor parents DSWG, CO 29-M-40 and CO 33-9 as well as all the tester parents (Table 13 e). In the dwarf backgrounds there was positive relationship between plant height and weight of grains per panicle in the case of DSWG, CO 29-M-40 and CO 33-9 while it was negative in the case of T(N)1. Among the testers, there was positive correlation in all cases except TIM 6. Though association between these two traits was absent in the dwarf donor parent TIM 6-10-12, it was present in all its crosses in the different generations (Table 13 f). Only in CO 33-9 the correlation between plant height and 1000 grain weight was positive among the dwarf donor parents while it was negative in CO 13 tester parent. The association was absent in the other parents. In the hybrid and segregating generations there was no association in most cases but where

it was present, it was positive in many cases (Table 13 g).

2. Genotypic, phenotypic and environmental correlations in P_2 and $P_{2(R)}$ generations under dwarf backgrounds

a) Yield vs other traits: The correlation coefficients of grain yield per plant with other traits at the genotypic, phenotypic and environmental levels under the different dwarf backgrounds were worked out for P_2 and $P_{2(R)}$ generations and the results are furnished in Tables 14 a to 14 d.

The magnitude of difference between genotypic and phenotypic correlation coefficients was considerable between grain yield per plant and plant height. A positive high genotypic correlation was obtained in all the crosses under the dwarf background except in the case of 5824 in P_2 and T(N)† in $P_{2(R)}$ which showed a negative correlation between the traits (Table 14 a). Positive and high genotypic correlation in respect of grain yield and tiller number were indicated in all the dwarf backgrounds, except under the backgrounds of 5824 showing no association in $P_{2(R)}$ and T(N)† having high negative association in P_2 (Table 14 a). All the segregating generations showed highly significant and positive genotypic correlation between grain yield per plant and number of internodes in all dwarf backgrounds with a few exceptions as in the case of P_2 of the crosses involving 5824 and $P_{2(R)}$ of the crosses involving T(N)† where negative association was noticed (Table 14 b).

In the crosses under the backgrounds of DGW, CO 29-M-40 and CO 33-9 in both the generations and in the F_2 generations of T(N)1 and TXN 6-10-12 positive genotypic correlation was observed between grain yield and leaf area. There was positive association at the genotypic level in $F_{2(R)}$ and negative in F_2 generation under the 5824 dwarf background (Table 14 b). As regards the relationship between panicle length and grain yield, the existence of consistent genotypic, phenotypic and environmental correlations was evident under all the dwarf backgrounds in both the generations. But the direction of association was negative for genotypic correlation in F_2 and $F_{2(R)}$ of T(N)1 crosses (Table 14 c). The genotypic association between grain yield per plant and number of grains per panicle was positive in the two generations of the crosses under all dwarf backgrounds except those involving CO 29-M-40 (both F_2 and $F_{2(R)}$) and 5824 ($F_{2(R)}$) only. At the phenotypic and environmental levels, the association was positive in both segregating generations in all the dwarf backgrounds except in the case of $F_{2(R)}$ of CO 33-9 (Table 14 e).

Positive association at the genotypic and phenotypic levels were observed between the weight of grains per panicle and the grain yield per plant in both the generations in all the crosses under different dwarf backgrounds, the exception being $F_{2(R)}$ of T(N)1 at the genotypic level. A negative environmental correlation was also observed in $F_{2(R)}$ of the crosses involving 5824 (Table 14 d). Relatively the

environmental influence for 1000 grain weight on yield was absent compared to other characters. The association of 1000 grain weight with yield proved to be either absent or negative in crosses involving 5824 and T(W)1. However, under all other dwarf backgrounds the genotypic correlation was not only positive and significant but the degree of correlation was very high (Table 14 d).

b) Plant height vs other traits: The association of plant height with other traits under the different dwarf backgrounds in terms of genotypic, phenotypic and environmental correlation coefficients was assessed for F_2 and $F_{2(R)}$ generations and the results are presented in Tables 15 a to 15 d.

The genotypic correlation coefficients with respect to plant height and tiller number for both F_2 and $F_{2(R)}$ of the crosses involving CO 29-M-40, TKN 6-10-12 and CO 33-9 were positive, while in the segregating generation of other crosses they were negative. The phenotypic correlation was absent in the crosses involving DGNB, 5824 and T(W)1 while it was positive in the other dwarf backgrounds except in the case of $F_{2(R)}$ of CO 29-M-40 (Table 15 a).

The association of plant height and number of internodes at the genotypic and phenotypic levels were positive in all crosses irrespective of generations and dwarf backgrounds (Table 15 a).

The estimates of the genotypic correlation coefficients between plant height and leaf area were positive in all

generations and crosses except $F_{2(R)}$ generations of T(N)1 and TKN 6-10-12 which were negative (Table 15 b).

The panicle length had positive association with plant height both at the genotypic and phenotypic levels in all generations under all dwarf backgrounds (Table 15 b).

There was no regular trend of association, at the genotypic level, of plant height with number of grains per panicle under the different dwarf backgrounds. The genotypic correlation coefficient was positive in both the generations under the backgrounds of DGN6 and CO 29-M-40 and negative under 5824 background. In the case of T(N)1 and CO 33-9 dwarf backgrounds, there was positive genotypic relationship in F_2 and the same was negative in $F_{2(R)}$ generation (Table 15 c).

The genotypic association between plant height and weight of grains per panicle was positive in both the generations and under all backgrounds the only exception being the F_2 generation of 5824 (Table 15 c). The plant height had positive association with 1000 grain weight at the genotypic level in both F_2 and $F_{2(R)}$ generations in the crosses involving T(N)1, CO 29-M-40 and CO 33-9. This association was positive in other dwarf backgrounds but was not consistent in F_2 and $F_{2(R)}$ generations. In general, the environmental correlation between the two traits was absent (Table 15 d).

VI. Study on Recombination between Plant Height and Other traits

With a view to determine the influence of different dwarf genotypes in the recombination of plant height with other traits, the F_2 and $F_{2(R)}$ data were grouped into four categories.

1. Dwarf segregants (Below 100 cm in height) combining character means lower than that of F_2 .
2. Dwarf segregants (Below 100 cm in height) combining character means higher than that of F_2 .
3. Tall segregants (100 cm and above) combining character means lower than that of F_2 .
4. Tall segregants (100 cm and above) combining character means higher than that of F_2 .

The percentages of genotypes in the F_2 and $F_{2(R)}$ generation under each one of the above four groups were estimated and the results are represented in Fig. 12 to 19. It is interesting to note that the general trend of recombinations of all the traits with plant height was nearly identical for the respective combinations. The diagrammatic representation revealed that the trend of recombination was more or less similar for F_2 and $F_{2(R)}$ in all crosses except for the crosses TKN 6-10-12 x CO 29 and CO 33-9 x TKN 6. The pattern of recombination under dwarf background DNGC, 5624, T(N)1 and CO 29-M-40 was different from those of TKN 6-10-12 and

CO 33-9 backgrounds. In the former group, the number of recombinants under category 2 vis., dwarf segregants with higher character means than the F_2 means as compared to other categories was, in general, low and the recombinants under the third and fourth categories were high. In the case of IKM 6-10-12 and CO 33-9 dwarf backgrounds, higher percentage of dwarf genotypes with higher character means than F_2 means was found. The pattern of recombination was different when CO 33 formed the tester parent, with higher percentage of genotypes belonging to the first two categories of dwarfs and with the exception of its crosses with CO 29-M-40.

Parent	Plant height (cm)	Stiller number	No. of inter-nodes	Leaf area (cm ²)	Panicle length (cm)	No. of grains per panicle	Wt. of grains per panicle (g)	1000 grains weight (g)	Grain yield per plant (g)
Parent group means (P₁)									
1000	90.59	7.26	5.89	25.15	21.06	80.20	2.20	25.28	16.74
5024	80.34	8.53	4.95	23.60	20.53	62.09	1.67	26.50	14.48
2(W) ¹	87.41	9.79	5.56	22.07	20.70	87.10	1.98	22.40	21.34
00 29-8-40	57.46	8.13	5.29	15.56	14.22	44.35	1.07	23.50	8.30
221 6-10-12	81.30	8.05	5.26	22.18	19.16	79.19	1.62	20.53	13.48
00 33-9	76.43	8.15	5.10	23.02	20.04	104.56	1.95	18.39	16.07
Parent means (P₂)									
00 29	131.69	10.90	5.93	27.13	21.10	77.26	1.92	23.25	21.02
221 6	135.13	8.86	6.07	21.49	22.37	83.70	1.61	18.89	14.97
00 33	76.85	8.18	4.89	22.28	19.59	95.61	1.76	17.77	14.46
00 13	151.72	8.93	6.03	26.52	21.58	82.35	2.11	24.52	18.20
1- 33	1.70	0.31	0.06	1.09	0.15	1.78	0.05	0.12	0.44
2- 33	1.46	0.26	0.05	0.89	0.12	1.43	0.04	0.10	0.32
3- 33 ₄	2.50	0.41	0.07	1.41	0.19	2.27	0.06	0.16	0.52
4- 00 (p=0.05)	4.94	0.87	0.16	3.03	0.40	4.57	0.13	0.34	1.77
5- 00 (p=0.05)	4.04	0.71	0.13	2.48	0.33	3.97	0.11	0.28	1.44
6- 00 (p=0.05)	4.51	0.79	0.15	2.77	0.37	4.44	0.12	0.31	1.61

1, 2 SE for the means of P₁ and P₂ respectively
3 SE of difference for comparison of a mean in P₁ and P₂
4, 5 CD for comparison of means among P₁ and P₂ respectively
6 CD for comparison of a mean in P₁ and a mean in P₂

Parents	Plant height	Tiller number	No. of internodes	Leaf area	Panicle length	No. of grains per panicle	Wt. of grains per panicle	1000 grains wt.	Grain yield per plant
Parent Amswari (P₁)									
3076	8.35	39.78	8.28	17.45	6.40	15.05	16.05	3.88	35.65
3024	7.53	29.83	9.10	11.90	3.78	14.50	17.15	3.38	32.38
3(H)1	6.65	33.25	10.70	11.73	5.50	17.80	22.85	4.68	29.80
00 29-H-40	7.45	34.48	9.43	9.85	4.45	14.95	22.50	2.88	34.00
2H 6-10-12	5.75	32.03	8.18	14.45	6.13	16.63	17.63	3.20	44.43
00 33-9	5.98	26.45	9.05	18.38	5.20	14.98	17.15	3.43	28.45
Parent Maswari (P₂)									
00 29	7.08	25.50	6.60	13.43	6.03	15.80	20.87	4.48	33.33
2H 6	5.87	33.65	7.95	16.20	6.50	18.07	23.93	6.02	36.60
00 33	6.45	31.37	9.50	12.53	6.32	16.78	19.35	5.33	31.88
00 13	7.22	34.08	8.08	14.88	5.07	17.67	20.72	4.65	26.50

Table 3 a. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Plant height (cm)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		GO 29	EXN 6	GO 33	GO 13		
D886	P_1	99.05	97.92	97.47	99.94		
	F_1	109.69	111.85	82.68	110.69	103.73	109.95
	$F_{1(R)}$	126.87	129.25	75.04	135.48	116.16	
	P_2	123.98	134.71	79.35	151.31		
	SE	1.97	2.13	1.45	2.40		
	GD ($P=0.05$)	5.56	6.01	4.09	6.77		
5824	P_1	78.18	80.44	87.87	74.88		
	F_1	98.65	119.09	77.16	103.11	99.50	99.69
	$F_{1(R)}$	104.71	98.16	78.42	118.22	99.88	
	P_2	119.19	129.82	82.02	133.28		
	SE	3.28	2.70	1.35	2.77		
	GD ($P=0.05$)	9.28	7.62	3.81	7.81		
X(W)1	P_1	78.14	86.81	92.34	92.34		
	F_1	104.66	126.49	74.88	100.52	101.64	109.18
	$F_{1(R)}$	124.14	129.18	70.11	142.78	116.55	
	P_2	132.52	139.64	81.16	150.42		
	SE	1.55	2.10	1.03	1.77		
	GD ($P=0.05$)	4.37	3.92	2.91	4.99		
GO 29-X-40	P_1	58.48	61.38	54.80	55.21		
	F_1	114.30	111.98	85.12	119.20	107.65	106.86
	$F_{1(R)}$	114.70	120.46	68.12	120.98	106.07	
	P_2	121.50	135.30	75.41	150.79		
	SE	1.45	1.48	1.58	1.94		
	GD ($P=0.05$)	4.09	3.95	4.46	5.47		
EXN 6-10-12	P_1	84.94	82.67	81.76	75.85		
	F_1	90.98	90.04	66.57	91.47	84.72	95.80
	$F_{1(R)}$	126.14	126.09	61.89	187.01	105.28	
	P_2	150.45	155.59	71.73	151.90		
	SE	1.96	1.80	0.96	3.01		
	GD ($P=0.05$)	5.53	5.88	2.71	8.49		
GO 33-9	P_1	79.80	75.87	75.30	76.75		
	F_1	113.25	74.86	59.19	90.27	84.39	98.25
	$F_{1(R)}$	117.45	114.83	63.51	152.81	112.10	
	P_2	142.54	135.76	71.45	172.61		
	SE	1.98	1.58	0.95	2.80		
	GD ($P=0.05$)	5.59	4.46	2.68	7.90		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	F_1	105.25	105.72	74.23	102.54		
	$F_{1(R)}$	119.00	119.66	69.15	129.55		
Mean of F_1 and $F_{1(R)}$ for the tester parent		112.15	112.69	71.69	116.05		

Table 3 b. Mean performance of P_1 and $P_{1(R)}$ hybrids in comparison with the parents.

Filler number

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				P_1 and $P_{1(R)}$ means of all tester parents	Mean of P_1 and $P_{1(R)}$ for the dwarf parent
		GO 29	TKN 6	GO 33	GO 13		
DOWO	P_1	7.50	7.50	6.50	7.55		
	P_1	6.95	8.50	11.40	9.10	8.99	9.25
	$P_{1(R)}$	10.10	7.75	11.15	9.00	9.50	
	P_2	11.20	9.20	8.80	9.00		
	SE	0.75	0.75	0.78	0.69		
	GD ($P=0.05$)	2.06	2.12	2.20	1.95		
3024	P_1	9.00	6.60	9.15	9.35		
	P_1	6.70	8.55	10.80	9.05	8.78	8.99
	$P_{1(R)}$	8.05	8.00	11.75	9.00	9.20	
	P_2	7.30	6.95	9.00	6.10		
	SE	0.52	0.59	0.85	0.63		
	GD ($P=0.05$)	1.47	1.66	2.40	1.78		
2(H)1	P_1	12.05	9.30	9.30	9.30		
	P_1	8.90	8.25	11.30	7.45	8.98	8.58
	$P_{1(R)}$	8.15	8.25	10.15	6.15	8.18	
	P_2	14.20	8.20	9.25	10.10		
	SE	0.75	0.65	0.71	0.61		
	GD ($P=0.05$)	2.12	ns	2.00	1.72		
GO 29-2-40	P_1	10.85	7.85	5.20	8.80		
	P_1	10.65	12.75	13.00	11.95	12.09	12.22
	$P_{1(R)}$	12.25	11.10	10.65	15.35	12.34	
	P_2	11.75	9.30	9.60	8.95		
	SE	0.81	0.94	0.93	0.80		
	GD ($P=0.05$)	ns	2.65	2.62	2.26		
TKN 6-10-12	P_1	7.90	8.50	7.50	8.30		
	P_1	13.15	6.95	12.20	12.55	11.21	11.57
	$P_{1(R)}$	14.20	8.20	10.65	13.05	11.53	
	P_2	10.15	11.05	6.35	10.70		
	SE	0.60	0.63	0.58	0.68		
	GD ($P=0.05$)	1.69	1.78	1.64	1.92		
GO 33-9	P_1	9.70	8.05	6.00	8.75		
	P_1	16.40	6.45	10.25	10.65	10.94	10.69
	$P_{1(R)}$	11.55	10.30	9.40	10.45	10.43	
	P_2	9.80	8.45	6.10	9.05		
	SE	0.56	0.61	0.51	0.80		
	GD ($P=0.05$)	1.58	1.72	1.44	ns		
P_1 and $P_{1(R)}$ means of all dwarf donor parents	P_1	10.46	8.58	11.49	10.13		
	$P_{1(R)}$	10.72	8.93	10.63	10.50		
Mean of P_1 and $P_{1(R)}$ for the tester parent		10.59	8.76	11.06	10.32		

Table 3 c. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Number of internodes

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		CO 29	TKM 6	CO 33	CO 13		
BGR3	P_1	5.55	5.70	6.20	6.10		
	F_1	5.85	6.20	5.55	5.80	5.85	5.77
	$F_{1(R)}$	6.05	5.60	4.90	6.15	5.68	
	P_2	5.90	6.10	4.65	5.90		
	SE	0.10	0.15	0.15	0.10		
	GD ($P=0.05$)	0.28	0.42	0.37	0.28		
3824	P_1	4.95	5.30	4.50	5.05		
	F_1	5.30	5.70	5.20	5.60	5.45	5.53
	$F_{1(R)}$	5.60	5.65	5.45	5.70	5.60	
	P_2	5.90	5.95	4.70	6.15		
	SE	1.41	0.12	0.11	0.10		
	GD ($P=0.05$)	ns	0.34	0.30	0.28		
T(H)1	P_1	5.45	5.60	5.60	5.60		
	F_1	6.10	6.05	4.90	5.45	5.63	5.69
	$F_{1(R)}$	6.50	6.05	4.80	5.65	5.75	
	P_2	6.05	6.00	4.95	5.60		
	SE	0.10	0.09	0.15	0.12		
	GD ($P=0.05$)	0.28	0.25	0.37	ns		
CO 29-N-40	P_1	5.40	5.25	5.10	5.40		
	F_1	5.65	5.70	4.90	5.90	5.44	5.53
	$F_{1(R)}$	5.70	6.10	4.95	6.10	5.61	
	P_2	5.95	6.40	5.20	6.05		
	SE	0.10	0.10	0.12	0.12		
	GD ($P=0.05$)	0.28	0.28	0.34	0.34		
TKM 6-10-12	P_1	5.60	5.15	5.20	5.10		
	F_1	5.45	5.35	4.50	5.25	5.11	5.24
	$F_{1(R)}$	5.95	5.90	4.30	5.30	5.36	
	P_2	5.70	5.85	5.15	6.00		
	SE	0.10	0.20	0.10	0.10		
	GD ($P=0.05$)	0.28	0.56	0.28	0.28		
CO 33-9	P_1	5.10	5.20	5.25	4.85		
	F_1	5.75	5.05	4.15	5.40	5.09	5.40
	$F_{1(R)}$	6.10	5.80	4.20	6.70	5.70	
	P_2	6.05	6.10	5.10	6.50		
	SE	0.08	0.09	0.09	0.12		
	GD ($P=0.05$)	0.25	0.25	0.25	0.34		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	F_1	5.68	5.66	4.80	5.57		
	$F_{1(R)}$	5.98	5.85	4.70	5.93		
Mean of F_1 and $F_{1(R)}$ for the tester parent		5.83	5.76	4.75	5.75		

Table 3 d. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Leaf area (cm^2)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		GO 29	TKM 6	GO 33	GO 13		
DOWO	P_1	25.24	25.62	26.70	25.03		
	F_1	23.86	19.22	24.82	22.66	22.64	
	$F_{1(R)}$	25.06	18.44	20.60	23.96	22.02	22.33
	P_2	27.64	21.77	27.78	28.05		
	SE	0.83	0.65	0.90	0.99		
	GD ($P=0.05$)	2.34	1.83	2.54	2.79		
5824	P_1	21.23	20.32	32.31	20.53		
	F_1	19.33	20.45	20.84	18.27	19.72	
	$F_{1(R)}$	17.86	20.75	23.47	18.51	20.15	19.94
	P_2	19.79	17.84	21.91	19.85		
	SE	0.63	0.65	0.59	0.61		
	GD ($P=0.05$)	1.78	1.83	1.66	1.72		
T(H)1	P_1	22.56	21.61	22.05	22.05		
	F_1	20.55	20.46	20.10	18.41	19.88	
	$F_{1(R)}$	21.08	21.91	19.18	18.07	20.06	19.97
	P_2	22.77	22.71	20.88	28.14		
	SE	0.52	0.66	0.56	0.56		
	GD ($P=0.05$)	1.47	1.86	1.58	1.58		
GO 29-H-40	P_1	15.79	15.62	16.02	14.81		
	F_1	21.10	17.80	17.93	17.53	18.60	
	$F_{1(R)}$	20.90	18.93	15.63	21.93	19.35	18.98
	P_2	28.67	22.48	25.30	25.03		
	SE	0.50	0.56	0.61	0.60		
	GD ($P=0.05$)	1.41	1.58	1.72	1.69		
TKM 6-10-12	P_1	27.34	22.19	17.99	21.01		
	F_1	24.08	14.45	17.77	20.39	19.18	
	$F_{1(R)}$	23.07	15.48	18.32	22.08	20.24	19.71
	P_2	36.98	21.64	18.93	27.82		
	SE	0.90	0.76	0.67	0.82		
	GD ($P=0.05$)	2.53	2.14	ns	2.31		
GO 33-9	P_1	21.39	24.42	19.02	27.23		
	F_1	19.45	19.51	18.17	18.02	18.79	
	$F_{1(R)}$	20.21	18.83	17.57	23.59	20.05	19.42
	P_2	26.92	22.52	18.88	37.15		
	SE	0.85	0.71	0.66	0.85		
	GD ($P=0.05$)	2.40	2.00	ns	2.40		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	F_1	21.40	18.65	19.94	19.22		
	$F_{1(R)}$	21.70	19.06	19.15	21.36		
Mean of F_1 and $F_{1(R)}$ for the		21.55	18.86	19.54	20.29		

Table 3 e. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Panicle length (cm)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		00 29	TW 6	00 33	00 13		
BONG	P_1	21.52	20.93	20.53	21.28		
	F_1	21.18	24.23	20.49	21.98	21.97	21.95
	$F_{1(R)}$	22.55	22.89	19.34	22.95	21.93	
	P_2	20.79	22.64	21.20	21.91		
	SE	0.33	0.51	0.27	0.30		
	GD ($P=0.05$)	0.93	1.44	0.76	0.85		
3824	P_1	20.51	20.58	21.50	19.95		20.99
	F_1	20.72	22.35	21.28	20.70	21.26	
	$F_{1(R)}$	20.83	21.19	20.00	20.83	20.71	
	P_2	20.75	21.70	20.44	20.71		
	SE	0.12	0.25	0.26	0.48		
	GD ($P=0.05$)	ns	0.71	0.73	ns		
T(H)1	P_1	20.05	20.29	21.24	21.24		21.22
	F_1	20.97	21.35	20.35	20.91	20.90	
	$F_{1(R)}$	21.46	21.96	20.16	22.57	21.54	
	P_2	21.17	22.95	20.17	21.90		
	SE	0.29	0.31	0.27	0.29		
	GD ($P=0.05$)	0.82	0.87	0.76	0.82		
00 29-H-10	P_1	14.41	14.72	14.08	13.68		19.03
	F_1	19.11	19.22	16.98	19.30	18.65	
	$F_{1(R)}$	19.61	21.52	16.78	19.89	19.40	
	P_2	20.26	22.36	18.24	21.43		
	SE	0.18	0.29	0.28	0.23		
	GD ($P=0.05$)	0.51	0.82	0.79	0.65		
28H 6-10-12	P_1	19.17	19.31	19.29	16.87		19.75
	F_1	19.57	19.48	17.96	19.36	19.09	
	$F_{1(R)}$	22.01	22.53	17.83	19.26	20.41	
	P_2	22.56	22.58	18.90	21.59		
	SE	0.52	0.35	0.30	0.60		
	GD ($P=0.05$)	0.90	0.99	0.85	1.69		
00 33-9	P_1	20.07	19.87	19.68	20.53		20.16
	F_1	20.28	19.79	17.72	19.34	19.28	
	$F_{1(R)}$	21.16	21.90	17.84	23.24	21.04	
	P_2	21.10	21.98	18.63	21.94		
	SE	0.35	0.27	0.25	0.23		
	GD ($P=0.05$)	0.99	0.76	0.71	0.65		
F_1 and $F_{1(R)}$ means of all dwarf parents	F_1	20.31	21.07	19.13	20.27		
	$F_{1(R)}$	21.27	21.97	18.66	21.46		
Mean of F_1 and $F_{1(R)}$ for the tester parent		20.79	21.52	18.90	20.87		

Table 3 f. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Number of grains per panicle

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		00 29	TKM 6	00 33	00 15		
DGW0	P_1	89.10	87.10	63.45	89.60		
	F_1	66.15	100.35	73.60	74.25	78.59	77.96
	$F_{1(R)}$	66.70	98.10	62.90	81.60	77.33	
	P_2	78.95	96.90	121.40	90.65		
	SE	2.82	3.67	3.02	1.60		
	GD ($P=0.05$)	7.96	10.35	8.52	4.51		
5824	P_1	61.90	53.90	68.70	63.85		
	F_1	63.15	82.85	79.55	68.55	73.53	73.94
	$F_{1(R)}$	73.85	69.40	85.00	69.10	74.34	
	P_2	67.70	73.10	106.00	74.05		
	SE	3.03	3.06	3.11	3.14		
	GD ($P=0.05$)	8.55	8.63	8.79	8.86		
R(H)1	P_1	80.65	85.35	91.20	91.20		
	F_1	67.55	88.10	70.25	73.25	74.79	79.44
	$F_{1(R)}$	81.35	92.95	78.90	83.10	84.08	
	P_2	81.35	82.00	100.80	85.45		
	SE	3.19	3.43	3.13	3.46		
	GD ($P=0.05$)	8.97	9.65	8.82	9.76		
00 29-H-40	P_1	41.75	50.45	46.05	39.15		
	F_1	68.50	75.60	86.10	73.10	75.83	75.98
	$F_{1(R)}$	73.20	87.10	76.00	68.20	76.13	
	P_2	73.70	87.60	74.15	83.60		
	SE	2.25	2.64	2.34	2.79		
	GD ($P=0.05$)	6.35	7.45	7.17	7.87		
SEK 6-10-12	P_1	68.40	79.10	86.10	83.15		
	F_1	87.65	77.10	68.15	58.25	72.79	77.07
	$F_{1(R)}$	96.75	100.20	71.45	57.00	81.35	
	P_2	84.00	83.80	86.80	87.70		
	SE	3.32	3.46	3.01	3.09		
	GD ($P=0.05$)	9.37	9.76	8.47	8.72		
00 33-9	P_1	103.00	106.85	106.10	100.30		
	F_1	103.15	92.55	82.55	84.50	91.19	92.52
	$F_{1(R)}$	96.90	93.05	88.45	97.00	93.85	
	P_2	75.85	76.80	84.50	72.65		
	SE	3.25	3.05	3.34	3.39		
	GD ($P=0.05$)	9.11	8.60	9.42	9.56		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	F_1	76.36	86.09	76.70	71.98		
	$F_{1(R)}$	81.46	90.15	77.12	76.00		
Mean of F_1 and $F_{1(R)}$ for the		78.91	88.11	76.91	73.99		

Table 3 g. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Weight of grains per panicle (g)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		00 29	TKM 6	00 35	00 15		
2076	P_1	2.43	2.57	1.59	2.39		
	F_1	1.75	2.02	1.62	1.94	1.83	1.90
	$F_{1(R)}$	1.80	2.52	1.25	2.25	1.96	
	P_2	2.06	1.90	2.62	2.33		
	SE	0.08	0.09	0.08	0.08		
	GD ($P=0.05$)	0.23	0.25	0.23	0.23		
5024	P_1	1.73	1.30	1.75	1.84		
	F_1	1.69	1.89	1.57	1.80	1.74	1.77
	$F_{1(R)}$	1.93	1.77	1.45	2.00	1.79	
	P_2	1.89	1.40	2.05	1.97		
	SE	0.08	0.07	0.06	0.09		
	GD ($P=0.05$)	0.21	0.18	0.17	ns		
2(H)1	P_1	1.87	2.05	1.97	2.02		
	F_1	1.67	1.89	1.54	1.95	1.76	1.84
	$F_{1(R)}$	1.95	1.94	1.43	2.30	1.91	
	P_2	1.75	1.47	1.85	2.29		
	SE	0.08	0.08	0.08	0.11		
	GD ($P=0.05$)	0.23	0.23	0.23	0.32		
00 29-H-40	P_1	1.13	1.20	1.05	0.90		
	F_1	1.39	1.72	1.49	1.74	1.64	1.61
	$F_{1(R)}$	1.69	1.86	1.23	1.54	1.58	
	P_2	2.02	1.69	1.10	2.18		
	SE	0.08	0.07	0.07	0.08		
	GD ($P=0.05$)	0.22	0.19	0.20	0.24		
TKM 6-10-12	P_1	1.42	1.88	1.62	1.78		
	F_1	1.51	1.60	1.35	1.28	1.44	1.56
	$F_{1(R)}$	2.16	2.22	1.16	1.17	1.68	
	P_2	1.98	1.60	1.47	2.29		
	SE	0.09	0.08	0.06	0.10		
	GD ($P=0.05$)	0.23	0.24	0.18	0.28		
00 35-9	P_1	2.00	1.98	1.93	1.89		
	F_1	2.00	1.63	1.41	1.67	1.68	1.76
	$F_{1(R)}$	1.93	1.69	1.44	2.31	1.84	
	P_2	1.83	1.46	1.46	1.63		
	SE	0.08	0.07	0.07	0.07		
	GD ($P=0.05$)	0.22	0.19	0.18	0.20		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	P_1	1.70	1.79	1.50	1.73		
	$F_{1(R)}$	1.91	2.00	1.33	1.93		
Mean of F_1 and $F_{1(R)}$ for the tester parent		1.81	1.90	1.42	1.85		

Table 3 h. Mean performance of P_1 and $P_{1(R)}$ hybrids in comparison with the parents.

1000 grain weight (g)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				P_1 and $P_{1(R)}$ means of all tester parents	Mean of P_1 and $P_{1(R)}$ for the dwarf parent
		GO 29	TKM 6	GO 33	GO 13		
D976	P_1	25.39	24.99	25.92	24.83		
	F_1	26.05	21.37	22.78	27.44	24.41	24.37
	$F_{1(R)}$	26.83	23.89	19.18	27.39	24.32	
	P_2	23.79	18.77	18.69	23.95		
	SE	0.30	0.24	0.42	0.31		
	GD ($P=0.05$)	0.85	0.68	1.18	0.87		
5824	P_1	26.59	26.35	26.55	26.49		
	F_1	25.73	22.24	21.89	26.34	24.06	23.73
	$F_{1(R)}$	24.84	23.60	18.41	26.71	23.39	
	P_2	24.50	18.68	17.55	26.17		
	SE	0.30	0.31	0.46	0.20		
	GD ($P=0.05$)	0.84	0.87	1.31	ns		
R(N)1	P_1	23.24	23.09	22.13	22.13		
	F_1	23.19	22.47	22.05	24.93	23.66	22.99
	$F_{1(R)}$	23.71	20.70	19.73	25.11	22.31	
	P_2	23.15	18.94	17.35	24.90		
	SE	0.32	0.30	0.40	0.29		
	GD ($P=0.05$)	0.91	0.84	1.13	0.82		
GO 29-N-40	P_1	23.52	24.02	22.33	24.14		
	F_1	23.08	21.69	16.93	24.43	21.53	21.16
	$F_{1(R)}$	23.23	20.81	16.08	23.07	20.80	
	P_2	24.08	18.70	17.11	24.80		
	SE	0.19	0.20	0.32	0.22		
	GD ($P=0.05$)	0.53	0.55	0.91	0.63		
TKM 6-10-12	P_1	20.24	20.54	20.60	20.76		
	F_1	18.93	20.70	19.32	21.40	20.09	20.10
	$F_{1(R)}$	21.77	20.04	16.56	22.07	20.11	
	P_2	21.59	19.23	17.88	24.00		
	SE	0.21	0.21	0.23	0.53		
	GD ($P=0.05$)	0.80	0.60	0.66	1.50		
GO 33-9	P_1	18.18	18.37	18.46	18.54		
	F_1	18.07	17.89	16.45	18.00	17.60	18.22
	$F_{1(R)}$	19.87	18.39	15.59	21.50	18.84	
	P_2	22.38	19.03	18.04	23.34		
	SE	0.32	0.16	0.21	0.27		
	GD ($P=0.05$)	0.91	0.45	0.59	0.76		
P_1 and $P_{1(R)}$ means of all dwarf donor parents	F_1	22.85	21.06	19.90	23.76		
	$F_{1(R)}$	23.38	21.24	17.59	24.31		
Mean of P_1 and $P_{1(R)}$ for the tester parent		23.12	21.15	18.75	24.04		

Table 3 1. Mean performance of F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Grain yield per plant (g)

Dwarf donor parents (P_1)	Generation	Tester parents (P_2)				F_1 and $F_{1(R)}$ means of all tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		CO 29	TKM 6	CO 33	CO 13		
D876	P_1	18.09	17.62	13.14	18.10		
	F_1	11.46	12.29	13.51	18.20	13.87	
	$F_{1(R)}$	18.64	21.38	10.55	20.53	17.78	15.83
	P_2	23.63	17.44	23.50	20.68		
	SE	2.69	1.76	0.99	1.68		
	OD ($P=0.05$)	7.59	4.96	2.79	ns		
3824	P_1	16.98	9.10	14.34	17.49		
	F_1	12.02	16.45	17.31	16.58	15.59	
	$F_{1(R)}$	16.20	14.78	18.39	17.77	16.79	16.19
	P_2	13.89	10.16	18.28	11.84		
	SE	1.21	1.20	1.48	1.37		
	OD ($P=0.05$)	3.41	3.39	ns	3.88		
2(N)1	P_1	28.55	19.22	19.23	18.73		
	F_1	15.19	16.57	15.25	15.09	15.53	
	$F_{1(R)}$	15.91	16.24	16.38	16.94	16.37	15.95
	P_2	24.50	14.74	17.45	17.69		
	SE	1.42	1.36	1.22	1.18		
	OD ($P=0.05$)	4.01	3.84	3.44	3.33		
CO 29-33-40	P_1	12.28	9.27	4.87	6.79		
	F_1	16.94	21.20	10.91	22.22	17.82	
	$F_{1(R)}$	21.09	21.00	8.25	17.10	16.86	17.34
	P_2	25.61	15.73	8.48	18.65		
	SE	1.45	1.36	0.75	1.15		
	OD ($P=0.05$)	4.09	3.84	2.12	3.24		
TKM 6-10-12	P_1	12.12	14.41	12.36	15.04		
	F_1	20.09	13.45	13.35	12.96	14.96	
	$F_{1(R)}$	30.43	17.69	9.72	12.06	17.48	16.22
	P_2	20.75	19.12	9.85	25.46		
	SE	1.64	1.30	1.08	1.34		
	OD ($P=0.05$)	4.63	3.67	3.05	3.78		
CO 33-9	P_1	20.16	16.66	11.12	16.33		
	F_1	27.28	10.26	10.95	20.04	17.13	
	$F_{1(R)}$	21.86	16.69	11.18	24.44	18.54	17.84
	P_2	17.79	12.63	9.52	14.86		
	SE	1.27	1.13	0.83	1.32		
	OD ($P=0.05$)	3.58	3.19	ns	3.72		
F_1 and $F_{1(R)}$ means of all dwarf donor parents	F_1	17.16	15.04	13.55	17.52		
	$F_{1(R)}$	20.69	17.96	12.41	18.14		
Mean of F_1 and $F_{1(R)}$ for the tester parent		18.93	16.50	12.98	17.83		

Table 4 a. Coefficient of variation per cent for P_1 and $P_1(R)$ hybrids in comparison with the parents.

		Plant height				P ₁ and P ₁ (R) means over tester parents	Mean of P ₁ and P ₁ (R) for the dwarf parent
Dwarf donor parents (P ₁)	Genera- tion	Tester parents (P ₂)					
		00 29	TKN 6	00 33	00 13		
DGNB	P ₁	8.9	9.6	7.5	7.4		
	P ₁	9.9	9.0	7.6	11.2	9.43	8.52
	P ₁ (R)	6.4	8.2	9.3	6.5	7.60	
	P ₂	5.9	5.9	6.8	8.7		
5824	P ₁	7.5	5.7	9.8	7.3		
	P ₁	17.4	6.7	6.4	17.9	12.10	13.39
	P ₁ (R)	19.5	21.4	5.8	12.0	14.68	
	P ₂	9.3	5.8	6.3	4.9		
T(H)1	P ₁	6.7	8.8	5.5	5.5		
	P ₁	6.2	7.1	4.6	7.2	6.28	6.47
	P ₁ (R)	5.4	9.4	6.8	5.0	6.65	
	P ₂	6.7	5.8	6.1	7.3		
00 29-H-40	P ₁	6.4	7.0	6.5	9.9		
	P ₁	5.4	5.9	8.0	6.0	6.33	7.36
	P ₁ (R)	6.5	4.6	16.1	6.3	8.38	
	P ₂	5.8	5.9	6.0	8.5		
TKN 6-10-12	P ₁	7.2	4.5	5.0	6.3		
	P ₁	10.2	11.7	5.5	17.2	11.15	10.23
	P ₁ (R)	6.9	6.8	7.4	16.1	9.30	
	P ₂	6.9	5.8	6.6	8.3		
00 33-9	P ₁	9.0	4.8	5.7	4.4		
	P ₁	6.1	4.7	7.1	12.5	7.60	8.27
	P ₁ (R)	8.1	9.1	5.5	13.0	8.93	
	P ₂	7.9	6.0	6.9	5.6		
P ₁ and P ₁ (R) means over dwarf donor parents	P ₁	9.2	7.5	6.5	12.0		
	P ₁ (R)	8.8	9.9	8.5	9.8		
Mean of P ₁ and P ₁ (R) for the tester parent		9.0	8.7	7.5	10.9		

Table 4 b. Coefficient of variation per cent for P_1 and $P_1(R)$ hybrids in comparison with the parents.

Tiller number							
Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				P_1 and $P_1(R)$ means over tester parents	Mean of P_1 and $P_1(R)$ for the dwarf parent
		00 29	TKM 6	00 33	00 13		
DGWC	P_1	40.9	42.7	37.2	38.3		
	P_1	46.6	38.6	40.2	30.8	39.05	
	$P_1(R)$	30.8	46.2	34.0	33.2	36.05	37.55
	P_2	32.7	36.9	30.1	40.1		
5824	P_1	22.8	30.7	31.6	34.2		
	P_1	45.2	36.7	37.2	35.0	38.53	
	$P_1(R)$	29.3	42.7	35.6	30.1	34.43	36.48
	P_2	24.0	22.6	43.9	34.4		
T(N)1	P_1	30.6	33.5	34.5	34.4		
	P_1	41.9	33.3	26.8	29.2	32.80	
	$P_1(R)$	33.4	31.4	36.2	33.9	34.23	33.52
	P_2	22.1	37.9	30.4	30.9		
00 29-M-40	P_1	30.2	32.9	37.0	37.8		
	P_1	28.8	42.9	40.1	26.2	34.50	
	$P_1(R)$	39.1	42.6	47.6	28.8	39.53	37.02
	P_2	25.4	35.6	38.0	37.8		
TKM 6-10-12	P_1	23.8	38.5	34.7	31.1		
	P_1	19.5	28.8	22.2	27.3	24.45	
	$P_1(R)$	24.0	23.8	27.7	25.2	25.68	25.07
	P_2	24.1	32.0	22.7	26.3		
00 33-9	P_1	24.6	28.3	24.2	28.7		
	P_1	18.9	32.4	30.2	36.2	29.43	
	P_1	17.8	31.0	28.8	28.5	26.53	27.98
	P_2	23.3	36.9	23.1	33.0		
P_1 and $P_1(R)$ means over dwarf donor parents	P_1	33.5	35.5	32.8	30.8		
	$P_1(R)$	29.1	36.6	33.0	30.0		
Mean of P_1 and $P_1(R)$ for the tester parent		31.3	36.1	33.9	30.6		

Table 4 c. Coefficient of variation per cent for F_1 and $F_1(R)$ hybrids in comparison with the parents.

Number of internodes							
Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_1(R)$ means over tester parents	Mean of F_1 and $F_1(R)$ for the dwarf parent
		00 29	TKM 6	00 33	00 13		
DOWG	P_1	9.2	8.2	8.4	7.3	11.20 8.38	9.79
	F_1	10.0	14.9	10.9	9.0		
	$F_1(R)$	3.7	10.7	13.1	6.0		
	P_2	3.2	10.3	10.3	7.6		
5824	P_1	11.3	10.8	10.4	4.4	8.98 9.68	9.33
	F_1	10.8	8.2	7.9	9.0		
	$F_1(R)$	9.0	10.4	11.1	8.2		
	P_2	9.4	8.6	10.0	8.0		
T(N)1	P_1	9.4	9.0	12.2	12.2	8.08 8.50	8.29
	F_1	7.3	6.5	9.1	9.4		
	$F_1(R)$	7.9	6.5	10.9	8.7		
	P_2	6.5	5.4	13.3	9.0		
00 29-M-40	P_1	9.3	8.5	8.8	11.1	9.43 9.23	9.33
	F_1	8.7	8.2	11.4	9.4		
	$F_1(R)$	8.2	5.0	15.1	8.6		
	P_2	3.8	7.8	10.1	8.4		
TKM 6-10-12	P_1	9.0	7.1	7.9	8.7	9.10 9.03	9.07
	F_1	7.0	10.8	11.4	7.2		
	$F_1(R)$	6.6	10.9	10.9	7.7		
	P_2	8.2	6.3	7.1	7.6		
00 33-9	P_1	6.0	7.9	8.5	13.8	7.55 7.23	7.39
	F_1	7.7	4.4	8.8	9.3		
	$F_1(R)$	5.0	7.1	9.8	7.0		
	P_2	6.5	9.1	6.0	7.9		
F_1 and $F_1(R)$ means over dwarf donor parent	F_1	8.6	8.8	9.9	8.9		
	$F_1(R)$	6.7	8.4	11.8	7.7		
Mean of F_1 and $F_1(R)$ for the tester parent		7.7	8.6	10.9	8.3		

Table 4 d. Coefficient of variation per cent for F_1 and $F_1(R)$ hybrids in comparison with the parents.

Leaf area

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_1(R)$ means over tester parents	Mean of F_1 and $F_1(R)$ for the dwarf parent
		GO 29	TKN 6	GO 33	GO 13		
DWS	P_1	13.4	12.6	17.5	26.3		
	F_1	19.3	16.8	10.8	11.0	14.48	13.88
	$F_1(R)$	11.4	16.1	15.8	9.8	13.26	
	P_2	13.7	11.2	13.9	17.2		
3824	P_1	12.8	9.0	10.2	15.6		
	F_1	12.9	16.7	10.1	13.6	13.33	13.59
	$F_1(R)$	17.2	10.2	13.3	14.7	13.85	
	P_2	14.6	20.9	8.0	13.2		
T(R)1	P_1	12.0	16.7	9.1	9.1		
	F_1	10.5	12.3	10.8	9.1	10.68	11.56
	$F_1(R)$	7.7	11.2	15.6	15.2	12.43	
	P_2	11.7	13.6	13.3	11.5		
GO 29-N-40	P_1	8.3	8.0	12.9	10.2		
	F_1	11.8	13.3	11.8	12.1	12.75	12.05
	$F_1(R)$	7.0	9.0	20.6	8.8	11.33	
	P_2	10.9	16.2	12.8	17.0		
TKN 6-10-12	P_1	11.5	18.9	13.2	14.2		
	F_1	16.1	19.8	13.0	14.8	15.93	15.46
	$F_1(R)$	15.3	17.6	12.0	14.8	14.98	
	P_2	11.6	16.9	11.6	17.0		
GO 33-9	P_1	21.1	16.1	19.7	16.6		
	F_1	14.1	10.8	18.1	14.5	14.38	11.92
	$F_1(R)$	11.9	9.5	6.9	9.5	9.43	
	P_2	18.1	18.4	15.6	13.4		
F_1 and $F_1(R)$ means over dwarf donor parents	F_1	14.1	15.3	12.4	12.5		
	$F_1(R)$	11.8	12.3	14.0	12.1		
Mean of F_1 and $F_1(R)$ for the tester parent		13.0	13.8	13.2	12.3		

Table 4 e. Coefficient of variation per cent for F_1 and $F_1(R)$ hybrids in comparison with the parents.

Panicle length

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_1(R)$ means over tester parents	Mean of F_1 and $F_1(R)$ for the dwarf parent
		00 29	TKM 6	00 33	00 13		
DONG	P_1	7.5	5.5	5.9	6.7	6.35	6.43
	F_1	6.5	7.0	4.9	7.0		
	$F_1(R)$	7.4	7.7	7.0	5.9		
	P_2	5.8	4.1	5.5	6.2		
5824	P_1	5.1	5.7	5.2	5.1	6.00	5.60
	F_1	4.0	6.4	7.7	5.9		
	$F_1(R)$	5.7	5.4	6.6	5.1		
	P_2	5.3	6.4	6.1	4.6		
T(W)1	P_1	5.7	5.7	6.3	6.3	6.90	6.30
	F_1	7.7	7.6	5.4	6.9		
	$F_1(R)$	4.4	6.7	5.7	6.0		
	P_2	6.9	6.4	6.5	5.1		
00 29-M-40	P_1	5.1	5.0	6.6	5.1	6.65	6.72
	F_1	5.5	7.5	8.3	5.4		
	$F_1(R)$	4.2	8.0	9.2	5.8		
	P_2	4.2	5.9	5.9	5.1		
TKM 6-10-12	P_1	6.4	6.0	5.6	6.5	8.45	8.08
	F_1	7.2	9.4	7.7	9.5		
	$F_1(R)$	6.7	6.6	8.0	9.5		
	P_2	7.5	7.6	7.6	4.5		
00 33-9	P_1	6.0	5.2	4.8	4.8	6.10	6.24
	F_1	8.0	4.6	7.3	4.5		
	$F_1(R)$	9.4	5.6	5.8	4.7		
	P_2	6.7	7.4	6.5	4.9		
F_1 and $F_1(R)$ means over dwarf donor parents		F_1	6.5	7.1	6.9	6.5	
		$F_1(R)$	6.4	6.3	7.1	5.8	
Mean of F_1 and $F_1(R)$ for the tester parent			6.5	6.7	7.0	6.2	

Table 4 f. Coefficient of variation per cent for P_1 and $P_1(R)$ hybrids in comparison with the parents.

Number of grains per panicle

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				P_1 and $P_1(R)$ means over tester parents	Mean of P_1 and $P_1(R)$ for the dwarf parent
		00 29	IKM 6	00 33	00 13		
DGWG	P_1	14.9	11.1	13.0	19.2	18.60 14.45	16.33
	P_1	22.8	21.8	16.7	13.1		
	$P_1(R)$	14.1	16.2	14.9	12.6		
	P_2	13.1	16.4	14.7	16.9		
5824	P_1	13.2	13.1	13.0	16.7	20.35 18.75	19.63
	P_1	22.4	15.4	19.9	24.5		
	$P_1(R)$	21.3	21.6	9.7	22.4		
	P_2	11.6	23.5	17.6	17.1		
T(N)1	P_1	17.1	17.5	18.3	18.3	15.63 18.48	17.08
	P_1	13.6	16.7	11.4	18.8		
	$P_1(R)$	22.2	19.6	12.7	19.4		
	P_2	16.6	16.0	18.3	17.7		
00 29-M.40	P_1	16.2	15.3	18.0	10.3	13.43 16.43	15.94
	P_1	12.1	20.2	7.5	21.9		
	$P_1(R)$	16.7	13.1	20.2	15.8		
	P_2	13.8	13.3	17.5	18.3		
IKM 6-10-12	P_1	16.1	21.2	13.4	15.8	19.20 19.03	19.53
	P_1	18.3	18.5	15.0	24.8		
	$P_1(R)$	18.4	13.7	23.8	23.3		
	P_2	13.8	20.2	16.3	16.2		
00 33-9	P_1	16.3	12.3	13.7	17.6	17.10 13.33	15.22
	P_1	12.1	16.1	21.6	18.6		
	$P_1(R)$	12.9	12.6	14.9	12.9		
	P_2	19.9	19.0	16.3	19.8		
P_1 and $P_1(R)$ means over dwarf donor parents		P_1	17.3	18.1	13.4	20.3	
		$P_1(R)$	17.6	16.1	16.0	17.8	
Mean of P_1 and $P_1(R)$ for the tester parent			17.5	17.1	13.7	19.1	

Table 4 g. Coefficient of variation per cent for F_1 and $F_1(R)$ hybrids in comparison with the parents.

Weight of grains per panicle

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_1(R)$ means over tester parents	Mean of F_1 and $F_1(R)$ for the dwarf parent
		00 29	TKN 6	00 33	00 13		
DGW	P_1	16.3	15.3	18.2	16.1	22.63 15.20	18.92
	F_1	23.6	24.7	23.8	18.4		
	$F_1(R)$	6.9	19.2	21.9	12.8		
	P_2	21.8	19.2	15.0	19.9		
5824	P_1	17.9	16.3	17.1	17.3	18.95 17.30	18.15
	F_1	16.9	18.4	15.3	23.0		
	$F_1(R)$	22.1	14.3	12.1	20.7		
	P_2	17.0	23.1	15.2	18.3		
T(H)1	P_1	23.1	23.3	22.0	23.0	21.30 17.88	19.69
	F_1	23.7	17.0	18.0	27.3		
	$F_1(R)$	15.8	13.6	20.0	22.1		
	P_2	19.3	26.1	20.1	22.0		
00 29-M-40	P_1	23.0	18.3	23.7	23.0	20.65 18.88	19.77
	F_1	12.8	14.1	27.0	28.7		
	$F_1(R)$	16.1	15.1	26.9	17.4		
	P_2	26.6	24.1	24.1	22.1		
TKN 6-10-12	P_1	15.4	21.6	15.1	18.4	27.00 23.60	25.30
	F_1	28.2	23.2	18.0	38.6		
	$F_1(R)$	22.7	14.3	27.0	30.2		
	P_2	17.5	27.1	20.3	24.2		
00 33-9	P_1	17.8	15.8	15.3	19.7	18.20 15.15	16.68
	F_1	16.6	16.3	24.4	15.3		
	$F_1(R)$	14.0	14.4	17.8	14.4		
	P_2	23.0	24.0	21.4	17.8		
F_1 and $F_1(R)$ means over dwarf donor parents	F_1	20.3	19.0	21.1	23.6		
	$F_1(R)$	16.3	15.2	21.0	19.6		
Mean of F_1 and $F_1(R)$ for the tester parent		18.3	17.1	21.1	22.6		

Table 4 b. Coefficient of variation per cent for F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

1000 grain weight

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_{1(R)}$ means over tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		GO 29	TKM 6	GO 33	GO 13		
DGWO	P_1	4.1	3.9	3.6	3.9		
	P_1	5.9	4.2	7.5	4.8	5.60	
	$F_{1(R)}$	6.6	5.5	12.0	5.7	7.45	6.55
	P_2	3.3	5.8	4.2	6.5		
5824	P_1	2.7	3.3	4.4	3.1		
	P_1	5.8	7.6	14.5	2.8	7.68	
	$F_{1(R)}$	7.0	7.0	12.0	3.5	7.38	7.55
	P_2	4.6	6.1	4.7	3.7		
T(N)1	P_1	4.1	5.4	4.7	5.5		
	P_1	6.1	6.6	8.6	5.5	6.70	
	$F_{1(R)}$	8.0	8.0	13.5	6.6	9.05	7.87
	P_2	5.0	3.8	5.7	4.2		
GO 29-M.40	P_1	3.2	2.6	2.9	2.8		
	P_1	2.8	4.2	9.3	5.4	5.45	
	$F_{1(R)}$	5.4	4.6	13.1	3.6	6.68	6.06
	P_2	2.0	5.2	5.8	4.2		
TKM 6-10-12	P_1	3.1	4.0	2.6	3.1		
	P_1	4.4	3.9	6.9	5.9	5.28	
	$F_{1(R)}$	5.6	5.5	7.1	12.6	7.70	6.49
	P_2	4.3	5.5	5.5	5.5		
GO 33-9	P_1	3.8	2.8	3.6	3.8		
	P_1	6.2	3.7	7.3	6.6	5.95	
	$F_{1(R)}$	10.9	3.9	4.2	8.2	6.80	6.38
	P_2	5.9	4.7	6.1	3.7		
F_1 and $F_{1(R)}$ means over dwarf parents	F_1	5.2	5.0	9.0	5.2		
	$F_{1(R)}$	7.3	5.8	10.5	6.7		
Mean of F_1 and $F_{1(R)}$ for the tester parent		6.3	5.4	9.7	6.0		

Table 4 1. Coefficient of variation per cent for F_1 and $F_{1(R)}$ hybrids in comparison with the parents.

Grain yield per plant

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_{1(R)}$ means over tester parents	Mean of F_1 and $F_{1(R)}$ for the dwarf parent
		00 29	TKM 6	00 33	00 13		
DGW8	P_1	34.1	42.3	30.3	27.6		
	F_1	48.7	47.4	33.8	33.1	45.75	44.22
	$F_{1(R)}$	42.6	48.1	41.4	38.6	42.88	
	P_2	43.3	41.7	19.9	28.2		
5R24	P_1	27.3	32.7	34.8	34.7		
	F_1	44.7	41.4	37.6	40.3	41.05	42.03
	$F_{1(R)}$	40.7	48.4	38.9	44.0	43.00	
	P_2	34.3	30.6	41.8	22.6		
T(N)1	P_1	24.7	30.2	33.7	30.6		
	F_1	30.3	41.9	27.2	28.2	31.95	34.09
	$F_{1(R)}$	37.8	39.6	33.2	34.3	36.23	
	P_2	30.3	33.3	32.0	29.3		
00 29-N-40	P_1	31.7	28.2	38.8	37.3		
	F_1	32.3	32.1	41.8	30.3	34.23	34.87
	$F_{1(R)}$	30.7	33.4	43.1	32.8	33.30	
	P_2	32.2	43.3	32.0	23.6		
TKM 6-10-12	P_1	48.1	46.4	42.7	40.3		
	F_1	42.7	33.8	40.3	46.9	40.93	40.46
	$F_{1(R)}$	27.6	33.2	33.7	43.4	39.98	
	P_2	29.1	31.0	30.3	26.6		
00 33-9	P_1	29.1	33.3	17.9	33.3		
	F_1	22.2	33.9	47.7	31.3	33.78	31.92
	$F_{1(R)}$	21.8	33.1	32.8	30.3	30.05	
	P_2	30.0	39.7	34.6	26.7		
F_1 and $F_{1(R)}$ means over dwarf donor parents	P_1	36.9	38.4	38.1	38.4		
	$F_{1(R)}$	33.3	39.6	40.9	37.6		
Mean of F_1 and $F_{1(R)}$ for the tester parent		33.2	39.0	39.5	38.0		

Table 4 1. Coefficient of variation per cent for F_1 and $F_1(R)$ hybrids in comparison with the parents.

Grain yield per plant

Dwarf donor parents (P_1)	Genera- tion	Tester parents (P_2)				F_1 and $F_1(R)$ means over tester parents	Mean of F_1 and $F_1(R)$ for the dwarf parent
		00 29	TKM 6	00 33	00 15		
DGW8	P_1	34.1	42.3	30.5	27.6		
	F_1	48.7	47.4	33.8	33.1	43.75	44.22
	$F_1(R)$	42.6	48.1	41.4	38.6	42.68	
	P_2	45.3	41.7	19.9	28.2		
5R24	P_1	27.3	32.7	34.8	34.7		
	F_1	44.7	41.4	37.6	40.3	41.05	42.03
	$F_1(R)$	40.7	48.4	38.9	44.0	43.00	
	P_2	34.3	30.6	41.8	22.6		
TKM 1	P_1	24.7	30.2	33.7	30.6		
	F_1	30.3	41.9	27.2	28.2	31.95	34.09
	$F_1(R)$	37.8	39.6	33.2	34.3	36.23	
	P_2	30.3	33.3	32.0	29.3		
00 29-N-40	P_1	31.7	28.2	38.8	37.3		
	F_1	32.3	32.1	41.8	30.3	34.23	34.87
	$F_1(R)$	30.7	33.4	45.1	32.8	33.30	
	P_2	32.2	43.3	32.0	23.6		
TKM 6-10-12	P_1	48.1	46.4	42.7	40.3		
	F_1	42.7	33.8	40.3	46.9	40.93	40.46
	$F_1(R)$	27.6	33.2	33.7	43.4	39.98	
	P_2	29.1	31.0	30.3	26.6		
00 33-9	P_1	29.1	33.3	17.9	33.3		
	F_1	22.2	33.9	47.7	31.3	33.78	31.92
	$F_1(R)$	21.8	33.1	32.8	30.3	30.03	
	P_2	30.0	39.7	34.6	26.7		
F_1 and $F_1(R)$ means over dwarf donor parents	F_1	36.9	38.4	38.1	38.4		
	$F_1(R)$	33.5	39.6	40.9	37.6		
Mean of F_1 and $F_1(R)$ for the tester parent		35.2	39.0	39.5	38.0		

Table 5 a. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1), tall parent (d_{11}) and dwarf parent (d_{111}).

Plant height (cm)							
Cross	d_1		d_{11}		d_{111}		
	P_1	$P_1(R)$	P_1	$P_1(R)$	P_1	$P_1(R)$	
DGWS x OO 29	- 1.82	15.36	-14.29	2.90	10.65	27.83	
TKM 6	- 4.46	12.94	-22.86	- 5.46	15.94	31.34	
OO 33	- 5.73	-15.37	-14.79	-24.43	5.33	- 6.31	
OO 13	-14.94	9.86	-40.62	-15.83	10.75	35.54	
5824 x OO 29	- 0.04	6.03	-20.55	-14.49	20.47	26.53	
TKM 6	13.96	- 6.97	-10.74	-31.66	38.65	17.73	
OO 33	- 7.78	- 6.52	-10.71	- 9.43	- 4.86	- 5.60	
OO 13	- 0.98	14.14	-30.18	-15.07	28.23	43.34	
Z(H)1 x OO 29	- 0.67	18.81	-27.86	- 8.38	26.53	46.01	
TKM 6	13.27	15.96	-13.15	-10.46	39.68	42.37	
OO 33	-11.88	-16.64	-17.47	-22.23	- 6.28	-11.05	
OO 13	-20.87	21.40	-49.91	- 7.65	8.18	50.44	
OO 29-N-40 x							
OO 29	24.31	24.71	- 7.20	- 6.80	55.83	56.23	
TKM 6	13.64	22.12	-23.33	-14.84	50.60	59.08	
OO 33	20.02	3.02	9.72	- 7.29	30.33	13.32	
OO 13	16.20	17.98	-31.59	-29.90	63.99	65.78	
TKM 6-10-12 x							
OO 29	-26.71	8.46	-39.45	-24.29	6.04	41.20	
TKM 6	-19.09	16.96	-45.53	- 9.50	7.38	43.43	
OO 33	-10.37	-14.85	-15.39	-19.69	- 5.36	- 9.84	
OO 13	-22.40	- 6.86	-60.53	-44.90	15.62	31.16	
OO 33-9 x							
OO 29	2.06	6.28	-29.31	-25.09	33.43	37.83	
TKM 6	-30.95	9.02	-60.90	-20.93	- 1.01	38.96	
OO 33	-13.19	- 9.07	-14.12	-10.00	-12.26	- 8.14	
OO 13	-34.41	28.13	-62.34	-19.80	13.52	76.06	

Table 5 b. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1) and better parent (d_{11}).

Cross	Tiller number			
	d_1		d_{11}	
	F_1	$F_{1(R)}$	F_1	$F_{1(R)}$
DGWO x 00 29	- 2.40	0.75	- 4.25	- 1.10
TKM 6	0.15	- 0.60	- 0.70	- 1.45
00 33	3.75	3.50	2.60	2.35
00 13	0.82	0.72	0.10	0
5824 x 00 29	- 1.45	- 0.10	- 2.30	- 0.95
TKM 6	1.77	1.22	1.60	1.05
00 33	1.72	2.67	1.65	2.60
00 13	1.32	1.27	- 0.30	- 0.35
T(N)1 x 00 29	- 4.25	- 4.98	- 5.30	- 6.05
TKM 6	- 0.50	- 0.50	- 1.05	- 1.05
00 33	2.02	0.87	2.00	0.85
00 13	- 2.25	- 3.55	- 2.65	- 3.95
00 29-N-40 x 00 29	- 0.65	0.95	- 1.10	0.50
TKM 6	4.17	2.52	3.45	1.80
00 33	5.60	3.25	3.40	1.05
00 13	3.17	6.57	3.00	6.40
TKM 6-10-12 x 00 29	4.12	5.17	3.00	4.05
TKM 6	- 2.85	- 1.58	- 4.10	- 2.85
00 33	5.27	3.72	4.70	3.15
00 13	3.05	3.55	1.85	2.35
00 33-9 x 00 29	6.65	1.80	6.60	1.75
TKM 6	- 1.80	2.05	- 2.00	1.85
00 33	4.20	3.35	4.15	3.30
00 13	1.75	1.55	1.60	1.40

Table 3 c. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1) and better parent (d_{11}).

Number of internodes

Cross	d_1		d_{11}	
	F_1	$F_{1(R)}$	F_1	$F_{1(R)}$
DGWG x 00 29	0.12	0.32	- 0.05	0.15
TKM 6	0.30	- 0.30	0.10	- 0.50
00 33	0.12	- 0.53	- 0.65	- 1.30
00 13	- 0.20	- 0.20	0.30	0.05
5824 x 00 29	- 0.15	0.17	- 0.60	- 0.30
TKM 6	0.07	0.02	- 0.25	- 0.30
00 33	0.60	0.85	0.50	0.75
00 13	0	0.10	- 0.55	- 0.45
T(N)1 x 00 29	0.35	0.75	0.05	0.45
TKM 6	0.25	0.25	0.05	0.05
00 33	- 0.18	- 0.28	- 0.70	- 0.80
00 13	- 0.15	0.05	- 0.15	0.05
00 29-M-40 x 00 29	- 0.05	0.02	- 0.30	- 0.25
TKM 6	- 0.15	0.27	- 0.70	- 0.30
00 33	- 0.65	- 0.60	- 0.70	- 0.65
00 13	0.17	0.57	- 0.15	0.05
TKM 6-10-12 x 00 29	- 0.20	0.30	- 0.25	0.25
TKM 6	- 0.25	0.40	- 0.60	0.05
00 33	- 0.68	- 0.88	- 0.70	- 0.90
00 13	- 0.30	- 0.25	- 0.75	- 0.70
00 33-9 x 00 29	0.17	0.52	- 0.30	0.05
TKM 6	- 0.60	0.15	- 1.05	0.30
00 33	- 1.05	- 0.98	- 1.10	- 1.05
00 13	- 0.28	1.02	- 1.10	0.20

Table 5 d. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1) and better parent (d_{11}).

Leaf area (cm²)

Cross	d_1		d_{11}	
	P_1	$P_{1(R)}$	P_1	$P_{1(R)}$
DGWG x 00 29	- 2.58	- 1.38	- 3.78	- 2.58
TKM 6	- 3.47	- 4.25	- 4.40	- 5.18
00 33	- 2.42	- 6.64	- 2.96	- 7.18
00 13	- 3.88	- 2.58	- 5.39	- 4.09
5824 x 00 29	- 1.18	- 2.65	- 1.90	- 3.37
TKM 6	1.37	1.67	0.13	0.43
00 33	- 6.27	- 3.64	-11.47	- 8.84
00 13	- 1.47	- 1.23	- 2.26	- 2.02
T(N)1 x 00 29	- 2.11	- 1.58	- 2.22	- 1.69
TKM 6	- 1.70	- 0.25	- 2.25	- 0.80
00 33	- 1.36	- 2.28	- 1.95	- 2.87
00 13	- 6.68	- 7.02	- 9.73	-10.07
00 29-x-40 x 00 29	- 1.13	- 1.33	- 7.37	- 7.77
TKM 6	- 1.23	- 0.12	- 4.68	- 3.55
00 33	- 2.73	- 5.03	- 7.37	- 9.67
00 13	- 2.37	2.01	- 7.48	- 3.10
TKM 6-10-12 x 00 29	- 8.18	- 7.19	-12.90	-11.91
TKM 6	- 7.46	- 6.43	- 7.74	- 6.71
00 33	- 0.67	- 0.14	- 1.14	- 0.61
00 13	- 4.02	- 2.33	- 7.43	- 5.74
00 33-9 x 00 29	- 4.70	- 3.94	- 7.47	- 6.71
TKM 6	- 3.96	- 4.64	- 4.91	- 5.59
00 33	- 0.78	- 1.38	- 0.85	- 1.45
00 13	-14.17	- 8.60	-19.13	-13.56

Table 5 a. Comparative evaluation of heterosis and heterobeltiosis as deviation from the values of mid-parent (d_1) and better parent (d_{11}).

Panicle length (cm)

Cross	d_1		d_{11}	
	P_1	$P_{1(R)}$	P_1	$P_{1(R)}$
DGW6 x 00 29	0.03	1.40	- 0.35	1.03
TKM 6	2.45	1.11	1.59	0.25
00 33	- 0.39	- 1.54	- 0.72	- 1.87
00 13	0.59	0.56	0.07	1.04
5824 x 00 29	0.09	0.20	- 0.03	0.08
TKM 6	1.21	0.05	0.65	- 0.51
00 33	0.31	- 0.97	- 0.22	- 1.50
00 13	0.57	0.50	- 0.02	0.12
T(N)1 x 00 29	0.36	0.85	- 0.20	0.29
TKM 6	- 0.28	0.34	- 1.60	- 0.99
00 33	- 0.35	0.54	- 0.89	- 1.08
00 13	- 0.67	1.00	- 0.99	0.67
00 29-M-40 x 00 29	1.78	2.28	- 1.16	- 0.66
TKM 6	0.68	2.78	- 3.14	- 1.04
00 33	0.82	0.62	- 1.26	- 1.48
00 13	1.74	2.33	- 2.14	- 1.54
TKM 6-10-12 x 00 29	- 1.31	1.14	- 3.00	- 0.55
TKM 6	- 1.47	1.59	- 3.11	- 0.05
00 33	- 1.14	- 1.23	- 1.34	- 1.45
00 13	- 0.87	- 0.98	- 2.23	- 2.33
00 33-9 x 00 29	- 0.31	0.58	- 0.83	0.06
TKM 6	- 1.13	0.98	- 2.19	- 0.08
00 33	- 1.45	- 1.31	- 1.96	- 1.84
00 13	- 1.90	2.01	- 2.60	- 1.50

Table 5 f. Comparative evaluation of heterosis and heterobeltiosis as deviation from the values of mid-parent (d_1) and better parent (d_{11}).

Number of grains per panicle

Cross	d_1		d_{11}	
	P_1	$P_{1(R)}$	P_1	$P_{1(R)}$
DGW x 00 29	-17.88	-17.33	-22.95	-22.40
TKM 6	8.35	6.10	3.45	1.20
00 33	-30.60	-41.30	-47.80	-58.50
00 15	-15.88	- 8.53	-16.40	- 9.05
5824 x 00 29	- 1.65	9.05	- 4.35	6.15
TKM 6	18.35	4.90	7.75	- 5.70
00 33	- 7.80	- 2.35	-26.45	-21.00
00 15	- 0.40	- 0.85	- 5.50	- 5.95
T(N)1 x 00 29	-13.45	0.35	-13.80	0
TKM 6	4.42	9.27	2.75	7.60
00 33	-23.75	-17.10	-30.55	-21.90
00 15	-15.08	- 5.25	-17.95	- 8.10
00 29-N-40 x 00 29	9.77	14.47	- 7.20	- 2.50
TKM 6	6.57	18.07	-12.00	- 0.50
00 33	26.02	15.92	11.99	1.89
00 15	12.72	6.82	-10.50	-15.40
TKM 6-10-12 x 00 29	11.45	20.55	3.65	12.75
TKM 6	- 4.35	18.75	- 6.70	16.40
00 33	-18.30	-15.00	-18.65	-15.35
00 15	-27.18	-28.43	-29.45	-30.70
00 33-9 x 00 29	14.72	6.47	0.15	- 8.10
TKM 6	0.72	1.22	-14.30	-13.80
00 33	-12.75	- 6.85	-23.55	-17.65
00 15	- 1.98	-10.52	-15.80	- 3.30

Table 5 g. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1) and better parent (d_{11}).

Weight of grains per panicle (g)

Cross	d_1		d_{11}	
	F_1	$F_{1(R)}$	F_1	$F_{1(R)}$
DGWC x OO 29	- 0.52	- 0.45	- 0.71	- 0.63
TKM 6	- 0.12	0.38	- 0.36	0.15
OO 33	- 0.48	- 0.85	- 1.00	- 0.57
OO 13	- 0.42	- 0.11	- 0.45	- 0.15
5824 x OO 29	- 0.12	0.12	- 0.19	0.04
TKM 6	0.50	0.38	0.49	0.37
OO 33	- 0.33	- 0.45	- 0.49	0.60
OO 13	- 0.10	0.10	- 0.17	0.04
T(N)1 x OO 29	- 0.14	0.14	- 0.19	0.08
TKM 6	0.13	0.18	- 0.15	- 0.11
OO 33	- 0.37	- 0.48	- 0.44	- 0.54
OO 13	- 0.21	0.19	- 0.33	0.01
OO 29-x-40 x OO 29	0.02	0.12	- 0.43	- 0.32
TKM 6	0.27	0.41	0.03	0.17
OO 33	0.42	0.16	0.37	0.12
OO 13	0.20	0	- 0.45	- 0.65
TKM 6-10-12 x OO 29	- 0.19	0.46	- 0.47	0.19
TKM 6	- 0.04	0.58	- 0.07	0.34
OO 33	- 0.20	- 0.59	- 0.27	- 0.47
OO 13	- 0.75	- 0.86	- 1.01	- 1.12
OO 33-9 x OO 29	0.08	0.01	0	- 0.69
TKM 6	- 0.09	- 0.03	- 0.35	- 0.30
OO 33	- 0.29	- 0.26	- 0.52	- 0.49
OO 13	- 0.10	0.55	- 0.23	0.42

Table 5 h. Comparative evaluation of heterosis and heterobeltiosis as deviations from the values of mid-parent (d_1) and better parent (d_{11}).

1000 grain weight (g)

Cross	d_1		d_{11}	
	P_1	$P_1(R)$	P_1	$P_1(R)$
DGUG x GO 29	1.46	2.24	0.66	1.44
TKM 6	- 0.51	2.01	- 5.63	- 1.10
GO 33	0.48	- 3.12	- 5.14	- 6.74
GO 13	3.05	3.00	2.61	2.56
5824 x GO 29	0.20	- 0.71	- 0.84	- 1.76
TKM 6	- 0.27	1.09	- 4.12	- 2.75
GO 33	- 0.16	- 3.65	- 4.66	- 8.15
GO 13	0.01	0.58	- 0.15	0.22
T(H)1 x GO 29	1.99	0.51	1.94	0.47
TKM 6	1.46	- 0.51	- 0.62	- 2.39
GO 33	2.31	- 0.01	- 0.07	- 2.39
GO 13	1.42	1.60	0.03	0.21
GO 29-M-40 x GO 29	- 0.73	- 0.57	- 1.00	- 0.85
TKM 6	0.33	- 0.55	- 2.33	- 3.21
GO 33	- 2.79	- 3.64	- 5.39	- 6.25
GO 13	- 0.04	- 1.40	- 0.57	- 1.73
TKM 6-10-12 x GO 29	- 1.99	0.85	- 2.67	0.18
TKM 6	0.81	0.15	0.16	- 0.50
GO 33	0.08	- 2.68	- 1.27	- 4.03
GO 13	- 0.98	- 0.32	- 2.61	- 1.94
GO 33-9 x GO 29	- 2.21	- 0.41	- 4.31	- 2.52
TKM 6	- 0.81	- 0.51	- 1.14	- 0.64
GO 33	- 1.80	- 2.66	- 2.01	- 2.87
GO 13	- 2.94	0.56	- 5.34	- 1.83

Table 5 1. Comparative evaluation of heterosis and heterobeltiosis as deviation: from the values of mid-parent (d_1) and better parent (d_{11}).

Grain yield per plant (g)

Cross	d_1		d_{11}	
	P_1	$P_{1(R)}$	P_1	$P_{1(R)}$
DGWO x 00 29	- 9.40	- 2.22	12.16	- 4.98
TKM 6	- 5.24	5.85	- 5.32	5.76
00 33	- 4.66	- 7.62	- 9.70	-12.66
00 13	- 1.19	1.15	- 2.49	- 0.16
5824 x 00 29	- 5.42	4.18	- 4.96	- 0.78
TKM 6	6.82	5.15	5.29	4.62
00 33	1.00	2.08	- 0.97	0.12
00 13	1.91	5.10	- 0.92	0.28
T(N)1 x 00 29	-11.16	-11.26	-13.01	-13.11
TKM 6	- 0.41	- 0.74	- 2.65	- 2.98
00 33	- 5.09	- 1.96	- 5.98	- 2.85
00 13	- 5.12	- 1.27	- 3.64	- 1.79
00 29-M-40 x 00 29	- 2.00	2.15	- 8.67	- 4.51
TKM 6	8.70	8.50	5.47	5.26
00 33	4.24	1.58	2.45	- 0.22
00 13	9.50	4.38	5.57	- 1.55
TKM 6-10-12 x 00 29	5.67	14.01	- 0.64	9.70
TKM 6	- 5.31	0.95	- 5.67	- 1.45
00 33	2.25	- 1.38	0.99	- 2.64
00 13	- 7.29	- 8.19	-12.51	-13.40
00 33-9 x 00 29	8.51	2.89	7.12	1.71
TKM 6	- 4.58	2.05	- 6.40	0.05
00 33	0.65	0.86	- 0.17	0.06
00 13	4.45	8.85	5.72	8.12

Table 6 a. Mean performance of F_2 population.

Plant height (cm)

Dwarf donor parents	Genera- tion	Tester parents				Mean
		00 29	TKM 6	00 33	00 13	
DOWG	F_2	113.46	125.78	73.74	128.41	110.34
	$F_2(R)$	117.35	126.83	68.67	118.62	107.86
	SE	2.45	1.92	1.26	2.59	1.06
	GD ($P=0.05$)	ns	ns	3.49	7.18	ns
5824	F_2	95.15	97.15	67.71	109.97	92.49
	$F_2(R)$	99.13	106.51	65.11	113.26	96.00
	SE	2.25	2.55	1.05	3.22	1.49
	GD ($P=0.05$)	ns	7.07	ns	ns	ns
T(N)1	F_2	102.56	123.28	79.63	129.16	108.65
	$F_2(R)$	110.66	130.56	78.20	124.81	111.05
	SE	1.50	2.22	1.30	2.14	1.15
	GD ($P=0.05$)	4.16	6.15	ns	ns	ns
00 29-M-40	F_2	110.62	109.30	85.45	128.15	108.38
	$F_2(R)$	115.43	117.70	102.09	128.19	115.85
	SE	1.24	1.94	2.33	2.60	1.05
	GD ($P=0.05$)	3.44	5.38	6.52	ns	2.91
TKM 6-10-12	F_2	66.81	108.77	72.08	115.18	90.71
	$F_2(R)$	99.50	129.74	81.66	114.27	106.29
	SE	1.66	2.89	2.08	2.36	1.15
	GD ($P=0.05$)	4.60	8.01	5.76	ns	3.19
00 33-9	F_2	91.39	69.47	72.16	101.57	83.64
	$F_2(R)$	104.72	104.28	71.52	137.42	104.48
	SE	1.88	1.92	0.88	3.22	1.07
	GD ($P=0.05$)	5.21	5.32	ns	8.92	2.97

Table 6 b. Mean performance of F_2 population.

		Tiller number				
Dwarf donor parents	Genera- tion	Tester parents				Mean
		CO 29	TKM 6	CO 33	CO 13	
DOWG	F_2	11.23	11.48	10.93	9.35	10.74
	$F_2(R)$	13.25	10.13	12.54	9.28	11.30
	SE	0.56	0.49	0.43	0.46	0.22
	CD ($P=0.05$)	1.55	ns	ns	ns	ns
5824	F_2	10.00	11.79	12.01	10.45	11.06
	$F_2(R)$	9.29	13.40	11.55	10.30	11.13
	SE	0.41	0.56	0.62	0.40	0.16
	CD ($P=0.05$)	ns	1.55	ns	ns	ns
T(N)1	F_2	10.79	10.08	10.53	8.53	9.98
	$F_2(R)$	12.63	10.28	12.13	9.53	11.14
	SE	0.96	0.44	0.48	0.40	0.22
	CD ($P=0.05$)	ns	ns	1.33	ns	0.61
CO 29-M-40	F_2	11.38	12.31	6.48	9.75	9.98
	$F_2(R)$	11.21	12.74	9.13	10.74	10.95
	SE	0.44	0.63	0.41	0.44	0.24
	CD ($P=0.05$)	ns	ns	1.14	ns	0.67
TKM 6-10-12	F_2	11.23	10.71	7.53	11.03	10.13
	$F_2(R)$	10.84	12.28	7.96	12.03	10.78
	SE	0.41	0.46	0.39	0.54	0.22
	CD ($P=0.05$)	ns	1.27	ns	ns	ns
CO 33-9	F_2	10.03	9.18	9.49	10.60	9.82
	$F_2(R)$	9.93	11.04	8.93	11.49	10.34
	SE	0.32	0.51	0.42	0.41	0.21
	CD ($P=0.05$)	ns	1.41	ns	ns	ns
Mean	F_2	10.78	10.92	9.49	9.93	10.29
	$F_2(R)$	11.19	11.64	10.37	10.56	10.94
	SE	0.18	0.20	0.20	0.18	0.10
	CD ($P=0.05$)	ns	0.33	0.33	0.30	0.28

ns = not significant.

Table 6 c. Mean performance of F_2 population.

Number of internodes

Dwarf donor parents	Generation	Tester parents				Mean
		00 29	TKM 6	00 33	00 13	
DGWG	F_2	5.66	6.00	4.90	5.58	5.53
	$F_2(R)$	5.83	5.76	4.50	5.58	5.41
	SE	0.08	0.10	0.07	0.07	0.04
	CD ($P=0.05$)	ns	ns	0.19	ns	0.11
5824	F_2	5.13	5.78	4.51	5.35	4.69
	$F_2(R)$	5.10	5.08	4.64	5.65	5.11
	SE	0.08	0.19	0.09	0.07	0.06
	CD ($P=0.05$)	ns	ns	ns	0.17	0.17
T(N)1	F_2	5.34	5.48	5.28	5.71	5.45
	$F_2(R)$	5.35	5.86	5.46	5.59	5.56
	SE	0.43	0.07	0.08	0.45	0.01
	CD ($P=0.05$)	ns	0.19	ns	ns	0.03
00 29-M-40	F_2	5.49	5.41	5.21	5.54	5.41
	$F_2(R)$	5.51	5.54	5.29	5.64	5.49
	SE	0.44	0.07	0.08	0.08	0.04
	CD ($P=0.05$)	ns	ns	ns	ns	ns
TKM 6-10-12	F_2	4.69	5.51	4.79	5.50	5.12
	$F_2(R)$	5.31	5.60	4.80	5.73	5.36
	SE	0.09	0.10	0.06	0.07	0.04
	CD ($P=0.05$)	0.25	ns	ns	0.19	0.11
00 33-9	F_2	4.83	4.39	4.74	5.01	4.74
	$F_2(R)$	5.26	5.09	4.75	5.84	5.23
	SE	0.11	0.09	0.08	0.08	0.02
	CD ($P=0.05$)	0.30	0.25	ns	0.22	0.06
Mean	F_2	5.19	5.30	4.90	5.44	5.21
	$F_2(R)$	5.39	5.48	4.90	5.67	5.36
	SE	0.03	0.04	0.03	0.03	0.02
	CD ($P=0.05$)	0.08	0.11	ns	0.08	0.06

ns = Not significant.

Table 6 d. Mean performance of F_2 population.

Leaf area (cm ²)						
Dwarf donor parents	Genera- tion	Tester parents				Mean
		00 29	TKN 6	00 33	00 13	
DGRG	F ₂	24.31	29.14	21.50	27.43	25.59
	F ₂ (R)	23.72	22.80	18.50	24.26	22.32
	SE	0.48	0.53	0.52	0.84	1.80
	CD (P=0.05)	ns	1.47	1.44	2.33	ns
5824	F ₂	20.28	22.69	19.09	18.57	20.15
	F ₂ (R)	20.17	22.76	17.30	20.24	20.11
	SE	0.51	0.49	0.43	0.48	1.50
	CD (P=0.05)	ns	ns	1.19	1.33	ns
T(N)1	F ₂	22.00	26.13	23.00	23.82	23.73
	F ₂ (R)	22.34	24.65	24.50	22.77	23.56
	SE	0.43	0.76	0.61	0.43	0.29
	CD (P=0.05)	ns	ns	ns	ns	ns
00 29-M-40	F ₂	22.64	26.31	21.68	23.80	23.60
	F ₂ (R)	23.62	22.93	21.35	23.03	22.73
	SE	0.41	0.55	0.63	0.55	0.27
	CD (P=0.05)	ns	1.52	ns	ns	0.75
TKN 6-10-12	F ₂	17.56	21.22	21.72	23.90	21.10
	F ₂ (R)	20.05	23.61	25.75	23.62	23.25
	SE	0.58	0.59	0.62	0.54	0.29
	CD (P=0.05)	1.61	1.64	1.72	ns	0.80
00 33-9	F ₂	20.34	16.43	18.57	21.77	19.32
	F ₂ (R)	20.02	19.94	18.12	23.95	20.50
	SE	0.59	0.55	0.50	0.54	0.27
	CD (P=0.05)	ns	1.52	ns	1.50	0.75
Mean	F ₂	21.22	23.65	20.92	23.21	22.25
	F ₂ (R)	21.65	22.78	20.92	22.97	22.08
	SE	0.22	0.41	0.25	0.25	0.52
	CD (P=0.05)	ns	ns	ns	ns	ns

ns = not significant.

Table 6 e. Mean performance of F_2 population.

Panicle length (cm)

Dwarf donor parents	Genera- tion	Tester parents				Mean
		GO 29	TKM 6	GO 33	GO 13	
DOWO	F_2	20.61	22.94	19.46	22.49	21.36
	$F_{2(R)}$	20.91	21.61	18.21	21.26	20.50
	SE	0.20	0.24	0.16	0.33	0.12
	OD ($P=0.05$)	ns	0.67	0.44	0.91	0.33
5824	F_2	20.18	20.03	19.05	19.74	19.75
	$F_{2(R)}$	19.56	20.46	18.49	19.86	19.59
	SE	0.22	0.25	0.24	0.27	0.12
	OD ($P=0.05$)	0.61	ns	ns	ns	ns
T(N)1	F_2	20.04	21.61	20.26	22.56	21.12
	$F_{2(R)}$	20.14	22.59	21.02	21.17	21.23
	SE	0.25	0.28	0.23	0.22	0.10
	OD ($P=0.05$)	ns	0.78	0.64	0.61	ns
GO 29-M-40	F_2	19.17	19.40	17.05	20.97	19.15
	$F_{2(R)}$	19.71	19.95	18.19	19.82	19.42
	SE	0.16	0.24	0.31	0.42	0.14
	OD ($P=0.05$)	0.44	ns	0.86	ns	ns
TKM 6-10-12	F_2	17.75	19.96	19.67	21.35	19.68
	$F_{2(R)}$	19.41	22.15	19.98	20.92	20.62
	SE	0.21	0.28	0.26	0.24	0.13
	OD ($P=0.05$)	0.58	0.78	ns	ns	0.36
GO 33-9	F_2	18.55	16.96	18.93	18.84	18.27
	$F_{2(R)}$	18.95	20.20	21.21	19.96	20.08
	SE	0.35	0.25	0.16	0.14	0.12
	OD ($P=0.05$)	ns	0.69	0.44	0.39	0.33
Mean	F_2	19.55	20.15	19.07	20.99	19.89
	$F_{2(R)}$	19.78	21.16	19.52	20.50	20.27
	SE	0.18	0.16	0.11	0.12	0.07
	OD ($P=0.05$)	ns	0.44	0.30	0.33	0.19

ns = not significant.

Table 6 g. Mean performance of F_2 population.

Weight of grains per panicle (g)

Dwarf donor parents	Genera- tion	Tester parents				Mean
		CO 29	TKN 6	CO 33	CO 13	
DGWG	F_2	2.05	2.19	1.63	2.41	2.07
	$F_2(R)$	2.01	1.83	1.53	2.08	1.86
	SE	0.063	0.066	0.055	0.086	0.034
	GD ($P=0.05$)	ns	0.183	ns	0.238	0.094
5824	F_2	1.49	1.68	1.58	1.91	1.66
	$F_2(R)$	1.58	1.76	1.38	1.84	1.64
	SE	0.484	0.068	0.039	0.109	0.036
	GD ($P=0.05$)	ns	ns	0.108	ns	ns
T(N)1	F_2	1.51	1.83	1.65	2.12	1.78
	$F_2(R)$	1.69	2.08	1.83	1.79	1.85
	SE	0.056	0.068	0.055	0.073	0.033
	GD ($P=0.05$)	0.155	0.188	0.152	0.202	ns
CO 29-N-40	F_2	1.67	1.45	1.21	1.91	1.56
	$F_2(R)$	1.65	1.58	1.26	1.95	1.61
	SE	0.053	0.044	0.061	0.078	0.030
	GD ($P=0.05$)	ns	0.122	ns	ns	ns
TKN 6-10-12	F_2	1.47	1.32	1.60	2.17	1.64
	$F_2(R)$	1.62	1.58	1.56	2.01	1.69
	SE	0.056	0.083	0.062	0.076	0.035
	GD ($P=0.05$)	ns	0.230	ns	ns	ns
CO 33-9	F_2	1.63	1.19	1.70	1.78	1.58
	$F_2(R)$	1.73	1.62	1.79	2.00	1.79
	SE	0.054	0.046	0.050	0.050	0.025
	GD ($P=0.05$)	ns	0.127	ns	0.139	0.069
Mean	F_2	1.64	1.61	1.56	2.05	1.72
	$F_2(R)$	1.71	1.74	1.56	1.94	1.74
	SE	0.02	0.03	0.02	0.03	0.03
	GD ($P=0.05$)	0.05	0.08	ns	0.08	ns

ns = not significant.

Table 6 h. Mean performance of F_2 population.

1000 grain weight (g)

Dwarf donor parents	Genera- tion	Tester parents				Mean
		CO 29	TKM 6	CO 33	CO 13	
DQWG	F_2	23.90	22.55	20.97	25.48	23.18
	$F_{2(R)}$	23.32	20.79	19.04	23.59	21.69
	SE	0.2118	0.2408	0.3281	0.2175	0.1269
	CD (P=0.05)	ns	0.6674	0.9093	0.6028	0.3317
5824	F_2	24.90	21.27	19.11	25.00	22.57
	$F_{2(R)}$	24.21	20.32	19.01	24.27	21.95
	SE	0.2098	0.7339	0.7772	0.2032	0.4729
	CD (P=0.05)	0.5814	ns	ns	0.5632	ns
T(N)1	F_2	22.96	19.21	19.53	23.69	21.33
	$F_{2(R)}$	22.84	18.89	18.23	22.96	20.73
	SE	0.2976	0.7167	0.3025	0.2653	0.1887
	CD (P=0.05)	ns	ns	0.8384	ns	0.5230
CO 29-M-40	F_2	22.78	21.12	19.17	22.92	21.50
	$F_{2(R)}$	22.53	19.33	16.47	22.90	20.31
	SE	0.1471	0.1830	0.3699	0.2416	0.1255
	CD (P=0.05)	ns	0.5210	1.0252	ns	0.3478
TKM 6-10-12	F_2	20.23	19.36	16.61	23.15	19.84
	$F_{2(R)}$	22.14	19.76	17.86	22.28	20.51
	SE	0.1274	0.1731	0.3595	0.5385	0.1706
	CD (P=0.05)	0.3531	ns	0.9963	ns	0.4728
CO 33-9	F_2	19.11	17.12	18.09	20.85	18.79
	$F_{2(R)}$	20.69	17.94	17.78	23.40	19.95
	SE	0.3047	0.2127	0.1865	0.3800	0.1402
	CD (P=0.05)	0.8445	0.5095	ns	1.0531	0.3886
Mean	F_2	22.31	20.07	18.91	23.52	21.20
	$F_{2(R)}$	22.62	19.51	17.40	23.23	20.69
	SE	0.11	0.21	0.19	0.14	0.05
	CD (P=0.05)	0.30	0.58	0.53	ns	0.14

ns = not significant.

Table 6 i. Mean performance of F_2 population.

Grain yield per plant (g)

Dwarf donor parents	Genera- tion	Tester parents				Mean
		OO 29	TKN 6	OO 33	OO 13	
DGWG	F_2	21.75	24.12	13.19	19.54	19.65
	$F_2(R)$	24.51	18.51	13.75	17.39	18.44
	SE	1.60	1.14	0.61	1.22	0.37
	CD (P=0.05)	ns	3.16	ns	ns	1.02
5824	F_2	13.54	16.43	15.89	16.49	15.59
	$F_2(R)$	12.54	19.74	13.95	17.15	15.85
	SE	0.70	1.04	1.06	0.90	0.46
	CD (P=0.05)	ns	ns	ns	ns	ns
T(N)1	F_2	15.21	17.70	16.61	16.90	16.61
	$F_2(R)$	19.18	19.51	20.68	15.08	18.61
	SE	1.00	1.19	1.04	0.88	0.31
	CD (P=0.05)	2.77	ns	2.88	ns	0.86
OO 29-M-40	F_2	17.39	14.76	9.79	17.99	14.98
	$F_2(R)$	17.69	15.70	9.20	17.83	15.11
	SE	0.96	0.92	0.74	0.83	0.37
	CD (P=0.05)	ns	ns	ns	ns	ns
TKN 6-10-12	F_2	12.79	19.71	11.80	20.67	16.24
	$F_2(R)$	16.57	20.73	12.33	20.71	17.54
	SE	1.04	1.03	0.72	1.12	0.50
	CD (P=0.05)	2.88	ns	ns	ns	ns
OO 33-9	F_2	13.97	9.76	15.23	14.66	13.41
	$F_2(R)$	14.56	15.03	16.56	20.32	16.57
	SE	0.78	0.82	0.94	0.82	0.41
	CD (P=0.05)	ns	2.27	ns	2.27	1.14
Mean	F_2	15.78	17.08	13.75	17.71	16.08
	$F_2(R)$	17.41	18.17	14.41	18.08	17.02
	SE	0.45	0.38	0.38	0.35	0.30
	CD (P=0.05)	1.25	1.05	ns	ns	0.78

ns = not significant.

Table 7 a. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Plant height

Cross	Phenotypic variance		Genotypic variance		PCV (%)		GCV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWG x 00 29	346.47	618.62	263.46	553.02	16.4	21.2	14.3	20.0
TKM 6	281.82	310.65	197.28	222.89	13.3	13.9	11.2	11.8
00 33	116.79	135.80	76.30	93.10	14.7	17.0	11.9	14.1
00 13	507.91	566.46	380.25	464.53	17.6	20.1	15.2	18.2
5824 x 00 29	360.02	451.59	210.09	260.91	19.9	21.4	15.2	16.3
TKM 6	490.50	548.00	443.33	374.68	22.8	22.0	21.7	18.2
00 33	136.09	130.04	94.57	89.67	17.2	17.5	14.4	14.5
00 13	802.77	851.88	664.34	760.60	23.8	23.8	23.4	24.4
I(N)1 x 00 29	1282.45	342.96	1233.00	292.79	34.9	16.7	34.2	15.5
TKM 6	583.35	202.70	515.68	112.09	19.6	10.9	18.4	8.1
00 33	191.16	75.93	170.59	51.67	17.6	11.1	16.4	9.2
00 13	290.44	439.96	223.92	373.98	13.2	16.8	11.6	15.5
30 29-M-40 x								
00 29	1118.91	128.98	84.99	89.17	9.9	9.8	8.3	8.2
TKM 6	354.08	250.60	312.07	212.87	17.2	13.4	16.2	12.4
00 33	734.62	151.94	708.39	100.85	31.7	12.1	31.1	9.8
00 13	793.30	287.51	713.78	204.05	22.0	13.2	20.8	11.1
TKM 6-10-12 x								
00 29	135.15	305.86	31.34	205.70	17.4	17.6	8.4	14.4
TKM 6	607.49	728.28	545.62	679.13	22.7	20.8	21.5	20.1
00 33	227.40	466.22	209.89	446.20	20.9	26.4	20.1	23.9
00 13	512.90	378.84	369.79	219.30	19.7	17.0	16.7	13.0
00 33-9 x								
00 29	249.30	314.51	174.35	225.12	17.3	16.9	14.4	14.3
TKM 6	214.49	377.56	183.92	315.09	21.1	18.6	19.3	17.0
00 33	91.02	31.95	71.11	13.96	13.2	7.9	11.7	3.2
00 13	863.34	793.55	787.88	627.98	29.0	20.5	27.6	18.2

Table 7 b. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

		Tiller number							
Cross		Phenotypic variance		Genotypic variance		POV (%)		GOV (%)	
		F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
MGW x	00 29	19.29	30.59	8.18	19.75	39.1	41.7	25.5	33.5
	TKM 6	23.04	13.51	12.17	1.96	41.8	36.5	30.4	13.8
	00 33	17.42	12.97	6.14	3.91	38.2	38.7	22.7	15.8
	00 13	19.80	14.56	10.07	4.45	47.6	41.1	33.9	22.7
1824 x	00 29	13.82	13.60	8.43	9.40	37.2	39.7	29.0	33.0
	TKM 6	20.32	29.03	15.04	22.94	38.4	40.2	32.9	33.7
	00 33	35.78	26.42	22.42	12.62	49.8	44.5	39.4	30.8
	00 13	13.36	11.76	5.13	4.44	35.0	33.3	21.7	20.5
E(W)1 x	00 29	17.07	17.43	4.63	7.15	38.3	33.1	19.9	21.1
	TKM 6	15.94	15.34	6.98	6.86	39.6	38.3	26.2	26.9
	00 33	16.92	20.62	7.83	10.08	39.1	37.4	26.6	6.5
	00 13	11.11	14.09	2.89	5.82	39.1	64.5	19.9	23.3
10 29-M-40 x	00 29	17.78	13.61	8.12	0 ¹	37.1	32.9	23.0	0 ¹
	TKM 6	31.99	32.20	16.12	18.85	45.9	44.5	32.6	34.1
	00 33	9.14	17.54	0 ¹	3.30	48.7	43.9	0 ¹	19.9
	00 13	15.53	15.41	4.92	1.56	40.4	36.6	22.7	11.6
TKM 6-10-12 x	00 29	12.47	14.06	6.67	6.59	31.4	34.6	23.0	23.7
	TKM 6	13.90	19.47	4.84	10.24	34.8	35.9	20.5	26.1
	00 33	9.99	12.39	4.59	6.53	42.0	53.9	28.5	32.1
	00 13	24.18	22.54	15.42	14.09	44.5	39.4	33.5	31.2
10 33-9 x	00 29	8.20	8.63	1.32	3.55	28.5	29.6	11.5	19.0
	TKM 6	19.43	21.43	12.99	13.06	48.0	41.9	39.3	32.7
	00 33	16.07	12.58	11.51	8.78	42.2	39.7	35.7	33.2
	00 13	12.61	14.23	2.20	5.81	33.5	32.8	14.0	21.0

1 = negative variance was obtained.

Table 7 a. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Number of internodes

Cross	Phenotypic variance		Genotypic variance		PCV (%)		GCV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
WFO x 00 29	0.38	0.75	0.14	0.62	10.9	14.9	6.6	13.5
TKM 6	0.73	0.74	0.29	0.41	14.2	14.9	9.0	11.1
00 33	0.39	0.35	0.10	0.05	12.7	13.1	6.5	5.0
00 13	0.37	0.32	0.15	0.15	10.9	10.1	6.9	6.9
824 x 00 29	0.54	0.57	0.23	0.28	14.3	14.8	9.3	10.4
TKM 6	0.54	0.60	0.27	0.29	14.6	15.2	10.3	10.6
00 33	0.35	0.40	0.15	0.15	13.1	13.6	8.6	7.8
00 13	0.38	0.31	0.20	0.14	11.5	9.9	8.4	6.6
N(N)1 x 00 29	0.77	0.43	0.57	0.21	16.4	12.3	14.1	8.6
TKM 6	0.33	0.40	0.16	0.23	10.5	10.8	7.3	8.2
00 33	0.51	0.56	0.16	0.19	13.5	13.7	7.6	8.0
00 13	0.49	0.55	0.16	0.23	12.3	13.3	7.0	8.6
10 29-M-40 x								
00 29	0.30	0.40	0.12	0.23	10.0	11.5	6.3	8.7
TKM 6	0.40	0.38	0.17	0.20	11.7	11.1	7.6	8.1
00 33	0.63	0.51	0.38	0.20	15.2	13.3	11.8	8.5
00 13	0.43	0.58	0.12	0.28	11.8	13.5	6.3	9.4
TKM 6-10-12 x								
00 29	0.45	0.80	0.24	0.59	14.3	16.8	10.4	14.5
TKM 6	0.63	1.04	0.41	0.81	14.4	18.2	11.6	16.1
00 33	0.32	0.29	0.13	0.11	11.8	11.2	7.5	6.9
00 13	0.33	0.41	0.14	0.21	10.4	11.2	6.8	8.0
10 33-9 x								
00 29	0.98	0.80	0.83	0.69	20.5	17.0	18.9	15.8
TKM 6	0.54	0.66	0.37	0.45	16.7	16.0	13.9	13.2
00 33	0.47	0.49	0.33	0.34	14.5	14.7	12.1	12.3
00 13	0.70	0.42	0.37	0.10	16.7	11.1	12.1	5.4

Table 7 d. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Leaf area

Cross	Phenotypic variance		Genotypic variance		PCV (%)		GCV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
OGWG x GO 29	18.81	18.23	3.23	6.96	17.8	18.0	7.4	11.1
TKM 6	29.70	14.77	2.31	6.93	18.7	16.9	15.8	15.6
GO 33	22.45	21.39	4.49	2.29	22.0	23.0	9.6	8.2
GO 13	63.95	50.19	39.71	26.15	26.9	29.2	23.0	21.1
5824 x GO 29	24.23	19.74	16.95	11.34	24.3	22.0	20.3	16.7
TKM 6	17.77	19.75	8.13	12.48	18.6	19.5	12.6	15.5
GO 33	18.18	11.57	12.05	3.69	22.3	19.7	18.2	11.1
GO 13	20.84	15.77	13.27	7.79	24.6	19.6	19.6	13.8
F(N)1 x GO 29	16.52	12.70	10.17	7.02	18.5	16.0	14.3	11.9
TKM 6	42.05	50.35	32.46	40.84	24.8	28.8	21.8	23.9
GO 33	38.12	22.32	32.66	15.44	26.8	19.3	24.8	16.0
GO 13	19.63	10.28	13.87	2.93	18.6	14.1	15.6	7.5
JO 29-M-40 x								
GO 29	16.07	11.03	10.18	6.48	17.7	14.1	14.1	10.8
TKM 6	34.08	14.54	26.68	8.64	22.2	16.6	19.6	12.8
GO 33	45.76	17.73	39.37	9.36	31.2	19.7	28.9	14.3
GO 13	34.52	13.54	26.90	6.17	24.7	16.0	21.8	10.8
TKM 6-10-12 x								
GO 29	20.21	34.28	5.72	19.78	23.6	29.2	13.6	22.2
TKM 6	18.92	36.39	6.13	23.84	20.5	23.5	11.7	20.7
GO 33	20.29	40.85	15.00	33.76	20.7	24.8	17.8	23.2
GO 13	15.96	29.98	2.46	15.93	16.7	23.2	6.6	16.9
GO 33-9 x								
GO 29	29.63	26.27	12.40	9.62	26.3	23.6	17.1	13.3
TKM 6	19.93	27.92	7.58	15.97	27.2	26.3	16.6	20.0
GO 33	19.44	20.52	8.28	12.47	23.7	23.0	13.3	19.3
GO 13	20.70	26.32	3.28	9.50	20.9	21.4	8.3	12.9

Table 7 a. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Panicle length

cross	Phenotypic variance		Genotypic variance		POV (%)		GOV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
GWG x 00 29	5.73	2.87	1.75	0.59	9.4	8.1	6.4	3.7
TKM 6	5.47	3.66	3.79	1.88	10.2	8.9	8.5	6.5
00 33	2.34	1.87	1.06	0.31	7.9	7.5	5.3	3.1
00 13	6.92	10.91	4.85	9.35	11.7	15.5	9.8	14.4
824 x 00 29	3.83	4.15	2.83	2.90	9.7	10.4	8.3	8.7
TKM 6	5.16	4.59	3.63	3.58	11.3	10.5	9.5	9.2
00 33	4.69	4.61	3.13	3.66	11.4	11.6	9.3	10.3
00 13	8.57	5.51	7.51	2.51	14.8	9.4	13.9	7.7
(N)1 x 00 29	4.97	4.82	3.14	3.37	11.1	10.9	8.8	9.1
TKM 6	7.26	5.29	5.49	3.67	12.5	10.2	10.8	8.5
00 33	4.20	4.64	2.63	3.03	10.1	10.2	8.0	8.3
00 13	2.96	4.56	1.25	2.94	7.6	10.1	5.0	8.1
10 29-M-40 x								
00 29	2.50	1.71	1.85	1.17	8.3	6.6	7.1	5.5
TKM 6	5.86	3.13	4.52	1.50	12.5	8.9	11.0	6.1
00 33	11.69	3.51	10.35	1.85	20.1	10.0	18.9	7.5
00 13	14.06	8.15	13.13	7.14	17.9	14.4	17.3	13.5
TKM 6-10-12 x								
00 29	3.00	4.12	0.93	1.99	9.8	10.5	5.4	7.3
TKM 6	8.97	3.75	6.44	1.59	15.0	8.7	12.7	5.7
00 33	4.88	5.93	3.17	4.17	11.2	12.2	9.1	10.2
00 13	4.74	4.69	2.81	2.76	10.2	10.4	7.9	7.9
10 33-9 x								
00 29	9.71	9.96	7.67	7.50	17.0	16.6	15.1	14.5
TKM 6	4.56	5.95	3.05	4.22	12.6	12.1	10.3	10.2
00 33	1.95	2.16	0.65	1.06	7.4	6.9	4.3	4.9
00 13	1.67	1.40	0.72	0.30	6.9	5.9	4.5	2.7

Table 7 f. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Number of grains per panicle

Cross	Phenotypic variance		Genotypic variance		PCV (%)		GCV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWS x								
00 29	242.38	281.06	60.39	145.54	19.0	20.2	9.5	14.5
TKM 6	538.57	406.91	264.04	208.57	23.6	24.2	16.5	17.3
00 33	362.59	494.15	148.28	301.94	23.1	26.9	14.8	21.0
00 13	712.89	402.73	513.04	199.50	29.9	22.9	25.4	16.1
5824 x								
00 29	207.63	469.76	98.22	344.67	25.0	34.9	17.2	29.9
TKM 6	747.35	600.58	572.93	406.01	34.9	28.8	30.6	23.7
00 33	690.44	431.20	454.55	256.63	33.0	27.3	28.4	21.0
00 13	230.68	551.44	44.67	382.17	21.5	31.9	9.5	26.6
T(N)1 x								
00 29	311.20	451.09	149.41	217.37	26.0	27.0	18.0	18.7
TKM 6	684.46	513.01	481.77	270.85	29.3	22.1	24.6	16.1
00 33	556.04	494.60	328.88	255.19	26.9	22.4	20.7	16.1
00 13	462.70	333.74	230.58	78.36	24.7	25.0	17.4	12.1
00 29-M-40 x								
00 29	299.55	354.61	213.90	242.09	23.8	25.0	20.1	20.7
TKM 6	215.06	443.51	72.32	336.81	21.6	23.3	12.5	22.0
00 33	964.30	36.80	871.49	178.04	47.6	24.5	45.2	17.8
00 13	669.04	410.12	499.93	288.07	32.9	26.2	28.4	22.0
TKM 6-10-12 x								
00 29	419.64	374.32	232.37	169.14	27.8	25.6	20.7	17.2
TKM 6	308.44	320.77	51.44	68.80	34.1	19.9	8.1	9.2
00 33	916.57	930.57	770.82	723.10	32.8	34.4	30.1	30.3
00 13	339.25	264.02	144.68	79.26	20.0	19.0	13.1	10.4
00 33-9 x								
00 29	373.91	331.64	149.50	106.44	21.1	21.9	14.5	12.4
TKM 6	459.75	613.13	257.07	438.38	30.7	28.1	23.0	23.7
00 33	381.44	472.31	141.41	281.01	20.7	21.1	12.6	16.3
00 13	294.86	323.53	40.27	98.71	20.0	21.4	7.4	11.8

Table 7 g. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Weight of grains per panicle

Cross	Phenotypic variance		Genotypic variance		POV (%)		GOV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWG x CO 29	0.30	0.34	0.13	0.21	26.7	29.0	17.6	22.8
TKM 6	0.34	0.36	0.18	0.20	26.6	32.8	19.4	24.4
CO 33	0.22	0.27	0.09	0.16	28.8	34.0	18.4	26.1
CO 13	0.63	0.56	0.47	0.41	32.9	36.0	28.4	30.8
5824 x CO 29	0.15	0.20	0.06	0.07	26.0	28.3	16.4	16.7
TKM 6	0.40	0.35	0.30	0.28	37.6	33.6	32.6	30.1
CO 33	0.14	0.11	0.06	0.04	23.7	24.0	15.5	14.5
CO 13	1.05	0.84	0.90	0.70	53.6	49.8	50.0	45.5
2(N)1 x CO 29	0.25	0.26	0.10	0.13	33.1	30.2	20.9	21.3
TKM 6	0.35	0.41	0.19	0.26	32.3	30.8	23.8	24.5
CO 33	0.24	0.25	0.10	0.11	29.7	27.3	19.2	18.1
CO 13	0.53	0.33	0.28	0.09	34.3	32.1	25.0	16.8
CO 29-Y-40 x								
CO 29	0.23	0.21	0.09	0.07	28.7	27.8	12.0	16.0
TKM 6	0.19	0.14	0.10	0.04	30.1	23.7	21.8	12.7
CO 33	0.24	0.33	0.15	0.27	40.5	47.0	32.0	41.2
CO 13	0.53	0.42	0.37	0.31	38.8	33.2	31.8	28.6
TKM 6-10-12 x								
CO 29	0.18	0.31	0.06	0.17	28.9	34.4	16.7	25.5
TKM 6	0.22	0.34	0.07	0.20	29.7	36.9	20.0	28.3
CO 33	0.37	0.25	0.30	0.16	39.0	32.1	34.2	25.6
CO 13	0.51	0.43	0.29	0.25	32.9	32.6	24.8	24.9
CO 33-9 x								
CO 29	0.20	0.27	0.07	0.14	27.4	30.0	16.2	21.6
TKM 6	0.15	0.20	0.06	0.10	20.6	27.6	13.0	19.3
CO 33	0.20	0.20	0.09	0.12	26.3	25.0	17.6	19.4
CO 13	0.17	0.24	0.07	0.13	23.2	24.5	14.9	18.0

Table 7 h. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

1000 grain weight

Cross	Phenotypic variance		Genotypic variance		PCV (%)		GCV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWC x CO 29	3.61	3.57	2.25	1.94	7.9	8.1	6.3	6.0
TKM 6	3.05	6.23	2.07	4.94	7.8	12.0	6.4	10.7
CO 33	6.05	11.18	4.56	8.94	11.7	17.6	10.2	15.7
CO 13	3.64	3.93	1.94	2.00	7.5	8.4	5.5	6.0
5824 x CO 29	3.42	3.62	2.08	2.03	7.4	7.9	5.8	5.9
TKM 6	5.17	3.49	3.54	1.89	10.7	9.2	8.8	6.8
CO 33	19.01	12.04	14.98	9.73	22.8	18.3	20.3	16.4
CO 13	3.40	3.21	2.69	2.37	7.4	7.4	6.6	6.3
T(N)1 x CO 29	6.41	7.76	4.85	5.81	11.0	12.2	9.6	10.6
TKM 6	3.14	4.84	1.72	3.23	9.2	11.6	6.8	9.5
CO 33	8.79	5.85	6.90	2.79	15.2	13.3	13.4	9.2
CO 13	5.44	5.82	4.12	4.21	9.8	10.5	8.6	8.9
CO 29-M-40 x								
CO 29	1.85	1.61	1.44	0.83	6.0	5.6	5.3	4.0
TKM 6	1.69	3.97	0.96	3.22	6.2	10.3	4.6	9.3
CO 33	16.85	5.03	15.55	3.09	21.4	13.6	20.6	10.7
CO 13	4.62	4.73	3.53	3.98	9.4	9.5	8.2	8.7
TKM 6-10-12 x								
CO 29	0.96	1.84	0.30	1.10	4.8	6.1	2.7	4.7
TKM 6	1.88	2.92	1.06	1.93	7.1	8.6	5.3	7.0
CO 33	6.20	14.51	5.20	13.64	15.0	27.5	13.7	26.6
CO 13	21.22	25.18	19.96	21.87	19.9	22.5	19.3	21.0
CO 33-9 x								
CO 29	6.49	8.37	5.33	6.05	13.3	14.0	12.1	11.9
TKM 6	2.38	4.85	1.88	4.32	9.0	12.3	8.0	11.6
CO 33	3.28	2.28	2.25	1.60	10.0	8.5	8.3	7.1
CO 13	7.64	3.26	6.75	2.11	13.3	7.7	12.5	6.2

Table 7 1. Phenotypic variance, genotypic variance and their coefficients of variation (%) in F_2 population.

Grain yield per plant

Cross	Phenotypic variance		Genotypic variance		POV (%)		GOV (%)	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWG x OO 29	165.47	246.23	104.25	174.32	51.1	64.5	46.9	54.3
TKM 6	146.76	150.77	99.29	79.40	50.2	67.1	41.3	48.7
OO 33	29.93	28.99	10.33	9.96	41.5	39.2	24.4	23.0
OO 13	140.33	99.73	86.09	59.21	60.6	57.4	47.4	44.2
5324 x OO 29	43.74	34.14	19.36	4.90	48.8	46.6	32.5	17.6
TKM 6	74.21	98.95	52.58	75.71	52.4	50.4	44.1	44.0
OO 33	110.39	69.36	68.77	24.85	66.1	59.7	52.2	33.7
OO 13	67.68	60.59	37.98	25.52	49.9	45.4	37.4	29.5
T(N)1 x OO 29	79.00	80.79	36.96	33.89	58.4	46.9	40.0	30.4
TKM 6	134.30	91.39	98.97	58.26	65.5	49.0	56.2	39.1
OO 33	57.08	114.65	26.95	80.40	45.5	51.8	31.3	43.4
OO 13	76.29	46.53	50.35	15.41	51.7	45.2	42.0	26.0
OO 29-M-40 x								
OO 29	82.85	65.53	41.00	19.83	52.4	45.8	36.7	25.2
TKM 6	68.10	67.67	35.02	33.64	55.9	52.4	40.1	36.9
OO 33	44.26	43.79	33.69	35.52	68.0	71.9	59.3	64.8
OO 13	44.82	65.89	19.78	45.65	57.2	45.5	24.7	37.9
TKM 6-10-12 x								
OO 29	99.37	75.09	51.28	28.12	77.9	52.9	56.6	32.4
TKM 6	80.81	89.62	47.30	51.51	45.6	45.7	34.9	34.6
OO 33	34.41	48.74	9.15	27.36	49.7	56.6	25.6	42.4
OO 13	107.15	94.58	67.19	55.94	50.1	47.0	40.0	36.4
OO 33-9 x								
OO 29	48.80	47.33	15.59	18.76	50.0	47.9	28.3	30.2
TKM 6	37.88	69.55	15.07	39.33	63.1	55.5	39.8	41.7
OO 33	72.86	67.81	58.84	58.45	56.0	49.7	50.4	46.2
OO 13	34.75	72.97	6.68	39.49	40.2	42.0	17.6	30.9

Table 8 a. Sealing test.

Plant height (cm)

Nearby donor parents	Tester parents			
	OO 29	TEM 6	OO 33	OO 13
D88G				
O	11.43 ± 9.97	46.79 ± 9.18	-47.22 ± 5.94	41.01 ± 11.99
O _(R)	7.37 ± 11.98	16.19 ± 9.59	-48.22 ± 6.36	-47.73 ± 11.83
5824				
O	-14.07 ± 11.78	-59.84 ± 10.71	-54.26 ± 6.09	75.50 ± 13.23
O _(R)	-10.27 ± 13.47	19.46 ± 14.21	-66.30 ± 5.93	8.44 ± 14.63
Σ(N)1				
O	- 9.74 ± 16.44	13.69 ± 11.79	- 4.94 ± 6.57	72.84 ± 8.71
O _(R)	-16.30 ± 9.10	37.43 ± 8.74	- 1.12 ± 4.72	-29.08 ± 10.22
OO 29-N-40				
O	33.90 ± 5.87	16.56 ± 9.15	41.35 ± 12.56	68.20 ± 13.38
O _(R)	52.34 ± 6.33	33.20 ± 7.77	141.91 ± 7.49	64.80 ± 8.87
TEM 6-10-12				
O	-150.09 ± 7.18	36.74 ± 12.14	2.09 ± 7.08	50.03 ± 12.69
O _(R)	-89.65 ± 9.14	48.52 ± 12.80	49.37 ± 9.97	27.31 ± 12.01
OO 33-9				
O	-83.24 ± 8.26	-83.47 ± 7.02	25.51 ± 4.88	76.38 ± 14.28
O _(R)	-38.36 ± 9.48	-24.17 ± 10.05	14.71 ± 3.29	94.70 ± 15.58
$O = 4\bar{Y}_2 - 2\bar{Y}_1 - \bar{P}_1 - \bar{P}_2 \quad O(N) = 4\bar{Y}_2(N) - 2\bar{Y}_1(N) - \bar{P}_1 - \bar{P}_2$				

Table 8 b. Sealing test.

Tiller number

Dwarf donor parents	Tester parents				
	00 29	TEM 6	00 33	00 13	
D080	0	12.32 ± 2.81	12.22 ± 2.80	5.62 ± 2.88	2.65 ± 2.59
	0(r)	14.10 ± 3.03	8.32 ± 2.52	12.56 ± 2.47	2.57 ± 2.42
5024	0	10.30 ± 2.22	16.51 ± 2.53	8.29 ± 3.40	8.25 ± 2.33
	0(r)	4.76 ± 2.04	24.05 ± 2.91	4.55 ± 3.16	7.75 ± 2.20
3(N)1	0	- 0.89 ± 2.73	6.32 ± 2.38	0.97 ± 2.47	- 0.18 ± 2.04
	0(r)	7.97 ± 2.48	15.12 ± 2.33	9.67 ± 2.78	5.72 ± 2.19
00 29-N-40	0	1.62 ± 2.53	6.59 ± 3.64	-14.88 ± 2.85	- 2.45 ± 2.48
	0(r)	- 2.26 ± 2.88	11.61 ± 3.44	0.42 ± 3.08	- 5.29 ± 2.84
TEM 6-10-12	0	0.65 ± 2.10	9.39 ± 2.18	- 8.13 ± 1.98	0.10 ± 2.81
	0(r)	- 3.09 ± 2.38	13.17 ± 2.44	- 3.31 ± 2.16	3.10 ± 2.72
00 33-9	0	-12.18 ± 2.03	7.32 ± 1.78	5.36 ± 2.31	3.30 ± 2.50
	0(r)	- 2.88 ± 1.76	7.06 ± 2.66	4.82 ± 2.28	7.26 ± 2.33

$$0 = 4\bar{Y}_2 - 2\bar{Y}_1 - \bar{P}_1 - \bar{P}_2 \quad , \quad 0(R) = 4\bar{Y}_2(R) - 2\bar{Y}_1(R) - \bar{P}_1 - \bar{P}_2$$

Table 8 e. Sealing test.

Number of intermodes

Donor donor parents	Tester parents			
	00 29	TKN 6	00 33	00 13
DONG	0	- 0.51 ± 3.49	- 0.20 ± 0.57	- 2.35 ± 0.39
	0 _(R)	- 0.23 ± 0.41	- 1.36 ± 0.50	- 2.65 ± 0.44
5824	0	- 0.93 ± 0.46	- 2.53 ± 0.46	- 1.56 ± 0.35
	0 _(R)	- 1.65 ± 0.45	2.23 ± 0.47	- 1.54 ± 0.41
T(N)1	0	- 2.34 ± 0.46	- 1.78 ± 0.35	1.17 ± 0.42
	0 _(R)	- 3.10 ± 0.40	- 0.26 ± 0.36	2.09 ± 0.39
00 29-N-40	0	- 0.69 ± 0.55	- 1.41 ± 0.37	1.54 ± 0.45
	0 _(R)	- 0.71 ± 0.61	- 1.69 ± 0.35	1.76 ± 0.46
TKN 6-10-12	0	- 3.44 ± 0.37	0.54 ± 0.48	- 0.19 ± 0.36
	0 _(R)	- 1.96 ± 0.46	- 0.40 ± 0.56	0.25 ± 0.35
00 33-9	0	- 3.33 ± 0.50	- 3.84 ± 0.39	0.31 ± 0.36
	0 _(R)	- 2.31 ± 0.44	- 2.54 ± 0.44	0.25 ± 0.37

$$0 \rightarrow Y_2 - 2\bar{Y}_1 - \bar{Y}_1 - \bar{Y}_2, \quad 0_{(R)} = 4\bar{Y}_2(R) - 2\bar{Y}_1(R) - \bar{Y}_1 - \bar{Y}_2$$

Table 8 d. Scaling test.

Leaf area (cm²)

Dwarf donor parents		Tester parents			
		00 29	TEM 6	00 33	00 13
D086	0	- 3.36 ± 3.04	32.73 ± 2.96	-18.12 ± 2.87	11.32 ± 4.17
	0(R)	- 5.12 ± 2.56	8.93 ± 2.33	-21.68 ± 2.95	- 3.96 ± 3.81
5024	0	1.44 ± 2.62	11.70 ± 2.60	-19.54 ± 2.28	- 1.74 ± 2.49
	0(R)	3.94 ± 2.51	11.38 ± 2.39	-31.96 ± 2.22	4.46 ± 2.33
T(N)1	0	1.57 ± 2.22	19.28 ± 3.29	8.87 ± 3.02	8.27 ± 2.28
	0(R)	1.87 ± 1.94	10.46 ± 3.52	16.71 ± 2.61	4.73 ± 2.07
00 29-M-40	0	3.90 ± 2.24	31.54 ± 3.01	9.54 ± 3.28	20.26 ± 2.97
	0(R)	8.22 ± 1.79	15.76 ± 2.06	12.82 ± 2.52	8.42 ± 2.11
TEM 6-10-12	0	-42.44 ± 2.91	12.15 ± 2.63	14.38 ± 2.38	5.99 ± 2.56
	0(R)	-34.46 ± 3.36	19.65 ± 3.20	29.44 ± 3.11	1.49 ± 3.12
00 33-9	0	- 5.05 ± 3.11	-20.24 ± 2.55	0.04 ± 2.68	-13.34 ± 2.79
	0(R)	- 8.65 ± 2.94	- 4.84 ± 2.80	- 0.56 ± 2.35	-15.76 ± 2.92

$$0 = 4\bar{P}_2 - 2\bar{P}_1 - \bar{P}_1 - \bar{P}_2, \quad 0(N) = 4\bar{P}_2(N) - 2\bar{P}_1(N) - \bar{P}_1 - \bar{P}_2$$

Table 8 e. Sealing test.

Panicle length (cm)

Dwarf donor parents	Tester parents				
	CO 29	TEM 6	CO 33	CO 13	
DW6	0	- 2.23 ± 1.15	- 0.27 ± 2.08	- 4.87 ± 0.90	2.81 ± 1.43
	0(R)	- 3.77 ± 1.15	- 6.91 ± 1.21	- 7.97 ± 0.93	- 4.04 ± 1.59
5824	0	- 1.98 ± 1.00	- 6.86 ± 1.22	- 8.30 ± 1.26	- 3.10 ± 1.45
	0(R)	- 4.68 ± 1.10	- 2.82 ± 1.10	- 7.98 ± 1.09	- 2.88 ± 1.08
Σ(M)1	0	- 3.00 ± 1.30	0.50 ± 1.45	- 1.07 ± 1.11	5.28 ± 1.08
	0(R)	- 3.58 ± 1.14	3.20 ± 1.46	2.35 ± 1.16	- 3.60 ± 1.19
CO 29-M-40	0	3.79 ± 0.87	2.08 ± 1.30	1.92 ± 1.69	10.17 ± 1.76
	0(R)	4.95 ± 0.72	0.08 ± 1.15	6.88 ± 1.11	4.39 ± 1.41
TEM 6-10-12	0	- 9.87 ± 1.10	- 1.01 ± 1.64	4.57 ± 1.23	8.22 ± 1.32
	0(R)	- 8.11 ± 1.22	1.65 ± 1.19	6.03 ± 1.33	6.70 ± 1.32
CO 33-9	0	- 8.41 ± 1.62	-13.59 ± 1.12	1.97 ± 0.91	- 5.75 ± 0.77
	0(R)	- 6.69 ± 1.71	- 4.85 ± 1.28	10.85 ± 0.87	- 9.11 ± 0.79

$$0 = 4\bar{Y}_2 - 2\bar{Y}_1 - \bar{V}_1 - \bar{V}_2 \quad 0(R) = 4\bar{Y}_{2(R)} - 2\bar{Y}_{1(R)} - \bar{V}_1 - \bar{V}_2$$

Table 8 f. Sealing test.

Number of grains per panicle

Dwarf donor parents	Feeder parents			
	00 29	TKM 6	00 33	00 19
3080	0	26.77 ± 10.48	8.50 ± 14.86	- 2.85 ± 11.30
	0 _(R)	30.67 ± 9.47	-46.44 ± 12.20	19.91 ± 11.87
5824	0	-25.10 ± 9.38	18.30 ± 14.14	33.48 ± 14.53
	0 _(R)	-28.90 ± 12.24	72.00 ± 13.52	-40.06 ± 11.07
2(R)1	0	-25.26 ± 10.16	13.45 ± 14.14	17.90 ± 12.44
	0 _(R)	-10.06 ± 13.20	56.87 ± 13.73	47.24 ± 12.24
00 29-M-40	0	35.91 ± 9.11	-17.33 ± 9.97	31.28 ± 14.59
	0 _(R)	37.47 ± 10.11	20.99 ± 11.18	27.52 ± 11.27
TKM 6-10-12	0	-32.84 ± 12.32	37.42 ± 12.30	59.60 ± 14.86
	0 _(R)	-44.18 ± 12.38	- 3.30 ± 11.41	39.36 ± 16.14
00 33-9	0	54.63 ± 13.46	-89.35 ± 12.48	21.34 ± 12.65
	0 _(R)	-42.45 ± 11.12	-16.79 ± 13.02	44.90 ± 12.21

$$0 = 4\bar{P}_2 - 2\bar{P}_1 - \bar{P}_1 - \bar{P}_2, \quad 0_{(R)} = 4\bar{P}_2(R) - 2\bar{P}_1(R) - \bar{P}_1 - \bar{P}_2$$

Table 8 g. Sealing test.

Weight of grains per panicle (g)

Dwarf donor parents	Tester parents				
	00 29	TKM 6	00 33	00 13	
DDW0	0	0.25 ± 0.33	0.45 ± 0.37	- 0.93 ± 0.28	1.04 ± 0.42
	0 _(R)	- 0.05 ± 0.30	- 1.99 ± 0.37	- 0.59 ± 0.28	- 0.90 ± 0.39
5824	0	- 1.04 ± 0.39	0.16 ± 0.33	- 0.62 ± 0.20	0.23 ± 0.52
	0 _(R)	- 1.16 ± 0.30	0.72 ± 0.30	- 1.18 ± 0.17	- 0.45 ± 0.47
TK(N)1	0	- 0.92 ± 0.32	0.02 ± 0.33	- 0.30 ± 0.30	0.27 ± 0.44
	0 _(R)	- 0.16 ± 0.30	0.92 ± 0.33	0.64 ± 0.30	- 2.15 ± 0.37
00 29-M-40	0	0.17 ± 0.26	- 0.53 ± 0.24	- 0.29 ± 0.28	1.08 ± 0.41
	0 _(R)	- 0.11 ± 0.24	- 0.29 ± 0.24	0.43 ± 0.30	1.64 ± 0.32
TKM 6-10-12	0	- 0.54 ± 0.30	- 1.20 ± 0.33	0.61 ± 0.28	2.05 ± 0.42
	0 _(R)	- 1.24 ± 0.35	- 1.40 ± 0.33	0.83 ± 0.26	1.63 ± 0.36
00 33-9	0	- 1.31 ± 0.28	0.82 ± 0.22	0.59 ± 0.24	0.26 ± 0.22
	0 _(R)	- 0.77 ± 0.28	- 0.34 ± 0.24	0.89 ± 0.22	- 0.14 ± 0.28
$0 = 4\bar{P}_2 - 2\bar{P}_1 - \bar{P}_1 - \bar{P}_2, \quad 0_{(R)} = 4\bar{P}_2(R) - 2\bar{P}_1(R) - \bar{P}_1 - \bar{P}_2$					

$$0 = 4\bar{Y}_2 - 2\bar{T}_1 - \bar{P}_1 - \bar{P}_2, \quad 0_{(R)} = 4\bar{Y}_2(R) - 2\bar{T}_1(R) - \bar{P}_1 - \bar{P}_2$$

Table 8 h. Soaling test.

1000 grain weight (g)

Dwarf donor parents	Tester parents		
	00 29	TKN 6	00 33
0886			
0	- 5.68 ± 1.13	2.90 ± 0.94	- 6.29 ± 1.37
0 _(R)	- 9.56 ± 1.19	- 8.36 ± 1.30	- 6.81 ± 1.83
5824			
0	- 2.99 ± 1.81	- 4.43 ± 1.30	-11.44 ± 2.43
0 _(R)	- 3.93 ± 1.19	-10.95 ± 1.26	- 4.88 ± 2.07
π(H)1			
0	- 4.93 ± 1.37	-10.13 ± 1.18	- 5.46 ± 0.92
0 _(R)	- 2.45 ± 1.54	- 7.87 ± 1.28	- 6.02 ± 1.64
00 29-H-40			
0	- 2.64 ± 1.27	- 1.62 ± 0.76	3.38 ± 1.98
0 _(R)	- 3.94 ± 0.82	- 7.02 ± 1.02	- 5.72 ± 1.40
TKN 6-10-12			
0	1.23 ± 0.62	- 3.73 ± 0.77	-10.68 ± 1.28
0 _(R)	3.19 ± 0.83	- 4.81 ± 0.95	-16.16 ± 1.80
00 33-9			
0	- 0.26 ± 1.29	- 4.70 ± 0.79	2.96 ± 1.01
0 _(R)	2.46 ± 1.65	- 2.42 ± 1.06	3.44 ± 0.79

$$0 = 4\bar{Y}_2 - 2\bar{Y}_1 - \bar{Y}_1 - \bar{Y}_2 \quad , \quad 0_{(R)} = 4\bar{Y}_2(R) - 2\bar{Y}_1(R) - \bar{Y}_1 - \bar{Y}_2$$

Table 8 1. Scaling test.

Grain yield per plant (g)

Dwarf donor parents	Tester parents			
	00 29	TKM 6	00 55	00 15
DGW				
0	22.56 ± 6.85	36.84 ± 6.45	-10.97 ± 3.47	2.98 ± 7.20
0(R)	18.24 ± 8.54	- 4.58 ± 7.55	- 2.82 ± 5.59	10.28 ± 5.91
5824				
0	- 0.75 ± 4.16	15.15 ± 5.00	- 3.68 ± 5.89	5.47 ± 4.98
0(R)	-13.11 ± 4.28	29.70 ± 5.56	-13.60 ± 5.51	5.75 ± 5.15
2(N)1				
0	-22.59 ± 5.03	3.70 ± 6.26	- 0.74 ± 4.50	1.00 ± 4.62
0(R)	- 8.15 ± 8.78	11.60 ± 5.43	13.28 ± 5.70	- 9.98 ± 4.50
00 29-N-40				
0	5.98 ± 5.23	- 8.36 ± 5.05	3.99 ± 3.68	2.08 ± 4.43
0(R)	- 9.51 ± 5.12	- 4.20 ± 5.10	7.25 ± 3.48	11.68 ± 4.58
TKM 6-10-12				
0	-21.87 ± 6.18	18.41 ± 4.93	- 1.71 ± 3.81	16.26 ± 5.75
0(R)	-28.25 ± 5.71	14.09 ± 5.57	8.67 ± 4.15	18.22 ± 5.59
00 55-9				
0	-36.65 ± 4.50	-10.77 ± 3.58	18.88 ± 4.56	-12.65 ± 4.15
0(R)	-24.25 ± 4.14	- 2.55 ± 4.86	25.24 ± 4.12	1.21 ± 5.28

$$0 = 4\bar{Y}_2 - 2\bar{Y}_1 - \bar{Y}_1 - \bar{Y}_2 \quad 0(R) = 4\bar{Y}_2(N) - 2\bar{Y}_1(N) - \bar{Y}_1 - \bar{Y}_2$$

Table 9 a. Estimates of persistence of heterosis.

Cross	Plant height			
	Per cent on mid-parent			
	F ₁	F ₁ (R)	F ₂	F ₂ (R)
DGWS x OO 29	98.36	113.77	101.74	105.23
TKM 6	96.16	111.12	108.14	109.04
OO 33	93.51	82.61	83.40	93.43
OO 13	88.11	107.85	102.22	85.85
5824 x OO 29	99.97	106.11	96.42	100.46
TKM 6	113.28	93.37	92.41	101.31
OO 33	90.84	92.32	79.72	76.65
OO 13	99.07	113.59	93.19	108.82
2(H)1 x OO 29	99.36	117.36	97.37	105.06
TKM 6	111.72	114.10	108.89	113.32
OO 33	86.32	80.82	91.79	90.14
OO 13	82.81	117.63	106.41	102.83
OO 29-M-40 x OO 29	127.01	127.46	122.92	128.27
TKM 6	113.87	122.49	111.15	119.69
OO 33	130.75	104.64	131.26	136.82
OO 13	115.73	117.46	124.42	124.46
TKM 6-10-12 x OO 29	77.31	107.19	56.77	91.09
TKM 6	82.51	113.34	99.67	118.89
OO 33	86.49	80.65	93.93	106.41
OO 13	80.33	93.98	101.15	100.35
OO 33-9 x OO 29	101.85	105.65	82.21	94.20
TKM 6	70.73	108.32	100.66	98.55
OO 33	81.79	87.48	99.71	98.83
OO 13	72.40	122.56	81.46	110.22

Table 9 b. Estimates of persistence of heterosis.

Cross	Tiller number			
	Percent on mid-parent			
	F_1	$F_1(R)$	F_2	$F_2(R)$
DW6 x 00 29	74.33	106.02	120.11	141.71
TKM 6	101.80	92.81	137.48	121.31
00 33	149.01	143.73	142.87	163.92
00 13	109.90	106.69	112.92	112.07
5824 x 00 29	82.20	98.77	122.69	113.98
TKM 6	126.10	117.99	173.89	197.64
00 33	118.94	129.40	132.26	127.20
00 13	117.07	116.42	135.18	133.24
T(N)1 x 00 29	67.78	62.07	82.17	96.19
TKM 6	94.28	94.28	115.20	117.48
00 33	121.76	109.37	113.46	130.71
00 13	76.80	63.40	87.93	98.24
00 29-N-40 x 00 29	94.24	108.40	100.70	99.20
TKM 6	148.60	129.37	143.47	148.48
00 33	148.64	143.91	87.56	123.37
00 13	136.10	129.27	111.04	122.38
TKM 6-10-12 x 00 29	145.62	157.25	124.38	120.04
TKM 6	71.06	83.84	109.30	123.36
00 33	176.04	153.67	108.63	114.86
00 13	132.10	137.36	116.31	126.84
00 33-9 x 00 29	168.20	118.46	102.87	101.84
TKM 6	78.18	124.84	111.27	133.82
00 33	169.42	133.37	136.86	147.60
00 13	119.66	117.42	119.10	129.10

Table 9 c. Estimates of persistence of heterosis.

Cross	Number of internodes			
	Per cent on mid-parent			
	P_1	$P_1(R)$	P_2	$P_2(R)$
DGWS x 00 29	119.55	105.58	98.78	101.75
TKM 6	105.08	94.92	101.69	97.63
00 33	102.21	90.24	90.24	82.87
00 13	96.67	102.50	93.00	93.00
5824 x 00 29	97.61	103.13	94.48	93.92
TKM 6	101.24	100.36	89.34	90.23
00 33	113.04	118.48	98.04	100.87
00 13	100.00	101.79	93.34	100.89
2(N)1 x 00 29	106.09	113.04	92.87	93.04
TKM 6	104.31	104.31	94.48	101.03
00 33	96.46	94.49	103.94	107.48
00 13	97.32	100.89	101.96	99.82
00 29-M-40 x 00 29	99.47	100.35	96.65	97.01
TKM 6	97.77	104.63	92.80	95.03
00 33	87.38	88.35	101.17	102.72
00 13	102.97	106.46	96.68	96.43
TKM 6-10-12 x 00 29	96.46	105.31	83.01	93.98
TKM 6	93.43	107.27	100.18	101.82
00 33	86.87	83.01	92.47	92.66
00 13	94.59	95.50	99.10	103.24
00 33-9 x 00 29	103.05	109.32	86.36	76.34
TKM 6	89.38	102.65	77.70	90.09
00 33	80.12	81.08	91.31	91.70
00 13	95.07	117.96	88.20	102.82

Table 9 d. Estimates of persistence of heterosis.

Cross	Leaf area			
	Per cent on mid-parent			
	F_1	$F_{1(R)}$	F_2	$F_{2(R)}$
DGWG x 00 29	90.24	94.78	91.94	89.71
TKM 6	84.21	81.27	128.43	100.48
00 33	91.12	75.62	78.93	67.91
00 13	85.38	90.28	100.70	91.41
5824 x 00 29	94.25	87.08	98.88	98.34
TKM 6	107.18	108.73	118.92	119.29
00 33	76.87	86.37	70.42	63.81
00 13	92.55	93.77	94.07	102.53
T(W)1 x 00 29	90.69	93.03	97.09	98.59
TKM 6	92.33	98.87	117.92	111.24
00 33	93.66	89.38	107.18	114.17
00 13	73.38	72.02	94.94	88.76
00 29-M-40 x 00 29	94.92	94.02	101.84	106.23
TKM 6	93.44	99.37	138.11	120.37
00 33	86.79	75.63	104.94	103.34
00 13	88.10	110.09	119.48	115.61
TKM 6-10-12 x 00 29	74.64	77.71	34.43	62.15
TKM 6	65.95	70.65	96.83	107.76
00 33	96.37	99.24	117.66	139.57
00 13	83.53	90.45	97.91	96.76
00 33-9 x 00 29	80.54	83.69	83.05	82.90
TKM 6	83.13	80.23	70.00	84.96
00 33	95.88	92.72	97.99	93.62
00 13	55.98	73.28	66.63	74.40

Table 9 e. Estimates of persistence of heterosis.

Panicle length

Cross	Per cent on mid-parent			
	P_1	$P_1(R)$	P_2	$P_2(R)$
DGWC x 00 29	100.14	106.62	97.45	98.87
TKM 6	111.25	105.10	105.33	99.22
00 33	91.18	92.67	93.24	87.25
00 13	101.81	106.30	104.17	98.47
5824 x 00 29	100.44	100.97	97.82	94.81
TKM 6	105.72	100.24	94.75	96.98
00 33	101.48	93.37	90.84	88.03
00 13	101.62	102.46	97.10	97.69
E(N)1 x 00 29	101.75	104.12	97.23	97.72
TKM 6	98.75	101.57	99.95	104.49
00 33	93.31	97.39	97.87	101.55
00 13	96.94	104.64	104.59	98.15
00 29-M-40 x 00 29	110.27	113.16	110.62	113.73
TKM 6	103.67	114.99	104.64	107.61
00 33	101.92	103.84	105.51	112.56
00 13	109.91	113.27	119.42	112.87
TKM 6-10-12 x 00 29	93.77	105.46	85.05	93.00
TKM 6	93.03	107.59	95.32	105.78
00 33	104.56	93.50	103.04	104.66
00 13	95.75	95.21	105.54	103.41
00 33-9 x 00 29	98.54	102.82	89.07	92.08
TKM 6	94.60	104.68	81.07	96.56
00 33	92.53	93.16	98.85	110.76
00 13	91.10	109.47	88.74	94.02

Table 9 f. Estimates of persistence of heterosis.

Number of grains per panicle

Cross	Per cent on mid-parent			
	P ₁	P ₁ (R)	P ₂	P ₂ (R)
DGWO x 00 29	78.72	79.38	97.32	98.81
TKM 6	109.08	106.63	106.85	90.70
00 33	70.63	60.36	78.98	79.31
00 13	82.38	90.34	99.13	97.04
5824 x 00 29	97.45	121.68	89.04	95.83
TKM 6	128.45	107.60	121.32	131.71
00 33	91.07	97.31	83.93	87.19
00 13	99.42	98.77	102.34	106.72
T(H)1 x 00 29	83.40	100.43	83.90	97.11
TKM 6	103.28	111.08	106.66	122.53
00 33	73.18	82.19	91.23	103.40
00 13	82.93	94.08	98.60	82.74
00 29-M-40 x 00 29	116.64	124.64	123.60	128.26
TKM 6	109.32	126.18	98.48	120.69
00 33	143.31	126.30	108.66	124.78
00 13	109.09	111.11	128.14	123.95
TKM 6-10-12 x 00 29	121.40	133.26	96.71	98.99
TKM 6	94.66	123.02	108.82	110.50
00 33	78.83	82.65	106.63	102.71
00 13	68.18	66.72	107.74	100.04
00 33-9 x 00 29	116.28	107.15	93.03	91.84
TKM 6	100.78	101.33	76.06	96.09
00 33	86.62	92.81	98.91	108.18
00 13	97.71	112.16	99.43	97.12

Table 9 g. Estimates of persistence of heterosis.

Weight of grains per panicle

Cross	Per cent on mid-parent			
	F_1	$F_{1(R)}$	F_2	$F_{2(R)}$
DGWG x 00 29	76.89	80.00	91.11	89.33
TKM 6	94.39	117.76	102.34	85.51
00 33	77.14	59.52	77.62	72.86
00 13	82.20	95.34	102.12	88.14
5824 x 00 29	93.37	106.63	82.32	87.29
TKM 6	135.97	127.34	120.86	126.62
00 33	82.63	76.32	83.16	72.63
00 13	94.74	105.26	100.53	96.84
T(N)1 x 00 29	92.27	107.73	83.43	93.37
TKM 6	107.39	110.23	103.98	118.18
00 33	80.63	74.87	86.39	93.81
00 13	90.28	106.48	98.15	82.87
00 29-M-40 x 00 29	101.27	107.64	106.37	105.10
TKM 6	118.62	128.28	100.00	108.97
00 33	139.25	114.95	113.08	117.76
00 13	112.99	100.00	124.03	126.62
TKM 6-10-12 x 00 29	88.82	127.06	86.47	93.29
TKM 6	97.56	135.37	80.49	96.34
00 33	87.10	74.84	103.23	100.65
00 13	63.05	57.64	106.90	99.01
00 33-9 x 00 29	104.17	100.52	84.90	90.10
TKM 6	94.77	98.26	109.30	94.19
00 33	82.94	84.71	100.00	105.29
00 13	94.89	131.25	101.14	113.64

Table 9 h. Estimates of persistence of heterosis.

1000 grain weight

Cross	Per cent on mid-parent			
	P ₁	P ₁ (R)	P ₂	P ₂ (R)
DGWO x 00 29	105.94	109.11	97.19	94.84
TKM 6	97.67	109.19	102.15	95.02
00 33	102.15	86.01	94.04	85.38
00 13	112.51	112.30	104.47	96.72
5824 x 00 29	100.78	101.14	97.46	94.76
TKM 6	98.80	104.84	94.49	90.27
00 33	99.27	85.49	86.67	86.21
00 13	100.04	101.44	94.95	92.18
T(N)1 x 00 29	108.58	102.20	98.97	98.45
TKM 6	106.95	98.52	91.45	89.91
00 33	111.70	99.95	98.94	92.55
00 13	106.04	106.81	100.77	97.66
00 29-M-40 x 00 29	96.97	97.61	95.71	94.66
TKM 6	101.54	97.45	98.88	90.50
00 33	85.85	81.54	97.21	85.52
00 13	99.84	94.28	95.67	95.58
TKM 6-10-12 x 00 29	90.49	104.06	96.70	105.85
TKM 6	104.07	100.75	97.54	99.55
00 33	100.42	86.07	86.55	72.04
00 13	95.62	98.61	105.44	99.55
00 33-9 x 00 29	89.10	97.98	94.25	102.02
TKM 6	95.67	98.54	91.55	95.94
00 33	90.14	85.42	99.12	97.42
00 13	85.96	102.67	99.57	111.75

Table 9 1. Estimates of persistence of heterosis.

Grain yield per plant

Cross	Per cent on mid-parent			
	P ₁	F ₁ (R)	F ₂	F ₂ (R)
DW6 x 00 29	54.94	89.56	104.27	116.54
TKM 6	70.11	121.96	137.59	104.45
00 33	74.35	57.95	72.59	75.56
00 13	93.86	105.88	100.77	89.69
5824 x 00 29	77.85	104.92	87.69	81.22
TKM 6	170.82	153.48	170.61	204.98
00 33	106.15	112.75	97.42	85.53
00 13	113.02	121.15	112.41	116.91
T(N)1 x 00 29	57.65	60.38	57.72	72.79
TKM 6	97.59	95.64	104.24	114.90
00 33	83.15	89.31	90.57	112.76
00 13	82.87	93.03	92.81	82.81
00 29-M-40 x 00 29	89.44	111.35	91.71	93.40
TKM 6	169.60	168.00	118.08	125.60
00 33	163.57	123.69	146.78	137.93
00 13	174.69	134.43	141.43	140.17
TKM 6-10-12 x 00 29	122.35	185.32	77.89	99.70
TKM 6	80.25	105.55	117.60	123.69
00 33	120.27	87.57	106.31	111.08
00 13	64.00	59.56	102.07	102.27
00 33-9 x 00 29	143.81	115.23	73.64	75.70
TKM 6	70.08	114.00	66.67	102.66
00 33	106.10	108.33	147.58	160.47
00 13	189.24	230.78	138.43	191.88

Table 10 a. Estimates of matroclinal effects.

Plant height

Cross	m	a	h
DW0 x 00 29	0.5390	97.8917	28.3025
TKM 6	0.3975	116.5909	15.5094
00 33	0.5264	61.4718	4.6622
00 13	0.3168	125.5253	5.6243
5824 x 00 29	0.2034	89.5136	12.9256
TKM 6	0.4275	100.1529	7.4224
00 33	0.3132	58.7538	20.7422
00 13	0.2562	110.9549	1.9714
T(N)1 x 00 29	0.3647	84.6531	34.9558
TKM 6	0.0577	125.0046	5.7223
00 33	0.4068	105.9515	41.2671
00 13	0.4401	140.5045	18.6511
00 29-M-40 x 00 29	0.0068	111.3598	5.3088
TKM 6	0.1262	107.4146	11.5839
00 33	-0.8872	100.2069	- 29.0058
00 13	0.0187	136.2338	- 15.8210
TKM 6-10-12 x 00 29	0.6249	- 11.6655	105.0215
TKM 6	0.6575	171.6609	- 65.4599
00 33	0.0163	90.2432	- 26.3223
00 13	0.1958	141.1772	- 45.4553
00 33-9 x 00 29	-0.0082	81.0835	34.2227
TKM 6	0.7501	65.4906	- 0.5114
00 33	-0.5040	71.6082	- 6.6342
00 13	0.6288	115.8178	0.4079

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 10 b. Estimates of matrocline effects.

Tiller number

Cross	m	a	h
DGWG x OO 29	0.7637	42.6169	-36.7385
TKM 6	-0.0761	13.0809	- 4.9400
OO 33	-0.1827	12.6070	- 1.8921
OO 13	-0.3201	9.6356	- 0.7736
5824 x OO 29	-0.6904	9.7442	- 2.0527
TKM 6	-2.4247	11.8575	- 4.6439
OO 33	-0.6290	12.7460	- 2.3205
OO 13	0.0161	11.7479	- 2.7016
T(N)1 x OO 29	-0.5769	10.8771	- 0.6693
TKM 6	0	12.1000	- 3.8500
OO 33	-1.3453	12.0684	- 2.1751
OO 13	-1.0043	7.5672	0.6859
OO 29-M-40 x OO 29	0.3502	10.8883	0.6425
TKM 6	-0.6422	13.9646	- 3.3497
OO 33	-0.6658	8.7612	1.2951
OO 13	0.3900	- 0.6307	17.3975
TKM 6-10-12 x OO 29	0.3130	3.8971	11.8965
TKM 6	0.6374	33.0544	-25.3462
OO 33	0.2965	- 0.9373	14.2589
OO 13	0.2829	8.0120	6.0898
OO 33-9 x OO 29	0	5.9750	8.0000
TKM 6	0.5814	16.9934	- 8.6184
OO 33	0.5373	2.7673	11.4414
OO 13	-1.7492	11.9501	- 2.4536

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 10 c. Estimates of matroclinous effects.

Number of internodes				
Cross	m	a	h	
DGW0 x 00 29	0.6292	4.4577	1.8755	
TKM 6	-0.1881	5.8689	0.0311	
00 33	0.4379	3.5127	1.5564	
00 13	-0.0136	5.3340	0.6494	
5824 x 00 29	0.2796	4.5033	0.9564	
TKM 6	-0.0814	4.5303	1.1410	
00 33	0.7328	- 4.6868	12.7853	
00 13	0.1148	5.3046	0.3519	
I(N)1 x 00 29	0.4712	2.1929	4.5972	
TKM 6	-0.0002	5.2877	0.7623	
00 33	0.0776	5.9937	- 1.1626	
00 13	-0.6253	5.6538	- 0.0846	
00 29-M-40 x 00 29	0.0942	5.2897	0.3853	
TKM 6	0.3541	4.6009	1.3402	
00 33	0.7017	10.8394	- 7.8046	
00 13	0.3244	4.6468	1.4852	
TKM 6-10-12 x 00 29	1.3942	9.4284	- 3.9053	
TKM 6	0.5610	5.3938	0.2771	
00 33	0.1767	5.5228	- 1.2891	
00 13	0.0692	6.0207	- 0.7661	
00 33-9 x 00 29	0.4738	2.2603	3.9799	
TKM 6	0.8743	- 3.9518	7.8113	
00 33	0.2662	6.0819	- 2.2697	
00 13	0.7292	0.4283	6.6314	

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 10 d. Estimates of matroclinal effects.

Leaf area			
Gross	m	a	h
DGWO x CO 29	0.2646	23.9621	- 0.2144
TKM 6	-1.4088	22.4976	- 1.4071
CO 33	0.3618	16.7854	3.3561
CO 13	-0.0180	28.2332	- 4.8661
5824 x CO 29	0.5381	27.8843	-11.5204
TKM 6	-0.1159	24.5664	- 4.1243
CO 33	-0.2786	14.8811	8.3336
CO 13	0.0084	20.4486	- 2.0790
T(N)1 x CO 29	0.8968	63.1636	-58.4329
TKM 6	-0.1656	28.2638	- 6.9410
CO 33	-0.1368	26.6512	- 6.7916
CO 13	-0.0460	27.6033	- 9.0616
CO 29-M-40 x CO 29	-0.0613	24.9430	- 3.8720
TKM 6	0.0814	32.0433	-13.7392
CO 33	-0.2252	23.7962	- 6.3030
CO 13	0.3134	30.5268	-10.8690
TKM 6-10-12 x CO 29	0.1311	12.4534	10.9622
TKM 6	1.2606	-75.7423	124.2975
CO 33	2.2622	8.3290	10.4518
CO 13	0.2242	28.6633	- 8.3472
CO 33-9 x CO 29	0.1222	21.4573	- 2.2294
TKM 6	-0.2688	16.7064	3.3747
CO 33	0.9327	46.9530	-44.0503
CO 13	0.5207	41.7497	-33.3141

m = coefficient of maternal effect; a = mid-parental value and h = deviation due to dominance.

Table 10 c. Estimates of matroclinal effects.

Panicle length

Cross	m	a	h
DGW0 x 00 29	-0.2517	20.2437	1.4741
TKM 6	-0.0976	21.3325	2.0546
00 33	0.3705	17.0531	2.2943
00 13	-0.4307	21.9066	0.2940
5824 x 00 29	0.4655	18.2282	2.3509
TKM 6	-0.6916	20.2251	1.2858
00 33	0.7307	6.6307	13.0155
00 13	0.1993	18.2505	2.6197
T(N)1 x 00 29	0.4108	16.9894	4.6442
TKM 6	0.2995	22.9082	- 1.2407
00 33	0.2104	20.0866	0.0492
00 13	-0.3805	21.9659	- 0.2771
00 29-M-40 x 00 29	0.0926	19.3349	0.2265
TKM 6	0.2737	17.9783	2.9413
00 33	-0.0627	16.0954	1.4789
00 13	0.0650	21.1567	- 1.4226
TKM 6-10-12 x 00 29	0.6991	6.3138	14.2879
TKM 6	0.8323	21.3249	- 0.0067
00 33	0.0502	22.0144	- 4.1774
00 13	0.0202	23.0433	- 3.7341
00 33-9 x 00 29	0.7912	0.3240	20.9049
TKM 6	1.2672	37.4723	-16.2716
00 33	0.1308	23.2522	- 5.6787
00 13	0.5729	12.3879	8.9691

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 10 f. Estimates of matroclinous effects.

Number of grains per panicle

Cross	m	a	h
DGWG x CO 29	-0.0471	96.1450	-28.9278
TKM 6	0.1127	79.4727	20.6699
CO 33	-0.1796	88.6723	-16.7396
CO 13	0.0260	100.2506	-22.8114
5824 x CO 29	0.7095	0.2477	77.2903
TKM 6	-0.5953	87.3269	-15.5399
CO 33	0.1258	62.6295	20.6310
CO 13	-0.0570	75.3747	- 7.0160
T(N)1 x CO 29	0.8240	92.1907	-48.4049
TKM 6	1.3853	87.3223	-21.4179
CO 33	1.1014	60.3121	17.5123
CO 13	-1.4964	75.6181	10.6410
CO 29-M-40 x CO 29	0.1469	76.0447	- 3.1075
TKM 6	0.3966	54.3367	35.1140
CO 33	-0.2501	59.9209	18.7386
CO 13	-0.1056	84.7955	-15.0316
TKM 6-10-12 x CO 29	0.4837	8.8611	98.3294
TKM 6	0.2523	87.9990	3.0808
CO 33	-0.7858	85.6503	- 8.5237
CO 13	0.1130	131.3426	-77.2579
CO 33-9 x CO 29	0.2717	49.1848	55.7947
TKM 6	0.0065	65.1022	27.7041
CO 33	-0.1417	107.3742	-20.6578
CO 13	-0.4025	83.7603	5.7628

m = coefficient of maternal effect; a = mid-parental value and h = deviation due to dominance.

Table 10 g. Estimates of matroclinal effects.

Weight of grains per panicle

Cross	m	a	h
DWG x OO 29	0.4729	4.5406	-3.8929
TKM 6	-0.8789	2.0566	0.1511
CO 33	-0.2878	1.5087	0.0760
CO 13	-1.2112	2.0856	0.1545
5824 x OO 29	0.7090	-0.0796	1.8923
TKM 6	-0.0312	1.6105	0.2126
CO 33	0.0045	1.4790	0.0201
CO 13	0.1929	1.8490	0.0482
T(H)1 x CO 29	0.1767	1.3015	0.5100
TKM 6	-0.4250	1.9839	-0.0674
CO 33	-0.2041	1.8360	-0.2795
CO 13	-0.1014	1.8134	0.5165
OO 29-M-40 x OO 29	-0.1200	1.6826	-0.0495
TKM 6	0.3413	0.7815	1.1828
CO 33	-0.3644	1.2521	0.0303
CO 13	-0.1588	2.1546	-0.5299
TKM 6-10-12 x OO 29	0.6250	0.0565	2.0081
TKM 6	-0.1685	1.1633	0.7101
CO 33	-0.6016	1.5772	-0.0910
CO 13	-0.1430	2.6422	-1.3190
CO 33-9 x OO 29	0.1381	1.2889	0.6855
TKM 6	-0.1645	1.8087	-0.1397
CO 33	0.0523	2.1099	-0.6998
CO 13	-0.0713	1.8181	0.1562

m = coefficient of maternal effect; a = mid-parental value and h = deviation due to dominance.

Table 10 h. Estimates of matroclinal effects.

1000 grain weight

Cross	m	a	h
DGWG x CO 29	-1.4563	25.6221	- 0.8125
TKM 6	-0.4358	21.3756	1.0255
CO 33	0.4666	17.1685	2.6587
CO 13	0.1423	20.2005	7.7164
5824 x CO 29	0.4882	22.6501	2.4006
TKM 6	-0.1934	19.4254	3.4277
CO 33	0.3404	17.8384	1.3290
CO 13	1.4394	35.7927	- 9.9133
T(W)1 x CO 29	0.1427	20.6312	4.0245
TKM 6	0.3898	12.9096	9.0404
CO 33	0.5003	11.6788	10.3684
CO 13	0.0480	21.3887	3.7039
CO 29-M-40 x CO 29	0.1423	22.1065	0.9389
TKM 6	0.2149	18.6599	2.5646
CO 33	0.2412	20.9867	- 5.4998
CO 13	0.3575	21.5410	1.8068
TKM 6-10-12 x CO 29	0.6598	26.3549	- 7.0999
TKM 6	0.2786	17.9265	2.6313
CO 33	1.0068	622.6451	-413.0659
CO 13	0.1451	24.1451	- 2.5245
CO 33-9 x CO 29	0.1968	21.6208	- 2.9754
TKM 6	1.0769	26.2141	- 0.2492
CO 33	0.0850	20.4560	- 4.6590
CO 13	0.7237	40.0145	- 23.3655

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 10 i. Estimates of matreolinous effects.

Grain yield per plant

Cross	m	a	h
DGW8 x 00 29	0.7036	82.6361	- 81.3559
TKM 6	-0.6590	21.8405	- 4.7314
00 33	-0.2778	12.9030	0.4927
00 13	0.0845	17.4072	1.9517
5824 x 00 29	-0.6318	12.2860	2.3382
TKM 6	-1.8724	21.2318	- 9.5194
00 33	0.1298	10.8795	7.2015
00 13	-0.1784	16.9444	- 0.1486
1(N)1 x 00 29	-0.0032	18.8002	- 3.2151
TKM 6	0.0854	21.2896	- 4.9480
00 33	0.5821	32.8631	- 0.5575
00 13	-1.1777	14.8034	2.3996
00 29-M-40 x 00 29	0.2910	14.8018	4.2429
TKM 6	-0.2779	13.7850	5.4460
00 33	-0.4000	10.2905	- 1.5411
00 13	-0.3589	18.9166	- 1.0890
TKM 6-10-12 x 00 29	0.6966	-65.4043	110.9383
TKM 6	0.6044	40.9055	- 27.1618
00 33	0.3703	12.9331	- 1.1310
00 13	-0.0860	26.9607	- 13.8396
00 33-9 x 00 29	0.2372	- 4.4436	30.7514
TKM 6	0.1378	11.1524	2.1364
00 33	-0.0171	20.5779	- 9.5235
00 13	0.8448	-75.1218	333.5510

m = coefficient of maternal effect; a = mid-parental value
and h = deviation due to dominance.

Table 11 a. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Plant height

Cross	h^2 (%)		GA		GA as % on mean	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DONG x GO 29	76.0	89.4	29.1	45.8	25.6	39.2
TKM 6	70.0	71.8	24.2	26.1	19.2	20.6
GO 33	65.3	68.6	14.3	16.3	19.7	24.0
GO 13	74.9	82.0	34.8	40.2	27.1	33.9
3824 x GO 29	58.4	57.8	22.8	23.3	24.0	25.3
TKM 6	90.4	68.4	41.2	33.0	42.4	31.0
GO 33	69.5	69.0	16.7	16.2	24.7	24.9
GO 13	82.8	89.3	48.3	33.7	43.9	47.4
T(N)1 x GO 29	96.2	83.4	71.0	32.6	69.2	29.3
TKM 6	88.4	53.3	44.0	16.1	33.7	12.3
GO 33	89.2	68.0	25.4	12.2	31.9	15.6
GO 13	77.1	83.0	27.1	36.7	21.0	29.4
GO 29-H-40 x						
GO 29	71.5	69.1	16.1	16.2	14.6	14.0
TKM 6	88.1	84.9	46.4	27.7	42.4	23.3
GO 33	96.4	66.4	33.8	16.9	63.0	16.8
GO 13	89.7	71.0	32.1	24.8	40.7	19.2
TKM 6-10-12 x						
GO 29	23.2	67.3	5.6	24.2	8.4	24.3
TKM 6	89.8	93.3	43.6	31.9	41.9	40.0
GO 33	92.3	95.7	28.7	42.6	39.8	32.1
GO 13	72.1	37.9	33.6	23.2	29.2	20.3
GO 33-9 x						
GO 29	69.9	71.6	22.7	26.2	24.8	23.0
TKM 6	83.7	83.3	23.9	33.4	37.3	32.0
GO 33	78.1	43.7	13.3	3.1	21.2	7.1
GO 13	91.0	79.1	33.1	43.9	34.2	33.4

Table 11 b. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Filler number

Cross	h^2 (%)		GA		GA as % on mean	
	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$
DWGC x CO 29	42.4	66.6	3.8	7.4	33.8	55.8
TKM 6	52.8	14.5	5.2	1.1	45.3	10.9
CO 33	35.3	30.1	3.0	2.2	27.4	17.5
CO 13	50.8	30.6	4.7	2.4	50.3	25.9
5824 x CO 29	61.0	69.1	4.7	5.2	47.0	36.0
TKM 6	73.3	79.0	6.8	8.8	37.7	65.7
CO 33	62.7	47.8	7.7	5.1	64.1	44.2
CO 13	38.4	37.7	2.9	2.7	27.8	26.2
T(N)1 x CO 29	27.1	41.0	2.3	3.5	21.3	27.7
TKM 6	43.8	44.1	3.6	3.6	35.7	35.0
CO 33	46.3	48.9	3.9	4.6	37.0	37.9
CO 13	26.0	41.3	1.8	3.2	21.1	33.6
CO 29-N-40 x						
CO 29	45.7	0	4.0	0	35.1	0
TKM 6	30.4	58.6	5.9	6.9	48.0	54.2
CO 33	0	18.8	0	1.6	0	17.5
CO 13	31.7	10.1	2.6	0.8	26.7	7.4
TKM 6-10-12 x						
CO 29	53.5	46.8	3.9	3.6	34.7	33.2
TKM 6	34.8	52.6	2.7	4.8	23.2	39.1
CO 33	45.9	52.7	3.0	3.8	39.8	47.7
CO 13	63.8	62.5	6.5	6.1	38.8	50.6
CO 33-9 x						
CO 29	16.1	41.2	0.9	2.5	9.0	25.2
TKM 6	66.9	60.9	6.1	5.8	66.4	52.5
CO 33	71.7	69.8	5.9	5.1	62.2	57.1
CO 13	17.5	40.9	1.3	3.2	12.3	27.9

Table 11 e. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Number of internodes

Cross	h^2 (%)		GA		GA as % on mean	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DW6 x CO 29	38.3	82.1	0.5	1.5	8.8	25.8
TKM 6	39.8	55.5	0.7	1.0	11.7	17.4
CO 33	25.8	13.1	0.3	0.2	6.1	4.0
CO 13	40.0	44.9	0.5	0.5	9.0	9.0
5824 x CO 29	41.8	49.3	0.6	0.8	11.7	15.7
TKM 6	50.2	48.4	0.8	0.8	15.9	15.7
CO 33	42.7	32.6	0.5	0.4	11.1	8.6
CO 13	52.7	44.4	0.7	0.5	13.1	8.8
T(N)1 x CO 29	73.4	47.7	1.3	0.6	24.3	11.2
TKM 6	47.9	57.1	0.6	0.7	10.9	11.9
CO 33	32.2	33.8	0.5	0.5	9.5	9.2
CO 13	33.0	42.0	0.5	0.6	8.8	10.7
CO 29-M-40 x						
CO 29	40.5	56.9	0.5	0.7	8.4	13.9
TKM 6	43.7	52.0	0.6	0.7	10.5	11.9
CO 33	60.7	38.4	1.0	0.6	19.0	10.6
CO 13	28.2	48.2	0.4	0.8	6.9	13.4
TKM 6-10-12 x						
CO 29	53.7	73.7	0.7	1.4	15.8	25.6
TKM 6	64.4	78.2	1.1	1.6	19.1	29.3
CO 33	41.3	39.3	0.5	0.4	10.0	9.0
CO 13	43.8	52.7	0.5	0.7	9.5	12.2
CO 33-9 x						
CO 29	84.8	85.7	1.7	1.6	35.8	30.0
TKM 6	67.9	67.7	1.0	1.1	23.5	22.2
CO 33	70.0	68.9	1.0	1.0	20.9	20.8
CO 13	53.7	25.2	0.9	0.3	18.6	5.8

Table 11 d. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Leaf area

Cross	h^2 (%)		GA		GA as % on mean	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGNG x 00 29	17.1	38.2	1.5	3.4	6.3	14.2
TKM 6	71.7	46.9	8.1	3.7	27.6	15.3
00 33	20.0	10.7	2.0	1.0	9.1	5.5
00 13	62.1	52.1	10.2	7.6	37.3	31.3
5824 x 00 29	69.9	57.5	7.1	5.3	35.0	26.1
TKM 6	45.7	63.2	4.0	5.8	17.5	25.4
00 33	66.3	31.9	5.8	2.2	30.5	12.9
00 13	63.7	49.4	6.0	4.0	32.3	20.0
T(N)1 x 00 29	61.5	55.3	5.2	4.1	23.4	18.2
TKM 6	77.2	81.1	10.3	11.9	39.5	48.1
00 33	85.7	69.2	10.9	6.7	47.4	27.5
00 13	70.7	28.7	6.5	1.9	27.1	8.3
00 29-M-40 x						
00 29	63.3	58.7	5.2	4.0	23.1	17.0
TKM 6	78.3	59.4	9.4	4.7	35.8	20.4
00 33	86.0	52.0	12.0	4.6	53.3	21.5
00 13	77.9	45.6	9.4	3.5	39.6	15.0
TKM 6-10-12 x						
00 29	28.3	57.7	2.6	7.0	14.9	34.7
TKM 6	32.4	65.3	2.9	8.1	13.7	34.3
00 33	74.0	87.3	6.9	11.5	31.6	44.7
00 13	13.4	53.1	1.3	6.0	5.3	25.4
00 33-9 x						
00 29	41.9	36.6	4.7	3.9	22.9	19.3
TKM 6	38.0	57.2	3.5	6.2	21.2	31.2
00 33	42.6	60.8	3.9	5.7	20.8	31.3
00 13	13.9	36.1	1.3	3.8	6.8	15.9

Table 11 c. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Panicle length

Cross	h^2 (%)		GA		GA as % on mean	
	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$
DGNG x 00 29	46.9	20.5	1.9	0.7	9.0	3.4
TKM 6	69.2	51.5	3.3	2.0	14.5	9.4
00 33	45.1	16.8	1.4	0.5	7.3	2.6
00 13	70.0	85.7	3.8	5.8	16.9	27.4
5824 x 00 29	75.9	69.6	3.0	2.9	14.8	14.9
TKM 6	70.3	78.0	3.3	3.4	16.4	16.8
00 33	66.8	79.3	3.0	3.5	15.6	18.9
00 13	87.6	65.6	5.3	2.5	26.7	12.7
1(N)1 x 00 29	63.1	70.0	2.9	3.2	14.5	15.7
TKM 6	75.6	69.3	4.2	3.3	19.4	14.5
00 33	62.6	65.2	2.6	2.9	13.0	13.7
00 13	42.2	64.5	1.5	2.8	7.3	13.4
00 29-N-40 x						
00 29	74.1	68.7	2.4	1.9	12.6	9.4
TKM 6	77.1	47.9	3.8	1.8	18.2	8.8
00 33	88.5	55.8	6.2	2.1	36.5	11.5
00 13	93.4	87.6	7.2	5.2	34.4	26.0
TKM 6-10-12 x						
00 29	30.9	48.1	1.1	2.0	6.2	10.4
TKM 6	71.8	42.5	4.4	1.7	22.2	7.7
00 33	65.0	70.4	3.0	3.5	15.0	17.7
00 13	59.2	59.0	2.7	2.6	12.5	12.6
00 33-9 x						
00 29	79.0	75.3	5.1	4.9	27.7	25.9
TKM 6	87.0	71.0	3.0	3.6	17.4	17.6
00 33	53.2	48.8	1.0	1.5	5.1	21.1
00 13	42.9	21.2	1.1	0.5	5.4	2.6

Table 11 f. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Number of grains per panicle

Cross	h^2 (%)		GA		GA as % on mean	
	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$	P_2	$P_{2(R)}$
DGWS x 00 29	24.9	51.8	8.0	17.9	9.8	21.5
TKM 6	49.0	51.3	23.4	21.3	23.8	25.6
00 33	40.9	61.1	16.0	28.0	19.5	33.9
00 13	72.0	49.5	39.6	20.5	44.3	23.4
5824 x 00 29	47.3	73.4	14.0	32.8	24.3	52.8
TKM 6	76.7	67.6	43.2	34.1	55.2	40.2
00 33	65.8	59.5	35.6	25.5	47.4	33.4
00 13	19.4	30.7	6.1	14.9	8.6	20.2
T(N)1 x 00 29	48.0	48.2	17.4	21.1	25.7	26.8
TKM 6	70.3	52.8	37.9	24.6	42.5	24.0
00 33	59.1	51.6	28.7	23.6	32.8	23.8
00 13	49.8	23.5	22.1	8.8	25.3	12.1
00 29-M-40 x						
00 29	71.4	68.3	25.5	26.5	35.1	35.2
TKM 6	33.6	75.6	10.2	32.9	14.9	39.5
00 33	90.4	52.9	57.8	20.0	88.6	26.7
00 13	74.7	70.2	39.8	29.3	50.2	37.9
TKM 6-10-12 x						
00 29	55.4	45.2	23.4	18.0	31.7	23.9
TKM 6	16.7	21.4	6.0	7.9	6.8	8.8
00 33	84.1	77.7	52.5	48.8	56.9	55.0
00 13	60.3	30.0	22.9	10.0	24.9	11.7
00 33-9 x						
00 29	39.8	32.1	15.9	12.0	18.9	14.3
TKM 6	55.9	71.5	24.7	36.3	33.3	41.3
00 33	37.1	59.5	14.9	26.6	15.8	25.8
00 13	13.7	30.5	4.9	11.3	5.6	13.5

Table 11 g. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Weight of grains per panicle

Cross	h^2 (%)		GA		GA as % on mean	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWO x 00 29	42.0	63.5	0.5	0.8	22.9	37.8
TKM 6	53.1	56.1	0.6	0.7	29.2	37.7
00 33	40.0	61.3	0.4	0.7	23.9	43.1
00 13	74.2	73.6	1.2	1.1	50.2	54.3
5824 x 00 29	38.5	36.1	0.3	0.3	20.8	20.9
TKM 6	76.8	79.4	1.0	1.0	59.5	55.1
00 33	40.5	36.0	0.3	0.3	19.6	18.1
00 13	86.2	84.0	1.8	1.6	95.3	86.4
T(H)1 x 00 29	38.9	49.3	0.4	0.5	26.5	30.8
TKM 6	53.8	63.5	0.7	0.8	36.1	40.4
00 33	43.4	45.7	0.4	0.5	26.7	25.7
00 13	52.3	26.4	0.8	0.3	36.8	17.3
00 29-M-40 x						
00 29	40.4	31.3	0.4	0.3	24.0	18.2
TKM 6	51.4	31.1	0.3	0.2	19.3	15.2
00 33	59.9	77.1	0.6	0.9	49.6	74.6
00 13	67.9	72.5	1.0	1.0	54.5	49.7
TKM 6-10-12 x						
00 29	33.0	54.3	0.3	0.6	19.7	38.3
TKM 6	31.4	38.2	0.3	0.7	22.7	44.3
00 33	81.2	66.5	1.0	0.7	63.8	43.6
00 13	57.0	57.8	0.8	0.8	38.7	38.8
00 33-9 x						
00 29	32.2	53.0	0.3	0.6	18.4	32.9
TKM 6	36.2	52.1	0.3	0.5	15.4	29.6
00 33	48.1	59.0	0.4	0.5	25.9	30.2
00 13	41.8	53.9	0.4	0.5	20.2	27.0

Table 11 h. Estimates of heritability per cent, (in broad sense) genetic advance (OA) and genetic advance as per cent on mean.

1000 grain weight

Cross	h^2 (%)		OA		OA as % on mean	
	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$	F_2	$F_{2(R)}$
DGWS x 00 29	62.3	54.3	2.4	2.1	10.2	9.0
TKM 6	67.8	79.4	2.4	4.1	10.9	19.6
00 33	75.5	79.9	3.8	5.5	18.3	28.9
00 13	53.4	50.9	2.1	2.1	8.2	8.8
5824 x 00 29	60.8	55.9	2.3	2.2	9.3	9.0
TKM 6	68.5	54.3	3.2	2.1	15.1	10.3
00 33	78.8	80.8	7.1	5.8	37.0	30.4
00 13	78.9	73.9	3.0	2.7	12.0	11.2
T(N)1 x 00 29	75.7	74.9	4.0	4.3	17.2	18.8
TKM 6	54.8	66.8	2.0	3.0	10.4	16.0
00 33	78.5	47.8	4.8	2.4	24.3	13.1
00 13	75.7	72.3	3.6	3.6	15.4	15.6
CO 29-M-40 x						
00 29	77.7	51.2	2.2	1.3	9.6	5.9
TKM 6	57.0	81.2	1.5	3.3	7.2	17.2
00 33	92.3	61.3	7.8	2.8	40.7	17.2
00 13	76.4	84.2	3.4	3.8	14.7	16.5
TKM 6-10-12 x						
00 29	31.8	59.7	0.6	1.7	3.2	7.5
TKM 6	56.6	66.0	1.6	2.3	8.3	11.7
00 33	83.8	93.9	4.3	7.4	25.9	53.2
00 13	94.1	86.9	8.9	9.0	38.6	40.3
00 33-9 x						
00 29	82.2	72.3	4.3	4.3	22.6	20.8
TKM 6	78.7	88.9	2.5	4.0	14.6	22.3
00 33	68.6	70.0	2.6	2.2	14.2	12.3
00 13	88.4	59.3	5.0	2.2	24.1	9.4

Table 11 i. Estimates of heritability per cent, (in broad sense) genetic advance (GA) and genetic advance as per cent on mean.

Grain yield per plant

Cross	h^2 (%)		GA		GA as % on mean	
	P_2	$P_2(R)$	P_2	$P_2(R)$	P_2	$P_2(R)$
DGNG x OO 29	63.0	70.8	16.7	22.9	76.7	94.2
TKM 6	67.7	57.7	16.9	13.3	70.1	72.8
OO 33	34.5	34.4	3.9	3.8	29.5	27.8
OO 13	61.3	59.4	14.9	12.2	76.6	70.3
5824 x OO 29	44.3	14.4	6.0	1.7	44.6	13.8
TKM 6	70.9	76.5	12.6	15.7	76.6	79.4
OO 33	62.3	35.8	13.5	6.1	84.8	44.0
OO 13	56.1	42.1	9.5	6.8	57.7	39.4
T(N)1 x OO 29	46.8	41.9	8.6	7.8	56.3	40.5
TKM 6	73.7	63.7	17.6	12.5	99.4	64.3
OO 33	47.2	70.1	7.4	15.5	44.3	74.8
OO 13	66.0	33.1	11.9	4.7	70.3	30.8
OO 29-M-40 x						
OO 29	49.5	30.0	9.3	3.0	53.4	28.3
TKM 6	51.4	49.7	8.7	8.4	59.2	53.6
OO 33	76.1	81.1	10.4	11.1	106.5	120.2
OO 13	44.1	69.3	6.1	11.6	33.8	65.0
TKM 6-10-12 x						
OO 29	51.6	37.4	10.6	6.7	82.9	40.8
TKM 6	58.5	57.5	10.8	11.2	54.9	54.1
OO 33	26.6	36.1	3.2	8.1	27.2	63.6
OO 13	62.7	60.2	13.4	12.1	64.7	58.2
OO 33-9 x						
OO 29	31.9	39.6	4.6	3.6	32.9	39.1
TKM 6	39.8	36.5	5.1	10.1	51.7	66.9
OO 33	80.8	86.2	14.2	14.6	93.3	88.3
OO 13	19.2	34.1	2.3	9.5	15.9	46.9

Table 12 a. Simple correlation coefficients between grain yield per plant and plant height.

Cross	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	P_2
DGWC x CO 29	-0.1501	0.6534	0.5381	0.3420	0.3050	0.5461
TKM 6		0.2183	0.7697	0.4944	0.6922	0.5524
CO 33		0.0916	0.5410	-0.2726	0.7675	0.2422
CO 13		0.2937	0.6074	0.2906	0.1507	0.4994
5824 x CO 29	-0.4114	0.5027	0.4120	0.4267	0.4238	0.5461
TKM 6		0.5722	0.1824	0.5457	0.0011	0.5524
CO 33		0.1000	0.5650	0.3619	0.2682	0.2422
CO 13		0.3860	0.6442	0.1172	0.3574	0.4994
T(N)1 x CO 29	0.6034	0.1420	0.6807	0.1795	0.5259	0.5461
TKM 6		0.5678	0.2367	0.3234	0.5663	0.5524
CO 33		0.7123	0.2900	-0.0026	0.3393	0.2422
CO 13		0.0534	0.6632	0.1847	0.1586	0.4994
CO 29-M-40 x						
CO 29	0.2921	0.4591	-0.3749	-0.1173	0.5384	0.5461
TKM 6		0.5479	0.4201	-0.0051	0.1176	0.5524
CO 33		0.7115	0.4292	0.5952	0.4259	0.2422
CO 13		0.5687	0.3459	-0.1671	0.2824	0.4994
TKM 6-10-12 x						
CO 29	0.3279	0.1693	0.8259	0.5753	0.2227	0.5461
TKM 6		-0.0103	0.4496	0.0689	0.1525	0.5524
CO 33		0.3512	0.3289	0.1764	0.4784	0.2422
CO 13		0.4258	0.5575	0.1387	0.4798	0.4994
CO 33-9 x						
CO 29	0.4636	0.4482	0.3575	-0.0407	-0.0085	0.5461
TKM 6		0.1396	0.1844	0.3260	0.7149	0.5524
CO 33		0.1150	0.6551	0.1903	0.2014	0.2422
CO 13		0.2765	0.8499	0.5180	-0.0172	0.4994

The correlation coefficient must exceed (1) 0.3124 and 0.4090 for P_1 , P_2 , F_1 and $F_{1(R)}$, (2) 0.2200 and 0.2868 for P_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 b. Simple correlation coefficients between grain yield per plant and tiller number.

Cross	P_1	P_2	P_1	$P_{1(R)}$	$P_{2(R)}$	P_2
DW6 x 00 29	0.8615	0.9374	0.8857	0.9285	0.9765	0.9509
TKM 6		0.7757	0.9466	0.9478	0.9375	0.7908
00 33		0.7777	0.3274	0.0330	0.6111	0.5496
00 13		0.7975	0.9630	0.9312	0.8450	0.7108
5824 x 00 29	0.9715	0.8343	0.7714	0.9378	0.7442	0.9509
TKM 6		0.7077	0.9577	0.7938	0.4943	0.7908
00 33		0.8544	0.8794	0.6096	0.5864	0.5496
00 13		0.9043	0.8949	0.8006	0.8366	0.7108
I(N)1 x 00 29	0.4445	0.6219	0.8830	0.9192	0.4798	0.9509
TKM 6		0.3764	0.9046	0.9367	0.5632	0.7908
00 33		0.2378	0.5677	0.1052	0.1666	0.5496
00 13		0.0460	0.9531	0.8470	0.1276	0.7108
00 29-M-40 x						
00 29	0.9282	0.8953	0.9272	0.9349	0.6495	0.9509
TKM 6		0.3259	0.8669	0.8883	0.8357	0.7908
00 33		0.8195	0.8413	0.5087	0.5413	0.5496
00 13		0.3256	0.8645	0.6332	0.6111	0.7108
TKM 6-10-12 x						
00 29	0.0731	0.5338	0.8155	0.8206	0.5154	0.9509
TKM 6		0.4274	0.9485	0.8885	0.4769	0.7908
00 33		0.7829	0.8066	0.7220	0.5868	0.5496
00 13		0.5769	0.8590	0.8452	0.2114	0.7108
00 33-9 x						
00 29	0.7205	0.6331	0.8789	0.7155	0.6123	0.9509
TKM 6		0.8340	0.8745	0.6823	0.4533	0.7908
00 33		0.2558	0.8914	0.3344	0.1919	0.5496
00 13		0.5419	0.5654	0.7245	0.7639	0.7108

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , P_1 and $P_{1(R)}$ (2) 0.2200 and 0.2846 for P_2 and $P_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 e. Simple correlation coefficients between grain yield per plant and number of internodes.

Cross	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	F_2
DGNG x 00 29	-0.0467	0.0324	-0.0104	-0.1137	0.0641	0.3840
TKM 6		-0.0408	0.0647	0.2304	0.2198	0.3042
00 33		-0.1295	0.4942	-0.0779	0.5164	-0.1173
00 15		0.3769	-0.0525	-0.1176	0.1619	-0.2817
5824 x 00 29	-0.2413	-0.0733	0.4232	0.2710	0.2380	0.3840
TKM 6		0.1051	0.0288	0.3487	-0.1141	0.3042
00 33		-0.2049	-0.1477	0.4014	0.0116	-0.1173
00 15		0.4894	0.2453	0.5199	0.0959	-0.2817
Z(N)1 x 00 29	0.2649	0.1196	0.2941	0.2503	0.2911	0.3840
TKM 6		0.0987	0.6432	-0.0672	0.4704	0.3042
00 33		0.8100	-0.2325	0.1685	-0.0061	-0.1173
00 15		0.0599	0.4310	-0.2818	0.1974	-0.2817
00 29-N-40 x						
00 29	0.2283	-0.0224	-0.0102	-0.0382	0.2459	0.3840
TKM 6		0.1077	0.2273	-0.1071	0.2119	0.3042
00 33		-0.0512	0.3741	0.6904	-0.1434	-0.1173
00 15		0.2089	-0.0437	-0.2406	0.0487	-0.2817
TKM 6-10-12 x						
00 29	0.2308	0.0759	0.9499	-0.2313	0.1479	0.3840
TKM 6		0.1298	-0.2346	0.2017	0.0798	0.3042
00 33		0.2494	0.0639	-0.1795	0.1078	-0.1173
00 15		0.1976	-0.7459	0.1804	0.7215	-0.2817
00 33-9 x						
00 29	-0.1270	0.5658	0.6728	-0.1649	0.4954	0.3840
TKM 6		0.5021	0.7508	0.3833	0.2104	0.3042
00 33		0.2370	-0.1886	-0.1566	0.0772	-0.1173
00 15		0.1911	0.3615	0.1198	-0.2224	-0.2817

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_{1(R)}$ (2) 0.2200 and 0.2868 for F_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 d. Simple correlation coefficients between grain yield per plant and leaf area.

Cross	P_1	P_2	F_1	$F_1(R)$	$F_2(R)$	P_2
DW6 x OO 29	0.4442	0.3298	0.4793	0.1184	0.0889	0.6855
TKM 6		0.1590	0.5123	0.2537	0.5444	0.7110
OO 33		0.0733	0.3088	-0.0142	0.2147	-0.2862
OO 13		0.0909	0.2902	0.2474	0.2073	0.2409
5824 x OO 29	0.5026	0.6229	-0.2822	0.3233	0.4002	0.6855
TKM 6		0.3063	0.2263	0.2155	0.1148	0.7110
OO 33		-0.1058	0.4396	-0.0360	0.2033	-0.2862
OO 13		0.3279	0.4350	0.2817	0.6632	0.2409
T(N)1 x OO 29	0.5404	0.5179	0.2287	-0.0909	0.4491	0.6855
TKM 6		0.4333	0.3643	0.1284	0.1996	0.7110
OO 33		0.4956	0.3449	-0.3694	0.6034	-0.2862
OO 13		0.4782	-0.0293	-0.1862	0.5063	0.2409
OO 29-M-40 x						
OO 29	0.6589	-0.0377	0.1945	0.0384	0.0418	0.6855
TKM 6		0.4123	0.4215	0.1409	-0.2244	0.7110
OO 33		-0.0992	-0.0812	0.3783	0.5945	-0.2862
OO 13		0.2359	0.3352	-0.1974	0.2868	0.2409
TKM 6-10-12 x						
OO 29	0.5488	0.0796	0.1508	0.1173	0.2901	0.6885
TKM 6		0.3330	0.5123	-0.0233	0.4761	0.7110
OO 33		0.4179	-0.0039	-0.0862	0.4273	-0.2862
OO 13		0.1091	0.5490	0.4221	0.2794	0.2409
OO 33-9 x						
OO 29	0.5102	0.5264	0.1299	0.0533	0.4531	0.6885
TKM 6		0.4162	0.0029	0.2383	0.6649	0.7110
OO 33		0.0268	0.6452	0.1833	0.2333	-0.2862
OO 13		0.5349	0.8911	0.4660	0.6283	0.2409

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_1(R)$ (2) 0.2200 and 0.2868 for P_2 and $F_2(R)$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 c. Simple correlation coefficients between grain yield per plant and panicle length.

Cross	P_1	P_2	F_1	$F_1(R)$	$F_2(R)$	P_2
DWG x GO 29	0.0274	0.7522	0.5138	0.5792	0.2727	0.4836
TKM 6		0.2441	0.5083	0.5224	0.4439	0.3552
GO 33		0.3380	-0.0217	0.1503	0.5746	0.3254
GO 13		0.5742	0.6564	0.0186	0.1066	0.2844
5824 x GO 29	0.2349	0.4998	0.3068	0.0665	0.4232	0.4836
TKM 6		0.5776	0.1982	0.2657	0.5492	0.3552
GO 33		0.1506	0.0740	0.9144	0.3482	0.3254
GO 13		0.5139	0.6381	0.4907	0.4611	0.2844
T(N)1 x GO 29	0.1543	0.3965	0.6723	0.3070	0.5896	0.4836
TKM 6		0.4915	0.6695	0.5634	0.5194	0.3552
GO 33		0.4037	0.2010	0.6116	0.3272	0.3254
GO 13		0.4064	0.6549	-0.0584	0.6196	0.2844
GO 29-H-40 x						
GO 29	0.1054	0.6647	0.2150	0.6713	0.7681	0.4836
TKM 6		0.6820	0.6161	0.2808	0.3014	0.3552
GO 33		0.4793	0.3863	0.0901	0.5349	0.3254
GO 13		0.6543	0.5203	0.4345	0.4001	0.2844
TKM 6-10-12 x						
GO 29	0.5655	0.2755	0.8882	0.7792	0.2433	0.4836
TKM 6		0.5459	0.7803	0.2511	0.3007	0.3552
GO 33		0.6010	0.7601	0.6377	0.5811	0.3254
GO 13		0.5987	0.6071	0.5215	0.3149	0.2844
GO 33-9 x						
GO 29	0.5089	0.5776	0.9277	0.2258	0.5328	0.4836
TKM 6		0.7670	0.2612	0.3452	0.6598	0.3552
GO 33		0.5831	0.6503	0.1231	0.5312	0.3254
GO 13		0.6172	0.8711	0.7404	0.7233	0.2844

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_1(R)$ (2) 0.2200 and 0.2868 for F_2 and $F_2(R)$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 f. Simple correlation coefficients between grain yield per plant and number of grains per panicle.

Cross	P_1	P_2	F_1	$F_1(R)$	$F_2(R)$	P_2
DGWO x OO 29	0.4965	0.6790	0.1535	0.7439	0.3739	0.8386
TKM 6		0.5796	0.4741	0.7743	0.7305	0.3805
OO 33		0.8692	0.1256	0.2910	0.2531	0.7091
OO 13		0.4237	-0.0125	0.5626	0.5597	0.7559
5824 x OO 29	0.5466	0.7551	0.5556	0.7368	0.6969	0.8386
TKM 6		0.7664	0.4064	0.6949	0.5785	0.3805
OO 33		0.4612	0.6331	0.6899	0.5807	0.7091
OO 13		0.5004	0.7206	0.7108	0.5009	0.7559
Z(N)1 x OO 29	0.3637	0.0956	0.8246	0.3283	0.7985	0.8386
TKM 6		0.9281	0.4984	0.5914	0.4100	0.3805
OO 33		0.0988	0.2593	0.5587	0.5735	0.7091
OO 13		0.2239	0.6660	0.3958	0.5681	0.7559
GO 29-N-40 x						
OO 29	0.3524	0.7218	0.3919	0.6785	0.6896	0.8386
TKM 6		0.8279	0.6748	0.4746	0.0927	0.3805
OO 33		0.3571	0.4547	0.4917	0.3541	0.7091
OO 13		0.3246	0.4759	0.7036	0.6986	0.7559
TKM 6-10-12 x						
OO 29	0.5638	0.1902	0.8979	0.8761	0.0998	0.8386
TKM 6		0.2444	0.8997	0.5707	0.0998	0.3805
OO 33		0.3992	0.7004	0.8157	0.4899	0.7091
OO 13		0.2769	0.5795	0.8239	0.4759	0.7559
GO 33-9 x						
OO 29	0.6889	0.6842	0.7860	0.4227	0.6026	0.8386
TKM 6		0.6278	0.2481	0.6857	0.7025	0.3805
OO 33		0.1940	0.6560	0.2433	0.4456	0.7091
OO 13		0.5968	0.6594	0.5353	0.5901	0.7559

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_1(R)$ (2) 0.2200 and 0.2868 for P_2 and $F_2(R)$ to be significant at the 0.05 and 0.01 level respectively.

Table 12 g. Simple correlation coefficients between grain
yield per plant and weight of grains per panicle.

Cross	P_1	P_2	F_1	$F_1(R)$	$F_2(R)$	P_2
DWG x OO 29	0.4530	0.6460	0.2304	0.7705	0.4292	0.8537
TKM 6		0.2958	0.5634	0.6968	0.7784	0.4683
OO 33		0.8085	0.0384	0.2997	0.1580	0.7043
OO 13		0.3471	0.0009	0.5380	0.5613	0.7219
5824 x OO 29	0.4814	0.8401	0.5656	0.7562	0.5462	0.8537
TKM 6		0.7438	0.4320	0.7045	0.5798	0.4683
OO 33		0.7729	0.5979	0.7888	0.0093	0.7043
OO 13		0.4876	0.7296	0.7097	0.3339	0.7219
T(N)1 x OO 29	0.0194	0.7598	0.8229	0.4189	0.4099	0.8537
TKM 6		0.4756	0.6611	0.0290	0.3261	0.4683
OO 33		0.2090	0.2228	0.3030	0.6026	0.7043
OO 13		0.7615	0.7106	0.3568	0.3710	0.7219
OO 29-H-40 x						
OO 29	0.4014	0.7431	0.3952	0.6267	0.4850	0.8537
TKM 6		0.5781	0.6905	0.5027	0.4507	0.4683
OO 33		0.4325	0.4364	0.5762	0.4475	0.7043
OO 13		0.5081	0.6729	0.6556	0.5614	0.7219
TKM 6-10-12 x						
OO 29	0.7606	0.3041	0.9563	0.4268	0.2984	0.8537
TKM 6		0.4941	0.8259	0.4142	0.4172	0.4683
OO 33		0.5869	0.7957	0.4971	0.6117	0.7043
OO 13		0.3477	0.6126	0.8346	0.2009	0.7219
OO 33-9 x						
OO 29	0.7131	0.7515	0.7870	0.1161	0.4569	0.8537
TKM 6		0.5671	0.2304	0.7132	0.3751	0.4683
OO 33		0.4456	0.7444	0.3081	0.3039	0.7043
OO 13		0.4326	0.9312	0.4592	0.5084	0.7219

The correlation coefficient must exceed (1) 0.3124 and 0.4030
for P_1 , P_2 , F_1 and $F_1(R)$ (2) 0.2200 and 0.2868 for F_2 and $F_2(R)$
to be significant at the 0.05 and 0.01 level respectively.

Table 12 h. Simple correlation coefficients between grain yield per plant and 1000 grain weight.

Cross	P_1	P_2	F_1	$F_1(R)$	$F_2(R)$	P_2
DW6 x 00 29	-0.0722	0.1999	0.4737	0.0936	-0.2372	-0.3224
TKM 6		-0.1064	-0.3233	0.0060	-0.2549	-0.0905
00 33		-0.1849	-0.1380	-0.2071	-0.5276	-0.4013
00 13		-0.0740	0.1740	-0.3762	-0.1875	-0.2837
5824 x 00 29	-0.2933	-0.1293	0.0063	0.0422	-0.4076	-0.3224
TKM 6		-0.1206	-0.0644	-0.3326	0.1487	-0.0905
00 33		0.2502	-0.2312	-0.4933	0.0107	-0.4013
00 13		0.2761	-0.7040	0.1332	0.2033	-0.2837
T(N)1 x 00 29	-0.0073	0.4612	0.3803	-0.2315	0.7240	-0.3224
TKM 6		0.6621	-0.3130	-0.2236	0.2402	-0.0905
00 33		0.2589	0.1177	0.1247	-0.3163	-0.4013
00 13		0.6196	0.4390	-0.0660	-0.3153	-0.2837
00 29-M-40 x						
00 29	-0.6443	-0.1190	0.0454	-0.4319	0.0987	-0.3224
TKM 6		0.2731	-0.5384	0.0449	-0.1187	-0.0905
00 33		0.1976	0.3840	0.3338	0.2112	-0.4013
00 13		0.1739	0.1086	0.2904	-0.2269	-0.2837
TKM 6-10-12 x						
00 29	-0.1566	0.0548	0.8485	0.4762	0.1411	-0.3224
TKM 6		0.1994	-0.5903	-0.0273	0.2713	-0.0905
00 33		0.2468	0.1419	0.1819	0.2876	-0.4013
00 13		0.2893	0.3637	0.6410	0.2799	-0.2837
00 33-9 x						
00 29	0.2934	0.3297	0.5884	-0.0448	0.2971	-0.3224
TKM 6		0.2411	-0.0776	0.3739	0.2336	-0.0905
00 33		0.1067	0.1214	0.0222	0.2361	-0.4013
00 13		0.1421	0.8940	0.3832	-0.3401	-0.2837

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_1(R)$ (2) 0.2200 and 0.2868 for P_2 and $F_2(R)$ to be significant at the 0.05 and 0.01 level respectively.

Table 13 a. Simple correlation coefficients between plant height and tiller number.

Cross	Generations					
	P ₁	P ₂	P ₁	P _{1(R)}	P _{2(R)}	P ₂
DOWS x OO 29	-0.4370	0.6291	0.6750	0.5326	0.2608	0.3882
TKM 6		0.2900	0.6214	0.5805	0.5955	0.4443
OO 33		0.1942	-0.0629	0.2643	0.2259	-0.1564
OO 15		-0.3569	-0.0004	0.2928	0.1874	0.7494
5824 x OO 29	-0.4614	0.3032	0.0169	0.1850	-0.0135	0.3882
TKM 6		0.3108	0.2676	0.0873	0.0034	0.4443
OO 33		-0.3826	0.2368	0.3834	-0.3568	-0.1564
OO 15		0.0738	0.3469	0.0238	-0.3247	0.7494
T(N)1 x OO 29	0.3927	0.2593	0.6239	0.1000	0.1997	0.3882
TKM 6		0.3459	0.0504	0.3442	0.6178	0.4443
OO 33		-0.1232	0.0839	-0.2714	0.0242	-0.1564
OO 15		0.2068	0.6853	0.1514	0.1899	0.7494
OO 29-N-40 x						
OO 29	0.0983	0.4115	-0.4047	0.0702	0.3988	0.3882
TKM 6		0.2988	-0.9282	0.1549	0.0843	0.4443
OO 33		0.5869	0.3283	0.1147	0.0663	-0.1564
OO 15		0.0455	0.3029	-0.1574	-0.2031	0.7494
TKM 6-10-12 x						
OO 29	0.3439	0.2080	0.5699	0.1967	0.1029	0.3882
TKM 6		0.3228	0.2987	-0.1303	-0.0004	0.4443
OO 33		0.0924	0.2936	-0.1287	-0.2176	-0.1564
OO 15		0.0977	0.2349	0.2360	-0.1951	0.7494
OO 33-9 x						
OO 29	0.2498	0.0025	0.3188	-0.3517	0.1765	0.3882
TKM 6		0.3377	0.2399	0.1783	0.2362	0.4443
OO 33		0.6275	0.5515	0.3504	0.2788	-0.1564
OO 15		0.2033	0.7774	0.0180	0.1537	0.7494

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P₁, P₂, P₁ and P_{1(R)} (2) 0.2200 and 0.2868 for P₂ and P_{2(R)} to be significant at the 0.05 and 0.01 level respectively.

Table 13 b. Simple correlation coefficients between plant height and number of internodes.

Cross	Generations					
	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	F_2
DGW x OO 29	0.4667	-0.1562	0.0916	0.0888	0.2069	0.2661
TKM 6		0.2987	-0.0106	0.4698	0.2343	-0.3952
OO 33		0.2148	0.6324	0.3390	0.3841	0.3218
OO 13		0.2521	0.1843	0.3663	0.6138	-0.2603
5824 x OO 29	0.2874	0.1924	0.7146	0.1655	0.3423	0.2661
TKM 6		0.5004	0.0955	0.2669	0.4133	-0.3952
OO 33		0.7321	0.2370	0.9731	0.1597	0.3218
OO 13		0.4678	0.3786	0.3687	0.2154	-0.2603
T(W)1 x OO 29	0.4008	0.6745	0.4992	0.3012	0.2185	0.2661
TKM 6		0.4391	0.0346	0.7426	0.7331	-0.3952
OO 33		0.3571	0.2306	0.5739	0.2437	0.3218
OO 13		0.1988	0.4203	-0.0746	0.1480	-0.2603
OO 29-M-40 x						
OO 29	0.2976	0.1567	0.2398	0.0417	0.0913	0.2661
TKM 6		0.1234	0.6398	-0.1816	0.0922	-0.3952
OO 33		0.4947	0.1738	0.8032	0.1373	0.3218
OO 13		0.1167	0.2360	0.6233	0.1154	-0.2603
TKM 6-10-12 x						
OO 29	-0.0592	0.5224	0.9271	0.1822	0.4396	0.2661
TKM 6		0.6241	0.1738	0.1018	0.2974	-0.3952
OO 33		0.3766	0.0308	0.2361	0.2796	0.3218
OO 13		0.2118	0.7365	0.7503	0.2294	-0.2603
OO 33-9 x						
OO 29	0.2968	0.8219	0.2793	-0.0198	0.3429	0.2661
TKM 6		0.4001	0.3621	0.2430	0.4817	-0.3952
OO 33		0.4493	-0.0639	-0.2369	0.2163	0.3218
OO 13		0.1989	0.0897	0.6226	0.7623	-0.2603

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_{1(R)}$ (2) 0.2200 and 0.2868 for F_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 13 c. Simple correlation coefficients between plant height and leaf area.

Cross	Generations					
	P ₁	P ₂	F ₁	F ₁ (R)	F ₂ (R)	P ₂
DGW x 00 29	0.3141	0.5619	0.5686	0.2570	-0.4531	0.3336
TKM 6		0.7610	0.8236	0.4230	0.0986	0.5522
00 33		0.5181	0.2600	0.8288	0.5550	0.2993
00 13		0.5628	0.3339	0.3913	0.4491	0.8408
5824 x 00 29	0.0942	0.7212	0.1257	-0.4639	0.3286	0.3336
TKM 6		0.8170	0.0941	0.2966	0.5757	0.5522
00 33		0.7647	0.9205	0.6795	0.4715	0.2993
00 13		0.4564	0.5043	0.1413	0.5219	0.8408
T(N)1 x 00 29	0.5254	0.0590	0.4061	0.5614	0.4958	0.3336
TKM 6		0.5289	0.1590	0.2365	0.5485	0.5522
00 33		0.5260	0.2701	0.3280	0.7177	0.2993
00 13		0.1570	0.2307	-0.2898	0.4006	0.8408
00 29-W-40 x						
00 29	0.1974	-0.0668	0.0528	0.0760	-0.1048	0.3336
TKM 6		-0.0837	0.5547	0.1965	0.2751	0.5522
00 33		0.0734	0.3373	0.8367	-0.0967	0.2993
00 13		0.0877	0.3157	-0.3768	-0.1924	0.8408
TKM 6-10-12 x						
00 29	0.5261	0.3426	0.3478	0.5021	0.2475	0.3336
TKM 6		0.1114	0.4491	-0.2057	0.1174	0.5522
00 33		0.4909	0.0487	0.8874	0.3997	0.2993
00 13		0.2276	0.8428	0.7909	0.4074	0.8408
00 33-9 x						
00 29	0.8079	0.4611	0.0593	-0.1999	0.6820	0.3336
TKM 6		0.0292	0.2773	0.3707	0.4759	0.5522
00 33		0.3886	0.4349	0.3660	0.5333	0.2993
00 13		0.5942	0.8784	0.8294	0.4469	0.8408

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P₁, P₂, F₁ and F₁(R) (2) 0.2200 and 0.2868 for P₂ and F₂(R) to be significant at the 0.05 and 0.01 level respectively.

Table 13 d. Simple correlation coefficients between plant height and panicle length.

Cross	Generations					
	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	P_2
DGWB x OO 29	0.3877	0.8363	0.5467	0.0998	-0.1520	0.4167
TKM 6		0.3500	0.8697	0.3345	0.3917	0.2921
OO 33		0.5767	-0.0209	0.6905	-0.2006	0.2233
OO 13		0.5836	0.8491	0.0267	0.4680	0.6562
5824 x OO 29	0.4756	0.7073	0.1671	-0.0161	0.4683	0.4167
TKM 6		0.7368	-0.0469	0.3301	0.3593	0.2921
OO 33		0.7796	0.2188	0.1039	0.9857	0.2233
OO 13		0.5578	0.6134	0.4092	0.4965	0.6562
T(N)1 x OO 29	0.0813	0.5438	0.8543	-0.2931	0.5867	0.4167
TKM 6		0.6694	0.1192	0.4943	0.2924	0.2921
OO 33		0.2620	0.4599	0.5271	0.5230	0.2233
OO 13		0.3508	0.7855	-0.1845	0.4182	0.6562
OO 29-M-40 x						
OO 29	0.5411	0.5150	0.1601	0.3057	0.4952	0.4167
TKM 6		0.6175	0.6016	0.1378	0.1124	0.2921
OO 33		0.7882	0.8533	0.2035	0.2421	0.2233
OO 13		0.2176	0.2204	0.1718	0.6475	0.6562
TKM 6-10-12 x						
OO 29	0.2644	0.6771	0.8622	0.4745	0.5211	0.4167
TKM 6		0.5400	0.6679	0.1351	0.4911	0.2921
OO 33		0.5661	0.3805	0.6844	0.6011	0.2233
OO 13		0.5009	0.8597	0.7852	0.4976	0.6562
OO 33-9 x						
OO 29	0.6693	0.7237	0.2430	0.6109	0.6895	0.4167
TKM 6		0.4106	0.2772	0.7624	0.3241	0.2921
OO 33		0.6863	0.4653	0.3959	0.4989	0.2233
OO 13		0.4903	0.3285	0.3759	0.0148	0.6562

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_{1(R)}$ (2) 0.2200 and 0.2868 for P_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 13 e. Simple correlation coefficients between plant height and number of grains per panicle.

Cross	Generations					
	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	P_2
DGWG x OO 29	0.4851	0.6359	-0.4369	0.2246	0.1370	0.5477
TKM 6		0.7131	0.7633	0.4430	0.7382	0.5989
OO 33		-0.0593	0.3914	0.6963	0.5586	0.4710
OO 13		0.4911	0.2575	0.4386	0.5518	0.5809
5824 x OO 29	-0.1140	0.5028	0.8850	0.7822	0.7060	0.5477
TKM 6		0.6489	0.1944	0.7318	0.2575	0.5989
OO 33		0.3324	0.6372	0.1165	0.4532	0.4710
OO 13		0.4641	0.8436	0.2615	0.5481	0.5809
T(N)1 x OO 29	-0.5329	-0.2761	0.6639	0.3633	0.6133	0.5477
TKM 6		0.4745	0.0911	0.2894	0.3076	0.5989
OO 33		0.6027	0.0259	0.3961	0.8009	0.4710
OO 13		0.2988	0.7731	0.1123	0.1171	0.5809
OO 29-M-40 x						
OO 29	0.5238	0.5025	-0.1150	0.1921	0.5091	0.5477
TKM 6		0.3553	0.4970	0.3619	0.2216	0.5989
OO 33		0.7417	0.5007	0.3933	0.3071	0.4710
OO 13		0.7552	0.1899	0.1547	0.4382	0.5809
TKM 6-10-12 x						
OO 29	0.0343	-0.6497	0.7234	0.7418	-0.3471	0.5477
TKM 6		-0.2411	0.6387	0.3423	-0.5490	0.5989
OO 33		0.6084	0.5203	0.4326	0.4714	0.4710
OO 13		-0.1198	0.7434	0.2434	-0.0719	0.5809
OO 33-9 x						
OO 29	0.6323	0.2640	0.2282	0.1232	0.1939	0.5477
TKM 6		0.4524	0.3012	0.1284	0.5961	0.5989
OO 33		0.6671	0.3125	0.1312	0.6181	0.4710
OO 13		0.2668	0.7542	0.0851	-0.3477	0.5809

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_{1(R)}$, (2) 0.2200 and 0.2868 for F_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 13 f. Simple correlation coefficients between plant height and weight of grains per panicle.

Cross	Generations					
	P ₁	P ₂	F ₁	F _{1(R)}	F _{2(R)}	P ₂
DGWS x OO 29	0.5199	0.8717	-0.2458	0.1924	0.1516	0.6606
TKM 6		0.1502	0.8081	0.4915	0.7559	0.2251
OO 33		0.0152	0.5580	-0.1983	0.5310	0.4699
OO 15		0.4847	0.1616	0.1876	0.6115	0.5296
5824 x OO 29	0.0439	0.6136	0.6837	-0.0286	0.5982	0.6606
TKM 6		0.6008	-0.2008	0.5125	0.2400	0.2251
OO 33		-0.0094	0.8447	-0.0479	0.0577	0.4699
OO 15		0.5430	0.8703	0.2994	-0.2875	0.5296
T(N)1 x OO 29	-0.4069	0.6473	0.6496	0.2220	0.4175	0.6606
TKM 6		0.1475	-0.0898	0.0069	0.6957	0.2251
OO 33		0.2975	0.2860	0.5909	0.3147	0.4699
OO 15		0.5718	0.8994	0.1029	0.4955	0.5296
OO 29-M-40 x						
OO 29	0.5880	0.5067	-0.0252	-0.1587	0.5119	0.6606
TKM 6		0.6799	0.5125	0.2966	0.2653	0.2251
OO 33		0.5718	0.5265	0.5765	0.1494	0.4699
OO 15		0.1725	0.5686	-0.0476	0.5024	0.5296
TKM 6-10-12 x						
OO 29	0.0745	0.2738	0.7696	0.7580	0.2965	0.6606
TKM 6		0.5009	0.5090	0.5381	0.2667	0.2251
OO 33		0.6276	0.5454	0.5171	0.5741	0.4699
OO 15		0.2436	0.8178	0.4492	0.5611	0.5296
OO 33-9 x						
OO 29	0.6872	0.5519	0.2813	0.1734	0.5976	0.6606
TKM 6		0.6421	0.4217	0.5805	0.1792	0.2251
OO 33		0.6053	0.6110	0.5478	0.6160	0.4699
OO 15		0.5897	0.8672	0.0777	0.2048	0.5296

The correlation coefficient must exceed (1) 0.5124 and 0.4030 for P₁, P₂, F₁ and F_{1(R)} (2) 0.2200 and 0.2868 for P₂ and F_{2(R)} to be significant at the 0.05 and 0.01 level respectively.

Table 13 g. Simple correlation coefficients between plant height and 1000 grain weight.

Cross	Generations					
	P_1	P_2	F_1	$F_{1(R)}$	$F_{2(R)}$	P_2
DW6 x 00 29	0.0018	0.7044	0.4571	-0.4836	-0.7413	-0.1844
TKM 6		0.1805	-0.4067	-0.1561	-0.7889	-0.2174
00 33		0.0209	0.2556	0.7455	-0.2694	-0.1131
00 13		0.2382	0.6301	-0.3636	-0.1316	-0.6235
5824 x 00 29	0.2215	-0.0574	0.0579	0.0082	0.0895	-0.1844
TKM 6		0.1117	0.5830	-0.3961	0.0062	-0.2174
00 33		-0.2215	-0.0665	0.4621	0.3847	-0.1131
00 13		-0.8640	0.4504	0.0080	0.0211	-0.6235
T(N)1 x 00 29	-0.1234	0.3412	0.7325	-0.7947	0.5111	-0.1844
TKM 6		0.3339	0.1286	-0.7770	0.4239	-0.2174
00 33		0.2479	-0.3465	0.6360	0.2816	-0.1131
00 13		0.6004	0.5761	-0.0101	0.3388	-0.6235
00 29-H-40 x						
00 29	0.1263	-0.1044	0.1626	0.3039	-0.1983	-0.1844
TKM 6		0.0085	0.8048	-0.0530	0.0074	-0.2174
00 33		0.2053	0.1340	0.0182	-0.2133	-0.1131
00 13		0.1801	0.8890	0.1346	0.2794	-0.6235
TKM 6-10-12 x						
00 29	-0.0505	0.3224	0.4337	0.5731	0.3001	-0.1844
TKM 6		0.3415	0.0555	0.1457	0.3385	-0.2174
00 33		0.0643	0.2910	0.0674	0.2033	-0.1131
00 13		0.1987	0.6436	0.6562	0.0999	-0.6235
00 33-9 x						
00 29	0.5229	0.2436	0.3350	0.8851	0.2998	-0.1844
TKM 6		0.1737	0.3540	0.3283	0.5079	-0.2174
00 33		0.2737	0.1233	0.4321	0.1142	-0.1131
00 13		0.5093	0.8250	0.4126	0.2011	-0.6235

The correlation coefficient must exceed (1) 0.3124 and 0.4030 for P_1 , P_2 , F_1 and $F_{1(R)}$ (2) 0.2200 and 0.2868 for F_2 and $F_{2(R)}$ to be significant at the 0.05 and 0.01 level respectively.

Table 14 a. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between grain yield per plant and other traits.

		a) Plant height			b) Tiller number		
Dwarf donor parents		g	p	e	g	p	e
DGW6	P_2	0.9500	0.5857	0.4782	0.5697	0.9295	0.9
	$P_{2(R)}$	0.9090	0.6431	0.2822	1.0087	0.9872	0.9
5824	P_2	-0.9890	0.1654	0.3479	0.2707	0.4456	0.3
	$P_{2(R)}$	0.9465	0.8388	0.4060	0.2031	0.5552	0.5
Z(N)1	P_2	0.8580	0.2686	0.2802	-0.8565	0.1762	0.2
	$P_{2(R)}$	-0.4557	0.1565	0.4005	0.9812	0.3612	0.3
GO 29-N-40	P_2	0.8654	0.6267	0.4409	0.5298	0.6505	0.4
	$P_{2(R)}$	0.9860	0.5575	0.5262	0.4458	0.6498	0.4
IKM 6-10-12	P_2	0.9890	0.5867	0.2408	0.8740	0.4966	0.4
	$P_{2(R)}$	0.9727	0.4147	0.2159	0.9282	0.5142	0.3
GO 33-9	P_2	0.8187	0.2656	0.1562	0.9897	0.4217	0.4
	$P_{2(R)}$	0.5925	0.2290	0.1789	0.9558	0.4649	0.4

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 level respectively.

Table 14 b. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between grain yield per plant and other traits.

Dwarf donor parents		c) Number of internodes			d) Leaf area		
		g	p	e	g	p	e
DGW6	r_2	0.9800	0.5076	0.0561	0.7965	0.5121	0.2014
	$r_{2(R)}$	0.9800	0.6091	0.1402	0.9562	0.4779	0.2622
5824	r_2	-0.9591	-0.0229	0.0065	-0.9782	-0.1656	0.2795
	$r_{2(R)}$	0.6161	0.1265	0.0172	0.5685	0.2020	0.2255
T(N)1	r_2	0.9860	0.2421	0.2395	0.8998	0.5451	0.5459
	$r_{2(R)}$	-0.6446	0.1492	0.2080	-0.1915	0.4065	0.4570
OO 29-M-40	r_2	0.9980	0.1718	0.0510	0.2716	0.1565	0.1598
	$r_{2(R)}$	0.9758	0.2409	0.0932	0.7153	0.1554	0.0913
TKM 6-10-12	r_2	0.9904	0.4380	0.1259	0.4549	0.5138	0.2702
	$r_{2(R)}$	0.8998	0.4456	0.2471	-0.0157	0.2619	0.3095
OO 33-9	r_2	0.9865	0.3052	0.1726	0.9909	0.5765	0.2156
	$r_{2(R)}$	0.6157	0.1468	0.0660	0.8728	0.5615	0.2856

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 levels respectively.

Table 14 e. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between grain yield per plant and other traits.

		e) Panicle length			f) Number of grains per panicle		
Dwarf donor parents		g	p	e	g	p	e
D8W6	F_2	0.9306	0.6291	0.5631	0.6429	0.5610	0.5507
	$F_{2(R)}$	0.8861	0.5665	0.5534	0.9499	0.5287	0.4598
5824	F_2	-0.9849	0.2275	0.6585	1.0027	0.5684	0.2682
	$F_{2(R)}$	0.8258	0.4598	0.5278	0.0458	0.3228	0.3653
T(H)1	F_2	0.9759	0.4469	0.4528	0.5316	0.4735	0.4883
	$F_{2(R)}$	-0.5124	0.3903	0.4728	0.5417	0.4686	0.4956
OO 29-M-40	F_2	0.5857	0.5439	0.5344	0.0792	0.4788	0.5338
	$F_{2(R)}$	0.9890	0.5597	0.4122	0.0624	0.3705	0.4732
TKM 6-10-12	F_2	0.8434	0.9227	0.9534	0.3564	0.2439	0.2200
	$F_{2(R)}$	0.9889	0.5112	0.3803	0.2887	0.2534	0.2542
OO 33-9	F_2	0.9856	0.4974	-0.3621	0.9971	0.5644	0.3829
	$F_{2(R)}$	0.0133	0.3990	0.4468	0.8839	0.1223	0.0205

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 levels respectively.

Table 15 a. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between plant height and other traits.

		a) Tiller number			b) Number of internodes		
Dwarf donor parents		g	p	e	g	p	e
D8W0	F_2	-0.2227	0.1311	0.2681	0.9944	0.5341	0.1200
	$F_{2(R)}$	-0.9900	0.2064	0.6471	0.9980	0.8672	0.2039
3824	F_2	-0.9890	-0.1643	0.0931	0.3826	0.2606	0.1387
	$F_{2(R)}$	-0.1034	-0.0452	-0.0327	0.6856	0.2762	0.1264
T(H)1	F_2	-0.6498	-0.0320	0.0952	0.7361	0.3919	0.3831
	$F_{2(R)}$	-0.9908	-0.0048	0.5423	0.9890	0.5335	0.3824
GO 29-M-40	F_2	0.4837	0.3520	0.2968	0.9890	0.3391	0.2997
	$F_{2(R)}$	0.6285	0.1592	0.0607	0.9898	0.3106	0.0883
TKM 6-10-12	F_2	0.5388	0.2902	0.1436	0.9812	0.6787	0.2785
	$F_{2(R)}$	0.9226	0.2335	-0.0377	0.9849	0.8378	0.7506
GO 33-9	F_2	0.9694	0.2980	0.1720	0.9584	0.4101	0.3188
	$F_{2(R)}$	0.9987	0.9965	0.6874	0.8719	0.5300	-0.3452

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 levels respectively.

Table 15 b. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between plant height and other traits.

		c) Leaf area			d) Panicle length		
Dwarf donor parents		g	p	e	g	p	e
D6W6	F_2	1.0025	0.8270	0.7356	0.7028	0.8276	0.5264
	$F_{2(R)}$	0.9434	0.3999	0.0232	0.8999	0.7365	0.1833
5824	F_2	0.3380	0.4815	0.5577	0.9790	0.6449	0.6362
	$F_{2(R)}$	0.6603	0.2525	0.1166	0.8880	0.2726	0.1322
T(H)1	F_2	0.5899	0.2745	0.2240	0.9896	0.5502	0.3665
	$F_{2(R)}$	-0.9980	0.1251	0.5405	0.4501	0.4467	0.5688
00 29-M-40	F_2	0.6130	0.1383	0.0266	0.6494	0.5403	0.5051
	$F_{2(R)}$	0.8682	0.1297	0.0167	0.9900	0.5609	0.3418
TKH 6-10-12	F_2	0.3200	0.3499	0.2418	0.8723	0.9001	0.9894
	$F_{2(R)}$	-0.2259	0.0551	0.1621	0.7177	0.4592	0.3493
00 33-9	F_2	0.8999	-0.0950	-0.6014	0.5169	0.3230	0.2734
	$F_{2(R)}$	1.0986	0.3297	0.2389	0.7690	0.3490	0.2261

The correlation coefficients must exceed 0.2200 and 0.2268 to be significant at the 0.05 and 0.01 levels respectively.

Table 15 e. Genotypic (g), phenotypic (p) and environmental (e) correlation coefficients between plant height and other traits

		e. Number of grains per panicle			f. Weight of grains per panicle		
Dwarf donor parents		g	p	e	g	p	e
D6W6	F_2	0.9608	0.4839	0.4485	0.8991	0.7198	0.5538
	$F_{2(R)}$	1.0249	0.3256	0.3101	0.9825	0.6829	0.3035
3824	F_2	-0.8068	-0.1780	0.2811	-0.1456	0.2814	0.4093
	$F_{2(R)}$	-0.3204	0.0375	0.1265	0.3240	0.1015	0.0732
T(H)1	F_2	0.4277	0.1621	0.0694	0.8775	0.3884	0.2239
	$F_{2(R)}$	-0.3390	0.0219	0.3795	0.6549	0.4009	0.4666
00 29-M-40	F_2	0.2376	0.4903	0.5944	0.8466	-0.9217	-0.8499
	$F_{2(R)}$	0.3086	0.2697	0.3051	0.9215	0.4375	0.2561
TKM 6-10-12	F_2	0.4351	0.1306	-0.0072	0.8345	0.4400	0.2401
	$F_{2(R)}$	0.0421	0.0408	0.0694	0.4645	0.1989	0.1342
00 33-9	F_2	0.4514	0.2939	0.2382	0.8785	0.4766	0.2814
	$F_{2(R)}$	-0.9060	-0.2534	0.1850	0.3766	0.1847	0.1689

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 level respectively.

Table 15 d. Genotype (g), phenotype (p) and environmental (e) correlation coefficients between plant height and other traits.

		g. 1000 grain weight		
Dwarf donor parents		g	p	e
DGWG	F_2	0.0440	0.3747	0.8402
	$F_{2(R)}$	0.9899	0.8958	0.1330
5824	F_2	0.8707	0.1584	-0.0141
	$F_{2(R)}$	0.1723	0.0651	0.0103
T(H)1	F_2	0.3014	0.2045	0.1337
	$F_{2(R)}$	0.4918	0.4432	0.3878
GO 29-M-40	F_2	1.0099	0.4237	0.1097
	$F_{2(R)}$	0.9132	0.4470	-0.0207
TKM 6-10-12	F_2	0.2081	0.1616	0.1081
	$F_{2(R)}$	0.3244	0.1605	0.0691
GO 33-9	F_2	0.9964	0.5460	0.2628
	$F_{2(R)}$	0.8164	0.5345	0.1874

The correlation coefficients must exceed 0.2200 and 0.2868 to be significant at the 0.05 and 0.01 level respectively.

DISCUSSION

DISCUSSION

The importance of alternate sources of dwarfism in rice breeding programmes to provide a broad genetic base has been increasingly recognised (Anon., 1973). It would therefore, be necessary to have a comparative evaluation of different dwarf sources in terms of their breeding value, so that suitable choices of alternate sources of dwarf plant types could be made available for hybridisation programmes in future.

This piece of investigation is directed towards this objective in view and the results obtained in the study are discussed for elucidating information on,

1. the genetic background of the different dwarf donors,
2. the breeding value of these different sources of dwarfism,
3. the genetic association of various economic traits with different dwarf backgrounds and
4. the worthiness of the different dwarf donors to bring about an useful level of recombination of important economic traits with plant height.

I. Sources of Dwarf Parents and Testers

The dwarf donor parents chosen for this study differed in their genetic background and geographical origin. DGS is

a spontaneous mutant of a tall indica variety from Taiwan (Hu, 1973). I(N)1 is a hybrid-derived dwarf from a cross between DGWG and a tall disease resistant variety Isai-yuan-chung (Chang, 1961). The donor parent 5824 is a natural dwarf variety from Assam, India (Shastri *et al.*, 1971). The other three dwarf donor parents are induced mutants of well adapted hybrid-derived varieties obtained through different mutagenic agents. CO 29-M-40 is a mutant of the variety CO 29 by the treatment of nitroso methyl urea, while CO 33-9 was obtained from the dwarf variety CO 33 by the treatment with ethyl methane sulphonate. The dwarf mutant TKM 6-10-12 was obtained by gamma irradiation of the variety TKM 6. Thus, the choice of dwarf donors fulfilled the primary requirement of varied sources of dwarfism, possessing diverse genetic backgrounds for the purpose of this investigation.

All the six dwarf parents were hybridised with four common testers. Three out of these testers viz., CO 29, TKM 6 and CO 33 were the parents of the respective induced dwarfs and the fourth one CO 13 which is a stabilised and highly adapted variety (Anon., 1941, 1954) served as a common tester. The three varieties CO 29, TKM 6 and CO 33 are known for their adaptability and combining ability. CO 29 formed the donor parent for the dwarf high yielding and popular commercial varieties viz., Kanchi and Vaigai having large hectareage in the State of Tamil Nadu, India (Rajagopalan *et al.*, 1971; Subramanian *et al.*, 1971; Chandra Mohan *et al.*, 1973 a;

Subramanian and Chandra Mohan, 1973). The variety IRT 1444, a high yielding dwarf and a drought resistant rice selection identified recently (Seshu, 1976), is also a derivative of CO 29. TKN 6 continues to be a potential tall indica donor parent for the evolution of quite a few high yielding dwarf varieties not only in the State of Tamil Nadu, India but also at the International Rice Research Institute, Philippines (Chandra Mohan and Subramanian, 1971; Beachell *et al.*, 1972; Freeman and Shastri, 1972; Anon., 1974, 1975 b). CO 33 is an early dwarf variety obtained as a hybrid derivative of IR 8 and ADT 27.

II. Inheritance of Dwarfism

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. In a review on the genetic investigation on height, Ramiah (1953) concluded that the moderately short height of many of the existing varieties was controlled by one to three pairs of genes. He opined that different genes belonging to different genetic systems were in operation. 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 *DGWG*, (3) presence of suppressor genes and (4) presence of genes d_1 , d_{11} etc., which control the typical dwarf habit. Bai (1973) reported that although a single recessive gene controlled dwarfism in the japonica semidwarf

variety, the inheritance of dwarf habit in T(N)1 was more complex. Ree (1974) reported that short height in rice was mainly controlled by a recessive gene but other genes with minor effects were also associated. Similar views were expressed by other workers (Anon., 1968, 1973; Sivasubramanian and Menon, 1973 a; Seahu et al., 1974). In this investigation, a study of the F_1 s of the crosses involving DG#C, T(N)1 and 5824 indicated that the mode of inheritance of dwarfism varied considerably. Based on the deviation from the mid-parental value (d_1) it was observed that all the F_1 s except those involving CO 29-M-40 exhibited heterosis towards dwarfism indicating a dominance inheritance for dwarfism under dwarf cytoplasm. The inheritance in the $F_{1(R)}$ generation tended to be dominant for tallness particularly when CO 29 and TKM 6 were used as testers. The inheritance of plant height under CO 29-M-40 background proved to be consistently dominant for tallness in both F_1 and $F_{1(R)}$ generations. Ganeshan and Whittington (1975) reported that genes at four loci with various degrees of dominance determined dwarfism. This indicated probably a genetic architecture for CO 29-M-40 different from that of other dwarf parents.

A study of segregating material revealed that the plant height was controlled by complex systems and influenced by modifiers with varying degrees of depressing and enhancing effects. Studies at the International Rice Research Institute, Philippines (Anon., 1965, 1966 a) had shown that plant height

was controlled by modifying genes and that T(N)1 differed from DGWG in that it has more modifying genes in the negative direction. According to Seetharaman and Srivastava (1969), the genetic systems for dwarfism in T(N)1 and DGWG were identical and controlled by a single major recessive gene. Similar opinion was also expressed by other workers (Anon., 1964, 1973). Ram (1973) opined that height in T(N)1, IR 8 and DGWG was controlled by two pairs of additive genes with cumulative effect on height. Seetharaman and Srivastava (1971) observed that semidwarf of S₂ mutant was controlled by two recessive genes along with the presence of modifiers. Sivasubramaniam and Menon (1973 a) reported that short stature might be controlled by the interaction of three recessive genes; the presence of any two of them led to the production of shorts. Ken Foster and Rutger (1975) however recognised three separate loci for plant height. The present results also indicated the existence of varying genetic systems for dwarfism in rice. This needs to be confirmed by appropriate and detailed genetic analysis which was beyond the scope of this study.

III. Breeding Value of Dwarf Parents

a) Character expression: In pedigree breeding programmes of rice in which improvement is sought over already well adapted varieties, the breeders always prefer to select closely related varieties as parents so as to have least destruction of the adapted genotype (Hu, 1973). Before launching a breeding

programme, it is imperative to have a knowledge on the breeding value of the parents chosen for hybridisation.

A reliable test for judging the value of genetic stocks would, however, be through their mean performance and genetic analysis. According to Gilbert (1958), the parents involved in any hybridisation programme should themselves possess the desirable traits in a high order of expression. The dwarf donor parents differed in their mean performance with respect to the characters under study. With regard to plant height, although the criterion for dwarfness was taken as less than 100 cm (Seetharaman, 1966; Anon., 1969; Chang and Tagumpay, 1970), the dwarf parents differed widely in respect of plant height. CO 29-M-40 was the shortest, while DGWG was the tallest. Dwarfs have also been grouped presently (Seetharaman and Srivastava, 1969) into 'semidwarfs' (71 to 100 cm) and 'dwarfs' (70 cm and below). According to this classification, CO 29-M-40 fell under 'dwarfs', while the other dwarf parents were grouped as 'semidwarfs'. The variety DGWG had the maximum expression of panicle length and weight of grains per panicle, while T(N)1 exhibited the highest tiller number and grain yield per plant. Among the 20 rice varieties comprising tall and dwarf indicas evaluated for their metric traits, Chandra Mohan and Narayanaswamy (1973) found the highest expression of panicle length in DGWG which was in conformity with the present finding. However, they also recorded high expression of number of grains per panicle in DGWG. Seetharaman (1969), while evaluating the

dwarf plant types for productivity, reported the potentiality of T(N)1 for higher tiller number and grain yield per plant. It is expected that the concentration of favourable traits may be exhibited by these two parents since they had undergone relatively longer periods of selection pressure under fairly wide range of adaptation. DGWG was recommended for commercial planting in 1951 (Huang, 1957), while T(N)1 was developed in 1956 (Huang et al., 1972). The variety GO 53-9 had the highest number of grains per panicle and the lowest 1000 grain weight. The Assamese dwarf parent 5824 had low number of internodes but possessed the highest 1000 grain weight. The dwarf mutant GO 29-M-40 was distinct from other donor parents with the poorest expression for most of the economic traits studied except for tiller number, number of internodes and 1000 grain weight. Similar poor performance of most of the induced dwarf mutants had been reported from the International Rice Research Institute, Philippines (Anon., 1971).

b. Variability: The second criterion taken for distinguishing the dwarf parents is the extent of variability or uniformity that is exhibited in the traits in each variety under study. The coefficient of variation recorded by the different dwarf parents revealed that the variability was low for all characters except in the cases of tiller number and grain yield per plant. The ranges of variability recorded in this investigation in respect of all the characters studied were mostly in agreement with the values reported by Burton and Moenaw (1965).

But, a higher degree of variation was found by Seetharaman et al. (1973) in respect of 1000 grain weight. The differences in magnitude of variation for different traits among the parents were not high. However, CO 29-M-40 had the least variation in regard to leaf area and 1000 grain weight. The variability among the parents as such do not afford much scope for distinguishing the dwarf donor parents.

c. Expression of heterosis: The third criterion for evaluation of dwarf donor parents is on the basis of the expression of hybrid vigour of F_1 resulting from crosses involving them. This information enables the breeder to gauge the genetic diversity among the parents.

In the present study all the hybrids involving the induced dwarf mutants CO 29-M-40, TKM 6-10-12 and CO 33-9 exhibited positive heterosis for yield and tiller number and negative heterosis for number of internodes, panicle length and weight of grains per panicle. However, the expression of heterosis was strikingly different in CO 29-M-40 hybrids which exhibited high heterotic behaviour for tallness, panicle length, number of grains per panicle, weight of grains per panicle, lighter grains and grain yield per plant. Among the testers, a distinct behaviour for heterosis was observed for CO 33 which uniformly induced heterosis for dwarfness, higher tiller number and low expression in number of internodes, number of grains per panicle and weight of grains per panicle. 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 from very early times; Vander stek (1908), Jones (1926), Idsumi (1957), Ramiah and Ramaswamy (1938, 1941), Brown (1953), Anon. (1963), Chandra Mohan and Srinivasan (1963), Madhusudhana Rao (1965), Dhulappayavar and Mensinkai (1967), Lee et al. (1968), Hsu et al. (1969), Palaniwamy and Palaniwamy (1973), Sivasubramanian and Menon (1973 b), Saini and Iskumar (1973), Bardhan Roy et al. (1975) to quote a few of them. Presence of heterosis in the traits, number of grains per panicle and leaf area had been recorded by Katayama (1975). Absence of heterosis for panicle length and dwarfness was reported by Rajagopalan et al. (1973) from a study of the hybrids of dwarf and tall indica varieties. Lack of heterosis in some crosses were reported by Sivasubramanian and Menon (1973 b). Negative heterosis in plant height was also observed by Kumaran (1974) in intra-racial hybrids involving different varieties including tall and dwarf indicas. Heterosis was not exhibited in the trait, grain yield per plant in many of the hybrids studied by Jennings (1967) and Karunakaran (1968). Lack of heterobeltiosis in respect of plant height, tiller number, panicle length and grain yield per plant was observed in the hybrids of crosses involving extremely different varieties (Chang et al., 1973). Absence of heterobeltiosis in F_1 hybrids for yield had also been reported (Hsu et al., 1969; Chang et al., 1971; Chang and Lin, 1972).

A high magnitude of heterosis may generally be expected when parents involved are all of diverse sources and also when

they have different alleles for large number of loci. In this study all the three induced dwarf mutants were from distinct lineage as they were isolated from entirely independent sources by different mutagenic agents. It was also observed that the induced dwarf mutants as a group differed from the other dwarf parents DOWG, 5824 and T(W)1 in their pedigree and genetic backgrounds.

d. Persistence of heterosis: A comparative evaluation on the magnitude of persistence of heterosis in the second generation of the crosses was considered as a fourth criterion to differentiate the dwarf donors. The estimate of the persistence of heterosis indicated that again CO 29-M-40 continued to maintain the heterotic influence to a higher magnitude in both F_2 and $F_{2(R)}$ generations in respect of plant height, leaf area, panicle length and number of grains per panicle and in certain crosses in respect of grain yield per plant also. Sivasubramaniam and Menon (1973 b) recorded lack of persistence of heterosis in the traits, plant height and grain yield per plant. This trend was however, noticed in the crosses involving other dwarf backgrounds. The existence of the predominant proportion of epistasis for most of the traits under CO 29-M-40 background was clearly revealed. Thus, CO 29-M-40 again proved to be different from other dwarfs.

e. Dwarfism and maternal effect: The role of cytoplasmic factors contributed by the female parents had been widely accepted as determinant factors on the phenotype of the hybrid.

An estimation of the magnitude of the maternal effect would also provide sufficient evidence for distinguishing the parents. This aspect of evaluation was taken as the fifth criterion in this investigation. The quantitative estimation of the matroclinous inheritance was done for all crosses, following the genetic model suggested by Chandraratna and Sakai (1960). A comparison of observed and expected values in hybrid population revealed the adequacy of the genetic model adopted for this purpose. The estimates of coefficient of maternal effect fitted well with the hypothesis of extra nuclear determinants transmitted to the hybrid through the cytoplasm of the female parent. The magnitude and direction of the coefficients of maternal effect ('m' value) indicated varying influence of matroclinous effects under different cross combinations. The influence of each one of the induced mutants TKM 6-10-12 and CO 33-9 was independent of the other dwarf donors as may be noted in the expression of higher maternal effects with respect to the characters, number of internodes, plant height, leaf area, panicle length and grain yield per plant. The influence of TKM 6-10-12 cytoplasm particularly on traits, plant height, tiller number, number of internodes, leaf area, panicle length, 1000 grain weight and grain yield per plant is worth mentioning.

The cytoplasmic determinant involved in TKM 6-10-12 was probably distinct from the other dwarf donors. In this respect CO 29-M-40 appeared to have a similar cytoplasmic background with DGN3, 5824 and T(N)1.

In general, maternal effect was evident in characters like plant height, number of internodes, panicle length and 1000 grain weight. Chandraratna and Sakai (1960) reported that 1000 grain weight in rice had been observed to exhibit matroclinal inheritance in a cross between two indica rice varieties, possessing coarse grain and fine grain respectively.

f. Genetic differences of dwarfism: Yet another criterion for the evaluation of the differences among the dwarf donors is to have an estimate of the presence or absence of epistasis. Mather's scaling test is one such technique to estimate the magnitude of additivity or otherwise. The scaling test for the various characters for the second generation revealed that epistasis was predominantly in evidence in crosses involving CO 29-M-40 for the traits plant height, number of internodes, leaf area and 1000 grain weight. The crosses of other induced dwarfs also failed to fit in the additive model for most of the characters, though of a lesser magnitude. But the test of additivity between the crosses of the induced dwarf mutants and those of other dwarfs, in general, varied widely. For instance, in respect of plant height the additivity test proved to be adequate in almost all crosses involving DOWG, 5824 and T(N)1, while inadequacy of additive assumption was observed when induced dwarfs formed the parents.

In the same way in several other instances the adequacy of additivity test was opposite under different tester parents. There was disagreement, in general, between the heterotic effect

and the estimate of deviation due to dominance (h) through the matroclinous analysis in many of the crosses. While the traits tiller number, panicle length and grain yield per plant exhibited heterosis, the corresponding estimates of ' h ' through the matroclinous analysis were either low or negative for these traits. This was a possible indication that the enhanced expression of the phenotypic values of F_1 was mainly contributed by the epistatic effect (additive x additive) rather than the influence of deviation due to dominance. This may serve as a favourable situation for commencing plant selection in the earliest segregating generation viz., F_2 . This may be the reason why in rice breeding the commencement of selection in the early generations resulted in success in identifying superior genotypes as compared to other crops where the dominance and epistasis hindered chances of selection in the F_2 . In the absence of data on the partitioning of the epistatic parameters, the role of epistatic influence could not be confirmed. In the present investigation, studies on other segregating generations like backcrosses and F_3 were not contemplated and as such the estimate on the interaction of genes could not be examined to confirm the possibility of influence of epistasis.

g. Selection worthiness of the segregating population: In any breeding programme for the improvement of quantitative traits, variability in the segregating population forms the basis for selection. The two segregating populations viz., F_2 and $F_{2(R)}$ in the present study were evaluated for their

expression of mean performance and variability in terms of estimates of genotypic variance and genotypic coefficient of variation for the nine characters studied. High variability to a relatively greater extent was in evidence in the traits plant height, tiller number, weight of grains per panicle and grain yield per plant (Fig. 2 and 3). Similar trends of high genotypic variability have been reported by Tripathi et al. (1973) and Govindaswamy et al. (1973) in respect of tiller number and number of grains per panicle, while Balakrishna Rao et al. (1973) observed high variability for number of grains per panicle only. Sivasubramanian and Menon (1973 c) obtained high values for genetic coefficient of variation in respect of grain yield, number of grains per panicle and tiller number in segregating progenies involving tall and dwarf crosses. The magnitude of variation was not appreciable as far as number of internodes and panicle length were concerned. The segregating generations involving the dwarf parent DGWG exhibited high variability for the traits, grain yield and tiller number but only minimum variation in other traits particularly in plant height, number of grains per panicle and 1000 grain weight (Fig. 2 and 3).

But the degree of variability alone in a population may not be a sure indication of the selection potential of the breeding material but a combination of mean performance and variability of the segregating generation could serve as an effective guideline. The plant breeder would prefer to make

selection in populations which exhibit high variability with reference to either high mean performance or low mean performance because such populations normally have the potentiality of throwing out a large number of superior transgressive segregants. The results of this investigation, when subjected to such a scrutiny, indicated that high variability and high mean performance were observed in the segregating populations involving DGWG for the characters, grain yield and tiller number. This indicated the superiority of this dwarf source over other dwarf donors for its capacity to induce variability for higher productivity in terms of grain yield per plant. Sastry et al. (1967) carried out elaborate studies on the relationship between grain yield and associate characters with a number of dwarf varieties and thereon concluded that DGWG possessed the best germ plasma for transforming short stature that is capable of making effective combinations with improvements in yield components. It is therefore, not surprising that this variety DGWG was one of the parents in the crosses from which the best yielders like I(N)1 and IR 8 were evolved (Beachell et al., 1972).

Better mean performance was observed in the characters panicle length, number of grains per panicle and weight of grains per panicle under the DGWG background but the variability was moderate. The next in order of importance was I(N)1 which had a high expression of mean performance for panicle length, number of grains per panicle and weight of

grains per panicle. But the variability in these characters was moderate. However, this variety expressed high degree of variability of grain yield per plant but lower variability for tiller number and plant height. This clearly indicated that this source of dwarfism had high potentiality as a donor parent for infusing desirable traits associated with yield in rice. Many of the high yielding dwarf varieties including IR 20 and Jaya now under large scale commercial planting in the State of Tamil Nadu (5), other States of India (27) as well as other countries (19) originated from the utilisation of T(N)1 or its derived lines as parents (Shastri, 1969; Subramanian *et al.*, 1971; Beachell *et al.*, 1972; Freeman and Shastri, 1972; Subramanian and Chandra Mohan, 1973; Seshu, 1976). Chandra Mohan *et al.* (1973) however opined after a study of the yield potential of varieties developed from T(N)1 and IR 8 dwarf sources that IR 8 a derivative of DGWG imparted its yielding ability better than T(N)1 in its progenies.

The Assamese dwarf source 5824 combined high mean expression and high variability for plant height, tiller number and number of grains per panicle. The mean for grain yield per plant was low and variability was moderate. Hence, the natural dwarf 5824 appeared to have very low potential as a donor for yield expression.

Further the data on the frequency distribution of the characters plant height, number of grains per panicle and grain yield per plant indicated transgressive segregation beyond

the parental values in the crosses involving DONG and 5824 particularly with the tester parents TKM 6 (Figs. 4 a, 5 a and 6 a) and OO 33 (Figs. 4 b, 5 b and 6 b). None of the induced dwarf mutants had resulted in a population with high mean performance and high variability except OO 29-M-40 which had exhibited high variability for panicle length and number of grains per panicle, although the mean performance was low to moderate. The induced dwarf donors failed to exhibit variability for most other yield components to the extent of those obtainable under natural dwarfs. A comparison of the nature of transgressive segregation for the group of crosses confirmed that the potentiality to produce transgressive segregants was relatively low for crosses involving induced dwarfs OO 29-M-40, TKM 6-10-12 and OO 33-9 as compared to the natural dwarfs (Figs. 4 a, 4 b, 5 a, 5 b, 6 a and 6 b). As the utilization of transgressive variation in F_2 is common in rice breeding (Li and Chang, 1970), these induced dwarfs may not be considered to be very useful as donor parents. The study on the segregating population, therefore, clearly indicated that the genetic background of DONG and T(N)1 on the one hand and the three induced dwarf mutants on the other were independent. Among the induced dwarf mutants, OO 29-M-40 appeared distinct from others.

The breeders, while choosing for the characters with complex inheritance along with yield, resort to seek information on heritability and genetic advance. High heritability associated with high genetic advance would serve as a more efficient

**FIG.4a FREQUENCY DISTRIBUTION OF PLANT HEIGHT IN PARENTS:
F₁, F₁(R), F₂ AND F₂(R)**

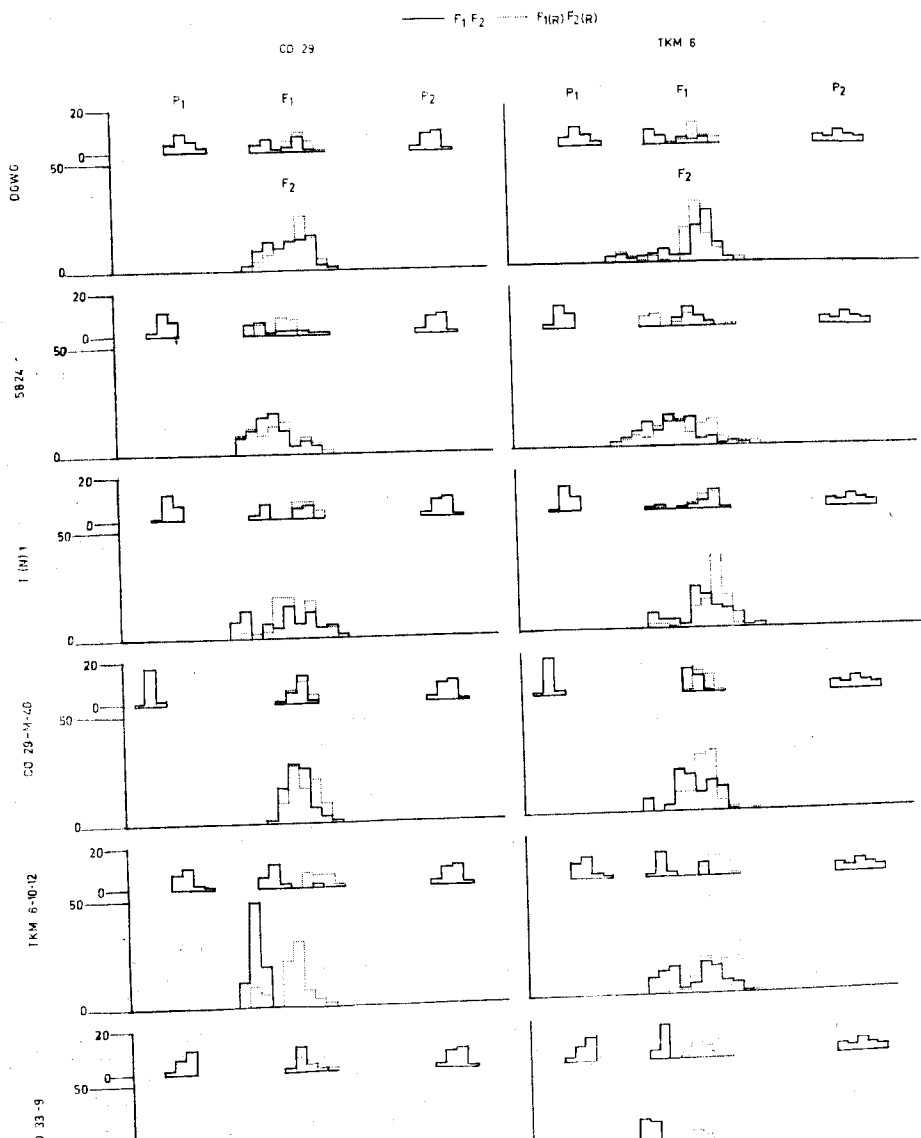


FIG.4b FREQUENCY DISTRIBUTION OF PLANT HEIGHT IN PARENTS
 F_1 , F_2 , F_3 AND $F_2(R)$

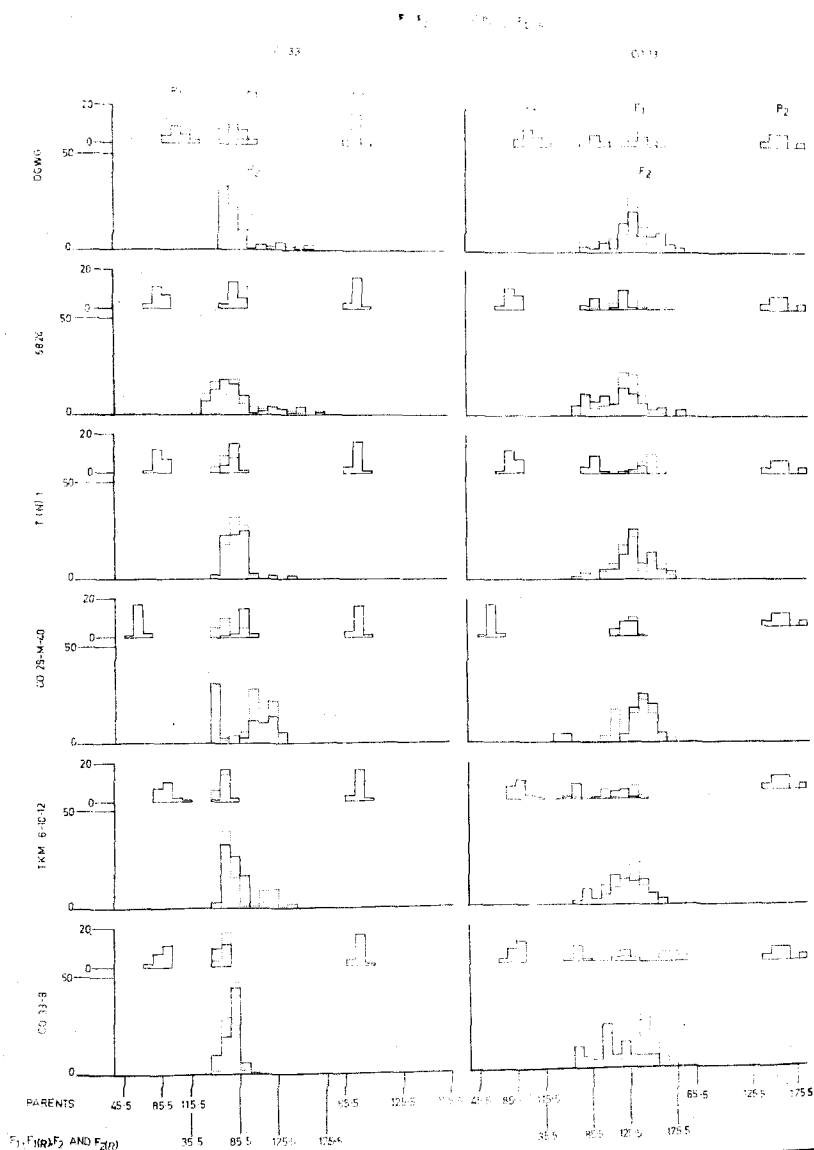


FIG.5a FREQUENCY DISTRIBUTION OF NUMBER OF GRAINS PER PANICLE IN PARENTS, F_1 , $F_1(R)$, F_2 AND $F_2(R)$

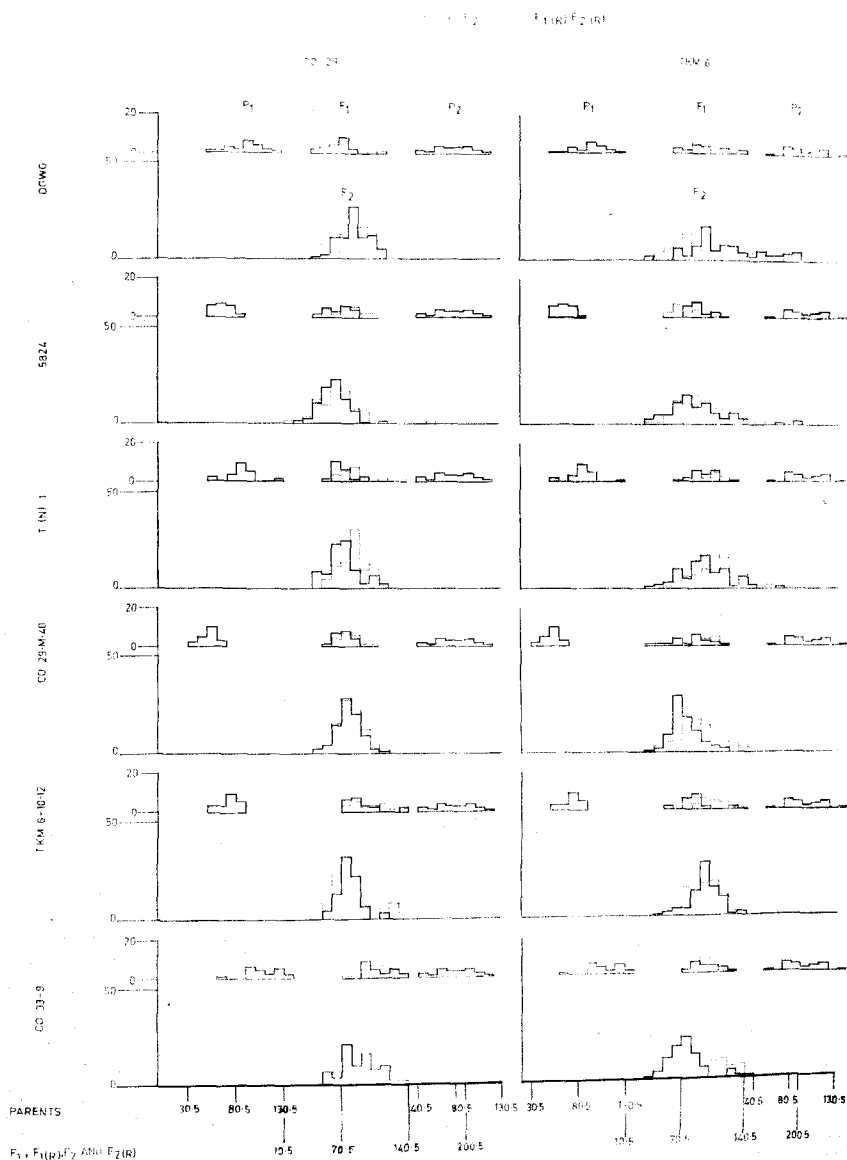


FIG.5b FREQUENCY DISTRIBUTION OF NUMBER OF GRAINS PER PANICLE IN PARENTS F_1 , $F_1(R)$, F_2 AND $F_2(R)$

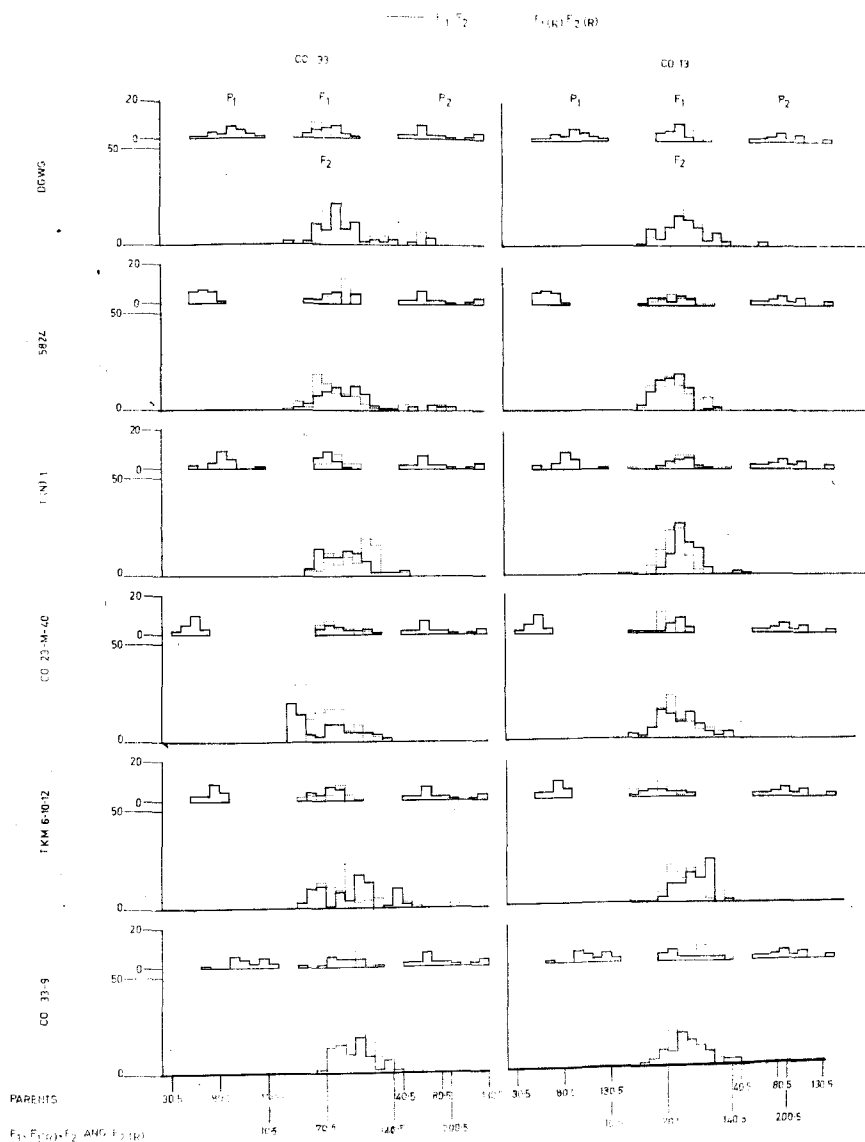


FIG.6a FREQUENCY DISTRIBUTION OF GRAIN YIELD PER PLANT
IN PARENTS. F_1 . $F_1(R)$. F_2 AND $F_2(R)$

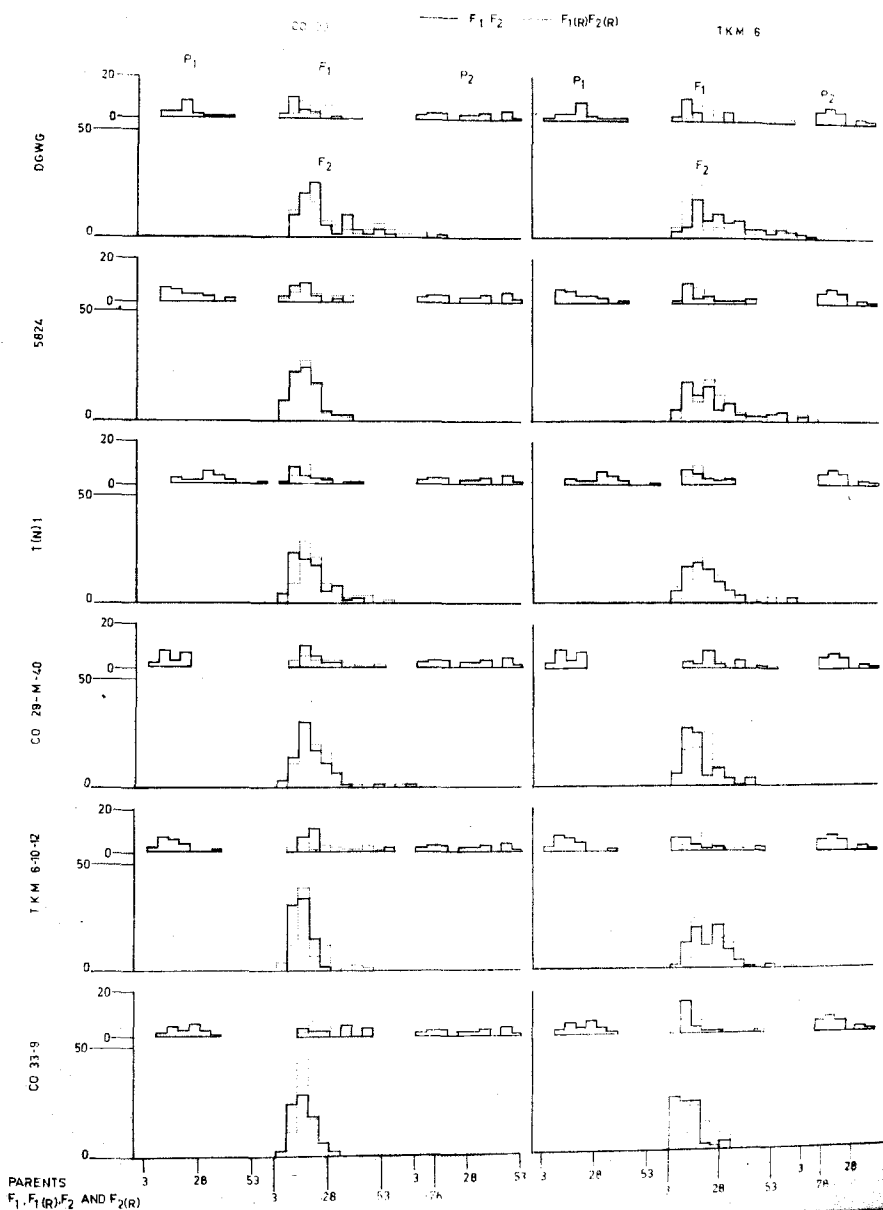
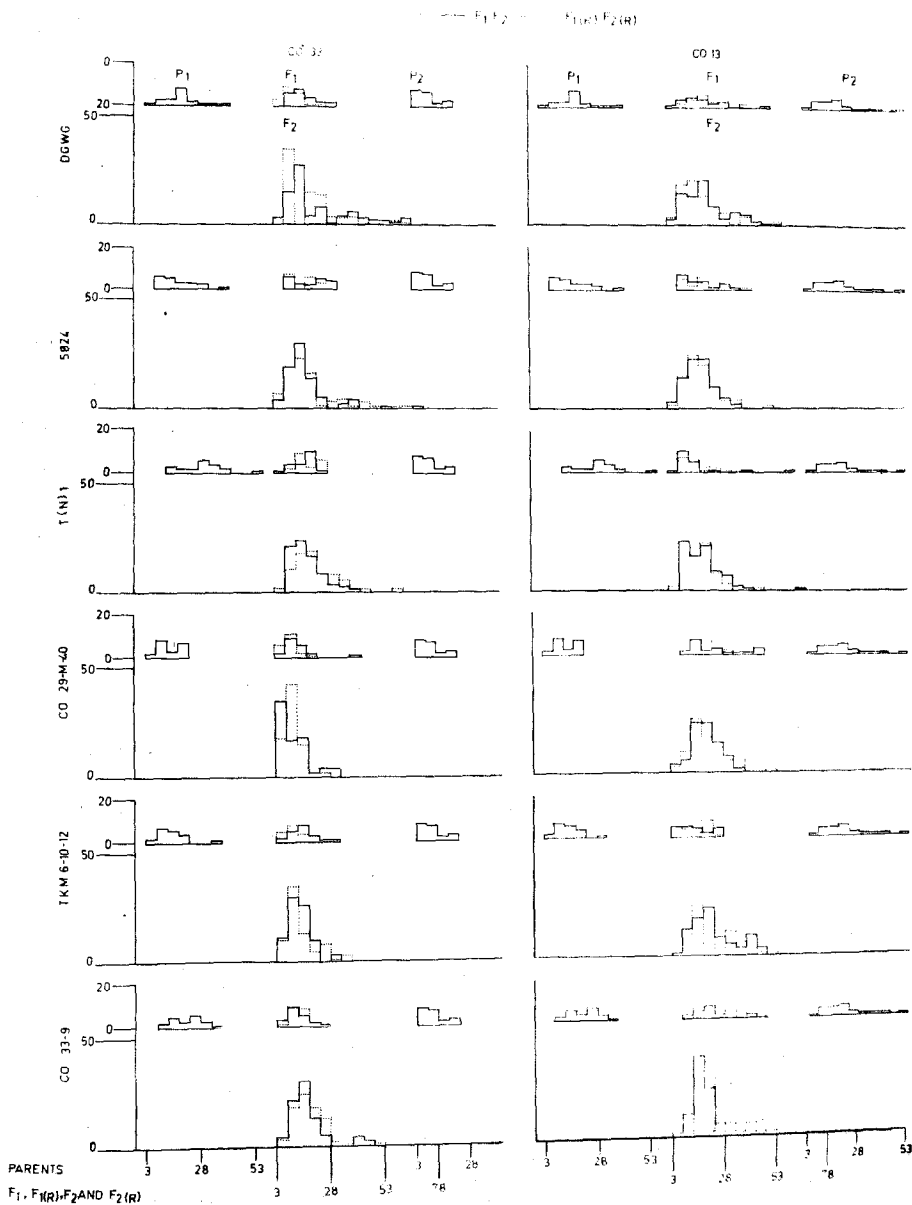


FIG.6b FREQUENCY DISTRIBUTION OF GRAIN YIELD PER PLAN
IN PARENTS. F_1 , $F_1(R)$, F_2 AND $F_2(R)$



selection criterion than selection based on the means of the complex character itself (Johnson et al., 1955). Swarup and Chaugale (1962) also suggested that genetic gain should also be considered along with heritability for selection on phenotypic values. With this objective in mind, estimates of heritability and genetic advance for the traits computed were analysed under various dwarf backgrounds.

Among the population involving dwarf donors, the combination of high genetic advance with high heritability was observed for grain yield per plant and weight of grains per panicle in many crosses involving DGWG (Figs. 11 and 10). Very high estimates of heritability were observed for plant height, tiller number, leaf area, panicle length and number of grains per panicle in the segregating population of dwarfs x tall at the International Rice Research Institute, Philippines (Anon., 1967, 1970). Low heritability values for tiller number and panicle length and grain yield per plant were registered by Horie et al. (1964), Chang (1967), Panwar and Gupta (1967), Garau (1970), Perez Ponce and Jimenez, (1974). Numerous rice workers have reported varying degrees of heritability for plant height and in this context, mention may be made of the reports by Toriyama and Futsuhara (1958), Chang et al. (1965), Wang (1965), Chang (1967), Panwar and Gupta (1967), Lin (1969), Sarathe et al. (1969), and Swamy Rao and Goud (1969)^{and} Vijayan (1971). High heritability estimates for tiller number, panicle length, number of grains per panicle, 1000 grain weight and grain yield per plant were also reported by Sakai and Niles (1957).

FIG.7 MAGNITUDE OF HERITABILITY (h^2) AND GENETIC ADVANCE (GA) PER CENT ON MEAN IN F_2 AND $F_{2(R)}$ GENERATIONS

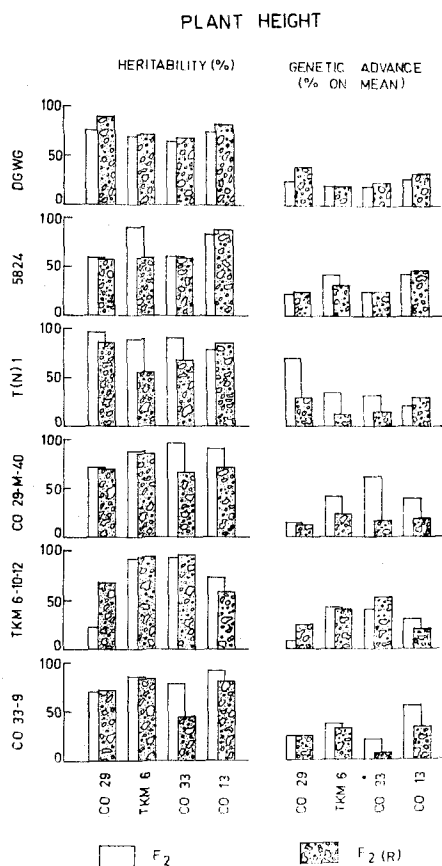


FIG.8 MAGNITUDE OF HERITABILITY (h^2) AND GENETIC ADVANCE (GA) PER CENT ON MEAN IN F_2 AND $F_2(R)$ GENERATIONS

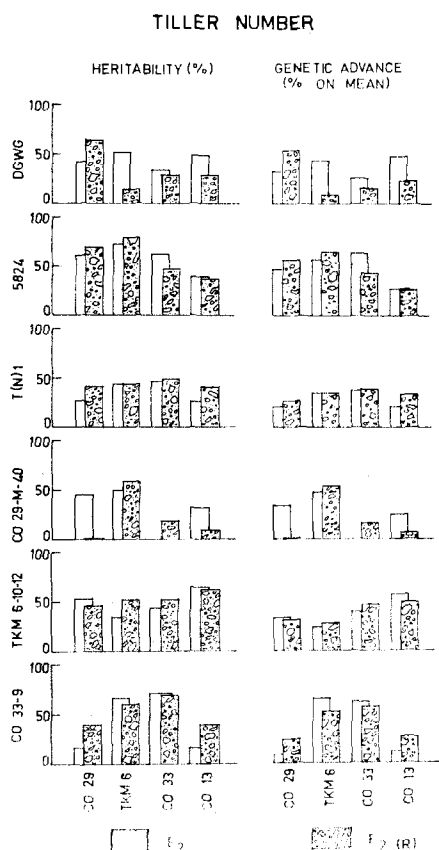
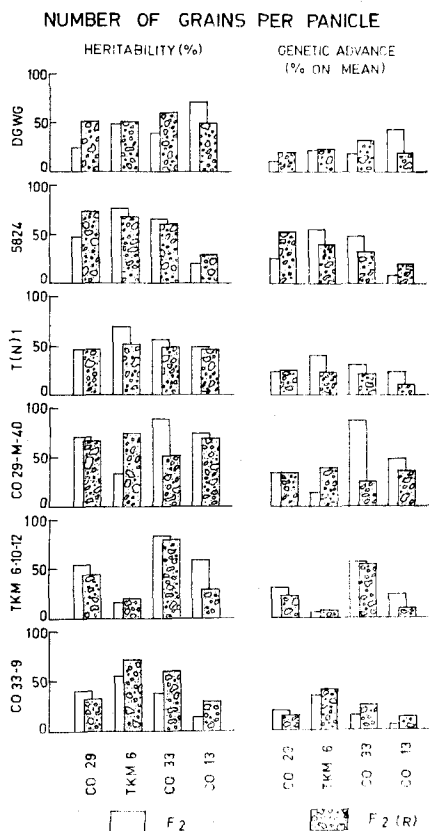


FIG.9 MAGNITUDE OF HERITABILITY (h^2) AND GENETIC ADVANCE (GA) PER CENT ON MEAN IN F_2 AND $F_{2(R)}$ GENERATIONS



Teriyama and Putschhara (1958), Latif and Saman (1965), Wang (1965), Mahanty and Singh (1969), Sarathe *et al.* (1969), Kaul (1972), Tripathi *et al.* (1973), Kaul and Khan (1974). Sivasubramanian and Menon (1973 d) also reported high heritability in the characters plant height, number of tillers, panicle length, number of grains per panicle and grain yield, by a study of F_2 generation involving tall and dwarf crosses. However, the segregating population involving DSWG failed to show genetic progress for panicle length, number of grains per panicle, plant height and 1000 grain weight. This may indicate that the scope of improvement in grain yield per plant was high for DSWG. But the contribution of yield was mainly due to the fairly high genetic progress in the weight of grains per panicle uniformly in all crosses. Sivasubramanian and Menon (1973 e) had further reported high genetic advance for grain yield and number of grains per panicle from a study of seven traits in F_2 population involving tall and dwarf inbreds and Tripathi *et al.* (1973) indicated low genetic advance for plant height and moderate values for panicle length and tiller number. However, they observed combination of high heritability and genetic advance for 1000 grain weight and number of grains per panicle. High genetic advance with high heritability for 1000 grain weight was reported by Sarathe *et al.* (1969). Almost similar trend in respect of the limits was noticed in this study except in the case of 1000 grain weight. Considering the low genetic progress for plant height (Fig. 7) panicle length and number of grains per

FIG.10 MAGNITUDE OF HERITABILITY (h^2) AND GENETIC ADVANCE (GA) PER CENT ON MEAN IN F_2 AND $F_2(R)$ GENERATIONS

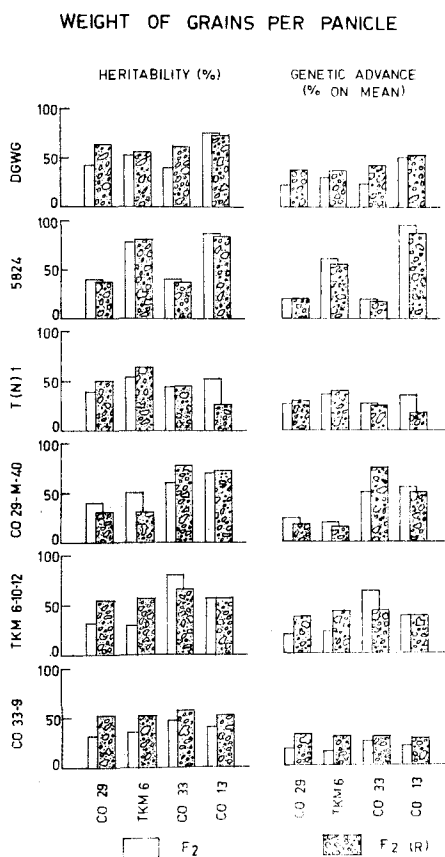
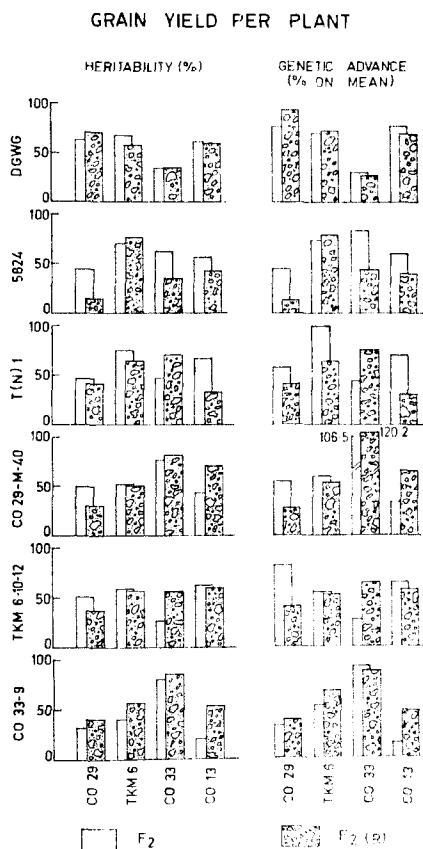


FIG.11 MAGNITUDE OF HERITABILITY (h^2) AND GENETIC ADVANCE (GA) PER CENT ON MEAN IN F₂ AND F₂(R) GENERATIONS



panicle (Fig. 9) under DSW background, it may be inferred that any further selection in these characters may have a limited scope. Combination of high heritability and genetic advance was observed for $T(N)!$ in respect of the characters grain yield per plant, 1000 grain weight and leaf area. The genetic progress was moderate for panicle length, number of grains per panicle and weight of grain. However, the heritability and genetic advance values were at the minimum for tiller number (Fig. 8). Hence, $T(N)!$ can only be relied upon for purpose of improving the traits like panicle length, number of grains per panicle, weight of grains per panicle, 1000 grain weight and grain yield. Among the induced dwarf donors, GO 29-M-40 recorded a high genetic progress with heritability for the traits plant height, panicle length, number of grains per panicle and grain yield per plant. However, the genetic progress for tiller number and 1000 grain weight was low under the background of GO 29-M-40. This analysis indicated that this parent may be considered as an alternate dwarf source for DSW and $T(N)!$. The other induced dwarfs proved to be poor sources for improvement of yield and yield components as they failed to combine high heritability and high genetic advance.

A character-wise analysis, in general, indicated that moderate to high magnitude of heritability was observed in all crosses for the characters grain yield, plant height, tiller number, panicle length and 1000 grain weight, while it greatly varied among the crosses for other traits. Similar findings have been reported by many workers Kaul (1972), Ghoshary et al.

(1973) and Govindaswamy *et al.* (1973) observed high heritability values for grain yield. Balakrishna Rao *et al.* (1973), Tripathi *et al.* (1973), Kaul and Khan (1974) and Perez and Jimenez (1974) for tiller number, Kaul (1972), Kaul and Khan (1974) and Tripathi (1973) for plant height and Govindaswamy *et al.* (1973) and Ghoshdary *et al.* (1973) for 1000 grain weight. The possible reason for such variation in heritability and genetic advance obtained among the crosses under different dwarf backgrounds is that the parents have a different genetic architecture in respect of all these characters. It is also probable that the performance of the progeny may vary, depending upon the other parent involved in the cross. In the present study, care was taken to see that all the dwarf sources were mated with four common testers. Hence, the difference in expression in these parameters could only be attributed to the dwarf backgrounds. According to Liang *et al.* (1968), the segregating generations like F_2 may have a differential response due to a given environment also.

IV. Correlated Changes in Other Traits with Plant Height

It is also possible that the magnitude and the direction of the association of different traits may vary in the segregating generations under different genotypic backgrounds. In this context, it is worthwhile to determine the magnitude and direction of genotypic correlation of plant height and yield with other economic traits. This would give an idea as to which of the mutants can be depended for favourable association of

traits based on the performance of the segregating generation. In this investigation the genotypic, phenotype and environmental correlations were worked out between plant height and the other individual characters under each of the dwarf backgrounds. It was found that the genotypic correlation of tiller number with plant height proved to be negative and significant in both the F_2 and $F_{2(R)}$ generations under the background of DGWG, 5824 and T(N)1, while it was positive under induced dwarfs viz., CO 29-M-40, TKN 6-10-12 and CO 33-9. The difference in the direction of association in these two traits clearly established that the induced dwarfs are independent of the sources of DGWG, 5824 and T(N)1. A somewhat similar trend of differential magnitude and direction of association was observed between these two groups of backgrounds for the relationship, plant height with number of grains per panicle. Similar evaluation in the present study indicated that the negative relationships of plant height and tiller number observed in the parents DGWG and 5824 had been modified towards significant positive associations in F_2 and $F_{2(R)}$ generations. Negative genotypic correlation between plant height and tiller number as well as grain yield was reported by Chang and Tagumpay (1970), while Chang *et al.* (1973) in another study found positive association at genotypic level between plant height on the one hand and tiller number, panicle length and grain yield on the other. Positive genotypic association between plant height and panicle length had also been reported by Syakude *et al.* (1952), Wei (1960) and Chang *et al.* (1965).

Positive relationship at the genotypic level between grain yield and plant height was also reported by Roy Choudhury (1968).

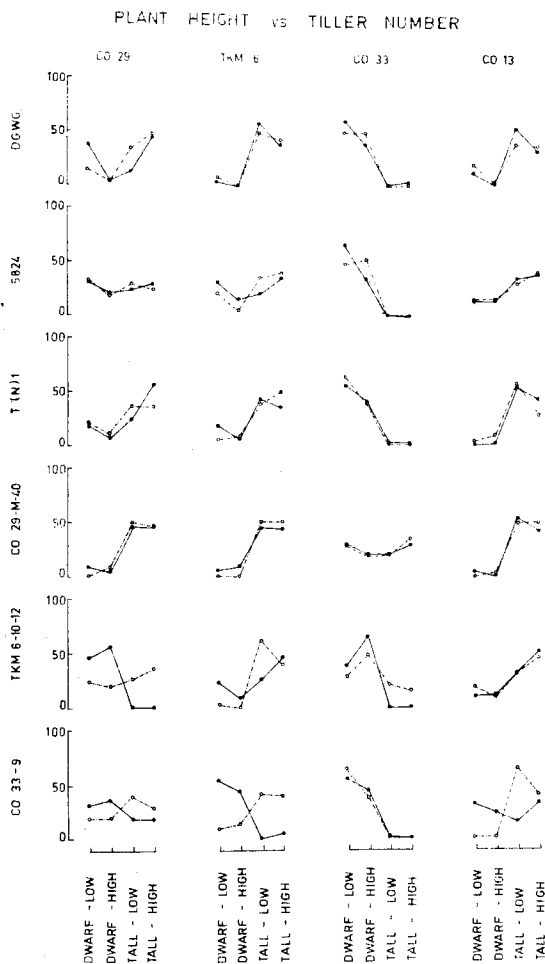
Similarly, the relationships involving the number of grains per panicle were observed to be either negative or absent with plant height in the parents 5824 and T(N)1. However, this relationship was observed to be positive and significant in the F_2 generation. This indicated that the tester parents had, in general, a significant impact on the crosses in breaking this antagonistic association. The association of plant height and 1000 grain weight was observed to be negative in tester parents as well as the dwarf donor T(N)1 and TKM 6-10-12, though the degree of association was negligible and not significant. This trend of association was modified towards positive direction even at the level of one per cent significance in certain instances. This indicated the scope for manipulation with reference to association of plant height and other traits for purpose of selection criteria while drawing up appropriate programming of hybridisation.

The association studies of this kind also proved that the induced dwarf mutants might have a different origin of genotypic background as compared to T(N)1 and DNGC.

V. Recombination Potential

The breeding value was also assessed by the magnitude of recombination for plant height and other economic traits under the common background of testers (Figs. 12 to 19). The

FIG.12 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION



OTHER TRAITS

LOW = LOWER THAN F_2 MEANS
HIGH = HIGHER THAN F_2 MEANS

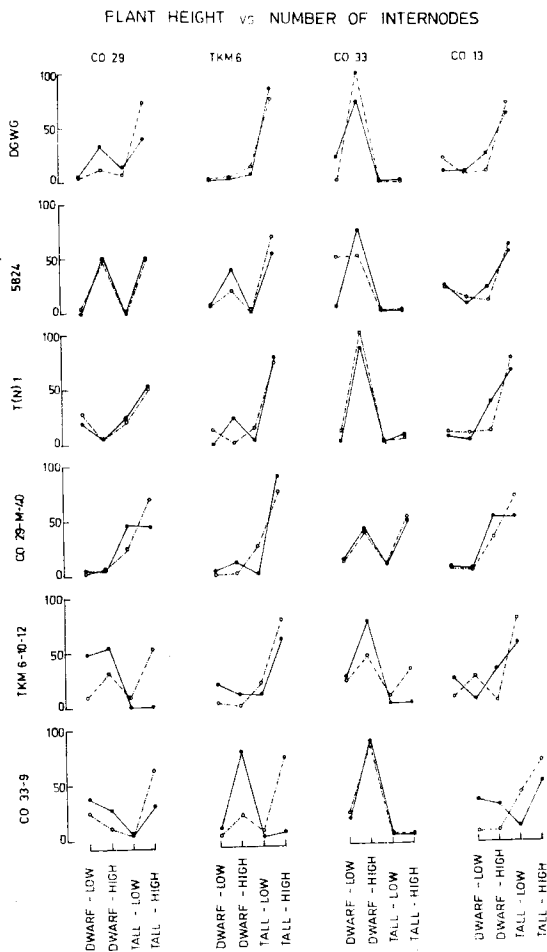
HEIGHT

DWARF = BELOW 100 CM
TALL = 100 CM AND ABOVE

—•— F_2

- - - ○ - - F_2 (R)

FIG.13 RELATIVE PROPORTION OF RECOMBINATION
SECOND GENERATION



OTHER TRAITS

LOW = LOWER THAN F_2 MEANS
HIGH = HIGHER THAN F_2 MEANS

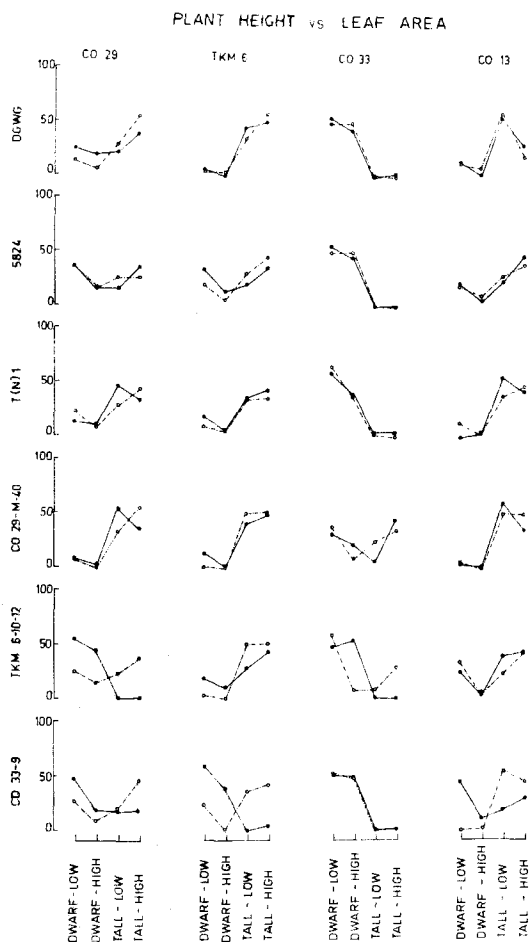
HEIGHT

DWARF = BELOW 100 CM
TALL = 100 CM AND ABOVE

• — • F_2

— • — $F_2(R)$

FIG.14 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION



OTHER TRAITS

LOW = LOWER THAN F_2 MEANS
HIGH = HIGHER THAN F_2 MEANS

HEIGHT

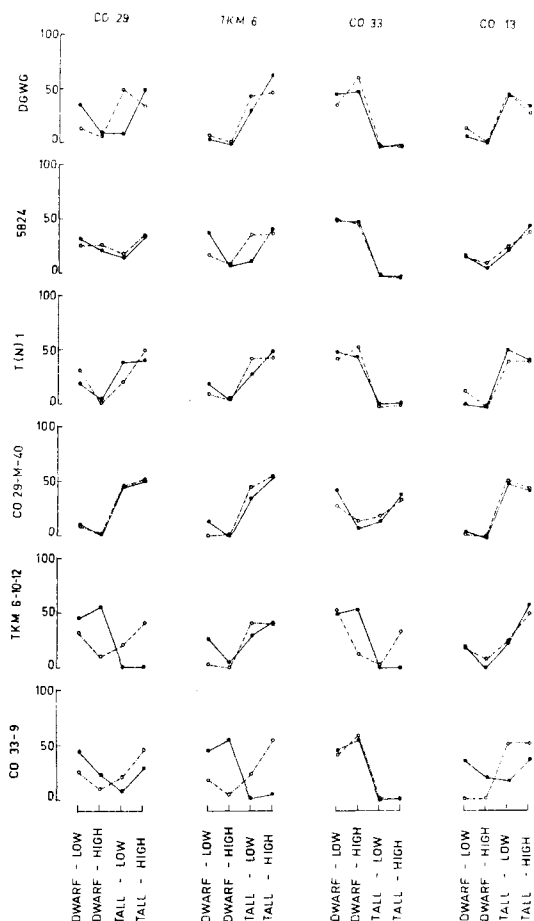
DWARF = BELOW 100 CM
TALL = 100 CM AND ABOVE

● — ● F_2

○ - - ○ $F_2(R)$

FIG.15 RELATIVE PROPORTION OF RECOMBINATION SECOND GENERATION

PLANT HEIGHT vs PANICLE LENGTH



OTHER TRAITS

LOW = LOWER THAN F₂ MEANS
HIGH = HIGHER THAN F₂ MEANS

HEIGHT

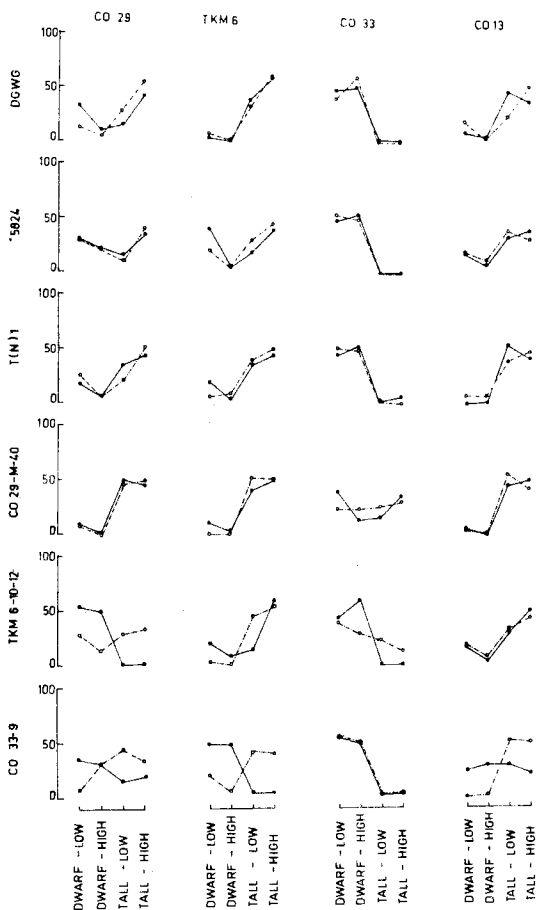
DWARF = BELOW 100 CM
TALL = 100 CM AND ABOVE

—●— F₂

- - -○- F₂(R)

FIG 16 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION

PLANT HEIGHT vs NUMBER OF GRAINS PER PANICLE



OTHER TRAITS

LOW = LOWER THAN F₂ MEANS
HIGH = HIGHER THAN F₂ MEANS

HEIGHT

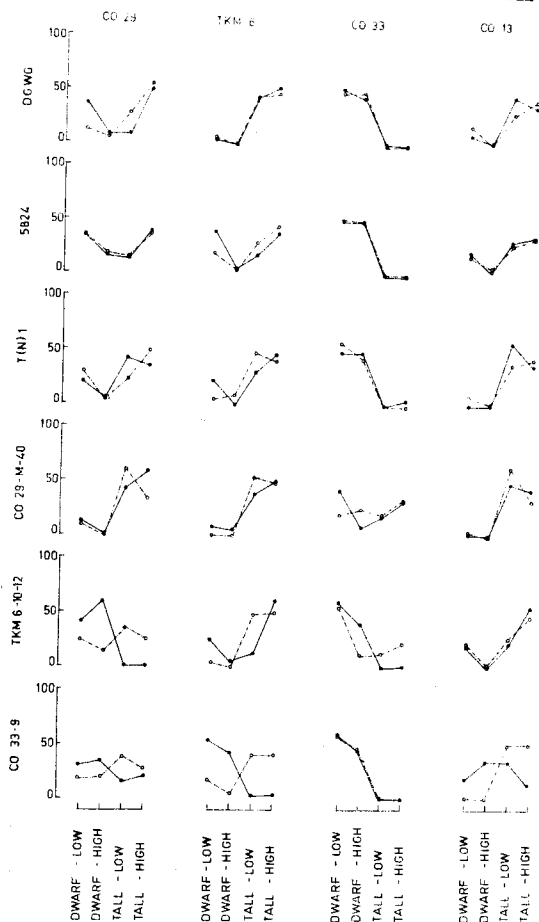
DWARF = BELOW 100 CM
TALL = 100 CM AND ABOVE

●—● F₂

○---○ F₂(R)

FIG.17 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION

PLANT HEIGHT vs WEIGHT OF GRAINS PER PANICLE



OTHER TRAITS

LOW : LOWER THAN F₂ MEANS
HIGH : HIGHER THAN F₂ MEANS

HEIGHT

DWARF : BELOW 100 CM
TALL : 100 CM AND ABOVE

●—● F₂

- - - ● F₂(R)

FIG.18 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION

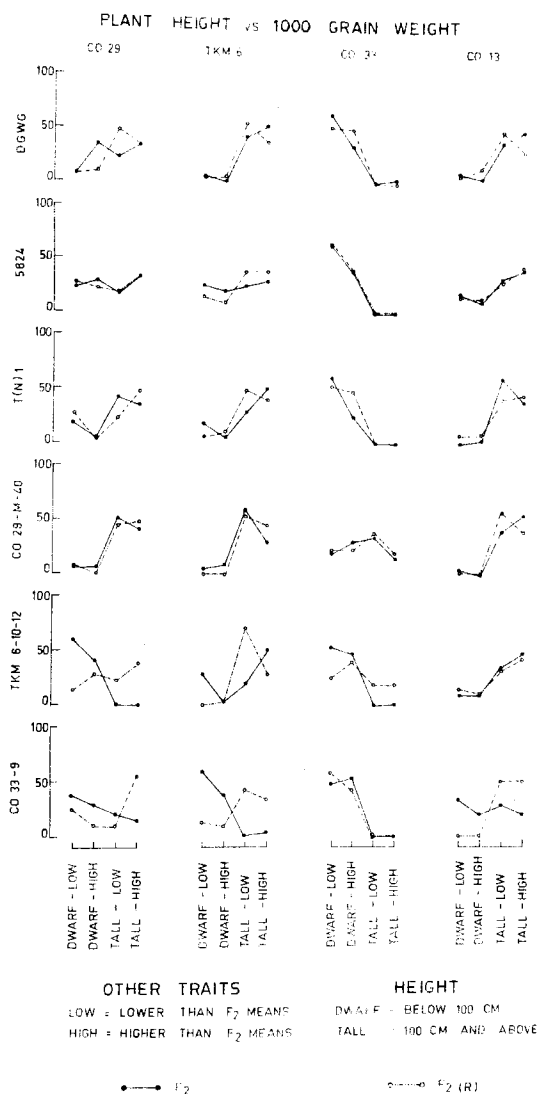
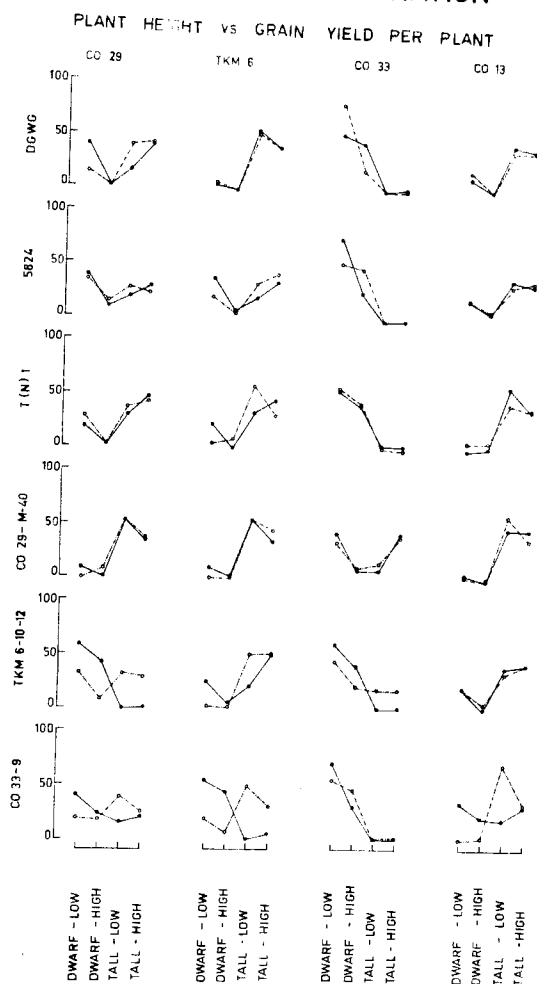


FIG.19 RELATIVE PROPORTION OF RECOMBINATION IN SECOND GENERATION



OTHER TRAITS

LOW = LOWER THAN F_2 MEANS
HIGH = HIGHER THAN F_2 MEANS

HEIGHT

DWARF = BELOW 100 CM
DWARF = 100 CM AND ABOVE

—●— F_2

- - -○- - $F_2(R)$

recombination was nearly identical in the crosses involving conventional dwarfs. The segregating generation of CO 29-M-40 behaved in a pattern of recombination, more or less similar to those of DGWG, 5824 and T(N)1. The trend of recombination of segregants under CO 29 and CO 33 testers conspicuously brought out the near close identity of CO 29-M-40 with DGWG, 5824 and T(N)1 than with TKM 6-10-12 and CO 33-9. When a common tester CO 13 was used, the induced dwarf CO 33-9 exhibited differences with other sources of induced mutants. Further, an assessment of the recombination pattern of the segregating population, when each of induced dwarfs was crossed with its respective original parent, indicated that these three induced dwarfs were independent sources. This trend was also in evidence in the pattern of segregation of the crosses involving TKM 6 tester parent. The foregoing discussion clearly indicates that DGWG, 5824 and T(N)1 are independent of the induced dwarf mutants which differ among themselves in the genotypic backgrounds. However, CO 29-M-40 tends to manifest some degree of closeness to DGWG, 5824 and T(N)1.

It may be concluded that the present investigation indicates evidence on the distinctiveness of the genetic backgrounds of the induced dwarf mutants not only among themselves but also from the conventional dwarfs and the Assamese natural dwarf. Based on the different criteria of evaluation, the dwarf parent DGWG is the desirable donor among the conventional dwarfs and CO 29-M-40 among the induced dwarfs. The magnitude

and direction of association of various economic traits with plant height differed widely between the backgrounds of conventional dwarfs and induced dwarfs.

The new dwarf source CO 29-M-40 characterized by its markedly short plant type proved to be a desirable parent with its high heritability and genetic advance for grain yield. Its recombination potential was also comparable to that of DGHG or T(N)1. Hence, the induced dwarf CO 29-M-40 may serve as a desirable alternative source of dwarfism in rice.

SUMMARY

SUMMARY

This thesis presents the results of the investigation which was aimed at studying the genetics and breeding value of different sources of dwarfism in rice.

1. Six dwarf donors were chosen for the study, two of them being conventional dwarfs DOWO and T(N)1 used in rice breeding, the third, an Assamese natural dwarf 5824 and the remaining three, induced dwarf mutants CO 29-M-40, TKM 6-10-12 and CO 33-3. They were crossed with four common testers, three of them being the basic original parents CO 29, TKM 6 and CO 33 from which the induced mutants were derived and the fourth variety CO 13.

2. A replicated and randomized design approximating to the compact family block model was adopted and a study was undertaken with all the six generations viz., parents, first generation hybrids and second generation progenies grown simultaneously.

3. Nine economic traits viz., plant height, tiller number, number of internodes, leaf area, panicle length, number of grains per panicle, weight of grains per panicle, 1000 grain weight and grain yield per plant were considered for the study on single plant basis and the data were subjected to biometrical scrutiny.

4. The estimates on heterosis, heterobeltiosis, matroclineous inheritance, heritability, genetic advance and

correlations of various traits with plant height and yield were worked out and the results discussed.

5. The choice of the dwarf donors fulfilled the primary requirement of varied sources of dwarfism, possessing diverse genetic background for the purpose of this investigation.

6. The inheritance of plant height tended to be dominant for dwarfism under the cytoplasmic background of all dwarf parents except CO 29-M-40 in which recessive inheritance for dwarfness was observed.

7. The variety DGG had the maximum expression of panicle length and weight of grains per panicle, while T(M)1 exhibited the highest tiller number and grain yield per plant. The induced mutant CO 29-M-40 was the shortest of all dwarf parents.

8. The expression of heterosis was strikingly different in the hybrids of the mutant CO 29-M-40 which exhibited high heterotic behaviour for tallness, panicle length, number of grains per panicle, weight of grains per panicle, lighter grains and grain yield per plant.

9. CO 29-M-40 continued to maintain the heterotic influence to a higher degree in both F_2 and $F_{2(R)}$ generations in respect of plant height, leaf area, panicle length and number of grains per panicle.

10. There was matroclinal influence of TKM 6-10-12 on the traits, plant height, tiller number, number of internodes, leaf area, panicle length, 1000 grain weight and grain yield per plant and as such, the cytoplasmic determinant involved in TKM 6-10-12 was distinct from the other dwarf donors.

11. The scaling test for the various characters in the second generation revealed that epistasis was predominantly evident in crosses involving CO 29-M-40 for the traits, plant height, number of internodes, leaf area and 1000 grain weight.

12. There was disagreement, in general, between the heterotic effect and the estimates of deviation due to dominance (h) through the matroclinal analysis in many of the crosses. Hence, the enhanced expression of phenotypic values for F_1 was mainly contributed by the epistatic effects like 'additive x additive' rather than the influence of deviation due to dominance.

13. High variability and high mean performance were observed in the segregating populations involving DGF0 for the characters, grain yield and tiller number. The next in order of importance was T(N)1 which had a high expression of mean performance for panicle length, number of grains per panicle and weight of grains per panicle. The induced dwarf donors failed to express variability for most other yield components to the extent that was obtainable under other dwarf parents.

14. The combination of high genetic advance with high heritability was observed for grain yield per plant and weight of grains per panicle in many crosses involving DGWG. Though the scope of improvement in grain yield per plant was high for DGWG, contribution to yield had been mainly due to the high genetic progress in relation to the weight of grains per panicle.

15. Among the induced dwarf donors, CO 29-M-40 was preferable as it recorded a high genetic progress with high heritability for the traits, plant height, panicle length, number of grains per panicle and grain yield per plant.

16. The genotypic correlation for tiller number with plant height proved to be negative and significant in both the F_2 and $F_{2(R)}$ generations under the background of DGWG, 5824 and T(N)1, while it was positive under induced dwarfs, CO 29-M-40, TM 6-10-12 and CO 33-9.

17. With reference to the pattern of recombination, the crosses of CO 29-M-40 behaved more or less similar to those of DGWG, 5824 and T(N)1. The trend of recombination of segregants under CO 29 and CO 33 testers conspicuously brought out nearer identity of CO 29-M-40 with DGWG, 5824 and T(N)1 than with the other induced dwarfs.

18. The different criteria of evaluation in this study had revealed that the dwarf parent DGWG was the desirable donor among the conventional dwarfs and CO 29-M-40 among the induced dwarf mutants.

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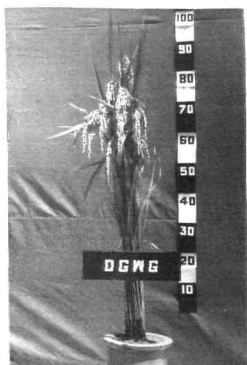
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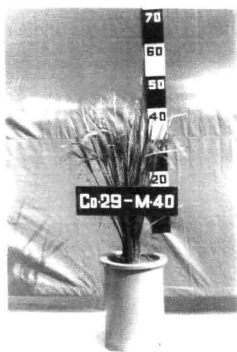
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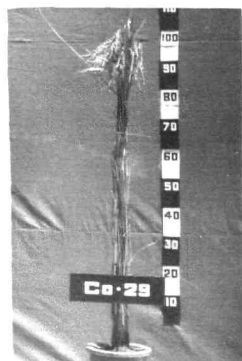
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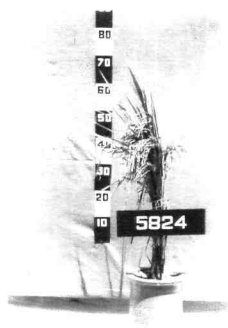
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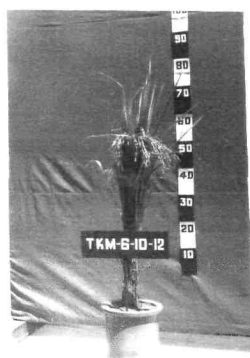
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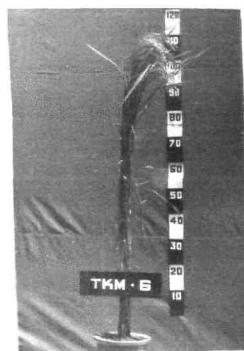
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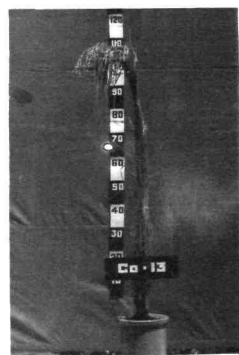
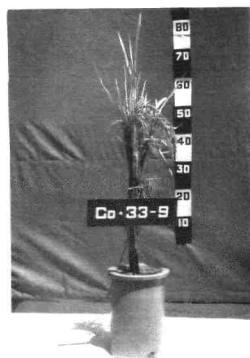
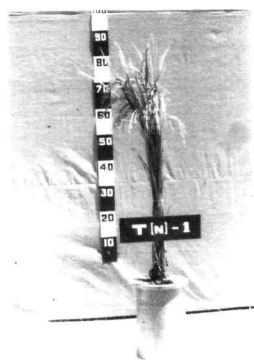
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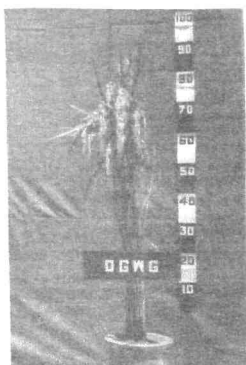


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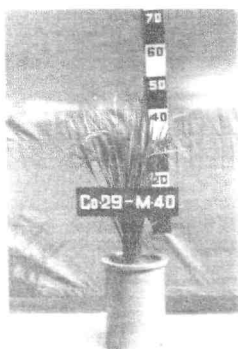


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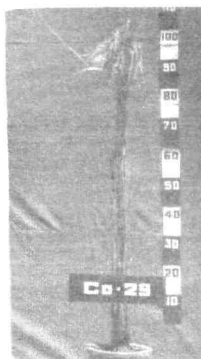
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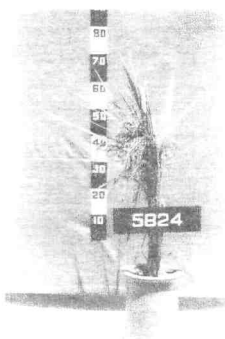
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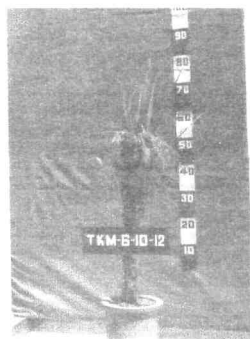
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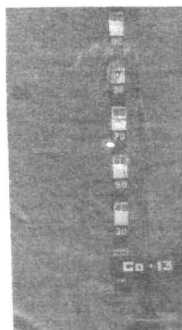
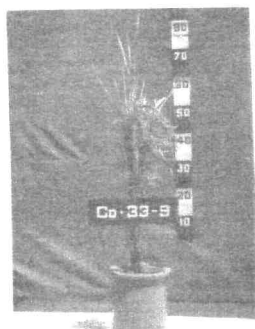
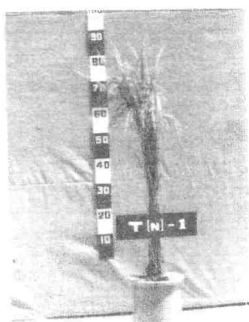
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ANNEXURES

LIST OF ANNEXURES

Annexure

- I Comparison of observed and expected values of traits on genetic model for matroclinal inheritance.
 - a. Plant height,
 - b. Tiller number,
 - c. Number of internodes,
 - d. Leaf area,
 - e. Panicle length,
 - f. Number of grains per panicle,
 - g. Weight of grains per panicle,
 - h. 1000 grain weight,
 - i. Grain yield per plant.

Breeding Methodology in Rice (*Oryza sativa* L.)—A Review *

by

J. CHANDRA MOHAN¹ and B. W. K. PONNAIYA²

Synopsis: The various methods of breeding employed for the improvement of rice crop have been discussed in detail. The conventional methods like introduction, mass selection, pure line selection and hybridisation and selection have been largely responsible for the evolution of many useful rice strains. The latest techniques like ploidy breeding and mutation breeding have also been adopted in this crop and their scope has been indicated.

Resume of History of Rice Breeding: Rice Breeding as an art was practised probably from ancient times. Huc (1938) quoted from the Memoirs of the Chinese Emperor K'ang-Hsi, (1662—1723) reports how “a chance stalk of rice in a field, more outstanding than others, was spotted out by the emperor and how the seeds were collected and raised to produce an improved variety”. However, organised scientific breeding in rice was initiated for the first time in 1893 in Japan with the opening of the Imperial Experimental Station at Tokyo (Ramiah and Vachani 1950) and after the dawn of this century systematic breeding was taken up in many of the rice growing countries.

McKerral (1913) reported about the progeny selection in Burma and Hanu (1914) about a method of selection in vogue in Java. Intervarietal selection and isolation of economic types by hybridisation in Java have been described by Viellard (1921) and Copeland (1924). Pureline selection for improvement of rice varieties was in vogue in Indo-China (Carle 1925), in Ceylon (Lord, 1929), in Malaya (Sands, 1924) and (Birkinshaw, 1940) and in New South Wales (Poggendorff, 1932). Chamblies and Jenkins (1923) reported about the first improved variety in U. S. A. developed by a private breeder S. L. Wright after 1910.

The Pioneers in rice breeding in India were Hector (1911) in Bengal and Parnell (1912) in Madras followed by Ramiah (1918). Graham (1911) in Central Provinces adopted the progeny selection which was later developed by Mahata and Dave (1931). In Bombay, pure-line and progeny selection were employed by Chibber (1919) followed by Bhide and Kadam (Ramiah,

* Part of the Dissertation submitted by the Senior author in partial fulfilment for the M. Sc. (Ag.) Degree of the University of Madras. (Received on 20—9—1952)

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1953). Alam (1932) isolated superior types from natural population of rice in Bihar, while inter-varietal hybridisation and selection were adopted in Assam by Mitra (1933) followed by Sethi (1940). From this modest beginning, rice breeding gathered momentum during last two decades with newer techniques of intensive and specific nature to produce economic strains.

Objectives in Rice Breeding and procedures adopted: Much work on breeding methodology in rice has been reported by various workers (Ramiah 1937, 1953; Richharia 1945, Ghose *et al* 1956 and Poehlman 1959).

The different objectives in rice breeding may be classified under the following heads.

BREEDING FOR			
Quantity	Quality	Resistance to pests & diseases	Specific objectives
Yield of grain and Straw	1. Fineness of grain 2. Milling quality 3. Cooking quality		1. Drought resistance 2. Saline resistance 3. Flood resistance 4. Lodging resistance 5. Seed Dormancy in short term rice 6. Earliness 7. Suitability for late planting 8. High fertility response 9. Plasticity 10. Seed fertility 11. Control of wild rice 12. Tolerance to cold water 13. Suitability for Mechanical harvest 14. Combining special traits like white rice, dense panicle, round grain, etc.

(a) *Introduction and acclimatisation:* Although this is the easiest and most rapid method of crop improvement, success has not been much in the case of rice. Ramiah and Rao (1953) record that "none of the varieties of rice introduced into India from sub-tropical regions of Japan, Korea, Italy and America have been of use except as parents in crosses". Liotard (1880) has described how the very first introduction viz., "Carolina Rice" from U. S. A. into India in 1868 by the Government of India was a failure despite its organised and systematic trial in all the provinces. Among the exotic rice varieties introduced into India certain Chinese varieties are the most successful, being adaptable to conditions existing in India (Ramiah 1953). Good performance of these Chinese rice varieties has been reported by Chatterjee (1952) in Uttar Pradesh, West Bengal and Orissa, Rania (1953) and Negi (1955) in Kashmir valley, Negi and Saini (1957) in the Kulu valley in the Punjab and Rajagopalan and Samad (1960) in Madras.

In India, introduction of varieties from one State into the other has been successful in many cases. Some of the successful introductions into Madras State are given below :

From	Variety	Special attributes
Bengal	Patnai	Yield
Uttar Pradesh	Basmati	Table rice, scented
Orissa	S. R. 26 - B	Saline resistance
Punjab	Sugadas	Aroma and flavour

Mem. Dept. Agric., Madras, 1954.

Collection of varieties from the different rice growing regions and maintenance of the "germ plasm" for direct introduction as well as for transference of genes possessing desirable traits have been in progress as part of the rice improvement programme in many countries. At Coimbatore, the world collection of rice varieties has exceeded 2,500 types (unpublished Agricultural Station Reports, 1960). The Central Rice Research Institute at Cuttack is one of the centres recognised by the F. A. O. for the collection and maintenance of World Rice genetic stock (Ghose *et al* 1956).

(b) *Mass selection*: Mass selection consisting of selecting phenotypically resembling desirable individual plants and breeding them *en masse* irrespective of their genotypic values, is now almost obsolete. This method was in vogue in Philippines, Italy, Spain and India (Ramiah 1953). In earlier years, this method was adopted in Madras at various Rice Research centres like Aduthurai, Maruteru, Pattambi and Berhampur (Ramiah 1937). A variety developed by this method will be pure only for physical features which are easily seen and differ in quantitative or yield attributes (Poehlman 1959). The improvement effected by this method is rather temporary and this procedure has to be repeated. Some of the examples of mass selected rice strains are PTB. 28, PTB. 29, PTB. 30 (*Annual Station Report, Madras, 1950—'51*).

(c) *Pure-line selection*: Johannson's pure-line concept has been utilised in this crop with the single plant as the basis for selection. Alam (1932) is of the opinion that "in this crop the variations are so profuse and distinct that practically all the requirements of the farmer could be met simply through the isolation of pure strains". Butany (1957) has recorded that the natural crossing in the cultivated rices in India varies from 0.1 per cent to 4.0 per cent and due to the self-fertilising nature of the crop, in-breeding and maintenance of pure lines are easily achieved. Majority of the improved varieties of rice evolved the world over are by this method (Ramiah 1957). Ghose (1956) reports that 394 out of 446 strains evolved in India have been developed by pure-line selection.

(d) *Hybridisation and selection*: Direct improvement in yield in most cases was not achieved in rice by hybridisation. But where physiological characteristics such as disease resistance, resistance to lodging, drought and salinity and to overcome sterility were sought to be incorporated in otherwise desirable strains, success has been phenomenal (Ramiah 1953). Ekbote (1930) and Krishnaswamy and Chandrasekaran *et al* (1960) are of the opinion that artificial hybridisation in rice was probably known in ancient China.

(i) *Intervarietal hybridisation*: The easy crossability and the high fertility of the intervarietal hybrids in rice have afforded much scope for exploiting fully this procedure for combining desirable traits available in certain varieties. Ghose (1956) has listed 52 strains evolved by this method in India alone. Four blast resistant strains, Taichung 171 in Taiwan and Co. 25, Co. 26 and ADT. 25 in India have been isolated with ten more cultures ready for release (Parthasarathy and Padmanabhan 1958). Hybridisation projects are in progress in various centres in India using Co. 4 as the blast resistant gene donor (Parthasarathy 1956), Ramachandra Rao and Hanumantha Rao (1956) and Samad (1958). Breeding for drought resistance, saline resistance and flood resistance in India has been reported by Ramiah (1953), Samad (1954), Samad *et al* (1960) and Venkatanadhachari (1958). Hybridisation and selection for non-shedding character (Daiya 1958) and for seed dormancy in short term rices (Samad 1960) are also in progress. Strains Co. 14 for non-lodging, ADT. 20 for round grain with short duration and ADT. 8 for earliness suitable for winter season are some of the outstanding varieties evolved in Madras (Parthasarathy 1954). TKM. 6 is another outstanding strain from Madras which combines fineness of grain and short duration. In addition, the seeds have dormant nature and unlike its parent GEB. 24, this strain is non-sensitive to photoperiod (Bhavanishankar Rao 1956).

Work on breeding varieties resistant to insect pests like stem borer in Egypt (Koshairy *et al* 1957) and rice bug in India (Sethi 1936) as well as for resistance to diseases like Hoja Blanca (Atkins and Judson 1958) and straight head in U. S. A. (Beachell and Crane 1957) has been reported. Puran Singh Sangwan (1956) has recorded the progress of breeding for resistance to drought, salinity, etc., in Egypt.

(ii) *Interracial hybridization*: Among the cultivated species of rice, three geographical races, viz., *O. sativa* var. *indica*, *O. sativa* var. *japonica* (Kato 1930) and *O. sativa* var. *javanica* (Terao and Mizushima 1939) have been recognized. These races are distinguished by their differences in morphological and physiological traits as well as by their photoperiod and fertilizer responses. *Indica-japonica* hybridisation to combine the high fertilizer response, non-lodging and non-shattering grain characters of the

japonicas with hardiness and tropical adaptability of the *indicas* has been in progress in India. Richharia and Misro (1959) and Parthasarathy (1960) have summarised the projects sponsored by the F. A. O. in 1950 and the I. C. A. R. in 1951, wherein different *indicas* from various Asian countries were crossed with few *japonicas* suggested by Dr. Morinaga. The results have indicated the prospects of isolating homozygous promising types from hybrids by F_2 generation despite the high percentage of sterility usually met with in F_2 and subsequent earlier generations.

(iii) *Interspecific hybridization*: Pal and Ramanujam (1944) have rightly pointed out that while agronomically useful genes like yield and quality are found in cultivated plants, those constituting hardiness and resistance have to be sought in the wild species through interspecific crosses. Ramiah (1953) Ghose *et al* (1956) and Morinaga (1959) have furnished the list of interspecific hybrids effected in rice. In most cases, the F_1 s were highly sterile. Morinaga and Fukushima (1956) reported that back cross method to bring about fertility and doubling their chromosome numbers by colchicine have not been successful. However, Srinivasan *et al* (1941) have reported the isolation of promising cultures with drought resistance from a cross of GEB. 24 (*Oryza sativa* L.) and *Oryza longistaminata* (*Oryza perennis*) in India.

Selection Procedures in Hybridisation: (i) *Pedigree method or Line method*: In this method "plants with the desired combinations of characters are selected in the F_2 generation and the progenies of each selected plant is re-selected in succeeding generations until genetic purity is reached" (Poelhman 1959). In the F_2 generation, the segregating population is grown in rows to facilitate detailed examination and selection. But in subsequent generations, small plots of 4' x 5' are adopted for each progeny. Recently the replicated progeny row technique evolved by Hutchinson and Panse (1937) in cotton is being adopted in rice at Coimbatore (*unpublished Agricultural Station Report, 1959 Madras*). Trials conducted by Abraham *et al* (1956) at Cuttack indicated the usefulness of this method in rice. Selection based on progeny mean has been found to be more reliable than selection based on single plant yields, as in the opinion of Panse (1942) the single plant yields are subject to a greater influence of environment than the means of a progeny.

(ii) *Bulk population method*: In this breeding procedure selection is delayed until the F_2 or F_3 after hybridisation by which time segregation would virtually have ceased. "This method which was first tried in barley at Svalof in Sweden has been adopted in rice and is known as 'Svalof method' (Ramiah 1937).

(iii) *Multiple cross method*: This is a complex system involving hybridization between eight or more varieties with the objective of combining useful traits existing in the different parents. Multiple crosses are produced by hybridizing pairs of parents at first and then crossing pairs of F_2 s until all parental combinations enter a common progeny. This method was adopted in rice in Madras with a view to isolate a cosmopolitan strain suitable for *Kuruvai*, *Kar* and *Samba* seasons and with this objective a project involving crosses between the different varieties suitable for each of the above seasons was initiated (Srinivasan 1942). F_2 s of the primary crosses of the same group were again crossed, but it was found that none of the isolates from these crosses gave better performance than the parental strains themselves. Based on the above results, Narasinga Rao (1951) concluded that this method had certain limitations in rice improvement programme.

(iv) *Back cross method*: Harlan and Pope in 1922 pointed out the usefulness of the back cross method in plant breeding as a form of recurrent hybridisation by which a superior specific character like disease resistance is added on to an otherwise desirable variety (Hayes *et al* 1955). This method has not been exploited to any considerable measure in rice breeding. Failure of this method to bring about fertility in interspecific hybrids has been reported by Morinaga and Fukushima (1956).

The partial success achieved by the work of Shigemura in 1943 in introducing blast resistance from *indicas* to *japonicas* by back crossing has been reported by Morinaga (1954). Briggs and Allard (1953) have isolated a new variety 'calrose' by introducing the medium grain size character of 'calady' into an otherwise desirable strain 'Caloro' by repeated back crossing. This appears to be the only instance of utilising the back cross method in rice improvement work. Sampath and Mohanty (1954) and Venkataswamy (1957) suggested that this method might be more helpful in distant crosses than in straight hybridisation. Gopalakrishnan (1960) is of the opinion that this method can be employed in rice especially for the transfer of wild genes to cultivated varieties.

Hence the back cross method of breeding which has resulted in the isolation of useful varieties in other small grains, viz., mildew and scald resistant 'Atlas' variety of Barley (Schaller 1951) and leaf rust and stem rust resistant *T. vulgare* (Shands 1941) and Allard (1949) may be utilised in the rice improvement programme also.

(e) *Ploidy breeding*: Ploidy breeding in rice has been attempted mainly to produce gigas characters and to overcome sterility in interracial and interspecific crosses.

Haploids as Blakeslee (1939) has pointed out have potential value in plant breeding as a means of getting a desired combination in a homozygous condition. Morinaga and Fukushima *et al* (1932), Ramiah *et al* (1932) Sethi (1937) have reported the occurrence of haploids in hybrid population which were completely sterile. Production of haploids by induced parthenogenesis has not been successful.

Although triploids have been found in intervarietal and interspecific crosses as reported by Nakamori (1932), Ramiah *et al* (1933), Nandi (1938), Ramannjam (1937) as well as spontaneous and X-ray mutant triploids recorded by Ichijima (1934) and Morinaga (1935), these have not been found useful economically.

Auto-tetraploids occurring spontaneously as well as induced by colchicine have been found to exhibit gigas characteristics in grain size, ear length etc. (Nakamori 1933), Morinaga and Fukushima (1936) and Nandi (1937). The high percentage of spikelet sterility found in them, however, make their cultivation unremunerative (Misro 1960). In addition, the artificially induced auto-tetraploids in varieties like G. E. B. 24, S. R. 26-B Indrasail and Seta, invariably exhibited awning which was absent in the diploids (Misro and Muralidharan *et al* 1960).

(f) *Mutation breeding*: Numerous instances of the occurrence of both spontaneous as well as induced mutations affecting almost every part of the rice plant and many of its physiological characters have been reported by various workers in India, Japan and other countries. Ramiah (1953) has compiled an exhaustive list of these mutations. X-ray and chemicals like Colchicine were the mutagens employed in the earlier years and almost all the induced mutations were recessive, uneconomical and of genetical interest only.

Soon after the pioneering work of Stadler (1928) in Barley with X-rays was reported, induction of mutation in rice by X-ray treatment was attempted in 1933 for the first time in India at Coimbatore by Ramiah and Parthasarathy (1938). Recent attempts reported by Chang and Hsieh (1957), Beachell (1957) and Oka *et al* (1958) where X-ray has been employed gave mutations showing variation in height, shattering of grain, chlorophyll deficiency etc., which were of no economic value. Irradiation of seed by thermal neutrons, Beeta rays from radio-active phosphorus and gama rays has been reported by Jodan (1958), Chalam *et al* (1959) and Yamaguchi and Ando (1959). These treatments have also resulted in inducing variation in duration and height.

Chemical mutagens like acenaphthene, benzene vapour and ceresan have been employed for artificial induction of mutations in rice by Narasinga Rao (1953) and variations in number of tillers, grain size, yield and duration have been reported.

Among the few artificially induced economic mutants, the dwarf mutant in the strain GEB.24 obtained by X-ray treatment (Ramiah and Parthasarathy 1938) which has profuse tillering and non-lodging habit is worthy of mention. Sukanya Bai *et al* (1957) reported isolation of economic mutants in acenaphthene treated GEB.24 and cersan treated Co. 13.

Certain spontaneous mutations that were recorded in rice have been found useful economically. The first improved strain of Madras viz. GEB.24 is reported to be a probable mutant isolated from a variety Konamani of Godavari District by Parnel in 1916. Examples of similar mutants are ADT. 15 from Kuruvai, AKP.13 from Maharaja bhogam and MTU.20 from Basangi (*Mem. Dept. Agric., Madras, 1954*).

It is seen from the above reports that mutation breeding in rice appears to have much scope in the improvement of rice crop and an intensive work in this line is warranted.

Acknowledgement: The senior author is thankful to the Department of Agriculture and the Government of Madras for awarding a Merit Scholarship for pursuing his post-graduate studies during which course the present review was compiled.

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Heterosis in Rice (*Oryza sativa* L.) *

Heterosis or hybrid vigour has been exploited by horticulturists and Stock breeders for quite a long time. With the phenomenal success of hybrid maize in U. S. A. the utilisation of heterosis for increasing the productivity of crop plants has been recognised in recent years as an efficient technique in the method of crop improvement. In India notable success in the exploitation of hybrid vigour in Bajra (*Pennisetum typhoides*) has been achieved. Of late attempts are being made to exploit heterosis even in a predominantly self-fertilised crop like cotton.

In rice the results of studies on heterosis have been reported by many workers since 1910. The manifestation of heterosis as recorded by the investigators is given below.

S. No.	Characters showing Heterosis	Author
1.	Height of plant	Ikeno (1927), Jones (1926 and 1928) and Ramiah (1933).
2.	Number of Tillers per plant or number of Panicles per plant.	Idsumi (1937), Jones (1926), Ramiah and Ramaswamy (1941) Ramiah (1935) and Parthasarathy (1960).
3.	Length of panicle	Capinpin and Punyasingh (1938), Idsumi (1937), Jones (1926), Ramiah and Ramaswamy (1941).
4.	Duration - earliness or lateness	Ramiah (1935), Brown (1953), Bhide (1926), Yamasaki (1925) and Vander Stok (1910).
5.	Hundred grains' weight	Brown (1953).
6.	Yield	Ramiah and Ramaswamy (1938 & 1941) Capinpin and Punyasingh (1938) Jones (1926), Idsumi (1937) and Kadam (1937).

From the above it is seen that hybrid vigour is exhibited not only in the case of yield but also in respect of most of the yield components in rice. Absence of the expression of hybrid vigour has also been observed by Kadam (1937) in panicle length and plant height, Capinpin and Punyasingh (1938) in number of tillers and Ramiah *et al* (1938) in hundred grains' weight.

Although increase in yield due to heterosis has been recorded, the possibility of exploitation of hybrid vigour on a commercial basis has not so far been attempted by rice breeders, probably because of the breeding mechanism of the crop where self fertilisation is the rule. Moreover, the snag in the proposition is the difficulty in producing hybrid seeds through hand emasculation methods where a spikelet produces only one seed and the non-availability of cyto-plasmic genetic male sterile lines as in maize.

The publications on the subject are given below:

Bhide, R. K.	1926	Inheritance and correlation of certain characters in rice crosses. <i>Poona Agric. Coll. Mag.</i> , 18: 78-85.
Brown, R. C.	1953	Hybrid vigour in Rice. <i>Malayan Agric. J.</i> , 36: 226-36.
Capinpin, J. M. and K. Punyasingh	1938	A study of varietal crosses and hybrid vigour in Rice. <i>Phil. Agrol.</i> 27: 255-77.
Idsumi, Y.	1937	Investigations in Heterosis in rice plants. <i>Plant Breed Abstract.</i> 7: No. 1665.
Ikeno, S.	1927	A monograph on rice genetics. <i>Biblis genetic.</i> 3: 245-312 (Quoted by Ramiah 1953).
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Correlation studies in Rice (*Oryza sativa* L.)—Correlation of Yield Components with Yield in the Strain TKM. 6 *

by
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Synopsis: The correlation coefficients in respect of seven characters which are components of yield in rice studied in a short duration strain TKM. 6 are recorded in this paper along with a detailed review of literature on the subject.

Introduction: Breeding for high yield is the major objective in any rice improvement programme. The study of the association of yield components with yield assumes importance to the rice breeder for fixing up characters which have a decisive role in influencing the yield so that these components of yield may form additional indices for selection from the breeding material. In this paper correlation coefficients in respect of seven characters which are components of yield in rice have been studied in a short duration popular fine rice strain of hybrid origin viz., TKM. 6 with a view to find out their degree of relationship with yield. A detailed review of the previous work in rice has also been given.

Review of Literature: In rice different degrees of association between yield and other characters have been recorded. Vibar (1920) reported that duration, height and length of panicle were correlated with yield although greater straw weight was not always associated with yield. Mendiola (1926) found inter-varietal variation in correlation of many characters with yield and Bhide (1926) and Bhide and Bhalerao (1927) found high correlation of tillering with yield and a low correlation in length of main panicle. Mahalanobis (1934) studying various characters of 147 rice varieties in Bengal found that mean yield moderately correlated with the number of tillers per plant and length of leaf but appeared to be independent of characters like grain dimensions, height, duration etc. Narasinga Rao (1937) also reported that the highest correlation of yield was found between yield and number of tillers followed by the number of grains per ear and panicle length. Chakravorthy (1940) found no significant relationship between minor characters like length, breadth and thickness of grain, flag leaf dimensions, exertions, etc. Ganguli and Sen (1941) stated that height of tillers, length of panicle and the number of grains per panicle were positively correlated with yields. Ramiah (1953) summarising the results obtained at various research stations reported that a moderate correlation existed between mean yield and number of tillers per plant. Height, ear length and the mean number of grains per ear were

* Part of the Dissertation submitted to the University of Madras for the award of M. Sc. (Ag.) Degree in 1961.

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Received on 30-3-1963.

feebly correlated with yield. Eikichi Iso (1954) recorded high correlations of yield with tillering, weight of ear, length of ear, number of grains per ear etc. Syed and Krishnamoorthy (1956) found the ear length and number of tillers contributing mainly to yield and ear bearing tiller number is the most potent yield component in rice crop. Ghose *et al.* (1956) after a study of inter-varietal correlation at Cuttack taking into account the number of panicles, length of panicle and height of plant at harvest, stated that contribution of height towards yield was negligible in all cases, while other factors showed positive correlation with variation in different degrees.

Material and Methods: The strain TKM. 6 which was grown under an inter-strain comparative yield trial was chosen for the study. A brief description of the strain is given below:

Name	... <i>Sanna swarnavari</i>
Origin	... Progeny of the cross GEB. 24 x Co. 18
Habit	... Erect
Height	... Medium
Number of tillers	... High
Pigmentation in plant parts	... Absent
Panicle type	... Open
Panicle length	... Long
Spikelet arrangement	... Ordinary
Kernel size	... Medium
Ripening colour of glume	... Straw
Awning	... Awnless

The trial was laid out in Randomised block design with 5 replications. TKM. 6 was planted in 5 plots with dimensions 3' 4" x 5' adopting a spacing of 10 inches between rows and 6 inches along the row. Single seedlings were planted and there were five rows of eleven plants each. The border rows in each plot were discarded for purposes of experiment leaving 3 rows of 9 plants each making a total of 27 plants in each plot.

Out of the net 27 plants in each plot, ten plants were selected at random with the help of "two digit random numbers" (Fisher and Yates, 1948). These plants were marked with paraffin paper labels. Thus 50 plants (10 plants from each of the 5 replications) were studied individually for the following characters: (1) Plant height, (2) Number of ear bearing tillers, (3) Length of primary ear, (4) Number of grains in primary ear, (5) Number of grains per plant, (6) Weight of 100 grains and (7) Yield of straw per plant. The plant height and length of main ear were measured to the nearest centimetre and millimetre respectively. The hundred grains weight and the yield of grain and straw were recorded in a precision balance correct to 1/100 of a gram.

In order to estimate the degree and strength of association of the six characters with yield as well as between the characters, correlation coefficients were calculated as per the method described by Panse and Sukhatme (1957). The significance was tested by means of Fisher's 't' test.

Results and Discussion: The mean values of characters and yield on individual plant basis are furnished in table 1 and the correlation co-efficients worked out between the characters and yield as well as between the characters themselves are given in table 2. A scrutiny of the values of correlation co-efficients reveals that among the characters studied, number of ear bearing tillers, number of grains per plant and yield of straw have very high correlation with yield. It is also interesting to note that the correlation coefficients have been found to be significant at 1% level. Plant height and number of grains per primary ear are moderately correlated with yield while length of ear and weight of 100 grains have very feeble insignificant correlation with yield. From the correlation coefficients between the various characters, it is seen that the three characters viz., number of ear bearing tillers, number of grains per plant and yield of straw, which have a very high association with yield are themselves having high correlation between each other. The character weight of hundred grains which has the least association with yield is also having very feeble and insignificant association with plant height, number of grains per primary ear and number of grains per plant and negative correlation with number of ear bearing tillers and length of ear.

The results obtained in the studies have indicated that the number of ear bearing tillers has high correlation with yield. Bhide and Bhalerao (1927), Narasinga Rao (1937), Ramiah (1953), Eikichi Iso (1954) and many other investigators have reported positive correlation between the number of ear bearing tillers and yield. Another yield attribute viz. number of grains per plant appears to have not been studied previously by investigators in rice. The results obtained in the present study have indicated that this character is very highly associated with yield. Yield of straw has also been found to have high and positive correlation with yield of grain. Very little work in rice has been done in this regard except the report of Vibar (1920) who has found that greater straw weight

TABLE 1.
The mean values of characters and yield on individual plant basis of the strain TKM. 6

1. Plant height in centimetres	...	=	109.80
2. Number of ear bearing tillers	...	=	10.10
3. Length of ear in centimetres	...	=	23.46
4. Number of grains per primary ear	...	=	91.42
5. Number of grains per plant	...	=	669.16
6. Weight of 100 grains in grams	...	=	1.63
7. Yield of straw per plant in grams	...	=	11.44
8. Yield of grain per plant in grams	...	=	11.33

TABLE 2.
Simple correlation coefficients of characters with yield as well as
between themselves

	Weight of grains per plant	Number of ear bearing tillers	Length of ear	Number of grains per pri- mary ear	Number of grains per plant	Weight of hundred grains	Weight of straw per plant
1. Plant height	0.578**	0.594**	0.550**	0.392*	0.557**	0.136	0.594**
2. Number of ear bearing tillers	0.715**		0.043	0.201	0.757**	0.155	0.869**
3. Length of ear	0.246			0.490**	0.280	0.009	0.313*
4. Number of grains per primary ear	0.475**				0.435**	0.086	0.263*
5. Number of grains per plant	0.987**					0.229	0.757**
6. Weight of hundred grains	0.106						0.136
7. Yield of straw	0.732**						

* Significant at 5% level.

** Significant at 1% level.

was not always associated with yield. In wheat, however, Smith (1936) and Simlote (1947) have recorded positive correlation between yield of straw and yield of grain. In this study, the character plant height has recorded positive correlation with yield. This is in conformity with the findings of Ganguli and Sen (1941) who also recorded positive correlation between these factors. Length of primary ear has been found to have very low and insignificant correlation with yield. Bhide and Bhalerao (1927) have reported similar results while Eikichi Iso (1954), Narasinga Rao (1937) and Syed and Krishnamoorthy (1956) however have recorded varying degree of associations of this character with yield. Number of grains per primary ear has been found to have moderate correlation with yield. This is in conformity with the results obtained by Eikichi Iso (1954) although other investigators like Ramiah (1953) and Abraham *et al.* (1954) have reported very low association of this character with yield. Weight of hundred grains has been found to have the least association with yield. Similar results have been obtained by Narasinga Rao (1937) and Eikichi Iso (1954).

Summary and Conclusion: Seven characters viz. plant height, number of ear bearing tillers, length of ear, number of grains per primary ear, number of grains per plant, weight of one hundred grains and yield of straw which are the components of yield in rice, were studied in relation to yield in the strain TKM. 6. Correlation coefficients were worked out between these characters and yield as well as between the characters themselves. It was found that while number of ear bearing tillers, number of grains per plant and yield of straw have very high association with yield, plant height and number of grains per primary ear showed moderate correlation with yield. However, the characters length of

ear and weight of 100 grains have very feeble correlation. From the present study as well as from the previous work done in rice it is seen that the number of ear bearing tillers has high association with yield and it can serve as an additional index for selection in rice.

Acknowledgement: The author wishes to express his thanks to Dr. B. W. X. Ponnaiya, Professor of Plant Breeding and Genetics and to Sri V. Srinivasan, Paddy Specialist for their help and guidance in the preparation of this paper. The author is also thankful to the University of Madras and the Madras Government for enabling him to pursue the post-graduate studies during which the present investigation was undertaken.

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Correlation Studies in Groundnut (*Arachis hypogaea* L.)—Correlation of Certain Quantitative Characters with Yield in the Strain TMV. 2

Breeding for high yield is the major objective in any groundnut breeding programme. The study of the association of quantitative characters with yield assumes importance to the groundnut breeder for fixing up characters which have a decisive contributory role in influencing the yield so that these components of yield may form additional indices for selection from the breeding material. In this paper correlation coefficients in respect of seven measurable quantitative characters have been studied in TMV. 2, a short duration groundnut strain with bunch habit of growth grown extensively in Madras state, with a view to find out their degree of relationship with yield.

In *Arachis hypogaea*, Mital and Mehta (1954) have reported positive correlation of leaflet length, breadth and ratio of length by breadth with seed size in spreading varieties. In erect types he found negative correlation of seed size with oil content. Studies in Madras State (Anon. 1954) showed a positive and significant correlation between the ratio of the average length of primaries to the height of the main axis and the weight of pods. Misra (1958) found significant correlation of leaf dimensions with seed size. Dorairaj (1962) recorded, positive correlation between number of pods, number of nodes in primaries, number of secondaries, mean length of primaries, height of the main axis and number of nodes in the main axis on the one hand, and the final yield of groundnut on the other in the case of the bunch variety.

The strain TMV. 2 grown in trial plots at the Agricultural Research Station, Bhavanisagar during the first crop season of 1964-'65 was chosen for the study. Three plants in each plot were selected at random with the help of "Two digit random numbers" (Fisher and Yates, 1948). The following characters were studied; (1) height of plant; (2) number of nodes in the main axis (3) number of mature pods (4) immature pods (5) number of tenders (6) weight of plant and (7) weight of immature pods. In order to estimate the degree and strength of association of these seven characters with yield as well as between the characters, simple correlation and partial correlation were calculated as per the method described by Panse and Sukhatme (1957). The significance was tested by means of Fisher's 't' test. The multiple regression function of the yield with the characters was also set up. The procedure given by Goulden (1959) was adopted.

The total and *inter se* correlation coefficient between the characters and yield are given in Table 1. Among the characters studied, number of mature pods and weight of plant (haulma) have high positive correlation with yield. These two characters which showed a very high association with yield are themselves have high correlation between each other. The results obtained in respect

TABLE 1. Total Correlation Coefficients between different Characters of Groundnut (TMV. 2)

	Plant height (cm.) (X1)	Number of nodes (X2)	Number of mature pods (X3) *	Number of immature pods (X4)	Number of tenders (X5)	Weight of plant (gm.) (X6)	Weight of immature pods (X7)
Weight of mature pods (Yield) Y	0.0473	0.2564	0.9450**	0.3813	0.0674	0.7901**	0.0734
Plant height in cm. (X1)	+1	0.6228**	0.1431	0.2507	-0.0304	0.1588	0.3774
Number of nodes (X2)		+1	0.3344	0.5234*	0.1816	0.5518*	0.4838
Number of mature pods (X3)			+1	0.5129*	0.1617	0.8607**	0.3363
Number of immature pods (X4)				+1	0.5306*	0.7421**	0.5067*
Number of tenders (X5)					+1	0.4216	0.3054
Weight of plant (X6)						+1	0.4450
Weight of immature pods (X7)							+1

of number of mature pods is in conformity with the report of Dorsairaj, (1962). The other yield attribute, weight of plant appears to have not been studied previously in groundnut. The partial correlations worked out and the multiple regression equation set up with all the characters are furnished below:—

Partial Correlations

ry 1	234567	= 0.0759
ry 2	134567	= 0.1488
ry 3	124567	= 0.8905 **
ry 4	123567	= 0.2257
ry 5	123467	= 0.1309
ry 6	123457	= 0.2173
ry 7	123456	= 0.7741 **

where 1, 2, 3, 4, 5, 6 and 7 stand for independent

X1, X2, X3, X4, X5, X6 and X7 respectively.

Coefficient of determination : $R^2 = 0.9666$ **

Multiple correlation Co-efficient : $R = 0.9831$ **

Regression Equation:—

$$Y = -0.0205 X_1 + 0.0516 X_2 + 0.9408^{**} X_3 - 0.0739 X_4 - 0.0322 X_5 + 0.1470 X_6 - 0.2784 X_7 - 1.6775$$

** = Significant at $P = 0.01$ levels.

The data on partial correlations show that besides number of mature pods, weight of immature pods also has highly significant positive correlation with yield. In the multiple regression function presented, only the partial

regression of yield on number of mature pods is highly significant. The multiple regression has a very high degree of predictability viz., 0.98 (or) 98 percent. The highly significant multiple correlation coefficient (0.9831) shows the closeness between the predicted values of yield and the observed values. This brings out the importance in predicting the yield on the character 'number of mature pods' which has a relatively more dominant role in influencing the ultimate yield than the other six characters.

Acknowledgement: The authors wish to record their deep sense of gratitude to Sri S. Rajarathinam, Agronomist and Associate Professor of Agronomy for his guidance and to Sri K. A. Seshu, Statistician, for kindly analysing the data and providing the statistical interpretation.

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STUDIES IN RICE-FORMULATION OF A SELECTION INDEX FOR
YIELD IN Oryza sativa L.

By

J. Chandra Mohan and B.W.X. Ponnaiya

-101-

One of the problems confronting the breeder from very ancient times has been the evaluation of breeding material for effective selection. The early methods were based on the individual ability of the breeder but this is now being replaced by rational methods of adjudging the genotype from its phenotypic values. The technique of discriminant function provides the best indication of the genotypic value of a plant from the observed values of its characters. This evaluation is achieved by assigning relative weights to the observed values of characters which influence yield, such as, number of tillers, height, length of panicle, etc., taken simultaneously so that the resulting compound score is highly correlated with the true genetic value of a plant.

In the present study an attempt has been made to formulate a selection index for yield in rice. Six characters viz., plant height, number of ear-bearing tillers, length of primary ear, number of grains in primary ear, number of grains per plant and yield of straw were studied with regard to ten varieties of rice representing types from geographical zones of South and South-East Asia like India, Japan, China and Burma. The correlation studies indicate that the number of earbearing tillers, number of grains per plant and yield of straw have strong and positive correlation with yield, while plant height, length of primary ear and number of grains per primary ear have only feeble correlation. The discriminant function formulated for all the varieties indicate that out of the three yield

components, the yield of straw exerts the maximum weight upon grain yield, followed by number of ear-bearing tillers while the number of grains per plant has an insignificant role. The discriminant function for Indian varieties showed a similar trend of results. However, the relative importance of the number of ear-bearing tillers is nearly six times that of the yield of straw. The two yield attributes viz., yield of straw and of ear-bearing tillers might therefore serve as indices in selection for yield in rice.

Kanchi (CO 34) and Cauvery (CO 35) - Two New Early Varieties of Rice from Tamil Nadu

by

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Introduction: The introduction of Taichung (Native) 1 in 1964 revolutionised the very concept of rice breeding in India. This Taiwan *indica* variety possessed a very high yield potential compared to tall *indica* so far grown. This highlighted a break through in the yield levels possible in India with the substitution of the improved plant type that the Taichung (Native) 1 possessed. The improved plant type refers to the change in the architecture of the rice plant characterised by dwarfness of about 90-100 cm in height, erect habit, and a dark green foliage which increase photosynthetic efficiency and high fertilizer responsiveness resulting in high yield potential and insensitiveness to photoperiod. Introduction of new varieties like T(N) 1 from abroad may not be a permanent solution to varietal needs of the diverse agro-climatic regions and consumer preferences in India. Hence, recognising the merit of dwarfism and improved plant type a hybridisation programme was initiated at the Paddy Breeding Station, Coimbatore in 1965 with the object of infusing this desired plant type into the local improved popular strains possessing other traits of local importance and consumer preferences. Two of the early examples of the successful out-come of this hybridisation programme are the new strains KANCHI (CO 34) and CAUVERY (CO 35).

Materials and Methods: With the object of infusing the improved plant type with the associated characters of Taichung (Native) 1 into the popular local varieties, crosses were effected at the Paddy Breeding Station, Coimbatore employing Taichung (Native) 1 as the female parent with local popular varieties CO. 29 and TKM. 6. CO. 29 is an early variety with moderate resistance to blast disease (*Pyricularia oryzae*) and relatively finer grain quality. TKM. 6 is another early variety with fine white rice. Both these varieties are cosmopolitan with wide adaptation and grown almost throughout Tamil Nadu. TKM. 6 is resistant to stem borer and possesses seed dormancy also. The important characteristics of the local parents CO. 29 and TKM. 6 are furnished below:

1. Rice Agronomist, 2. Assistant in Paddy, 3. Assistant Crop Specialist (Paddy), 4. Rice Breeder and 5. Crop Specialist (Paddy) Agricultural College and Research Institute, Coimbatore.

	CO. 29	TKM. 6
Origin	CO. 13 × CO. 4	CO. 18 × GEB. 24
Maturity in days	110	115
Tillering	10 - 12	8 - 10
Plant height (cm)	125 - 130	130 - 135
Anthocyanin pigment	Present	Absent
Panicle length (cm)	22.5	22.0
Rice Colour	Dull white	White
Abdominal white	Absent	Absent
1000 - grain wt	22.8	17.8
Grain size (mm)		
Length	8.4	8.0
Breadth	2.6	2.0
Thickness	1.9	1.7
Commercial grade	Medium bold	Medium slender
Cooking quality	Good	Good
Disease resistance (Blast)	Resistant	Susceptible
Pest resistance (Stem borer)	Susceptible	Resistant
Lodging resistance	Susceptible	Susceptible

After intensive study of the progenies in the early generations upto F4 or F5 promising selections were carried over to the All India Coordinated Rice Improvement Project for testing under the Initial evaluation Trials (IET). The promising selections were then promoted to the Uniform Variety Trial (UVT) for assessing their yield potential simultaneously in different locations in India. Finally they were tried in the districts of Tamil Nadu before release as strains.

Results: The pedigree along with the development of the strains are described below:

a) *Pedigree of the Varieties:*

	IET.400	IET.355
Rabi 1965	The cross T(N)1 × CO.29 effected	The cross T(N)1 × TKM.6 effected
Kharif 1965	F1 plants studied	F1 plants studied
Rabi 1966	F2 progenies studied	F2 progenies studied
Kharif 1966	Promising selections studied in F3 generation	Promising selections studied in F3 generation
Rabi 1967	Promising progenies studied in the F4 generation	Promising selections carried over and tested under the Initial Evaluation Trial in F4 generation
Kharif 1967	Promising selections carried over and tested under the IET in the F5 generation	The promising selections tested under the Preliminary Variety Trial (PVT)
Rabi 1968	The promising selections again tested under IET	One of the promising selections IET. 355 promoted and tested under the UVT with other early varieties in different locations

	IET. 400	IET. 355
Kharif 1968	One of the promising selections IET. 400 promoted and tested under the UVT with other early varieties in different locations	Again tested under UVT
Rabi 1969	IET.400, tested again under UVT	IET.355 tested again under UVT
Kharif 1969	IET.400 tried in the districts	IET.355 tried in the districts

b) *Yield performance of the Varieties:* The selection IET. 400 gave the highest yield from 14 locations in the UVT conducted under the All India Coordinated Rice Improvement Project during Kharif 1968. In the same trials during Kharif 1969 it ranked first in 30 locations all over India. In Tamil Nadu it gave the highest yield during both Rabi and Kharif seasons from 1968 onwards. In the other trials conducted in the State it has recorded substantial increase over CO. 29 i. e. up to 37% under high level of manuring and has consistently recorded higher yields than Karuna (CO. 33) and ADT. 27. It has recorded the maximum yield of 7.33 tonnes of grain per ha at Kancheepuram. The data of yield performance of the varieties are furnished in Table 1.

TABLE 1. *Kanchi as compared to Local Varieties in the Trials of the All India Coordinated Rice Improvement Project in 18 locations in India during Kharif, 1969*

Average grain yield kg/ha

Locations	Kanchi			Local		
	High manuring	Low manuring	Mean	High manuring	Low manuring	Mean
Wangbad	5104	3437	4271	4375	3437	3906
Faizabad	4215	3433	3824	3706	3507	3637
Nagina	4810	4511	4661	5440	4736	5088
Karnal	3845	3363	3604	3250	3194	3222
Kapurthala	4093	4093	4093	4428	3977	4202
Kanke	4667	3352	3859	4237	3510	3875
Bhubaneswar	4400	3049	4024	4813	4261	4537
Jabalpur	5500	5997	5748	3424	3238	3331
Rewa	5260	4708	4984	3379	3421	3400
Rajendranagar	4099	3943	4021	2543	2498	2521
Amaravathi	5044	4076	4560	2874	2519	2697
Garikapadu	5261	4059	4660	3945	2987	3466
Nawagam	5607	4334	4971	5482	4022	4752
Sindewahi	3747	3645	3696	3443	3110	3276
Ratnagiri	3984	3750	3367	3734	3739	3737
Coimbatore	5289	3774	4531	3868	3611	3740
Adathurai	4610	4457	4533	4245	3791	4019
Pattambi	3913	3930	3921	3963	4385	4174

Kanchi as compared to the local strains in Tan'il Nadu (Average yield kg/ha)

	High level of manuring	Percentage over local	Low level of manuring	Percentage over local
Kanchi	4823	137 *	3440	105
CO.29	3526	100	3292	100
Kanchi	5072	102	4472	102
Karuna	4976	100	4368	100
Kanchi	4610	103	4245	112
ADT.27	4457	100	3791	100

Performance of Kanchi in the different Districts in Tamil Nadu (Average yield kg/ha)

	High level of manuring	Low level of manuring
1969-70 Early Samba		
Novlock	4580	5300
Kccla Gudalur	4416	4333
Danishpet	4500	4500
Mettur	4866	4666
Kariyiruppu	4583	3583
Meagaram	3500	4833
Kancheepuram	7333	6166
Vandatayanpet	4076	3396
Siru Kaveripakkam	5000	4333
1969-70 Late Samba		
Kancheepuram	7166	6666
Novlock	5541	5000
Danishpet	4333	3666
Mettur	3833	3666

The Selection IET. 355 has recorded the highest yield in four location under the UVT conducted under the AICRIP during *Kharif* 1969 and in general it was among the highest yielders in the trials of the AICRIP during both the seasons in 1968 and 1969. In the trials conducted in Tamil Nadu IET. 355 registered consistently substantial increase over TKM. 6 upto 52% under high level of manuring. It has also recorded higher yields over CO. 2, Karuna and ADT. 27 with increase ranging from 4% to 32%. A maximum yield of 9.4 tonnes per ha. was recorded at Athiyandal under high level of manuring. The data of yield performance of the variety are furnished in Table 2.

TABLE 2. *Cauvery as compared to local varieties in the trials of the All India Coordinated Rice Improvement Project in 18 locations in India during Kharif 1969*

Average grain yield kg/ha

Locations	IBT. 355			Local		
	High	Low	Mean	High	Low	Mean
Wangbad	4979	3594	4036	4375	3437	3906
Farizabad	3681	3036	3359	3706	3567	3637
Nagina	3986	3641	3814	5440	4736	5088
Karnal	3811	3363	3587	3250	3194	3222
Kapurthala	3575	3691	3633	4428	3977	4202
Kanke	3969	3198	3583	4239	3510	3875
Bhubaneswar	3385	2725	3055	4813	4261	4537
Jabalpur	4583	5298	4941	3424	3238	3331
Rewa	4029	4454	4242	3379	3421	3400
Rajendranagar	4008	4337	4172	2543	2498	2521
Amaravathi	4613	3892	4252	2874	2319	2697
Garikapadu	4850	3934	4392	3945	2987	3466
Nawagam	6108	4471	4290	5482	4022	4752
Sindewahi	2893	3262	3077	3443	3110	3276
Ratnagiri	4106	3955	4031	3734	3739	3737
Coimbatore	4829	3780	4305	3868	3611	3740
Aduthurai	4557	4351	4454	5245	3894	4019
Pattambi	3710	4216	3963	3933	4385	4174

Cauvery as compared to the local strains in Tamil Nadu

	High level of manuring	Percentage over local	Low level of manuring	Percentage over local
Cauvery	4400	132	3445	105
CO.29	3326	100	3292	100
Cauvery	5196	104	4576	104
Karuna	4976	100	4388	100
Cauvery	4537	105	4245	112
ADT.27	4351	100	3794	100
Cauvery	6370	152	—	—
TKM.6	4335	100	—	—

Kanchi (CO 34) and Cauvery (CO 35)

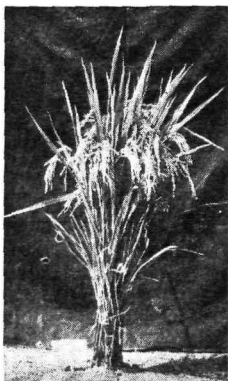
35

Performance of Cauvery in the different districts in Tamil Nadu

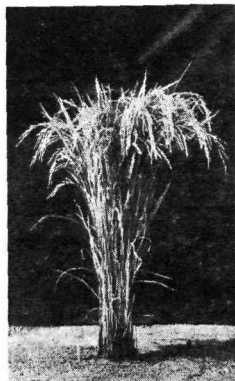
(Average yield kg/ha)

	High level of manuring	Low level of manuring
1969-70 Early Samba		
Navlock	4180	3230
Keeja Gudalur	5000	3833
Danishpet	4500	4000
Mettur	6333	5500
Melagaram	6500	6833
Kancheepuram	6833	4156
Athiyandal	9400	8736
Vandarsanpet	4076	3396
Siru Kaveripakkam	4750	3833

c) *Release of the Varieties:* During the annual workshop meeting of the All India Coordinated Rice Improvement Project held at Cuttack in May, 1970 these two selections IET. 400 and IET. 355 were recommended for release as improved strains and proposals for their release were approved by the Central Variety Release Committee at its meeting held in New Delhi on 15th September, 1970. Subsequently on 24th November 1970 the Tamil Nadu State Seed Committee released IET. 400 in the name of Kanchi (CO. 34) and IET. 355 in the name of Cauvery (CO. 35) (Plate 1 and 2).



Kanchi (CO. 34)



Cauvery (CO. 35)

The morphological and Physiological description of the varieties are given in Appendix I. The Package of practices for both the varieties are furnished in Appendix II.

APPENDIX - I

	Kanchi (CO.34)	Cauvery (CO.35)
Habit	Erect	Erect
Plant Height	85 cm to 90 cm	85 cm to 90 cm
Maturity	110 to 115 days	100 to 108 days
Tillering	10 - 12	10 - 12
Anthocyanin Pigment	Present	Absent
Leaf sheath	Light purple lines at the base	Green
Axil	Very light purple	Green
Internode	Green	Green
Juncture	Colourless	Colourless
Auricle	Colourless	Colourless
Ligule	White	White
Pulvinus	Green	Green
Septum	Green	Green
Leaf blade	Green	Green
Flag leaf	Medium and Acute	Medium and Acute
Lemma and Palca	Green when immature, developing into straw with occasional dirty colour when ripe	Green when immature, developing into straw when ripe
Apiculus	Light purple	Green
Awns	Absent	Absent
Panicle	Long and compact	Long and compact
Kernel (Rice)	White, translucent non-glutinous	White, translucent non-glutinous
Scent	Absent	Absent
Abdominal white	Absent	Absent
1000 - grain wt	21.3	22.3
Grain size (mm)		
i) Length	8.34	8.38
ii) Breadth	2.94	2.93
iii) L/B ratio	2.28	2.32
Commercial grade of grain	Medium fine	Medium fine
Hulling percentage	77	80
Milling percentage	62.4	61.4
Head rice recovery (% of milled rice)	70	69
Cooking quality	Very good	Very good
Photosensitivity	Insensitive	Insensitive
Lodging resistance	High	Moderate
Fertilizer responsiveness	High	High
Shattering resistance	Medium	Medium
Protein percentage	9.3	8.9
Adaptability	Wide range of adaptability; can be grown wherever CO 29 is grown	Wide range of adaptability best suited to fit in the multiple cropping pattern

APPENDIX II

Important package of practices over and above the usual cultivation practices to be adopted for the varieties

1. Seed rate: 45 kg/ha to be sown at the rate of 1.5 kg per cent.
2. Treat the seed with organo-mercuric compound at 2 gm per kg of seed.
3. Raise 30 cents of nursery for planting one hectare.
4. Transplant 20-22 days old seedlings.
5. Plant two seedlings per hole.
6. Spacing of 20 cm×10 cm may be adopted.
7. Manuring and fertilization: apply 12.5 tonnes of Farm-Yard Manure or compost or 5.7 tonnes of green manure per ha. Fertilizer schedule (kg/ha).

	N	P	K
Basal - 1 At last ploughing	60	60	60
Top dressing:			
25 days after transplanting	60	—	—
Total kg/ha	120	60	60

8. After cultivation: One or two weedings as found necessary.
9. Plant protection (a) spray 0.05% parathion or 0.04% Endrin a week before pulling out the seedlings (b) Spray the transplanted crop once in 15 days till boot leaf stage with parathion or Endrin and with copper fungicide at 1.5 kg per hectare. (c) If other insect pests like jassids, leaf eating caterpillars are found in the main field, dust BHC 10% and DDT. 5% in equal quantity. (d) Dust BHC 10% against earhead bug and fulgorid bug at milk stage of the crop.

Conclusion: The new early strains Kanchi (CO. 34) and Cauvery CO. 35) are examples of successful incorporation of the improved plant type into the local promising varieties. "Kanchi" [T (N) 1×CO. 29] possesses high yield potential, fertilizer responsiveness non-lodging character, good quality grain, wide adaptability and is intended to replace CO. 29 wherever the latter is grown. Cauvery [T (N) 1×TKM. 6] also possesses the above traits with earliness and finer grains. It is intended to replace TKM. 6 and can be grown whenever the latter is raised. Because of its earliness it can fit in well in the multiple cropping pattern of the different areas brought under irrigation.

Acknowledgements: The authors' thanks are due to the All India Co-ordinated Rice Improvement Project under whose auspices testing of these varieties were undertaken in different centres in India and to many other rice workers who have helped in testing these varieties in the research stations as well as in the district trials.

Strain TKM.6 — A Potential Tall *Indica* Donor Parent for Crop Improvement in Rice

Among the early maturing tall *indica* strains under spread in Tamil Nadu, TKM 6 ranks first because of its high yield potential, earliness, fine quality of rice, non-sensitivity to photoperiod and wider adaptability to suit varied environmental conditions. Recognition of this strain as a potentially good parent in the breeding programmes on varietal improvement in rice all over the world has led to the development of a few outstanding dwarf statured strains of high yield potential which have just started spreading in many rice growing countries of the tropics. Strain IR 20, developed at the International Rice Research Institute, Philippines is a derivative of a cross between IR 262 $\times$ TKM 6. Variety Ratna and three more pre-release varieties, CR 44-1 and CR 44-35 evolved at Central Rice Research Institute, Cuttack, and Pusa 2-21 developed at Indian Agricultural Research Institute, New Delhi are all derived from the crosses made between IR 8 and TKM 6. The variety Cauvery which was released by the Central Varietal Release Committee in 1970, was evolved at Paddy Breeding Station, Coimbatore from the crosses effected at the Station in 1965 between T(N) 1 and TKM 6. It is also interesting to observe that eight out of 15 varieties currently under test in the multilocal uniform variety trials under the All India Coordinated Rice Improvement Project are all derivatives involving TKM 6 as one of the parents. Strain TKM 6 has thus proved to be a highly promising source of parent material among tall *indicas* for the development of superior strains when combined with the dwarf *indicas* like T(N) 1, IR 8 and IR 262. The object of this note is to discuss the merits and defects of strain TKM 6 and the extent of improvement brought about by crossing it with dwarf *indicas*.

Strain TKM 6 has many desirable traits such as earliness, high yielding ability at lower levels of fertilizer, insensitivity to photoperiod, wider adaptability, long slender grains, good cooking quality and a fair degree of resistance to stem borer, green leaf hoppers and bacterial blight. Several thousands of crosses have been effected between TKM 6 and a number of other important varieties at the International Rice Research Institute, Philippines and at the major rice research stations in the Indian Union for evolving strains resistant to stem borers. TKM 6 had combined well with dwarf *indicas* and the derivatives of such crosses, besides possessing the desirable traits of TKM 6 combine in them, the improved plant type, resistance to lodging and the N responsive traits acquired from the dwarf statured parents. The characteristic features of the best six among the Dwarf *Indica* $\times$ TKM 6 derivatives as compared to IR 8 and TKM 6 are furnished in Table 1.

TABLE 1. *Characteristic features of the promisi*

1. Name	IR 8	TKM 6	IR 20
2. Institution responsible for the development of the variety	IRRI, Philippines	Rice Research Stn., Tirurkuppam, Tamil Nadu, India	IRRI, Philip
3. Parentage	Peta×Dee-gee-woo-gen	GEB 24×CO 18	IR 26
4. Duration seed to seed	130-135	115-120	125-130
5. Yield in Tamil Nadu (Tonnes/ha)	5 to 8	3 to 5	5 to 8
6. Height (cm)	90-95	130-135	85-90
7. Sensitivity to photoperiod	Non-sensitive	Non-sensitive	Weak
8. Kernel size (mm)	6.42×2.55	7.3×1.4	5.76×2.5
9. 1000 grain weight (g)	27.28	17.30	19.9
10. Commercial grade	Long bold	Long slender	Medium
11. Presence or absence of abdominal white	Present	Absent	Absent
12. Cooking quality	Average	Very good	Very good
13. Dormancy	Weakly dormant	Dormant	Dormant
14. Resistance to stemborer	Susceptible	Resistant	Moderately
15. Resistance to blast	Moderately resistant	Moderately resistant	Moderately
16. Resistance to bacterial blight	Susceptible	Resistant	Moderately resistant
17. Economic attributes as compared to IR 8 and TKM 6	a) High yield	Lower in yield than IR 8	Almost yield to superior TKM 6 in matu
	b) Resistant to lodging	Susceptible to lodging	Higher of resist lodging
	c) Sensitive to cold weather	Tolerant to cold weather	Tolerant weather
	d) Susceptible to stem-borer	Resistant to stem borer	Higher of resistant borer th less resi TKM 6
	e) Susceptible to bacterial blight	Relatively resistant to bacterial blight	Resistant
	Quality of rice-average	Quality of rice-superior to IR 8	Quality almost a TKM 6

IR 8 × TKM 6 crosses as compared to IR 8 and TKM 6

	Pusa 2-21 IARI, New Delhi, India	Ratna CRRI, Cuttack, India	CR 44-1 CRRI, Cuttack, India	CR 44-35 CRRI, Cuttack, India
46	IR 8 × TKM 6	IR 8 × TKM 6	IR 8 × TKM 6	IR 8 × TKM 6
	105-110	125-130	115-120	120-125
	4 to 7	4 to 6	4 to 6	4 to 6
	80-85	80-85	80-85	80-85
	Non-sensitive	Non-sensitive	Non-sensitive	Non-sensitive
	5.56 × 2.50	6.84 × 1.97	5.58 × 1.65	6.51 × 1.87
	22.2	21.5	20.9	22.2
	Short bold	Long slender	Short slender	Long slender
	Present	Absent	Absent	Absent
	Very good	Average	Very good	Good
	Dormant	Dormant	Dormant	Dormant
Resistant	Moderately resistant	Resistant	Resistant	Moderately resistant
	Moderately resistant	Susceptible	Susceptible	Susceptible
	Moderately susceptible	Moderately susceptible	Moderately susceptible	Moderately susceptible
in yield id to IR 8	Yield higher than TKM 6 and nearly equal to IR 8.	Higher in yield than TKM 6 and lower than IR 8	Higher in yield than TKM 6 and lower than IR 8; Same duration as TKM 6	Higher in yield than TKM 6, but lower than IR 8
Both IR 8	Earlier in maturity to IR 8 and TKM 6			
Resistance of lodging	Resistant to lodging	Resistant to lodging	Resistant to lodging	Resistant to lodging
cold	Resistant to cold weather	Not studied	Not studied	Not studied
Resistance of stem borer but less than	Higher degree of resistance to stem borer than IR 8	More resistant to stem borer than IR 8	Resistant to stem borer	Slightly less resistant to stem borer than TKM 6
Resistant to TKM 6 susceptible	Moderately susceptible	Moderately susceptible	Moderately susceptible	Moderately susceptible
Quality of rice - far superior to IR 8 but inferior to TKM 6	Quality of rice - superior to IR 8	Quality of rice - far superior to IR 8 and almost equal to TKM 6	Quality of rice - far superior to IR 8	Quality of rice - far superior to IR 8 and almost equal to TKM 6

Even though the parents involved in the crosses are of more than 115 days duration, two of the derivatives, Cauvery and Pusa 2-21 were distinctly earlier even to the short duration parent TKM 6. The yield potential of the two varieties is higher than TKM 6 by 50 to 75% and both of them have also higher degree of resistance to lodging than strain TKM 6. In per day production, the two strains compare favourably with that of IR 8. Varieties, Ratna, CR 44-1 and CR 44-35 yield much higher than TKM 6 and they excel IR 8 in possessing higher degree of resistance to stem borer all of them being superior to IR 8 in having good quality of rice, which makes up their slightly lower yield potential as compared to IR 8. In the mid duration group, IR 20 has proved to be the best, combining in it the desirable traits of both TKM 6 and IR 8. Due to its higher degree of resistance to pests and diseases and superior quality of rice, strain IR 20 is fast replacing IR 8 in Tamil Nadu. Pusa 2-21 among the early maturing strains and IR 20 among the mid duration strains are being utilised for bringing about greater stability in yield and higher degree of resistance to pest and diseases in the existing strains. As Pusa 2-21 is tolerant to cold weather, it is also being utilised as a parent for incorporating this trait in the varietal improvement programme for releasing improved strains best suited for 'Kharif' season.

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Genetic Expression of Yield to Environmental Variations in Rice Varieties

BY

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ABSTRACT

The tall *Indica* varieties of rice showed negative response to high dose of fertilizer application, but the yield differences between tall and dwarf varieties were not as conspicuous at low fertility level as at high level. Variety 'Kanchi' exhibited its stability in yield even under low levels of manuring. Though the performance of most of the improved varieties was found to be better in *rabi* season than in *Kharif* some of the varieties like Pankaj, Hansa, Cauvery and Padma did better in *Kharif* season than in *rabi* under Coimbatore conditions. Attempt to bring out the yielding ability of the new varieties developed from T (N) 1 and IR. 8, indicates that variety IR. 8, may be more profitably utilised in the hybridisation programme than T (N) 1.

INTRODUCTION

Using Taichung (Native) 1 and IR. 8 as donor parents, hybridisation programme was initiated in a number of centres with a view to incorporating the dwarfing gene along with high degree of concentration of yield genes in many of the local varieties. Most of the promising cultures thus developed tested in multi-locations in India resulting in quick release of many high yielding varieties within a short time. The most important among these, along with the promising cultures recognised fit for pre-release multiplication and varieties from Taiwan, the International Rice Research Institute, Philippines, Central Rice Research Institute, Cuttack and tall *indicas* popularly grown in Tamil Nadu were tested at Coimbatore and the yield data obtained were utilised to assess the degree of genetic expression

of yield potential to environmental variations in respect of season and fertilization. An attempt has also been made to evaluate the relative capacity of IR 8 and T(N) 1 as donor parents to transmit the yield characters along with the dwarfing trait in the progenies.

MATERIALS AND METHODS

Yield trials on rice were conducted at Paddy Breeding Station, Tamil Nadu Agricultural University, Coimbatore from 1966 onwards in both *rabi* and *kharif* seasons. The newly released varieties and promising cultures under pre-release multiplication were tested against local varieties in a split plot design with two fertilizer levels. The fertilizer levels (1) 80 N, 40 P₂O₅, 40 K₂O kg per ha and (2) 160 N, 80 P₂O₅, 80 K₂O kg per ha were in the main plot, while the varieties were in the sub-plot replicated four times. Data on

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TABLE 1. Influence of fertilizer levels and seasons on yield

Variety	Grain yield in kg/ha		Grain yield in kg/ha	
	Low level	High level	Rabi	Kharif
Dwarf indicas				
Dee geo-Woo-gen	4201	4983	4433	4731
IR. 20	6434	7009	7763	5678
Kannaki	5322	7118	7630	5311
LET. 849	5736	6608	7112	5132
CR. 44-35	5599	6404	7444	4848
Mamasa	3897	5377	3284	4989
Cauvery	3758	5212	3962	5508
Tainan. 3	3655	4722	4345	4032
Jaya	4498	5777	5533	4742
T (N). 1	4073	5215	4695	4593
Karuna	3508	4359	4903	3464
Kanchi	5196	5335	5757	5074
IR. 8	4950	5411	5257	4744
Padma	3843	4576	3848	4571
Krishna	4675	5116	5336	4455
Bala	3250	3792	3335	3707
CR-44-1	5031	5872	6012	4891
CR-44-1T	4740	5454	5509	4685
Sona	4444	5213	5357	4300
CR-10-114	4346	4831	5706	3471
Ratna	4740	5454	5509	4685
I.R. 22	4035	4826	4638	4223
Vijaya	4632	5309	4953	4989
Pankaj	3982	4618	3310	5290
Jaganath	3352	3828	3328	3851
Tall indicas				
Co. 25	3639	3418	3643	3409
Co. 32	4913	4663	4538	4941
Cult. 2410	3267	2964		
Mean			4069	5604

Low : 80 N, 40 P, 40 K kg/ha.

High : 160 N, 80 P, 80 K kg/ha.

TABLE 2. Grain yield [kg/ha] of the varieties developed from T [N] 1 and IR.8

T [N] 1 derivatives			IR. 8. derivatives		
Variety T [N] 1	Parentage	Grain yield [kg/ha] 4944	Variety IR. 8	Parentage	Grain yield [kg/ha] 6000
	Tsai-yuan-shung X Dee-geo-Woc-gen			Peta X Dee-geo- Wood-gin	
Cauvery	T [N] 1 X TKM 6	4485	Kannaki	IR. 8 X TKM 6	6470
Padma	T 141 X T [N] 1	4210	CR.44-35	TKM 6 X IR. 8	6002
Jaya	T [N] 1 X T. 141	5138	Karuna	IR. 8 X ADT 27	3934
Krishna	GEB.24 X T [N] 1	4896	C.R.44.1	IR. 8 X TKM.6	5452
Kanchi	T [N] 1 X Co.29	5416	CR.44-11	IR.8 X TKM.6	5097
Hamsa	H.R.12 X T [N] 1	4612	C.R.10-114	T.90 X IR.8	4588
Bala	N 22 X T [N] 1	3521	Ratna	IR.8 X TKM.6	5097
ET.849	T [N] 1 X Co.29	6122	IR.22	IR 8 X Tadukan	4431
Sona	GEB.24 X T [N] 1	4828	Vijaya	IR.8 X T.90	4972
Mean		4803			5116

grain yield collected from the various experiments in different seasons were subjected to statistical scrutiny.

RESULTS AND DISCUSSION

The degree of variation in the expression of yield among the varieties under two levels of fertilization and in two seasons as well as the capacity of T(N)1 and IR. 8 to transmit the yield traits in the progenies were studied. There was significant differences in all cases.

Response to fertilizer :

The dwarf varieties have exhibited positive response to high fertilization

as compared to the tall *indica* varieties although there is varietal difference in the degree of response (Table 1). However, at lower level of fertilization, the yield differences between the tall and dwarf varieties are not as conspicuous as in the case of higher level. The yielding ability of the varieties IR.20, kannaki, IET. 849 and CR. 44-35 is found to be good under both low and high levels of fertilization. Response to higher dose of fertilizer is more in the varieties Hamsa and Cauvery followed by Tainan-3, Jaya, T(N)1 and Karuna. The fluctuation of yield between high and low level of

fertilization is the least in Kanchi with marginal increase of only 8.3 per cent. Tall *indica* varieties Co. 29, Co. 32 and Cult. 2410 have shown negative response to higher fertilization with decreased yield.

Seasonal effect on yield : From the grain yield (Table 1), it is seen that the average increase in yield in *rabi* is 538 kg per ha and 10 per cent over *kharif*, although some varieties like CR. 10-114 have recorded as high as 2235 kg per ha and 65 per cent increased yield in *rabi* over *kharif*. The genetic expression of yield potential of the varieties like CR. 10-114, CR. 44-35 Kannagi, Karuna. IET. 849, Ratna and IR. 20 is very high in *rabi* as they have recorded increase between 37 to 65 per cent, whereas the varieties Pankaj, Hamsa, Cauvery, Padma and Jaganath show higher yielding ability in *kharif* than in *rabi* with increases upto 37 per cent. The seasonal effect on yield in some varieties like Vijaya and T(N)1 is quite negligible and these can be expected to be adaptable to wide range of climatic conditions. Availability of such varieties make it possible to raise satisfactory crops at any time of the year with economic benefits.

In order to bring out the differences if any, in the yielding ability of the new varieties developed from T(N) 1 and IR.8 the grain yield data of these varieties are tabulated and presented in Table 2. It is evident that the yield potential of varieties developed from IR. 8 is much better than those developed from T(N)1, as they have recorded an average increased yield of 313 kg per ha over the varieties developed from T(N)1. This shows that the dwarfing gene in IR.8 background is probably superior to the one in T(N)1 background in its capacity to transmit the yield traits together with dwarfing gene to the progenies. Therefore the variety IR 8 appears to be a better donor in the hybridisation programme than T(N)1.

ACKNOWLEDGEMENT

Thanks are due to the Indian Council of Agricultural Research under whose auspices testing of varieties was taken up under the All India Co-ordinated Rice Improvement Project at the Paddy Breeding Station, Coimbatore.

Studies on Crosses Between Dwarf and Tall *indica* Rice Varieties

By

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ABSTRACT

Expression of heterosis in F_1 generation and pattern of segregation and association of characters in F_2 population in respect of crosses involving varieties IR. 8 and T (N). 1 possessing the new plant type and other popular tall varieties ADT. 27, Co. 29, TKM. 6, Co. 32 and ASD. 1 and the relationship of ear length, spikelet number and length of internode in the three promising dwarf varieties Karuna (IR. 8 x ADT. 27), Kanchi (T (N). 1 x Co. 29) and Cauvery (T (N). 1 x TKM. 6) have been studied.

Heterosis was observed in the characters height, ear number, spikelet sterility, grain yield and straw yield. More than one gene appeared to be involved in the inheritance of the characters habit, foliage colour, height, husk colour, apiculus pigmentation and kernel colour. Panicle length was more correlated with spikelet number in the tall F_2 population than in the dwarf progenies. In the dwarf segregants panicle length showed higher correlation with grain yield than spikelet number while spikelet number was highly correlated with grain yield in the tall population. Ear number had very high correlation with grain yield and the degree of association was more in the case of tall progenies than in the dwarf population. Again in the dwarf segregants the correlation between ear number and plant height was feeble. In the case of dwarf varieties Karuna, Kanchi and Cauvery ear length was highly correlated with spikelet number as well as the length of three basal internodes.

INTRODUCTION

Since the introduction of dwarf *indica* rice varieties, Taichung (Native) 1 from Taiwan in 1965 and IR. 8 from the International Rice Research Institute, the Philippines in 1966-67, these two varieties possessing a new plant type have been utilised extensively in the rice breeding programme of our country. In Tamil Nadu, Taichung (Native) 1 was grown for the first time during rabi 1965 (January-May) season at the Paddy Breeding Station, Coimbatore from a small seed sample brought from the Central Rice Research Institute, Cuttack. During the same year this variety was crossed with some of the more popular rice strains of Tamil Nadu with the objective to evolve

short, stiff straw rice varieties possessing resistance to lodging, response to high fertility combined with acceptable grain characteristics and maturity to fit into the cropping season. Again during 1966 and 1967, IR. 8 was crossed with some more rice strains of Tamil Nadu with similar objective. While evaluating the breeding material, the progenies and parent varieties were critically studied for morphological characters and yield components and some of the observations made during these studies are presented in this paper.

MATERIAL AND METHODS

The F_1 s of crosses T (N). 1 x Co. 29, T (N). 1 x TKM. 6 and T (N). 1 x ASD. 1 were grown and studied during 1965

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Fig. 1.

Spikelet sterility in F_1 of IR. 8 $\times$ Co. 32

1960; Butany *et al.* 1961 and Sampath, 1964). According to Jennings (1966) heterotic sterility in *indica x japonica* rice hybrids had been one of the unfavourable hurdles in breeding successful homozygous derivatives in the tropics. However, in the present studies involving varieties with different plant types, fully fertile segregants have been bred out by rigorous selection from all the crosses. In spite of the high degree of sterility (41.2%) in IR. 8 $\times$ ADT. 27, F_1 grain yield increase was observed reflecting the high contribution towards yield by the parents involved. Ear length of F_1 s was not much different from the parental values. Compact panicle appeared to be dominant over open type in all the $T(N).1$ crosses. Grain shattering and ear exertion in F_2 s were found to be mostly intermediate between the parental values. The length of four basal internodes in F_1 plants was

also mostly intermediate between the parents except in the case of the cross IR.8 $\times$ ADT.27. Thickness of the three basal culms was more in the F_1 s of the crosses IR.8 $\times$ ADT. 27 and $T(N).1 \times$ ASD.1 than the respective parents. F_2 s of crosses IR.8 $\times$ ADT.27 and $T(N).1 \times$ TKM.6 recorded higher spikelet number than both the parents while it was intermediate in the case of the other crosses. Heterosis was positively expressed in straw yield in all hybrids except in the cross $T(N).1 \times$ CO.29.

b. F_2 Segregation:

The F_2 population of the cross, $T(N).1 \times$ ASD.1 was studied phenotypically for certain traits and the ratios fitted up are furnished in Table 2.

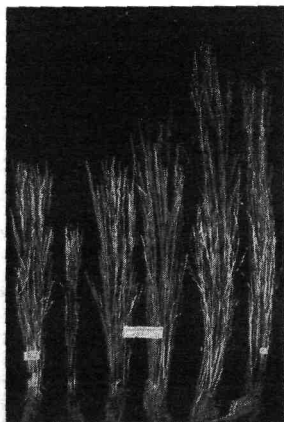


Fig. 2.

F_2 segregants with height variation and parent varieties

The characters, habit i.e. spreading vs erect and husk colour i.e. brown vs

TABLE . Segregation for different characters with phenotypic frequencies and probable ratios

	Characters	Frequency	Ratio	'Chi' square	Probability
Habit	Erect	442	9:7	0.6186	$P = 20-50$
	Spreading	662			
Height	Short	307	45:19	1.94	$P = 10-20$
	Tall	793			
Foliage colour	Light green	327	45:19	0.408	$P = 60-95$
	Dark green	676			
Apiculus pigmentation	Absent	344	45:19	1.215	$P = 20-50$
	Present	768			
Kernel colour	White	367	45:19	5.724	$P = 10-20$
	Red	724			
Husk colour	Straw	484	9:7	0.3557	$P = 60-95$
	Brown	600			

straw seemed to be controlled by two genes showing a segregation of 9:7. All other characters, height i.e. tall vs short (Fig.2), foliage colour i.e. dark green vs light green, apiculus pigmentation i.e. present vs absent and kernel colour i.e. red vs white gave phenotypic frequencies tending to a segregation of 45:19 indicating that these characters are also controlled by more than one gene. Therefore, it appeared that some of the desirable characters associated with the high yielding plant types like habit, foliage colour and height are controlled by more than one gene in the crosses. The coloured apiculus was generally known to be simple dominant to colourless apiculus while dwarfness was controlled by single recessive gene (Jennings, 1966). Red kernel was controlled by two complementary genes (Nagao, 1951). The modified F_2 segregation ratios obtained in the present studies may be as a result of hybrid sterility as has been already reported (Te-Tzu, 1964).

c. Correlation studies in F_2 population:

The total and *inter se* correlation coefficients between different char-

acters and yield in respect of the dwarf (below 100 cm in height) and tall (above 100 cm in height) F_2 segregants of the cross T(N). $1 \times \text{ASD}$. 1 are furnished in Table 3.

Significant correlations have been obtained between the characters and yield as well as among the characters themselves although the degree of association varied. Correlation between height and ear length was high both in the tall and dwarf populations but the correlation between height and grain yield was low in the dwarf population. Correlation between panicle length and spikelet number has been higher in the taller group. Again in the dwarf F_2 population, panicle length showed higher correlation with grain yield than spikelet number while spikelet number was highly correlated with grain yield in the tall population with feeble correlation in the case of dwarf population. Hence it is seen that the recombination of ear length and spikelet number has not been achieved to the desirable extent in the progenies and back crossing may have to be resorted to get these characters together in the dwarf plant type. Ear number had very high correlation with

TABLE 3. Total Correlation coefficients between different characters in F₂ population of T(N). 1 x ASD. 1

	Plant height (X ₁)	Panicle length (X ₂)	Spikelet number (X ₃)	Ear number (X ₄)	Straw weight per plant (X ₅)
1) Dwarf segregants (below 100 cm in height)					
Grain weight per plant (Y)	0.25*	0.58**	0.39**	0.75**	0.50**
Plant height (X ₁)		0.75**	0.50**	0.36**	0.51**
Panicle length (X ₂)			0.47**	0.57**	0.60**
Spikelet number (X ₃)				0.44**	0.20**
Ear number (X ₄)					0.60**
2) Tall segregants (above 100 cm height)					
Grain weight per plant (Y)	0.60**	0.60**	0.63**	0.87**	0.66**
Plant height (X ₁)		0.97**	0.50**	0.57**	0.58**
Panicle length (X ₂)			0.77**	0.57**	0.45**
Spikelet number (X ₃)				0.44**	0.76**
Ear number (X ₄)					0.73**

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

TABLE 4. Total and *inter se* correlation coefficients between characters in the varieties Karuna, Kanchi and Cauvery.

		Ear length X ₁	Length of internode from base to top			
			X ₂	X ₃	P ₄	X ₅
KARUNA (CO. 33)						
Spikelet Number (Y)		0.55**	0.46**	0.21	0.24	0.27
Ear length	X ₁		0.43*	0.89**	0.77**	0.20
	X ₂			0.40*	0.53**	0.46**
Internode Length	X ₃				0.60**	0.00**
numbered from base to top	X ₄					0.54**
KANCHI (CO. 34)						
Spikelet Number (Y)		0.62**	0.26	0.54**	0.10	0.20
Ear length	X ₁		0.47**	0.48**	0.68**	0.26
	X ₂			0.62**	0.56**	0.50
Internode length	X ₃				0.82**	0.28
	X ₄					0.67**
CAUVERY (CO. 35)						
Spikelet Number (Y)		0.50**	0.05	0.08	0.43*	0.46**
Ear length	X ₁		0.40*	0.36*	0.41*	0.40*
	X ₂			0.40*	0.18	0.32
Internode length	X ₃				0.83**	0.69**
	X ₄					0.17

grain yield and the degree of association was higher in the tall segregants than in the dwarf population. Again ear number was closely associated with all characters in both groups except with plant height in the case of dwarf population where the correlation was feeble.

d. Correlation between ear length, spikelet number and internode length in the three varieties developed:

The correlation coefficients worked out between ear length, spikelet number and length of five basal internodes in the three promising dwarf varieties released as a result of study of the above crosses viz., *Karuna* (IR8 x ADT, 27), *Kanchi* T(N).1 x Co. 29) and *Cauvery* (T(N).1 x TKM. 6) are given in Table 4. It is seen that spikelet number is significantly and positively correlated with ear length in all the three dwarf varieties *Karuna*, *Kanchi* and *Cauvery*. Ear length was also correlated with the length of three basal (X_2 , X_3 and X_4) internodes in the varieties while spikelet number did not have any consistent association with the length of the basal internodes. Selecting dwarf progenies of about 100 cm, where height is one of the major contributing factors for lodging resistance and high nitrogen response, is important in the breeding of high yielding new varieties. Besides, recombination of ear length and good grain number per ear is important for selecting progenies with lesser 1000 grain weight (18 to 20 gm) as compared to 28 gm in IR. 8 in the improvement of grain size and high grain yield. An attempt has been made

to find out whether short plant height might be a barrier for not obtaining good ear length and grain number since dwarfing is due to shortened internodes. Correlation coefficients between spikelet number, ear number and length of five basal internodes determined in the studies showed that ear length had high positive correlation with length of three basal internodes in all the three short high yielding varieties *Karuna*, *Kanchi* and *Cauvery* possessing good grain quality developed from the above crosses. In addition, spikelet number also showed high positive correlation with ear length in all these three dwarf varieties.

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Correlation of Yield Components and Other Metric Traits with Yield in Tall and Dwarf indica Rice

By

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ABSTRACT

Correlation studies with 20 rice varieties of tall and dwarf *indicas* indicated that number of panicles and straw weight per clump were highly associated with yield followed by grain weight and grain number. Panicle length, grain length and breadth, plant height, leaf area and length of three basal internodes were found to be associated with yield only in a few varieties. Number of chaff per panicle is not correlated with yield while weight of chaff is associated with yield in nine out of twenty varieties.

INTRODUCTION

In rice, the association of different plant attributes with yield have been reported by many workers. (Narasinga Rao, 1937; Ramiah, 1953; Eikiche, 1954; Syed and Krishnamoorthy, 1956 and Chandra Mohan, 1964, 1968). All these reports relate to the tall *indicas* which have become mostly obsolete. A few investigators (Rajagopalan *et al.* 1973 and Mishra *et al.* 1973) however have reported in dwarf varieties and segregants, positive correlation of panicle length, grain number, ear number, grain weight and straw weight with yield. Hence the present study was undertaken in dwarf *indicas* of recent origin along with tall *indicas* to find out the correlation of yield components and other metric traits with yield.

MATERIALS AND METHODS

Twenty varieties of tall and dwarf

indicas of different origin possessing a wide range of variability in respect of the characters chosen for study were selected. Varieties M9, M10 and M40 were dwarf artificial mutants from Co 29, a popular tall *indica* variety in Tamil Nadu. The trial was laid out in a randomised block design replicated four times and the varieties were planted in 20 x 10 cm spacing in lines and fertilized with 120 kg N + 60 kg P₂O₅ + 60 kg K₂O/ha. Ten plants from each plot were selected at random and studied. Simple correlation coefficients were calculated and the significance was tested by means of Fisher's 't' test.

RESULTS AND DISCUSSION

Among the tall *indicas* Co 13 and TKM6 recorded the highest grain and straw yield per plant. In PTB 10 the grain weight per plant was on par with Co 13 but the straw weight was less.

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Panicle number, grain number and grain weight were higher in TKM6, *Jeeraga-samba* and *Blue Bonnet*. (Table 1) Number of chaff per panicle and weight of chaff

in TKM6 and T 909 and weight of chaff in Co 13 were higher. Breadth of grain in PTB 10 and T 909 and length of grain in *Blue Bonnet* were higher.

TABLE 1. Mean data on yield and yield components and other metric traits of some Tall and Dwarf indica rice varieties

Varieties	Grain Yield plant (g)	Yield components					
		No. of panicle clump	Grain No./ panicle	1000 grains wt (g)	Panicle length (cm)	Chaff/No/ panicle	Chaff wt/ panicle (g)
	Y	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆
TKM. 6	20.0	16.2	79	18.7	22.2	33	1.60
Co. 13	23.9	14.4	78	22.0	19.6	21	1.30
Cul. 2410	15.3	8.9	109	18.9	23.3	15	0.34
SLO. 16	14.5	11.9	88	15.4	19.8	17	0.56
ADT. 16	5.7	9.6	47	14.8	16.2	24	0.57
T. 909	11.9	6.9	89	20.3	19.9	31	1.30
Rascadem	19.5	14.1	155	11.1	21.2	26	0.30
Jeeragasmba	13.3	6.8	182	10.8	24.4	26	0.30
Basumathi	17.1	11.0	79	20.6	21.6	11	0.37
Blackputtu	18.0	6.9	113	23.4	23.7	16	0.59
PTB. 10	23.9	13.0	78	24.8	20.3	14	0.78
Blue Dawn	9.4	3.2	143	22.5	21.7	18	0.24
Blue Bonnet	11.1	11.1	160	25.3	24.2	29	0.44
DGWW	12.4	5.0	86	27.0	21.3	11	0.23
TR. 1	14.5	5.8	75	24.8	19.2	11	0.38
IR. 8	17.4	7.1	86	30.3	20.0	17	0.78
Annappurna	20.3	23.5	66	24.4	20.3	18	1.15
M. 9	9.9	14.0	51	13.0	12.5	22	0.64
M. 10	11.7	48.8	12	18.6	7.9	5	0.50
M. 40	13.5	15.8	37	23.3	12.2	13	0.66

Table 1. (continued).

Varieties	Other metric traits					
	Grain length (mm)	Grain Breadth (mm)	Plant height (cm)	Inter- node length (cm)	Leaf area (sq. cm)	Straw Wt/ci clump (g)
	X ₇	X ₈	Y ₉	X ₁₀	X ₁₁	X ₁₂
1	8.51	2.52	135	14.8	45.7	51.4
2	8.76	2.88	130	19.8	60.3	46.4
3	8.03	2.61	121	16.4	46.1	12.4
4	8.76	2.23	118	16.5	55.5	14.6
5	8.10	2.49	101	16.4	31.5	14.1
6	8.61	3.08	148	19.6	48.6	28.0
7	5.93	2.55	123	16.1	69.2	35.8
8	5.97	2.34	134	21.3	63.6	11.2
9	9.94	2.46	154	28.8	46.4	16.7
10	9.19	2.94	140	20.4	76.9	19.6
11	8.91	3.15	113	23.6	47.1	25.3
10	9.39	2.57	100	12.1	50.4	5.2
11	10.44	2.61	107	19.4	62.0	9.4
12	8.32	3.34	97	13.6	73.0	13.4
13	7.36	3.22	80	8.7	48.4	10.0
14	9.43	3.20	83	7.3	56.9	13.7
15	8.37	3.13	79	13.4	41.3	18.4
16	6.25	2.90	65	19.0	49.7	16.2
17	8.23	2.74	57	16.4	14.5	11.0
18	8.72	3.16	56	11.0	29.5	15.0

1. TKM. 6, 2. Co. 13, 3. Cul. 2410, 4. SLO. 16, 5. ADT. 16, 6. T. 909, 7. Rascadam
8. Jeeragasamba, 9. Basumathi, 10. Blackputu, 11. PTB. 10, 12. Blue Dawn, 13. Blue
Bonnet, 14. DGWG, 15. TN. 1, 16. IR. 8, 17. Annapoorna, 18. M. 9, 19. M. 10, 20.
M. 40.

Sept.-Dec. 1973]

CORRELATION OF YIELD COMPONENTS

Simple correlation coefficient values of yield components and other metric traits with yield (Y)

Varieties	Yield components				Other metric traits	
	No. panicles clump X_1	Grain No./ panicle X_2	1000 grains Wt. X_3	Panicle Length X_4	Chaff No. per panicle X_5	Chaff Wt. per panicle X_6
1	0.7588 *	- 0.6916	0.6094 *	0.3538	0.2176	0.7849 **
2	0.8152 *	0.3799	0.0691	0.5843	- 0.0131	0.0879
3	0.9440 **	- 0.1495	0.8174 **	0.6554 *	- 0.0374	0.5299 *
4	0.6626 *	- 0.0025	- 0.1916	0.1371	- 0.1897	0.0033
5	0.6870 *	0.7051*	0.6989 *	- 0.5380	- 0.5924	0.6220 *
6	0.3738	0.6365*	0.1764	0.5976 *	- 0.3278	0.0321
7	- 0.1442	- 0.1030	- 0.0134	- 0.3060	0.0843	0.7795 **
8	0.6604 *	0.4562	- 0.8273	0.0936	0.3206	- 0.4744
9	0.8003 **	0.2099	0.6704 *	0.4896	0.4322	0.7300
10	0.2385	0.4918	- 0.0230	- 0.3802	- 0.3396	0.4058
11	0.8472 **	0.1172	0.4413*	- 0.0906	0.0313	0.5369
12	0.4756*	0.3066	- 0.3224	0.0658	0.2355	0.4173
13	0.6757*	- 0.0920	0.5946	0.2834	0.0305	0.2942
14	0.5514*	0.8771**	0.3019	0.5269	- 0.3322	- 0.1768
15	0.7395*	0.3691	- 0.5732 *	0.1099	0.1468	0.3842
16	0.5190 *	0.3418	0.6162 *	0.5781	0.7181 *	0.8209 **
17	0.7855 **	0.4140	0.5519 *	0.2275	- 0.0387	0.6494 *
18	0.3137	0.7512 *	- 0.1384	0.5016	- 0.1506	- 0.0769
19	- 0.4015	0.2247	0.6062 *	0.2927	- 0.2509	- 0.1105
20	0.8250 **	0.4005	0.2315	0.1211	- 0.1945	0.6299 *

* Significant at 5% level;

** Significant at 1% level

1. TKM. 6	2. Co. 13	3. Cult. 2410	4. SLO. 16	5. ADT. 16	6. T. 909
7. Rascadam	8. Jeeragasamba	9. Besumathi	10. Blackputtu	11. PTB 10	
12. Blue Dawn	13. Blue Bonnet	14. DGWG	15. TN 1	16. IR. 8	17.
Annapoorna	18. M. 9	19. M. 10	20. M. 40		

TABLE 2. [Continued]

Varieties	Other metric traits					
	Grain length X_7	Grain breadth X_8	Plant height X_9	Internode length X_{10}	Leaf area X_{11}	Straw Wt. per clump X_{12}
1	0.0016	0.4673*	-0.1764	-0.2349	-0.3526	0.7137
2	0.1434	0.2931	-0.0694	-0.0644	-0.2812	0.2528
3	-0.1911	-0.2235	-0.4820	0.3501	0.1770	0.9031**
4	-0.0661	0.2337	-0.0918	0.0234	0.1196	0.5695*
5	...0.1948	...0.0354	0.6048*	0.4992*	0.5059*	0.7512*
6	0.5376*	0.1189	0.0416	0.0051	0.1567	0.0963
7	...0.0123	0.5381	0.0242	...0.4091	...0.1480	0.1279
8	...0.5762	...0.1937	0.0324	0.3004	0.2459	0.0655**
9	...0.3371	...0.5128	0.1767	...0.0917	0.7369	0.7910
10	0.1086	0.4253	0.2940	0.4181	0.3251	0.8493**
11	0.3016	0.1584	0.4806	...0.4011	0.5764	0.7727*
12	0.1564	0.5402	0.3339	0.0024	0.3840	0.4748*
13	0.2716	0.2896	0.0907	0.1656	0.2733	0.4390*
14	...0.0345	...0.2676	0.7585*	...0.9566**	0.7028*	0.7988**
15	...0.2290	0.0105	0.0292	0.1228	0.0100	0.2881
16	...0.5389	...0.4583	3.3265	0.1929	0.4370	0.4789*
17	0.6953*	...0.5890	0.5933	0.2536	0.3022	0.6687*
18	0.5286	0.4346	0.4570	0.0710	0.2863	0.3738
19	...0.1340	...0.2126	0.4246	...0.1539	...0.2121	0.4926*
20	...0.4919	...0.1221	0.2930	...0.4758	0.2288	0.7866**

* Significant at 5% level;

** Significant at 1% level

1. TKM. 6 2. Co. 13 3. Cult. 2410 4. SLO. 16 5. ADT. 16 6. T. 909
 7. Rascadam 8. Jeeragasamba 9. Basumethi 10. Blackputtu 11. PTB 10
 12. Blue Dawn 13. Blue Bonnet 14. DGWG 15. TN 1 16. IR. 8 17.
 Annappoorna 18. M. 9 19. M. 10 20. M. 40

Basumathi, T 909 and *Black puttu* were tallest among the varieties studied, where as the length of the three basal internodes was highest in *Basumathi* PTB 10. Leaf area was higher in *Black puttu*, *Rascadam* and *Jeeragasamba*. In the varieties with improved plant type the characters number of panicle per plant, chaff number per panicle, chaff and straw weight per plant and grain yield were higher in *annapurana*. In *Dee-gee-Woo-gen* grain number, panicle length, grain breadth, height, length of the three basal internodes and leaf area and in IR. 8, grain weight and grain length were the highest. Among the dwarf mutants grain yield per plant, grain and chaff weight, panicle length, length and breadth of grain and straw weight were higher in M40; number of panicle in M 10, grain number, chaff number, height, length of the three basal internodes and leaf area in M9 were also higher.

The scrutiny of values of correlation coefficients in (Table 2) reveals that number of panicles per clump has very high correlations with yield in all the varieties studied except in T 909 *Rascadam*, *Black puttu*, M 9 and M10. Number of grains per panicle has high correlation with yield in *Dee-gee-woo-gen*, M 9, ADT 16 and T 909 and moderate correlation in *Black puttu*. However in the case of other varieties the association of this character is feeble and insignificant. Weight of 1000 grains exhibited positive correlation with yield in nine out of 20 varieties. In SLO 16 *Rascadam*, *Jeeragasamba*, *Black puttu*, *Blue dawn* and M 9, 1000 grain weight exhibited

negative correlation with yield. In rice, number of panicles per clump, number of grains per panicle and 1000-grain weight are the major characters for yield. The results indicated that either all these three characters or any one or two of them are associated with yield in all the varieties studied except in *Rascadam* in which negative association is seen. Panicle length indicated positive correlation with yield only in three varieties Cult. 2410, T 909 and IR 8. The study therefore indicates that length of ear in rice is not always associated with yield. Similar results have been reported by Bhide and Bhalerao (1927) and Chandra Mohan (1964 and 1968). Number of chaff per panicle showed either negative or insignificant association with yield in all the varieties while weight of chaff in nine varieties, leaf area in three varieties and internode length in two varieties exhibited high correlation with yield. Minor characters like grain length and breadth showed moderate correlation with yield only in three varieties TKM6, T909 and *Annapoorana*. Hence it is seen that these characters have no significant relationship with yield. The plant height was found to be correlated only in two varieties ADT 16 and *Dee Geo-Woo-Gen* indicating that this character is not associated with yield. Rajagopalan *et al.* (1973) have also reported that the correlation between plant height and grain yield was low in the dwarf population, while Chandramohan (1964) reported positive correlation of this character with yield.

Yield of straw has been found to have a very high significant correlation with yield in 15 out of 20 varieties studied. It is also interesting to note that even in the remaining five varieties though the 'r' values have not attained the level of significance, the association of straw weight with yield is found to be feeble but not negative. Only a few investigators appear to have studied the aspect of straw weight in rice and reported its positive association with grain yield (Chandra Mohan, 1964, 1968 and Rajagopalan *et al.* 1973). However, Vibar (1920) has reported that greater straw weight is not always associated with yield.

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An Early Maturing High Yielding Variety of Rice - Selection 6543

Among the high yielding dwarf statured early maturing strains under spread, Bala is the earliest taking about 90-100 days to mature and it gives on an average four tonnes of grains per hectare. With a view to evolve an early strain with a higher yield potential than Bala, hybridisation work was taken up at the Paddy Breeding Station, Coimbatore during June, 1971. An early Culture 340 (a derivative of a cross between CH 2 and ADT 3) available in the germplasm collections was crossed with strains Co 29, Kannaki and Bala. From the segregating population of the crosses effected, several thousands of single plants with earliness and other economic attributes were selected. Among those that reached the stage of yield assessment, Selection 6543 of a cross between Culture 340 and Kannaki was found to be early coming to maturity in 95 days after sowing.

Studies on yield assessment of Culture 6543 revealed that it was superior to Bala and Culture 7711 (an early culture evolved at Aduthurai from IR 262 x ADT 27 cross) in yield. As against the yields of 4978 kg and 4899 kg recorded by Bala and Culture 7711 respectively, Culture 6543 yielded 5931 kg of grain per hectare. As the trans-

planted crop of 6543 occupied the field only for a period of 70 days, the per day productivity worked out to 85 kg of grain per hectare. As this new culture combines in it earliness and high yield potential, it is proposed to advance it for large scale trials in the districts in *Swarnavari*, *Kor*, *Kuruvai* and *Nayorai* seasons in Tamil Nadu to test its suitability.

Economic attributes of Culture 6543

Duration from seed to seed	: 95 days
Yield potential	: 5931 kg/ha
Plant height	: 74 cm
Number of tillers	: 8-9
Number of grains per panicle	: 78
Weight of 1000 grains	: 23.1 g
L/B ratio	: 2.56
Colour of rice	: White

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Co. 36 - A New High Yielding Rice Variety to Replace Co. 32

Co. 32 (*Tiruchengode samba*) is a fine quality rice largely grown in *khurif* (July-August to November-December) in Coimbatore and Salem districts of Tamil Nadu. But it is tall and susceptible to lodging. In order to improve the plant type and make it fertilizer responsive with high yield potential combined with fine quality rice, crosses were effected between IR 8 and Co. 32 in 1966, at the Paddy Breeding Station, Coimbatore. The progenies were studied in successive generations and selections made for high yield and fine quality rice resembling that of Co. 32. The F_1 and early generation progenies were studied in detail for yield components.

Hybrid vigour for ear number was pronounced in F_1 . Spikelet sterility was quite high (81.8 per cent). However, fully fertile segregates have been bred out by rigorous selection as reported earlier (Rajagopalan *et al.*, 1973). Height of plant, 1000-grain weight,

length of internode, length, breadth and angle of flag leaf and maturity duration in F_1 were found to be intermediate between the parental values. Heterosis was positively expressed in straw yield.

In *rabi*, 1968, 5000 plants were studied in F_2 generation and 196 semi-dwarf single plants with high fertility and good ear and grain characters were selected. During *khurif*, 1968 the F_3 generation progenies were evaluated and 181 single plants possessing desirable recombinations were advanced to F_4 . A total of 134 promising single plants selected were evaluated during *khurif*, 1969 and *rabi*, 1970 seasons respectively and 34 homozygous progenies of 120-140 days maturity were selected and advanced for preliminary yield trial.

In the preliminary yield trial conducted in *khurif*, 1970, culture 14466 was outstanding. Therefore, this culture was compared for yield against IR 8, IR 20, IR 22 and Co 32 during 1971 and 1972 at Coimbatore and Bhavanisagar. The data of yield performance of the varieties are furnished in Table 1. Culture 14466 recorded the highest yield in all the trials registering an increase of 17.3 and 18.6 per cent respectively over Co 32 and IR 20.

The test of adaption and yield potential of culture 14466 in the farmers' field in Coimbatore district con-

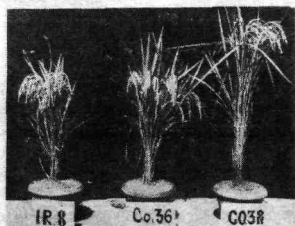


Plate 1 Plant type of Co 36 and parents

TABLE 1. Yield of Culture 14466 as compared to its parent varieties IR 20 and IR 22

Year and season	Varieties	Maturity (days)	Grain yield kg/ha
Paddy Breeding Station, Coimbatore			
1970 Kharif			
	Cult 14466	120	7782
	IR 8	135	7765
	Co 32	135	6741
	IR 20	130	6403
	IR 22	125	5751
1971 Rabi			
	Cult 14466	135	7333
	IR 8	135	7389
	IR 20	125	7000
	IR 22	120	5444
1971 Kharif			
	Cult 14466	135	7547
	Co 32	135	7141
	IR 20	130	5141
	IR 22	126	4594
1972 Kharif			
	Cult 14466	130	8089
	Co 32	135	7080
	IR 20	125	7423
	IR 22	120	6073

1	2	3	4
Agricultural Research Station, Bhavanisagar			
1971 Kharif			
	Cult. 14466	125	5885
	IR 8	135	4971
	IR 20	125	5320
	Co 32	135	4400

ducted during 1971 and 1972 seasons showed that it was superior in yield to Co 32 and IR 20. The average yield was 7915 kg/ha with an increase of 71.5 and 24.5 per cent over Co 32 and IR 20 respectively. Based on these results the high yielding culture 14466 was released as Co. 36 for replacing Co 32 grown over nearly 60,000 hectares in Coimbatore and Salem districts.

The authors thank the Superintendent, Agricultural Research Station, Bhavanisagar, former USAID Team, Coimbatore and the District Agricultural Officers of Coimbatore Division for the help in testing this variety in the Research Station and in the district.

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Vaigai (Co. 37) - A New High Yielding Rice Variety for Tamil Nadu

With the introduction of Taichung Native 1 into Tamil Nadu in 1965, the very concept of rice breeding underwent a radical change and the capacity for high yield of varieties possessing the improved plant type was recognised. A hybridization programme was initiated at Coimbatore with the object of infusing this improved plant type into the local tall *indica* varieties. As a result, Kanchi, a derivative of T (N) 1 and Co. 29 possessing the improved plant type and capable of yielding upto 37 per cent over Co. 29 was developed. Other varieties possessing the improved plant type were also developed viz., Karuna, Cauvery, Pennai, Kannaki, Karikalan and Co. 36. Among the innumerable hybrid derivatives of crosses involving tall and dwarf *indica* varieties under intensive testing, a promising variety Vaigai (Co. 37) has been isolated.

The variety Vaigai (Co. 37) is a derivative of T (N) 1 and Co. 29 with a maturity of 115 to 120 days. It possesses the improved plant type, high yield potential, fertilizer responsiveness, non-lodging character, good quality grain and wide adaptability. It has recorded the maximum yield of 7.387 tonnes per hectare at the Paddy Breeding Station, Coimbatore and 7.375 tonnes per hectare in the Farmers' holding with an average of 6.067 tonnes and 5.743 tonnes respectively.

TABLE 1. Performance of Co 37 compared to Kanchi

Season	Grain yield (kg/ha)	
	Co 37	Kanchi (Co. 34)
a) At Paddy Breeding Station Coimbatore		
Kharif 1969	5008	4820
Rabi 1970	5746	4820
Kharif 1970	6621	5408
Rabi 1971	7387	6128
Kharif 1971	5628	4932
Rabi 1972	5392	5173
Kharif 1972	5752	5063
Rabi 1973	6818	6369
Kharif 1973	6452	5731
Mean	6067	5337
b) In Farmers' holdings		
Rabi 1973		
Perundurai	4938	4063
Kangayam	5625	5269
Lingagoundanvalasu	4655	4435
Modakurichi	7375	6550
Pelligoundanpalayam	4000	3800
Nathakadayur	7075	6800

Table 1 (Continued)

Vellodu	5800	4800
Kodumudi	4703	4538
Nasianur	6000	5425
Veerappanpalayam	5600	5150
<i>Kharif 1973</i>		
Kolanelli	7025	4950
Sundaraperi	5750	4260
Periamuthu	7000	3360
Arasampatti	4750	4250
Average for Rabi and Kharif seasons in 14 locations	5743	4789

Co. 37 has consistently registered higher yields over Kanchi recording 13.7 per cent increases. The important attributes of the variety are furnished in Table 1.

It is suitable for growing in all seasons and is intended to replace Kanchi and Co. 29 in the districts of Chinglepet, South Arcot, North Arcot, Coim-

TABLE 2. Important attributes of Co 37 as compared to Kanchi

Particulars	Co 37	Kanchi
Maturity (days)	115-120	115-120
Grain yield range (tonnes/ha)	5-7	4-6
Average yield (tonnes/ha)	6	5
Plant height (cm)	85-90	85-90
No. of tillers	10-12	8-10
Panicle length (cm)	19	20
Number of grain/panicle	85	90
Weight of 1000 grains (g)	19.7	21.3
Grain to straw ratio	1.3	1.03
L/B ratio	2.41	2.2
Reaction to blast	Moderately resistant	Susceptible
Reaction to bacterial leaf blight	Moderately tolerant	Susceptible
Reaction to hopper	Moderately resistant	Susceptible

batore, Dharmapuri, Salem and Madurai.

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Correlation of Certain Quantitative Characters with Yield in *Gossypium hirsutum* L.

The yield of crop is affected considerably by plant characters. Bhatt *et al.* (1967) considered the number of bolls per plant, number of loculi per boll, seeds per boll and weight and boll size as the main components of yield in their study of genetic variability in *G. hirsutum*. A field experiment to determine the water requirement of winter cambodia cotton MCU 1 was carried out in split plot design with 4 replications with a spacing of 75×22.5 cm during the *kharif*, 1965-66 at Bhavanisagar. Four plants were randomly selected in each plot (25 sq.m) and the following characters were studied. (1) Number of nodes (excluding cotyledonary node at which sympodial branch appears); (2) plant height in cm (from cotyledonary node

to terminal bud); (3) Number of internode on the main stem (full length of plant); (4) Leaf area and measurements; 2 mature leaves for each plant on main stem in the middle zone, 6th and 7th leaf from the top), (a) (i) leaf length in cm, (ii) sinus length in cm (b) area of leaf; (5) boll characters (a, size of boll, (b) number of locule per boll, (c) number of seeds per locule (6) boll index. The total and *inter se* correlation coefficient worked out between the characters and yield are presented in Table 1.

Among the characters studied, plant height, number of internode, area of the leaf, number of bolls, number of seeds per locule per boll and number of seeds per locule

TABLE 1. Total correlation coefficient between different characters of cotton MCU 1

Characters	Yield	Plant height (X_1)	No. of internode (X_2)	No. of bolls per plant (X_3)	No. of loculi per boll (X_4)	No. of seeds per locule (X_5)
Plant height (X_1)	.5666**		.7279**	.5170**	.3561**	.2392**
No. of internode (X_2)	.3281**			.3253**	.2920**	.0995
No. of bolls/plant (X_3)	.9337**				.3424**	.2896**
No. of loculi/boll (X_4)	.4409**					.0636
No. of seeds / locule (X_5)	.3560**					

showed significant positive correlation with yield. Significant negative correlation of the yield was seen only for the boll index. The characters given in the Table I were positively inter-correlated with each other except number of seeds per locule with number of internode and number of locules per boll. The high positive correlation of boll number with yield supports the similar findings of earlier workers like Stroman (1930) and Venkataraman and Santhanam (1962). Saxena (1963) found significant positive correlation of plant height with yield whereas Stroman (1930) and Chinnadurai (1972) observed negative correlation with yield.

In order to find out real contributors, a linear production function was fitted by Abbreviated Doolittle method with the selected characters viz. plant height, number of internode, number of bolls per plant, number of loculi per boll and number of seeds per locule. The procedure given by Goulden (1952) was adopted and the multiple regression equation fitted is given below:

$$Y = 25.008 - 0.1377 X_1 - 0.0858 X_2 + 0.8211^{**} X_3 + 0.1304 X_4 + 0.0854 X_5 \\ (R^2 = .7484, R = .8651, N = 128)$$

In the equation (Y) represents the yield of *kapas* per plant in g. The

coefficient of determination (R^2) multiple correlation coefficient (R) high. This brings out importance of the selected five characters in predicting the yield in winter camb cotton MCU 1. Of all the characters studied number of bolls per plant, number of loculi per boll has relatively more dominant role in influencing yield than others.

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CORRELATION STUDIES IN COTTON (*GOSSYPIMUM
HIRSUTUM* L.) INFLUENCE OF MOISTURE REGIMES
AND NITROGEN LEVELS ON YIELD AND QUALITY
CHARACTERS OF COTTON MCU-1

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[Received on 18-6-1972]

Correlation studies in winter cambodia cotton MCU 1 showed that the correlation coefficients are changed by moisture regimes and nitrogen levels. Multiple regression equations fitted for the selected five characters viz. plant height, number of internode, number of bolls per plant, number of loculi per boll and number of seeds per locule showed a high degree of prediction in yield of cotton. Plant height under low nitrogen, level the number of seeds per locule under high nitrogen levels and number of loculi per boll under pooled condition, significantly and positively influenced the yield of *kapas*. In the quality characters application of nitrogen influenced seed index and lint index only. Linear regression equation showed significant and close association between ginning percentage and lint index, ginning percentage and seed index and between seed index and lint index

INTRODUCTION

Cotton crop is extremely sensitive to cultural, moisture and adaptive factors that affect not only yield but also to some extent, the fibre quality. Scarsbrook *et al.* (11) reported the soil moisture with nitrogen had effects on yield, seed and fibre. In the present study an attempt has been made to identify the yield attributing characters and to establish their functional relationship with the yield and quality of cotton MCU 1 under various moisture regimes and nitrogen levels.

MATERIALS AND METHODS

An irrigation cum manual experiment was laid out in split plot design with four replications on winter cambodia cotton MCU 1 during the *kharif* season of 1965-66 at Bhavanisagar. The soil type was red gravely loam and poor in nitrogen. The crop was sown on 1-10-1965 with a spacing of 75 cm $\times$ 22.5 cm. One plant per hole was allowed to stand. The four moisture regimes consisted of (1) I_0 —Irrigation to field capacity at 0 per cent available moisture; (2) I_1 —at 20

per cent available moisture; (3) I_2 —at 40 per cent available moisture and (4) I_1 60 per cent available moisture. The permanent wilting point of the soil 8.5 and field capacity was 20. The irrigations were given by moisture deficit method and irrigation was measured through 90° triangular weir. The sub plot treatments consisted of four nitrogen levels viz., (1) N_0 -- 0 kg/ha, (2) N_1 -- 22.4 kg/ha, (3) N_2 -- 44.8 kg and (4) N_3 -- 67.2 kg.

Four plants each plot (25 m²) were selected and the following characters studied (1) Number of nodes (excluding cotyledonary node at which symp branch appears); (2) Plant height in cm (from cotyledonary node to terminal node); (3) Number of internode on the main stem (full length of the plant); (4) Leaf area and measurement of 2 mature leaves for each plant on main stem in the middle 6th and 7th leaf from the top (a) (i) Leaf length in cm (ii) lobe length in cm (iii) lobe width in cm, (iv) Sinus length in cm; (b) Area of leaf, (5) Boll character size of boll, (b) Number of locule per boll, (c) Number of seeds per locule (6) index. The quality characters such as halo length, ginning percentage, boll strength, maturity coefficient, lint index and seed index are studied. The total inter se correlation coefficient between the characters and yield were worked out. In order to find out the real contributors, a linear production function was fitted. Abbreviated Doolittle method with the selected characters.

RESULTS AND DISCUSSION

(a) *Correlation value:* Significant total correlation worked out for the various characters with yield under various moisture regimes and nitrogen levels are furnished in Table 1.

At lower irrigation levels (I_0 and I_1) number of loculi/boll is not correlated with yield. At higher levels of nitrogen (N_2 and N_3) plant height and number of internode are not correlated with yield. Number of seeds/locule is not correlated with nitrogen except highest level N_3 . It is interesting to note that in the present data all the characters given in the Table 1 are correlated with yield. It is observed that the 'r' values are affected by moisture regimes and nitrogen levels. The positive correlation of boll number and yield supports the similar findings of other workers like Stroman (12), Manning (8), Kotaiah and Butany (7), Venkatarani and Santhanam (16). Plant height was positively correlated with yield whereas negative correlation was observed by Stroman (13) and Chinnadurai (3).

(b) *Multiple regression equation:* Linear production functions were fitted to find out contribution of characters to kapas yield with characters viz. Plant height (x_1), number of internode (x_2), number of bolls per plant (x_3), number of loculi/boll (x_4) and number of seeds per locule (x_5) under various moisture regime, nitrogen levels and also with pooled data. The procedure given by Goulden (5) was adopted. In the equations $\hat{Y}$ represents the yield of kapas per plant in grams.

(i) Moisture regimes :

$$\hat{I}_0 = Y = 22.72 - 0.1894 x_1 + 0.1562 x_2 + 1.0678 x_3^* + 0.1217 x_4 + 0.0015 x_5 \\ (R^2 = .9400, R = .9695, n = 32)$$

$$\hat{I}_1 = Y = 10.33 + 0.0798 x_1 + 0.1454 x_2 + 0.8894 x_3^{**} + 0.0591 x_4 - 0.1803 x_5^{**} \\ (R^2 = .9421, R = .9706, n = 32)$$

$$\hat{I}_2 = Y = 21.44 - 0.0187 x_1 - 0.0721 x_2 + 0.8720 x_3 + 0.0605 x_4 + 0.0437 x_5 \\ (R^2 = .8352, R = .9139, n = 32)$$

$$\hat{I}_3 = Y = 16.80 + 0.1168 x_1 - 0.0412 x_2 - 0.7395 x_3^{**} + 0.1122 x_4 + 0.1476 x_5 \\ (R^2 = .8800, R = .9381, n = 32)$$

The coefficient of determination (R^2) and multiple correlation coefficient (R) at all levels are significant and they are given below the respective functions. Thus in all moisture regimes the highly significant multiple correlation coefficient shows the closeness between the predicted yield and observed values. The character number of bolls per plant is significantly influencing yield in all moisture regimes except I_2 . The character number of seeds per locule under I_1 is significant but negative. The optimum soil moisture regime for irrigated MCU 1 cotton was found to be from field capacity to 20 per cent moisture availability (I_1) measured upto 30 cm depth (2). At I_1 level number of bolls per plant alone is significantly influencing the yield and other characters such as plant height, number of internode, number of loculis per boll is not contributing to yield.

(ii) Nitrogen levels :

$$\hat{N}_0 = Y = 8.13 + 0.1674 x_1^* - 0.1119 x_2 + 0.9220 x_3^{**} - 0.0452 x_5 \\ (R^2 = .9363, R = .9676, n = 32)$$

$$\hat{N}_1 = Y = 10.93 + 0.1024 x_1 - 0.0660 x_2 + 0.7708 x_3^{**} + 0.1685 x_4 + 0.1101 x_5 \\ (R^2 = .9088, R = .9533, n = 32)$$

$$\hat{N}_2 = Y = 20.58 - 0.0355 x_1 - 0.0404 x_2 - 0.8073 x_3^{**} + 1.291 x_4 + 0.2088 x_5^* \\ (R^2 = .8527, R = .9234, n = 32)$$

$$\hat{N}_3 = Y = 20.80 + 0.0361 x_1 + 0.0066 x_2 + 0.8035 x_3^{**} + 0.0765 x_4 + 0.2385 x_5^{**} \\ (R^2 = .8996, R = .9485, n = 32)$$

From the equations it can be observed that in all levels of N , number of boll per plant is positively contributing to the yield of *kapas*. Under lower nitrogen level (N_0) the character plant height is positively contributing to yield whereas under