STUDIES ON GENETIC DIVERGENCE, CHARACTER ASSOCIATIONS AND PATH ANALYSIS IN DROUGHT TOLERANT RICE (Oryza sativa L.) GENOTYPES

Thesis submitted to the
University of Agricultural Sciences, Dharwad
in partial fulfilment of the requirements for the
Degree of

Master of Science (Agriculture)

in

GENETICS AND PLANT BREEDING

By

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UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD - 5

MARCH, 1993

Th. 3632

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C E R T I F I C A T E

This is to certify that the thesis entitled "STUDIES ON GENETIC DIVERGENCE, CHARACTER ASSOCIATIONS AND PATH ANALYSIS IN DROUGHT TOLERANT RICE (*Oryza sativa* L.) GENOTYPES" submitted by Mr. NEMAPPA G. HANAMARATTI to the University of Agricultural Sciences, Dharwad in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in GENETICS AND PLANT BREEDING is a record of research work done by him during the period of his study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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Affectionately Dedicated
To My Beloved Parents,
Gangappa Hanamaratti
and
Padmavati

A C K N O W L E D G E M E N T

It is a great pleasure to look back and recall the path one traverses during the days of hard work and perseverance. It is still a great pleasure at this juncture to recall all the faces and spirits in the form of teachers, friends and near and dear ones. I would consider this work incomplete without acknowledging the help received during this endeavour of mine. Although these may not depict the real quivering puslations in the depth of my heart, I hope they aid me in doing my duty.

I feel immense pleasure in expressing my deep sense of gratitude and profound indebtedness to Dr. S.K. NADAF, Maize Breeder, Agricultural Research Station, Arabhavi and esteemed Chairman of my Advisory Committee, for his sincere exhortations, persistent encouragement and affectionate dealing throughout the period of investigation and during preparation and presentation of the manuscript.

With great privilege, I place on record my profound reverence to Dr. S.J. PATIL, Professor, Division of Genetics and Plant Breeding, UAS, Dharwad, who offered inspiring suggestions, elderly advice and academic enlightment as a member of my Advisory Committee.

I avail this opportunity to express my heartfelt gratitudes to Dr. M.V. CHANNABYRE GOWDA, Associate Professor, Division of Genetics and Plant Breeding and Dr. M.B. CHETTI, Professor of Plant Physiology, UAS, Dharwad, who evinced keen interest in my academic career and offered critical suggestions during the period.

I am deeply indebted to Shriyuts P.N.Umapathy, Farm Superintendent, V.V. Angadi, Jr. Agronomist (Rice), H.D.Mohankumar,

Jr. Rice Breeder, Miss. Yashoda Hegde, Jr. Pathologist (Rice) and other staff members of Agricultural Research Station, Mugad, for their valuable suggestions during the experimentation and in the preparation of thesis.

With all my love and affection, I regard my indebtedness to Govind Naik, Gopali, Nandeesh, Venkatesh Bhat, Police Goudar, Kantesh, Hanchinamani, Suresh, Annigeri, Sugoor, Shimpiger, Channabasava, Prabhu, Sunil, Hullambi, G. Shivanna, Kasamalagi, Pasannavar and all other friends for their help and sustained co-operation during the course of study.

I owe my respectful gratitude to my beloved parents, brothers and sisters for their blessings, ambitious encouragement, unflagging interest, unquantifiable love and affection showered on me which have brought me to this status. I would like to extend my heartfelt respects and affection to respected teaching community since school days, Shri. M.M. Kurkuri, Shri B. J. Pasannavar and their family members for their keen interest in my career and constant ambitious encouragement which spurred me towards higher studies.

I acknowledge the financial assistance provided to me by the University of Agricultural Sciences, Dharwad in the form of Merit Scholarship, with sincere gratitude. I am also grateful to C.D. Patil Charitable Trust, Kogilageri, for the financial aid.

Finally, I wish to thank Shri. M.S. Rao, Joshi and Prakash, for having spared their deep experience, patience and skill by way of neat typing of this dissertation.

DHARWAD

8 March, 1993

(NEMAPPA G.HANAMARATTI)

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CHAPTER-I

INTRODUCTION

I INTRODUCTION

Rice [*Oryza sativa* L.] is the world's most important food crop. More than ninety per cent of the world's rice is grown and consumed in Asia, where more than half the world's population live and nearly eighty per cent of the world's poor are concentrated. It acts as a "grain of life" for most Asians including Indians, as it supplies about 22 per cent of calories and 17 per cent of proteins. Scientists estimated that world's annual rice production must boost from 460 million tonnes during 1987 to 560 million tonnes by 2000 A.D.and to 760 million tonnes by 2020 A.D., a 65 per cent increase, just to keep up with the population growth (Anon., 1989).

Upland rice is grown in Asia, Africa and Latin-America, which contributes about 13 per cent of world area. In India most upland rice is grown in eastern and north-central states and along the south-western coast, contributing about fifteen per cent of the national rice area (Gupta and Toole, 1986). Drought tolerance in upland rice is one of the most important desirable traits, as it is cultivated under rainfed conditions. It is also a desirable trait in midland and shallow water rainfed drill sown rice. In recent years, the annual rainfall in upland rice growing area is inadequate to grow rice and often erratic in distribution during cropping season, even when the total rainfall is more. The rainfall in the months of September and October is insufficient and erratic in distribution [Appendix-I], which coincides with the

reproductive stage, a stage, more sensitive to water stress in upland rice. To develop varieties for upland condition, the drought tolerant genotypes with suitable plant type are to be selected from a diverse gene pool and utilized as parents in hybridization programme.

In self pollinated crops, the selection of parents for hybridization programme is largely based on wide adaptation, high yield potential and genetic diversity. It is a general belief that the more diverse the parents, within overall limits of fitness, the greater is the chance of obtaining higher amount of heterotic expression in F_1'S and broad spectrum of variability in segregating generations (Harrington, 1940; Anand and Murty, 1968). Estimation of genetic divergence has been emphasized by several workers (Murty and Arunachalam, 1966; Singh and Bains, 1968 and Singh and Gupta, 1968) as it permits precise comparison among all possible pairs of populations in any given group before effecting actual crosses. In the past, ecological or geographic diversity was considered as an index of genetic diversity. Recent studies have indicated that genetic diversity is not necessarily associated with geographic diversity (Murty and Qadri, 1966; Sinha et al., 1977; Ratho, 1984; Pande and Ghorai, 1987; Selvakumar et al., 1989; Gomathinayagam et al., 1990) and statistical tools such as Mahalanobis' D^2- statistic can be utilized in plant breeding for obtaining information about genetic diversity among a group of genotypes.

After hybridization, in order to initiate effective selection programme, it is essential to assess the degree of association of various component characters and their direct and indirect effects on yield.

The present study therefore, was conducted with the following objectives using 50 rice genotypes known for drought tolerance.

1. To study the genetic divergence present among the selected drought tolerant genotypes of rice over seasons in order to facilitate the identification of genetically diverse parents.
2. To examine the nature of association between yield and its components over seasons.
3. To know the direct and indirect effects of component characters on grain yield over seasons.

CHAPTER-II

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The relevant information available from the literature is presented under the following sub-heads.

2.1 Genetic divergence

2.1.1 Genetic divergence and selection of parents for hybridization

Besides the importance of D^2 analysis in taxonomic problems in biological population at intervarietal, sub-specific and species levels, D^2 statistic is also important in the selection of the parents for hybridization programme.

The germplasm in a self pollinated crop can be considered as a heterogeneous set of groups, each group being homogeneous within itself. Selecting the parents for a breeding programme in such crops is a critical event because the success of the programme particularly when the aim is to improve the complex quantitative characters like yield depends upon the segregants of the cross. Besides the parents should have complementary traits to be improved among themselves. Generally maximum improvement can be obtained from crosses which release the maximum amount of variation.

The cultivars from widely separated localities have been usually included in the hybridization programmes presuming the presence of genetic divergence and maximum likelihood of recovering promising segregants. As per expectation, this has not yielded very satisfactory and consistent results.

Ecogeographic diversity has been regarded as a reasonable index of genetic diversity (Vavilov, 1926; Ram and Panwar, 1970). However, it was reported later that there does not exist any parallelism between geographic distribution and genetic diversity (Murty and Anand, 1966 in linseed; Arunachalam and Ram, 1967 in sorghum; Bhatt, 1970 in greengram; Lee and Kaltsikes, 1973 in durum wheat; and Kanwal et al., 1983; Ratho, 1984; Pande and Ghorai, 1987; Selvakumar et al., 1989; Biswas and Samsal, 1990; and Gomathinayagan et al., 1990 in rice).

Since last three decades multivariate analysis have been put to good use enabling quantification of degree of divergence between populations (Michener and Sokal, 1957; Morishima and Oka, 1960; Murty and Qadri, 1966). Rather than infering from the earlier used indices like morphological similarity, ecogeographic diversity, phylogenetic relationship and similar other criteria, Manalanobis' generalised distance estimated by D^2 statistic (Rao, 1952) has been found to be a potent biometrical tool in quantifying the degree of divergence between biological populations viz., crop plants and also to assess the relative contribution of different components to the total divergence (Maurya and Singh, 1977; Suyambulingom and Jebarani, 1978; Singh, 1983; Kotaiah et al., 1986; De et al., 1988; Selvakumar et al., 1989; Biswas and Samsal, 1990). The concept of Mahalanobis' D^2 statistic is based on the technique of utilizing the measurements in respect of an aggregate of characters. Further, the estimates are obtained from a study of the potential parents. Hence,

the required information is available prior to crossing and thus, can be used with advantage in the choice of parental combinations.

To assist the plant breeder in the process of selection, different methods have been evolved to identify the parents that nick better (Allard, 1961). The following are the three types by which such selection can be made (Bhatt, 1970).

i) testing of hybrid performance
ii) methods to identify crosses which give rise to superior transgressive segregants
iii) methods to study the performance of homozygous lines from which the parents are to be selected

In the first method the parents are selected using the techniques *viz*., combining ability and diallel analysis (Whitehouse *et al*., 1958). But these methods have been criticised because (a) It puts a limit on the number of lines that could be tested at a time and (b) the F_1 and F_2 performance on which the method concludes are not necessarily the true indicators of the performance of the segregants in the later generations.

The second method is also criticised because, it involves the study of F_4 and further generations, which when the number of entries increases, could be difficult to employ.

The third method involves the assessment of genetic diversity (Murty and Arunachalum, 1966) and analysis for yield and yield components through multivariate technique has been

favoured (Bhatt, 1973). These methods involve less labour and time.

2.1.2 Nature of genetic divergence and role of characters in genetic divergence :

The relative studies on the analysis of genetic divergence in rice are reviewed as under.

Ram and Panwar (1970), while studying interspecific divergence in rice, reported that the characters viz., plant height, number of productive tillers, and panicle length related to yield and fitness were potent enough to distinctly discriminate the indica and japonica types; early, medium and late maturity groups; varieties of China, Japan and Taiwan, and hilly and plain varieties of India which indicated that genetic diversity might be related to geographic diversity in rice. The nature of evolutionary pattern had been traced out indicating the most important role of flowering time in the major axis of differentiation. The authors also put forth a brief scheme of the indica X japonica hybridization programme based on genetic divergence for maximum exploitation of heterotic effect.

An attempt was made to know evolutionary trends in cultivated rice based on the results of genetic divergence by D^2 statistic using 74 strains of rice selected at random but representing all the geographical groups of *Oryza Sativa* viz., indica, japonica, ponali, javanica and another cultivated species, *Oryza glaberrima*, from Africa by Sinha et al., (1977). These strains were grouped into 16 clusters. The

authors found that genetic diversity among indica strains was generally attributable to geographic diversity with few exceptions. The strains of japonica, ponali, javanica and *Oryzo glaberrima* had shown for less genetic diversity within respective races or species than the indica strains. The characters contributing maximum to D^2 values were number of effective tillers, number of grains, plant height, heading duration and yield in order of magnitude.

It was conceived from a study on `Genetic divergence in rice by Maurya and Singh (1977) that, in cases where geographically distant locations do not differ sufficiently in elements of climate, biotype, soils and management,merely barriers of distance may not be potent enough to accumulate variability. In addition to this, prolonged selection and accumulation of variation suited to those conditions were the important factors for geographical diversities. Further, the authors reported that although the materials which they studied, were the product of only few crosses and bred under unidirectional selection force, yet they exhibited sufficient diversity. Maturity time, plant height and tillers contributed most to divergence.

Suyambulingom and Jebarani (1978) reported that the largest contribution to the total divergence was made by the lodging character, grain weight and number of days to first flowering. The pattern in which the different varieties formed different clusters was fairly at random, which showed

that the forces other than the geographical separation were also responsible for the diversity.

Multivariate analysis by Mahalanobis' D^2 statistic and canonical analysis of 100 strains of rice, which were evaluated for yield and eleven yield related traits revealed that panicle weight, number of days to maturity, height and grain size contributed most towards divergence (Kanwal et al., 1983). The strains were grouped into nine clusters which were not correlated with geographical diversity.

Thirty two varieties from India, Philippines, China and Bangladesh were grouped into nine clusters using multivariate analysis of genetic divergence. Varieties from the same ecogeographic region were found in different clusters, indicating no relation between geographic diversity and genetic diversity. Plant height made the largest contribution to total genetic diversity, followed by sterile grains per panicle and grains per panicle (Singh, 1983).

Analysis of data on yield per plant and twelve related traits from 26 diverse genotypes revealed that days to 50 per cent heading, grain breath, plant height and per cent grain protein contributed most to total divergence (Kotaiah et al., 1986). The authors further concluded that D^2 analysis is more precise and refined for studying germplasm collections.

Nadaf et al. (1986) screened 120 elite lines of diverse origin and selected primarily for multiple disease resistance and analysed the yield component data by means of Mahalanobis'

D^2 statistic and suggested the parents for hybridization to evolve multiple disease resistant rice varieties by considering the lines from clusters with more divergence and having multiple disease resistance.

On the basis of D^2 analysis of ten characters, sixty seven random genotypes from the Assam rice collection (ARC) together with two genotypes from each subspecies; indica, japonica, javanica and ponali were grouped into 13 clusters, with 100 grain weight and grains per panicle making the greater contribution to D^2 values (De et al., 1988). The authors also suggested that, javanica strains could be synthetic assemblages of indica and japonica genotypes. Sun and Xu (1988) reported that, forty nine genotypes were grouped into nine clusters with genetic distances (D^2) of 364.26 between the farthest pair and 22.29 between the nearest pair of clusters. Kotaiah et al., (1988) studied genetic divergence, in long duration genotypes of rice and found that, days to 50 per cent heading and 100-grain weight were the main contributors to total divergence.

A total of 32 varieties originating from IRRI, India, Korea, Sri Lanka and Vietnam were subjected to cluster analysis (Buichi and Tran, 1989). Five clusters were produced by Tocher's method with days to 50 per cent flowering and plant height contributing most to divergence. In a study of eight yield traits in 40 accessions from various geographical areas using Mahalanobis' D^2 statistic, the clustering pattern indicated that geographic diversity was not reliable guide to

genetic diversity (Selvakumar et al., 1989). The authors observed a wide range of variation in intra-cluster mean values for each trait. Yield component traits such as number of grains per panicle and number of fertile tillers contributed most to the genetic divergence.

Anandkumar and Subramanian (1989) determined genetic diversity in 23 drought resistant varieties, using Mahalanobis' D^2 analysis. Using Tocher's clustering technique genotypes were grouped into six clusters some of which were highly divergent and use of these genotypes in breeding programmes was expected to result in a large degree of heterosis.

D^2 statistic on upland rice varieties was studied by Gomathinayagam et al. (1990) and grouped forty entries into four different clusters by Tocher's method and found that, there was wide genetic diversity in the material from the same geographical location, which could result from non-characteristic selection forces in the region or due to genetic drift in the material chosen. The authors suggested intercrossing of genotypes from the clusters showing superior cluster means for desired characters might result in the production of better upland rice varieties.

2.1.3 Effect of environment on the genetic divergence

Stability of genetic divergence between a sample of varieties across varying environments is desirable from the plant breeding point of view but it was found that the varieties belonging to different D^2 clusters not only differed

in their mean yield but also in their response for yield and clustering pattern in varying environments (Upadhyay and Murty, 1970; Jain et al., 1981). A few studies directed towards this point in rice and other crops are briefly reviewed here.

Somayajulu et al. (1970) studied the genetic divergence among a set of 67 wheat strains in three different environments representing different levels of fertility. The number of clusters into which 67 strains could be grouped differed from environment to environment and composition of clusters also varied. However, a closer study of grouping revealed that such instability was restricted to only those clusters, the divergence between which was quite low, whereas the widely divergent clusters remained distinct in all environments.

Upadhyay and Murty (1970) while studying genetic divergence in the world collection of Pannisetum typhoides from 14 geographic regions under stress and non stress conditions, reported that genetic and geographical diversity are not related. Genetic drift and selection under different environments could have caused greater divergence than the geographical distance.

Rana and Murty (1971) and Murty et al. (1973) observed that the grouping through statistical distance remained stable over the environments. Since these workers studied this aspect only over two environments, it is essential to examine such stability over a series of contrasting environments to

derive valid conclusions. On the contrary, Peter (1975) observed that the grouping pattern in tomato varied over four different environments. In a study of divergence with 32 genotypes of chickpea in eight environments, the pattern of clustering was highly influenced by environment and while making general statement on this aspect, the experimental conditions should be taken into consideration (Jain et al., 1981).

A study in eight environments on genetic divergence for yield and six other related characters in 48 diverse rice cultivars indicated that, it was not consistent with their geographical origins; clustering differed significantly between characters and was greatly influenced by environment (Pande and Ghorai, 1987). Pradhan and Roy (1990) studied genetic divergence on 25 breeding lines of rice from diverse pedigree, in two levels of regimes (shallow and intermediate water). The study revealed six and seven clusters of varying constellations. The composition of clusters differed in two situations due to pronounced genotype-environment interactions.

Sarawgi and Shrivastava (1991) evaluated 16 varieties and their 72 F_1 hybrids in irrigated and rainfed conditions for seven yield components in order to determine their genetic divergence and heterosis. Parents and hybrids were grouped into seven and fifteen clusters in two conditions respectively. The authors found limited diversity under irrigated condition while, significant diversity was noticed

in rainfed condition. Mean of grains per plant was highest for cluster II in irrigated condition (20.16 g) and cluster XIII in rainfed condition (40.52 g).

2.2 Character associations

The attainment of characteristic form and function in a crop plant depends upon a chain of inter-related events which are sequential in time, gene regulated at critical sites and times, and subject to also the modifying influences of non genetic forces. Moreover, these events do not occur haphazardly, but fallow an integrated pattern. Yield of seed is an obvious example of integration and its expression is dependent upon action and interaction of various components. As Grafius (1959) has suggested, there may not be genes for yield *per se* but there are genes for various yield components.

Association of economically important quantitative characters, which is statistically determined by correlation coefficient, has been quite helpful as a basis of selection. Galton (1889) developed the basic concept of correlation and was later elaborated and discussed by Fisher (1918, 1936) and Wright (1921) for plant breeding programme. It was stated that estimates of phenotypic and genotypic correlations among the characters are useful in planning and evaluation of breeding programmes (Johnson *et al*., 1955). Hence a knowledge of correlation may facilitate the interpretation of results already obtained.

A number of studies have been done on correlations between various characters in different fixed cultivars and

segregating populations in rice. Some of the relevant ones are presented here.

In a study, Bhide (1926) recorded high positive correlation between tillering and yield, while yield registered low correlation coefficient with panicle length. Similarly, Mahalanobis (1934), Narasinga Rao (1937), Ganguli and Sen (1941) and Morimoto (1951) reported positive association of yield with tiller number as well as grain number per panicle and panicle length. Choudhary and Sen (1953) revealed positive association between length of panicle and tiller number. Strong association between yield and plant height, panicle length and number of grains per panicle and moderate association of plant yield with number of tillers per plant were reported by Ramiah (1953). Yield was associated with plant height and number of productive tillers in positive direction (Abraham, et al., 1956) while Ghose et al. (1956) reported the positive correlation of yield with panicle length and number of panicles per plant and plant height's attribution to yield was negligible.

Grain yield recorded significant association with number of productive tillers, ear length and grains per panicle (Ahmed and Suryanarayana Rao, 1967). Lin s report (1970) included panicle weight while Sindhu (1973), included total number of tillers and 1000 grain weight along with the above three determinants and observed a negative association of heading date with yield.

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Highest positive correlation between total spikelets and yield was also reported by Abraham et al. (1962) and Roychoudhary (1967). The authors also observed that yield had much contribution from plant height, length of panicle and panicle number per plant.

In an inheritance study by Dhulappanavar (1963), yield registered negative correlation with panicle exsertion and panicle length, while plant height had positive and negative association with early flowering and late flowering respectively. A study on six varieties conducted by Yeh (1965) revealed positive association of tiller number, culm length and panicle weight with yield. Ghose et al.(1966) observed significant and positive correlation for plant height and 1000-grain weight and negative association for grain number per panicle with grain yield. Chang (1967) observed close association between panicle number and plant height under close spacing and between length and weight of panicle under wide spacing.

In the advanced generations of two rice crosses, Swamy Rao (1970) found positive association between grain yield and panicle length and the latter was correlated to grain number per panicle. Kaul (1972) recorded positive correlation of the number of spikelets, grains per panicle and tiller number per plant with grain yield while shoot height was negatively correlated with yield. Positive correlation was observed between number of grains per panicle and 100-grain weight, whereas tiller number and grain yield were negatively

correlated, but number of productive tillers was positively and significantly correlated with yield (Balakrishna et al., 1973).

Mukherji and Mandal (1973) observed from their study that the number of effective tillers, panicle length and nature of flag leaf are negatively correlated with five characters (plant height, ear length, flag leaf length, flag leaf breadth and single plant yield) in case of all the three plant types. The three groups differed in the nature of associations between tiller number and plant height and no significant correlation could be found in flag leaf length, flag leaf breadth and single plant yield.

In segregating generations Eunus et al. (1974) reported that grain yield was correlated negatively with plant height and flag leaf angle but positively with flag leaf length, second leaf length, the number of panicles per unit area and number of filled grains per unit area. It was reported from the study on character association in 33 varieties of rice by Talwar and Goud (1974) that significant phenotypic and genotypic correlations were found between grain yield per plant and 1000-grain weight, plant height, 1000 grain volume, while the number of days to flowering was negatively correlated with grain yield per plant. Sathpathy and Nanda (1978) noticed that the traits viz., productive tillers, per cent fertile grains and 1000-grain weight registered positive correlation with yield and among themselves.

Significant positive correlation existed for grain yield with days to flowering, grain number per panicle, plant height and 100-grain weight (Yadav and Singh, 1979). While Suyambulingom and Jebarani (1979) reported significant correlation of grain yield with plant height and number of tillers in short duration tall and dwarf varieties. The authors also observed significant but negative correlation between grain yield and fineness of the grain. Plant height was significantly correlated with compactness of the panicle and fineness of the grain. But in the dwarf varieties it was found that the grain yield was significantly correlated with plant height, number of tillers and fineness of grain.

Unnikrishnan (1980) observed positive significant correlation of plant height, productive tillers, panicle weight and grain number with yield both genotypically and phenotypically in F_2 populations of three rice crosses. Consonantly, Amirthadevarathinam (1983) reported positive correlation of grain yield with productive tillers as well as total tillers but plant height had negative association with grain yield while the grain yield per plant was positively correlated with plant height, number of productive tillers, panicle weight and panicle length in two different segregating populations, while in another population productive tillers showed negative association with yield (Sukanya, 1984).

The thousand grain weight was significantly and positively correlated with plant height and lengths of second, third and fourth internodes from the top (Awan and Cheema,

1986). Chauhan et al. (1986) found positive and significant association of yield per plant with days to flowering, leaf length, plant height, panicle length, tillers per plant and grains per panicle. Flag leaf area was correlated with grain weight per panicle and grain number per panicle.

Negative correlations were obtained between yield and flag leaf length, second leaf length and flag leaf angle by Yu et al. (1987). Dhanraj et al. (1987) reported a significant positive correlation of yield with number of effective tillers, 1000-grain weight, number of grains per panicle and panicle length, while days to flowering showed a negative correlation with grain yield and all other characters.

Grain yield showed positive correlations with number of productive tillers per plant ($r = 0.65$) and grain : straw ratio ($r = 0.90$) in a study by Tahir et al. (1988). The authors also noted that, the plant height was negatively correlated with number of tillers per plant ($r = -0.87$), grain:straw ratio ($r = -0.58$) and grain yield ($r = 0.65$), but positively correlated with panicle exsertion ($r = 0.74$). Another study revealed positive and significant correlation of grain yield per plant with total spikelets per panicle, fertile grains per panicle and 100-grain weight and negatively and significantly associated with sterility (Prasad et al., 1988). The author also observed that, fertile grains per panicle were significantly and positively correlated with total spikelets per panicle and negatively correlated with sterility. Plant height and flag leaf length were positively

and significantly correlated with days to flowering and panicle length. Gomathinayagam et al. (1988) reported positive association of grain yield with duration (r = 0.29) and plant height (r=0.32).

Manul and Palaniswamy (1989) observed significant positive correlation of grain yield with days to flowering, plant height, flag leaf area, panicles per plant, panicle length and grains per panicle. Grain yield was positively and significantly correlated with 1000-grain weight (r = 0.72) and filled spikelets per panicle (r = 0.71) in an experiment with six varieties in rainfed conditions (Suorez et al., 1989). Deosarkar et al. (1989) concluded that selection should be based on plant height, 1000-grain weight and grains per panicle based on correlation study. Sampath et al. (1989) noticed significant association of yield with 100-grain weight, panicle length and number of grains per panicle in parents but not in the hybrids, in which yield was correlated with the number of primary and secondary branches per panicle, number of days to panicle emergence and tiller number.

A study of low P-tolerant parents and their F_1s which were grown in upland lateritic soil indicated that, eighteen characters were significantly and positively correlated with yield and the most important of these were plant height, fertile tillers, panicle length, branches per panicle and grains per plant (Majumder et al., 1990). Amirthadevarathinam (1990) observed positive association of plant yield with days to 50 per cent flowering, tiller number and panicle length in

indicas while in japonicas positive association with days to 50 per cent flowering and negative association with tiller number. From the study on F_2s of inter-varietal hybrids in rice, positive and significant correlation existed between yield and five of its components namely, plant height, productive tillers, panicle length, grain number per panicle and grain weight (Marimuthu et al., 1990). The authors also observed both positive and negative correlations between days to flowering and other yield components. Significant and positive correlations between plant height and tiller number and panicle length; tiller number and panicle length; panicle length and grain number were observed. In a different study, panicle length, number of grains per panicle and straw yield per plant had significant and positive association with grain yield per plant. Significant negative association with plant height and panicle length and highly significant negative association with number of grains per panicle and grain yield per plant were also observed (Reddy and Nerkar, 1990).

Correlations between agronomic traits (growth attributes and yield components) and yield would also depend upon the material chosen for study. Kedarnath et al. (1960) in linseed and Mukherji and Mandal (1973) in rice found varying associations in three morphological groups. Srivastava et al. (1977) took up extensive study on intra-group correlations in three maturity groups of pegion pea. It was observed that out of 36 character associations 13 associations were different in three maturity groups based on homogeneity study of correlation coefficients. Similarly Nadaf (1980) studied on

homogeneity of correlation coefficients in four maturity groups in rice and observed three character pair comparisons with different associations out of 15 character comparisons viz., grain yield per plot, plant height and number of effective tillers related with days to 50 per cent flowering differed with respect to four maturity groups. In all the maturity groups, only number of grains per panicle was positively and significantly correlated with grain yield per plot, while significant negative associations were observed between character pairs, plant height and number of effective tillers, number of effective tillers and 250-grain weight and between number of effective tillers and grains per panicle the correlation coefficients of which were pooled.

The correlation of yield and its related traits also varied with growing seasons (Roychoudhary, 1967; Pinheiro et al., 1985; Malik and Hasija, 1987; Salam and Subramanian, 1988; Tanisaka et al., 1989). The consistent correlations of characters across the environments would be more valuable for assessing character associations.

Roychoudhary (1967) studied character association in 30 different genotypes consecutively for three years and observed the significant correlation of grain yield with number of panicles per plant in each of three years and with the plant height in only one of the years and was independent of panicle length. Number of panicles per square meter, number of grains per panicle and 1000-grain weight were positively correlated with yield in both dry and wet seasons (Ismail, 1984).

Accordingly, Chauhan and Tondon (1984) reported that, under upland environments plant height, grains per panicle and 1000-grain weight had positive and significant correlation with grain yield and also among themselves. Grain yield had positive and significant correlation only with panicle-bearing tillers under irrigated conditions, while other positive and significant associations in this environment were between days to flower and days to maturity and their relationship with the panicle-bearing tillers and between plant height and panicle length.

A total of 90 hybrids were tested along with their parents in three seasons by Sukanya and Rathinam (1984a). The genotypic correlation coefficients of grain yield per plant with plant height, tiller number, panicle length and 100-grain weight were significant and positive, while with length-breadth ratio of grain was significant and negative in all three seasons. Number of grains per panicle was significantly associated with yield in only one season while positively but not significantly correlated in other two seasons. Straw yield was negatively associated with yield in two seasons while in another season, it was positive and significant. The association among the yield attributing characters varied across seasons also in some other combinations. Pinheiro et al. (1985) studied, the relationships between yield, yield components and morphological and physiological characteristics in upland rice. The authors noticed that days to flowering, per cent filled grains and leaf angle were the main factors determining

yield under water stress but with adequate water supply, yield was influenced positively by number of panicles per square meter and leaf area index (LAI) and negatively by leaf width.

Grain yield was correlated with flowering date, panicle length and grains per panicle in both under bacterial blight stress condition and disease free environment. Yield was associated with plant height in disease free environment, while with panicles per square meter under disease stress (Malik and Hasija, 1987). In a study on IR-20 rice grown in 3 seasons, root weight was correlated with plant height, tiller production and dry matter production in all seasons (Salam and Subramanian, 1988). The authors observed strongest correlation between root weight and total dry matter weight during summer where as that between root weight and grain yield was strongest during the north east monsoon season. Tanisaka et al. (1989), while studying environmental variations of induced plant type and its component characters in rice observed that the genetic correlations between component characters varied with growing season and eight pairs of characters showed close correlations in all seasons.

2.3 Path coefficient analyses

Seed yield is a complex trait dependent on a number of interrelated component characters. When the correlation coefficients of these characters alone with yield are considered (to practice indirect selection for high yield), it could be misleading. By path coefficient analysis it is possible to identify the extent of direct contribution of

character and also indirect contribution through other characters through which it is influencing yield. The characters associated can be considered together as criteria for selection by attaching appropriate weightages to each of them. The term path coefficient was coined by Wright (1921) while Li (1956) presented a detailed account of both basic and applied aspects of path coefficient analysis. Dewey and Lu (1959) applied the path coefficient technique for the first time in the crested wheat grass.

The earlier report of path analysis of yield and yield components in rice came from International Rice Research Institute in 1964 (Anon., 1964). It was found that panicle number per plant exerted the greatest influence directly and indirectly upon yield and that the grain number per panicle was second in order of merit in influencing the yield followed by 100-grain weight. It was also pointed out that the contribution of grain weight via grain number was greater than its direct contribution. The positive influence of effective tillers, panicle weight and grain number per panicle was found on yield (Gupta and Padlia, 1971). Swamy Rao and Goud (1971) found direct influence of productive tillers and grains per panicle on yield.

Kumar and Saini (1973) studied path co-efficient analysis between yield and yield components and reported that tiller number, spikelet number and days to maturity had appreciable direct effect on yield. It was also noted that the varieties which take longer time from heading to maturity are conducive

to higher yield. Singh and Nanda (1975) attempted path analyses of yield and yield components. The role of panicle number, panicle length and grains per panicle was emphasised than the grain weight in the expression of grain yield. Maximum direct effects of spikelet number per panicle followed by number of panicles, panicle length, days to heading and 1000-grain weight in semidwarf rice cultures was recorded by Saini and Gangeja (1975). In semidwarf varieties of rice, number of panicles and plant height exhibited maximum direct contribution on yield as noticed by Agarwal et al. (1978). Days to flowering and grain number had positive direct effects on grain yield (Yadav and Singh, 1979). Path analysis in segregating and non segregating populations of rice disclosed high positive effect of panicle bearing tillers, 1000-grain weight and fertile grains per panicle on yield (Singh, 1980). Unnikrishnan (1980) observed importance of productive tiller number and grain number in IR-20 X S-317; productive tillers, panicle weight and grain number in Mangala X S-317; productive tillers and panicle weight in Madhu X S-705 in selection for yield.

Chaya (1983) studied path analyses in the segregating populations of rice under different fertility levels and observed the maximum contribution of spikelet number to yield, followed by panicle number, 1000-grain weight and fertility percentage. Direct effects of productive tillers and grains per panicle on yield were revealed by path analyses carried out at different fertility levels in 26 rice genotypes (Hegde, 1983). Amirthadevarathinam (1983) disclosed the positive

direct contribution of total tillers and days to flowering to grain yield by path analysis. Lin and Chiu (1984) reported that number of grains per panicle is an important factor in yield.

In a study under upland and irrigated conditions by Chauhan and Tondon (1984), the path analysis has revealed that days to flower, plant height, panicle bearing tillers, grains per panicle, 1000-grain weight and per cent spikelet fertility had considerable positive effects on grain yield, but negative effects were observed for days to maturity and length of panicle under both environments. Further, plant height, grains per panicle and 1000-grain weight exerted sufficient positive direct effects on grain yield through each other under upland environment. The F_1 progenies of ten varieties disclosed that, grain : straw ratio exerted the highest direct effect on yield, followed hy straw yield, panicle length, plant height and 100-grain weight (Sukanya and Rathinam, 1984b). Fertile grains per panicle had direct positive effect on grain yield per plant in a study by Awasthi and Borthakur (1986). The author also found direct positive effect of panicle length, 1000-grain weight on grain yield per plant. Path coefficient analysis revealed considerable positive direct and indirect effects of second and fourth internal length from top and a negative effect of third internal length on 1000-grain weight (Awan and Cheema, 1986).

Malik and Hasija (1987) found that panicles per square meter and grains per panicle had greatest direct effects on

yield in both diseased and disease free environments. Plant height had a greater effect on yield under disease stress, while seed weight had a positive effect under normal conditions but negative effect under disease stress. Path analysis revealed maximum direct contributions to yield from plant height, number of productive tillers, whereas, contributions from pollen sterility and number of sterile spikelets per plant were negative (Shivakumar Swamy, 1987).

Plant height, number of tillers per plant and grain: straw ratio had the greatest direct effects on grain yield in a study by Tahir et al. (1988), while Gomathinayagam et al. (1988) reported that plant height contributed indirectly to the grain yield through all characters studied except 1000-grain weight. In studies by Ismail (1988) and Bui and Do (1988), the filled grains per panicle contributed greatly on yield. Similarly Lu (1988) and Prasad et al. (1988) reported direct effects of fertile grains per panicle followed by panicle number per plant and test weight. Reuben and Katuli (1989) also suggested the importance of filled grains per panicle on yield, followed by plant height and tillers per plant. The authors further suggested need of compromise for the optimum combination of these characters as, relationships between filled grains per panicle and plant height and tillers per plant were negative. The path analysis revealed the highest direct effects on yield by productive tiller number followed by panicle length and days to 50 per cent flowering. Highest negative direct effect was observed for plant height on yield (Mini, 1989).

Direct and indirect associations of four yield components with grain yield were measured in the drought tolerant lines by Ibrahim et al. (1990) and study revealed high direct effect of productive tillers, moderate direct effects of panicle length and flowering duration and slightly negative effect of plant height on grain yield. Path analysis of yield components showed that seedling height and culm length had considerable direct effect in both indica and japonica types (Amirthadevarathinam, 1990). In addition, tiller number in indica types and days to 50 per cent flowering in japonica types had positive direct effects. Bashar et al. (1991) reported the significant effects of flag leaf area on grain yield through grains per panicle and panicle length.

CHAPTER-III

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The present investigation was undertaken during Kharif, 1990 and 1991 and summer, 1992 at the Agricultural Research Station, Mugad, situated 11 km to the west of Dharwad city and falls in the Malnad (transitional) tract. It is located at 15°-50′ N latitude, 44°-40′ E longitude and at an altitude of 697 meters above the mean sea level. Another experiment was conducted during Kharif 1991 at Botanical Garden, University of Agricultural Sciences, Dharwad which is situated at 15°-26′ N latitude, 75°-07′ E longitude and at an altitude of 678 meters above the mean sea level. The three seasons during which the experiment was conducted at Agricultural Research Station, Mugad are referred as Kharif 1990, Kharif 1991(M) and Summer 1992 and the season of the experiment at Dharwad as Kharif 1991(D).

3.1 Experimental Material

The experimental material used in present investigation comprised of 44 genotypes, known for drought tolerance, received from Dr. M.Arradeau, Upland rice Breeder at International Rice Research Institute (IRRI), Los Banos, Philippines and six local checks. These genotypes exhibit wide range of variability for morphological and agronomic traits and are presented in Table 1.

3.2 Experimental Methods

The experimental material was sown directly in the main field with a spacing of 20 cms between rows in Randomized

Table 1. List of rice genotypes included in the study

Sl.No.	Genotypes	Grain type*	Place of origin
1	IR53236-275-2	LB	IRRI
2	IR53236-70-2	LB	"
3	IR53236-77-1	LB	"
4	IR53236-139	LS	"
5	IR53236-218-3	LB	"
6	IR53234-27-7	LB	"
7	IR53234-27-6	LB	"
8	IR53167-17	LB	"
9	IR55549-1-2	LB	"
10	IR55419-4	LB	"
11	IR55411-53	LS	"
12	IR55411-50	LB	"
13	IR57924-24	LS	"
14	IR57924-9	LB	"
15	IR57893-73	LB	"
16	IR57893-26	LB	"
17	IR55411-50	LB	"
18	IR60080-49	LB	"
19	IR60080-46B	LB	"
20	IR60080-45	LB	"
21	IR60080-42	LB	"
22	UPLRi-7	LB	Philippines
23	IRAT 288	LB	Africa
24	IRAT 216	LB	"
25	IRAT 212	LB	"
26	IRAT 144 (B)	LB	"
27	IRAT 104(A)	LB	"
28	IRAT 10	MB	"
29	IR47691-37-4-1	LB	IRRI
30	IR47691-17-1-B	MB	"
31	IR47686-30-2-1	LB	"
32	IR 47686-12-5-B-1	LB	"
33	IR47686-6-2-1-1	MB	"

Table 1. Contd....

Sl.No.	Genotypes	Grain type*	Place of origin
34	IR47686-6-1-1	LB	"
35	IR 47686-5-10-B	LB	"
36	IR47686-1-1-B	LB	"
37	IAC 165	LB	Brazil
38	IAC 25	LB	"
39	CT6727-5-3-3	LB	Colombia
40	CNA4130	LB	Brazil
41	CT6510-24-1-2	LB	Colombia
42	CNA5164	LB	Brazil
43	CNA4173	LB	"
44	CNA4136	LB	"
45	IET 2254	LB	India
46	IET 7991-11-2	MB	"
47	IET 1444	LB	"
48	Gama-318	LB	"
49	IET 5882	LB	"
50	IET 7564-4-3	LS	"

* LB : Long bold; LS : Long slender; MB : Medium bold

complete Block Design layout with two replications. Each experimental plot consisted six rows of three meter length. The thinning of rows was followed after the germination to maintain uniform population in all experimental plots. All the recommended agronomic packages of practices were followed to grow a successful crop. Ten plants from each experimental plot were randomly considered for recording the observations (Gomez, 1972). Data on days to 50 per cent flowering were recorded on plot basis and the data in respect of the remaining characters were recorded on the aforesaid plants.

The characters studied and techniques adopted to record observations are given below :

3.2.1 Days to 50 per cent flowering : This is expressed as the number of days after sowing until 50 per cent of the plants in a plot will come to flowering.

3.2.2 Plant height : Plant height was measured on ten randomly selected plants from ground level to the tip of the terminal spikelet. The average height of the plant was worked out from the samples and recorded in cm.

3.2.3 Culm length : Culm length was measured in cm from ground level to the base of panicle and average of ten culms was recorded.

3.2.4 First internode length : The first internode from top was measured in cm from base of panicle to the first node and mean of ten randomly selected plants was recorded.

3.2.5 Leaf area : The length of the third leaf from the panicle was measured in cm from joint of leaf blade with leaf sheath to tip of leaf blade. The leaf breadth was measured in cm at the middle portion of leaf blade. The leaf area was worked out by multiplying leaf length, leaf breadth and a factor 0.67 (Yoshida et al., 1976). The average leaf area was worked out from ten leaves of randomly selected plants.

3.2.6 Per cent green leaves : The number of green leaves per hill was counted at physiological maturity and number of dry leaves on the same hill was counted and percentage of green leaves was computed. The average per cent green leaves was worked out from ten randomly selected hills.

3.2.7 Panicle length : The length of panicle was measured in cm from base of the panicle to the tip of terminal spikelet. The average length of ten randomly selected panicle was recorded.

3.2.8 Flag leaf length : The flag leaf of ten randomly selected plants were measured in cm from the leaf base to the leaf tip and average was recorded.

3.2.9 Panicle Exsertion : The distance between panicle base and flag leaf collar was measured in cm and noted as positive panicle exsertion. The negative panicle exsertion was noted if the part of panicle was inside the flag leaf sheath by measuring the distance to what extent the panicle base was inside flag leaf sheath from collar of flag leaf and average of ten observations was recorded in cm.

3.2.10 Number of tillers per meter row : The tillers per meter row were counted and average of ten such observations was worked out and recorded.

3.2.11 Number of productive tillers per meter row : Panicle bearing tillers were counted in ten randomly considered one meter rows in a plot and its average was recorded.

3.2.12 Panicle weight : The ten matured panicles were selected randomly and weighed in grams and average panicle weight was recorded.

3.2.13 Number of grains per panicle : The filled grains in ten panicles randomly selected, were counted and mean number of grains per panicle was noted.

3.2.14 Per cent fertile grains in panicle : Fertile and sterile (chaffy) grains in ten matured panicles were counted and per cent fertile grains in panicle was computed and average per cent fertile grains in panicle was recorded.

3.2.15 1000-grain weight : One thousand grains from net plot yield which was dried were counted, weighted in grams and recorded.

3.2.16 Grain yield per plot : Net plots were harvested after removing the border rows. After threshing, winnowing, cleaning and sun-drying the produce, the grain weight for the individual plots was recorded.

3.3 Statistical method

3.3.1 Analysis of variance

The mean values of the genotypes in each replication were used for the analysis of variance. The replication mean values were subjected to RBD analysis (Snendecor and Cochran, 1967) separately for all four seasons data. The significance of differences among all the genotypes were tested by `F' test.

ANOVA TABLE

Source of Variation	D.F	M.S.S	Expectations	Variance ratio of `F'
Replication	r-1	RMSS		
Genotypes	v-1	VMSS	$\sigma_e^2 + r\,\sigma_g^2$	VMSS/EMSS
Error	(r-1)(v-1)	EMSS	σ_e^2	
Total	(rv-1)			

Where,

r = number of replications

v = number of genotypes

where, $S.Em. = \sqrt{\frac{EMSS}{r}}$

After testing for significance of difference among the means of different genotypes further computations were done as detailed below :

3.3.2 Genetic divergence

3.3.2.1 Estimation of D^2 values

The genetic divergence of 50 rice genotypes was estimated by using Mahalanobis' D^2 statistic, as suggested by Rao

(1952). The steps involved in the calculation of D^2 values utilising fifteen characters of the investigation were as follows :

i) A set of uncorrelated linear combinations (Y's) was obtained by the pivotal condensation of the common dispersion matrix (Rao, 1952) of a set of fifteen correlated variables (X's). The common dispersion matrix was arranged with the help of error mean sum of squares and sum of products.

ii) Using the relationship between Y's and X's the mean values of differant characters for each genotype (X_1 to X_{15}) were transformed into the mean values of a set of uncorrelated linear combinations (Y_1 to Y_{15}).

iii) The D^2 value for `K characters between i^{th} and j^{th} genotypes was computed as $D^2 = \sum_{t=1}^{k} (Y_{it} - Y_{jt})^2$

3.3.2.2 Group constellation

The significance of D^2 values was tested by treating them as χ^2 values at `t degrees of freedom at the significance level P = 0.05, where t' is the number of variables or characters considered.

The genotypes were grouped into a number of clusters, D^2 being treated as the square of generalised distance, according to the method described by Tocher (Singh and Chaudhary, 1979). The criterion used in clustering by this method was that any two varieties belonging to the same cluster should atleast on the average, show a smaller D^2 value than those belonging to two different clusters. If by the addition of a genotype the

increase in average D^2 value was beyond the level which should be approximately near to the maximum D^2 value shown by a genotype to nearest population, then the genotype was not included in that cluster. The smallest maximum D^2 value shown by a genotype to nearest population (100.98) among four seasons was considered as fixed level to include any genotype into a cluster.

3.3.2.3 Average intra-cluster and inter-cluster distance

For the measure of average intra-cluster distances in formula was $\Sigma Di^2/n$. Where ΣDi^2 was the sum of distance between all possible combinations (n) of the genotypes included in a cluster. The average D^2 of all possible combinations of genotypes in one cluster with those in the other was computed and its square root was used to represent distance between two clusters (Inter-cluster distance).

3.3.2.4 Contribution of individual characters towards divergence

In all combinations each character was ranked on the basis of $d_i = Y_i^i - Y_i^k$ values. Rank one was give to the highest mean difference and rank `t' to the lowest mean difference. The ranks were totalled for each D^2 component over all combinations and the rank totals were obtained.

Percentage contribution of Character
`X' = N(x) X 100/1225

Where,

N(x) = Number of genotypic combinations which were ranked first for character `X' out of total genotypic combinations of 1225 (All possible combinations between 50 genotypes).

3.3.3 Estimation of correlations

The analysis of covariance (ANCOVA) was conducted by following the method described by Singh and Chaudhary (1979) for 16 characters :

ANCOVA TABLE

Source of Variation	D.F	M.S.P	Expectations
Replication	r-1	RMSP	
Genotypes	v-1	VMSP	$\sigma_{e_1e_2} + r\,\sigma_{g_1g_2}$
Error	(r-1)(v-1)	EMSP	$\sigma_{e_1e_2}$
Total	(rv-1)		

$$Cov_{xy}\ (g) = \frac{VMSP-EMSP}{r}$$

$$Cov_{xy}\ (e) = EMSP$$

$$Cov_{xy}\ (p) = Cov_{xy}(g) + Cov_{xy}(e)$$

Phenotypic correlation

$$r_{xy}(P) = \frac{Cov_{xy}(p)}{\sqrt{Vx(p)\ X\ Vy(p)}}$$

Genotypic correlation

$$r_{xy}\ (g) = \frac{Cov_{xy}\ (g)}{\sqrt{V_x(g)\ x\ V_y(g)}}$$

Where,

Cov_{xy} (g) = Genotypic covariance between characters x and y

Cov_{xy} (p) = Phenotypic covariance between characters x and y

Cov_{xy} (e) = Error covariance between characters x and y

V_x(p) = Phenotypic variance of character X

V_y(p) = Phenotypic variance of character y

V_x(g) = Genotypic varince of character x

V_y(g) = Genotypic varince of character y

r_{xy}(p)= Phenotypic correlation coefficient among characters x and y

r_{xy}(g) = Genotypic correlation coefficient among characters x and y.

The significance of correlation coefficients was tested by comparing `r' values at (n-2) degrees of freedom where, n is number of genotypes tested.

The phenotypic and genotypic correlation coefficients for each character pair representing different environments were tested for their homogenity according to the method of Ausemus et al. (1938) as given by Hayes et al. (1955) by using Chi-square test as,

$$\aleph^2 = \sum (n_i-3)\, z_i^2 - \frac{[\Sigma (n_i-3)z_i]^2}{(n_i-3)}$$

For k-1, degrees of freedom

Where,

K = number of correlation coefficients to be tested

n_i = number of observations in i^{th} season

z_i = Fisher's transformed value for i^{th} correlation coefficient

The calculated $\aleph^2$ was tested against table value at five per cent level of significance. If calculated $\aleph^2$ is less than

table N^2 the hypothesis that correlation coefficients do not differ significantly is accepted. In such cases, the sum of weighted z's [$\Sigma (n_i-3)z_i$] was divided by sum of weights [$\Sigma (n_i-3)$] to get the average value of z. This was then transformed to `r' the average correlation coefficient.

3.3.4 Estimation of path-coefficients

The phenotypic correlation coefficients were further partitioned into direct and indirect effects with the help of path-coefficient analysis as suggested by Wright (1921) and Dewey and Lu (1959).

Grain yield per plot was assumed to be the dependent variable (effect) which is influenced by 14 other characters, the independent variables (causes) directly as well as indirectly through other characters. The variation in grain yield per plot unexplained by the fourteen causes was presumed to have been contributed by a residual factor `R' which is uncorrelated with other factors.

Path coefficients were obtained by solving the simultaneous equations which express the basic relationship between correlations and path coefficients. The equations were as follows :

$$r_{1,y} = P_{1,y} + r_{1,2}P_{2,y} + r_{1,3}P_{3,y} + \cdots\cdots + r_{1,14}P_{14,y}$$

$$r_{2,y} = P_{2,y} + r_{2,1}P_{1,y} + r_{2,3}P_{3,y} + \cdots\cdots + r_{2,14}P_{14,y}$$

$$r_{3,y} = P_{3,y} + r_{3,1}P_{1,y} + r_{3,2}P_{2,y} + \cdots\cdots + r_{3,14}P_{14,y}$$

$$\vdots$$

$$r_{14,y} = P_{14,y} + r_{14,1}P_{1,y} + r_{14,2}P_{2,y} + \cdots\cdots + r_{14,13}P_{13,y}$$

Where, $r_{1,y}$ to $r_{14,y}$ denote the correlation coefficients between independent characters 1 to 14 and dependent character `y', $r_{1,2}$ to $r_{13,14}$ denote the correlation coefficients between all possible combinations of independent characters and $P_{1,y}$ to $P_{14,y}$ denote the direct effects of characters 1 to 14 on character Y.

The above equations can also be written in matrix from as shown below ;

$$\begin{bmatrix} r_{1,y} \\ r_{2,y} \\ r_{3,y} \\ \vdots \\ r_{14,y} \end{bmatrix} = \begin{bmatrix} 1 & r_{1,2} & r_{1,3} & \cdots & r_{1,14} \\ & 1 & r_{2,3} & \cdots & r_{2,14} \\ & & 1 & \cdots & r_{3,14} \\ & & & & \vdots \\ & & & & 1 \end{bmatrix} \begin{bmatrix} P_{1,y} \\ P_{2,y} \\ P_{3,y} \\ \vdots \\ P_{14,y} \end{bmatrix}$$

A B C

`B' matrix was inverted and the inverted `B' matrix was multiplied by `A' matrix to obtain path coefficients. Residual factor which measures the contribution of rest of the characters of usual scheme was obtained as fallows ;

$$P_{xy} = \sqrt{1-R^2}$$

Where,

$$R^2 = \sum P^2_{i,y} + 2\sum_{i<j} P_{i,y}\, P_{j,y}\, r_{i,j}$$

which is the square of the multiple correlation coefficient (R) and is known as coefficient of determination.

CHAPTER-IV

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of the investigation are presented under the following sub-heads.

1. Analysis of variance
2. Analysis of genetic divergence
3. Character associations
4. Path coefficient analysis

4.1 Analysis of variance

Before proceeding with the detailed statistical analysis a general analysis of variance was conducted separately for four seasons with respect to 16 characters to test the significance of difference between various genotypes. The mean sum of squares for 16 characters analysed for four seasons are presented in Table 2.

Analysis of variance revealed that the genotypes differed significantly even at one percent probability level for all the characters and in all four seasons. This indicated that there were inherent genetic differences among the genotypes studied for all the characters considered. The mean performance of the genotypes for all 16 characters is presented in Appendices III to VI.

4.2 Analysis of genetic divergence

4.2.1 Season-1 [Kharif, 1990 at ARS, Mugadl

4.2.1.1 Mahalanobis' generalised distance (D^2)

A generalised distance (D^2) was calculated for all n(n-1)/2 pair of combinations; among the 1225 possible

Table 2. Analysis of variance for sixteen charecters in rice

	D.F.	MEAN SUM OF SQUARES														
		Plant height (cm)	Culm length (cm)	First internode length (cm)	Leaf area (cm^2)	% green leaves	Panicle length (gm)	Flag leaf length (cm)	Panicle exsertion (cm)	No. of effective tillers/m	No. of effective tillers/m	Days 50 % flowering	Panicle weight (gm)	Number of fertile grains/p (gm)	% fertile grains/p	1000 grain vieght (gm)	Plot yield (gm)
SEASON I																	
Replication	1	328.062	242.750	31.25	8.242	69.500	5.527	55.828	1.705	745.312	488.406	7.312	4.219	2621.187	12.062	13.414	71080.00
Genotypes	49	236.274	173.354	18.03	75.882	144.326	12.709	32.612	7.735	701.777	528.171	282.576	1.367	1069.512	76.440	50.236	239372.51
Error	49	17.256	10.647	3.866	6.794	29.405	2.449	5.923	0.452	111.554	112.573	5.983	0.154	168.123	18.275	7.254	13971.75
S.Em.±		2.937	2.307	1.39	1.843	3.834	1.107	1.721	0.475	7.468	7.502	1.729	0.277	9.169	3.023	1.904	83.582
C.D. (0.05)		8.348	6.557	3.951	5.238	10.897	3.146	4.892	1.350	21.226	21.323	4.914	0.787	26.061	8.592	5.412	237.562
C.D. (0.01)		11.136	8.747	5.270	6.988	14.537	4.197	6.525	1.801	28.316	28.445	6.556	1.050	34.766	11.462	7.219	316.916
SEASON II																	
Replication	1	5.000	34.781	1.593	2.703	68.250	16.683	26.535	1.295	296.812	892.750	0.562	2.399	186.500	0.000	2.882	58336.000
Genotypes	49	211.173	173.986	20.519	60.631	101.306	9.744	22.927	5.848	1465.897	1292.733	278.051	1.144	776.719	55.868	37.328	519776.000
Error	49	26.887	22.058	3.827	11.393	47.609	2.579	6.282	0.475	170.449	133.770	0.896	0.180	86.372	17.039	4.519	25881.950
S.Em.±		3.667	3.321	1.914	2.387	4.879	1.136	1.772	0.487	9.232	8.178	0.669	0.300	6.572	2.919	1.503	113.758
C.D. (0.05)		10.423	9.439	5.440	6.784	13.867	3.229	5.036	1.384	26.239	23.244	1.901	0.853	18.679	8.297	4.272	323.330
C.D. (0.01)		13.904	12.592	7.257	9.051	18.499	4.307	6.719	1.847	35.005	31.008	2.537	1.138	24.919	11.068	5.699	431.334
SEASON III																	
Replication	1	250.313	134.594	0.059	0.023	21.781	22.199	2.930	0.955	1036.844	372.500	2.000	0.035	426.063	2.688	22.086	10140.000
Genotypes	49	214.556	155.639	20.297	91.356	108.113	12.247	30.298	7.173	446.228	176.241	266.103	0.359	181.313	300.616	69.435	29281.920
Error	49	22.32	16.300	2.408	5.706	25.899	3.093	4.410	0.257	87.003	45.082	2.653	0.051	59.233	28.841	3.599	3808.755
S.Em.±		3.341	2.855	1.097	1.689	3.599	1.244	1.485	0.358	6.596	4.748	1.152	0.160	5.442	3.797	1.341	43.639
C.D. (0.05)		9.496	8.115	3.119	4.801	10.229	3.535	4.221	1.019	18.748	13.496	3.274	0.455	15.469	10.794	3.813	124.046
C.D. (0.01)		12.668	10.826	4.161	6.405	13.646	4.716	5.631	1.359	25.011	18.004	4.368	0.607	20.637	14.400	5.087	165.484
SEASON IV																	
Replication	1	114.218	81.296	9.855	22.943	26.640	2.496	53.009	0.344	94.093	0.016	3.687	0.019	111.343	13.625	2.335	14232.000
Genotypes	49	90.882	58.611	9.767	32.444	76.582	9.500	18.119	8.342	742.069	361.964	284.474	0.117	125.436	240.396	64.164	67645.300
Error	49	9.791	5.305	1.368	2.972	17.285	3.070	1.179	0.348	62.192	20.132	1.363	0.015	25.791	17.541	2.538	2042.449
S.Em.±		2.213	1.630	0.827	1.219	2.939	1.239	0.768	0.419	5.576	3.173	0.826	0.087	3.591	2.962	1.126	31.957
C.D. (0.05)		6.289	4.630	2.351	3.465	8.353	3.522	2.183	1.185	15.848	9.018	2.348	0.247	10.207	8.419	3.200	90.830
C.D. (0.01)		8.391	6.177	3.136	4.622	11.144	4.698	2.912	1.581	21.142	12.031	3.132	0.329	13.616	11.231	4.269	121.171

All the genotypes differ significantly at 0.01 level of probability in all seasons.

combinations about 99.51 per cent of the D^2 statistics were significant at the 0.05 level of probability.

4.2.1.2 Contribution of different characters towards divergence

Each character contributed a different proportion to the total D^2 statistics. The days to 50 per cent flowering was the largest contributor in 576 cases out of 714 comparisons (47.02%), plot yield in 153 cases (12.49%), panicle exsertion in 147 cases (12.00%), total tillers in 98 combinations (8.00%), 1000-grain weight in 83 cases (6.78%). The contributions to total genetic divergence by plant height, leaf area, flag leaf length, per cent green leaves, panicle weight, productive tillers, per cent fertile grains, culm length and first internode length were 4.89, 2.28, 1.63, 1.31, 1.22, 0.89, 0.82, 0.41 and 0.25 per cent respectively, while contribution of panicle length to total genetic divergence was zero. It was apparent that days to 50 per cent flowering was the major contributor to the differences among these genotypes. The plot yield and panicle exsertion moderately contributed to genetic divergence.

4.2.1.3 Group constellations

All the genotypes with different grain types (plate-1) were grouped into thirteen clusters in such a way that genotypes within each cluster had smaller D^2 statistics than those from other clusters, that is, average intra-cluster divergence did not exceed 101.00. Table 3 lists the genotypes in each of the thirteen clusters. The clustering pattern revealed the formation of cluster I by 11 genotypes with long

PLATE - 1. Grain types of genotypes

Long slender (LS)	Long bold (LB)	Medium bold (MB)
4. IR53236-139	1. IR53236-275-2	28. IRAT 10
11. IR55411-53	9. IR55549-1-2	30. IR47691-17-1-B
13. IR57924-24	10. IR 55419-4	
50. IET7564-4-3	14. IR57924-9	
	27. IRAT 104(A)	
	34. IR47686-6-1-1	
	41. CT6510-24-1-2	

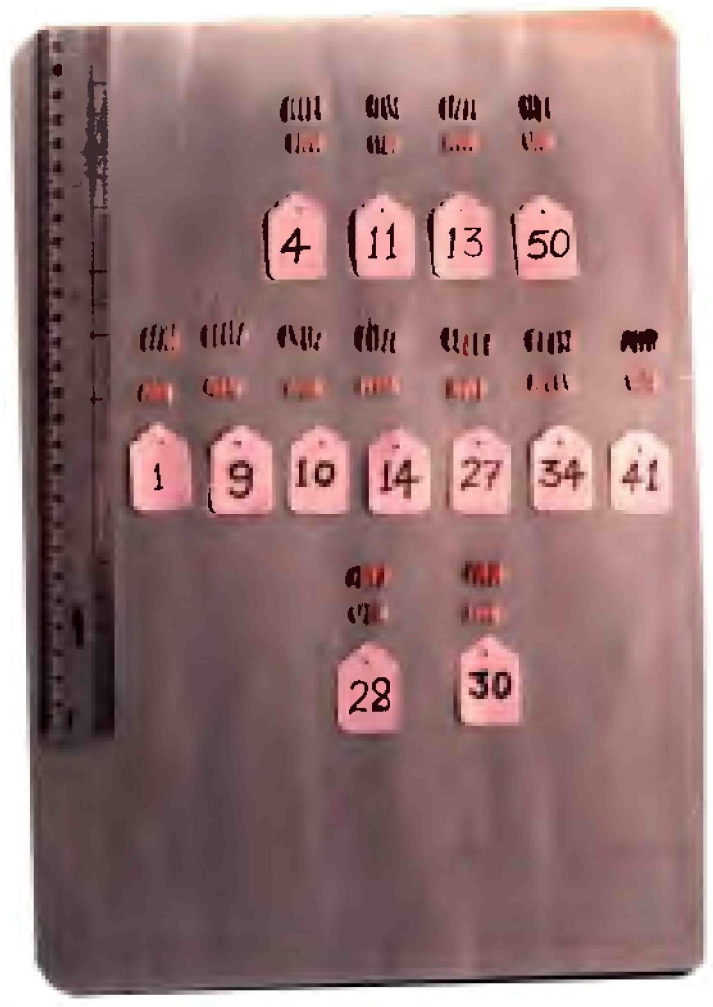


PLATE – 1

Table 3. Distribution of 50 rice genotypes in different clusters (Season-I)

Cluster No.	Number of genotypes	Genotypes included	Origin or Source
I	11	IR53167-17, IR57893-26, IR55411-50, IRAT288, IR47691-37-4-1, IAC165, IAC25, CNA4130, CNA5164, CNA4173, CNA4136	IRRI, AFRICA, BRAZIL
II	10	IR53236-275-2, IR53236-77-1, IRAT212 IR53236-139, IRAT10, IR53236-218-3, IR53234-27-7, IR53234-27-6, IRAT144(B), IET7564-4-3	IRRI, AFRICA, INDIA
III	7	IR60080-49, IR60080-45, IRAT104(A), IR47686-12-5-B-1, IR47686-6-2-1-1, IR47686-6-1-1, IR47686-5-10-B	IRRI, AFRICA
IV	10	IR55411-53, IR55411-50-1, IR57924-24, IR60080-46B, IR60080-42, IRAT216, CT6727-5-3-3, IET1444, Gama-318, IET5882	IRRI, AFRICA, COLOMBIA, INDIA
V	2	IR55549-1-2, IR47686-30-2-1	IRRI
VI	3	IR55419-4, UPLRi 7(B), CT6510-24-1-2	IRRI, PHILIPPINE COLOMBIA
VII	1	IR 53236-70-2	IRRI
VIII	1	IR57924-9,	IRRI
IX	1	IR57893-73	IRRI
X	1	IR47691-17-1-B	IRRI
XI	1	IR47686-1-1-B	IRRI
XII	1	IET2254	INDIA
XIII	1	IET7991-11-2	INDIA

bold grain type. Four genotypes were IRRI lines, one from Africa and remaining six genotypes were from Brazil. Cluster II with ten genotypes contained mostly lines of IRRI (6), three lines from Africa and one line from India (IET 7564-4-3) which was having long slender grain type. The line IR53236-139 was also with long slender grain type, while IRAT 10 was having medium bold grain type and all other lines in this cluster were having long bold grains. Six IRRI lines and an African line IRAT 104 (A) form cluster III. Variety IR47686-6-2-1-1 had medium bold graines, while others had long bold grains. Three Indian lines viz., IET 1444, Gama 318 and IET 5882 along with five IRRI lines, one African line and one from Colombia were grouped in cluster IV in which IR55411-53 and IR57924-24 had long slender grains and others had along bold grains. Clusters V and VI contained two IRRI lines and three lines (from IRRI, Philippines and Colombia) respectively. Seven clusters (VII to XIII) contained only one genotype each.

A marked inter-cluster variation may be ascertained from the cluster means for characters depicted in Table 4. These values give an idea of the productivity and other features of each cluster. A close examination of the means of cluster revealed considerable differences between the clusters for all the characters studied. The remarkable differences have been observed for panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight and plot yield. However, these values were not varied conspicuously for plant height, culm length, first internode length, leaf area, per

Table 4. Cluster means for different characters in rice (Season - I)

Cluster	1 Plant height (cm)	2 Culm length (cm)	3 First internode length (cm)	4 Leaf Area (cm^2)	5 % green leaves	6 Panicle length (cm)	7 Flag leaf length (cm)	8 Panicle exsertion (cm)	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50 % flowering	12 Panicle weight (gm)	13 %fertile grains	14 1000 grain weight (gm)	15 Plot yield (gm)
I	86.60	67.51	29.33	22.43	53.07	18.90	24.95	2.91	50.64	44.05	87.73	3.13	90.23	33.97	1078.45
II	71.04	53.87	26.44	15.16	49.26	17.47	19.11	1.84	68.15	51.40	76.45	2.01	90.73	33.08	683.00
III	93.89	70.01	30.62	28.09	52.49	22.83	25.59	1.76	49.86	45.29	101.00	4.23	91.21	34.94	1335.00
IV	78.91	58.14	27.29	23.51	47.74	20.79	23.11	-0.42	65.90	58.20	102.20	2.85	83.50	25.17	1235.70
V	97.42	74.65	35.69	34.95	46.22	22.77	28.22	4.82	47.00	40.50	101.50	3.62	88.80	33.20	910.50
VI	75.76	56.62	28.77	20.93	33.03	20.53	26.13	2.26	67.33	58.33	98.33	3.06	85.55	26.48	1138.00
VII	82.85	64.90	30.15	13.65	29.60	17.95	18.45	5.45	72.00	49.00	72.00	1.79	89.55	32.25	537.00
VIII	80.39	58.54	27.70	27.55	54.80	21.85	27.75	-0.98	109.00	95.00	112.50	3.03	73.90	25.35	1929.00
IX	83.61	64.88	26.24	20.60	57.45	18.70	19.60	0.98	73.00	58.00	86.00	2.45	90.45	33.40	432.00
X	77.75	58.05	29.00	24.50	49.75	19.70	22.45	3.35	36.00	36.00	105.50	3.33	92.90	30.65	1572.00
XI	94.78	71.31	31.31	30.95	56.15	23.45	27.55	-0.37	48.00	41.00	104.00	3.58	92.15	35.95	612.00
XII	54.65	35.08	25.50	22.40	55.65	18.00	21.70	-0.85	104.00	94.00	88.00	2.05	81.05	24.15	906.00
XIII	65.19	47.69	23.37	15.05	35.55	17.45	17.85	-1.92	105.00	97.00	88.00	1.90	69.65	27.95	1383.00

cent green leaves, panicle length, flag leaf length, per cent fertile grains and 1000-grain weight. The clusters IV, VIII, XI, XII, and XIII showed negative panicle exsertion (-0.42, -0.98, -0.37, -0.85, and -1.92 cm, respectively) indicating that they were comprised of genotypes with poor panicle exsertion. Clusters V, VII and X had higher panicle exsertion (4.82, 5.45, and 3.35 cm, respectively). The mean for productive tillers was minimum for cluster X (36.00) and higher for clusters VIII (95.00), XII (94.00) and XIII (97.00). The total and productive tillers were moderate for genotypes belonging to other clusters. The clusters II and VII showed low mean values for days to 50 per cent flowering (72.00 and 76.45 respectively) indicating that they were comprised of early genotypes. Cluster VIII had the highest mean for days to 50 per cent flowering (112.50). Regarding panicle weight cluster III occupied top position with mean panicle weight of 4.23 grams followed by clusters V, XI, X and I. Cluster VII had the lowest panicle weight (1.79 gm). In respect of percentage of fertile grains the cluster X had high mean value (92.90) followed by clusters XI, III, II, IX and I.

Considering the variation in yield, cluster VIII had a variety with highest grain yield per plot (1929.00 gm) followed by clusters X (1572.00 gm), XIIII (1383.00 gm), III (1335.00 gm), IV (1235.70 gm), VI (1138.00 gm) and cluster I (1078.45 gm). Clusters VII and IX revealed low grain yield per plot of 537.00 and 432.00 grams respectively.

Average intra and inter-cluster D^2 values have been given in Table 5 (upper diagonal values). The table suggests that

Table 5. Average intra and inter-culture D^2 (upper diagonal) and D (lower diagonal) values (season - I)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
I	87.78 (9.36)	174.51	162.73	175.52	190.83	152.18	274.10	321.95	118.90	183.36	203.71	336.75	251.72
II	13.21	77.41 (8.79)	391.12	276.08	378.28	202.59	139.43	519.72	109.66	375.85	381.19	201.42	186.11
III	12.75	19.77	77.97 (8.83)	148.57	150.90	215.16	565.39	196.70	235.92	114.73	117.38	484.79	362.79
IV	13.24	16.61	12.18	82.22 (9.06)	220.29	136.62	483.59	135.62	173.24	130.99	148.14	237.73	184.48
V	13.81	19.44	12.28	14.84	41.17 (6.41)	181.01	402.06	375.03	225.73	135.59	133.31	504.71	506.22
VI	12.33	14.23	14.66	11.68	13.45	84.87 (9.21)	283.30	273.74	189.76	130.27	261.56	221.46	213.38
VII	16.55	11.80	23.77	21.99	20.05	16.83	-	850.87	224.63	519.66	574.23	429.82	407.29
VIII	17.94	22.79	14.02	11.64	19.36	16.54	29.16	-	369.12	201.63	244.29	344.79	242.49
IX	10.90	10.47	15.35	13.16	15.02	13.77	14.98	19.21	-	308.73	138.70	234.66	204.32
X	13.54	19.38	10.71	11.44	11.64	11.41	22.79	14.19	17.57	-	215.06	399.05	359.72
XI	14.27	19.52	10.83	12.17	11.54	16.17	23.96	15.82	11.77	14.66	-	445.07	400.52
XII	18.35	14.19	22.02	15.42	22.46	14.88	20.73	18.56	15.31	19.97	21.09	-	110.33
XIII	15.86	13.64	19.20	13.58	22.49	14.60	20.18	15.57	14.29	18.96	20.01	10.50	-

Figures in parenthesis are intra-cluster D values.

average intra-cluster divergence varies from 41.17 to 87.78. Minimum intra cluster D^2 value was observed in cluster V which included two lines of IRRI. However, cluster I had the highest intra-cluster D^2 value and comprised of eleven varieties from IRRI, Africa and Brazil. Clusters VII to XIII had no intra cluster distance (zero) as each of them possessed single genotype.

As regards inter-cluster distances, cluster VII and cluster VIII were maximum distantly related (850.87). Cluster II revealed least distance with cluster IX (109.66). The moderate genetic distances were observed between clusters II and VIII (519.72), III and VII (565.39), V and XII (504.71), V and XIII (9506.22), VII and X (519.66) and clusters VII and XI (574.23). Cluster I and IX, II and VII, III and X, III and XI, IV and VI, IV and VIII, IV and X, V and XI, VI and X, IX and XI and clusters XII and XIII were not much distantly related. The statistical distance between thirteen clusters as represented by intra and inter-cluster average D ($\sqrt{D^2}$) values have been presented in Table 5 (lower diagonal values) and pictorially represented in Fig 1. The table and figure depicting intra and inter-cluster distances revealed the same pattern of relationship as described by using intra and inter-cluster D^2 values.

4.2.2 Season-II [Kharif, 1991 at ARS, Mugad]

4.2.2.1 Mahalanobis' generalised distance (D^2)

The correlated unstandardised means of characters were transformed to standardised set of variables. The statistical distance (Mahalanobis' D^2) between pairs of genotypes was

The inter-cluster distances (D) are given in Table 5.

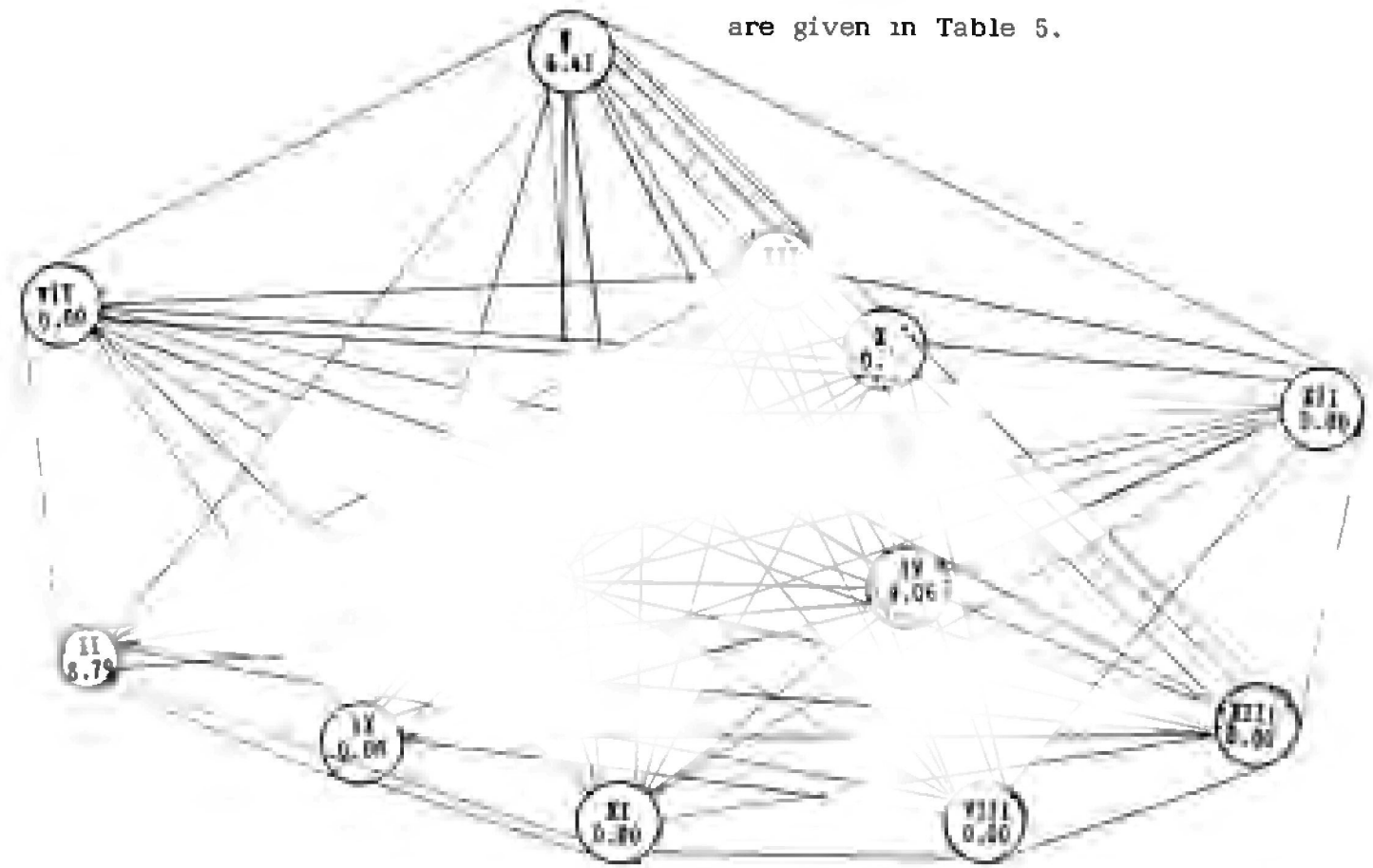


FIG.1. AVERAGE INTRA AND INTER-CLUSTER DISTANCES (D) AMONG 50 GENOTYPES OF RICE (SEASON-I)

obtained as the sum of squares of differences between pairs of corresponding uncorrelated values of any two genotypes. Since each cultivar produced 49 combinations, 1225 D^2 values were obtained for 50 cultivars. The D^2 values obtained for a pair of cultivar was taken as the calculated value of χ^2 and tested against the tabulated value of χ^2 for 15 degrees of freedom. Among all D^2 values 122 (99.75%) were found to be significant at 0.05 level of probability.

4.2.2.2 Contribution of different characters towards divergence

The proportion of contribution of each character to the total D^2 statistics was different. Days to 50 per cent flowering was the single largest contributor in 842 cases out of 1225 combinations (68.735%) followed by grain yield per plot (15.755%), 1000-grain weight (3.918%), panicle weight (2.857%), panicle exsertion (2.694%), total tillers (1.633%), plant height (1.551%), per cent fertile grains (0.816%), panicle length (0.735%) and flag length (0.571%). The contribution of both length of first internode and leaf area were lowest (0.327) while culm length and per cent green leaves did not contribute any thing towards total genetic divergence. It was apparent that days to 50 per cent flowering was the only major contributor to differences among the different cultivars, supplimented by moderate contribution of plot yield and 1000-grain weight.

4.2.2.3 Group constellations

By using the estimated D^2 values, fifty cultivars were grouped into 18 clusters following the method suggested by

Tocher (Rao, 1952). The distribution pattern of cultivars into various clusters is shown in Table 6. The clustering pattern revealed cluster I to be the largest of all cluster consisting of twelve genotypes with long bold grains except IR 53236-139 (with long slender grains). Among twelve clusters, nine belonged to IRRI in this group while remaining were from Brazil (IAC 25 and CNA 4130) and India (IET 7991-11-2). Based on cluster means for different characters, it is evident that this largest group consisted mostly the cultivars with early flowering with average height of 89.06 cms. The genotypes of this cluster had medium panicle length (19.26 cms), low panicle weight (1.947 gms) and low yielding ability (706.76 gms/plot). Cluster II consisted of eight genotypes with long bold grains from sources of IRRI, Africa and Colombia. Most of the genotypes in this cluster had medium height (84.34 cms), moderate panicle weight (2.587 gms) and moderately high yielding ability (1033.05 gms/plot) coupled with medium flowering. Five IRRI lines along with a line from Colombia (CT-6727-5-3-3) were distinctly separated together from others to form the cluster III in which IR55441-53 had long slender grains while others had long bold grains. These genotypes were medium flowering and high yielding with high tillering ability (115.4 tillers/meter row). Cluster IV contained five genotypes of which four were from Brazil and IET 7564-4-3 (with long slender grains) from India. Average yield of these genotypes was low (663.74 gms/plot) except for IR 7564-4-3 which was moderate in yielding ability (1003.5 gms/plot). Interestingly all of them were early flowering. Clusters V

Table 6. Distribution of 50 rice genotypes in different clusters (Season-II)

Cluster No.	Number of genotypes	Genotypes included	Origin or Source
I	12	IR53236-275-2, IAC25, IR53236-70-2, IR53236-77-1, CNA4130, IR53236-139, IR53236-218-3, IR53234-27-7, IR53234-27-6, IR53167-17, IR53893-73, IET7991-11-2	IRRI, BRAZIL, INDIA
II	8	IR60080-49, IR60080-42, IRAT216, IR47691-37-4-1, IR47686-6-2-1-1, IR47686-6-1-1, IR47686-5-10-B, CT6510-24-1-2	IRRI, AFRICA, COLOMBIA
III	6	IR55419-4, IR55411-53, IR55411-50-1, IR57924-9, IR55411-50, CT6727-5-3-3	IRRI, COLOMBIA
IV	5	IAC165, CNA5164, CNA4173, CNA4136, IET7564-4-3	BRAZIL, INDIA
V	2	IR55549-1-2, IRAT288	IRRI, AFRICA
VI	2	IR57893-26, IRAT212	IRRI, AFRICA
VII	4	UPLRi 7(B), IRAT104(A), IR47691-17-1-B, IR47686-12-5-B-1	PHILIPPINE AFRICA, IRRI
VIII	1	IR57924-24	IRRI
IX	1	IR60080-46B	IRRI
X	1	IR60080-45	IRRI
XI	1	IRAT144(B)	AFRICA
XII	1	IRAT10	AFRICA
XIII	1	IR47686-30-2-1	IRRI
XIV	1	IR47686-1-1-B	IRRI
XV	1	IET2254	INDIA
XVI	1	IET1444	INDIA
XVII	1	Gama-318	INDIA
XVIII	1	IET5882	INDIA

and VI, each had two genotypes. Both genotypes in cluster V were taller and medium flowering while genotypes of cluster VI were dwarf (63.08 cms) and early flowering with short panicle (14.00 cms). However, all genotypes in both clusters were moderately yielding. Clusters VII included four genotypes, shared one each by Philippines and Africa and two by IRRI which were relatively late flowering (97.12 days) and moderately low yielding. Clusters VIII to XVIII, each possessed only one genotype.

It is evident from Table 7 that clusters differed significantly for all the characters studied. The genotypes IR 57924-24, Gama 318 and IET 5882 constituting clusters VIII, XVII and XVIII respectively were high yielders and comparatively late flowering with medium panicle length and had relatively more tillers. Plant height, culm length and flag leaf length were maximum in cluster XI consisting IR 60080-46B which was early flowering and low yielding. The total and productive tillers were moderately high in this variety while panicle length was low. Cluster X had a genotype of moderate yielding (1202.00 gms/plot) ability and moderately late maturing with maximum panicle length (24.40 cms), moderate total and productive tillers and high panicle weight (3.370 gms). Dwarf variety IRAT 144(B) constituting cluster XI had moderate panicle length (17.05 cms), moderate total (54.00) and productive tillers (47.75), high percentage of fertile grains (93.65%) with maximum 1000-grain weight and it was moderate yielder (1065.60 gms/plot). Although cluster XII with IRAT 10 having medium bold grain type had higher

Table 7. Cluster means for different charecters in rice (Season - II)

Cluster	1 Plant height (cm)	2 Culm length (cm)	3 First internode length (cm)	4 Leaf Area (cm^2)	5 % green leaves	6 Panicle length (cm)	7 Flag leaf length (cm)	8 Panicle exsertion (cm)	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight (gm)	13 %fertile grains	14 1000 grain weight (gm)	15 Plot yield (gm)
I	89.06	69.89	29.44	24.43	56.18	19.26	24.60	2.86	81.51	73.88	70.08	1.974	90.50	31.15	706.76
II	84.34	64.46	28.94	24.32	58.23	19.66	22.32	3.01	92.12	86.03	90.87	2.587	83.68	29.08	1033.05
III	86.46	65.89	29.51	22.59	58.65	20.53	24.21	2.17	115.40	107.33	87.58	2.825	87.30	25.52	1994.80
IV	88.19	70.52	27.66	22.96	49.45	17.68	22.50	1.98	112.25	105.00	73.10	2.939	85.98	30.49	663.24
V	94.60	77.17	30.53	24.17	56.50	17.37	22.48	4.12	112.12	103.87	85.25	2.390	86.52	29.70	1001.20
VI	63.08	49.57	22.12	13.87	58.75	14.00	16.55	0.67	93.50	88.00	74.00	1.963	92.42	34.02	1083.00
VII	86.78	65.95	29.93	27.46	57.50	21.08	24.69	2.99	97.50	84.75	97.12	2.758	87.15	27.35	838.93
VIII	81.00	60.90	28.70	15.90	57.10	22.60	20.70	2.62	112.50	94.50	91.50	3.010	82.35	23.75	1852.00
IX	103.90	87.30	29.35	26.25	62.75	16.60	25.10	4.08	128.00	120.00	67.50	3.300	92.65	27.25	820.30
X	94.40	70.00	30.45	31.60	58.65	24.40	17.00	2.70	103.50	93.75	92.00	3.370	84.70	23.40	1202.00
XI	66.75	49.80	23.70	22.85	56.55	17.05	19.70	5.33	54.00	47.75	79.50	2.070	93.65	35.30	1065.60
XII	68.70	52.10	25.70	30.50	81.85	16.60	20.35	-0.56	37.50	34.00	75.00	3.660	87.35	29.30	628.00
XIII	103.20	82.70	37.00	35.20	64.60	20.50	23.70	8.20	110.00	102.00	93.50	2.380	85.05	31.65	1007.50
XIV	95.75	76.95	29.25	27.75	67.00	18.85	23.70	2.46	44.00	42.00	91.00	4.470	94.95	33.80	657.90
XV	71.80	53.80	25.15	13.95	57.80	18.00	19.10	-1.16	98.00	89.00	104.50	2.150	82.80	25.85	641.50
XVI	89.50	69.60	34.65	19.10	48.80	20.10	21.05	4.94	173.50	163.50	103.50	2.440	93.05	21.10	900.20
XVII	72.50	55.05	23.75	16.20	45.35	17.46	16.65	0.18	131.00	126.75	98.50	1.940	77.80	25.90	1868.20
XVII	90.70	70.35	34.50	25.55	57.10	20.35	22.60	1.84	91.50	71.00	112.00	2.800	93.00	20.80	1811.90

panicle weight (3.660 gms) and per cent green leaves in at hill (81.85%), it was lowest with respect to yielding ability (628.00 gms/plot) owing to lower panicle length (16.60 cms) and lowest total (37.50) and productive tillers (34.00). Cluster XIII had highest length of first internode from panicle base (37.00 cms) and leaf area (35.20 cm^2), whereas, these traits were lowest in cluster VI. Medium tall and medium flowering genotype, IR 47686-1-1-B constituting cluster XIV had highest panicle weight (4.470 gms) and per cent fertile grains in a panicle (94.95%). However, it was low yielding (657.90 gms/plot) as it had less number of total and productive tillers. Cluster XV with genotype IET 2254 showed lower yield (641.50 gms/plot). Moderately late maturing genotype IET 1444 revealed highest total and productive tillers whereas, it had lowest 1000-grain weight (21.10 gms) and lower panicle weight (2.440 gms) and showed fairly lower yield (900.20 gms/plot). Panicle exsertion was negative in clusters, XII (-0.56) and XV (-1.16), whereas, it was positive in all clusters and highest in cluster XIII (8.20 cms).

Intra and inter-cluster average D^2 values have been presented in Table 8 (upper diagonal values). If we look at the intra (within) cluster distance, cluster VI with two genotypes, one each from IRRI and Africa revealed the maximum genetic diversity (93.35) among themselves, whereas, cluster V comprising of two genotypes showed lowest divergence (41.91) among its constituents. However, clusters VIII to XVIII each had a single genotype, thus having no intra-cluster distance (zero). The intra-cluster distance was also high in cluster

Table 8. Average intra and inter-cluster D^2 (upper diagonal) and D (lower diagonal) values (Season - II)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII
I	77.33 (8.79)	791.85	636.94	123.21	487.91	142.85	1308.90	848.55	179.82	959.19	293.97	207.84	1173.73	980.84	1866.72	2143.95	1307.99	2668.13
II	28.13	74.08 (8.60)	195.22	562.66	106.80	658.12	148.84	150.08	686.69	108.98	325.06	591.92	143.35	175.65	340.21	481.13	202.40	452.59
III	25.23	13.97	84.68 (9.20)	477.45	163.00	472.81	410.87	117.23	731.65	266.95	292.55	598.63	354.67	494.03	692.99	755.20	226.95	962.47
IV	11.10	23.72	21.85	68.57 (8.28)	292.79	179.19	975.25	612.55	111.63	660.19	291.84	189.26	888.56	683.31	1453.48	1649.25	1016.59	2207.78
V	22.08	10.33	12.75	17.11	41.91 (6.47)	433.11	282.54	165.11	474.07	166.69	229.15	421.05	211.75	209.85	589.77	665.73	346.05	1007.65
VI	11.91	25.65	21.74	13.38	20.81	93.35 (9.66)	1155.75	673.51	336.32	874.87	197.16	189.67	1084.45	920.61	1579.14	1952.28	994.77	2347.66
VII	36.17	12.20	20.26	31.22	16.80	33.99	92.62 (9.62)	252.31	1327.70	131.61	668.72	997.59	126.69	167.95	161.05	239.79	229.35	367.26
VIII	29.12	12.25	10.82	24.74	12.84	25.95	16.07	-	906.39	160.12	405.75	746.11	271.41	384.82	460.46	489.13	144.00	711.40
IX	13.40	29.47	27.04	10.56	21.77	18.33	36.43	30.10	-	943.63	527.75	354.7	1169.13	929.82	1936.26	1985.1	1445.73	2716.51
X	30.97	10.43	16.33	25.69	12.91	29.57	11.47	12.65	30.71	-	517.93	715.60	142.90	176.44	324.63	338.13	247.34	571.79
XI	13.92	18.02	17.10	17.08	15.13	14.04	25.85	20.14	22.97	22.75	-	273.13	547.15	539.99	1091.21	1362.55	644.57	1632.89
XII	14.41	24.32	24.46	13.75	20.51	13.77	31.58	27.31	18.83	26.75	16.52	-	991.76	644.49	1386.54	1844.61	1097.15	2189.26
XIII	34.25	11.97	18.83	29.80	14.55	32.93	11.25	16.47	34.19	11.95	23.39	31.49	-	224.58	373.70	296.85	290.87	502.19
XIV	31.31	13.25	22.22	26.14	14.48	30.34	12.95	19.61	30.49	13.28	23.23	25.38	14.98	-	333.18	524.60	495.94	737.16
XV	43.20	18.44	26.32	38.12	24.28	39.73	12.69	21.45	44.00	18.01	33.03	37.23	19.33	18.25	-	240.09	258.20	232.29
XVI	46.30	21.93	27.48	40.61	25.80	44.18	15.48	22.11	44.55	18.38	36.91	42.94	17.22	22.90	15.49	-	379.10	198.19
XVII	36.16	14.22	15.06	31.88	18.60	31.53	15.14	12.00	38.02	15.72	25.38	33.12	17.05	22.26	16.06	19.47	-	413.38
XVIII	51.65	21.27	31.02	46.98	31.74	48.45	19.16	26.67	52.12	23.91	40.40	46.79	22.40	27.15	15.24	14.07	20.33	-

Figures in parenthesis are intra-cluster D values.

VII (92.62) and III (84.68), whereas, cluster I (77.33) cluster II (74.08) and cluster IV (68.57) showed moderate diversity among their constituents.

With regard to the inter (between) cluster distances, it was observed that clusters IX and XVIII were most distantly related with an inter cluster distance of 2716.51. Cluster II revealed the least distant relationship with cluster V (106.80). Clusters I and VII (1308.90), I and XIII (1173.73), I and XV (1866.72), I and XVII (1307.99), IV and XV (1453.48), IV and XVI (1649.25), IV and XVII (1016.59), V and XVIII (1007.65), VI and VII (1155.75), VI and XIII (1084.45, VI and XV (1579.14), VII and IX (1327.70), VII and XII (997.59), IX and XIII (1169.13), XI and XVII (1445.73), XI and XV (1091.21), XI and XVI (1362.55), XI and XVIII (1632.89), XII and XV (1386.54), XII and XVI (1844.61) and XI and XVII (1097.15) were moderate with respect to genetic divergence as shown within brackets. The between cluster distance was also high in clusters I and XVI (2143.95), I and XVIII (2668.13), IV and XVIII (2207.78), VI and XVI (1952.28), VI and XVIII (2347.66), IX and XV (1936.26), IX and XVI (1985.10) and XII and XVIII (2189.26). The statistical distance between eighteen clusters as represented by intra and inter cluster average D ($\sqrt{D^2}$) values have been given in Table 8 (lower diagonal values) and pictorially represented in Fig 2. These intra and inter cluster distances revealed the same pattern of relationship with regard to diversity as described by utilizing intra and inter cluster D^2 values.

The inter cluster distances (D) are given in Table 8.

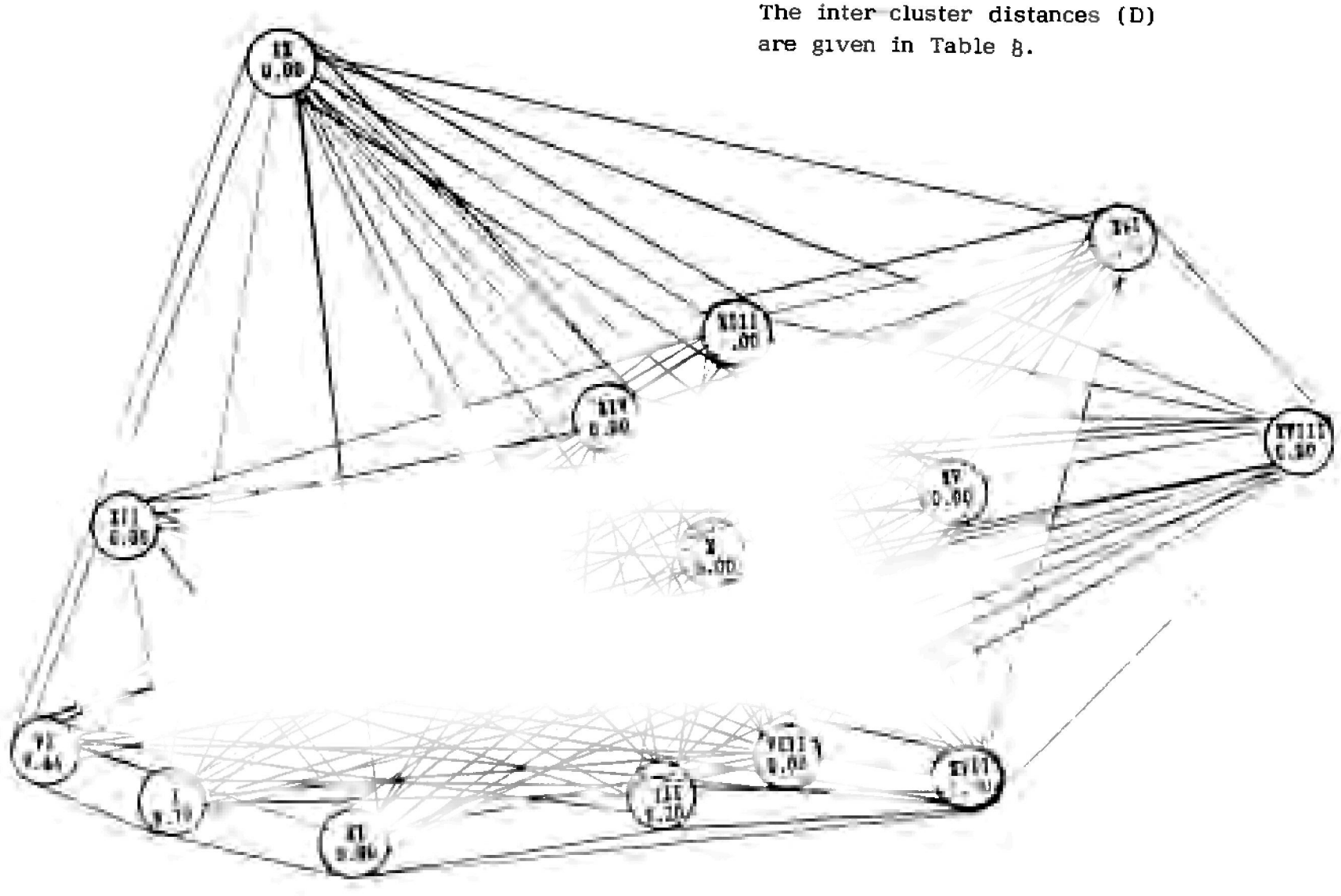


FIG.2. AVERAGE INTRA AND INTER-CLUSTER DISTANCES (D) AMONG 50 GENOTYPES OF RICE (SEASON II).

4.2.3 Season III. [Kharif, 1991 at UAS, Dharwad]

4.2.3.1 Mahalanobis' generalised distance (D^2)

A generalized distance (D^2) was calculated for each pair of genotypes; among the 1225 possible combinations about 99.84 per cent of the D^2 statistics were significant at the 0.05 level of probability.

4.2.3.2 Contribution of different characters towards divergence

The proportional contributions of characters towards the total D^2 statistics were different. Days to 50 per cent flowering was the single largest contributor in 658 cases out of 1225 combinations (53.714%), followed by 1000-grain weight in 182 cases (14.857%), panicle exsertion in 136 cases (11.102%), plot yield in 70 cases (5.714%), leaf area in 58 cases (4.735%), per cent fertile grains in 44 cases (3.592%) and panicle weight in 27 cases (2.204%) whereas, total tillers (1.224%), plant height (1.061%), panicle length (0.653%), productive tillers (0.408%), length of first internode (0.408%), culm length (0.245%) and per cent green leaves (0.082%) were the lowest contributors to the total D^2 statistics and flag leaf length had no contribution towards total divergence (zero). It was apparent that days to 50 per cent flowering was the only major contributor to the differences among the different genotypes, supplimented by the moderate contribution of 1000-grain weight, panicle exsertion, plot yield and leaf area.

4.2.3.3 Group constellations

All the 50 cultivars were grouped into seventeen clusters with the estimated D^2 values following the method suggested by Tocher (Rao, 1952). The distribution pattern of cultivars into various clusters is shown in Table 9. The clustering pattern revealed that cluster I was the largest of all, consisting of ten (six IRRI lines and two each from Africa and Brazil) cultivars. All of them were low to medium yielding cultivars and most of the cultivars were characterised by early flowering, medium tall with average panicle length of 17.16 cms and higher 1000-grain weight (32.26 gms) (Table 10). Three IRRI genotypes grouped together in cluster II which were high yielding and late flowering (99.33 days) with tall stature (89.78 cms). Cluster III consisted six genotypes of different origin. These genotypes were late flowering and moderately yielding. Six IRRI genotypes along with an African line were distinctly separated together from others to from cluster IV. Most of the genotypes in this cluster had hightest panicle length (22.06 cms), flag leaf length (26.40 cms) and medium yielding ability. These genotypes vary with respect to plant height and panicle exsertion. Cluster V contained four late flowering genotypes all from IRRI which were medium yielding. These genotypes had poor panicle exsertion (-1.73 cms) and lowest per cent fertile grains (53.98%). Two late flowering Indian cultivars viz., IET 1444

Table 9. Distribution of 50 rice genotypes in different clusters (Season-III)

Cluster No.	Number of genotypes	Genotypes included	Origin o Source
I	10	IR53236-70-2, IR53236-77-1, IR53236-139, IR53236-218-3, IR53234-27-7, IR53167-17, IRAT212, IRAT144(B), CNA4130, CNA4173	IRRI, AFRICA, BRAZIL
II	3	IR5549-1-2, IR47686-30-2-1, IR47686-6-2-1-1	IRRI
III	6	IR55419-4, IRAT216, IR47691-31-4-1, IT47691-17-1-B, CT6727-5-3-3, CNZ4136	IRRI, AFRICA, COLAMBIA, BRAZIL
IV	7	IR60080-49, IR60080-46B, IR60080-45, IR47691-17-1-B, CT6727-5-3-3, CNA4136	IRRI, AFRICA
V	4	IR55411-53, IR55411-50-1, IR57924-24, IR57924-9	IRRI
VI	2	IET1444, Gama318	INDIA
VII	4	IR57893-73, IRAAT288, IAC165, IAC25	IRRI, AFRICA, BRAZIL
VIII	3	IR55411-50, UPLRi7(B), IET5882	IRRI PHILIPPIN INDIA
IX	2	IR47686-6-2-1-1, IR47686-6-1-1	IRRI
X	2	IET7991-11-2, IET7564-4-3	INDIA
XI	1	IR53236-275-2	IRRI
XII	1	IR53234-27-6	IRRI
XIII	1	IR57893-26	IRRI
XIV	1	IRAT10	AFRCIA
XV	1	CT6510-24-1-2	COLAMBIA
XVI	1	CNA5164	BRAZIL
XVII	1	IET2254	INDIA

yield. Cluster VII had four genotypes of different sources which were medium flowering and low yielding. The genotypes IR 55411-50, UPLRi 7 (B) and IET 5882 were included in cluster VIII which were of medium to dwarf stature and low yielding with lower panicle weight (0.89 gms). Two IRRI lines and two Indian cultivars were separately included in cluster IX and X respectively. The genotypes in cluster IX had highest per cent green leaves (60.20%) and panicle weight (2.74 gms) and thus showed higher yield (450.00 gms/plot), whereas, genotypes in cluster X showed lowest percent green leaves at harvest (30.27%), lower panicle weight (1.06 gms) and negative panicle exsertion (-1.74 cms). Total tillers of these genotypes were maximum (93.25/m). However productive tillers were less (39.25/m) and were of lower yielding ability. Clusters XI to XVII had only one genotype each.

It is evident from Table 10 that clusters differed considerably for all characters studied. Cluster XI had minimum length of first internode (18.45 cms) and days to 50 per cent flowering (70.50). The cluster XIII showed maximum panicle exsertion (4.40 cms), per cent fertile grains (95.55%) and 1000-grain weight (38.35 gms) while it had lowest total tillers (44.50) and it had medium yielding ability. The genotype CT6510-24-1-2 (cluster XV) revealed highest plot yield (648.00 gms) and length of first internode (30.50 cms). Cluster XVIII with dwarf stature genotype IET 2254 showed lowest leaf area (9.21 mc^2), panicle weight (0.85 gms) and had lowest yield per plot (112.00 gms).

Table 10. Cluster means for different characters in rice (Season - III)

Cluster	1 Plant height (cm)	2 Culm length (cm)	3 First internode length (cm)	4 Leaf Area (cm^2)	5 % green leaves	6 Panicle length cm	7 Flag leaf length (cm)	8 Panicle exsertion cm	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight (gm)	13 %fertile grains	14 1000 grain weight (gm)	15 Plot yield (gm)
I	72.99	55.15	24.52	19.68	44.73	17.16	19.01	2.06	57.25	3.10	74.90	1.51	87.35	32.26	284.62
II	89.78	69.20	30.03	30.25	43.25	20.55	23.72	3.17	45.00	34.83	99.33	1.72	83.88	29.88	565.67
III	70.53	52.35	23.46	20.28	41.76	19.02	19.13	1.33	50.16	37.42	95.75	1.42	83.76	27.17	359.63
IV	78.91	56.70	27.53	30.08	42.38	22.06	26.40	-0.14	52.36	35.36	97.64	1.73	77.13	27.29	367.43
V	74.06	54.00	23.56	12.10	38.86	20.06	22.16	-1.73	62.75	39.25	104.37	1.14	53.98	20.73	339.25
VI	54.43	38.07	20.22	20.49	39.27	16.40	19.17	-2.30	75.25	40.25	103.50	1.07	76.20	18.57	286.00
VII	72.21	55.04	22.93	17.39	44.16	16.07	18.58	2.24	54.00	37.13	85.50	1.51	87.98	33.90	198.25
VIII	67.25	47.68	23.67	22.76	38.26	19.58	23.58	0.88	71.17	37.00	95.83	0.89	62.43	17.60	251.67
IX	82.75	60.98	27.20	28.47	60.20	21.77	25.43	1.98	45.50	35.00	100.00	2.74	85.83	36.35	450.00
X	63.07	46.77	22.82	20.76	30.27	16.67	18.40	-1.74	93.25	39.25	75.00	1.06	73.90	23.42	252.00
XI	53.75	37.90	18.45	15.98	41.23	15.85	17.00	1.75	58.50	31.00	70.50	1.08	87.30	29.90	134.00
XII	64.65	55.35	24.30	19.92	42.65	16.80	17.20	0.35	50.50	33.50	71.50	1.29	93.70	25.10	258.80
XIII	81.65	63.85	29.35	28.56	43.40	15.30	24.00	4.40	44.50	37.00	77.00	1.86	95.55	38.35	373.00
XIV	55.70	39.60	19.60	13.74	44.75	16.10	13.60	-1.07	71.50	49.00	82.50	1.05	84.40	25.25	246.00
XV	70.00	50.00	30.50	25.74	30.55	20.00	19.40	2.47	46.00	35.00	94.00	1.44	91.60	26.25	648.00
XVI	73.00	55.25	28.00	21.53	48.70	17.75	22.75	0.65	53.00	30.50	84.50	1.88	81.85	29.25	376.00
XVII	43.75	30.75	21.45	9.21	42.90	16.40	18.10	2.16	80.00	51.50	84.00	0.85	63.25	20.70	112.00

Intra and inter-cluster average D^2 values have been presented in Table 11 (upper diagonal values). The intra-cluster D^2 values of seventeen clusters revealed that cluster I with ten genotypes had the maximum genetic diversity (88.26) among themselves, whereas, cluster VI with two genotypes showed lowest divergence (47.89) among themselves. Nevertheless, clusters XI to XVII had no intra cluster distance (zero) as they were represented by a single genotype only. The intra-cluster distances were moderate in other clusters.

The inter-cluster D^2 values of seventeen cluster revealed that maximum divergence occured between clusters IX and XI (955.51) while close proximity existed between II and XV clusters (107.73). The between cluster distance was also high in clusters I and VI (705.64), II and X (765.76), II and XI (919.74), II and XVII (732.06), IV and XI (765.21), V and XI (819.43), V and XIII (705.55), VI and XI (847.44), VI and XIII (818.90), IX and X (936.30), IX and XII (728.48) and IX and XVII (746.33), whereas, the genetic divergence between clusters I and II (530.77), I and V (610.48), I and IX (571.97), II and XII (609.95), II and XIV (524.06), IV and X (536.30), IV and XVII (571.85(\), V and X 9522.34), V and XII (579.15), VI and IX (551.30), VI and X (546.52), VI and XIII (626.29), VI and XVII (536.00), VIII and IX (523.60), VIII and XI (522.50), VIII and XIII (514.96), IX and XIV (608.63), X add XV (546.44), XI and XV (689.49) and XV and XVII (550.08) were moderate as shown within brackets. The inter-cluster distance between other clusters were lower. The statistical

Table 11. Average intra and inter cluster D^2 (upper diagonal) and D (lower diagonal) values (Season - III)

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII
I	88.26 (9.39)	530.77	322.94	478.43	610.48	705.64	140.17	405.82	571.97	238.80	143.72	120.44	135.66	187.65	411.60	149.78	252.07
II	23.03	59.31 (7.63)	175.09	138.53	348.13	407.02	352.52	341.77	141.64	765.76	919.74	609.95	340.18	524.06	107.73	209.22	732.06
III	17.97	13.23	72.99 (8.54)	133.16	204.35	209.49	163.17	160.61	253.86	440.82	500.47	340.00	322.17	191.78	134.21	134.28	343.96
IV	21.87	11.76	11.53	77.47 (8.80)	200.15	208.16	313.57	205.98	212.03	536.30	765.21	487.77	419.43	339.74	155.72	167.33	571.85
V	24.70	18.65	14.29	14.14	69.83 (8.35)	146.16	404.54	142.71	478.65	522.34	819.43	579.15	705.55	328.04	342.40	304.36	430.21
VI	26.56	20.17	14.47	14.42	12.08	47.89 (6.92)	471.55	176.38	551.30	546.52	847.44	626.29	818.90	303.12	323.33	400.32	536.00
VII	11.83	18.77	12.77	17.70	20.11	21.71	81.60 (9.03)	285.93	363.76	342.61	238.11	214.37	157.40	158.11	307.44	120.52	232.90
VIII	20.14	18.48	12.67	14.35	11.95	13.28	16.91	83.82 (9.15)	523.60	314.94	522.50	354.56	514.96	210.23	267.63	236.54	243.54
IX	23.91	11.90	15.93	14.56	21.87	23.47	19.07	22.88	86.94 (9.32)	936.30	955.51	728.48	358.55	608.63	278.90	248.84	746.33
X	15.45	27.67	20.99	23.15	22.85	23.37	18.50	17.74	30.59	72.72 (8.52)	225.69	128.02	468.42	148.29	546.44	294.37	238.49
XI	11.98	30.32	22.37	27.66	28.62	29.11	15.43	22.85	30.91	15.02	-	138.42	345.97	185.11	689.49	364.72	169.86
XII	10.97	24.69	18.44	22.08	24.06	25.03	14.64	18.83	26.99	11.31	11.76	-	265.59	133.62	429.77	184.23	221.29
XIII	11.65	18.44	17.95	20.48	26.56	28.62	12.55	22.69	18.93	21.64	18.60	16.29	-	373.18	313.71	124.82	473.93
XIV	13.69	22.89	13.84	18.43	18.11	17.41	12.57	14.49	24.67	12.17	13.60	11.55	19.31	-	331.86	167.31	149.74
XV	20.28	10.37	11.58	12.47	18.48	17.98	17.53	16.35	16.70	23.37	26.25	20.73	17.71	18.22	-	159.39	550.98
XVI	12.24	14.46	11.58	12.93	17.44	20.01	10.98	15.38	15.77	17.16	19.09	13.57	11.17	12.93	12.62	-	321.54
XVII	15.88	27.06	18.55	23.91	20.74	23.15	15.26	15.61	27.32	15.44	13.03	14.84	21.77	12.24	23.45	17.93	-

Figures in parenthesis are intra-cluster D values.

distance between seventeen clusters as represented by intra and inter cluster average D ($\sqrt{D^2}$) values have been given in Table 11 (lower diagonal values). The diagrammatic representation depicting the spatial position of each cluster in relation to the others is presented in Fig.3. These intra and inter-cluster distances revealed the same pattern of relationship with regard to diversity as described utilizing intra and inter-cluster D^2 values.

4.2.4 Season IV [Summer, 1992 at ARS, Mugad]

4.2.4.1 Mahalanobis' generalised distance (D^2)

The statistical distance (Mahalanobis' D^2) between pairs of genotypes was obtained as the sum of squares of the differences between pairs of corresponding uncorrelated values of any two genotypes. Since each cultivar produced 49 combinations, 1225 D^2 values were obtained for 50 cultivars. The D^2 values obtained for a pair of cultivars was taken as the calculated value of χ^2 and tested against the tabulated value χ^2 for 15 degrees of freedom. All the D^2 values were found to be significant at 0.05 level of probability.

4.2.4.2 Contribution of different characters towards divergence

Each character contributed a different proportion to the total divergence. Days to 50 per cent flowering was the largest contributor in 677 cases out of 1225 comparisons (55.265%), followed by plot yield in 194 cases (15.837%) and panicle exsertion in 107 cases (8.735%). Contributions of 1000-grain weight (5.878%), flag leaf length (3.102%),

The inter-cluster distances (D) are given in Table 11.

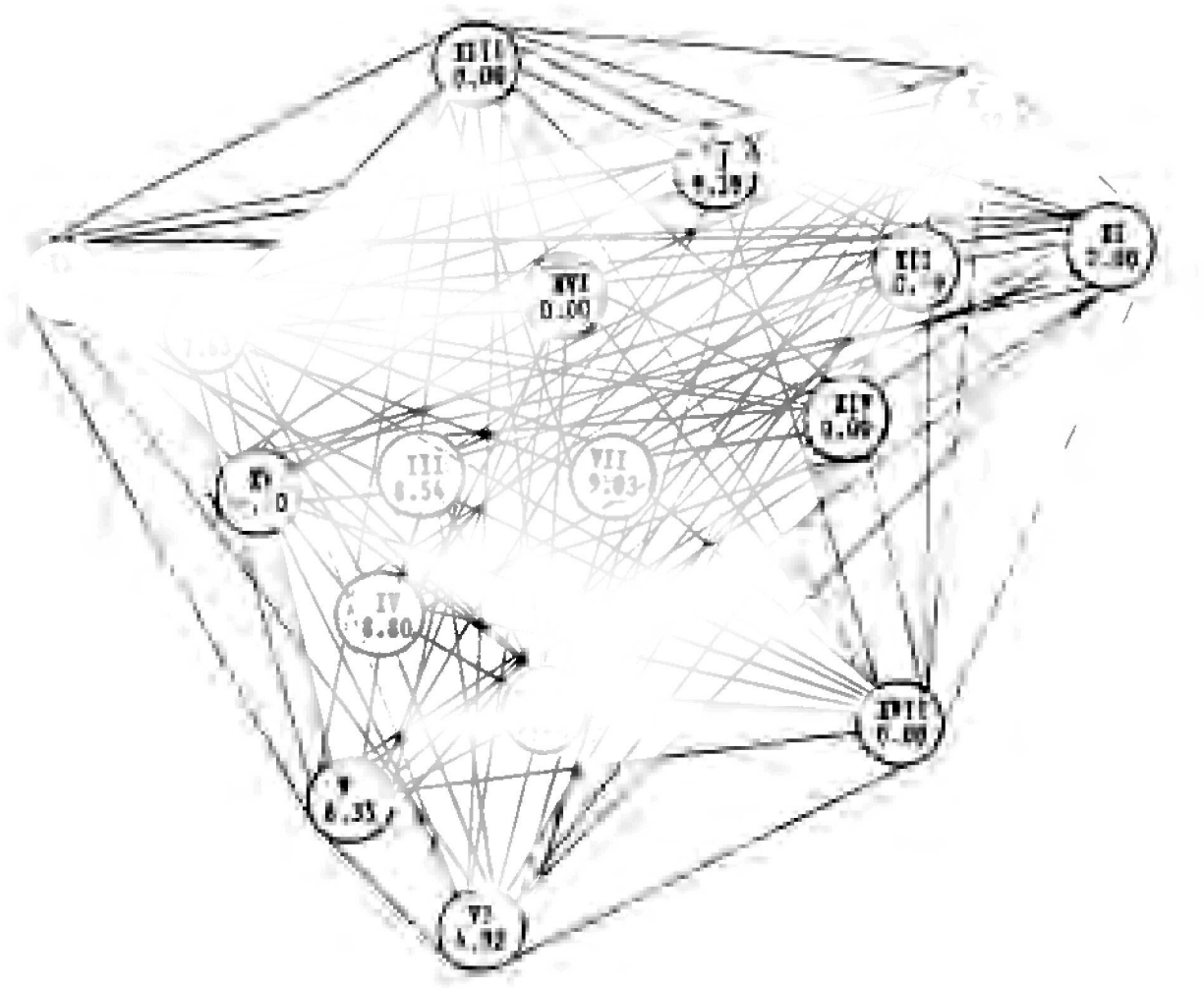


FIG.3. AVERAGE INTRA AND INTER CLUSTER DISTANCES (D) AMONG 50 GENOTYPES OF RICE (SEASON-III).

productive tillers (3.102%), per cent fertile grains (2.367%) and panicle weight were moderate towards total divergence whereas, length of first internode (1.061%), leaf area (1.061%), total tillers (0.816%), plant height (0.490%) and panicle length (0.245%) were the lowest contributors to the total D^2 statistics while culm length and per cent green leaves did not contribute towards total divergence. It was apparent that days to 50 per cent flowering was the only major contributor to the differences among different genotypes, supplimented by contribution of grain yield and panicle exsertion.

4.2.4.3 Group constellations

On the basis of estimated D^2 values, 50 genotypes were grouped in to 38 clusters following the method suggested by Tocher (Rao, 1952). The distribution pattern of cultivars into various clusters is shown in Table 12. The clustering pattern related that cluster I consisted four genotypes one from Africa and three from Brazil which were medium flowering. Cluster II being largest of all the clusters consisted of six genotypes, four of which belong to IRRI and another two belong one each to Africa and Colombia. Most of the genotypes were characterised by medium to late flowering. Interestingly all of them were medium yielding. Clusters III, IV, V and VI contained two genotypes each, all of which were from IRRI. Among these cluster VI comprising IR 47686-6-2-1-1 and 47686-6-1-1 had highest average plant height (74.30 cms), panicle weight (2.01 gms), 1000-grain weight (36.30 gms) and plot yield (1068.00 gms) where as others had genotypes with

Table 12. Distributiion of 50 rice genotypes in different clusters (season - IV)

Cluster No.	Number of genotypes	Genotypes included	Origin or Source
I	4	IRAT144(B), IAC165, IAC25, CNA4173	AFRICA, BRAZIL
II	6	IR55549-1-2, IR55419-4, IRAT216, IR47691-37-4-1, IR47686-1-1-1-B, CT-6727-5-3-3	IRRI, AFRICA, COLOMBIA
III	2	IR60080-49, IR47686-12-5-B-1	IRRI
IV	2	IR60080-45, IR60080-42	IRRI
V	2	IR55411-53, IR47691-17-1-B	IRRI
VI	2	IR47686-6-2-1-1, IR47686-6-1-1	IRRI
VII	1	IR53236-275-2	IRRI
VIII	1	IR53236-70-2	IRRI
IX	1	IR53236-77-1	IRRI
X	1	IR53236-137	IRRI
XI	1	IR53236-218-3	IRRI
XII	1	IR532334-27-7	IRRI
XII	1	IR53234-27-6	IRRI
XIII	1	IR53167-17	IRRI
XIV	1	IR53167-17	IRRI
XV	1	IR55411-50-1	IRRI
XVI	1	IR57924-24	IRRI
XVII	1	IR57924-9	IRRI
XVIII	1	IR57893-73	IRRI
XIX	1	IR57893-26	IRRI
XX	1	IR55411-50	IRRI
XXI	1	IR60080046B	IRRI

.... Contd.

Table 12. Contd....

Cluster No.	Number of genotypes	Genotypes included	Origin or Source
XXII	1	UPLRi7(B)	PHILIPPINES
XXIII	1	IRAT288	AFRICA
XXIV	1	IRAT212	AFRICA
XXV	1	IRAT104(A)	AFRICA
XXVI	1	IR AT10	AFRICA
XXVII	1	IR47686-330-2-1	IRRI
XXVIII	1	IR47686-5-10-3	IRRI
XXIX	1	CNA4130	BRAZIL
XXX	1	CT6510-24-1-2	COLO MBIA
XXXI	1	CNA5164	BRAZIL
XXXII	1	CNA4136	BRAZIL
XXXIII	1	IET2254	INDIA
XXXIV	1	IET7991 11-2	INDIA
XXXV	1	IET1444	INDIA
XXXVI	1	Gama318	INDIA
XXXVII	1	IET5882	INDIA
XXXVIII	1	IET7564-4-3	INDIA

medium yielding ability. Thirty two clusters (VII to XXXVIII) each containing one genotype varied with respect to yielding ability and all other characters.

Cluster means for fifteen characters are shown in Table 13. It is seen from the table that there was wide range of variation in cluster means for almost all characters under study. The higher value for plant height was observed for cluster VI (74.30 cms) and minimum for cluster XXXIV (42.00 cms). A cultivar (CT 6510-24-1-2) forming cluster XXX had highest length of first internode (27.25 cms) while a genotype (IET 7991-11-2) had lowest length of first internode (17.00 cms). The mean for leaf area was maximum in cluster XXVII (26.15 cm^2), while the minimum leaf area was noticed in cluster XXXIV (7.65 cm^2). The mean values of all the remaining clusters were intermediate. Regarding per cent green leaves, the mean values vary from 30.95 in cluster XXX to 61.45 in cluster XVII. Cluster XXVII had highest mean panicle length (21.15 cm) followed by clusters VI (19.83 cm), XXVII (19.60 cm), XXV (19.30 cm) and XXII (19.25 cm), whereas, cluster XXXIV had lowest panicle length (10.25 cm). Average flag leaf length was maximum in cluster XXX (25.80 cm) and minimum in cluster XXIV (11.50 cm). Genotypes in clusters III IV, XII, XVII, XVIII, XX, XXV, XXIX, XXXI, XXXIII, XXXV, XXXVI and XXXVII had negative panicle exsertion, while other clusters had positive panicle exsertion in which cluster IX (with IR53236-77-1) had higher panicle exsertion (3.00 cm). Regarding total and productive tillers, cluster VIII had highest mean value, whereas, cluster XXV had lowest total and

Table 13. Cluster means for different characters in rice (Season IV)

Cluster	1 Plant height (cm)	2 Culm length (cm)	3 First internode length (cm)	4 Leaf Area (cm^2)	5 % green leaves	6 Panicle length (cm)	7 Flag leaf length (cm)	8 Panicle exsertion (cm)	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50 % flowering	12 Panicle weight (gm)	13 %fertile grains	14 1000 grain weight (gm)	15 Plot yield (gm)
I	61.20	46.84	21.31	15.88	52.85	14.33	17.84	1.03	56.25	39.63	85.88	1.11	86.98	33.05	555.00
II	67.50	50.18	22.67	16.44	48.75	17.32	15.75	1.66	58.33	43.25	100.67	1.18	82.79	27.12	657.00
III	67.10	48.62	21.37	19.52	46.67	18.47	16.00	-3.10	60.50	42.75	99.75	1.31	73.10	29.93	851.75
IV	67.37	49.40	24.63	21.22	45.00	17.98	18.12	-1.78	53.00	36.75	87.75	1.16	71.15	22.25	851.00
V	70.30	53.50	22.25	13.52	48.72	16.80	15.32	1.54	67.25	41.00	103.25	0.92	67.90	22.57	892.75
VI	74.30	54.48	24.40	18.97	53.35	19.83	18.30	1.80	54.00	43.75	102.75	2.01	84.28	36.30	1868.00
VII	63.05	46.75	24.40	15.35	46.20	16.30	15.95	0.70	106.50	82.00	72.00	0.94	83.05	28.85	472.00
VIII	63.80	47.20	21.30	15.60	36.90	16.60	19.00	1.75	125.00	101.00	70.50	1.01	76.15	29.25	515.50
IX	61.50	45.00	21.00	17.40	41.55	16.50	15.35	3.00	105.50	61.50	71.50	1.04	88.10	28.20	669.50
X	63.05	47.30	20.85	16.10	49.25	15.07	16.50	2.15	70.50	50.00	78.50	1.21	72.25	29.80	521.50
XI	63.70	49.75	23.80	14.55	37.45	13.85	20.25	0.90	70.00	48.00	72.50	1.26	85.10	34.20	405.00
XII	59.75	43.30	22.50	15.90	48.00	16.45	17.50	-1.35	75.50	41.00	73.00	1.37	88.75	32.45	628.50
XIII	56.45	44.60	22.45	10.10	39.35	11.85	13.25	1.21	68.50	43.50	72.00	1.22	88.45	25.30	618.50
XIV	66.55	52.40	20.25	12.75	52.30	14.15	14.00	1.56	48.50	30.50	79.50	1.27	86.65	28.90	799.50
XV	71.70	55.00	20.75	15.00	47.05	16.70	15.80	2.75	97.50	55.50	113.50	0.90	59.30	17.65	921.00
XVI	67.95	51.40	22.75	15.60	47.35	16.55	19.85	1.65	98.00	75.50	104.50	0.97	49.60	20.40	1001.50
XVII	58.45	42.10	20.00	18.55	56.00	16.35	20.80	-3.10	77.00	53.50	112.50	1.06	56.65	22.50	926.50
XVIII	68.70	49.90	21.00	14.25	61.45	18.80	19.90	-2.00	106.50	41.00	86.50	1.05	77.50	33.25	429.50
XIX	74.00	56.75	25.75	18.15	48.35	17.25	20.50	1.71	60.00	42.00	78.50	1.27	90.60	36.40	689.00
XX	64.35	47.40	20.00	14.50	50.05	16.95	16.15	-2.10	66.50	50.50	98.00	0.93	63.60	19.75	1004.50
XXI	60.85	46.25	24.75	22.00	42.85	14.60	21.15	2.60	95.50	54.50	100.00	1.23	74.30	25.10	998.00
XXII	64.10	44.80	20.75	12.65	37.45	19.25	17.40	1.38	88.00	65.50	101.00	0.84	72.60	20.35	841.00
XXIII	63.80	49.80	22.00	19.80	45.00	14.35	18.60	1.17	45.00	36.50	90.50	1.02	85.80	32.00	748.00
XXIV	54.25	40.25	21.00	9.45	47.95	14.00	11.50	1.17	45.50	30.50	80.00	0.96	78.15	29.40	513.00
XXV	67.80	48.50	23.50	21.00	47.05	19.30	18.50	-3.15	40.50	27.50	102.00	0.94	71.35	27.30	437.50
XXVI	52.30	37.40	20.70	12.90	42.00	14.90	14.75	1.65	97.00	43.50	85.59	0.99	80.65	24.15	778.00
XXVII	72.55	51.40	24.75	26.15	42.45	21.15	23.55	0.75	50.00	40.00	102.50	1.16	77.05	28.10	750.00
XXVIII	73.30	55.85	25.00	24.30	56.35	17.45	16.90	1.70	59.50	45.50	102.50	0.94	86.30	30.45	826.00
XXIX	58.00	44.65	17.00	13.60	53.10	15.75	16.85	-2.00	81.50	34.50	87.50	0.99	91.60	33.50	577.50
XXX	65.80	48.50	27.25	19.15	30.95	17.30	25.80	0.65	70.00	54.50	97.00	1.13	89.15	25.05	974.50
XXXI	65.75	48.80	22.00	17.65	54.10	16.95	23.50	-3.15	80.00	47.00	86.50	1.20	80.35	28.45	624.50
XXXII	59.70	45.25	19.50	11.55	56.55	14.45	16.75	0.87	41.00	30.50	98.50	1.00	86.70	28.50	857.00
XXXIII	58.00	34.25	20.70	11.25	46.40	13.75	12.25	-4.65	60.50	48.50	88.50	0.74	62.40	20.10	387.50
XXXIV	42.00	31.75	17.00	7.65	37.80	10.25	11.60	0.74	70.50	50.50	89.00	0.93	71.70	23.00	663.50
XXXV	63.85	46.65	21.00	20.10	43.70	17.20	10.60	-1.95	80.00	47.50	111.50	1.07	77.90	14.15	654.00
XXXVI	65.45	48.10	22.50	13.15	47.95	17.35	13.50	-2.80	67.00	51.50	108.50	0.93	71.65	21.05	612.50
XXXVII	63.20	43.60	21.10	17.45	44.70	19.60	16.95	-4.85	61.00	36.50	90.50	0.90	47.35	12.55	628.50
XXXVIII	63.15	46.50	23.25	10.05	39.05	16.65	14.90	1.36	74.00	66.00	78.50	0.97	66.75	21.75	595.00

productive tillers. The cultivars in cluster VII, VIII, IX, XI, XII and XIII were earliest in flowering while the cultivars in clusters II, V, VI, XV, XVI, XVII, XXI, XXII, XXV, XXVII, XXVIII, XXXV, and XXXVI were late in flowering. The mean values of other clusters were intermediate.

The genotypes IR 47686-6-2-1-1 and IR47686-6-1-1 which are distinctly separated together from others to form the cluster VI showed highest panicle weight (2.01 gm), whereas, cluster XXXIII had lowest panicle weight (0.74 gm). The panicle weight for other clusters was intermediate. Clusters I, VI, IX, XI, XII, XIII, XIV, XIX, XXIII, XXVIII, XXIX, XXX and XXXII had higher mean values for per cent fertile grains, whereas, clusters, XV, XVI, XVII and XXVII showed lower per cent fertile grains. Regarding 1000-grain weight, cluster XIX had the highest mean value (36.40 gm) followed by cluster VI (36.30 gm) and XI (34.20 gm). Cluster XXXVII had the lowest 1000-grain weight (12.55 gm). Cluster VI having two cultivars had highest grain yield (1068.00gm) followed by clusters XX (1004.50 gm), XVI (1001.50 gm), XXI (998.00 gm), XXX (974.50 gm), XVII (926.50 gm) and XV (9921.00 gm). The cultivars in clusters XXXIII, XI, XVIII, XXV, VII, XXIV, VIII, X and I were low yielders while remaining clusters had moderate yielders.

Intra and inter-cluster average D^2 values have been given in Table 14 (upper diagonal values). This table suggests that the intra-cluster divergence values ranged from 48.51 to 100.52. Minimum intra-cluster D^2-value was observed in cluster III that included two cultivars selected from IRRI.

Table 14. Average intra and inter cluster D^2 (upper diagonal) and D (lower diagonal) values (Season - IV)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
I	81.59 (9.03)	430.61	610.76	568.56	863.10	669.63	473.83	795.69	382.11	154.46	451.48	358.70	310.00	148.02	1621.86	1023.83	1352.90	251.39	158.55
II	20.75	76.06 (8.72)	228.64	217.36	188.42	221.97	1397.13	1848.34	1234.01	766.43	1535.66	1263.73	1055.20	484.32	512.96	350.17	459.64	773.10	818.83
III	24.71	15.12	48.51 (6.96)	136.44	292.26	197.49	1476.84	1968.03	1417.40	1029.70	1797.68	1289.00	1310.27	668.54	665.03	371.67	274.43	816.29	939.18
IV	23.84	14.74	11.68	60.13 (7.75)	235.91	291.37	1368.26	1924.88	1240.15	933.28	1638.81	1147.36	1064.69	583.88	658.77	335.20	349.32	812.50	838.89
V	29.38	13.73	17.09	15.36	67.29 (8.20)	296.05	2025.93	2560.25	1764.38	1273.67	2258.92	1834.13	1533.40	773.53	191.70	208.08	295.91	1189.32	1303.95
VI	25.88	14.90	14.05	17.07	17.21	100.52 (10.02)	1763.54	2213.27	1580.08	1114.18	1827.69	1514.07	1461.20	696.32	612.63	407.79	407.17	1020.73	984.82
VII	21.76	37.37	38.42	36.98	45.01	41.99	-	127.20	133.86	238.03	176.82	210.71	249.94	615.79	3070.58	1899.36	2569.25	563.97	298.33
VIII	28.20	42.99	44.34	43.87	50.59	47.04	11.27	-	324.05	409.75	308.44	555.28	585.77	989.61	3565.42	2225.05	3110.04	950.50	569.97
IX	19.54	35.12	37.64	35.21	42.00	39.75	11.56	18.00	-	159.53	175.25	141.02	107.82	368.70	2769.53	1830.33	2524.17	440.42	201.02
X	12.42	27.68	32.08	30.54	35.68	33.37	15.42	20.24	12.63	-	212.53	270.74	163.75	197.45	2095.63	1331.42	1924.40	304.69	166.15
XI	21.24	39.18	42.39	40.48	47.52	43.90	13.29	17.56	13.23	14.57	-	186.05	219.38	587.88	3401.79	2322.73	3017.87	497.71	220.34
XII	18.93	35.54	35.90	33.87	42.82	38.91	14.51	23.56	11.87	16.45	13.64	-	144.94	395.07	2972.42	2006.44	2426.05	278.89	163.01
XIII	17.60	32.48	36.19	32.62	39.15	38.22	15.80	24.20	10.38	12.79	14.81	12.03	-	252.62	2542.05	1727.89	2326.57	415.93	225.08
XIV	12.16	22.00	25.85	24.16	27.81	26.38	24.81	31.45	19.20	14.05	24.24	19.87	15.89	-	1532.43	1059.24	1466.82	296.48	211.56
XV	40.27	22.64	25.78	25.66	13.84	24.75	55.41	59.71	52.62	45.77	58.32	54.51	50.41	39.14	-	281.38	331.75	2021.27	2266.31
XVI	31.99	18.71	19.27	18.30	14.42	20.19	43.58	47.17	42.78	36.48	48.19	44.79	41.56	32.54	16.77	-	235.87	1458.87	1434.23
XVII	36.78	21.43	16.56	18.69	17.20	20.17	50.68	55.76	50.24	43.86	54.93	49.25	48.23	38.29	18.21	15.35	-	1683.35	1916.89
XVIII	15.85	27.80	28.57	28.50	34.48	31.94	23.74	30.83	20.98	17.45	22.30	16.70	20.39	17.21	44.95	38.19	41.02	-	265.53
XIX	12.59	28.61	30.64	28.96	36.11	31.38	17.27	23.87	14.17	12.88	14.84	12.76	15.00	14.54	47.60	37.87	43.78	16.29	-
XX	28.48	16.49	11.42	11.07	12.20	17.47	41.17	46.90	39.77	34.54	45.90	39.57	37.57	27.31	20.47	13.19	14.03	33.12	34.40
XXI	23.97	15.82	17.95	12.15	16.79	17.86	36.28	42.04	33.42	29.68	39.27	34.28	31.93	25.16	25.53	16.50	21.88	30.09	23.23
XXII	24.99	12.62	15.28	12.88	12.25	17.63	37.65	42.75	36.02	30.45	41.76	37.71	34.34	25.91	20.03	10.47	17.11	31.78	31.39
XXIII	11.70	14.49	17.66	16.41	21.98	18.13	27.34	33.24	24.99	19.10	28.58	25.10	23.54	14.53	33.12	24.32	29.14	21.37	16.66
XXIV	11.99	23.96	28.91	25.90	31.05	31.02	21.24	29.45	17.45	12.42	20.87	17.42	11.26	11.59	42.42	34.92	40.34	17.82	15.89
XXV	21.08	12.92	12.98	12.37	18.61	18.54	36.48	43.12	34.84	28.78	38.44	33.52	33.17	24.54	27.90	22.78	29.78	24.95	28.26
XXVI	17.22	22.64	26.00	20.89	26.95	28.45	25.55	33.69	19.94	19.51	27.34	20.57	16.53	15.79	37.93	30.51	35.77	19.87	19.69
XXVII	21.65	13.18	14.42	12.13	18.05	14.95	36.35	41.53	34.77	28.76	38.27	34.44	33.81	25.07	26.83	18.54	20.86	28.56	26.67
XXVIII	25.49	12.11	11.11	12.85	13.37	12.10	40.88	46.53	39.15	33.38	44.12	39.15	37.83	26.62	21.70	17.05	17.17	32.07	31.53
XXIX	13.10	22.04	22.97	24.23	29.08	26.40	26.49	33.26	23.41	18.92	26.21	20.54	21.91	14.32	39.78	33.62	35.67	11.59	17.23
XXX	24.43	22.47	22.33	16.63	25.34	23.39	33.66	39.66	32.37	30.51	36.33	31.55	30.99	27.28	35.13	24.08	28.20	30.98	25.44
XXXI	13.05	24.52	23.34	22.43	31.51	27.43	20.72	27.93	20.33	16.66	22.07	15.62	19.67	16.45	42.56	32.75	35.79	11.70	12.97
XXXII	21.77	10.38	14.53	14.30	12.61	13.50	39.53	45.77	36.64	30.11	40.92	35.86	33.30	21.39	23.50	20.13	20.76	28.60	28.99
XXXIII	20.20	22.22	21.52	19.41	27.73	29.39	26.69	34.59	28.33	23.37	32.02	26.17	24.44	23.01	37.60	28.62	30.49	23.38	26.41
XXXIV	17.36	17.02	22.59	19.82	22.62	25.37	28.23	34.32	26.30	20.28	31.47	28.18	22.27	18.36	32.09	24.08	30.14	25.52	25.04
XXXV	32.12	16.02	17.25	15.94	14.07	20.14	47.21	52.77	45.52	38.90	50.04	45.16	42.83	33.43	16.64	17.43	12.74	36.31	39.84
XXXVI	32.32	16.38	14.48	16.64	14.07	19.95	46.70	52.60	46.29	39.45	50.73	45.49	43.27	33.52	17.82	17.38	11.37	36.76	40.33
XXXVII	24.03	21.57	19.80	14.82	22.96	27.38	32.57	39.64	31.39	26.73	36.70	30.03	28.21	23.22	32.23	24.56	26.91	24.90	28.86
XXXVIII	16.34	26.88	30.53	27.20	33.06	33.33	15.41	21.23	15.54	11.31	19.94	19.70	13.51	17.20	43.18	31.97	40.72	22.75	17.22

....Contd.

Table 14. Contd....

	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
I	811.20	571.10	624.50	136.86	143.88	444.29	216.60	468.00	649.69	171.55	596.07	170.21	433.72	407.80	301.29	1031.69	1044.61	577.35	263.02
II	271.81	250.31	159.21	289.32	574.18	163.08	512.67	473.84	146.76	485.69	594.07	691.19	107.83	493.52	209.70	256.52	260.22	465.75	232.43
III	130.50	322.19	233.65	312.06	935.69	150.75	676.28	298.03	123.45	527.46	498.61	544.92	211.09	463.17	510.23	202.51	209.59	391.95	932.16
IV	122.47	147.51	165.97	269.18	671.15	152.96	436.50	147.17	165.14	587.20	276.63	593.96	204.45	376.71	392.09	254.00	277.32	219.42	739.86
V	140.84	201.83	150.13	483.13	960.39	346.50	726.47	325.76	176.73	945.20	642.34	993.18	159.89	769.20	511.85	197.96	193.96	537.99	1893.25
VI	395.39	319.28	310.77	350.45	962.36	343.74	809.37	123.45	146.40	697.26	546.81	752.50	102.22	963.88	643.64	485.66	398.12	749.64	1111.08
VII	1684.95	1316.02	1417.97	747.32	451.14	1330.51	652.84	1321.66	1671.39	701.57	1133.22	420.24	1562.50	712.19	797.21	2238.39	2181.41	1060.91	233.41
VIII	2199.34	1767.51	1897.72	1104.83	967.31	1059.11	1134.01	1124.36	2165.41	1106.27	1532.82	779.44	2095.23	1146.60	1176.16	2794.74	2766.52	1571.69	459.30
IX	1591.56	1116.90	1287.49	624.67	304.59	1204.20	397.72	1208.91	1532.78	508.24	1047.62	413.40	1342.47	882.49	691.84	2012.48	2142.72	985.03	341.50
X	1103.15	980.76	927.92	364.62	159.33	620.31	340.73	927.19	1114.07	358.14	831.11	277.52	986.13	546.09	413.51	1513.54	1555.97	714.50	127.06
XI	3107.93	1542.07	1743.84	817.14	435.69	1477.79	747.85	1464.99	1946.38	687.40	1320.31	447.33	1414.81	1925.27	990.64	2504.40	2573.41	1346.97	397.57
XII	1565.50	1175.41	1412.37	638.15	393.48	1723.56	423.11	1186.31	1532.38	421.90	805.61	244.19	1285.81	695.12	794.23	2039.56	2069.17	991.79	387.84
XIII	1411.76	1019.83	1179.22	554.20	126.81	1108.47	273.30	1103.39	1431.51	419.96	960.92	996.01	1109.13	517.54	495.92	1834.23	1872.46	799.03	302.64
XIV	745.84	632.79	671.34	211.00	134.40	692.32	248.38	628.47	798.51	205.20	748.47	279.61	857.72	529.31	337.03	1117.28	1123.92	539.15	395.93
XV	410.90	652.13	401.24	1097.05	1709.87	779.69	1438.65	719.76	471.96	1582.56	1234.25	1911.26	552.25	1413.65	1930.85	276.79	313.46	1939.88	1864.61
XVI	174.07	272.38	189.54	591.45	1218.34	519.12	930.91	343.84	290.65	1138.51	819.90	1072.70	805.84	919.35	519.63	303.94	301.98	693.37	1931.93
XVII	196.67	479.02	313.59	849.93	1621.59	431.94	1279.54	435.10	294.91	1212.75	795.33	1281.20	430.94	929.97	808.22	162.29	129.28	734.19	1658.08
XVIII	1096.90	995.34	1999.93	456.19	317.72	622.29	390.88	915.52	1029.31	134.42	959.70	136.45	817.69	546.11	651.14	1316.90	1351.21	620.87	513.66
XIX	1161.66	797.05	945.56	277.52	252.62	798.56	397.42	711.53	994.20	206.81	641.35	168.25	840.44	697.59	626.91	1587.63	1626.52	833.04	296.55
XX	-	272.31	116.68	435.86	936.02	301.52	691.83	301.82	175.99	770.88	508.69	762.21	213.33	521.68	473.99	202.72	175.39	330.00	930.91
XXI	16.50	-	129.16	259.01	640.76	347.04	350.02	143.19	235.13	667.17	153.02	594.94	265.93	571.56	353.16	359.99	484.97	439.04	699.19
XXII	11.26	11.36	-	287.61	139.19	201.39	507.52	176.56	176.00	703.06	339.91	705.73	196.92	484.02	274.46	227.96	241.33	347.85	680.53
XXIII	20.88	16.13	17.35	-	185.92	251.09	296.26	167.75	273.01	227.01	288.70	240.13	209.02	409.93	247.62	649.76	665.96	469.02	330.41
XXIV	30.56	26.28	27.19	76.91		610.83	162.40	725.71	905.05	214.57	748.31	306.12	892.82	326.65	212.69	1227.46	1293.53	521.63	176.37
XXV	17.36	18.63	16.77	15.87	24.71		565.46	147.26	201.61	437.42	881.61	434.31	222.04	312.95	415.72	254.25	246.24	297.43	794.68
XXVI	26.11	18.71	22.53	17.21	12.36	23.76	-	561.40	333.59	334.80	887.41	338.29	514.85	359.75	210.25	931.26	1014.35	375.95	294.68
XXVII	17.37	11.96	13.29	12.95	26.94	12.14	23.69	-	130.86	519.03	217.57	498.21	222.30	566.95	466.70	305.32	409.44	462.09	354.47
XXVIII	11.26	15.33	13.17	16.52	30.98	14.20	27.08	11.44	-	668.21	448.64	700.92	136.67	665.90	550.18	256.20	222.04	594.81	1022.01
XXIX	21.76	25.71	26.51	15.07	16.57	20.91	19.30	24.06	25.65		749.52	148.45	454.42	465.51	426.97	988.94	975.65	593.34	526.88
XXX	22.55	12.37	18.41	16.99	32.35	21.94	21.15	14.75	21.09	27.21	-	513.37	467.08	618.60	545.11	692.09	812.61	594.94	679.88
XXXI	27.61	24.39	26.57	15.50	17.50	20.04	19.17	22.14	21.22	12.98	22.66		622.53	353.62	488.00	1041.47	1045.35	416.30	340.78
XXXII	18.61	16.31	14.00	14.46	24.55	14.93	22.69	14.91	11.70	21.31	21.61	24.95	-	574.70	343.23	328.92	296.75	538.98	849.31
X2XIII	22.94	24.01	22.00	28.25	18.07	17.69	18.97	23.81	26.17	21.58	25.49	18.80	23.97	-	213.81	729.23	628.94	176.51	354.26
XXXIV	21.77	19.79	16.57	15.74	14.58	20.39	11.50	11.60	23.45	20.66	23.35	22.10	18.53	14.62	-	652.41	625.23	363.39	264.22
XXXV	15.50	18.95	15.19	25.49	35.04	15.94	30.52	17.43	16.01	31.45	26.31	32.27	17.11	26.98	25.54		107.02	512.97	1333.58
XXXVI	13.24	22.92	15.53	25.61	34.69	15.69	31.81	20.22	14.90	31.23	28.51	32.94	17.23	24.92	25.99	18.35		503.28	1323.27
X2XVII	17.99	30.93	19.61	21.63	22.84	17.25	19.39	21.50	24.31	24.34	24.47	20.40	22.19	13.24	19.86	22.65	23.31		504.58
XXX9111	30.51	26.25	26.09	19.25	13.28	28.01	17.17	27.47	31.97	22.94	26.97	18.06	29.75	18.82	16.25	36.52	36.39	22.46	-

Figures in parenthesis are intra cluster D values

However, cluster VI had the highest intra-cluster D^2 value. Nevertheless, 32 clusters (VII to XXXVIII) had no intra cluster distance (zero) as they were represented by only one cultivar. The intra-cluster distance was moderate in clusters I, II, IV and V among their constituents.

The inter-cluster D^2 values revealed minimum divergence between clusters XXXV and XXXVI, II and XXXII and between clusters IX and XIII (107.02, 107.83 and 107.82 respectively) while maximum divergence existed between clusters VIII and XV (3565.42). The inter-cluster distance of cluster I with XV, XVI, XVII, XXV and XXXVI; II with VII, VIII, IX, XI, XII and XIII; III with VII, VIII, IX, X, XI and XII; IV with VII, VIII, IX, XI, XII and XIII; V with IX, X, XII, XIII, XVIII, XIX and XXXVIII; VI with VII, IX, X, XI, XII, XIII, XVIII and XXXVIII; VII with XVI, XX, XXI, XXII, XXV, XXVII, XXVIII, XXX, XXXII and XXXVII; VIII with XXI, XXII, XXIII XXV, XXVI, XXVII, XXIX, XXX, XXXIII, XXXIV and XXXVII; IX with XVI, XX, XXI, XXII, XXV, XXVII, XXVIII, XXX and XXXII; X with XVII, XX, XXVIII, XXXV and XXXVI; XI with XXI, XXII, XXV, XXVI, XXVIII, XXX, XXXII, XXXIII and XXXVII; XII with XX, XXI, XXII, XXV, XXVII and XXVIII; XIII with XVI, XX, XXI, XXII, XXV, XXVII, XXVIII, XXXII, XXXV and XXXVI; XIV with XVIII, XIX, XXIV, XXVI, XXIX, XXXI and XXXVIII; XVIII with XXIII, XXIV, XXVI, XXIX, XXX, XXXI, XXXII, XXXIV, XXXVII and XXXVII; XVI with XVII, XIX, XXIV, XXIX, XXXI and XXXVIII; XVII with XX, XXVII, XXXV and XXVI; XIX with XX, XXXV and XXXVI; XXIV with XXXV and XXXVI and between clusters XXVI and XXXVI, XXVIII and

XXXVIII, XXXI and XXXV, XXXI and XXXVI, XXXV and XXXVIII and XXXVI and XXXVIII were moderate (1000 to 2000).

The inter-cluster distance was also high in clusters V and VII (2025.93), V and VIII (2560.25), V nd XI (2258.92), VI and VIII (2213.27), VII and XV (3070.58), VII and XVII (2569.25), VII and XXXV (2228.38), VII and XXXVI (2181.41), VIII and XV (3565.42), VIII and XVI (2225.05), VIII and XVII (3110.04), VIII and XX (2199.34), VII and XXVIII (2165.41, VIII and XXXII (2095.23), VII and XXXV (2784.74), VIII and XXXVI (2766.52), IX and XV (2769.53), IX and XVII (2524.17), IX and XXXV (2072.48), IX and XXXVI (2142.72), X and XV (2095.63), XI and XV (3401.79), XI and XVI (2322.73), XI and XVII (3017.87), XI and XX (2107.03), XI and XXXV (2504.40), XI and XXXVI (2573.41), XII and XV (2972.42), XII and XVI (2006.44), XII and XVII (2426.05), XII and XXXV (2039.56), XII and XXXVI (2069.17), XII and XV (2542.05), XIII and XVII (2326.57), XV and XVIII (2021.27) and XV and XIX (226.31. The statistical distance between 38 clusters as represented by intra and inter·cluster average D ($\sqrt{D^2}$) values have been given in Table 14 (lower diagonal values). These results revealed the same pattern of relationship with regard to diversity as described by utilizing intra and inter cluster D^2 values.

4.3 Character Associations

The estimates of phenotypic and genotypic correlations between yield and fifteen characters in four seasons are presented in Table 15. Wherever the correlation coefficient (r) values for four seasons were not found to differ by N^2

Table 15. Phenotypic (r_p) (above diagonal values) and genotypic (r_g) (below diagonal values) correlation coefficients for grain yield per plot and some charecrters in four environments in rice

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1.	Plant height		0.963**	0.711**	0.565**	0.159	0.610**	0.493**	0.345*	-0.445**	-0.149	0.207	0.691**	0.362**	0.178	0.254	0.231	(1)
										0.061			0.153				-0.086	(2)
										-0.438**			0.428**				0.493*	(3)
										-0.129			0.383**				0.316*	(4)
2.	Culm length	0.978**		0.658**	0.500**	0.168	0.413**	0.413**	0.405**	-0.445**	-0.158	0.099	0.396**	0.272	0.254	0.336*	0.154	
										0.068							-0.144**	
										-0.431**							0.473*	
3.	First internode length	0.781**	0.730**		0.522**	0.069	0.544**	0.544**	0.421**	0.146**	-0.059	0.168	0.558**	0.405**	0.178	0.148	0.302	
										-0.378**			0.024				0.105	
										0.123*							-0.044**	
										-0.357**			0.414*				0.480**	
4.	Leaf area	0.629**	0.551**	0.610**		0.139	0.508**	0.578**	0.119	-0.108			0.348**				0.145*	
										-0.236**	-0.178	0.562**	0.693**	0.612**	0.089	0.168	0.334	
												-0.008	0.279**	0.118**			-0.188**	
												0.206	0.410**	0.399**			0.390**	
												0.322	0.239	0.468**			0.286**	
5.	% green leaves	0.244	0.207	0.099	0.149		0.069	0.045	0.089	-0.235**	-0.254*	0.009	0.178	0.035	0.149	0.235	0.0005	
												0.033						
												-0.026						
												0.184**						
6.	Panicle length	0.658**	0.493**	0.652**	0.722**	0.050		0.500**	-0.027	-0.139	-0.059	0.454**	0.684**	0.477**	-0.109	-0.089	0.309*	
					0.455**								0.099					
					0.680**								0.233					
					0.782**								0.213					
7.	Flag leaf length	0.578**	0.508**	0.641**	0.808**	0.023	0.650**		0.059	-0.110	0.089	0.409**	0.620**	0.318*	0.0007	0.097	0.168	
					0.490**		0.390**					-0.155**	0.055**					
					0.673**		0.817**					0.452**	0.384**					
					0.652**		0.439**					0.132	0.175					
8.	Panicle exsertion	0.380**	0.446**	0.635**	0.025**	0.079	-0.077**	0.107		-0.284*	-0.319*	-0.178	0.050	-0.0007	0.388**	0.388**	0.00001	
				0.680*	0.446**		0.452**			0.094	0.066							
				0.345	0.154		-0.225			-0.323	-0.088							
				0.210	-0.073		-0.273			0.129	0.224							

Table 15. Contd...

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
9. Number of tillers/m row	-0.664**	-0.629**	-0.696**	-0.300*	-0.171	-0.441**	-0.483**	-0.405**		0.900**	-0.040	-0.456**	-0.168	-0.235	-0.362*	0.04
	0.154	0.165	0.196		-0.595**	0.067	-0.013	0.112		0.941**		0.054				
	-0.509**	-0.509**	-0.462**		-0.559**	-0.406**	-0.192	-0.407**		0.663**		-0.388**				
	-0.151	-0.173	-0.131		-0.325*	-0.031	0.115	0.115		0.776**		-0.226				
10. Productive tillers/m row	-0.637**	-0.642**	-0.695**	-0.235	-0.454**	-0.127	-0.137	-0.476**	0.934**		0.059	-0.148	-0.059	-0.187	-0.309*	0.158
	0.065	0.083	0.116					0.082	1.023**							
	-0.228	-0.221	-0.095					-0.127	0.630**							
	-0.062	-0.087	0.080					0.213	0.781**							
11. Day to 50 % flowering	0.235	0.109	0.207	0.646**	0.079	0.598**	0.490**	-0.178	-0.045	0.085		0.535**	0.430**	-0.336*	-0.388**	0.523**
				0.007			-0.206					0.171				
				0.231			0.531**					0.062				
				0.354*			0.129					0.036				
12. Panicle weight	0.802**	0.696**	0.710**	0.814**	0.240	0.845**	0.824**	0.137	-0.605**	-0.447**	0.627**		0.822**	0.216	0.371**	0.327*
	0.215	0.226	0.053	0.372**	0.092	0.093	0.026		0.122	0.108	0.210		0.379**			
	0.603**	0.561**	0.550**	0.520**	0.712**	0.388**	0.452**		-0.520**	-0.254	0.079		0.657**			
	0.423**	0.421**	0.364**	0.299	0.225	0.269	0.241		-0.243	-0.185	0.041		0.630**			
13. Number of grains/panicle	0.567**	0.336*	0.444**	0.716**	-0.012	0.730**	0.723**	0.035	-0.226	-0.107	0.812**	0.855**		0.105	-0.297*	0.421**
	0.137		0.343*	0.160	0.010		0.103				0.487**	0.357*			-0.316*	
	0.453**		0.719**	0.642**	0.472**		0.580**				0.388**	0.705**			0.093	
	0.589**		0.648**	0.627**	0.105		0.310*				0.346*	0.814**			0.240	
14. % fertile grains/p	0.226	0.309*	0.195	0.105	0.235	-0.197	-0.035	0.485**	-0.327*	-0.624**	-0.388**	0.235	0.077		0.412**	-0.127
							0.228			-0.235					0.288*	
							-0.338*			-0.104					0.629**	
							0.098			-0.247					0.749**	
15. Test weight	0.300*	0.371**	0.460**	0.225	0.380**	-0.137	0.148	0.430**	-0.604**	-0.684**	-0.430**	0.294*	-0.287	0.486**		-0.178
			-0.148						-0.467**	-0.455**		0.005	-0.407**	0.343*		
			0.225						-0.596**	-0.257		0.684**	0.175	0.751**		
			0.144						-0.189	-0.201		0.563**	0.340*	0.749**		
16. plot yield	0.232	0.149	0.083	0.349*	-0.030	0.422**	0.207	-0.005	0.038	0.187	0.564**	0.596**	0.747**	-0.336*	-0.305*	
	-0.148	-0.219	-0.012	-0.258					0.367**			0.155	0.372**	-0.152	-0.406**	
	0.603**	0.561**	0.667**	0.496**					-0.349*			0.520**	0.729**	0.199	0.116	
	0.385**	0.351*	0.201	0.326*					-0.063			0.324*	0.393**	-0.231	-0.205	

Note : (1) Kharif 1990 at ARS, Mugad, (2) Kharif 1991 at ARS, Mugad (3) Kharif 1991 at UAS, Dharwad (4) Summer 1992 at ARS, Mugad

* Significant at 5 per cent, ** Significant at 1 per cent level of probability

test, only a combined value has been given. Out of 120 character pair comparisons only 24 had different associations in four environments with respect to phenotypic correlation while with respect to genotypic correlation 54 character pair comparisons had different associations in four seasons and for each remaining character pair only a pooled correlation coefficient was good enough to indicate the nature of association irrespective of seasons.

A general observation of the data revealed that genotypic correlations with few exceptions were larger than the corresponding phenotypic values among all the characters studied. A critical examination of the Table 15 envisages that grain yield was positively and significantly correlated both at phenotypic and genotypic levels with days to 50 per cent flowering (r_p=0.523 and r_g=0.564) and panicle length (r_p=0.309 and r_g=0.422). Yield was also positively and significantly correlated with panicle weight (r_p=0.327) and number of grains per panicle (r_p=0.421) irrespective of seasons at phenotypic level, but they vary with seasons at genotypic level although the correlation coefficients were positive and significant except with panicle weight during Kharif 1991 (M) which was not significant (r_g=0.155). However, correlation coefficients were high during Kharif 1990 and Kharif 1991 (D). The association of grain yield with flag leaf length and productive tillers was also positive but nonsignificant both at phenotypic and genotypic levels irrespective of seasonal differences. The correlation of grain yield with per cent green leaves and panicle exsertion

was positive at phenotypic level, whereas, negative at genotypic level. However, correlation coefficients were negligible.

The phenotypic correlation between grain yield and total tillers was positive but negligible irrespective of environments, where as, at genotypic level the association varies, which was positive in two seasons and negative in another two seasons. However, correlation reached level of significance in two seasons. The grain yield was negatively correlated with per cent fertile grains (r_p=-0.127) and 1000-grain weight (r_p=-0.178) irrespective of seasons at phenotypic level but associations were nonsignificant, whereas, the correlations was negative in three seasons and positive during Kharif 1991 (D) at genotypic level. However, grain yield's genotypic correlation reached level of significance in one season with per cent fertile grains and with 1000-grain weight in two seasons. Both phenotypic and genotypic correlations between grain yield and plant height was positive in three seasons (Kharif 1990, (M) Kharif 1991 (D) and Summer 1992) and significant in latter two seasons, whereas, negative in Kharif 1991 (M) but nonsignificant. Culm length was positively associated with grain yield in three seasons and it was negative in one season both at phenotypic and genotypic levels. However, correlation reached significance level only in two seasons (Kharif 1991 (D) and Summer 1992). First internode length was significantly and positively associated with grain yield only in one season both at phenotypic and genotypic level but in other seasons the

association was nonsignificant. The association between leaf area and grain yield both at phenotypic and genotypic level was significant and positive in three seasons but non significant and negative in Kharif 1991 (M).

Plant height was positively and significantly correlated with culm length, first internode length, leaf area, panicle length, flag leaf length and panicle exsertion and positively but nonsignificantly associated with per cent green leaves, days to 50 per cent flowering and per cent fertile grains both at phenotypic and genotypic levels in all the seasons, whereas, its correlation with 1000-grain weight was positive and significant only at genotypic level. Plant height was correlated positively and significantly with grains per panicle irrespective of environments at phenotypic level while it varies with seasons at genotypic level, wherein, it was positive and significant in three seasons and nonsignificant during Kharif 1991 (M). The association of productive tillers with plant height was negative but nonsignificant in all seasons at phenotypic level, whereas, it was negative in three seasons and positive during Kharif 1991 (M) at genotypic level. However, it reached significance only during Kharif 1990. In three seasons the association between plant height and total tillers was negative and was significant in two seasons both at phenotypic and genotypic levels, while it was positive but nonsignificant in Kharif 1991 (M). Both phenotypic and genotypic correlations between plant height and panicle weight were positive and nonsignificant to highly significant in all four seasons.

Irrespective of environments, culm length was positively and significantly associated with first internode length, leaf area, panicle length, flag leaf length, panicle exsertion and 1000-grain weight and nonsignificantly correlated with per cent green leaves and days to 50 per cent flowering both at phenotypic and genotypic levels while it was positively and significantly correlated with grains per panicle and per cent fertile grains at genotypic level but it was non-significant at phenotypic level. Panicle weight was significantly correlated with culm length at phenotypic level irrespective of seasons, whereas, genotypic correlation varies with season, although positive in all seasons studied. Culm length was negatively and nonsignificantly correlated with productive tillers in all seasons at phenotypic level while at genotypic level it was negatively correlated with productive tillers in three seasons but positively correlated in one season and correlation was significant only during Kharif 1990. The culm length was significantly and negatively correlated with total tillers both at phenotypic and genotypic levels in two seasons (Kharif 1990 and Kharif 1991 (D)) while the association in other two seasons was not significant.

The association of first internode length with leaf area, panicle length and flag leaf length was positive and significant even at 0.01 level of probability while it was non significant with per cent green leaves, days to 50 per cent flowering and per cent fertile grains both at phenotypic and genotypic levels irrespective of seasons. First internode length was positively and significantly correlated with

panicle exsertion and grains per panicle (r_p=0.421 and 0.405 respectively) at phenotypic level irrespective of seasons, where, the correlation coefficients vary from nonsignificant tc highly significant at genotypic level. The phenotypic correlation was positive but nonsignificant between first internode length and 1000-grain weight in all seasons studied, whereas, genotypic correlation was positive in three seasons and negative in one season but it was significant only during Kharif 1990. The assosiation between first internode length and productive tillers was negative but nonsignificant over all seasons at phenotypic level while at genotypic level, it was negative and significant only during Kharif 1990 (r_g=-0.695)and association was nonsignificant in other three seasons. Negative and significant association was found between first internode length and total tillers in two seasons and it was not significant in other two seasons both at phenotypic and genotypic levels. The phenotypic and genotypic correlations between first internode length and panicle weight were positive in all seasons studied but significant only in three seasons.

Leaf area was significantly and positively correlated with panicle length and flag leaf length in all environments and both at phenotypic and genotypic levels, whereas, its association although positive, was insignificant with per cent green levels, per cent fertile grains and 1000-grain weight. The correlation of leaf area with total tillers was negative and significant only at genotypic level and negative and nonsignificant with productive tillers both at phenotypic and

genotypic level irrespective of seasons. Panicle exsertion and leaf area were positively but nonsignificantly associated with each other in all seasons at phenotypic level, whereas, their association at genotypic level was positive in three seasons and negative during summer 1992 but association was significant only in one season. In two seasons leaf area was associated positively and significantly with days to 50 per cent flowering while it was nonsignificant during other two seasons both at phenotypic and genotypic levels. Leaf area revealed positive correlation with panicle weight in all four seasons and significant in three seasons at phenotypic level and significant in all four season at genotypic level. Similarly leaf area and grains per panicle were positively correlated both at phenotypic and genotypic levels in all seasons studied and significant in three seasons with strong association (r_p=0.612 and r_g=0.716) during Kharif 1990.

The trait per cent green leaves had positive significant correlation with 1000-grain weight only at genotypic level while it was correlated both at phenotypic and genotypic levels with panicle length, flag leaf length, panicle exsertion and per cent fertile grains irrespective of seasons. Per cent green leaves and days to 50 per cent flowering were positively associated each other in all seasons at genotypic level while their association at phenotypic level was positive in three seasons and negative during Kharif 1991 (D). However, the correlation coefficients were of low values. The association between per cent green leaves and panicle weight was positive but insignificant in all seasons at phenotypic

level, whereas, positive and significant during Kharif 1991 (D) at genotypic level. The phenotypic correlation between per cent green leaves and grains per panicle was nonsignificant and positive in all seasons, whereas, genotypic correlation was significant during Kharif 1991 (D) and nonsignificant in other three seasons. Per cent green leaves and total tillers were associated each other negatively both at phenotypic and genotypic levels in all the seasons but only genotypic correlations reached level of significance in three seasons. Similarly, the trait per cent green leaves was negatively correlated with productive tillers irrespective of seasons both at phenotypic and genotypic levels but association was significant only at genotypic level.

Panicle length was associated positively and significantly with flag leaf length, days to 50 per cent flowering and grains per panicle while the association was negative and nonsignificant with productive tillers, per cent fertile grains and 1000-grain weight both at phenotypic and genotypic levels in all environments. The phenotypic correlation between panicle length and panicle exsertion was also negative but nonsignificant in all seasons, whereas, genotypic correlation between same characters was negative in three seasons but positive and significant during Kharif 1991 (M). Similarly, panicle length was negatively but nonsignificantly correlated with total tillers at phenotypic level, whereas at genotypic level, the association was significant and negative in two seasons (Kharif 1990; r_g=-0.441 and Kharif 1991 (D); r_g=-0.406) and nonsignificant

in other two seasons. In all seasons, flag leaf length was positively but nonsignificantly associated with panicle exsertion and 1000-grain weight both at phenotypic and genotypic levels, whereas, its phenotypic correlation was positive but genotypic correlation was negative in both cases and the association was not significant. The association of flag leaf length and grains per panicle was significantly positive (r_p=0.318) at phenotypic level irrespective of seasons while genotypic correlation was positive and significant in all seasons except during Kharif 1991 (M) where in it was nonsignificant. The association of flag leaf length and per cent fertile grains was positive at phenotypic level in all seasons but correlation coefficient was negligible, whereas, at genotypic level the association was negative in two seasons and positive in other two seasons. However, the association reached level of significance only during Kharif 1991 (D) (r_g=-0.338). Flag leaf length was positively associated both at phenotypic and genotypic level with days to 50 per cent flowering in three seasons. This correlation was significant in two seasons but it was negatively correlated with the same character in Kharif 1991 (M). It was also associated positively with panicle weight in all seasons both at phenotypic and genotypic levels but attained significance level in two seasons.

In all four seasons studied, panicle exsertion had positive and significant correlation with per cent fertile grains and 1000-grain weight, whereas, its correlation was nonsignificant and positive with panicle weight and negative

with days to 50 per cent flowering both at phenotypic and genotypic level. The correlation although of low order between panicle exsertion and grains per panicle was negative at phenotypic level and positive at genotypic level. Panicle exsertion was negatively and significantly correlated with total tillers in two seasons, whereas, it had positive but insignificant association in other two seasons both at phenotypic and genotypic levels. Similarly, it had negative and positive correlation with productive tillers in two seasons each, with just attaining the level of significance during Kharif 1990.

Number of total tillers was negatively correlated with days to 50 per cent flowering and grains per panicle both at phenotypic and genotypic levels and significantly negatively correlated with per cent fertile grains only at genotypic level. The phenotypic correlation between total tillers and 1000-grain weight was significantly negative irrespective of seasons, whereas, at genotypic level the association was significant in three seasons. The phenotypic and genotypic correlations were positive and significant between total and productive tillers in all seasons but strong associations were observed in Kharif 1990 and Kharif 1991 (M). The negative phenotypic and genotypic correlations were found between total tillers and panicle weight in three seasons and significant in two seasons, while they were positive and nonsignificant in Kharif 1991 (M). Negative and significant correlation was found between productive tillers and 1000-grain weight at phenotypic level, whereas at genotypic level, the association

varies from insignificant to highly significant. The phenotypic correlation of productive tillers was nonsignificantly negative with panicle weight, grains per panicle and per cent fertile grains and positive with days to 50 per cent flowering while genotypic correlation was nonsignificant and positive with days to 50 per cent flowering and negative with grains per panicle irrespective of seasons, whereas, the genotypic correlation of productive tillers with panicle weight was negative in three seasons but significant only in one season (Kharif, 1990) and positive and nonsignificant during Kharif 1991 (M), while it was negative in all seasons with per cent fertile grains but attained level of significance only during Kharif 1990 (r_g=-0.624).

In all seasons, the phenotypic correlation between days to 50 per cent flowering and grains per panicle was significantly positive (r_p=0.430) while genotypic correlation was positive and significant to highly significant in all four seasons, whereas, the association both at phenotypic and genotypic levels was negative between days to 50 per cent flowering and and per cent fertile grains as well as days to 50 per cent flowering and 1000-grain weight was significantly negative. Days to 50 per cent flowering offered positive association with panicle weight both at phenotypic and genotypic levels in all seasons, although association was significant only during Kharif, 1990.

The association of panicle weight with grains per panicle was positive and significant at phenotypic and genotypic

levels in all seasons. However, correlation coefficients were not homogeneous in all four seasons. Panicle weight was positively correlated with per cent fertile grains both at phenotypic and genotypic levels in all seasons while its association with 1000-grain weight was significantly positive irrespective of seasons only at phenotypic level, whereas, at genotypic level it varies from weak to strong association across seasons. Number of grains per panicle was positively but nonsignificantly associated with per cent fertile grains both at phenotypic and genotypic levels in all seasons, whereas, its correlation with 1000-grain weight at phenotypic and genotypic levels was significantly negative in two seasons and positive but nonsignificant in other two seasons. The correlation between per cent fertile grains and 1000-grain weight was significantly positive in all seasons. However, the extent of association varies among seasons both at phenotypic and genotypic levels.

4.4 Path coefficient analyses

Path coefficient analysis was employed to partition the phenotypic correlation coefficient of fourteen characters with grain yield per plot into direct and indirect effects for each season separately. The results of various causes influencing grain yield per plot (effect) have been presented in Tables 16, 17, 18 and 19. The results of path analyses pertaining to different seasons are described in following pages.

4.4.1 Season-I [Kharif, 1990 at ARS, Mugad]

Perusal of the Table 16 reveals that days to 50 per cent flowering had the largest direct effect (0.546) on grain yield

Table 16. Path analysis of yield and its components showing the direct and indirect effects in rice (Season - I)

	1 Plant height	2 Culm length	3 first internode length	4 leaf area	5 % green leaves	6 Panicle length	7 Flag leaf length	8 Panicle exsertion	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight	13 % fertile grains/ panicle	14 1000 grain weight	Correltion with grain yield
Plant height	<u>-0.239</u>	0.357	-0.101	-0.165	0.0038	0.007	0.025	0.015	-0.034	-0.063	0.164	0.312	-0.028	-0.022	0.231
Culm lenght	-0.229	<u>0.371</u>	-0.094	-0.147	0.004	0.005	0.022	0.019	-0.033	-0.068	0.099	0.269	-0.035	-0.027	0.154
First internode length	-0.186	0.269	<u>-0.139</u>	-0.143	0.0037	0.007	0.028	0.022	-0.028	-0.054	0.110	0.252	-0.022	-0.022	0.105
Leaf area	-0.153	0.212	-0.072	<u>-0.257</u>	0.003	0.007	0.029	0.0008	-0.024	-0.031	0.307	0.313	0.005	-0.005	0.334 *
% green leaves	-0.042	0.070	-0.022	-0.037	<u>0.021</u>	0.000	0.006	0.004	-0.007	-0.013	0.005	0.061	-0.020	-0.023	0.002
Panicle length	-0.153	0.178	-0.080	-0.160	0.000	<u>0.011</u>	0.027	-0.002	-0.018	-0.021	0.298	0.309	0.008	0.002	0.396 **
Flag leaf length	-0.142	0.197	-0.086	-0.179	0.003	0.007	<u>0.042</u>	0.004	-0.025	-0.039	0.223	0.280	0.004	-0.011	0.277
Panicle exsertion	-0.087	0.166	-0.068	-0.085	0.002	-0.0008	0.004	<u>0.042</u>	-0.022	-0.054	-0.143	0.032	-0.046	-0.030	-0.21
Total tillers/m	0.106	-0.165	0.049	0.081	-0.002	-0.002	-0.014	-0.012	<u>0.076</u>	0.154	-0.044	-0.206	0.038	0.034	0.092
Productive tillers/m	0.088	-0.148	0.041	0.047	-0.001	-0.001	-0.009	-0.013	0.068	<u>0.171</u>	0.064	-0.141	0.045	0.035	0.244
Days to 50% flowering	-0.071	0.067	-0.026	-0.145	0.0002	0.006	0.017	-0.011	-0.006	0.020	<u>0.546</u>	0.242	0.030	0.023	0.692 **
Panicle wieght	-0.165	0.221	-0.072	-0.178	0.002	0.007	0.026	0.003	-0.034	-0.053	0.292	<u>0.452</u>	-0.016	-0.015	0.469 **
% fertile grains/panicle	-0.055	0.106	-0.024	0.010	0.003	-0.0007	-0.001	0.015	-0.023	-0.063	-0.132	0.059	<u>-0.123</u>	-0.029	-0.258 *
1000 grain weight	-0.076	0.142	-0.041	-0.019	0.007	-0.0003	0.007	0.018	-0.036	-0.084	-0.177	0.100	-0.051	<u>-0.071</u>	-0.282

Residual effect (R) = 0.399 (15.92%)
The underlined figures denote the direct effects.

followed by panicle weight (0.452) and culm length (0.371) while leaf area had high negative direct effect (-0.257) followed by plant height (-0.239) and first internode length (-0.130). Direct effect of productive tillers (0.171), total tiller per plant (0.076), panicle exsertion (0.042), flag leaf length (0.042), per cent green leaves (0.021) and panicle length (0.011) were also positive, on grain yield but were of less magnitude. Per cent fertile grains and 1000-grain weight also had negative direct effects (-0.123 and -0.071 respectively) on grain yield.

Though leaf area had negative direct effect on yield, the positive association between these characters (r=0.334) appeared to be resulting from its high indirect effects via panicle weight (0.313), days to 50 per cent flowering (0.307) and culm length (0.212), it had negative indirect effect via plant height (-0.153) to counteract positive effects. Plant height had high indirect positive effect on grain yield through culm length (0.357), panicle weight (0.312) and days to 50 per cent flowering to counteract its lnegative indirect effects via first internode length (-0.101) and leaf area (-0.165) as well as negative direct effect to give positive association with grain yield. Culm length also influenced positively to the grain yield indirectly through panicle weight, however its negative indirect effects via plant height (-0.229) and leaf area (-0.147) reduced its strength of association with grain yield.

Even though both first internode length and leaf area had both negative direct and indirect effects via plant height and

leaf area, wherein, first internode length had positive correlation with grain yield due to high positive indirect effects via culm length, days to 50 per cent flowering and panicle weight. Effect of per cent green leaves per hill on grain yield appeared to be due to less direct (0.021) and indirect effects through all characters considered.

The indirect effects of panicle length on grain yield was high through panicle weight (0.309) followed by days to 50 per cent flowering (0.298) and culm length (0.178) to have its positive significant association with grain yield (r=0.396), although negative indirect effects via leaf area (-0.160) and plant height (-0.153) were found. Flag leaf length also had high positive indirect effects via panicle weight (0.280), days to 50 per cent flowering (0.223) and culm length (0.197) to counter act high negative indirect effects via plant height (-0.142) and leaf area (-0.179), even when its direct effect was less (0.042). Panicle exsertion had negative indirect effects via all the characters except through culm length, per cent green leaves, flag leaf length, panicle weight and its direct effect to give its negative association on grain yield.

Number of total tillers was not much associated with grain yield as its direct and indirect positive effects are counter acted by negative indirect effects through other characters. Productive tillers showed positive direct and indirect effects via plant height (0.088), days to 50 per cent flowering, (0.064), total tillers (0.068), first internode length (0.041), leaf area (0.047), per cent fertile grains

(0.045) and 1000-grain weight (0.035) to have positive correlation with grain yield. However, its high negative indirect effects via culm length (-0.148) and panicle weight (-0.141) minimised the strength of association.

It is evident from Table 16 that the strong positive association between days to 50 per cent flowering and grain yield was both due to sufficiently high positive direct and indirect effects via panicle weight (0.242). However, negative indirect effects through leaf area (-0.145) and plant height (-0.071) were main forces to counter act both positive direct and indirect effects. Similarly the positive significant association of panicle weight with grain yield was due to both higher direct and indirect effects via days to 50 per cent flowering (0.292) and culm length (0.221), although its high indirect effects via plant height (-0.165), first internode length (-0.072) and leaf area (-0.178) did counter act the positive effects.

Per cent fertile grains influenced negatively to grain yield directly as well as indirectly via days to 50 per cent flowering (-0.132), productive tillers (-0.063) and plant height (-0.055) to a considerable extent. However, it had high positive indirect effect via culm length (0.106). 1000-grain weight had negative indirect effect via all the characters except through culm length (0.142), per cent green leaves (0.007), flag leaf length (0.007), panicle exsertion (0.018) and panicle weight (0.100) and thus had significant negative correlation with grain yield.

The residual factor (R) was assumed to be independent of remaining variables and the effect of which revealed that the unknown factors account for only 15.92 per cent of variability in the grain yield, while remaining 84.08 per cent was explained by the characters under study.

4.4.2 Season - II (Kharif, 1991 at ARS, Mugad)

A close examination of the Table 17 envisages that in Season-II (Kharif 1991 (D)), total tillers had large positive direct effect (0.426) on grain yield followed by days to 50 per cent flowering (0.311), plant height (0.216), panicle length (0.203), panicle weight (0.162), flag leaf length (0.107), per cent green leaves (0.099), per cent fertile grains (0.044), and panicle exsertion (0.019) while first internode length had high negative direct effect (-0.327) on grain yield followed by productive tillers (-0.267), leaf area (-0.249), culm length (-0.158) and 1000-grain weight (-0.134).

Plant height had negative association with grain yield even though its direct effect was positive, which was attributed to its high negative indirect effects via culm length (-0.154), first internode length (-0.242) and leaf area (-0.152) counteracting positive direct and indirect effects on grain yield. Culm length had high positive indirect effect via plant height but the negative direct effect and indirect effects through first internode length (-0.219) and leaf area (-0.140) made it to associate negatively with grain yield. Although first internode length had large negative direct effect and indirect effects through leaf area (-0.127), culm

Table 17. Path analysis of yield and its components showing the direct and indirect effects in rice (Season - II)

	1 Plant height	2 Culm length	3 first internode length	4 leaf area	5 % green leaves	6 Panicle length	7 Flag leaf length	8 Panicle exsertion	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight	13 % fertile grains/ panicle	14 1000 grain weight	Correltion with grain yield
Plant height	0.261	-0.154	-0.242	-0.152	0.011	0.102	0.056	0.009	0.026	-0.011	-0.015	0.024	0.01	-0.012	-0.086
Culm lenght	0.255	-0.158	-0.219	-0.140	0.007	0.064	0.049	0.009	0.029	-0.014	-0.043	0.024	0.011	-0.020	-0.144
First internode length	0.194	-0.106	-0.327	-0.127	0.013	0.122	0.061	0.011	0.052	-0.027	0.064	0.004	0.008	0.010	-0.044
Leaf area	0.160	-0.089	-0.166	-0.249	0.025	0.087	0.047	0.006	-0.096	0.072	0.002	0.045	0.005	-0.031	-0.180
% green leaves	0.029	-0.011	-0.044	-0.064	0.099	0.043	0.004	0.003	-0.159	0.095	0.010	0.007	0.005	0.002	0.020
Panicle length	0.132	-0.049	-0.197	-0.107	0.021	0.203	0.046	0.005	0.008	0.005	0.104	0.016	0.000	0.029	0.218
Flag leaf length	0.137	-0.073	-0.188	-0.110	0.004	0.088	0.107	0.004	-0.021	0.020	-0.048	0.009	0.008	-0.020	-0.082
Panicle exsertion	0.127	-0.074	-0.188	-0.082	0.016	0.058	0.026	0.019	0.040	-0.017	0.003	-0.024	0.012	-0.026	-0.108 *
Total tillers/m	0.016	-0.010	-0.040	0.056	-0.037	0.003	-0.005	0.001	0.426	-0.251	0.072	0.008	-0.005	0.044	0.279
Productive tillers/m	0.011	-0.008	-0.033	0.067	-0.035	-0.004	-0.008	0.001	0.401	-0.267	0.068	0.005	-0.005	0.046	0.240 **
Days to 50% flowering	-0.013	0.021	-0.067	-0.002	0.003	0.068	-0.016	0.0002	0.099	-0.059	0.311	0.027	-0.011	0.062	0.423
Panicle wieght	0.040	-0.023	-0.008	-0.069	0.004	0.020	0.006	-0.003	0.023	-0.009	0.053	0.152	0.002	-0.011	0.187
% fertile grains/panicle	0.061	-0.042	-0.059	-0.031	0.012	0.0002	0.02	0.005	-0.053	0.032	-0.084	0.007	0.044	-0.038	-0.125 *
1000 grain weight	0.023	-0.024	0.025	-0.058	-0.001	-0.045	0.016	0.003	-0.14	0.092	-0.144	0.014	0.012	-0.134	-0.359

Residual effect (R) = 0.644 (41.47%)
The underlined figures denote the direct effects.

length (-0.106) and productive tillers (-0.027), its positive indirect effects through all other variables counter acted negative effects considerably. The negative direct and indirect effects via culm length (-0.089), first internode length (-0.166), total tillers (-0.096) and 1000-grain weight (-0.031) made leaf area to associate negatively with grain yield. However, high positive indirect effect via plant height and other positive indirect effects of leaf area were the forces to counter act the negative direct and indirect effects. The per cent green leaves influenced little directly as well as indirectly, thus revealing its meagre association with grain yield. However, it has more negative indirect effect on grain yield via total tillers.

The positive association of panicle length with grain yield was due to its positive direct effect and indirect effects via all the characters except via culm length (-0.049), first internode length (-0.197) and leaf area (-0.107). Flag leaf length had positive direct effect and high positive indirect effect via plant height, whereas, its association with grain yield was negative which is attributed mainly to higher negative indirect effects via culm length (-0.073), first internode length (-0.188) and leaf area (-0.110). Panicle exsertion had high negative indirect effects via first internode length (-0.188), leaf area (-0.082) and culm length (-0.074) to get negative association with grain yield. However, its positive indirect effect through plant height (0.127) and few other characters reduced the strength of association.

It is evident from table 17 that, although total tillers had highest direct effect (0.426), its negative indirect effect via productive tillers (-0.215) reduced its strength of association with grain yield. On the contrary although productive tillers had negative direct effect (-0.267), its large positive indirect effect via total tillers made it to associate positively with grain yield. The higher positive direct effect (0.311) and indirect effects via total tillers (0.099), panicle length (0.068) and 1000-grain weight (0.062) led to positive significant correlation of days to 50 per cent flowering with grain yield while its negative indirect effects influenced least.

The positive association of panicle weight with grain yield was mainly due to its positive direct effect whereas, its indirect effects were meagre. Although per cent fertile grains had positive direct effect, it had negative association with grain yield (r=-0.125) due to negative indirect effects via culm length (-0.042), first internode length (-0.059), leaf area (-0.031), total tillers (-0.053), days to 50 per cent flowering (-0.084) and 1000-grain weight (-0.038), whereas, it had less positive indirect effects via other characters. The association of 1000-grain weight was negative with grain yield as it had negative direct effect and high negative indirect effects through days to 50 per cent flowering (-0.144) and total tillers (-0.140) while the positive indirect effects were insufficient to counter act negative direct and indirect effects. The effect of residual

factors showed that only 58.53 per cent of variability was explained by the characters under study.

4.4.3 Seasons-III [Kharif, 1991 at UAS, Dharwad]

The path analysis of data on the drought tolerant rice genotypes, in fully upland condition, in Botany garden U.A.S., Dharwad during Kharif 1991 (Table 18) revealed that culm length had large positive direct effect on grain yield (0.569) followed by days to 50 per cent flowering (0.451), first internode length (0.243), panicle weight (0.215), leaf area (0.177), productive tillers (0.141) and panicle length. Whereas, flag leaf length had high negative direct effect (-0.357) followed by plant height (-0.312) and per cent green leaves (-0.108).

The large positive indirect effects of plant height via culm length (0.549) first internode length (0.161), panicle weight (0.092), days to 50 per cent flowering (0.083), leaf area (0.083) and panicle length (0.078) resulted in its significant positive association with grain yield, though its direct effect was negative and it also had high negative indirect effect via flag leaf length (-0.169). The higher positive direct effect (0.569) and indirect effect through first internode length (0.149) of culm length lowered by high negative indirect effects via plant height (-0.310) and flag leaf length (-0.118) to some extent. The positive association of first internode length with grain yield was attributed to its positive direct effect and high positive indirect effect via culm length (0.351). However, its higher negative

Table 18. Path analysis of yield and its components showing the direct and indirect effects in rice (Season - III)

	1 Plant height	2 Culm length	3 first internode length	4 leaf area	5 % green leaves	6 Panicle length	7 Flag leaf length	8 Panicle exsertion	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight	13 % fertile grains/ panicle	14 1000 grain weight	Correltion with grain yield
Plant height	<u>-0.321</u>	0.549	0.161	0.083	-0.015	0.078	-0.169	0.014	-0.025	-0.031	0.083	0.092	0.013	-0.019	0.493**
Culm lenght	-0.310	<u>0.569</u>	0.149	0.071	-0.019	0.055	-0.118	0.018	-0.024	-0.029	0.027	0.085	0.021	-0.021	0.473**
First internode length	-0.214	0.351	<u>0.243</u>	0.093	-0.006	0.067	-0.194	0.015	-0.020	-0.012	0.067	0.089	0.011	-0.010	0.480**
Leaf area	-0.157	0.238	0.132	<u>0.171</u>	-0.006	0.063	-0.204	0.008	-0.016	-0.024	0.092	0.088	0.015	-0.010	0.390**
% green leaves	-0.047	0.102	0.013	0.01	<u>-0.108</u>	-0.002	0.007	0.008	-0.014	-0.036	-0.011	0.091	0.015	-0.013	0.013
Panicle length	-0.190	0.236	0.123	0.081	0.002	<u>0.132</u>	-0.217	-0.009	-0.017	-0.022	0.233	0.050	-0.015	0.002	0.390**
Flag leaf length	-0.153	0.189	0.132	0.098	0.002	0.081	<u>-0.357</u>	-0.001	-0.009	-0.019	0.203	0.082	-0.017	0.002	0.233
Panicle exsertion	-0.096	0.217	0.075	0.028	-0.018	-0.025	0.008	<u>0.048</u>	-0.018	-0.012	-0.138	0.053	0.039	-0.026	0.136
Total tillers/m	0.141	-0.246	-0.086	-0.049	0.027	-0.039	0.062	-0.015	<u>0.057</u>	0.093	-0.032	-0.083	-0.026	0.020	-0.178
Productive tillers/m	0.072	-0.120	-0.020	-0.029	0.027	-0.021	0.048	-0.004	0.037	<u>0.141</u>	0.039	-0.030	-0.004	0.008	0.144
Days to 50% flowering	-0.059	0.034	0.036	0.035	0.002	0.068	-0.161	-0.014	-0.004	0.012	<u>0.451</u>	0.013	-0.037	0.018	0.395**
Panicle wieght	-0.137	0.225	0.100	0.070	-0.045	0.031	-0.137	0.011	-0.022	-0.019	0.028	<u>0.215</u>	0.028	-0.023	0.324*
% fertile grains/panicle	-0.051	0.148	0.033	0.033	-0.020	-0.025	0.077	0.023	-0.018	-0.007	-0.206	0.076	<u>0.081</u>	-0.028	0.115
1000 grain weight	-0.134	0.270	0.053	0.039	-0.030	-0.007	0.016	0.027	-0.025	-0.025	-0.180	0.112	0.051	<u>-0.045</u>	0.123

Residual effect (R) = 0.469 (21.99%)
The underlined figures denote the direct effects.

indirect effects via plant height (-0.214) and flag leaf length (-0.194) counter acted the positive effects. The positive indirect effect of leaf area via culm length (0.238) was of large magnitude followed by that via first internode length (0.132), days to 50 per cent flowering (0.092) and panicle weight (0.088) while it had high negative indirect effects via flag leaf length (-0.204) and plant height (-0.157). The negative direct contribution of per cent green leaves (-0.108) was counter acted by its positive indirect effects via culm length (0.102) and panicle weight (0.091) resulting in weak association of this character with grain yield.

Panicle length had positive direct effect (0.132) as well as indirect effects via culm length (0.236), days to 50 per cent flowering (0.233) and first internode length (0.123). However, negative indirect effects via flag leaf length (-0.217) and plant height (-0.190) were the main forces to counter act positive effects. Although, flag leaf length had negative direct effect (-0.357) and indirect effect through plant height (-0.153) it had positive association with grain yield which was mainly due to positive indirect effects via days to 50 per cent flowering (0.203), culm length (0.189) and first internode length (0.132). Though panicle exsertion contributed least (0.048) towards yield directly, its effect was further enhanced by the indirect positive effects via culm length (0.217), first internode length (0.075) and other positive indirect effects, the combined effects of which inturn were lowered by negative indirect effects via days to

50 per cent flowering (0.138), plant height (0.096) and other negative effects.

Even total tillers had slight positive direct effect and indirect effect via plant height (0.141), it had high negative indirect effect via culm length (-0.246) followed by first internode length (-0.086) and panicle weight (-0.83) which made it to associate negatively with grain yield. The main cause of positive association of productive tillers with grain yield was its positive direct effect while its negative indirect effects were eliminated by positive indirect effects. Days to 50 per cent flowering contributed mostly by direct effect towards yield. However, its indirect effect via flag leaf length (-0.161) lowered its direct effect to some extent.

Panicle weight had positive indirect effects through culm length (0.255) followed by via first internode length (0.100) and leaf area (0.070) while it had high negative indirect effects via plant height (-0.137) and flag leaf length (-0.137). The high negative indirect effect of per cent fertile grains through days to 50 per cent flowering was noticed which was counteracted by its positive direct effect and indirect effects via culm length (0.148), flag leaf length (0.077) and panicle weight (0.076) to get positive association of it with grain yield. The negative direct effect and high indirect effects of 1000-grain weight via days to 50 per cent flowering (-0.180) and plant height (-0.134) were counteracted by positive indirect effects mainly through culm length (0.270) and panicle weight (0.112) resulting in positive association of this character with yield.

The effect of residual factors (R=0.469) showed that 78.00 per cent of variability was explained by the characters under investigation.

4.4.4 Season-IV [Summer, 1992 at ARS, Mugad]

Persual of Table 19 revealed that in fourth season plant height had maximum direct contribution (3.708) towards yield. Its indirect effects via panicle weight (0.157) and days to 50 per cent flowering (0.152) also added the positive contribution to yield, whereas, high negative indirect effects via culm length (-2.710), panicle length (-0.990) and first internode length (-0.098) lower the value of correlation with yield. The positive association of culm length was mainly due to high positive indirect effects via plant height (3.509), panicle weight (0.156) and days to per cent flowering (0.118). However, it had high negative direct effect (-2.864) and indirect effect via panicle length (-0.605) to counter act positive effects. First internode length had larger positive indirect effects via plant height (2.393) and panicle weight (0.143). But the negative direct effect (-0.153) and high negative indirect effects via culm length (-1.784) and panicle length (-0.595) considerably lowered the positive effects. The direct contribution of leaf area (0.138) towards yield was further enhanced by its indirect effects via plant height (1.871), days to 50 per cent flowering (0.130) and other positive effects. However, high negative indirect effects via culm length (-1.202) and panicle length (-0.691) were main forces to counter act the positive direct and indirect effects. The high positive indirect effect of per cent green

Table 19. Path analysis of yield and its components showing the direct and indirect effects in rice (Season - IV)

	1 Plant height	2 Culm length	3 first internode length	4 leaf area	5 % green leaves	6 Panicle length	7 Flag leaf length	8 Panicle exsertion	9 Total tillers per m.	10 Productive tillers per m.	11 Days to 50% flowering	12 Panicle weight	13 % fertile grains/ panicle	14 1000 grain weight	Correltion with grain yield
Plant height	3.708	-2.710	-0.098	0.070	-0.012	-0.990	0.043	0.057	-0.004	0.002	0.152	0.157	-0.018	-0.032	0.316*
Culm lenght	3.509	-2.864	-0.095	0.058	-0.014	-0.605	0.039	0.090	-0.005	0.002	0.118	0.156	-0.040	-0.047	0.302*
First internode length	2.393	-1.784	-0.153	0.066	0.005	-0.595	0.047	0.064	-0.003	-0.004	0.042	0.143	-0.045	-0.029	0.145
Leaf area	1.871	-1.202	-0.072	0.138	-0.006	-0.691	0.074	-0.014	-0.004	0.003	0.130	0.098	-0.017	-0.022	0.286*
% green leaves	0.762	-0.652	0.012	0.014	-0.062	-0.096	-0.002	-0.023	-0.006	0.013	0.074	0.028	-0.023	-0.069	-0.028
Panicle length	2.561	-1.202	-0.063	0.066	-0.004	-1.442	0.033	-0.044	-0.001	-0.002	0.161	0.087	0.037	0.017	0.205
Flag leaf length	1.248	-0.878	-0.056	0.080	0.0004	-0.375	0.128	-0.022	0.004	-0.004	0.053	0.072	-0.018	-0.022	0.209
Panicle exsertion	0.715	-0.874	-0.033	-0.007	0.004	0.214	-0.009	0.296	0.004	-0.009	-0.053	0.071	-0.083	-0.062	0.174
Total tillers/m	-0.478	0.418	0.016	-0.017	0.012	0.049	0.015	0.038	0.035	-0.032	-0.090	-0.093	0.031	0.038	-0.056
Productive tillers/m	-0.067	0.154	-0.015	-0.011	0.020	-0.095	0.013	0.066	0.027	-0.041	-0.071	-0.065	0.037	0.043	-0.004
Days to 50% flowering	1.395	-0.840	-0.016	0.044	-0.011	-0.575	0.017	-0.038	-0.007	0.007	0.404	0.015	0.074	0.078	0.547**
Panicle wieght	1.423	-1.093	-0.053	0.033	-0.004	-0.307	0.022	0.051	-0.007	0.006	0.014	0.411	-0.070	-0.105	0.321*
% fertile grains/panicle	0.328	-0.542	-0.032	0.011	-0.006	0.254	0.010	0.115	-0.005	0.007	-0.142	0.135	-0.212	-0.136	-0.231
1000 grain weight	0.562	-0.649	-0.021	0.014	-0.020	0.120	0.013	0.087	-0.006	0.008	-0.150	0.205	-0.137	-0.211	-0.183

Residual effect (R) = 0.452 (20.43%)
The underlined figures denote the direct effects

leaves via plant height (0.762) was counter acted by its negative indirect effects via culm length (-0.652) and other negative effects thus resulted in weak association of this character with grain yield.

Panicle length had high positive indirect effects via plant height (2.561) and days to 50 per cent flowering (0.161) which along with other positive indirect effects, though low in magnitude made this character to associate positively. However, its negative direct effect (-1.442) and high negative indirect effect via culm length counter acted to lower the strength of association. Flag leaf length had positive direct effect (0.128) and indirect effects via plant height (1.248), leaf area (0.080), days to 50 per cent flowering (0.053) and panicle weight (0.072), whereas, negative indirect effects via culm length (-0.878), first internode length (-0.056), panicle length (0.375) were observed while indirect effects through other characters was negligible. The direct effect of panicle exsertion was positive (0.296) which was further enhanced by high indirect effects via plant height (0.715) and panicle length (0.214) which made this character to associate positively with yield. However, high negative indirect effect via culm length (-0.874) lowered the strength of correlation while indirect effects via other characters was not enough to alter the association considerably. Total tillers had negligible contribution towards yield (0.035), though its negative indirect effects via plant height (-0.478) and others were compensated by positive indirect effects via culm length (0.418) and others to make the association of this character

with yield feable. The direct and indirect effects of productive tillers irrespective of their signs, showed less contribution towards yield thus indicated negligible correlation coefficient (-0.004).

Days to 50 per cent flowering had highly significant positive correlation with grain yield which could be attributed to its high positive indirect effects via plant height (1.395) and positive direct effect (0.404). Whereas, the high negative indirect effects via culm length (-0.840) and panicle length (-0.575) were major forces to counter act positive effects. The positive indirect effects of panicle weight via plant height (1.423) and its direct effect (0.411) and other indirect effects via other traits, though less in magnitude resulted in positive association of panicle weight with grain yield. However, it had high negative indirect effects via culm length (-1.093), panicle weight (-0.307) and 1000-grain weight. The direct effects of per cent fertile grains and 1000-grain weight were -0.212 and -0.211 respectively. These also had negative indirect effects via one another as well as via culm length, first internode length, per cent green leaves, productive tillers and days to 50 per cent flowering, whereas, both of them had positive indirect effects via other characters.

The effect residual factors revealed that 79.57 per cent of variability was accounted for by the characters under investigation.

DISCUSSION

CHAPTER- 5

V DISCUSSION

Genetic improvement in any crop plant depends on the existence of variability and its efficient exploitation through selection. Although hybrid rice is gaining importance recently, the difficulty in hybrid seed production made it impracticable in India. The main thrust on genetic improvement of rice is through careful choice of parents and exploitation of the variability through hybridization. To develop varieties for upland conditions, drought tolerant genotypes with suitable plant type are to be selected from a diverse gene pool and utilised as parents in hybridization programme. It means that the parents chosen for hybridization should be diverse enough to release substantial genetic variability in respect of yield related and specific characters viz., drought tolerance in high yielding segregants. The importance of identifying suitable and genetically diverse parental combination lies in the fact that the nature (magnitude and desirability) of the variability released in the segregating generations depends greatly on the diversity existing between the parents. All the efforts of practicing selection may turn futile if this key factor is not given its due importance. To study the magnitude of genetic diversity existing in the germpalsm collection, different methods of classificatory analysis have been employed in many crop plants. These techniques asses the diversity based on multiple trait measurements. Since rice is exposed to diverse climatic conditions and seasonal fluctuations, it is important

to know whether the nature of diversity observed in the collection is different/consistent across environments.

After assessing the genetic diversity among the genotypes, the next important aspect is to acquire information about the associations of agronomic, physiologic and yield related attributes among themselves and with grain yield and about their contribution (direct and indirect) to grain yield to help in effective selection programme after hybridization.

An attempt has been made to obtain information on the aforesaid aspects in collection of 50 genotypes grown in four environments viz., Kharif, 1990; Kharif, 1991(M); Kharif, 1991 (D) and Summer, 1992. The prevalence of long dry spell (15 days) during Kharif 1990, which coincided with the reproductive stage of crop growth, a most sensitive stage for water stress, was ideal to assess the yielding ability of genotypes under drought. Kharif, 1991 (M) at ARS, Mugad was most congenial for rice growing. Hence, crop growth and yields were superior in that season, while crop growth and yield during Kharif 1991 (D) at UAS, Dharwad were adversely affected because rice was grown as fully upland without any stagnation of water throughout the cropping period. Similarly, the growth and yield in summer, 1992 were affected as compared to Kharif 1990 and Kharif 1991 (M) because of dry spell of 20 days due to withholding of irrigation. The meteorological data highlighting the rainfall pattern during the cropping seasons are presented in Appendix II. The results obtained on all these aspects in these four seasons

have been compared and discussed below in light of the available literature.

5.1 Analysis of genetic divergence

The utility of discriminant function has been greatly emphasized in the problems of classification and selection of plants (Fisher, 1936). Among the available statistical methods, principal component analysis, canonical analysis and the method of generalised distance (D^2-analysis) were used to classify the rice germplasms (Murty and Quadri 1966; Kanwal et al., 1983; Ratho, 1984; Sasmal, 1987; Pande and Ghorai, 1987; Selvakumar et al., 1989; Biswas and Sasmal, 1990 and Gomathinayagam et al., 1990). However, a comparison of these methods with large number of characters has indicated the superiority and consistency of D^2-analysis and canonical analysis which were complementary to each other (Rao, 1952).

In rice, although many reports pertaining to the study of genetic divergence through effective quantitative approaches are available, the reports with more number of genotypes in more than one season are rare. Hence, it is intended to show the range of genetic diversity in the collection of genotypes from different eco-geographic regions and analysing the role of quantitative characters through multivariate analysis in four different seasons.

5.1.1 Genetic divergence through Mahanalobis' D^2-analysis

Data collected on various quantitative characters from 50 rice genotypes grown over a period of four seasons has been subjected to assess the genetic diversity using the concept of

generalised distance (D^2). The utility of concept of generalised distance would be dependent on the consistency of results of classification of population under defferrent environments. The overall D^2 value between two populations represents a complex variable made up of the contribution of several relatively simple variables. The magnitude of all possible D^2 values ranged from 16.96 to 850.87 in Kharif 1990; 19.91 to 3122.83 in Kharif 1991 (M), 19.90 to 1023.11 in Kharif 1991 (D) and from 33.52 to 3565.42 during Summer 1992 revealing substantial divergence in the material. The D^2 values were found to be higher during summer 1992 season which may be attributed because of pronounced environmental effect on the quantitative traits in that season.

In the present study, the clustering pattern varied from season to season. All the 50 genotypes were grouped under 13 clusters in Kharif, 1990; 18 clusters in Kharif, 1991 (M); 17 clusters in Kharif, 1991 (D), while in summer, 1992 38 clusters were formed such that most of genotypes (32) grouped singly because of high D^2 values owing to the expression of higher variability in that season which did not represent typical rice growing season. The composition of clusters were different under these four diverse seasons. The genotypes IR47686-6-2-1-1 and IR47686-6-1-1 remained in the same cluster in all four seasons indicating that these two genotypes have similar genetic architecture that is least affected with seasonal fluctuations. The cultivar IET2254 remained isolated with all genotypes in all four seasons. All other genotypes did not fall in any common cluster in all four seasons.

However, some genotypes formed common cluster with respect to three seasons. Such similarity and dissimilarity of the clustering pattern and constituents in a cluster in such cases could be attributed to two things; firstly, pronounced genotype-environment interactions which differed in varying seasons might have influenced the process of discrimination as opined by Upadhyay and Murty (1970), Peter (1975), Jain et al. (1981), Pande and Ghorai (1987) and Pradhan and Roy (1990) and Sarawgi and Shrivastava (1991) and secondly, the level of average increase in D^2 value which will be fixed arbitrarily to know whether or not to include a genotype in a particular cluster might have come in the way of discrimination.

From the clustering pattern of 50 rice genotypes, it was observed that the clusters were constituted by some cultivars which had their origin from different geographic area in all the four seasons. In other words, the cultivars have been clustered randomly irrespective of their origin which gave an evidence that a geographic diversity is not a reasonable index of genetic diversity while Mahalanobis' D^2-analysis of quantitative traits is a powerful tool for measuring genetic divergence amongst the material selected even from the same geographic origin. These indicated that the geographic diversity though important may not be the only factor in determining genetic divergence and the factors other than geographic diversity such as genetic drift, selection pressure and environment may be responsible for the differential grouping of the varieties. This is in consonance with the findings of Maurya and Singh (1977), Suyambulingom and

Jebarani (1978), Ratho (1984), Sasmal (1987) and Gomathinayagam et al. (1990).

It is concluded from the present investigation that in general, there was no parallelism between genetic and geographic diversity in all four seasons. This is in consonance with the results observed by Kanwal et al. (1983), singh (1983), Nadaf et al. (1986), Pande and Ghorai (1987), Selvakumar (1989) and Biswas and Sasmal (1990), while Ram and Panwar (1970) and Sinha et al. (1977) found that genetic diversity might be related to geographic diversity in rice. The disagreement of genetic diversity to follow geographical diversity may be partly because of the consistent cultivation of genotypes having common origin, in different geographic regions. In some cases, varieties originating at the same place may also have different architecture and likewise certain cultivars may posses similarity with respect to some traits though they had their origin at different centers. Maurya and Singh (1977) reasoned for the similar finding that, not the barriers of distance between two locations but of climate, biotype, soils and management are potent to accumulate variability. The authors observed sufficient diversity in the material from the product of only few crosses and bred under unidirectional selection force in same location. The other possibility is that varieties with same geographic origin could have undergone modifications in their characteristics under stress conditions which in strict sense is an accumulation of abundant variability in the material due to natural selection even at a single location. This leads to

suggest that the selection of parental material for hybridization merely based on geographic diversity may be arbitrary and erroneous.

The analysis for estimating the contribution of various characters towards the expression of genetic divergence has indicated that days to 50 per cent flowering was the single character which contributed most towards genetic divergence in all four seasons studied. The characters grain yield, panicle exsertion, 1000-grain weight, total tillers and panicle weight were also found to contribute more towards total genetic distance in all seasons. It is therefore, apparent that the days to 50 per cent flowering is the basic component of genetic divergence substituted by the characters mentioned above. Nadaf (1980), Kotaiah et al. (1986 and 1988) also reported that days to 50 per cent flowering contributed maximum towards genetic divergence. Kanwal et al. (1983) reported that panicle weight contributed most towards divergence. The test weight made greater contribution to D^2 values in the reports of De et al. (1988), Kotaiah et al. (1988) and pradhan and Roy (1990). Selvakumar et al. (1989) reported that yield components such as grains per panicle and fertile tillers contributed most to the genetic divergence between genotypes. The study also revealed that the other yield component characters had played relatively lesser role in causing genetic divergence between the genotypes.

The role of different plant traits in the inter cluster divergence can also be studied by comparing cluster means for

different traits in four seasons. In Kharif 1990, it could be observed that the distances between solitary clusters VII (IR 53236-70-2) and VIII (IR57924-9), VII and X (IR 47691-17-1-B), VII and XI (IR47686-1-1-B), cluster III consisting genotypes IR60080-49, IR60080-45, IRAT 104 (A), IR47686-12-5-B-1, IR47686-6-2-1-1, IR47686-6-1-1 and IR 47686-5-10-B with cluster VII (IR53236-70-2), cluster II (comprising IR53236-275-2, IR53236-77-1, IR53236-139, IR 53236-218-3, IR53234-27-7, IR53234-27-6 and IET 7564-4-3) and cluster VIII (IR57924-9), cluster V (IR55549-1-2 and IR 47686-30-2-1) and XII (IET 2254), V and XII (IET 7991-11-2) were higher in order of magnitude and hence the cultivars between these clusters were more divergent. Difference of cluster means in the above seven pairs of clusters were observed in common for first internode length and flag leaf length. Besides, differences in cluster means were noticed differentially in different pairs viz., in first pair-leaf area, per cent green leaves, panicle length, panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and grain yield; in second pair-leaf area, per cent green leaves, total and productive tillers, days to 50 per cent flowering, panicle length and grain yield; in third pair-leaf area, per cent green leaves, panicle length, panicle exsertion, total tillers, days to 50 per cent flowering and panicle weight, in fourth pair-plant height, culm length, leaf area, per cent green leaves, panicle length, days to 50 per cent flowering, panicle weight and grain yield; in fifth pair-plant height,

leaf area, panicle length, panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and grain yield; in sixth pair-plant height, culm length leaf area, panicle length panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weights and 1000-grain weight; in seventh pair-plant height, culm length, leaf area, panicle length, panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains and grain yield. This indicated that these characters contributed maximum to the genetic distance between the clusters of above sets. The crosses between cultivars of these clusters, each of the above pairs may throw some useful transgressive segregants provided there is no sterility. The minimum distance between clusters I and IX, II and VII, III and X, III and XI, IV and VI, IV and VII, IV and X, V and XI, VI and X, IX and XI and between clusters XII and XIII (Table 4) indicates that the cultivars of these individual cluster pairs were comparatively closer to each other.

In Kharif 1991 (M), it could be observed that the distance of solitary cluster XVII (IET5882) with clusters I, IV, VI, IX, and XII; cluster XVI (IET 1444) with clusters I, IV, VI, IX and XII; cluster XV (IET 2254) with clusters I, VI and IX were higher in order of magnitude and hence the genotypes (Table 7) between these fourteen pairs of clusters were more divergent. The traits culm length, first internode length, per cent green leaves, flag leaf length, and per cent

fertile grains were found almost common among the above mentioned clusters. In first two pairs-days to 50 per cent flowering, 1000-grain weight and grain yield in addition to and panicle weight in first pair and panicle length in second pair; in third pair-plant height, leaf area, panicle length, days to 50 per cent flowering, panicle weight, 1000-grain weight and grain yield; in fourth pair-plant height, panicle length, total and productive tillers, days to 50 per cent flowering, panicle weight and grain yield; in fifth and sixth pairs-plant height, panicle length, total and productive tillers, days to 50 per cent flowering, 1000-grain weight, grain yield and panicle length and panicle weight in sixth pair only; in seventh and eight pair-total and productive tillers, days to 50 per cent flowering, panicle weight and panicle length in eighth pair only; in ninth, tenth and eleventh pairs-plant height, leaf area, panicle length, total and productive tillers, days to 50 per cent flowering panicle weight and 1000-grain weight; in twelfth pair-plant height, panicle exsertion, days to 50 per cent flowering, and 1000-grain weight; in last two pairs-plant height, panicle length, days to 50 per cent flowering, grain yield and panicle weight were observed to contribute for differences, indicating that these characters exerted maximum influence to the genetic divergence between the clusters of above sets. The minimum distance between clusters I and IV, II and V, II and X, IV and IX, VII and X and between clusters VII and XIII (Table 8) indicated that genotypes of these individual cluster pairs were comparatively closer to each other.

In Kharif 1991 (D), it could be observed that the distance between clusters I (comprising genotypes, IR53236-70-2, IR53236-77 1, IR53236-139, IR53236-218-3, IR53236-27-7, IR53167-17, IRAT 212, IRAT 114 (B), CNA 4130 and CNA 4137) and VI (containing genotypes, IET 1444 and Gama 318), II (containing IR55549-1-2, IR47686-30-2-1 and IR47686-5-10-B) with clusters X (IET 7991-11-2 and IET 7564-4-3), XI (IR53236-275-2) and XVII (IET 2254); clusters IV and XI, V and XI, V and XII, VI and XI, VI and XIII and distance of cluster IX (comprising IR47686-6-2-1-1 and IR47686-6-1-1) with clusters X, XI, XII and XVII were higher in order of magnitude and hence the genotypes between these thirteen pairs of clusters were more divergent genetically. Difference of cluster means in the above pairs of clusters were found in common for first internode length, flag leaf length and per cent green leaves.

Besides, in first pair-plant height, culm length, panicle exsertion, total and productive tillers, days to 50 per cent flowering and 1000-grain weight; in second pair-plant height, culm length leaf area, per cent green leaves, panicle length, panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and grain yield; in third pair plant height, culm length, leaf area, panicle length, days to 50 per cent flowering, panicle weight and grain yield; in fourth pair-plant height, culm length leaf area, panicle length, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and

grain yield; in fifth pair plant height, culm length leaf area, panicle length, panicle exsertion, days to 50 per cent flowering, panicle weight, per cent fertile grains and grain yield; in sixth pair plant height, panicle length, panicle exsertion, days to 50 per cent flowering, per cent fertile grains, 1000-grain weight and grain yield; in seventh pair-plant height, leaf area, panicle weight, per cent fertile grains and 1000-grain weight; in eighth pair-panicle exsertion, total and productive tillers, days to 50 per cent flowering, per cent fertile grains, 1000-grain weight and grain yield; in ninth pair plant height, culm length, panicle exsertion, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and grain yield; and almost all characters considered between cluster IX and X, XI, XII and XVII were observed to reveal difference. This indicated that these characters contributed maximum to the genetic divergence between above mentioned clusters. The crosses between genotypes of these clusters of each of the above pairs would be expected to throw some useful transgressive segregants provided there is no sterility. The distance between clusters II and IV, III and IV, cluster XII with I, X and XI; cluster XIII and I, XIV and XII, XV and II, XV and III, XVI and VII and between clusters XVI and XIII were found to be lower indicating that the genotypes of these individual cluster pairs were comparatively closer to each other.

In Summer 1992, an higher order of inter cluster distance was noticed between clusters VII and V, XV, XVII, XXXV, and

XXXVI. cluster VIII also recorded higher values of inter cluster distances with clusters V, VI, XV, XVII, XX, XXVII, XXXII, XXXV and XXXVI. Simultaneously, the genetic distance of cluster XI with clusters V, XV, XVI, XVII, XX, XXXV and XXXVI; cluster XV with clusters IX, X, XII, XIII, XVIII and XIX; cluster XVII with clusters IX , XII and XIII were also higher in magnitude. Cluster V contained two genotypes viz., IR55411-53 and IR47691-17-1-B while cluster VI is constituted by IR47686-6-2-1-1 and IR47686-6-1-1, whereas, all other clusters were solitary (Table 12). Differences of cluster means in above thirty pairs of clusters were observed almost in common for culm length, first internode length, per cent green leaves and flag leaf length while other characters studied were observed to have difference between individual cluster pairs. This indicated that the characters viz., plant height, leaf area, panicle length, panicle exsertion, total and productive tillers, days to 50 per cent flowering, panicle weight, per cent fertile grains, 1000-grain weight and grain yield contributed maximum to the genetic distance between the clusters of above sets. The crosses between genotypes of these clusters of each of the above pairs might throw useful transgressive segregants in the segregating populations. The minimum distance between clusters I and XIV, XXIII and XXIV, cluster II with XXVII and XXXII, III with IV and XXVII, IV with XX and XXVII, between clusters V and XX, VI and XXVII, cluster VII with VIII and IX, IX with XII and XIII, between clusters XII and XIII, XIII and XXIV, XIV and XXIV, XVI and XXII, XVII and XXXVI, XX and XXII, XXI and XXII, XXI and

XXVII, XXV and XXVII, XXVII and XXVIII, XXVIII and XXXII and XXXV and XXXVI (Table 14) indicated that cultivars of these individual cluster pairs were comparatively closer to each other.

5.1.2 Choice of genotypes for hybridization

Any success through hybridization followed by selection depends primarily on the selection of parents having high genetic variability for different characters (Murty and Arunachalam, 1966; Bhatt, 1970). Multivariate analysis by means of D^2 statistics developed by Mahalanobis (1936), is a powerful tool in quantifying the degree of divergence among biological populations. Change in environments alters clustering pattern due to genotype-environment interactions (pande and Ghorai, 1987; Pradhan and Roy, 1990 and Sarawgi and Shrivastava, 1991). This sensitivity to environmental variations casts doubt on reliability of D^2 analysis in a single environment and points to the need of making such studies under multiple environmental conditions. Under such situations stable diverse genotypes which cluster in groups with large inter-cluster distances between them, in all environments consistently prove to be of great significance.

While chosing genotypes as parents for hybridization, the per se performance of the genotypes with higher D^2 value should be taken into consideration in addition to maximum inter-cluster genetic divergence among the genotypes. The important practical objective of D^2 study is to identify pairs of genotypes suitable for hybridization. If these genotypes

are genetically diverse, the cross will be capable of releasing maximum variability. The D^2 value is estimated based on multiple measurement, wherein importance is attached to all the characters included in the study. Some of these characters may have substantial contribution towards yield, while some may have relatively lower contribution. If the mean per se performance of the two genotypes is too low, such pair is not likely to throw very high yielding segregants, revealing transgressive segregation of an exceptionally high order, to be of any practical value. Other practical considerations in upland rice such as drought tolerance and grain type etc. should also be taken into account in addition to genetic divergence. The parents should have almost desirable traits in complementary with each other.

In the present study, it has been found that the genotypes IR53236-275-2, IR53236-70-2, IR53236-77-1, IR 53236-139, IR53236-218-3, IR53236-27-7, IR53234-27-6 and IET 7564-4-3 together showed high D^2 values with some genotypes viz., IR5411-50-1, IR57924-9, IR60080-49, IR 60080-45, IR47686-6-2-1-1, IR47686-6-1-1, IET 1444 and Gama-318 consistently in all seasons (Table 20). The intra-group D^2 values of these eight genotypes are found to be lower in all seasons indicating that they are genetically closer together. The per se performance of these genotypes was observed to be lower. However, cultivars namely IR 53236-77-1, IR53236-27 7, IR53234-27-6 and IET 7564-4-3 were found to he comparatively better. Therefore crossing these genotypes with better yielding genotypes having higher divergence would expectedly

Table 20. Average D^2 values of selected genotypes showing high divergence with some genotypes in all four seasons consistantly

Genotypes in a group	Intra-group D^2 value	IR5411-50-1	IR57924-9	IR60080-49	IR60080-45	IR47686-6-2-1-1	IR47686-6-1-1	IET1444	Gama-318
IR53236-275-2 (S1=504, S2=646, S3=134, S4=472) IR53236-70-2 (S1=537, S2=509, S3=190, S4=516) IR53236-77-1 (S1=768, S2=610, S3=364, S4=670) IR53236-139 (S1=642, S2=942, S3=356, S4=522)	S1=73.14	455.62 (1257)	600.28 (1929)	391.40 (1170)	358.00 (1173)	424.83 (1434)	450.09 (1465)	426.80 (1443)	392.17 (1359)
IR53236-218-3 (S1=498, S2=631, S3=240, S4=405) IR53236-27-7 (S1=714, S2=764, S3=265, S4=629) IR53234-27-6 (S1=654, S2=594, S3=259, S4=619) IET7564-4-3 (S1=882, S2=1004, S3=241, S4=595)	S2=74.52	677.71 (21.02)	921.45 (2776)	878.56 (1078)	939.99 (1202)	88.79 (1090)	815.51 (1285)	2108.51 (900)	1278.11 (1868)
	S3=124.54	786.53 (270)	724.54 (435)	610.03 (405)	597.36 (306)	678.66 (394)	802.77 (506)	866.06 (262)	676.82 (310)
	S4=254.52	2785.25 (921)	2444.55 (927)	1489.27 (927)	1330.77 (878)	1640.78 (1029)	1530.51 (1107)	2038.89 (654)	2060.62 (613)

Figures in parenthesis indicate per se performance of genotypes under which they are mentioned

S1= Kharif, 1990 at ARS, Mugad S2= Kharif, 1991 at ARS, Mugad
S3= Kharif, 1991 at UAS, Dharwad S4= Summer, 1992 at ARS, Mugad

throw desirable high yielding segregants in segregating populations suitable for upland conditions. These all genotypes are found to be drought tolerant of which IR47686-6-2-1 1 (plate-2) and IR47686-6-1-1 (plate-3) performed better in upland condition.

The other method of identifying the ideal parental combinations could be to pick up the genotypes with highest yielding ability along with most of desirable characters and observe all possible D^2 values among them and select the pair which has highest D^2 value in all four seasons. In the present investigation, the eleven genotypes (IR55411-53, IR 55411-50-1, IR57924-24, IR57924-9, IR60080-49, IR60080-45, IR60080-42, IR47686-6-2-1 1, IR47686-6-1 1, IR47686-5-10-B and CT 6510-24-1-2) have been found superior with respect to grain yield and desired traits in all four environments and having differences with respect to panicle characters in upland condition (Plate-4). When these eleven superior genotypes were surveyed for all possible D^2 values among them, majority were found to have low D^2 values revealing that these are not much divergent genetically. However, it is interesting to note that some genotypes which are good in performance and showed more D^2 values, shared with other genotypes in all seasons studied. The long slender grained genotype IR55411-53, registered comparatively higher D^2 value with IR47686-5-10-B with long bold grain type in all four seasons (Table 21). Both these genotypes are observed to be complementary with respect to some desirable traits. An hybridization between these two genotypes would represent a

PLATE - 2. Crop[illegible] stand of the genotype IR47686-6-2-1-1 in upland condition.


IR47-8865
21-1

PLATE – 2

PLATE - 3. Crop[illegible] stand of the genotype IR47686-6-1-1 in upland condition.



PLATE – 3

PLATE - 4. Panicle characters of genotypes

9. IR55549-1-2
10. IR55419-4
11. IR55411-53
12. IR55411-50-1
13. IR57924-24
14. IR57924-9
15. IR57893-73
17. IR55411-50
18. IR60080-49
20. IR60080-45
21. IR60080-42
23. IRAT 288
24. IRAT 216
27. IRAT 104(A)
31. IR47686-30-2-1
32. IR47686-12-5-3-1
33. IR47686-6-2-1-1
34. IR47686-6-1-1
39. CT6727-5-3
40. CNA4130
46. IET7991-11-2
47. IET1444
48. Gama-318



PLATE - 4

Genotypes	IR55411-53	IR55411-50-1	IR57924 -24	IR57924 -9	IR60080 -49	IR60080 -45	IR60080 -42	IR47686 -6-2-1-1	IR47686 -6-1-1	IR47686 -5-10-B	CT6510 -24-1-2	
IR55411-53	(1224)	65.99	99.50	178.63	115.33	75.90	55.31	104.76	129.76	215.46	64.89	(1)
	(1948)	68.49	125.06	127.28	267.10	289.73	215.26	315.55	259.47	191.08	167.96	(2)
	(431)	98.46	77.21	73.52	266.53	109.49	87.87	445.70	485.48	304.91	267.18	(3)
	(888)	210.66	156.28	291.67	258.39	141.98	246.14	309.48	327.04	205.29	595.33	(4)
IR55411-50-1		(1257)	135.00	145.22	147.54	94.98	152.86	108.93	135.04	184.44	144.69	
		(2102)	88.89	77.95	241.12	240.76	220.53	233.10	189.12	112.85	136.93	
		(270)	64.33	46.33	346.07	172.59	146.48	474.53	531.57	406.88	393.86	
		(921)	281.38	331.75	614.36	554.23	763.32	573.45	651.81	471.06	1236.25	
IR57924-24			(1389)	92.30	170.56	129.82	50.67	107.07	94.88	239.45	162.69	
			(1852)	155.94	160.51	160.12	123.39	200.60	151.42	120.13	124.24	
			(221)	59.14	275.40	120.69	98.77	478.60	531.29	442.03	393.50	
			(1002)	235.87	333.12	311.44	358.97	395.24	420.34	290.65	579.90	
IR57924-9				(1929)	288.09	212.46	183.75	188.71	140.05	270.15	233.08	
				(2776)	396.20	412.53	344.00	350.52	272.76	209.35	270.97	
				(435)	258.22	149.55	133.90	406.14	475.90	331.01	315.08	
				(937)	249.91	308.47	390.12	402.32	412.02	294.91	795.33	
IR60080-49					(1170)	35.82	123.49	57.50	71.17	95.43	108.06	
					(1078)	35.99	72.35	66.13	71.50	89.48	102.99	
					(4054)	80.96	148.28	175.51	180.66	122.19	142.00	
					(927)	107.53	200.49	250.85	149.14	125.01	547.06	
IR60080-45						(1173)	111.78	77.73	63.61	112.36	94.59	
						(1202)	75.02	121.49	113.71	128.22	122.12	
						(305)	38.46	295.35	250.91	218.64	186.25	
						(878)	60.13	269.57	190.68	115.50	335.52	
IR60080-42						(1242)	116.91	114.52	242.04	114.18		
						(738)	117.59	89.96	85.21	43.80		
						(334)	339.40	269.37	247.34	147.62		
						(824)	396.04	3309.22	214.78	217.74		
IR47686-6-2-1-1							(1434)	37.27	95.19	137.13		
							(1090)	20.95	62.53	79.79		
							(394)	86.94	145.87	296.56		
							(1029)	101.52	171.60	568.42		
IR47686-6-1-1								(1485)	72.36	159.24		
								(1285)	42.46	62.47		
								(506)	197.49	261.24		
								(1107)	121.21	525.21		
IR47686-5-10-B									(1206)	199.42		
									(1304)	48.80		
									(688)	93.82		
									(826)	444.64		
CT6510-24-1-2										(1224)		
										(710)		
										(648)		
										(975)		

Figures in parenthesis indicate per se performances of selected genotypes
(1) : Kharif 1990 at ARS, Mugad (2) : Kharif 1991 at ARS, Mugad (3) : Kharif 1991 at UAS, Dharwad (4) : Summer 1992 at ARS, Mugad.

compromise between superior per se performance and higher D^2 values. The genotype IR57924-9 having long bold grains, on an average had higher D^2 values with other four superior genotypes (IR60080-49, IR47686-6-2-1-1, IR47686-5-10-B and CT6510-24-1-2) in all four seasons among which IR47686-6-2-1-1 is having medium bold grain type while others have long bold grains. The genotype IR57924-9 was observed to be complementary with above mentioned four genotypes for desired traits. This indicates that it may be combined with the remaining four superior genotypes.

5.2 Character associations

Grain yield, an extremely complex trait, is the result of growth function of the plant. It is an example of integration in which the components of yield are partially interdependent in their development. Therefore, an estimation of the interrelationships between grain yield and the yield influencing traits is vital because this would facilitate effective selection simultaneously for improving one or more yield influencing components. Moreover, it is also possible that indirect selection for one or more components of yield may prove more effective than direct selection for yield itself. Grafius (1959) opined that there may not be any genes for yield as such, but there exist genes for its components. Yield is a character controlled by polygenes and would have low heritability. It is also an end-product of the interaction of their interrelated attributes. hence, an important step in the designed process of breaking the barrier

of yield improvement is the critical analysis of character associations.

The intensity and direction of association among characters may be measured by genotypic and phenotypic correlation coefficients. The knowledge of correlations of metric traits with each other and especially with grain yield is useful in designing an effective breeding programme. Genotypic correlations provide a reliable measure of genetic association between the traits and help to differentiate the vital associations useful in breeding from the non-vital associations (Falconer, 1981). Genotypic correlation may arise from genetic linkage, pleiotropy or from developmentally induced relationships (Stebbins, 1950 and Adams, 1967).

In most of the cases, the genotypic correlations differed from the corresponding phenotypic correlations. The differences in the correlation coefficients assessed at genotypic and phenotypic levels can be attributed to the masking or modifying effect of environment on genetic association between characters (Johnson et al., 1955 and Pinheiro et al., 1985). In some instances, the phenotypic and genotypic correlations were almost same, indicating the negligible environmental effects pertaining to the expression of such traits. The interrelationship of various yield components in a inter-linked complex system probably may depend on material chosen for study (Mukherji and Mandal, 1973, Srivastava et al., 1977; and Nadaf, 1980) and also varied with growing Season (Roychoudhary, 1967; Malik and

Hasija, 1987; Salam and Subramanian, 1988 and Tanisaka et al., 1989). The consistent correlations of characters across the seasons would be more valuable for assessing character associations.

Perusal of the Table 18 indicates that only 24 character pair comparisons at phenotypic level and 54 character pair comparisons at genotypic level had different associations while remaining other associations were proved to suffice the relationship amongst themselves by a pooled correlation coefficient irrespective of seasons.

In all four seasons grain yield showed positive and significant associations with panicle length, days to 50 per cent flowering, panicle weight and fertile grains per panicle and positively but nonsignificantly associated with flag leaf length and productive tillers at phenotypic and genotypic levels. A similar positive relationship of yield attributes indicated that they had certain inherent relationship with grain yield which was also reported in rice by Lin (1970), Yadav and Singh (1979), Unnikrishnan (1980), Sukanya (1984), Chauhan et al. (1986), Malik and Hasiji (1987), Prasad et al. (1988), Sampath et al. (1989), and Amirthadevarathinam (1990) while Sindhu (1973) reported negative association of yield with heading date although it had significant positive association with productive tillers, panicle length and grains per panicle. A study in three seasons by Sukanya and Rathinam (1984a) revealed significantly positive association of grain yield with panicle length, tiller number in all three seasons

and with grains per panicle in only one season while the association in other two seasons was insignificant. On the contrary to the present investigation some authors reported that the grain yield was negatively correlated with days to 50 per cent flowering (Talwar and Goud, 1974; Dhanraj et al., 1987), panicle length and effective tillers (Mukharji and Mandal, 1973), grains per panicle (Ghose et al., 1966) and flag leaf length (Yu et al., 1987). The nonsignificant positive association of grain yield with flag leaf length is in accordance with finding of Mukharji and Mandal (1973) while Eunus et al. (1974) reported significant positive association between same characters.

Irrespective of seasons, the correlation of grain yield with per cent green leaves and panicle exsertion was positive phenotypically but negative genotypically. However, correlation coefficients were negligible suggesting that these traits do not influence yield in this material. But in an inheritance study, Dhulappanavar (1963) reported negative correlation between grain yield and panicle exsertion, where as, the association between same characters was positive indicating that the complete panicle exsertion avoid loss in yield due to spikelet sterility and disease in a study by Unnikrishnan (1980).

The phenotypic correlation between grain yield and total tillers was insignificant in all seasons but at genotypic level total tillers had significantly associated with grain yield during Kharif, 1991 (M) which was lowland condition

without any water stress. This suggests that more total tillers are desirable to get more grain yield provided no water stress which is in consonance with reports of Kaul (1972), Sindhu (1973), Suyambulingom and Jebarani (1979), Amirthadevarathinam (1983) and Chauhan et al. (1986). Whereas, this association was significantly negative during Kharif, 1991 (D) which was upland condition suggesting limited total tillers, most of which would be productive, are desirable to get better yield in upland condition which is in consonance with the findings of Balakrishna et al. (1973) and Amirthadevarathinam (1990) in rice.

Both phenotypic and genotypic correlations between yield and plant height indicated positive association in three seasons while association was slightly negative during Kharif, 1991 (M) which might be due to diversion of more resources to build height while sufficient plant height is required during other three seasons. Likewise Roychoudhary (1967) reported positive association between grain yield and plant height in one season from a study in three seasons. While Sukanya and Rathinam (1984a) noticed positive association between same traits in all three seasons studied. Similarly many authors reported positive association of plant height with grain yield (Eunus et al., 1974; Talwar and Goud, 1974; Suyambulingam and Jebarani, 1979; Unnikrishnan, 1980; Sukanya, 1984; Chauhan et al., 1986; Marimuthu et al., 1990) and on the contrary some reported negative association between yield and plant height (Kaul, 1972; Amirthadevarathinam, 1983 and Reddy and Nerkar, 1990). In line with Yeh (1965), culm length showed positive

correlation with yield in three seasons but negative in one season on the contrary, both at phenotypic and genotypic levels. Similarly, first internode length also showed positive association with yield in three seasons and association was negative in one season. Leaf area showed significantly positive association in three seasons and negative association in one season with yield while Enus et al. (1974) and Chauhan et al. (1986) found positive association of yield with leaf length and positive association was observed between flag leaf area and yield by Manul and Palaniswamy (1989).

Grain yield was observed to be negatively associated associated with per cent fertile grains and 1000-grain weight in three seasons while they had positive but nonsignificant association during Kharif 1991 (D) which was fully upland condition where in the genotypes with more proportion of fertile grains and bold grains are desirable. Suyambulingom and Jebarani (1979) reported negative association of grain yield with fineness in tall varieties while the association was positive in dwarf varieties.

The variation between the seasons in respect of intensity and direction of association for different traits with yield in some cases may be attributed to the extreme environmental fluctuations. In general genotypic correlation values were higher than the phenotypic correlation values in all four seasons. The similar trend was also seen in rice by Sukanya (1984), Chauhan et al. (1886), Prasad et al. (1988) and Sundaram et al. (1990).

On considering the association of other traits among themselves, a strong positive association of seven traits (leaf area, panicle length, flag leaf length, panicle exsertion, panicle weight, grains per panicle and 1000-grain weight) with plant height, culm length and first internode length in all four seasons revealed the considerable commonness in the expression of genes responsible for these traits. The culm length and first internode length are components of plant height and hence they showed strong positive association among themselves in consonance with finding of Awan and Cheema (1986) who reported strong positive association of plant height, and lengths of second, third and fourth internodes with 1000-grain weight. Amirthadevarathinam (1990) reported positive association of culm length with days to 50 per cent flowering, panicle length and grains per panicle. Chang (1967) and Sukanya and Rathinam (1984a) also observed positive association of plant height with panicle length while its association was negative with panicle length in studies by Mukharji and Mandal (1973) and Reddy and Nerkar (1990). Other authors also reported positive association of plant height with leaf length (Chauhan et al., 1986), panicle exsertion (Tahir et al., 1988) and grains per panicle (Sukanya and Rathinam, 1984a; Chauhan et al., 1986 and Sundaram et al., 1990) while its associations with flag leaf nature (Mukherji and Mandal, 1973) and grain weight (Sukanya and Rathinam, 1984a and Sundaram et al., 1990) were negative. The trait plant height was also found to be positively but nonsignificantly associated with per cent green leaves which

was not found in earlier reports, days to 50 per cent flowering as reported by Prasad et al. (1988), per cent fertile grains in all seasons. Plant height showed negative association with total and productive tillers in three seasons in consonance with findings of Mukharji and Mandal (1973), Nadaf (1980), Sukanya and Rathinam (1984a) and Tahir et al. (1988) while the association between same characters was positive in one season as reported by Marimuthu et al. (1990).

Days to 50 per cent flowering was found to be associated positively and significantly with panicle length and grains per panicle while negatively and significantly with per cent fertile and grains and 1000-grain weight in all seasons. The trait days to 50 per cent flowering was also showed positive association with leaf area and flag leaf length in two seasons out of four seasons studied and with panicle weight in only one season. Dhanraj et al. (1987) observed negative association of days to 50 per cent flowering with all characters (plant height, productive tillers, panicle length, grains per panicle, 100-grain weight and yield) studied while Chauhan and Tondon (1984) reported positive association of days to 50 per cent flowering with days to maturity and panicle bearing tillers and negative association with plant height, panicle length, grains per panicle, 1000-grain weight and per cent spikelet fertility. Prasad et al. (1988) reported positive association of days to 50 per cent flowering with plant height and flag leaf length. Amirthadevarathinam (1990) noticed positive association of days to 50 per cent flowering with culm length, tiller number, panicle length and

grains per panicle and Marimuthu et al. (1990) also observed positive and negative associations of days to 50 per cent flowering with other yield components studied.

In all seasons leaf area was positively and significantly associated with panicle length, flag leaf length, panicle weight and with grains per panicle in three seasons and the association of the same trait with per cent green leaves, per cent fertile grains and 1000-grain weight was positive but not significant both phenotypically and genotypically suggesting that more leaf area is beneficial in producing longer and heavier panicle with more grain. This is in accordance with results obtained by Chauhan et al. (1986) and Manul and Palaniswamy (1989). In conformity with result of Manul and Palaniswamy (1989) the leaf area was positively and significantly associated with days to 50 per cent flowering in two seasons while the correlation between same traits was insignificant in other two seasons. The leaf area was negatively associated with total and productive tillers in consonance with findings of Chauhan et al.(1986).

Per cent green leaves at harvest was observed to have no significant association with any of the characters studied at phenotypic level. However, genotypic correlation of per cent green leaves and 1000-grain weight was positive and significant irrespective of environments suggesting that photosynthesis in more proportion of green leaves would be helpful in grain filling and thus increases the grain weight. In all seasons the genotypic correlation of per cent green

leaves with total and productive tillers were negative indicating that heavy tillered genotypes could not retain green in more proportion of leaves. Only during Kharif 1991 (D) a fully upland condition, the significantly positive association of per cent green leaves with panicle weight and grains per panicle was noticed suggesting that the genotypes which are slow in senescence would be desirable to get heavy panicles with more grains, by photosynthesis during grain filling stage.

In consonance with reports of Prasad et al. (1988) and Manul and Palaniswamy (1989), panicle length was correlated positively and significantly with flag leaf length in all seasons both at phenotypic and genotypic levels. However, Sampath et al. (1989) reported negative association between the same characters. Panicle length was associated positively with days to 50 per cent flowering, panicle weight and grains per panicle revealing some sort of commonness in the genes responsible for these characters and suggests that the medium early flowering types with desirable panicle size and with more grains and weight could be obtained. This is in consonance with reports of Unnikrishnan (1980), Chauhan et al. (1986), Prasad et al. (1988), Panwar et al. (1989) Manul and Palaniswamy (1989) and Amirthadevarathinam (1990). However, Dhanraj et al. (1987) reported significant negative association of panicle length with grains per panicle. Chauhan and Tondon (1984) reported negative association between panicle length and days to 50 per cent flowering in upland condition while association between panicle length and

grains per panicle was positive. Sukanya and Rathinam (1984a) observed significant positive association in two seasons and negative association in another season between panicle length and grains per panicle. The panicle length and panicle exsertion were correlated positively and significantly only at genotypic level during Kharif 1991 (M), a totally low land condition in consonance with observation of Unnikrishnan(1980) while the association in other three seasons was nonsignificant but slightly negative. In two seasons genotypic correlations were negative and significant between panicle length and total tillers in conformity with reports of Chauhan et al. (1986) and Sampath et al. (1989), However, Unnikrishnan (1980), Gomathinayagam et al. (1988) and Amirthadevarathinam (1990) reported positive association between panicle length and tillers number.

Sampath et al. (1989) reported positive correlation of flag leaf length with grains per panicle and days to panicle emergence both in parents and hybrids while its association with panicle bearing tillers was significantly negative in hybrids. Consonantly in the present study, phenotypic and genotypic correlations of flag leaf length with panicle weight and grains per panicle were positive indicating the importance of flag leaf for getting desirable panicle type while its association with days to 50 per cent flowering was significantly positive in two seasons genotypically and phenotypically, whereas, genotypic correlation between flag leaf length and total tillers was significantly negative during Kharif 1990.

The genotypes with more total tillers naturally have more productive tillers in all seasons in consonance with reports of Gomathinayagam et al. (1988) and Sampath et al. (1989). Total and productive tillers exerted negative association with panicle weight in three seasons, grains per panicle, per cent fertile grains and 1000-grain weight in all four seasons both at phenotypic and genotypic level in accordance with findings of Chauhan and Tondon (1984) and Chauhan et al. (1986). Sukanya and Rathinam (1984a) also reported negative association of tiller number with grains per panicle, whereas, its association was positive with 100-grain weight in all three seasons considered. Sampath et al. (1989) reported that panicle bearing and non panicle bearing tillers were negatively associated with 100-grain weight. However, some authors reported that, the trait, productive tillers was positively associated with panicle weight (Unnikrishnan, 1980), grains per panicle (Unnikrishnan, 1980; Gomathinayagam et al. 1988 and Amirthadevarathinam, 1990) and 1000-grain weight (Dhanraj et al., 1987). Sundaram et al. (1990) reported positive association of productive tillers with grains per panicle while its association was negative with 1000-grain weight.

Both phenotypic and genotypic correlation between panicle weight and grains per panicle were positive in all seasons while genotypic correlation between panicle weight and 1000-grain weight was positively significant in three seasons. Association of panicle weight with per cent fertile grains was positive but insignificant irrespective of seasons both at

phenotypic and genotypic levels, since heavier panicle will carry more and heavy fertile grains. Lin (1970) reported positive association of panicle weight with panicle length and grain number. Similarly, Unnikrishnan (1980) also observed appreciable positive relationship of panicle weight with grain weight and grain number. The negative phenotypic and genotypic correlations between grains per panicle and 1000-grain weight in two seasons indicated that as grain number per panicle increases, the grain weight is known to be reduced. The associations in other two seasons were however found nonsignificant. This result is in accordance with Unnikrishnan (1980), Chauhan and Tondon (1984), Panwar et al. (1989) and Sundaram et al. (1990). However, Dhanraj et al. (1987), Gomathinayagam et al. (1988) and Sampath et al. (1989) noticed positive association between grains per panicle and 1000-grain weight. In conformity with findings of Sathpathy and Nanda (1978); Chauhan and Tondon (1984), the per cent fertile grains and 1000-grain weight are observed to be positively associated each other in all seasons both phenotypically and genotypically.

It may, therefore, be stated that in rice association between grain yield and plant height, culm length, first internode length and leaf area at genotypic level and in addition between grain yield and panicle weight, grains per panicle, per cent fertile grains and 1000-grain weight at genotypic level undoubtedly vary, from one season to another season. At genotypic level, correlations between more character combinations (54) are sensitive to environment

compared to phenotypic correlations (24), which may be because of masking effect of environments on phenotypic correlations. Srivastava et al. (1977) reported that twelve character combinations were found to vary according to different maturity groups in pegion pea. While Nadaf (1980) observed differences among three traits based on a correlation study in rice by a method of Ausemus (Hayes et al., 1955). Many others noticed the differences of correlations from environment to environment (Roychoudhary, 1967; Chauhan and Tondon (1984); Pinhereio et al., 1985; Malik and Hasija, 1987 and Salam and Subramanian, 1988).

In the present investigation it should be possible to visualise high yielding medium tall varieties in upland conditions by incorporating more number of productive tillers and more leaf area. Irrespective of seasosns, days to flowering has to be delayed little to complete its vegetative growth and judicious selection index involving all above attributes could lead to gains in yield. Moreover, panicle length, panicle weight and grains per panicle would be taken as selection criterion irrespective of seasons.

It should be emphasized here that, the observed associations apply only to the specific populations under study and also specific to a particular environment. The interrelationship may be naturally quite different in different materials owing to the existence of different gene associations or the mean values of characters may differ from the levels observed in the present investigation.

5.3 Path analysis

The coefficient of correlation denotes only the extent of association existing between pairs of characters. A dependent character like grain yield is controlled by several componental characters, which are themselves mutually associated. Pleiotropy and linkage are the major causes for the basic association of two traits but it is not easy to determine the contribution of these causes to the association. Although the estimates of correlation coefficients are helpful in determining the components of complex trait such as yield, they do not provide an exact picture of the relative importance of direct and indirect effects of each of them. But the technique of path analysis introduced by Wright (1921 and 1923), which is simply standardised partial regression analysis, appears to be helpful in elucidating patterns of association through direct and indirect effects. However, Shrivastava and Sharma (1976) have pointed out a flaw in the use of this technique, from their analysis in rice. The authors found that there is no definite criteria for selection of characters to be included in the analysis and that the analytical results varied according to the characters that were chosen.

In rice, several workers studied path analysis in fixed as well as segregating populations. In the present investigation an attempt has been made to resolve the effects of the independent traits on grain yield by path analyses in four different environments. This is helpful to compare and

contrast the effects of traits with respect to different environments.

A critical examination of the tables 16 to 19 reveal that contribution of characters towards yield apparently varied with different environments. However, days to 50 per cent flowering and panicle weight are observed to have considerable positive direct effects on grain yield irrespective of environments. Yadav and Singh (1979), Amirthadevarathinam (1983), Chauhan and Tondon (1984), Mini (1989) and Ibrahim et al. (1990) reported positive direct effect of days to 50 per cent flowering on grain yield, while panicle weight is reported to contribute towards yield in studies of Gupta and Padlia (1971) and Unnikrishnan (1980). The trait panicle exsertion also had positive direct effect on yield in all four seasons but contribution was more in summer 1992, whereas, negative direct effect was observed of 1000-grain weight on yield was observed in all four seasons.

In general, the direct effects of all characters were quite different from the total correlation coefficients suggesting that the variability in these characters was profoundly influenced by the variability among themselves.

Plant height influenced the grain yield in positive direction only in summer 1992, wherein, crop was grown as fully upland rice and irrigation was withheld during flowering stage, through high direct effect (3.708) as also reported by Malik and Hasija (1987) and Reuben and Katuli (1989), whereas, in other seasons it seemed to have negative effect on grain

yield either directly or indirectly through other traits indicating that short statured high yielding genotypes could be selected in these seasons. Mini (1989) and Ibrahim et al. (1990) have also reported negative direct effect of plant height on grain yield. Culm length influenced either directly or indirectly in three seasons except during Kharif 1991 (M), a lowland condition. Amirthadevarathinam et al. (1990) reported positive direct effect of culm length on grain yield.

During Kharif 1991 (D), a fully upland condition, first internode length influenced grain yield positively, while it had negative direct effect in other three seasons. In a study by Awan and Cheema (1986), second and fourth internode lengths from top had positive and third internode length had negative direct effect on 1000-grain weight. The trait leaf area contributed positively during three seasons directly or indirectly mainly through days to 50 per cent flowering and panicle weight although negative counteracting forces were of considerable magnitude. This indicated that sufficient leaf area would be beneficial to get heavy panicles which in turn contribute to grain yield. No direct contribution of per cent green leaves was apparent in any season supporting its feable correlation with grain yield in all seasons studied. The trait per cent green leaves was also observed to have meagre contribution through all characters studied in all environments except during summer 1992, in which it had considerable positive effect through plant height but effect through culm length and some other traits were negative which appeared to counterbalance the positive contributions.

The positive correlations between panicle length and grain yield in three seasons were mainly due to positive direct effect and indirect effects through days to 50 per cent flowering and panicle weight, while direct effect of panicle length on grain yield was high and negative in summer, 1992. However, high positive indirect effects through plant height and days to 50 per cent flowering counterbalanced the negative effects. Amirthadevarathinam (1990) noticed similar counterbalancing of negative direct effect of panicle length by indirect effects through days to 50 per cent flowering, culm length and tiller number to provide a positive association in japonica types, while direct effect of panicle length was positive in indica types. Many authors also reported positive direct contribution of panicle length to yield (Sukanya and Rathinam, 1984b, Awasthi and Borthakur, 1986., Mini, 1989 and Ibrahim et al., 1990).

Flag leaf length contributed directly and mainly through days to 50 per cent flowering and panicle weight towards grain yield in Kharif 1990, while contribution was mainly direct and through plant height during Kharif 1991 (M) and summer 1992, whereas, direct contribution of flag leaf length was negative in Kharif 1991 (D). However, its indirect effects through days to 50 per cent flowering and panicle weight were considerable and positive. Bashar et al. (1991) reported that flag leaf area contributed to yield through grains per panicle and panicle length. The contributions of total and productive tillers were observed to be positive and substantial in three environments, while the contributions were not apparent during

summer, 1992. This is in consonance with findings of Singh (1980), Tahir et al. (1988) and Ibrahim et al. (1990).

The contribution of per cent fertile grains towards yield was negative through days to 50 per cent flowering in accordance with findings of Chauhan and Tondon (1984). Besides, its direct effect was considerable and negative in Kharif 1990 and summer 1992, while in latter season, per cent fertile grains had high negative indirect effects via culm length and positive indirect effects through plant height, panicle length and panicle weight.

Thus the characters which played a major role in contributing towards grain yield per plot were days to 50 per cent flowering and panicle weight irrespective of environments. Further, culm length and productive tillers in Kharif 1990, a partial upland condition in which there was no rainfall for fifteen days at reproductive stage. Plant height, panicle length and total tillers mainly contributed to yield in fully lowland condition (Kharif 1991, at ARS, Mugad). During Kharif 1991 (at UAS, Dharwad), a fully upland condition, the grain yield was influenced mainly by culm length, first internode length, leaf area, panicle length and productive tillers. The traits viz., plant height, leaf area, flag leaf length and panicle exsertion registered major contribution towards train yield in summer, 1992.

A critical examination of the path analyses envisages that the days to flowering have to be extended little so as to get sufficient time to build a required plant structure to get

more grain yield through balanced source-sink relationship. Besides, panicle weight should be taken into account as a criterion in the selection irrespective of seasons while culm length and productive tillers are important to be considered for selection in upland condition.

The direct effect of the residual factors revealed the fact that in Kharif, 1990 only 15.92 per cent of the total variability was attributed to the other factors which were not included in the study including the environmental factors and that during the Kharif 1991 (M), Kharif 1991 (D) and summer 1992 was found to be 41.47, 21.99 and 20.43 per cent, respectively. This varying nature of direct effect of residual factors with respect to seasons indicated that environmental factors might have played a major role in explaining the variability in this material, where it was not possible to extract the variability only by the charaters taken under study. This result is in consonance with findings of Nadaf (1980). Several authors have also reported residual effects (R) to the extent of 0.6101 (Agarwal et al., 1978) and 0.462 in indica and to the extent of 1.473 in japonica types (Amirthadevarathinam, 1990).

5.4 Future line of work

The parental combinations suggested for future breeding programme based on divergence studies and per se performance are:

i) IR53236-77-1 x IR47686-6-2-1-1

ii) IR53236-77-1 x IR47686-6-1-1

iii) IR53236-77-1 x IET1444

iv) IR53236-77-1 x Gama-318

v) IR53236-27-7 x IR47686-6-2-1-1

vi) IR53236-27-7 x IR47686-6-1-1

vii) IR53236-27-7 x IET1444

viii) IR53236-27-7 x Gama-318

ix) IET7564-4-3 x IR47686-6-2-1-1

x) IET7564-4-3 x IR47686-6-1-1

xi) IET7564-4-3 x IET1444

xii) IET7564-4-3 x Gama-318

xiii) IR55411-53 x IR47686-5-10-B

xiv) IR57924-9 x IR60080-49

xv) IR57924-9 x IR47686-6-2-1-1

These parental combinations should be tested to know their true potentiality in giving high heterotic vigour in F_1 and throwing wide range of variability in F_2. The hybrids produced by these as parents could be compared with hybrids developed by crossing parents, selected on the basis of per se performance only to understand the importance of classificatory analyses viz., D^2 statistic in selecting parents for hybridization.

The associations and contributions (direct and indirect) of different traits to grain yield should be tested to understand whether these would get changed in segregating populations or remain stable in the limits of significance.

SUMMARY

CHAPTER- VI

VI SUMMARY

The investigation was carried out with a view to get an idea about the extent of genetic diversity present among 50 rice (*Oryza Sativa* L.) (forty four drought tolerant lines received from IRRI and six local checks) genotypes, to know the degree of association between yield and its different component characters and their direct and indirect effects on grain yield in four different seasons, the knowledge of which is helpful for selecting the parents for hybridization programme. The genetic divergence of 50 rice genotypes was estimated by Mahalanobis' D^2 statistics. The phenotypic and genotypic correlations involving sixteen characters were determined amongst themselves in four seasons separately and jointly (where `r' values were homogeneous). The phenotypic correlation coefficients of four seasons were subjected to path coefficient analyses.

The magnitude of all possible D^2 values as well as clustering pattern and composition varied from season to season. All the 50 genotypes were grouped under 13, 18 and 17 clusters in Kharif 1990, Kharif 1991 (M) and Kharif 1991 (D), while in summer 1992, 38 clusters were formed, such that most of genotypes (32) grouped singly because of high D^2 values owing to the expression of higher variability. The genotypes IR47686-6-2-1-1 and IR47686-6-1-1 remained in the same cluster, while the cultivar IET 22[illegible]4 remained isolated with all genotypes in all four environments and some genotypes formed common clusters with respect to three seasons. In

general, there was no parallelism between genetic and geographic diversity, since cultivars have been clustered irrespective of their origin. Of the fifteen characters studied, days to 50 per cent flowering was the character that contributed considerably most towards genetic divergence, substituted by characters viz., grain yield, panicle exsertion, 1000-grain weight, total tillers and panicle weight in all four seasons.

The maximum genetic diversity has been observed between solitary clusters VII (IR53236-70-2) and VIII (IR57924-9) in Kharif 1990, IX (IR60080-46B) and XVIII (IET5882) in Kharif 1991 (M), IX(with genotypes, IR47686-6-2-1-1 and IR47686-6-1-1) and XI (IR53234-27-6) during Kharif 1991 (D) and between clusters VIII (IR53236-70-2) and XV (IR55411-50-1) during summer 1992 indicating that the genotypes between these clusters were highly divergent during respective seasons. Significant differences of cluster means of these four environments were observed for all the characters except for culm length, first internode length, per cent green leaves and flag leaf length.

Crossing the genotypes namely, IR53236-77-1, IR53236-27-7, IR53234-27-6 and IET7564-4-3 which are found to be comparatively better with respect to per se performance with better yielding genotypes such as IR5411-50-1, IR57924-9, IR60080-49, IR60080-45, IR47686-6-2-1-1, IR47686-6-1-1, IET1444 and Gama 318 that had higher genetic divergence consistently in all seasons, would expectedly throw desirable

high yielding transgressive segregants in segregating populations suitable for upland conditions. The D^2 values among the eleven genotypes which performed better with desirable traits in all four seasons were found to be low in majority of the cases. However, it was interesting to note that the long slender grained genotype, IR5411-53 registered comparatively higher D^2 values with IR47686-5-10-B with long bold grain type and the genotype, IR57924-9 had higher D^2 values with other four superior genotypes in all four seasons. These genotypes were complementary to each other in some desirable traits. Thus these could be utilised as parents in hybridization programme.

Of the 120 character association comparisons only 24 characters pair comparisons at phenotypic level and 54 character pair comparisons at genotypic level had different associations while remaining associations were proved to suffice the relationship amongst themselves by a pooled correlation coefficient irrespective of environments. In all four seasons grain yield showed positive and significant associations with panicle length, days to 50 per cent flowering, panicle weight and fertile grains per panicle and positive but nonsignificantly associated with flag leaf length and productive tillers at both phenotypic and genotypic levels. The traits per cent green leaves and panicle exsertion did not influence yield, since they had very feable correlations irrespective of seasons. The genotypic correlation between total tillers and grain yield was significant and positive in fully lowland condition and

negative in fully upland condition. Both phenotypic and genotypic associations of plant height and culm length with yield, were found to be positive in three seasons, whreas, the associations were slightly negative in fully low land condition (Kharif 1991(M)). Similarly first internode length and leaf area showed positive association in three seasons and negative association in one season with grain yield. Grain yield was observed to be negatively associated with per cent fertile grains and 1000-grain weight in three seasons while they had positive but nonsignificant association in fully upland condition. The variation between the seasons in respect of intensity and direction of association for different traits with yield in some cases may be attributed to the extreme environmental fluctuations. In general genotypic correlation values were higher than the phenotypic correlation values in all four seasons.

Path analyses revealed that contribution of the characters towards yield apparently varied with different seasons. However, days to 50 per cent flowering and panicle weight were observed to have considerable positive direct effects on grain yield irrespective of seasons. The trait panicle exsertion also had positive direct effect on yield in all four seasons but contribution was more in summer 1992, whereas, negative direct effect was observed for 1000-grain weight on yield in all four seasons. Further, plant height positively influenced the grain yield only in summer 1992, whereas, in other three seasons it seemed to have negative effect on the yield either directly or indirectly. The

positive correlations between panicle length and grain yield in three seasons were mainly due to positive direct effect and indirect effects through days to 50 per cent flowering and panicle weight. The traits culm length and productive tillers were important to be considered for selection in upland condition along with panicle weight and panicle exsertion. The varying nature of direct effects of residual factors in different seasons indicated that environmental factors might have played a major role in explaining the variability.

CHAPTER- VII

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VII REFERENCES

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* Original not seen.

APPENDICES

Appendix I. Rainfall during September and October in ten years (1982 to 1991)

Days	1982		1983		1984		1985		1986		1987		1988		1989		1990		1991	
	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct	Sept	Oct
1	0.0	0.0	1.0	0.0	0.0	0.0	0.0	65.0	0.0	11.0	0.0	0.0	2.5	1.2	0.1	0.0	3.4	20.0	0.0	50.8
2	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.3	10.2	2.0	0.0	8.5	1.2	0.0	0.0	14.4
3	0.0	0.0	0.0	1.0	0.0	0.0	0.0	3.0	0.0	0.0	3.4	7.2	0.0	3.2	0.0	0.0	1.0	0.0	0.0	0.0
4	0.0	0.0	0.0	13.5	0.0	0.0	0.0	7.4	0.0	10.5	0.0	0.0	7.2	0.0	1.0	0.0	4.4	0.0	0.0	26.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	2.5	1.0	0.0	7.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	7.8
6	2.8	0.0	0.0	3.2	0.0	2.5	0.0	3.0	5.5	0.0	0.0	17.2	0.0	1.2	0.0	0.0	11.8	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	19.5	14.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.2	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	25.8	3.3	6.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	18.3	1.4	0.0
9	0.0	5.0	0.0	0.0	0.0	26.5	3.2	1.4	5.0	0.0	0.0	25.0	1.5	0.0	0.0	0.0	0.0	16.4	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	7.5	0.0	3.0	1.5	0.0	0.0	48.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	10.0	0.0	0.0	0.0	0.0
12	0.0	0.0	11.0	0.0	22.0	13.2	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0
13	6.5	0.0	0.0	0.0	7.5	0.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	3.8	2.0
14	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2	0.4	26.0	0.0	0.0	0.0	11.2	0.0	0.2	0.0
15	0.0	0.0	7.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	0.0	0.0	0.0	0.0	1.2	46.8	0.0
16	0.0	0.0	27.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.1	0.0	14.0	0.0	0.0	0.0	0.0	2.2	1.2	0.0
17	0.0	0.0	7.0	0.0	0.0	0.0	2.4	0.0	15.5	0.0	0.0	1.4	4.0	0.0	0.0	0.0	0.0	0.0	16.2	0.0
18	0.0	1.8	5.4	0.0	0.0	0.0	0.0	0.0	1.0	0.0	8.0	0.0	4.2	0.0	2.0	0.0	0.0	0.0	0.0	2.2
19	0.0	8.5	5.3	8.2	0.0	0.0	0.0	0.0	0.0	0.0	23.0	0.0	4.0	0.0	3.0	0.0	0.0	0.0	0.0	16.2
20	0.0	0.0	4.0	0.0	0.0	0.0	0.0	7.0	14.5	0.0	42.2	0.0	2.0	0.0	85.0	0.0	0.0	0.0	0.0	5.2
21	0.0	7.2	0.0	0.0	55.5	0.0	0.0	0.0	5.0	0.0	1.0	7.3	5.6	0.0	17.0	0.0	0.0	0.0	0.0	0.0
22	25.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	22.4	15.0	0.0	0.0	0.0	0.0	0.0	26.6	0.0
23	10.5	0.0	5.0	0.0	8.5	0.0	0.0	0.0	26.0	0.0	0.0	17.2	9.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	3.4	33.0	0.0	0.0	28.4	35.5	0.0	0.0	0.0	0.0	10.0	0.0	20.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0
25	0.0	3.2	55.5	0.0	0.0	0.0	0.0	0.0	4.5	0.0	10.1	0.0	48.0	0.0	0.0	0.0	0.0	73.0	2.2	0.0
26	0.0	2.0	12.5	1.4	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	14.2	0.0	3.0	0.0	0.0	10.0	0.0	0.0
27	0.0	7.8	2.0	3.0	12.0	0.0	27.4	0.0	4.0	0.0	0.0	0.0	24.0	0.0	0.0	0.0	0.0	19.0	1.2	0.0
28	0.0	9.0	0.0	3.5	28.5	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.0	0.0	0.0	16.4	1.2	0.0
29	0.0	6.0	3.2	0.0	10.5	0.0	0.0	0.0	0.0	0.0	17.2	0.0	0.0	0.0	9.0	0.0	0.0	0.0	12.4	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	7.2	2.0	0.0	0.0	0.0	0.0
31	-	0.0	-	0.0	-	0.0	-	0.0	-	1.5	-	0.0	-	0.0	-	15.0	-	0.0	-	0.0

Appendix II. Meteorological data in cropping seasons

Months	Rainfall (mm)	Average* Rainfall	Relative humidity (%)	Temparature (°C)	
				Maximum	Minimum
Season I (Kharif, 1990 at Mugad)					
JUNE	117.0	187.44	80.15	28.3	20.2
JULY	198.6	212.20	87.35	26.4	19.8
AGUST	235.3	185.51	90.95	25.3	19.8
SEPTEMBER	53.0	120.09	86.00	28.1	19.6
OCTOBER	176.5	95.11	81.00	29.8	18.8
NOVEMBER	28.9	34.60	81.00	29.4	16.9
Season II (Kharif, 1991 at Mugad)					
JUNE	350.3	187.44	82.00	29.3	21.1
JULY	244.5	212.20	92.00	25.4	20.6
AGUST	232.9	185.51	91.00	25.8	20.3
SEPTEMBER	117.4	120.09	82.00	29.1	19.8
OCTOBER	124.4	95.11	81.00	29.7	19.4
NOVEMBER	6.4	34.60	82.00	29.0	16.1
Season III (Kharif, 1991 at Dharwad)					
JUNE	344.5	105.80	82.00	29.3	21.1
JULY	160.5	160.00	92.00	25.4	20.6
AGUST	122.2	103.00	91.00	25.8	20.3
SEPTEMBER	89.8	107.20	82.00	29.1	19.8
OCTOBER	125.6	131.00	81.00	29.7	19.4
NOVEMBER	3.4	32.20	82.00	29.0	16.1
Season IV (Summer, 1992 at Mugad)					
JANUARY	0.0	2.76	81.00	29.4	12.7
FEBRUARY	0.0	0.72	75.00	32.0	15.9
MARCH	0.0	8.95	67.00	36.1	19.3
APRIL	5.6	47.37	65.00	37.0	20.8
MAY	59.7	81.27	67.00	35.3	20.8

* Rainfall at Mugad is average of 19 years (1973-1991) and at Dharwad is average of 40 years (1950-1989)

Appendix III The mean performance of 50 genotypes during kharif 1990 at ARS Mugad

Sl No	Genotypes	Plant height (cms)	Culm length (cms)	First internode length (cms)	Leaf area (cm2)	% Green leaves	Panicle length (cms)	Flag leaf length(cms)	Panicle exsertion (cms)	Total tillers per m.	Productive tillers per m.	Days to 50 % flowering	Panicle weight (gms)	Fertile grains/ panicle	% Fertile grains	1000-Grain weight (gms)	Grain yield per plot (gms)
1	IR53236-275 2	68.10	50.70	26.28	14.45	58.70	16.10	19.25	1.95	60.08	52.00	71.50	1.60	43.28	98.95	34.40	584.00
2	IR53236-78-2	82.85	64.98	38.15	13.65	29.68	17.95	18.45	5.45	72.88	49.08	72.08	1.79	51.78	89.55	32.25	537.08
3	IR53236-77-1	81.45	62.75	29.98	16.48	61.25	18.70	28.28	3.48	75.80	47.80	71.50	2.39	69.20	97.65	32.15	768.80
4	IR53236-139	74.45	57.45	25.75	15.35	56.45	17.80	19.78	1.40	97.00	61.80	75.80	1.66	46.68	86.25	32.85	642.80
5	IR53236-218-3	77.10	58.08	26.85	16.98	38.48	19.25	17.25	0.29	36.00	28.00	72.50	2.49	61.78	91.98	37.40	498.88
6	IR53234-27-7	71.21	52.82	26.35	17.30	48.80	18.40	28.28	2.15	67.88	41.00	72.58	1.89	56.98	98.65	35.28	714.00
7	IR53234-27-6	65.16	49.45	24.18	13.78	48.55	15.78	17.25	-8.45	64.88	38.80	73.88	1.46	48.90	94.25	35.20	654.00
8	IR53167-17	82.11	64.38	27.37	21.85	52.65	17.48	24.30	2.48	74.08	59.88	81.80	2.73	79.88	96.55	33.28	855.80
9	IR55549-1-2	95.45	73.65	35.65	38.78	58.80	21.88	25.88	4.68	49.08	41.08	108.58	3.88	98.60	88.18	38.85	989.08
10	IR55419-4	71.37	52.45	25.88	18.95	38.10	18.18	22.18	2.87	67.08	64.08	99.00	2.16	76.30	86.75	26.28	729.00
11	IR55411-53	80.21	59.72	28.92	28.85	48.55	20.58	22.80	1.85	69.88	63.88	99.58	2.61	89.70	88.15	25.88	1224.88
12	IR55411-50	77.60	57.68	28.55	25.60	51.35	28.80	22.50	2.03	69.00	57.80	113.00	2.74	92.98	87.88	25.48	1257.80
13	IR57924-24	77.95	55.18	27.40	28.88	49.98	22.85	24.85	-1.95	44.88	38.88	104.50	3.84	98.40	71.88	26.38	1389.08
14	IR57924-9	88.39	58.54	27.78	27.55	54.80	21.85	27.75	-8.98	109.88	95.00	112.50	3.83	103.28	73.98	25.35	1929.80
15	IR57893-73	83.61	64.88	26.24	20.60	57.45	18.70	19.60	8.98	73.00	58.80	86.80	2.45	66.80	98.45	33.48	432.88
16	IR57893-26	93.48	65.33	28.40	20.88	55.70	17.55	23.65	4.10	47.58	41.80	78.50	2.46	63.88	98.90	36.85	726.08
17	IR55411-58	88.75	66.70	31.55	17.05	53.55	22.00	21.75	3.65	72.00	59.88	98.50	3.12	85.08	81.18	33.88	1452.08
18	IR60888-49	108.16	78.56	31.38	27.45	48.15	24.60	24.45	2.48	42.08	36.80	99.58	4.59	138.88	93.55	31.85	1170.88
19	IR60080-468	79.85	58.75	27.58	26.25	48.78	20.70	27.35	8.80	78.08	70.80	108.50	3.39	118.58	95.78	28.88	1356.08
20	IR60888-45	91.44	65.84	38.79	31.58	43.55	25.68	23.55	1.78	56.00	58.00	98.08	4.12	117.68	87.15	31.85	1173.88
21	IR60888-42	86.15	68.89	29.42	28.75	45.18	25.55	27.28	-1.52	47.08	40.08	97.08	3.31	127.80	89.78	22.88	1242.08
22	QPLR1-7	75.58	59.30	38.75	18.75	34.75	21.20	26.65	3.18	88.08	70.88	99.80	2.89	104.50	91.78	25.95	1461.08
23	IRAT 288	86.75	69.65	29.88	28.65	57.75	17.18	22.28	4.39	38.88	36.80	88.58	3.14	75.40	88.98	37.85	1898.08
24	IRAT 216	75.21	55.68	28.88	28.45	56.98	19.68	22.28	-1.15	63.08	56.88	99.58	2.59	88.70	84.95	26.48	843.00
25	IRAT 2t2	69.49	44.79	24.77	13.20	54.25	15.70	15.50	2.26	71.00	52.88	80.50	2.38	82.90	89.55	27.45	749.00
26	IAAT 144 (8)	73.15	53.80	31.20	16.90	59.85	19.35	24.45	4.05	51.08	53.80	85.50	2.68	58.00	91.44	41.68	576.00
27	IRAT 104(A)	81.50	61.38	27.35	26.78	57.48	20.20	25.55	-8.42	47.80	42.88	103.00	4.67	113.48	93.88	39.45	1557.88
28	IRAT 10	61.26	43.59	24.55	14.68	48.70	17.65	19.85	1.35	72.88	63.00	85.58	1.85	55.58	86.95	38.18	843.80
29	IR47691-37-4-1	77.20	51.22	25.93	28.98	39.85	17.95	20.78	2.34	39.00	35.88	96.58	2.51	81.08	94.15	28.18	1113.80
30	IR47691-17-1-8	77.75	58.85	29.08	24.50	49.75	19.78	22.45	3.35	36.88	36.00	105.58	3.33	100.18	92.90	38.65	1572.88
31	IR47686-30-2-1	99.39	75.64	35.73	39.20	41.65	23.75	31.45	5.03	45.08	48.80	102.58	4.14	107.58	89.50	35.68	912.88
32	IR 47686-12-5-8-1	97.04	74.88	29.62	29.30	48.45	21.28	25.95	0.26	60.00	50.88	108.58	4.14	117.08	94.40	33.45	1320.88
33	IR47686-6-2-1-1	92.55	66.85	32.15	19.75	59.98	21.70	24.38	3.40	49.88	43.08	103.88	3.74	96.90	88.65	35.08	1434.80
34	IR47686-6-1-1	90.98	67.52	29.82	27.68	57.58	23.50	26.38	1.23	49.88	48.08	101.50	3.93	94.70	93.25	38.05	1485.80
35	IR 47686-5-18-8	103.58	83.89	33.26	34.38	68.58	23.80	29.05	8.71	46.88	40.80	101.58	4.44	118.50	88.45	34.95	1286.80
36	IR47686-1-1-8	94.78	71.31	31.31	30.95	56.15	23.45	27.55	-0.37	48.88	41.88	104.08	3.57	92.20	92.15	35.95	612.88
37	IAC 165	88.65	71.10	28.78	21.88	51.10	17.55	25.65	4.38	40.88	38.88	86.50	2.86	75.70	86.45	35.98	1858.88
38	IAC 25	93.26	73.92	32.05	28.88	56.25	19.35	29.25	3.29	50.50	42.50	86.08	3.32	99.80	98.58	31.35	1818.88
39	CT6727-5 3 3	89.70	67.68	38.23	29.85	48.25	22.18	28.90	-8.60	53.00	46.00	99.50	2.62	80.60	77.75	27.75	972.88
40	CNA4130	94.83	75.08	30.55	19.35	56.05	19.85	22.90	2.13	51.88	48.80	86.58	3.71	95.10	94.25	36.25	1380.88
41	CT6518-24 1 2	80.43	58.12	29.75	25.10	26.25	22.38	29.65	1.62	55.80	41.88	97.08	4.14	126.28	78.28	27.58	1224.88
42	CNA5164	80.35	62.15	28.97	27.05	52.85	18.68	31.40	0.65	41.80	34.80	85.50	3.57	94.98	84.88	34.68	756.88
43	CNA4173	85.25	64.58	30.34	18.70	55.38	28.80	25.85	2.99	61.80	51.00	81.80	3.32	101.60	92.15	29.78	1826.88
44	CNA4136	91.60	71.80	29.00	29.80	54.35	19.80	26.75	1.75	43.80	41.80	96.58	3.65	94.28	93.55	36.05	1389.08
45	IET 2254	55.65	35.88	25.58	22.40	55.65	18.00	21.78	-8.85	104.88	94.00	88.80	2.85	84.18	81.05	24.15	986.88
46	IET 7991-11 2	64.19	47.69	23.36	15.05	35.55	17.45	17.85	-1.92	105.00	97.88	88.00	1.98	55.20	69.65	27.95	1383.88
47	IET 1444	78.70	59.65	26.00	22.80	42.65	19.15	20.70	-1.15	84.08	72.88	111.00	2.83	125.20	89.25	19.20	1443.88
48	Gamma-318	66.93	48.43	20.05	18.85	46.65	17.60	15.78	-1.45	83.00	78.00	107.50	2.52	95.40	84.45	22.45	1359.88
49	IET 5882	78.45	58.58	26.85	29.70	47.35	19.85	19.75	8.57	69.00	62.80	90.08	2.85	92.20	76.20	27.65	1272.88
50	IET 7564-4 3	77.91	60.41	24.91	12.75	34.35	16.90	17.58	2.03	88.50	79.00	77.00	1.73	71.50	87.70	24.45	882.08

Appendix IV. The mean performance of 50 genotypes during kharif 1991 at ARS, Mugad

Sl. No.	Genotypes	Plant height (cms)	Culm length (cms)	First internode length (cms)	Leaf area (Sq.cm)	% Green leaves	Panicle length (cms)	Flag leaf length(cms)	Panicle exsertion (cms)	Total tillers per m.	Productive tillers per m.	Days to 50 % flowering	Panicle weight (gms)	Fertile grains/ panicle	% Fertile grains	1000-Grain weight (gms)	Grain yield per plot (gms)
1	IR53236-275-2	93.70	71.20	32.60	30.80	54.70	22.40	30.95	2.88	64.75	58.00	68.00	1.59	89.00	87.40	31.85	646.00
2	IR53236-70-2	90.90	72.05	30.20	22.50	59.95	19.15	23.30	3.25	63.75	58.75	70.00	1.76	75.80	92.95	31.85	509.40
3	IR53236-77-1	81.75	65.65	27.70	22.50	57.20	17.10	19.30	4.40	120.00	104.25	69.50	2.18	59.30	95.85	30.80	610.00
4	IR53236-139	95.05	74.65	32.40	26.25	60.70	20.40	28.80	4.95	78.00	74.75	72.50	1.65	64.20	91.30	31.25	941.80
5	IR53236-218-3	91.75	72.45	30.15	21.60	52.35	19.30	25.85	3.35	54.90	48.40	66.50	2.53	74.50	92.50	35.45	630.90
6	IR53234-27-7	90.70	71.10	28.65	23.35	55.40	19.60	23.15	2.35	78.75	74.50	69.00	1.85	65.60	88.30	33.90	764.00
7	IR53234-27-6	87.55	69.35	28.80	25.50	54.00	18.20	25.40	3.20	67.25	60.75	72.50	1.40	81.30	93.45	34.55	593.80
8	IR53167-17	91.40	71.60	28.20	25.15	56.40	19.50	27.00	2.54	109.75	96.00	69.50	2.59	58.50	95.45	31.95	592.00
9	IR55549-1-2	99.75	81.05	31.65	25.05	56.80	18.70	26.65	4.20	123.25	110.75	85.50	2.67	91.20	88.00	27.55	1160.80
10	IR55419-4	82.70	63.60	28.20	25.45	58.30	19.10	24.20	1.69	106.00	99.00	83.50	2.75	107.00	86.90	22.45	1708.00
11	IR55411-53	89.60	69.00	31.40	20.55	56.20	20.60	26.35	1.16	129.00	121.00	85.00	3.53	93.30	89.55	25.55	1947.80
12	IR55411-50	88.15	65.45	30.90	23.30	68.05	22.70	24.10	4.56	123.50	117.00	87.50	2.70	93.40	89.80	25.25	2102.30
13	IR57924-24	81.00	60.90	28.70	15.90	57.10	22.60	20.70	2.62	112.50	94.50	91.50	3.01	108.30	82.35	23.75	1852.00
14	IR57924-9	84.50	63.80	28.60	21.80	56.05	20.70	26.00	1.09	117.50	100.50	91.50	3.36	82.20	85.40	27.80	2776.00
15	IR57893-73	72.95	57.40	27.50	17.00	51.15	15.55	19.30	-0.29	75.00	68.50	72.50	2.38	83.00	85.35	25.70	1428.30
16	IR57893-26	61.70	48.00	22.30	13.05	54.15	13.70	19.20	1.51	106.50	99.50	74.00	1.97	47.30	94.85	38.10	1265.00
17	IR55411-50	86.05	65.00	28.20	20.00	59.60	20.75	22.60	2.59	117.00	110.00	91.00	2.11	77.20	90.40	25.30	2053.50
18	IR60080-49	92.60	71.60	28.30	29.50	53.55	21.00	19.70	2.56	111.00	106.00	91.00	3.92	85.00	88.20	30.70	1077.60
19	IR60080-46B	103.90	87.30	29.34	26.25	62.75	16.60	25.10	4.08	128.00	120.00	67.50	3.30	53.10	92.65	27.28	820.30
20	IR60080-45	97.40	70.00	30.45	31.60	58.65	24.40	17.00	2.70	103.50	93.75	92.00	3.37	124.60	84.70	23.40	1202.00
21	IR60080-42	77.15	58.45	27.05	18.70	48.80	18.70	20.30	1.15	102.00	96.00	91.50	1.87	72.70	78.55	21.80	738.00
22	UPLRi-7	77.40	57.35	30.85	20.65	51.10	21.05	24.75	4.30	128.00	119.00	96.00	3.19	106.70	92.90	27.40	941.60
23	IRAT 288	89.45	73.30	29.40	23.30	56.20	16.05	18.33	4.04	101.00	97.00	85.00	2.11	47.00	85.05	31.85	841.60
24	IRAT 216	71.15	51.20	28.40	17.15	55.25	18.20	23.10	1.60	94.00	90.00	90.50	2.10	62.50	73.30	24.85	1073.90
25	IRAT 212	64.45	51.15	21.95	14.70	63.35	14.30	13.90	-0.18	80.50	76.50	74.00	1.96	57.50	90.00	29.95	901.00
26	IRAT 144 (B)	66.75	49.80	23.70	22.85	56.55	17.05	19.70	5.33	54.00	47.75	79.50	2.07	60.30	93.65	35.30	1065.60
27	IRAT 104(A)	84.45	64.30	27.95	34.75	51.00	20.15	24.60	1.55	56.00	51.50	96.00	3.79	90.40	88.25	27.55	828.00
28	IRAT 10	68.70	52.10	25.70	30.50	81.85	16.60	20.35	-0.56	37.50	34.00	75.00	3.66	56.50	97.35	29.30	628.00
29	IR47691-37-4-1	87.10	67.40	28.00	19.90	69.95	19.70	20.80	4.30	72.00	68.00	89.50	2.44	88.00	88.20	29.85	987.00
30	IR47691-17-1-B	89.50	66.60	30.60	23.90	73.80	22.60	24.20	4.20	77.50	67.50	97.50	1.34	44.58	86.80	25.10	714.30
31	IR47686-30-2-1	103.20	82.70	37.00	35.25	64.60	20.50	23.70	8.20	110.00	102.00	93.50	2.38	66.50	85.05	31.65	1007.50
32	IR 47686-12-5-B-1	95.80	75.25	30.60	30.55	54.10	20.55	25.20	1.92	128.50	101.00	99.00	2.71	77.40	80.65	29.35	871.80
33	IR47686-6-2-1-1	95.10	74.70	32.30	31.00	65.45	20.40	24.70	4.40	79.50	76.50	92.00	3.39	69.80	81.25	35.65	1089.60
34	IR47686-6-1-1	85.30	64.55	27.95	27.20	59.20	20.75	21.80	2.70	70.50	63.25	92.00	3.41	99.70	84.75	34.20	1284.50
35	IR 47686-5-10-B	86.70	68.25	27.15	27.50	53.45	18.45	21.60	4.02	107.00	92.50	91.00	1.73	62.50	88.30	29.10	1303.80
36	IR47686-1-1-B	95.75	76.95	29.25	27.75	67.00	18.85	23.70	2.47	44.00	42.00	91.00	4.47	114.50	94.35	33.80	657.90
37	IAC 165	89.90	71.40	28.91	30.35	55.00	15.50	23.30	1.75	104.00	90.75	75.00	2.45	62.40	83.45	31.40	462.00
38	IAC 25	105.65	82.70	35.25	37.70	60.70	22.80	27.70	3.94	73.50	63.50	70.00	2.09	59.70	95.15	34.95	574.00
39	CT6727-5-3-3	87.75	68.50	29.75	24.45	53.75	19.30	22.00	1.95	101.00	96.50	87.00	2.50	83.50	81.75	26.80	1439.90
40	CNA4130	97.10	78.70	31.05	20.75	59.30	18.40	23.20	2.54	89.00	85.75	68.50	1.88	55.25	91.45	24.35	552.60
41	CT6510-24-1-2	79.65	59.55	32.35	23.60	60.20	20.10	26.55	3.32	101.00	96.00	89.50	1.84	92.80	86.95	26.50	710.00
42	CNA5164	83.25	67.20	27.25	23.05	44.45	16.01	25.35	1.51	128.50	124.75	73.00	3.20	50.90	81.05	33.65	455.50
43	CNA4173	80.80	63.75	26.15	20.70	56.20	17.25	18.05	2.39	107.00	103.75	71.00	3.40	60.80	86.95	27.65	596.50
44	CNA4136	96.60	79.10	28.00	24.55	43.95	17.50	26.10	1.82	128.75	114.25	70.50	3.95	44.50	91.40	34.40	798.70
45	IET 2254	71.80	53.80	25.15	13.95	57.80	18.00	19.10	-1.16	89.00	98.00	104.50	2.15	70.00	92.80	25.85	641.50
46	IET 7991-11-2	70.25	51.55	21.80	20.05	52.30	18.70	21.25	1.29	103.50	93.50	72.50	1.81	60.20	76.90	27.15	638.40
47	IET 1444	89.50	69.60	34.65	19.10	48.80	20.10	21.05	4.94	173.50	163.50	103.50	2.44	102.20	93.05	21.10	900.20
48	Gama-318	72.50	55.05	23.75	16.20	45.35	17.40	16.65	0.18	131.00	126.75	98.50	1.94	62.80	77.80	25.90	1868.20
49	IET 5882	90.70	70.35	34.50	25.55	57.10	20.35	22.60	1.84	91.50	71.00	112.00	2.80	91.10	93.00	20.80	1811.90
50	IET 7564-4-3	90.40	71.15	28.00	16.80	48.65	19.15	19.70	2.47	93.00	91.50	76.00	1.70	60.40	87.05	25.35	1003.50

Appendix V The mean performance of 50 genotypes during kharif 1991 at UAS Dharwad

Sl No	Genotypes	Plant height (cms)	Culm length (cms)	First internode length (cms)	Leaf area (Sq.cm)	% Green leaves	Panicle length (cms)	Flag leaf length(cms	Panicle exsertion (cms)	Total tillers per m.	Productive tillers per m.	Days to 50 % flowering	Panicle weight (gms)	Fertile grains/ panicle	% Fertile grains	1000-Grain weight (gms)	Grain yield per plot (gms
1	IR53236-275 2	53.75	37.90	18.45	15.99	41.23	15.85	17.08	1.75	58.50	31.00	70.50	1.08	36.88	87.38	29.90	134.00
2	IR53236-70-2	76.75	57.35	25.30	16.09	33.13	17.50	19.38	1.48	54.58	33.58	71.00	1.24	.32.00	77.05	38.35	190.00
3	IR53236-77-1	75.65	50.38	24.80	12.57	41.54	17.35	16.98	3.38	74.58	44.58	72.00	1.57	38.58	93.70	28.75	364.00
4	IR53236-139	76.00	57.95	27.45	21.44	51.40	16.90	28.95	2.53	76.88	35.58	73.00	1.75	39.28	76.20	29.75	356.88
5	IR53236-218-3	33.50	55.90	24.25	18.47	49.90	17.60	17.25	1.28	35.88	22.08	71.50	1.93	47.88	88.15	34.78	240.00
6	IR53234-27-7	72.10	54.35	24.80	71.86	44.30	18.00	19.05	2.00	50.00	24.00	72.00	1.85	48.50	93.38	32.95	264.80
7	IR53234-27-6	64.65	55.35	24.38	19.92	42.65	16.00	17.20	8.35	50.50	33.50	71.50	1.29	36.25	91.78	25.18	258.80
8	IR53167-37	79.90	64.25	23.05	25.27	43.88	15.65	17.45	2.70	72.50	50.00	77.50	1.28	33.30	93.88	33.65	369.40
9	IR55549-1-2	94.05	72.85	30.95	28.19	49.78	21.15	22.20	3.55	49.00	31.50	99.88	2.86	63.40	86.40	29.55	516.00
10	IR55419-4	71.90	53.78	22.15	17.48	37.95	10.20	21.95	1.42	67.50	48.00	97.88	1.79	33.50	75.88	26.25	448.90
11	IR55411-53	77.65	58.20	24.90	11.52	40.35	19.45	19.00	-1.65	76.00	59.50	98.88	1.24	46.90	59.68	20.48	431.80
12	IR55411-50	72.10	53.15	21.95	10.26	48.78	18.95	20.25	-1.20	68.00	33.00	109.08	1.81	39.30	58.08	17.98	278.80
13	IR57924-24	75.85	53.95	26.50	15.80	37.55	21.98	24.60	-2.25	48.88	28.50	102.08	1.87	29.10	46.18	21.25	221.80
14	IR57924-9	70.65	50.70	22.90	11.57	28.85	19.95	24.00	-1.32	69.00	44.00	108.58	1.26	38.70	52.25	23.35	435.80
15	IR57893-73	72.50	52.25	23.08	20.48	47.88	15.75	23.50	0.91	70.58	40.50	86.58	2.18	32.85	82.38	32.98	158.80
16	IR57893-26	91.65	63.85	29.35	28.57	43.40	15.30	24.00	4.40	44.50	37.08	77.80	1.86	45.58	95.55	38.35	373.80
17	IR55411-50	72.25	52.10	22.98	20.81	47.50	20.15	21.70	-0.16	68.58	29.50	95.58	0.98	33.98	67.30	19.70	231.88
18	IR60080-49	88.60	64.85	29.85	38.90	32.20	24.55	29.40	1.48	41.50	30.58	97.80	1.82	50.78	70.28	79.75	405.80
19	IR60888-468	71.90	51.10	27.65	33.49	35.70	20.85	28.65	2.08	77.58	52.00	99.08	1.78	56.60	77.38	25.95	313.00
20	IR60888-45	81.75	50.10	29.88	29.36	47.90	23.65	27.80	-1.81	56.58	48.58	97.88	1.48	50.70	71.28	23.75	386.80
21	IR60080-42	78.85	48.90	27.65	20.37	45.75	21.90	25.48	-1.42	47.80	28.58	95.88	1.39	64.20	79.68	28.98	334.00
22	GPLRi-7	78.00	49.20	25.60	27.63	25.55	20.85	28.75	2.32	76.88	49.50	96.88	8.88	32.80	71.65	28.85	212.80
23	IRAT 288	69.75	54.80	23.58	9.88	45.50	14.95	19.75	3.75	46.88	31.00	87.08	1.31	36.50	87.55	31.05	198.00
24	IRAT 216	67.15	48.48	24.90	28.29	36.98	18.75	10.10	8.34	63.00	54.00	96.08	1.53	56.18	95.58	24.45	496.00
25	IRAT 212	59.15	43.00	27.15	12.29	46.80	16.15	15.60	1.89	59.50	44.50	77.58	1.27	36.70	80.65	38.25	234.00
26	IRAT 144 (Q)	67.00	48.58	23.75	17.92	46.95	17.88	21.75	3.07	40.50	29.50	81.50	1.14	38.58	87.25	36.85	246.08
27	IRAT 104(A)	65.50	45.75	23.50	28.08	48.15	18.75	25.00	-1.87	45.80	34.00	98.58	2.46	64.78	73.65	28.60	397.08
28	IRAT 18	55.70	39.68	19.68	13.74	44.75	16.10	13.68	-1.07	71.50	49.80	82.50	1.05	34.58	84.40	25.25	246.80
29	IR47691-37-4-1	72.40	54.48	26.65	21.41	44.78	18.00	22.30	1.94	30.50	27.00	94.00	1.45	48.58	87.35	25.75	265.00
30	IR47691-17-1-8	74.40	55.75	24.58	21.86	58.65	18.65	17.90	3.08	38.00	19.00	99.50	1.17	38.98	77.58	25.05	247.80
31	IR47686-30-2-1	91.15	60.68	28.65	36.06	39.85	20.50	25.10	1.94	38.00	26.50	100.50	1.62	46.58	79.38	29.58	493.00
32	IR 47686-12-5-B-1	83.00	61.75	26.00	34.04	52.05	21.25	23.15	-1.15	55.00	29.08	97.50	1.69	48.78	76.95	30.95	417.00
33	IR47686-6-2-1-1	85.80	64.30	27.75	26.18	56.45	20.78	25.75	3.15	48.50	34.50	188.50	2.74	55.88	79.50	36.78	394.80
34	IR47686-6-1-1	80.50	57.65	26.65	30.17	63.95	22.85	25.18	0.81	42.58	35.50	99.58	2.75	57.88	92.15	36.08	506.80
35	IR 47686-5-10-8	94.15	74.15	38.50	25.89	41.00	20.80	23.85	4.02	48.88	48.50	98.58	1.47	61.18	85.95	38.60	688.00
36	IR47686-1-1-8	90.75	64.25	29.10	25.51	34.95	23.50	25.68	0.19	44.00	33.00	99.50	1.57	43.58	89.85	31.15	408.80
37	IAC 165	69.10	52.60	21.35	28.32	39.88	16.50	15.38	3.88	50.80	31.50	84.00	1.44	36.58	88.85	34.68	222.00
38	IAC 25	77.50	60.58	23.85	18.97	44.35	17.18	15.75	1.21	49.50	45.50	84.50	1.17	29.18	93.55	35.85	223.00
39	CT6727-5 3 3	67.85	49.58	21.70	17.10	39.50	28.85	18.15	-0.72	58.58	41.00	94.00	1.33	38.88	79.38	30.38	386.00
40	CNA4130	73.75	57.35	20.85	19.51	47.25	14.50	18.48	1.98	49.00	25.08	75.00	1.27	33.60	95.88	34.28	348.88
41	CT6518-24 1 2	70.80	50.88	30.50	25.24	30.55	20.80	19.48	2.47	46.88	35.80	94.00	1.44	48.40	91.68	26.25	648.08
42	CNA5164	73.00	55.25	28.88	21.53	48.78	17.75	22.75	8.65	44.50	30.50	84.58	1.88	47.75	81.85	29.25	376.80
43	CNA4173	75.35	54.50	23.75	27.24	43.05	20.95	23.50	0.59	53.88	22.50	78.08	1.17	31.50	87.55	31.15	234.00
44	CNA4136	69.50	52.35	20.85	23.88	40.90	19.65	16.40	1.85	43.50	35.50	94.88	1.74	33.28	88.18	31.25	483.80
45	IET 2254	43.75	30.75	21.45	9.21	42.98	16.40	18.10	2.16	08.00	51.58	04.08	8.85	30.30	63.25	28.78	112.80
46	IET 7991-11 2	55.65	40.65	19.65	17.15	26.85	15.75	15.98	-1.83	102.80	62.00	78.50	1.07	48.80	75.18	24.45	263.88
47	IET 1444	54.80	37.90	20.05	23.17	40.60	16.68	20.40	-2.70	75.88	33.00	105.50	1.19	36.60	81.15	15.18	262.00
48	Gama-318	54.85	38.25	28.48	17.82	37.95	16.20	17.95	-1.98	75.50	47.50	103.50	8.96	36.48	71.25	22.85	318.80
49	IET 5882	59.50	41.75	22.58	20.64	41.75	11.75	20.38	0.50	69.00	32.00	96.08	8.98	32.85	48.35	12.25	312.00
50	IET 7564-4 3	70.50	52.98	26.00	24.38	33.70	17.60	20.90	1.65	04.50	36.50	71.58	1.86	34.78	72.70	22.40	241.00

Appendix VI The mean performance of 50 genotypes during summer 1992 at ARS Mugad

Sl No	Genotypes	Plant height (cms)	Culm length (cms)	First internode length (cms)	Leaf area (Sq.cm)	% Green leaves	Panicle length (cms)	Flag leaf length(cms)	Panicle exsertion (cms)	Tolal tillers per m.	Productive tillers per m.	Days to 50 % flowering	Panicle weight (gms)	Fertile grains/ panicle	% Fertile grains	1000-Grain weight (gms)	Grain yield per plot (gms)
1	IR57236-275 2	63.05	46.75	24.40	15.35	46.28	16.38	15.95	8.78	186.50	82.00	72.00	8.94	33.58	83.85	28.85	472.88
2	IR53136-70-2	63.80	47.28	21.38	15.60	36.98	16.60	19.80	1.75	125.08	101.08	70.50	1.01	32.65	76.15	29.25	515.50
3	IR53236-77-1	61.58	45.88	21.88	17.48	41.55	16.58	15.35	3.88	105.58	61.58	71.58	1.04	37.58	89.10	28.28	669.50
4	IR53236-179	63.85	47.38	28.85	16.18	49.25	15.87	16.58	2.15	70.58	50.00	78.58	1.21	38.48	72.25	29.88	521.50
5	IR53236-218-3	63.70	49.75	23.80	14.55	37.45	13.95	28.25	8.90	70.88	48.00	72.58	1.26	45.50	85.18	34.28	485.80
6	IR53234-27-7	59.75	43.30	22.50	15.98	48.00	16.45	17.58	-1.35	75.50	41.88	73.08	1.37	45.58	98.75	32.45	620.50
7	IR53234-27-6	56.45	44.60	22.45	10.10	39.35	11.85	13.25	1.21	68.50	43.58	72.88	1.22	38.28	88.45	25.38	618.50
8	IR53167-17	66.50	52.40	20.25	12.75	52.38	14.15	14.00	1.56	48.50	30.50	79.50	1.27	35.08	86.65	28.98	799.50
9	IR55549-1-2	75.65	57.50	25.75	19.88	47.35	18.15	15.55	2.75	58.50	42.50	182.50	1.43	59.75	85.18	26.35	767.00
10	IR55419 4	61.85	46.35	20.00	9.78	43.80	15.50	15.35	0.78	52.00	37.50	100.08	1.27	39.60	73.88	26.35	684.58
11	IR55411-53	67.00	58.90	21.80	13.30	47.38	16.10	16.85	8.78	75.58	43.58	101.50	8.91	43.70	58.98	28.65	887.58
12	IR55411-50	71.78	55.00	20.75	15.00	47.85	16.78	15.80	2.75	97.58	55.58	113.50	8.90	41.75	59.38	17.65	921.00
13	IR57924-24	67.95	51.40	22.75	15.60	47.35	16.55	19.85	1.65	98.88	75.58	184.58	8.97	33.58	49.68	28.48	1881.50
14	IR57924-9	58.45	42.10	28.08	18.55	56.88	16.35	28.88	-3.18	77.00	53.58	112.58	1.86	38.85	56.65	22.58	926.50
15	IR57893-73	68.78	49.98	21.00	14.25	61.45	18.80	19.90	-2.00	106.50	41.00	86.50	1.85	39.95	77.58	33.25	429.50
16	IR57893-26	74.00	56.75	25.75	18.15	48.35	17.25	28.58	1.71	60.88	42.08	79.58	1.27	48.08	98.68	36.48	689.00
17	IR55411-58	64.35	47.40	20.00	14.50	50.05	16.95	16.15	-2.10	66.58	58.58	98.08	8.93	33.85	63.68	19.75	1804.50
18	IR60080-49	67.00	47.70	19.75	21.00	43.18	19.30	15.78	-3.18	57.50	41.58	99.58	1.31	47.08	68.28	29.35	926.50
19	IR60080-468	60.45	46.25	24.75	22.00	42.85	14.60	21.15	2.68	95.58	54.50	100.00	1.23	53.88	74.38	25.18	998.00
20	IR60080-45	67.40	48.38	22.75	22.78	46.00	19.18	17.60	-1.24	48.00	38.00	98.50	1.14	46.00	68.98	23.85	878.00
21	IR60080-42	67.35	50.50	26.50	19.75	44.08	16.85	18.65	-2.32	58.80	43.50	97.00	1.18	48.45	73.48	20.65	824.00
22	UPLRi-2	64.10	44.80	20.75	12.65	37.45	19.25	17.40	1.38	88.88	65.58	101.80	8.84	36.85	72.60	28.35	841.00
23	IRAT 288	63.80	49.68	22.00	19.88	45.00	14.35	18.60	1.17	45.88	36.58	90.50	1.82	36.90	85.80	32.88	748.80
24	IRAT 216	62.48	45.05	21.75	19.15	51.10	17.35	17.18	1.85	63.58	52.50	100.00	1.17	56.00	89.85	24.38	683.80
25	IRAT 212	54.25	40.25	21.80	9.45	47.95	14.00	11.58	1.17	45.50	38.58	80.00	0.96	34.85	78.15	29.48	513.80
26	IRAT 144 (B)	59.20	43.10	20.50	18.40	47.95	16.10	17.25	1.60	69.00	46.58	85.50	1.18	42.65	83.88	35.75	568.08
27	IRAT 104(A)	67.88	48.58	23.58	21.08	47.05	19.30	18.58	-3.15	40.50	27.50	102.08	0.94	53.88	71.35	27.38	437.58
28	IRAT 10	52.38	37.48	20.70	12.90	42.00	14.90	14.75	1.65	97.88	43.58	85.58	0.99	39.25	80.65	24.15	778.00
29	IR17691-37-4-1	71.18	53.95	22.25	28.05	45.75	17.15	18.30	1.48	53.88	39.58	97.50	1.86	48.75	85.45	25.28	744.58
10	IR47691-17-1-B	73.60	56.10	23.58	13.75	58.15	17.58	14.68	2.38	59.00	38.50	105.00	8.90	41.88	76.90	24.58	890.00
31	IR47686-30-2-1	72.55	51.40	24.75	26.15	42.45	21.15	23.55	8.75	50.80	40.00	102.50	1.16	46.85	77.05	28.18	750.00
32	IR 47686-12-5-B-1	67.20	49.55	23.00	18.85	50.25	17.65	16.30	-3.10	63.58	44.00	100.00	1.31	58.58	78.88	38.50	777.08
33	IR47686-6-2-1-1	76.85	57.05	25.85	17.55	54.65	19.80	20.00	1.75	48.50	41.58	184.58	2.89	62.88	81.25	36.78	1829.88
34	IR47686-6-1-1	71.75	51.98	23.75	28.48	52.05	19.85	16.60	1.85	59.50	46.88	101.00	1.93	57.75	87.38	35.98	1187.80
35	IR 47686-5-18-B	73.30	55.85	25.88	24.18	56.35	17.45	16.98	1.78	59.50	45.58	182.58	8.94	43.15	86.38	38.45	826.80
36	IR47686-1-1-B	75.25	55.78	25.75	16.65	53.60	19.55	14.55	2.18	63.50	47.00	104.50	1.17	42.25	87.85	38.65	525.50
17	IAC 165	62.90	49.68	21.25	11.88	49.95	13.38	15.85	0.70	52.50	37.00	88.50	1.34	39.88	47.85	33.30	522.88
38	IAC 25	62.08	48.40	21.50	16.18	56.35	13.58	68.85	0.81	52.00	37.88	88.00	0.97	38.18	90.75	32.48	528.88
39	CT6727-5 3 3	58.80	42.55	20.50	14.10	58.90	16.25	13.65	1.14	59.50	44.50	99.58	0.95	37.58	74.70	29.85	617.50
40	CNA4130	58.00	44.65	17.00	13.68	53.10	15.75	16.85	-2.00	81.50	34.50	87.50	8.99	33.45	91.68	33.58	577.58
41	CT6510-24 1 2	65.80	48.50	27.25	19.15	30.95	17.38	25.88	8.65	70.00	54.50	97.00	1.13	45.05	89.15	25.85	974.50
42	CNA5164	65.75	48.80	22.00	17.65	54.10	16.95	23.50	-3.15	80.80	47.80	86.50	1.20	46.75	80.35	28.45	624.58
43	CNA4173	69.70	46.25	22.88	17.25	57.15	14.45	28.20	1.03	51.58	38.00	81.50	8.96	31.95	86.35	38.75	682.00
44	CNA4136	59.70	45.25	19.50	11.55	56.55	14.45	16.75	0.87	41.00	30.50	98.58	1.80	32.45	86.78	29.50	857.88
45	IET 2254	50.00	34.25	28.70	11.25	45.40	13.75	12.25	-4.65	60.50	48.50	88.50	8.74	31.85	62.40	28.18	387.50
46	IET 7991 11 2	42.00	31.75	17.00	7.65	37.80	10.25	11.60	0.74	70.50	50.50	89.00	0.93	35.98	71.70	23.00	663.50
47	IET 1444	63.85	46.65	21.80	20.10	43.70	67.20	29.60	-1.95	80.00	47.58	111.50	1.87	33.50	77.90	14.15	654.00
48	Gawa-318	65.45	48.10	22.50	13.15	47.95	67.35	13.58	-2.80	67.00	51.50	108.50	8.93	35.90	71.65	21.05	612.50
49	IET 5882	63.20	47.60	21.18	17.45	44.70	19.60	16.95	-4.85	61.08	36.50	90.50	8.90	32.90	47.35	12.55	620.50
58	IET 7564 4 3	63.15	46.50	23.25	10.05	39.05	16.65	14.90	1.36	74.00	66.08	78.50	0.97	35.35	66.75	21.75	595.00

ಅನುಸೂಚಿ ಸಂ Th.3632
ಪ. ಸಂ .....