# STABILITY ANALYSIS OF KUNJUKUNJU RICE CULTURES (*Oryza sativa* L.)



By
**JYOTHI, R.**

**THESIS**
**Submitted in partial fulfilment of the requirement for the degree of**

## Master of Science in Agriculture

**Faculty of Agriculture**
**Kerala Agricultural University**

**Department of Plant Breeding and Genetics**
**COLLEGE OF HORTICULTURE**
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA
**2002**

## DECLARATION

I hereby declare that this thesis entitled **"Stability analysis of Kunjukunju rice cultures (*Oryza sativa* L.)** " is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
18/1/03

R. Jyothi
Jyothi, R.

## CERTIFICATE

Certified that this thesis entitled **"Stability analysis of Kunjukunju rice cultures (*Oryza sativa* L.)"** is a record of work done independently by **Kum. Jyothi, R.**, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara,
19-1-03

**Dr.V.V.Radhakrishnan**
Chairman, Advisory Committee
Associate Professor
Department of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

# CERTIFICATE

We the undersigned members of the Advisory Committee of **Kum.Jyothi, R.**, a candidate for the Degree of **Master of Science in Agriculture**, agree that this thesis entitled **"Stability analysis of Kunjukunju rice cultures (*Oryza sativa* L.)"** may be submitted by **Kum.Jyothi, R.**, in partial fulfillment of the requirement for the degree.

18/01/03

**Dr. Radhakrishnan, V.V.**
(Chairman Advisory Committee)
Associate Professor
Department of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

18/1/03

**Dr. Pushkaran, K.**
(Member, Advisory Committee)
Professor and Head
Department of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

18/01/03

**Sri. Krishnan, S.**
(Member, Advisory Committee)
Assistant Professor
Department of Agricultural Statistics
College of Horticulture
Vellanikkara

18/01/03

**Dr. Arya, K.**
(Member, Advisory Committee)
Assistant Professor
Department of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

18/1/03

**EXTERNAL EXAMINER**
Dr. K. Thiyagarajan
Prof & Head, PBS
TNAU.

# ACKNOWLEDGEMENT

*I have immense pleasure to express my deep sense of gratitude and indebtedness to **Dr.Radhakrishnan, V.V.**, Associate Professor, Department of Plant Breeding and Genetics and Chairman of my advisory committee for his valuable guidance, critical suggestions, unfailing patience and, constant encouragement through out the investigation and timely help especially during field trips and for the critical scrutiny of the manuscript.*

*I express my heartful gratitude and indebtedness to **Dr.Arya, K.**, Assistant Professor, Department of Plant Breeding and Genetics and member of my advisory committee for kind concern, expert advice and whole hearted cooperation during the field work and through out the study.*

*I express my sincere gratitude to **Dr.Pushkaran, K.**, Professor and Head, Department of Plant Breeding and Genetics and member of advisory committee for his technical advice and constant encouragement through out study.*

*I express my heartful gratitude to **Sri. Krishnan, S.**, Assistant Professor, Department of Agricultural Statistics and member of advisory committee for his kind concern, expert advice and ever willing help rendered in the statistical analysis of the data and subsequent interpretations.*

*My heartful thanks are expressed to Dr.Elsy, C.R., Assistant Professor, Department of Plant Breeding and Genetics for providing the seed materials for conducting the experiment.*

*I extend my sincere thanks to Mr.Aravindakshan, Mrs.Prasanna and Mrs.Janaki for allowing me to carry out my research work in their fields and timely help especially for making the labourers available during the field work.*

*I take this opportunity to Extend my gratitude to all the teaching and non teaching staff of the Department of Plant Breeding and Genetics for their unbounded support and whole hearted cooperation at different stages of the study.*

*I accord my sincere thanks to Smt.Prasanna,V., and her family members for their sincere help at different stages of the study , where I have laid the field experiment.*

*A note of thanks to Mr. Santhosh Kumar Instructor of Computer club, College of Horticulture and Joy, JMJ Computer Centre for assisting me in compilation of thesis.*

*The help rendered by my friends Ushavani, Shinoj, Binu, Vanisree, Suresh, Chandrasekhar Reddy, Roshini, Rani, Hena, Ardita, Rinku, Sanal Kumar, Karuppayya Arunachalam and Ganapathi at various stages of this investigation, petty though it might seem, is invaluable and I thank them all from the bottom of my heart.*

*The award of Junior Fellowship by Kerala Agricultural University is gratefully acknowledged.*

*Words cannot express my soulful gratitude to my father Sri.Ramanaiah, my mother Smt.Aruna, my sister Prasuna and my brother Ravi, without whose encouragement the study would have never seen light.*

*Above all, I bow my head before the lotus feet of Lord Venkateswara, for the unmerited blessings, which lead to every step of the way.*

*Jyothi. Ravilla*

# CONTENTS

## LIST OF TABLES

# LIST OF FIGURES

## LIST OF PLATES

*Dedicated to My Family*

# Introduction

# INTRODUCTION

In India a number of new high yielding rice varieties were evolved and released through crop improvement programmes, but many of them were unadapted and unaccepted both by the farmers and consumers. The local varieties are still prevailing in the major parts of the cultivated area. Such local types constitute an essential basis for further advances in rice breeding and acts as sources of resistant genes for diseases, pests, and local adaptation and specialised grain qualities, which are decided by local people.

In Kerala the area under rice has been drastically reduced from 8.75 lakh hectares in 1975 to 3.87 lakh hectares in 1998, out of which 37 percent is under high yielding varieties. Eventhough more than 60 high yielding rice varieties were released for various agro ecological situations of Kerala, majority of the area (63%) under rice cultivation is still with local cultivars. (State Planning Board, 1998).

In the present system of crop improvement programmes, the domains of released cultivars are defined inadequately and appropriate cultivars are not reaching to farmers where as inappropriate cultivars are being recommended. Farmers are encouraged to grow them in areas to which they are unadapted (Witcombe *et al.*, 1996). The agricultural research is underlined by three components. Genotype (G) or genetic contribution of variety, the environment (E) in which the variety is grown and genotype-environment (GxE) interaction, among which GxE interaction is usually given less importance by the breeder while crop breeding programme is initiated.

The performance of any genotype mainly depends on environmental interaction. Estimation of phenotypic stability, which involves regression analysis, has proved to be a valuable technique for assessing the response of various genotypes under changing environmental conditions and evaluation of genotype-environmental interaction gives an idea of buffering capacity of gene under study. The low magnitude of genotype-environmental interactions indicates consistent performance of a population over varied environments.

Finley and Wilkinson in 1963, made the first systematic approach to the analysis of phenotypic stability of cultivars or genotypes. Here two parameters, namely mean values over locations and regression coefficients are used to assess stability. In 1966 Eberhart and Russell made further improvements in stability analysis by partitioning the genotype-environmental interaction of each genotype into two parts, slope of regression line and deviation from regression line. This model measures three parameters of stability, viz., mean values over environments, regression coefficients and deviation from regression lines and thus provide reliable information about stability.

Kunjukunju is a popular short duration rice cultivar of Palakkad and Thrissur districts with high yield and consumer preference. Some of the preliminary studies conducted with these cultivars revealed that it is a mixture of different morphotypes under the title Kunjukunju. A premier study under the title "Group Approach for Locally Adapted Sustainable Agriculture (GALASA) seed research programme" was carried out and six distinct cultures were identified through pure line selection with better adaptability and consumer preference.

Yield stability is genetically controlled and use of adaptable genotypes for general cultivation over a wide range of environmental conditions will help in achieving stabilisation in crop production over locations. Stability analysis will help in understanding the adaptability of the Kunjukunju cultivars over wide range of environmental conditions and in the identification of best adaptable genotypes from them.

In view of the above the present study was undertaken with the following objectives.

- Yield stability over various locations
- Response of genotypes in changed environments
- Identification of best genotypes for various locations

# Review of Literature

# 2. REVIEW OF LITERATURE

An over view of works concluded in rice related to the aspects of genetic variability, heritability, genetic advance, expected genetic gain, correlation studies, path coefficient analysis and stability parameters is presented here under.

## 2.1 Genetic variability

Information on genotypic and phenotypic coefficients of variability is derived from data on seven yield related traits in 25 genotypes of early upland rice grown under four different environments. Highest genotypic and phenotypic coefficients of variation were recorded for number of grains per panicle (Reddy, 1992).

According to the data presented on genetic variation for 14 genotypes from different thum (Shifting cultivation) fields of hills of Assam, highest genotypic coefficient of variation was observed for panicles $m^{-2}$ followed by 100 grain weight and grain yield per plant (Sarma and Roy, 1993).

Genetic variance was determined for ten quantitative traits on nine genotypes grown during 1989. Genotypic variance was high for grains per panicle followed by plant height, days to 50 per cent flowering, seedling height and flag leaf length (Kumar *et al.*, 1994).

In the data on eight yield components in 75 genotypes and their hybrids, the genotypes showed a wide range of variation for all the measured characters. High coefficients of variation were observed for grains per panicle, grain yield per plant and plant heights (Sawant and Patil, 1995).

Morpho-agronomic characterization of 88 long, slender scented Basmati rice germplasm collected from northern India (U.P and Haryana) revealed significant variability in leaf length, culm number and panicle length (Patra and Dhua, 1996).

According to the data presented on genetic variation for 22 genotypes of rice, growing in India the genotypic coefficient of variability was highest for straw yield per plant followed by grain yield per panicle, grain yield per plant, height of plant, total biological yield per plant and number of fertile florets per panicle (Panwar *et al.*, 1997).

Information on genotypic and phenotypic coefficients of variability derived from data on eight quantitative characters in 25 lines of rice revealed that all lines showed significant differences for all the characters studied, except number of effective tillers per plant and straw yield per plant. Genetic coefficient of variation was high for grain yield per plant whereas estimates were low to moderate for the remaining traits (Datke *et al.*, 1997).

Fifteen rice genotypes were grown at Bapatla during kharif 1994-95 under three sowing dates and evaluated by Lalitha and Sreedhar (1999) for grain quality traits and grain yield. Variability was high for alkali value (gelatinization temperature) while it was low for protein content.

A study of 11 experimental rice hybrids and four standard varieties grown at Hebbal over four seasons (the kharif and summer seasons of 1993 and 1994) on genetic variance of 10 quantitative traits was done by Lohithaswa *et al.* (1999) revealed that significant genotypic differences were there in all four seasons for all the traits except number of tillers per plant, number of productive tillers per plant and panicle length.

Genetic variability was studied by Priyanka *et al.* (2000) in 26 rice genotypes during 1997-98. Genetic parameters for eight traits are presented. Analysis of variance revealed that the mean squares due to genotypes were highly significant for all traits, indicating the presence of sufficient variation among genotypes used in the investigation.

Genetic variability for yield and its components was studied in 15 genotypes of rice for 10 characters (days to 50 per cent flowering, days to maturity, plant height, tillers per plant, panicle length, panicles per plant, number of grains per panicle and per plant, 1000 grain weight, and grain yield per plant). Appreciable amount of genotypic coefficient of variation, heritability and genetic advance were observed for total grains per panicle, total grains per plant and grain yield per plant (Yadav, 2000).

Data on variability and correlations studies of 15 rice varieties revealed that moderate to high coefficient of variation were observed for plant height, number of grains per panicle, spikelet sterility, amylose content, gel consistency, kernel elongation ratio, 100 rice grain weight and yield per plant (Satyavathi *et al.*, 2001).

## 2.2 Heritability, Genetic advance and Genetic gain

Heritability and genetic advance were studied in 82 populations of rice by Vishwakarma *et al.* (1989). Heritability was moderate for grain yield and low for number of tillers. Genetic advance was high in grains per panicle and medium to low in grain yield, test weight and number of tillers.

Information on heritability and genetic variance was derived from data on eight yield components in 28 cultivars of rice grown during 1979 by Lokanathan *et al.* (1991). Value for expected genetic advance ranged from 32.3 per cent (panicle weight) to 69.4 per cent (plant height). Plant height also showed high values of heritability (94.2%) indicating high potential for selection.

Chauhan *et al.,* (1992) studied 45 varieties and elite lines of indica rice under rain fed conditions and data was recorded on 12 quality traits. Grain length, alkali-digestion value, length-breadth ratio of grain and grain breadth showed consistent high heritabilties of above 75 per cent. Grain breadth and alkali digestion value gave high values for genetic advance, and low values for genetic advance were recorded for hulling and milling recovery.

Among the eight characters studied in three crosses of rice, panicle weight, 100 seed weight and number of fertile spikelets per panicle recorded high heritability coupled with moderate to high genetic advance (Lokaprakash *et al.*, 1992).

Information on heritability and genetic advance was derived from data on seven yield related traits in 25 genotypes of early upland rice grown under different environments. All the traits exhibited moderate to high estimates of heritability ranging from 67.9 per cent for grain yield per hill to 99.5 per cent for days to 50 per cent flowering. Plant height and number of grains per panicle showed high estimates of genetic advance along with high estimates of heritability (Reddy, 1992).

High heritability and genetic advance were found for panicle $m^{-2}$, grains per panicle, 100 grain weight and percentage sterility in the data presented for 14 genotypes of rice, by Sarma and Roy (1993).

Plant height showed high heritability in the narrow sense when five yield components were studied in eight diverse cultivars of rice (Singh *et al.*, 1993).

Twenty rice varieties were evaluated for eight yield traits by Chaubey and Singh (1994). Heritability was high in all traits, but was highest for total number of spikelets followed by grain yield per plant and 100 grain weight. Genetic advance as a percentage of the mean was highest for grain yield per plant followed by panicle weight and total number of spikelets.

Estimates of variability, heritability and genetic advance were high for high density grains per panicle and 1000 grain weight, in 20 advanced breeding lines of rice (Govindarasu and Natarajan, 1995).

Information on heritability is derived from data on eight yield components in 75 genotypes of rice and their hybrids. High value of heritability coupled with expected genetic advance were observed for the characters grains per panicle, plant height, grain yield per plant and 1000 grain weight (Sawant and Patil, 1995).

Data from traits of ten scented rice genotypes over four seasons indicated high heritability estimates for all characters except number of tillers per hill, panicle length, and number of chaffs per panicle indicating better scope for selection. However genetic advance was low for most of the traits (Mishra *et al.*, 1996).

High heritability coupled with high genetic advance was observed for 1000 grain weight, height of plant, flag leaf area, grain yield per plant and straw yield per plant in the data presented for 22 genotypes of rice by Panwar *et al.*, (1997).

Thirty four rice genotypes were evaluated for yield traits by Shanthakumar *et al.* (1998). Significant genotypic coefficient of variability together with high heritability and genetic advance was observed for plant height, total tillers per hill, and grain yield per hectare.

Twenty semi deep water scented local rice varieties were studied for yield components at Ambikapur in kharif 1997-1998. Plant height and panicle length exhibited high genotypic and phenotypic variation. High genotypic coefficient of variation, heritability and genetic advance were observed for grain yield (Tripathi *et al.*, 1999).

Yadav (2000) studied 15 genotypes of rice during kharif 1997-98 in Raigarh and data was recorded for 10 characters. Appreciable amount of genotypic coefficient of variation, heritability and genetic advance were observed for total grains per panicle, total grains per plant and grain yield per plant.

Broad sense heritability and genetic advance were studied in $F_2$ population of *Oryza sativa* by Ali *et al.* (2000). Heritability estimates were maximum for plant height, 100 seed weight, number of tillers per plant, spikelet density and panicle length but maximum genetic gain relative to the mean was expected for number of tillers per plant, plant height and spikelet density.

Genetic variability, heritability and genetic advance for yield and yield components in 25 rice genotypes were studied and observations were recorded for eight traits (Roy *et al.*, 2001). Heritability ranged from 50 per cent (grain yield per hill) to 90 per cent (grain breadth). Genetic advance as a percentage of mean was highest for number of filled grains per panicle (70.34) followed by grain yield (68.62). Number of filled grains per panicle, 1000 grain weight, grain length and breadth exhibited less environmental effect and high heritability coupled with moderate to high genetic advance.

## 2.3 Phenotypic and Genotypic correlations

In 1985, 25 varieties were tested for grain quality using the following criteria: hulling, milling and head recovery; grain length and breadth; alkali spreading value; elongation ratio. Although L/B ratio was inversely associated with head recovery there was no association between L/B ratio and elongation ratio. The lowest alkali spreading value was in Basmati 370 (Malik, 1989).

Grain yield was positively correlated with 1000 grain weight and number of grains per panicle, when six crosses and five parental rice genotypes were compared by Mirza *et al.* (1992).

Grain yield exhibited positive genotypic and phenotypic correlation with height, number of productive tillers and grain number, the latter two characters showed major influence on yield. This information was got from data on eight characters in 40 rice genotypes (Rajarathinam and Raja, 1992).

Correlation studies in 37 genotypes of upland rice during 1991 indicated that grain yield per plant was positively and significantly correlated with straw yield per plant and filled grains per panicle (Mahajan *et al.*, 1993).

Seventy five rice cultivars were studied for test weight, length and breadth of polished kernels. Correlation indicated that weight of grain was influenced more by length than of L/B ratio of kernels (De *et al.*, 1994).

In a study of 14 varieties in a yield trail by Paul and Nanda (1994), panicle density and number of filled grains per panicle showed a significant positive correlation with yield.

High density per panicle was significantly and positively correlated with number of spikelets per panicle and high density grain index when 20 advanced breeding lines of rice were studied by Govindarasu and Natarajan (1995).

Grain yield was positively associated with days to 50 per cent flowering, spikelets per panicle and milling percentage when 11 characters were studied in 99 genotypes of rice by Roy *et al.* (1995).

Number of tillers per hill and number of grains per panicle exhibited positively high significant correlation with yield when data from trails of 10 scented rice genotypes were analyzed by Mishra *et al.* (1996)

Positive and significant correlations were observed between yield per plot and plant height, length of panicle, days to maturity, 1000 grain weight, length of grain and L/B ratio when data from 73 rice varieties on 14 yield related traits were analyzed by Marekar and Siddique (1996).

Correlation studies in 49 recombinant inbred lines of Koshihikari X Nakateshinsenbon by Kato (1996) revealed that yield sink capacity was positively correlated with grains per panicle ($r = 0.75$) and negatively correlated with ripened grain percentage ($r = -0.96$).

Thirty six rice lines were evaluated by Kihupi (1998) for yield and other components. Correlation coefficient analysis revealed that grain yield per plant was positively correlated with all the characters except percent unfilled grains and days to 50 per cent flowering.

Genetic variability and correlations among grain yield and its attributing traits studied in $F_2$ population in rice by Thakur *et al.* (1999) indicated that grain yield had positive association with plant height, tillers per plant, and panicle weight.

The lengthwise elongation showed significantly positive correlation with milled grain breadth, breadth thickness ratio, length elongation, water absorption percentage and gel consistency. Most of the physical quality traits had positive correlations among themselves when data from traits of rice lines for 15 characters were analyzed by Sarawgi *et al.* (2000).

Variability and character association for yield and several grain quality characters studied in 26 aromatic rice genotypes revealed that yield per plant had a very strong genotypic correlation with test grain weight. The latter, how ever was positively correlated with grain length but was negatively correlated with grain breadth. Grain length and width were negatively correlated and elongation ratio had very strong positively correlation with grain length after cooking and amylose content was positively correlated with grain length and test weight (Sadhukhan and Chattopadhyay, 2000).

Information on correlation coefficient derived from data on nine yield traits in the parents and $F_2$ progeny of rice cross Anupama X IR 50 suggested that biological yield and panicle weight were positively associated with grain yield (Thakur *et al.*, 2000).

A study was conducted by Bala (2001) to understand interrelationship of the economic traits in upland rice in Ramanathapuram, Tamil nadu, India. Results indicated that grain yield $m^{-2}$ and panicle length recorded positive and significant correlation, and positive direct effect with plot yield.

Correlation analysis on 28 genetically diverse rice genotypes revealed that rice seed yield was positively and significantly correlated with number of tillers per plant, length of panicle, days to maturity, test weight and number of grains per panicle. Number of tillers per plant had maximum positive direct effect on seed yield and positive indirect effect via length of panicle, days to maturity and number of grains per panicle (Singh *et al.*, 2002).

## 2.4 Path analysis:

Path analysis of rice grain yields under rain fed low land conditions indicated that number of productive tillers had high direct effect on grain yield while panicle length and flowering duration had moderate direct effects on grain yield (Ibrahim *et al.*, 1990).

Data on characters associated and path analysis were presented from yield trails with 48 low land rice cultivars from Uttar Pradesh. Test weight, grain breadth, number of grains per panicle and number of internodes were the most important components of yield (Singh *et al.*, 1990).

Path analysis of red rice (*Oryza sativa* L.) competition with cultivated rice indicated that the number of panicles per plant and spikelets per panicle were the most important yield components determining the responses of fecundity and grain yield to competition. The direct effects of rice and red rice densities on panicles per plant and spikelets per panicle were always negative. In contrast, the effects of density on percent filled florets and grain weight varied from positive to negative and were relatively small, implying that they were determined primarily by density independent factors (Pantone *et al.*, 1992).

Path analysis in 80 indica rice varieties indicated that panicle weight made the highest contribution to grain yield (Chaubey and Richharia, 1993).

Path analysis studies by Gravois and Mc New (1993) revealed positive direct effects for both panicle number and panicle weight on rice yield, with panicle weight exhibiting larger direct effects on yield than panicle number.

According to Mahajan *et al.* (1993) path analysis of 37 genotypes of upland rice revealed that filled grains per panicle exerted a positive direct effect on yield, hence it is considered as the most important yield contributing character.

Sarma and Roy (1993) reported that spikelets per panicle had highest positive direct effect on yield followed by panicles $m^{-2}$ and plant height.

The greatest direct positive effects on grain yield were recorded for number of ear bearing tillers followed by plant height, 100 grain weight and total number of spikelets. The study was carried out by Chaubey and Singh (1994) using 20 rice varieties.

Path coefficient analysis in rice by Marwat *et al.* (1994) found that productive tillers, panicle length and 1000 grain weight had the highest direct effect on grain yield per plant.

Eleven early rice varieties were studied for ten quantitative characters, during 1984-85 at Ambasamudram. Grains per panicle had the highest positive indirect effect via productive tillers, panicle weight and grain weight (Sundaram and Palanisamy, 1994).

Study of eight $F_2$ progeny and their nine parents grown at three plant densities revealed that number of panicle bearing tillers had the greatest direct effect on yield, followed by 1000 seed weight (Yadav *et al.*, 1995).

Path coefficient analysis in 34 rice genotypes by Kumar *et al.* (1998) found that high direct effect of spikelet fertility and moderate direct effects of plant height, panicle length and 1000 grain weight to yield.

According to Kihupi (1998) path analysis of 36 rice cultivars revealed that number of filled grains per panicle, number of panicles per plant and 1000 grain weight to be important characters that influence grain yield. How ever, number of filled grains per panicle had a significant negative indirect effect through number of panicles per plant and 1000 grain weight.

Path coefficient analysis in 28 rice genotypes of *Oryza sativa* by Balan *et al.* (1999) indicated that number of panicles $m^{-2}$ exerted high positive direct effects with grain yield. Days to 50 per cent flowering exerted a high positive indirect effect on grain yield through number of panicles $m^{-2}$.

Path coefficient analysis revealed that plant height; spikelets per panicle, and grains per panicle had high direct effects on single plant yield. The effects of these characters were further increased by the positive indirect effect of plant height through spikelets and grains per panicle; productive tillers through plant height, spikelets per panicle, and grains per panicle; panicle length through plant height. The major yield contributing characters, based on indirect and direct effects, were plant height, spikelets per panicle, and grains per panicle (Janardhanam *et al.*, 2001).

According to Singh *et al.* (2002) correlation analysis on 28 genetically diverse rice genotypes India, revealed that rice seed yield was positively and significantly correlated with number of tillers per plant, length of panicle, days to maturity, test weight and number of grains per panicle. Number of tillers per plant had maximum positive direct effect on seed yield and positive indirect effect via length of panicle, days to maturity and number of grains per panicle.

**2.5 Stability analysis**

Stability analysis of 28 rice genotypes over four environments concluded a significant genotype environment interaction and found that genotypes NAU81804, RP 1714-111-732 and NDR 312-1 were stable and produced the highest grain yield (De *et al.*, 1990).

Data on stability analysis in upland rice presents from trails with nine rice (*Oryza sativa*) cultivars grown during 1989 over three locations. Genotype x environment interaction (GxE) was observed particularly for days to 50 per cent flowering and 100 grain weight and straw weight of the genotypes RAU 4068-105-5 and RAU 4045-2a exhibited highest stability for grain weight (Kumar and Prasad, 1991).

Samonte and Hernandez (1991) analysed the adaptability and stability of yield data belonging to four maturity groups of rice genotypes and found that genotypes IR 42068-22-3-3-1-3, BPIR-12 were well adapted to all environments.

Information on stability and genotype x environment interactions derived from 47 low land rice genotypes indicated that GxE interactions were predominantly linear for ear bearing tillers per hill and non linear for grain yield. The most stable genotypes were GR 728-7-2-2-, CR 673-431 and Utkal Prava (De *et al.*, 1992).

Bogabordhan the local rice variety showed insignificance in regression of yield across the years indicated the good stability and it has out yielded both controls (Manoharsali and Jaya) when study conducted for stability with twenty local rice varieties (Baruah *et al.*, 1993).

Six short duration, semi dwarf rice lines, derived from an IR36 breeding were evaluated in different seasons during 1987-91, together with IR36 and high yielding Jyothi as controls, by Rosamma *et al.* (1993). They found that genotypes KAU 8754 and KAU 8755 had regression coefficient close to unity and yields higher than the pooled mean. These four cultivars are recommended for use in breeding for high yield potential and adaptability. KAU 8754 and KAU 8756 were recently released in Kerala as Kairali (ptb 49) and Kanchana (ptb 50).

Five cultivars and one advanced line of medium duration rice genotypes were evaluated for stability over four environments. Significant genotype x environment interactions were observed for panicles per plant, filled grains per panicle, spikelet fertility, 100 grain weight, plant yield. ADT 38 and CO 45 had stable yield over the four environments (Geetha *et al.*, 1994).

Genotype x environment (GxE) interaction studies of 99 *Oryza sativa* genotypes revealed genotypes RP2151-173-1-8, HKR 42, HKR 111, HKR 40, PR 108, IR 58028-170B and IR 39404-100-1-1 performed best under average environmental conditions, while IET 4141 and IR 54742-18-17-20-2 were specifically adaptable to favourable conditions (Roy and Panwar, 1994).

RCPL3-6, RCPL3-2 and TURA 490 were recommended for cultivars in Sikkim due to their stable performance based on information on GxE interaction studies of 15 rice genotypes grown in six environments (Singh *et al.*, 1995).

Stability analysis of 13 early duration rice genotypes concluded that varieties Aditya and Tellahamsa had regression coefficient values close to unity, indicating their highly stable performance over three test years. These varieties yielded above average and were released for upland cultivation in India (Rao *et al.*, 1996).

Fourteen genotypes of rice were tested for stability parameters over four environments. Pooled analysis of variance showed significant differences for all characters studied. Genotypes BPT 6873, BPT 6881 and BPT 6853 had the highest stability (Reddy and Kumar, 1996).

Thirty-four genotypes of rice were studied for phenotypic stability during the three seasons of 1990.The results indicated the presence of genotype x environment interactions for all five yield related characters studied. None of the genotypes were stable for all characters. Jaya, HP 10 and IR54 were most suitable for dry wet environments, while KBCP 1 was the most suited to all the environments (Shantakumar *et al.*, 1997).

Adaptability studies of 30 diverse genotypes of rice (*Oryza sativa*) over two locations and two dates of planting revealed that three varieties namely IR 8, IR 106, IR 64 exhibited stability in their performance for grain yield with unit regression (Singh *et al.*, 1997).

The stability of some promising rice hybrids was studied at Mandya in Karnataka in the 1994 wet season and found highly significant GxE interactions for yield and its components. None of the hybrids, evaluated showed stability for yield over the environments studied. Correlation analysis between stability parameters for grain yield and yield components indicated that stability parameters in rice hybrids may be governed by different genes and gene interactions (Hedge and Vidyachandra, 1998).

Sixteen early maturing rice varieties were evaluated for stability of yield performance under 15 varied environments (Smita and Mahapatra, 1998). Of the three high yielding genotypes identified (Annapurna, Badami and Annada) only Annada was found to exhibit average response under both the sets of environments, there by indicating its wide adaptability.

Stability analysis of yield performance of rice cultivars, which was conducted by the method of Eberhart and Russell, showed no significant interaction for cultivar x environment (linear), that means limited genetical differences among cultivars concerning adaptability and stability. The deviation mean squares from the regression line was significant, because of significant deviation MS of lines 400 and 403. All cultivars have moderate to good stability. The most stable genotype was line 397 (Honarnejad *et al.*, 1999).

Fifty two indigenous and exotic genotypes of rice were evaluated for their stability with respect to quality characters under four environments .The variation due to GxE was significant for all the characters studied (Hulling, milling percentage, grain length, breadth and amylose content). The genotypes WGL 3962, IR 10198, PMS 3 B, IET 4114, HKR 239 and HB 1 were best for average environmental conditions, while IR 50, IR 56 and BR 51-202-8 were more suitable for favourable conditions with respect to the five characters (Kandhola and Panwar, 1999).

Stability analysis studies of 12 early maturing rice varieties in respect of grain yield and seven component characters by Mahapatra and Das (1999) over 30 environments revealed that variation due to genotypes (G), environments (E) and G x E interactions were highly significant for all eight characters, and a large portion of the interactions was explained by linear regression. The association of yield with component traits varied from environment to environment. Highly significant G x E interactions for linear components indicated differential response of the varieties to changing environments. Stability parameters (X, b, S2d and a) estimated for yield and its components revealed that stability in yield differed with level of stability in the component traits. It was found that stability in grain yield was due to stability in some component traits and plasticity in others, and this pattern of stability and plasticity in component traits differed from variety to variety.

Atroch *et al.* (2000) conducted field studies in four different locations, to evaluate the adaptability and stability of nine rice cultivars (Guarani, Douradao, Caiapo, Confidanca, CNA 7911, Maravilha, CNA 6975-2, Canastra and CNA 7024), and to quantify the effects of different variables on the genotype x environment interaction. Individual analysis of variance and joint analyses for the three year period revealed that the genotype x systems interaction was not significant. The magnitude of variance of the genotype x location interaction was larger than that of the genotype x year interaction, suggesting that the evaluations be accomplished in a larger number of locations. Significant differences in grain yield stability were observed among the cultivars. Canastra and CNA 6975-2 exhibited significant grain yield stability, while Maravilha, Confianca and CNA 7911 were unstable.

Shadakshari *et al.* (2001) evaluated forty promising long duration rice genotypes across six farming situations in Karnataka during 1998 kharif season to study the genotype x environment interaction and to identify stable genotypes of high grain and straw yield for lowland situations. Both linear and non linear components of genotype x environment interaction were significant for days to 50 per cent flowering, grain and straw yields and only non-linear component was significant for plant height. Among the 40 genotypes, 33 were stable for grain yield over the locations. Among these, IR 57773, IET 13736, Puttabatta, IET 11865, KHRS 28, PUB and BKB showed average response to changes in environmental conditions. IRLON 90/39, Mattalaga, IET 11865, ASD 10 and Halugidda showed average performance over environments with unit regression coefficient value and deviation from regression coefficient near to zero. Regression coefficients of more than one for KHRS 21, IET 10549 and less than one for PUB and Kaggari Kirwana indicated their suitability for favourable and unfavourable environments, respectively. Genotypes Intan, KHRS 28, KHRS 22, Biliakki, IET 10549, Mattalaga, Hemavathi and KHRS 32 were stable for days to 50 per cent flowering over environments. KHRS 21, IET 14349, Intan, KHRS 22, KHRS 37 and Mattalaga were stable for plant height with average performance. IET 11865, KHRS 32, IET 10549, CN 647 and RRR 27 were suitable genotypes for favourable environments. BKB, Kempu Sannakki, PUB and IRLON 90/39 for unfavourable environments. IR 57773, IET 13736, Puttabatta, IET 11865, KHRS 22, KHRS 28, PUB and BKB were the high yield stable genotypes for grain yield across the six farming situations.

# Materials and Methods

# 3. MATERIALS AND METHODS

The present investigation was conducted in the department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara during the period 2001 to 2002. Field experiments were laid out in three districts of Kerala state, namely Palakkad, Thrissur and Ernakulam during Kharif 2001.Climatological and geographical positions of the three districts are provided in Table1.

Table1. Climatological and geographical positions of the three districts

| Particulars | Palghat | Thrissur | Ernakulam |
|---|---|---|---|
| Latitude | $10^{0}.46^{1}$ | $10^{0}.30^{1}$ | $10^{0}.00$ |
| Longitude | $76^{0}.42^{1}$ E | $76^{0}.14^{1}$ E | $76^{0}.15^{1}$ E |
| MSL (m) | 76.2 | 22.6 | 7.6 |
| Soil type | Red soil | Laterite | Sandy loam |
| Mean RF (mm) | 2389 | 3262 | 3274 |
| Maximum Temperature ($C^{o}$) | $37 \pm 0.2$ | $35 \pm 0.2$ | $32 \pm 0.1$ |
| Relative Humidity (%) | 69-92 | 70-90 | 71-90 |

Source: Economic review (1998).

### 3.1.1 Materials

Six distinct cultures of local cultivar Kunjukunju developed under the "GALASA" (Group Approach for Locally Adapted Sustainable Agriculture) seed research programmes for purification and genetic improvement of Kunjukunju cultivars along with parental Kunjukunju and a popular high yielding variety Kanchana constituted the materials for the study (Table2).

Table 2. Particulars of rice cultures used for the experiment

| Sl. No. | Name of the culture |
|---|---|
| 1 | K-6 |
| 2 | K-10-2 |
| 3 | K-10-3 |
| 4 | K-68-4 |
| 5 | K-67-5 |
| 6 | K-68-6 |
| 7 | Local Kunjukunju |
| 8 | Kanchana |

### 3.1.2 Methods

Selected six distinct cultures of Kunjukunju and two standard checks viz., parental Kunjukunju and rice variety Kanchana were evaluated for genotype x environmental interactions in the selected places of three districts of Kerala as detailed below.

| District | Place selected |
|---|---|
| 1.Palakkad | Koyalmannam |
| 2.Thrissur | Madakkathara |
| 3.Ernakulam | Aduvasseri |

The experiments at these three locations were laid out in randomized block design with three replications. Each plot was of size 6.48 $m^2$ consisting of 20 rows of 20 plants each at a spacing of 15 cm x 10 cm. A random sample of best ten plants per plot was selected and observations were recorded for the following characters. Observations were taken as per the standard evaluation system suggested by Shouichi *et al.* (1976), IRRI (1995) and Directorate of Rice Research (1995).

### 3.1.2.1 Characters

**1. Number of days to 50 percent flowering**

Number of days was counted from date of germination to about 50 per cent flowering stage of the plants in a plot.

**2. Height of the plant at harvest**

Plant height was measured in centimeters from ground level to tip of the tallest panicle about one week prior to harvest.

**3. Total number of tillers**

Total number of tillers in each plant was counted after 50 per cent flowering.

**4. Number of panicles per plant**

Number of panicle bearing tillers in each plant was recorded prior to harvest.

**5. Number of days to harvest**

Number of days from germination to grain ripening (when 85 per cent of grains in a panicle were matured) were recorded.

**6. Number of spikelets per panicle**

Ten panicles from selected plants of each plot at random and number of spikelets were counted and average was worked out.

**7. Per plant grain yield**

Grain yield of all plants in a square meter of each plot was taken and divided by number of plants per square meter and recorded in grams.

**8. Grain yield per plot**

The entire plants from each plot were harvested discarding border rows and the grain yield was expressed in kg $ha^{-1}$.

**9. Straw yield per plot**

The entire plants from each plot were harvested discarding border rows and the straw yield was expressed in kg $ha^{-1}$.

**10. 100 grain weight**

Hundred fully ripened, filled and healthy grains were taken at random from each plot, weighed and recorded in grams.

**11. Density of grain**

Volume of known weight of 100 grains was measured by the displacement of water using a measuring cylinder and calculated the density as weight by volume.

**12. Pest and Disease incidence**

Pest and disease incidence was scored using standard procedure as mentioned in 'Standard evaluation system' for rice (IRRI, 1995).

**13. Kernel length**

Kernel length of ten randomly selected healthy, fully dehusked grains from each plot was measured in mm using vernier calipers and mean values worked out.

**14. Kernel breadth**

Kernel breadth of the above ten randomly selected kernels from each plot was measured in mm by using a vernier calipers and mean values worked out.

**15. L/B ratio of kernel**

L/B ratio of kernel was found out from the mean values of kernel lengths and breadths.

**16. Hulling percentage**

Seeds collected from each plot were cleaned and dried to 14 per cent moisture content. The sample was parboiled by double steaming method and dried to 14 per cent moisture. Then the sample was dehulled using laboratory model satake rubber roller. Hulling percentage was calculated as follows (Arumugachamy *et al.*, 1995).

$$\text{Hulling percentage} = \frac{\text{Weight of dehulled grains}}{\text{Weight of paddy}} \times 100$$

**17. Milling percentage**

The dehulled paddy samples were milled for 30 seconds in a McGill miller.

$$\text{Milling percentage} = \frac{\text{Weight of milled paddy}}{\text{Weight of paddy}} \times 100$$

**18. Cooking quality**

Amylose content and alkali spreading value are important characters in determining the cooking quality of rice (Ghosh and Govindaswamy, 1972). Different cooking qualities like amylose content, alkali spreading value, water uptake, volume expansion ratio and kernel elongation ratio were studied.

**a) Amylose content**

100 mg parboiled milled rice was powdered. In this sample, one ml of distilled ethanol was added.10.0 ml of 1N NaOH was added to this and it was kept over night. The volume was made up to 100 ml. 2.5 ml of the extract was taken and added 20.0 ml of distilled water and three drops of phenolphthalein. Then 0.1 N HCl was added drop by drop until the pink colour just disappeared. To this 1.0 ml of iodine reagent was added and made up to 50 ml and the colour developed was read at 590 nm using spectrometer 0.2, 0.4, 0.6, 0.8 and 1.0 ml of standard amylose solution was taken and developed the colour as in the case of sample. Using the standard graph the amount of amylose present in the sample was calculated .One ml of iodine was taken and diluted to 50 ml for a blank (Sadasivam and Manickam, 1992).

Absorbance corresponds to 2.5 ml of the test solution = X mg amylose.

$$\text{100 ml extract} = \frac{X}{2.5} \times \text{100 mg /100 ml amylose} = \text{\% amylose}$$

Rice varieties are grouped on basis of their amylose contents into waxy (1-2% amylose), low amylose (8-19%), intermediate amylose (20-25%), or high amylose (>25%) (IRRI, 1972).

**b) Alkali spreading value**

Ten milled rice kernels were placed in 10.0 ml of 1.7 per cent KOH in shallow container (petriplate). The kernels were so arranged that they did not touch each other. They were allowed to stand for 23 hours at 30°C. The appearance and disintegration of the kernels were rated usually after incubation based on the following numerical scale (IRRI, 1980).

| Description | Score |
|---|---|
| Kernel not affected | 1 |
| Kernel swollen | 2 |
| Kernel swollen, collar incomplete or narrow | 3 |
| Kernel swollen, collar complete and wide | 4 |
| Kernel split or segmented; collar complete and wide | 5 |
| Kernel dispersed, merging with collar | 6 |
| Kernel completely dispersed and intermingled | 7 |

A rating of 1 to 2 was classified as high final gelatinization temperatures, 3 as high intermediate, 4 to 5 as intermediate (70-74°C); and 6 to 7 as low final gelatinization temperature (< 70°C).

**c) Water uptake**

Ten whole milled rice kernel per sample were used to study water absorption. Weight of the samples was recorded before and after cooking. Excess water was removed from the cooked grain with the help of blotting paper. The difference in weights divided by the weight of uncooked sample was taken as the amount of water absorbed per unit of rice (Sadananda *et al.*, 1987).

**d) Volume expansion ratio**

The volume of raw rice as well as cooked rice was determined by water displacement using a measuring cylinder (Onate and Del Mundo, 1966).

$$\text{Volume expansion ratio} = \frac{\text{Volume of cooked rice}}{\text{Volume of raw rice}}$$

**e) Kernel elongation ratio**

Kernel elongation was determined as described by Azeez and Shafi (1966). Ten raw and ten cooked kernels were taken at random and their length was measured.

$$\text{Kernel elongation ratio} = \frac{\text{Mean length of cooked kernel}}{\text{Mean length of raw kernel}}$$

### 3.1.3 Statistical analysis

The data were subjected to the following statistical analysis

The data obtained from three locations viz. Koyalmannam (location 1), Madakkathara (location 2) and Ernakulam (location 3) were subjected to location wise analysis of variance followed by stability analysis. Measures like means, variance, standard deviation, phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were calculated as per Snedecor (1946). Heritability, genetic advance (GA), genetic gain (GG), genotypic and phenotypic correlation, path analysis were carried out following methods compiled by Singh and Chaudhary (1985).

The model of Eberhart and Russell (1966) was used for stability analysis with eight varieties tested in three environments. For carrying out the various statistical analysis the software package SPAR 1 was used.

# Results

# 4. RESULTS

The present investigation was carried out in three locations namely Palghat, Thrissur and Ernakulam with eight treatments, which includes six cultures, one standard check and local Kunjukunju. Data of various observations on quantitative and qualitative parameters were subjected to statistical analysis both location wise and pooled analysis for variances, heritability, genetic advance, genetic gain, association of characters, direct and indirect effects. The stability analysis over three environments was also carried out. The results of this analysis are presented under various titles.

## 4.1 Genetic Variability

Results pertaining to analysis of variance of different characters of the eight rice genotypes in three locations Palghat, Thrissur and Ernakulam are presented in Table 3.

The results revealed that the eight genotypes differed significantly for most of the characters namely number of days to flowering, number of days to harvest, height of the plant, L/B ratio, hulling percentshr, milling percentage, volume expansion ratio, kernel elongation ratio, amylose content, alkali spreading value in case of Palghat, number of days to flowering, number of days to harvest, height of the plant, grain yield per hectare, straw yield per hectare, per plant yield, grain density, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, amylose content, alkali spreading value in case of Thrissur, number of days to flowering, number of days to harvest, height of the plant, number of spikelets per panicle, grain yield per hectare, straw yield per hectare, per plant yield, pest and disease incidence, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, kernel elongation ratio, amylose content, alkali spreading value incase of Ernakulam. For the characters number of tillers per plant, number of panicles per plant, water uptake, 100 grain weight there were no significant difference among the genotypes in all the three locations studied. In the experiments at Palghat only 10 characters were significantly

Table 3. Analysis of variance for grain yield and associated characters in Kunjukunju rice cultures for location Palghat, Thrissur and Ernakulam

| Characters | MSS of | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Genotype df = 7 | Replication df = 2 | Error df = 14 | Genotype df = 7 | Replication df = 2 | Error df = 14 | Genotype df = 7 | Replication df = 2 | Error df = 14 |
| | Palghat | | | Thrissur | | | Ernakulam | | |
| $X_1$ | 24.54** | 2.53 | 1.92 | 26.76** | 2.62 | 1.52 | 24.92** | 1.53 | 2.30 |
| $X_2$ | 24.54** | 2.54 | 1.92 | 29.9** | 5.79 | 2.02 | 25.71** | 1.62 | 2.30 |
| $X_3$ | 39.37** | 4.03 | 2.6 | 87.21** | 12.66 | 6.42 | 60.70** | 1.50 | 5.69 |
| $X_4$ | 1.00 | 2.35 | 2.88 | 5.2 | 1.11 | 2.42 | 1.41 | 3.00 | 0.81 |
| $X_5$ | 0.62 | 1.01 | 1.44 | 3.27 | 2.49 | 2.36 | 1.25 | 0.94 | 1.19 |
| $X_6$ | 79.04 | 15.78 | 51.36 | 97.99 | 63.28 | 44.24 | 500.92** | 55.53 | 51.73 |
| $X_7$ | 1574689.1* | 7898081.7 | 917810.43 | 1970002* | 20150134 | 642520 | 851986** | 117625 | 290501 |
| $X_8$ | 9617748.1 | 7879970.8 | 4318277.1 | 46998231* | 16995895 | 15504037 | 2572560.3* | 283073 | 900993.2 |
| $X_9$ | 3.6 | 18.07 | 2.08 | 5.75* | 36.21 | 2.01 | 1.95* | 0.27 | 0.66 |
| $X_{10}$ | 0.90 | 1.20 | 1.34 | 982.9 | 1509.4 | 574.9 | 4.55* | 3.66 | 1.51 |
| $X_{11}$ | 0.023 | 0.02 | 0.012 | 0.026 | 0.006 | 0.012 | 0.0072 | 0.0025 | 0.0055 |
| $X_{12}$ | 0.0058 | 0.0057 | 0.0035 | 0.0016** | 0.00024 | 0.00025 | 0.0040 | 0.0014 | 0.0017 |
| $X_{13}$ | 0.20** | 0.03 | 0.02 | 0.17** | 0.0043 | 0.013 | 0.15** | 0.0070 | 0.0094 |
| $X_{14}$ | 6.84** | 0.73 | 0.18 | 9.8** | 0.27 | 0.087 | 6.43** | 1.41 | 0.72 |
| $X_{15}$ | 9.97** | 0.20 | 0.64 | 12.14** | 0.55 | 0.27 | 9.8** | 0.64 | 0.30 |
| $X_{16}$ | 0.003 | 0.00045 | 0.002 | 0.0028 | 0.00055 | 0.0015 | 0.00087 | 0.000036 | 0.00085 |
| $X_{17}$ | 0.12** | 0.06 | 0.02 | 0.16** | 0.0089 | 0.013 | 0.26** | 0.011 | 0.049 |
| $X_{18}$ | 0.028** | 0.0036 | 0.0027 | 0.0085 | 0.0029 | 0.0036 | 0.0022** | 0.00010 | 0.000080 |
| $X_{19}$ | 15.27** | 0.23 | 0.49 | 11.98** | 1.03 | 1.30 | 13.62** | 0.16 | 1.11 |
| $X_{20}$ | 5.30** | 0.16 | 0.16 | 4.23** | 0.12 | 0.26 | 5.5** | 0.16 | 0.071 |

* - Significant at 0.05%; ** - Significant at 0.01%

$X_1$ = Number of days to 50 per cent flowering; $X_2$ = Number of days to harvest; $X_3$ = Height of the plant; $X_4$ = Number of tillers per plant; $X_5$ = Number of panicles per plant; $X_6$ = Number of spikelets per panicle; $X_7$ = Grain yield ha$^{-1}$; $X_8$ = Straw yield ha$^{-1}$; $X_9$ = Per plant yield; $X_{10}$ = Pest and disease incidence; $X_{11}$ = 100 grain weight; $X_{12}$ = Grain density; $X_{13}$ = L/B ratio; $X_{14}$ = Hulling percentage; $X_{15}$ = Milling percentage; $X_{16}$ = Water uptake; $X_{17}$ = Volume expansion ratio; $X_{18}$ = Kernel elongation ration; $X_{19}$ = Amylose content; $X_{20}$ = Alkali spreading value differed and the rest were non significant, whereas 13 characters in Thrissur and 15 characters in Ernakulam showed significant difference among genotypes.

The results revealed the presence of high amount of variability in differential levels in each location for many characters studied. There exists differential range of values for many characters in each location with respect to many of the traits studied. The range, mean and various estimates of genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), Genetic advance (GA), and Genetic gain (GG) in three locations are presented in the Tables 4 and 5.

**Number of days to flowering**

The mean number of days to 50 per cent flowering ranged from 80.33 to 89.00 in Palghat, 82.00 to 91.00 in Thrissur and 81.67 to 91.00 in Ernakulam with a mean of 84.91, 85.5 and 85.08 respectively for three locations. PCV values of 3.62, 3.69 and 3.69 were recorded for the three locations respectively and highest GCV of 3.39 recorded at Thrissur followed by 3.23 at Palghat and 3.23 at Ernakulam. Both PCV and GCV showing low values for the three locations indicating low amount of variability. But the high heritability values of 79.7 per cent, 84.6 per cent and 76.6 per cent in the three locations respectively indicating the less influence of environment on this particular character. But the lower values of genetic gain like 5.9 per cent, 6.4 per cent and 5.8 per cent respectively for three locations indicating the limited scope for further selection.

**Number of days to harvest**

The mean number of days to harvest ranged from 106.33 to 115 in Palghat, 108.00 to 117.00 in Thrissur and 107.67 to 117.00 in Ernakulam with a mean of 110.91, 111.33 and 111.00 respectively for three locations. The highest PCV of 3.02 at Thrissur followed by 2.87 at Ernakulam and the lowest of 2.77 at Palghat were recorded followed by same trend in case of GCV like 2.74, 2.51 and 2.48 for three locations respectively. Both the PCV and GCV showing low values for all the three

Table 4. Range (R) and Mean (M) values for grain yield and associated characters in Kunjukunju rice cultures in locations Palghat, Thrissur and Ernakulam

| Characters | Range (R) | | | Mean (M) | | |
|---|---|---|---|---|---|---|
| | Palghat | Thrissur | Ernakulam | Palghat | Thrissur | Ernakulam |
| $X_1$ | 80.33-89.00 | 82.00-91.00 | 81.67-91.00 | 84.91±1.13 | 85.5±1.00 | 85.08±1.20 |
| $X_2$ | 106.33-115.00 | 108.00-17.00 | 107.67-117.00 | 110.91±1.13 | 111.33±1.168 | 11.00±1.20 |
| $X_3$ | 90.67-99.33 | 80.00-94.67 | 80.33-93.67 | 94.73±1.13 | 87.91±2.07 | 86.37±1.94 |
| $X_4$ | 8.03-9.77 | 7.23-11.50 | 4.4-6.5 | 8.69±1.38 | 8.41±1.27 | 5.32±0.73 |
| $X_5$ | 6.3-7.6 | 6.17-9.30 | 3.1-4.87 | 7. 14±0.98 | 7.30±1.25 | 4.10±0.89 |
| $X_6$ | 98-113 | 92.67-110.00 | 80.67-104.33 | 103.5±5.8 | 98.20±5.43 | 86.08±5.87 |
| $X_7$ | 7714-9956 | 6509.67-8548.60 | 2809-4237 | 8375.7±782 | 7727.27±654 | 3508.9±440 |
| $X_8$ | 14728-19223 | 16460-27167 | 4473-7507 | 16933±12 | 20733.7±321 | 5640.9±775 |
| $X_9$ | 11.66-15.06 | 9.86-12.95 | 4.2-6.4 | 12.67±1.17 | 1185±1.15 | 5.31±0.66 |
| $X_{10}$ | 1.13-2.74 | 1.26-48.33 | 1.76-5.46 | 1.92±0.95 | 19.30±19.5 | 2.57±1.00 |
| $X_{11}$ | 2.38-2.63 | 2.35-2.58 | 2.44-2.61 | 2.48±0.09 | 2.44±0.09 | 2.53±0.06 |
| $X_{12}$ | 0.85-0.99 | 0.89-0.95 | 0.86-0.97 | 0.92±0.04 | 0.92±0.013 | 0.91±0.03 |
| $X_{13}$ | 2.24-3.06 | 2.30-3.03 | 2.29-2.99 | 2.49±0.12 | 2.53±0.09 | 2.54±0.07 |
| $X_{14}$ | 73.66-78.16 | 72.92-78.66 | 74.44-78.49 | 75.34±0.35 | 75.45±0.23 | 75.87±0.69 |
| $X_{15}$ | 63.94-68.95 | 63.13-69.04 | 63.05-68.35 | 65.42±0.65 | 65.16±0.42 | 64.87±0.45 |
| $X_{16}$ | 0.58-0.67 | 0.61-0.68 | 0.60-0.65 | 0.62±0.036 | 0.64±0.031 | 0.62±0.02 |
| $X_{17}$ | 4.25-4.93 | 4.33-5.05 | 4.14-4.90 | 4.43±0.12 | 4.48±0.09 | 4.39±0.18 |
| $X_{18}$ | 1.37-1.61 | 1.31-1.5 | 1.32-1.40 | 114.33±0.04 | 1.38±0.04 | 1.37±0.07 |
| $X_{19}$ | 22.86-29.38 | 24.53-29.10 | 22.63-28.40 | 25.77±0.57 | 25.99±0.93 | 25.82±0.86 |
| $X_{20}$ | 2.33-6.67 | 2.67-7.00 | 2.00-6.67 | 4.45±0.36 | 4.58±0.35 | 4.45±0.30 |

$X_1$ = Number of days to 50 per cent flowering; $X_2$ = Number of days to harvest; $X_3$ = Height of the plant; $X_4$ = Number of tillers per plant; $X_5$ = Number of panicles per plant; $X_6$ = Number of spikelets per panicle; $X_7$ = Grain yield $ha^{-1}$; $X_8$ = Straw yield $ha^{-1}$; $X_9$ = Per plant yield; $X_{10}$ = Pest and disease incidence; $X_{11}$ = 100 grain weight; $X_{12}$ = Grain density; $X_{13}$ = L/B ratio; $X_{14}$ = Hulling percentage; $X_{15}$ = Milling percentage; $X_{16}$ = Water uptake; $X_{17}$ = Volume expansion ratio; $X_{18}$ = Kernel elongation ration; $X_{19}$ = Amylose content; $X_{20}$ = Alkali spreading value

Table 5. Estimation of genetic parameters for grain yield and associated quantitative and qualitative characters in Kunjukunju rice cultures in locations Palghat, Thrissur and Ernakulam.

| Characters | PCV | | | GCV | | | Heritability % | | | Genetic advance (GA) | | | Genetic gain (GG) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| $X_1$ | 3.62 | 3.69 | 3.69 | 3.23 | 3.39 | 3.23 | 79.7 | 84.6 | 76.6 | 5.05 | 5.50 | 4.95 | 5.9 | 6.4 | 5.8 |
| $X_2$ | 2.77 | 3.02 | 2.87 | 2.48 | 2.74 | 2.51 | 79.7 | 82.1 | 76.9 | 5.05 | 5.69 | 5.04 | 4.5 | 50.2 | 4.5 |
| $X_3$ | 4.08 | 6.57 | 5.68 | 3.69 | 5.90 | 4.96 | 82.1 | 80.7 | 76.3 | 6.53 | 9.60 | 7.71 | 6.8 | 10.9 | 8.9 |
| $X_4$ | 19.53 | 21.83 | 18.95 | 0.36 | 11.57 | 8.42 | 0.0 | 28.1 | 19.7 | 0.00 | 1.60 | 0.41 | 0 | 19.0 | 7.7 |
| $X_5$ | 16.83 | 22.36 | 26.81 | 0.44 | 7.54 | 3.63 | 0.1 | 11.4 | 1.8 | 0.00 | 0.38 | 0.04 | 0 | 5.2 | 0.9 |
| $X_6$ | 7.52 | 8.03 | 16.49 | 2.93 | 4.31 | 14.21 | 15.2 | 22.8 | 74.3 | 2.44 | 4.68 | 21.73 | 2.3 | 4.7 | 25.24 |
| $X_7$ | 12.73 | 13.48 | 19.70 | 5.59 | 8.61 | 12.33 | 19.3 | 40.8 | 39.2 | 423.06 | 875.1 | 557.8 | 5.05 | 11.3 | 15.8 |
| $X_8$ | 14.57 | 24.59 | 21.41 | 7.85 | 15.63 | 13.23 | 29.0 | 40.4 | 38.2 | 1475.2 | 4241 | 950.8 | 8.7 | 20.44 | 16.85 |
| $X_9$ | 12.73 | 15.24 | 19.70 | 5.67 | 9.42 | 12.35 | 19.8 | 38.2 | 39.3 | 0.66 | 1.42 | 0.85 | 5.2 | 3.54 | 16.00 |
| $X_{10}$ | 60.32 | 138.09 | 61.69 | 1.64 | 60.40 | 38.93 | 0.1 | 19.1 | 39.8 | 0.00 | 10.51 | 1.30 | 0 | 54.4 | 50.58 |
| $X_{11}$ | 5.08 | 5.33 | 3.09 | 2.43 | 2.83 | 0.95 | 22.8 | 28.2 | 9.5 | 0.06 | 0.08 | 0.02 | 2.4 | 3.27 | 0.79 |
| $X_{12}$ | 7.10 | 2.92 | 5.49 | 2.97 | 2.35 | 3.03 | 17.4 | 65.0 | 30.5 | 0.02 | 0.04 | 0.03 | 2.1 | 4.3 | 3.29 |
| $X_{13}$ | 11.65 | 10.34 | 9.46 | 9.99 | 9.25 | 8.65 | 73.5 | 80.0 | 83.7 | 0.44 | 0.43 | 0.41 | 17.6 | 16.9 | 16.1 |
| $X_{14}$ | 2.06 | 2.43 | 2.14 | 1.98 | 2.40 | 1.82 | 92.2 | 97.4 | 72.4 | 2.95 | 3.67 | 2.42 | 3.91 | 4.8 | 3.1 |
| $X_{15}$ | 2.96 | 3.16 | 2.88 | 2.70 | 3.05 | 2.75 | 82.9 | 93.5 | 91.3 | 3.31 | 3.96 | 3.51 | 5.05 | 6.0 | 5.4 |
| $X_{16}$ | 7.82 | 6.84 | 4.71 | 2.98 | 3.28 | 0.38 | 14.5 | 23.0 | 0.7 | 0.01 | 0.02 | 0.00 | 1.61 | 3.1 | 0 |
| $X_{17}$ | 5.44 | 5.64 | 7.93 | 4.24 | 5.03 | 6.10 | 60.8 | 79.6 | 59.2 | 0.30 | 0.41 | 0.43 | 6.77 | 9.1 | 9.7 |
| $X_{18}$ | 7.45 | 5.26 | 2.08 | 6.50 | 2.91 | 1.98 | 76.0 | 30.7 | 90 | 0.17 | 0.05 | 0.05 | 11.8 | 3.6 | 3.6 |
| $X_{19}$ | 9.03 | 8.48 | 8.91 | 8.61 | 7.26 | 7.91 | 90.8 | 73.2 | 78.8 | 4.36 | 3.33 | 3.74 | 16.9 | 12.8 | 14 |
| $X_{20}$ | 31.48 | 32.20 | 35.25 | 29.87 | 30.81 | 34.26 | 91.1 | 91.5 | 94.5 | 2.61 | 2.78 | 3.06 | 58.65 | 60.6 | 68 |

$X_1$ = Number of days to 50 per cent flowering; $X_2$ = Number of days to harvest; $X_3$ = Height of the plant; $X_4$ = Number of tillers per plant; $X_5$ = Number of panicles per plant; $X_6$ = Number of spikelets per panicle; $X_7$ = Grain yield $ha^{-1}$; $X_8$ = Straw yield $ha^{-1}$; $X_9$ = Per plant yield; $X_{10}$ = Pest and disease incidence; $X_{11}$ = 100 grain weight; $X_{12}$ = Grain density; $X_{13}$ = L/B ratio; $X_{14}$ = Hulling percentage; $X_{15}$ = Milling percentage; $X_{16}$ = Water uptake; $X_{17}$ = Volume expansion ratio; $X_{18}$ = Kernel elongation ration; $X_{19}$ = Amylose content; $X_{20}$ = Alkali spreading value locations indicating the low variability. But a high amount of heritability for all the three locations indicated a predominant genotype influence for this character. Genetic advance of 5.05, 5.04 and 5.69 days and genetic gain of 4.5 per cent, 50.2 per cent and 4.5 per cent in three locations indicated the lower scope for further selection.

**Height of the plant**

The mean height of the plant ranged from 99.33 cm to 90.67cm in Palghat, 80.00 cm to 94.67 cm in Thrissur and 80.33 cm to 93.67 cm in Ernakulam with mean of 94.70 cm, 87.91 cm and 86.37 cm respectively for three locations. The PCV values of 4.08 at Palghat, 6.57 at Thrissur, 5.68 at Ernakulam with a corresponding trend of GCV like 3.69, 5.90 and 4.96 respectively for three locations showing that variability of the character was comparatively higher in Thrissur both at phenotypic and genotypic level. Broad sense heritability at Palghat 82.1 per cent, 80.7 per cent at Thrissur and 76.3 per cent at Ernakulam indicating that this character is genetically controlled irrespective of environment. The extent of variability and further scope of exploitation of the genotypes for improving the character among the treatments is meagre as reflected in the values of genetic advance 6.80 cm, 10.90 cm and 8.90 cm respectively for three locations.

**Number of tillers per plant**

The mean number of tillers per plant ranged from 8.03 to 9.77 in Palghat, 7.23 to 11.50 in Thrissur and 4.40 to 6.50 in Ernakulam with mean of 8.69, 8.41 and 5.32 respectively for three locations. Highest PCV of 21.83 at Thrissur followed by 19.53 at Palghat and lowest of 18.95 at Ernakulam were recorded. But highest GCV of 11.57 was recorded at Thrissur followed by Ernakulam with GCV of 8.42 and the lowest GCV of 0.36 was recorded at Palghat for this particular character. PCV and GCV values indicating comparatively high amount of variability in Thrissur both at phenotypic and genotypic levels and the least amount of genotypic variability in Palghat. Low heritability values of nil, 28.10 per cent, 19.70 per cent for three locations respectively indicating the predominant environment influence for this character. Highest genetic gain of 19.00 per cent at Thrissur followed by 7.70 per cent at Ernakulam and no genetic gain at Palghat were recorded. These low values of heritability and genetic gain indicating the limited scope for further selection.

**Number of panicles per plant**

The mean number of panicles per plant ranged from 6.30 to 7.60 in Palghat, 6.17 to 9.30 in Thrissur and 3.10 to 4.87 in Ernakulam with mean of 7.14, 7.30 and 4.10 respectively for three locations. Highest PCV of 26.81 at Ernakulam followed by 22.36 at Thrissur and lowest of 16.83 at Palghat were recorded. GCV values of 0.44, 7.54 and 3.63 were recorded for three locations respectively. These values indicating the variability for this character was higher in Ernakulam at phenotypic level but at genotypic level higher variability was recorded in Thrissur. But a low amount of heritability for all the three locations like 0.10 per cent, 11.40 per cent and 1.80 per cent respectively indicating that this character was mainly influenced by environment. This was clearly indicated the limited scope for selection for improving this character. This was also supported by lower values of genetic gain as nil, 5.20 per cent and 0.90 per cent for the three locations respectively.

**Number of spikelets per panicle**

The mean number of spikelets per panicle ranged from 98.00 to 113.00 in Palghat, 92.67 to 110.00 in Thrissur and 80.67 to 104.33 in Ernakulam with a mean of 103.50, 98.20 and 86.08 respectively for three locations. The highest PCV of 16.49 at Ernakulam followed by 8.03 at Thrissur and the lowest of 7.52 at Palghat were recorded followed by same trend in case of GCV like 14.21, 4.31 and 2.93 at Ernakulam, Thrissur and Palghat respectively. These values showed the high amount of variability in Palghat for this character both at phenotypic and genotypic level. A Broadsense heritability value of 15.20 per cent at Palghat, 28.80 per cent at Thrissur and 74.30 per cent at Ernakulam showing highest heritability for this character was at Ernakulam indicating the less influence of environment. Genetic gain values of 2.30 per cent, 4.70 per cent and 25.24 per cent for the three locations respectively indicating the limited scope for selection.

**Grain yield per hectare**

The mean values of grain yield per hectare ranged from 7714.00 kg $ha^{-1}$ to 9956.00 kg $ha^{-1}$ in Palghat, 6509.67 kg $ha^{-1}$ to 8548.60 kg $ha^{-1}$ in Thrissur and 2809.00 kg $ha^{-1}$ to 4237.00 kg $ha^{-1}$ in Ernakulam with a mean of 8375.70 kg $ha^{-1}$, 7727.70 kg $ha^{-1}$ and 3508.90 kg $ha^{-1}$ respectively for three locations. These values showing that highest yield was recorded at Palghat followed by Thrissur and lowest at Ernakulam. Highest PCV and GCV values of 19.70 and 12.33 were recorded at Ernakualm indicating the high amount of variability for this character at Ernakulam followed by Thrissur with PCV and GCV of 13.48, 8.61 and lowest PCV, GCV values of 12.73, 5.59 were recorded at Palghat indicating the low variability for this character at this location. But a low amount of heritability values like 19.30 per cent, 40.80 per cent and 39.20 per cent for the three locations respectively indicating a limited genotypic influence for this character. Lower values of genetic gain like 5.05 per cent, 11.30 per cent and 15.85 per cent for the three locations respectively showing the limited scope for the further selection.

**Straw yield per hectare**

The mean straw yield values per hectare ranged from 14728.00 kg $ha^{-1}$ to 19223.00 kg $ha^{-1}$ in Palghat, 16460.00 kg $ha^{-1}$ to 27167.00 kg $ha^{-1}$ in Thrissur and 4473.00 kg $ha^{-1}$ to 7507.00 kg $ha^{-1}$ in Ernakulam with mean values of 16933.00 kg $ha^{-1}$, 20733.70 kg $ha^{-1}$ and 5640.00 kg $ha^{-1}$ respectively for three locations. These values indicating the highest yield was recorded at Thrissur followed by Palghat and the lowest at Ernakulam. The highest PCV and GCV of 24.57 and 15.63 at Thrissur followed by 21.41 and 13.23 at Ernakulam and the lowest of 14.57 and 7.85 at Palghat were recorded. Both PCV and GCV values indicating the low amount of variability but among them highest variability recorded in Thrissur both at phenotypic and genotypic level. Broad sense heritability values of 29.00 per cent, 40.40 per cent and 38.20 per cent for the three locations respectively indicating the major influence of environment on this particular character. A low genetic gain values of 8.70 per cent, 20.40 per cent and 16.80 per cent for all the locations respectively and low heritability values showing the limited scope for the utilization of variability of the genotypes for improving the character through selection.

**Per plant yield**

The mean values of this character ranged from 11.66 g to 15.08 g in Palghat, 9.86 g to 12.95 g in Thrissur and 4.20 g to 6.40 g in Ernakulam with a mean values of 12.67 g,11.85 g and 5.31 g respectively for three locations. The highest PCV of 19.70 was recorded at Ernakulam followed by Thrissur with a PCV of 15.24 and lowest of 12.73 at Palghat. The same trends were followed incase of GCV also. Heritabilitiy values of 19.80 per cent, 38.20 per cent and 39.30 per cent respectively for the three locations indicating the low heritability of this character. A genetic advance of 0.66 g, 0.85 g and 1.42 g and a genetic gain of 5.20 per cent, 3.54 per cent and 16.00 per cent indicated the lower scope for further selection.

**Pest and disease incidence**

The mean values for pest and disease incidence ranged from 1.13 per cent to 2.74 per cent in Palghat, 1.26 per cent to 48.33 per cent in Thrissur and 1.76 per cent to 5.46 per cent in Ernakulam with mean values of 1.92 per cent, 19.30 per cent and 2.57 per cent respectively for three locations. The highest PCV of 138.09 at Thrissur followed by 61.69 at Ernakulam and the lowest of 60.32 at Palghat were recorded. The same trend in case of GCV was followed with 60.40 at Thrissur, 38.93 at Ernakulam and 1.64 at Palghat. Both PCV and GCV values showing higher values for this character at Thrissur compared with other locations indicating the high amount of variability among the treatments. But a low amount of heritability among the treatments like 0.10 per cent, 19.10 per cent and 39.80 per cent for the three locations respectively indicating the limited genotypic influence for this character. The extent of variability, scope of exploitation of the genotypes for improving the character among the treatments was high at Ernakulam.

**100 Grain weight**

The mean 100 grain weight values ranged from 2.38 g to 2.63 g in Palghat, 2.35 g to 2.58 g in Thrissur and 2.44 g to 2.61 g in Ernakulam with mean values of 2.48 g, 2.44 g and 2.53 g respectively for three locations. The PCV values of 5.08, 5.33 and 3.09, and GCV values of 2.43, 2.83 and 0.95 respectively for the three locations showing that the presence of low amount of variability among the treatments for this particular character. Low heritability values of 22.80 per cent, 28.20 per cent and 9.50 per cent indicated the high effect of environment on this character. These low heritability values were showing the limited scope for selection, which was supported by the low values of genetic gain like 2.40 per cent, 3.27 per cent and 0.79 per cent respectively for three locations.

**Density**

The mean values of density ranged from 0.85 g $cc^{-1}$ to 0.99 g $cc^{-1}$ in Palghat, 0.89 g $cc^{-1}$ to 0.95 g $cc^{-1}$ in Thrissur and 0.86 g $cc^{-1}$ to 0.97 g $cc^{-1}$ in Ernakulam with a mean of 0.92 g $cc^{-1}$, 0.92 g $cc^{-1}$ and 0.91 g $cc^{-1}$ respectively for three locations. The PCV values of 7.10, 2.92 and 5.49, and GCV values of 2.97, 2.35 and 3.03 for this character indicating lower amount of variability among the treatments. This limited extent of variability showing low scope for further selection. This was supported by low values of genetic gain as 2.10 per cent, 4.30 per cent and 3.29 per cent and low heritability values like 17.40 per cent, 65.00 per cent and 30.50 per cent respectively for the three locations.

**L/B ratio**

The mean L/B ratio values ranged from 2.24 to 3.06 in Palghat, 2.30 to 3.03 in Thrissur and 2.29 to 2.99 in Ernakulam with a mean of 2.49, 2.53 and 2.54 respectively for the three locations. The highest PCV of 11.65 and GCV of 9.99 were recorded at Palghat followed by PCV of 10.34 and GCV of 9.25 at Thrissur and the lowest PCV and GCV of 9.46 and 8.65 were recorded at Ernakulam. These values showed the low amount of variability. But the high values of heritability for this character as 73.50 per cent, 80.00 per cent and 83.70 per cent respectively for three locations indicating the predominant genotypic influence on this character. A genetic gain of 17.60 per cent, 16.90 per cent and 16.10 per cent indicating the limited scope for the further selection.

**Hulling percentage**

The mean values of hulling percentage ranged from 73.66 per cent to 78.16 per cent in Palghat, 72.92 per cent to 78.66 per cent in Thrissur and 74.44 per cent to 78.49 per cent in Ernakulam with a mean of 75.34 per cent, 75.45 per cent and 75.87 per cent respectively for three locations. Low PCV values of 2.06, 2.43 and 2.11 were recorded for the three locations respectively. The same trend of low GCV values of 1.98, 2.4 and 1.82 indicating the lower amount of variability. But a high amount of heritability for all the three locations like 92.20 per cent, 97.00 per cent and 72.40 per cent indicating a predominant genotypic influence for this character. A genetic advance of 2.95 per cent, 2.42 per cent and 3.67 per cent and genetic gain of 3.91 per cent, 4.80 per cent and 3.10 per cent respectively for the three locations indicating the limited scope for further selection.

**Milling percentage**

The mean values of milling percentage ranged from 63.94 per cent to 68.95 per cent in Palghat, 63.13 per cent to 69.00 per cent in Thrissur and 63.05 per cent to 68.35 per cent in Ernakulam with a mean of 65.42 per cent, 65.16 per cent and 64.87 per cent respectively for three locations. Comparatively higher PCV of 3.16 recorded at Thrissur followed by 2.96 at Palghat and the lowest PCV of 2.88 at Ernakulam were recorded. In case of GCV highest was recorded at Thrissur (3.05) followed by Ernakulam (2.75) and lowest was recorded at Palghat (2.70). These low values of PCVand GCV indicating the lower amount of variability. But the high heritability values of 82.90 per cent, 93.50 per cent and 91.30 per cent respectively for three locations indicating less influence of environment on this particular character. But the low values of genetic gain like 5.05 per cent, 6.00 per cent and 5.40 per cent respectively for three locations indicating the limited scope for further improvement of these genotypes through selection.

**Water uptake**

The mean values of water uptake ranged from 0.58 to 0.67 in Palghat, 0.61 to 0.68 in Thrissur and 0.60 to 0.65 in Ernakulam with a mean of 0.62, 0.64 and 0.62 respectively for three locations. Highest PCV of 7.82 at Palghat followed by 6.84 at Thrissur and the lowest of 4.71 at Ernakulam were recorded where as the highest GCV of 3.28 at Thrissur followed by 2.98 at Palghat and the lowest of 0.38 at Ernakulam were recorded. Both lower values of PCV and GCV indicating the lower amount of variability for this character. At the same time low values of heritability and genetic gain indicating the limited scope for further selection.

**Volume expansion ratio**

The mean values of volume expansion ratio ranged from 4.25 to 4.93 in Palghat, 4.33 to 5.05 in Thrissur and 4.14 to 4.90 in Ernakulam with a mean of 4.43, 4.48 and 4.39 respectively for three locations. Highest PCV and GCV values of 7.93 and 6.10 were recorded at Ernakulam followed by 5.64 and 5.03 at Thrissur and the lowest PCV and GCV of 5.44 and 4.24 were recorded at Palghat. But PCV and GCV showing low values for all the three locations indicating the low variability. But medium to high amount of heritabiltiy values indicating a slight dominant genotypic influence for this character. A genetic advance of 0.30, 0.41 and 0.43 respectively for three locations indicating the limited scope for further selection.

**Kernel elongation ratio**

The mean values of Kernel elongation ratio ranged from 1.37 to 1.61 in Palghat, 1.31 to 1.50 in Thrissur and 1.32 to 1.40 in Ernakulam with a mean of 1.43, 1.38 and 1.37 for three locations respectively. PCV values of 7.45, 5.26 and 2.08 were recorded respectively for three locations, followed by same trend of GCV values of

6.50, 2.91 and 1.98 for three locations indicating the low amount of variability. Highest heritability of 90 per cent at Ernakulam followed by Palghat (76%) indicating predominant genetic influence for this character but in Thrissur low heritability values of 30.70 per cent indicating the high influence of environment. A genetic advance of 0.17, 0.05 and 0.05 and a genetic gain of 11.85 per cent, 3.60 per cent and 3.60 per cent for the three locations respectively indicating the limited scope for further selection.

**Amylose content**

The mean values of amylose content ranged from 22.86 to 29.38 in Palghat, 24.53 to 29.10 in Thrissur and 22.63 to 28.40 in Ernakulam with a mean of 25.77, 25.99 and 25.82 respectively for three locations. Highest PCV of 9.03 at Palghat followed by 8.91 at Ernakulam and the lowest of 8.48 at Thrissur were recorded. GCV values of 8.61, 7.91 and 7.26 followed same trend as PCV. Low values of both PCV and GCV indicating the lower amount of variability for this character. But higher values of heritability as 90.80 per cent, 73.20 per cent and 78.80 per cent respectively for three locations indicating the less influence of environment. A genetic gain of 16.95 per cent, 12.80 per cent and 14.00 per cent for the three locations respectively indicating the limited scope for further selection.

**Alkali spreading value**

The mean values of this character ranged from 2.33 to 6.67 in Palghat, 2.67 to 7.00 in Thrissur and 2.00 to 6.67 in Ernakulam with mean of 4.45, 4.58 and 4.45 respectively for three locations. Highest PCV of 35.25 at Ernakulam followed by Thrissur (32.20) and the lowest of 31.48 were recorded followed by same trend of GCV values of 29.87, 30.81 and 34.26 respectively for three locations. But high heritability values as 91.10 per cent, 91.50 per cent and 94.50 per cent along with high genetic gain values indicating the less influence of environment on this character and considerable scope for further selection.

## 4.2 Association of characters

In order to have an insight in the variation of expression of characters among the genotypes in relation to the fluctuations of environment, a study of the association of characters in each location has been conducted. The association of characters both at phenotypic and genotypic level has been estimated location wise in Tables 6, 7 and 8. For calculating the genotypic correlation, between yield and its attributes and among themselves only characters having the significant differences have been taken for analysis. At Palghat 11 characters namely number of days to 50 per cent flowering, number of days to harvest, height of the plant, grain yield per hectare, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, kernel elongation ratio, amylose content and alkali spreading value which significantly differed among genotypes were used for computing genotypic correlation. Among the yield attributes four characters namely hulling percentage (1.354), milling percentage (1.253), kernel elongation ratio (1.072) and alkali spreading value (0.897) were positively associated to grain yield. Number of days to flowering (-0.803), number of days to harvest (-0.803), height of the plant (-0.735), L/B ratio (-0.932), volume expansion ratio (-0.371) and amylose content (-0.915) were negatively associated to grain yield. Comparatively low significant positive correlations such as hulling percentage (0.533), milling percentage (0.533), kernel elongation ratio (0.461) and alkali spreading value (0.388) and negative correlations such as number of days to flowering (-0.371), number of days to harvest (-0.371), L/B ratio (-0.571), volume expansion ratio (-0.23) amylose content (-0.38) were noticed at phenotypic level with yield and its components. Here after correlations denote the genotypic correlations.

Height of the plant was positively correlated with characters like L/B ratio (0.629), volume expansion ratio (0.667) and amylose content (0.47). Hulling percentage (-0.225), kernel elongation ratio (-0.515) were negatively associated to height of the plant.

Table 6. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in Kunjukunju rice cultures

Palghat

| Sl. No. | Characters | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of days to flowering (X1) | 1 | 1 | 0.392 | -0.803** | 0.464* | -0.619** | -0.644** | 0.541* | -0.45* | 0.436 | -0.12 |
| 2 | Number of days to harvest (X2) | 1 | 1 | 0.392 | -0.803** | 0.464* | -0.618** | -0.643** | 0.541* | -0.45* | 0.436 | -0.12 |
| 3 | Height of the plant (X3) | 0.293 | 0.293 | 1 | -0.735** | 0.629** | -0.225 | 0.019 | 0.667** | -0.515* | 0.47* | 0.008 |
| 4 | Grain yield (X4) | -0.371 | -0.371 | -0.107 | 1 | -0.932** | 1.354** | 1.253** | -0.371 | 1.072** | -0.915** | 0.897** |
| 5 | L/B ratio (X5) | 0.407 | 0.407 | 0.386 | -0.571** | 1 | -0.653** | -0.488* | 0.934** | -0.583** | 0.694** | -0.37 |
| 6 | Hulling% (X6) | -0.537* | -0.537* | -0.169 | 0.533* | -0.569** | 1 | 0.927** | -0.247 | 0.234 | -0.458* | 0.407* |
| 7 | Milling% (X7) | -0.492* | -0.492* | 0 | 0.533* | -0.47* | 0.864** | 1 | -0.148 | 0.248 | -0.253 | 0.295 |
| 8 | Volume expansion ratio (X8) | 0.485* | 0.485* | 0.432* | -0.23 | 0.637** | -0.278 | -0.091 | 1 | -0.377 | 0.464* | -0.17 |
| 9 | Kernel elongation ratio (X9) | -0.316 | -0.316 | -0.388 | 0.461* | -0.471* | 0.243 | 0.261 | -0.278 | 1 | -0.735** | 0.372 |
| 10 | Amylose content (X10) | 0.395 | 0.395 | 0.351 | -0.38 | 0.615** | -0.408 | -0.198 | 0.326 | -0.598** | 1 | -0.23 |
| 11 | Alkali spreading value (X11) | -0.087 | -0.087 | 0 | 0.338 | -0.235 | 0.387 | 0.201 | -0.189 | 0.309 | -0.213 | 1 |

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 7. Genotypic (upper diagonal ) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in Kunjukunju rice cultures

Thrissur

| Sl. No. | Characters | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of days to flowering (X1) | 1 | 1.001** | 0.534* | -0.141 | 0.317 | 0.166 | -0.067 | -0.074 | 0.652** | -0.621** | -0.397 | 0.864** | 0.825** |
| 2 | Number of days to harvest (X2) | 0.971** | 1 | 0.55* | -0.045 | 0.389 | 0.235 | 0.07 | 0.035 | 0.607** | -0.582** | -0.322 | 0.845** | 0.832** |
| 3 | Height of the plant (X3) | 0.401 | 0.403 | 1 | 0.396 | 0.722** | 0.594** | 0.889** | 0.254 | 0.676** | -0.442 | -0.361 | 0.732** | 0.267 |
| 4 | Grain yield (X4) | -0.205 | -0.154 | 0.295 | 1 | 0.603** | 0.994** | 0.48* | 0.769** | 0.012 | 0.796** | 0.922** | 0.223 | -0.121 |
| 5 | Straw yield (X5) | 0.29 | 0.313 | 0.377 | 0.438 | 1 | 0.748** | 0.232 | 1.103** | 0.645** | -0.127 | 0.11 | 0.855** | 0.149 |
| 6 | Perplant yield (X6) | 0.083 | 0.129 | 0.382 | 0.851** | 0.725** | 1 | 0.294 | 0.773** | 0.463* | 0.541* | 0.697** | 0.65** | 0.174 |
| 7 | Density (X7) | -0.126 | -0.109 | 0.506* | 0.337 | 0.298 | 0.256 | 1 | 0.759** | -0.163 | -0.26 | -0.022 | -0.022 | -0.294 |
| 8 | L/B ratio (X8) | -0.054 | 0.015 | 0.242 | 0.369 | 0.599** | 0.467* | 0.187 | 1 | 0.012 | 0.117 | 0.401 | 0.256 | -0.353 |
| 9 | Hulling % (X9) | 0.45 | 0.435 | 0.593 | 0.066 | 0.3 | 0.268 | 0.004 | -0.066 | 1 | -0.372 | -0.417 | 0.947** | 0.705** |
| 10 | Milling % (X10) | -0.585** | -0.534* | -0.335 | 0.516* | -0.099 | 0.35 | -0.083 | 0.098 | -0.289 | 1 | 0.904** | -0.41 | -0.272 |
| 11 | Volume expansion ratio (X11) | -0.321 | -0.23 | -0.34 | 0.536* | 0.138 | 0.45* | -0.085 | 0.387 | -0.41 | 0.85 | 1 | -0.275 | -0.19 |
| 12 | Amylose content (X12) | 0.728** | 0.718** | 0.484* | 0.054 | 0.492* | 0.374 | -0.098 | 0.162 | 0.699 | -0.39 | -0.196 | 1 | 0.666** |
| 13 | Alkali spreading value (X13) | 0.668** | 0.667** | 0.202 | -0.19 | -0.092 | 0.011 | -0.318 | -0.24 | 0.58* | -0.207 | -0.171 | 0.586** | 1 |

* - Significant at 5 per cent level

** - Significant at 1 per cent level

Table 8. Genotypic (upper diagonal) and phenotypic (lower diagonal) correlation coefficients between yield and yield characters in Kunjukunju rice cultures

Ernakulam

| Sl. No. | Characters | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Number of days to flowering (X1) | 1 | 1 | 0.68** | -0.973** | -0.172 | -0.131 | -0.172 | 1.016** | 0.882** | -0.639** | -0.458* | 0.727** | -0.839** | 0.63** | -0.155 |
| 2 | Number of days to harvest (X2) | 0.997** | 1 | 0.68** | -0.966** | -0.127 | -0.102 | -0.127 | 1.002** | 0.862** | -0.595** | -0.418 | 0.731** | -0.823** | 0.629** | -0.165 |
| 3 | Height of the plant (X3) | 0.446* | 0.451* | 1 | -0.805** | -0.018 | -0.401 | -0.019 | 0.789** | 0.657** | -0.269 | -0.207 | 0.648** | -0.688** | 0.637** | -0.488* |
| 4 | Number of spikelets (X4) | -0.662** | -0.647** | -0.726** | 1 | 0.494* | 0.62** | 0.494* | -0.981** | -0.886** | 0.594** | 0.556* | -0.594** | 0.845** | -0.81** | 0.024 |
| 5 | Grain yield (X5) | -0.103 | -0.062 | 0.04 | 0.209 | 1 | 0.83** | 1 | -0.035 | -0.55* | 0.901** | 1.174** | 0.271 | 0.468* | -0.059 | -0.449* |
| 6 | Straw yield (X6) | -0.109 | -0.09 | -0.234 | 0.263 | 0.703** | 1 | 0.83** | -0.027 | -0.267 | 0.648** | 1.027** | 0.31 | 0.224 | -0.356 | 0.118 |
| 7 | Perplant yield (X7) | -0.103 | -0.063 | 0.039 | 0.21 | 1 | 0.704** | 1 | -0.035 | -0.55* | 0.901** | 1.173** | 0.271 | 0.468* | -0.059 | -0.448* |
| 8 | pest and disease incidence (X8) | 0.626** | 0.616** | 0.333 | -0.497* | -0.267 | 0.054 | -0.267 | 1 | 0.951** | -0.812** | -0.402 | 1.33** | -0.936** | 0.831** | -0.231 |
| 9 | L/B ratio (X9) | 0.681** | 0.671** | 0.436 | -0.628** | -0.323 | -0.157 | -0.323 | 0.555* | 1 | -0.68** | -0.648** | 0.53 | -1.025** | 0.201 | 0.154 |
| 10 | Hulling % (X10) | -0.575** | -0.575** | -0.139 | 0.29 | 0.36 | 0.325 | 0.36 | -0.353 | -0.558* | 1 | 0.87** | -0.47 | 0.652** | -0.183 | 0.232 |
| 11 | Milling % (X11) | -0.382 | -0.351 | -0.143 | 0.497* | 0.672** | 0.536* | 0.672** | -0.234 | -0.531* | 0.748** | 1 | -0.03 | 0.586** | -0.145 | -0.169 |
| 12 | Volume expansion ratio (X12) | 0.449* | 0.461* | 0.614** | -0.367 | 0.114 | -0.079 | 0.113 | 0.343 | 0.355 | -0.355 | 0.058 | 1 | -0.564** | 0.504* | -0.643** |
| 13 | Kernel elongation ratio (X13) | -0.694** | -0.672** | -0.532* | 0.702** | 0.35 | 0.154 | 0.351 | -0.615** | -0.928** | 0.455* | 0.524* | -0.359 | 1 | -0.258 | -0.103 |
| 14 | Amylose content (X14) | 0.453* | 0.442 | 0.389 | -0.584** | -0.039 | -0.174 | -0.039 | 0.288 | 0.218 | -0.14 | -0.158 | 0.333 | -0.229 | 1 | -0.274 |
| 15 | Alkali spreading value (X15) | -0.081 | -0.089 | -0.435 | 0.05 | -0.268 | -0.007 | -0.268 | -0.131 | 0.154 | 0.169 | -0.137 | -0.467* | -0.081 | -0.248 | 1 |

* - Significant at 5 per cent level

** - Significant at 1 per cent level

L/B ratio was positively associated with characters like volume expansion ratio (0.934) and amylose content (0.694) and it showed negative correlation with characters like hulling percentage (-0.653), milling percentage (-0.488), kernel elongation ratio (-0.583) and alkali spreading value (-0.37).

Hulling percentage was positively associated with milling percentage (0.927), kernel elongation ratio (0.234) and alkali spreading value (0.407). Volume expansion ratio (-0.247), amylose content (-0.458) showed negative correlation with hulling percentage.

Milling percentage was positively associated with kernel elongation ratio (0.248), alkali-spreading value (0.295) and negatively associated with amylose content (-0.253).

Volume expansion ratio was positively associated with amylose content (0.464) and negatively associated with kernel elongation ratio (-0.377).

Kernel elongation ratio was positively associated with alkali spreading value (0.372) and negatively associated with amylose content (-0.735).

Amylose content was negatively associated with alkali spreading value (-0.23).

Thirteen characters namely number of days to 50 per cent flowering, number of days to harvest, height of the plant, grain yield per hectare, straw yield per hectare, per plant yield, density, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, amylose content and alkali spreading value which differed among the genotypes at Thrissur were used for computing genotypic correlations. Among the yield attributes eight characters namely height of the plant (0.396), straw yield (0.603), per plant yield (0.994), density (0.48), L/B ratio (0.769), milling percentage (0.796), volume expansion ratio (0.922), amylose content (0.223) were positively associated to grain yield. None of the yield attributes showed significant negative correlation with grain yield. Comparatively low significant positive correlations such as height of the plant (0.295), L/B ratio (0.369), milling percentage (0.516), volume expansion ratio (0.536) were noticed at phenotypic level with yield and its attributes. Here after correlations denote the genotypic correlations.

Number of days to 50 per cent flowering was positively associated with characters like number of days to harvest (1.001), height of the plant (0.534) straw yield (0.317), hulling percentage (0.652), amylose content (0.864), alkali spreading value (0.826). Milling percentage (-0.621) and volume expansion ratio (-0.397) were negatively associated with number of days to 50 per cent flowering.

Number of days to harvest was positively associated with characters like height of the plant (0.55), straw yield (0.389), per plant yield (0.235), hulling percentage (0.607), amylose content (0.845), alkali spreading value (0.832). Milling percentage (-0.582) and volume expansion ratio (-0.322) were negatively associated with number of days to harvest.

Height of the plant was positively associated to straw yield (0.722), per plant yield (0.594), density (0.889), L/B ratio (0.254), hulling percentage (0.676), amylose content (0.732) and alkali spreading value (0.267). Milling percentage (-0.442) and volume expansion ratio (-0.362) showed negative correlations with height of the plant.

Straw yield showed positive correlations with yield attributes such as per plant yield (0.748), density (0.232), L/B ratio (1.103), hulling percentage (0.645), and amylose content (0.855).

Per plant yield was positively associated with density (0.294), L/B ratio (0.773), hulling percentage (0.463), milling percentage (0.541), volume expansion ratio (0.697) and amylose content (0.65).

Density was positively associated with L/B ratio (0.759) and negatively associated with characters like milling percentage (-0.26), alkali spreading value (-0.294).

L/B ratio showed positive correlations with volume expansion ratio (0.401) and amylose content (0.256) and negative correlation with alkali spreading value (-0.353).

Hulling percentage was positively associated with amylose content (0.947) and alkali spreading value (0.705) and negatively associated with milling percentage (-0.37) and volume expansion ratio (-0.417).

Milling percentage was positively associated with volume expansion ratio (0.904) and negatively associated with amylose content (-0.41) and alkali spreading value (-0.272).

Volume expansion ratio was negatively associated with amylose content (-0.275) and alkali spreading value (-0.19). Amylose content showed positive correlation with alkali spreading value (0.66).

In Ernakulam 15 characters namely number of days to 50 per cent flowering, number of days to harvest, height of the plant, grain yield per hectare, straw yield per hectare, per plant yield, pest and disease incidence, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, kernel elongation ratio, amylose content and alkali spreading value which differed significantly among genotypes were considered for assessing genotypic correlations. Among the yield attributes seven characters namely number of spikelets per panicle (0.494), straw yield (0.830), per plant yield (1.00), hulling percentage (0.901), milling percentage (1.174), volume expansion ratio (0.271), kernel elongation ratio (0.468), showed positive correlations with grain yield. Hulling percentage (-0.55) and alkali spreading value (-0.449) showed negative correlation with grain yield. Comparatively low significant correlations were noticed at phenotypic level with yield and its components. Here after correlations denote the genotypic correlations.

Number of days to 50 per cent flowering was positively associated with characters like number of days to harvest (1.00), height of the plant (0.68), pest and disease incidence (1.016), L/B ratio (0.882), volume expansion ratio (0.727) and amylose content (0.63). Number of spikelets per panicle (-0.973), hulling percentage (-0.639), milling percentage (-0.458) and kernel elongation ratio (-0.839) were negatively associated to number of days to 50 per cent flowering.

Number of days to harvest showed positive correlation with height of the plant (0.68), pest and disease incidence (1.002), L/B ratio (0.862), volume expansion ratio (0.731) and amylose content (0.629). Number of spikelets (-0.966), hulling percentage (-0.595), milling percentage (-0.418) and kernel elongation ratio (-0.823) were negatively associated with number of days to harvest.

Height of the plant was positively associated with yield attributes like pest and disease incidence (0.789), L/B ratio (0.657), volume expansion ratio (0.648) and amylose content (0.637). Number of spikelets per panicle (-0.805) straw yield (-0.401), hulling percentage (-0.269), milling percentage (-0.207), kernel elongation ratio (-0.688) and alkali spreading value (-0.488) showed negative correlation to height of the plant.

Number of spikelets per panicle was positively associated with straw yield (0.62), per plant yield (0.494), hulling percentage (0.594), milling percentage (0.556) and kernel elongation ratio (0.845). Pest and disease incidence (-0.981), L/B ratio (-0.866), volume expansion ratio (-0.564) amylose content were negatively associated with number of spikelets per panicle.

Straw yield showed positive correlation with characters like per plant yield (0.83), hulling percentage (0.648), milling percentage (1.027), volume expansion ratio

(0.31), kernel elongation ratio (0.224). L/B ratio (-0.267) and amylose content (-0.356) were positively associated to straw yield.

Per plant yield was positively associated with hulling percentage (0.901), milling percentage (1.173) kernel elongation ratio (0.468) and negatively associated to L/B ratio (-0.55) and alkali spreading value (-0.448).

Pest and disease incidence showed positive correlation with characters like L/B ratio (0.951), volume expansion ratio (1.33), amylose content (0.831) and negatively correlated with hulling percentage (-0.812), milling percentage (-0.402), kernel elongation ratio (-0.936) and alkali spreading value (-0.231).

L/B ratio was positively correlated with volume expansion ratio and negatively correlated with hulling percentage (-0.68), milling percentage (-0.648) and kernel elongation ratio (-1.025).

Hulling percentage was positively correlated with milling percentage (0.87), kernel elongation ratio (0.652), alkali spreading value (0.232) and negatively associated with volume expansion ratio (-0.47).

Milling percentage was positively associated with kernel elongation ratio (0.586).

Volume expansion ratio was positively associated with amylose content (0.504) and negatively associated with kernel elongation ratio (-0.564) and alkali spreading value (-0.643).

Kernel elongation ratio negatively associated with amylose content (-0.258) and amylose content negatively associated with alkali spreading value (-0.274).

## 4.3 Path coefficient analysis

To assess the relative contribution of yield components towards yield and its reflection in different environments path coefficient analysis was carried out in location wise after taking significantly differed characters. The genotypic correlations of grain yield with its attributes were partitioned into direct and indirect contribution of the components on grain yield.

At Palghat the estimates showed that 98.50 per cent of the variability in grain yield was contributed by the ten component characters. It is seen from the Table 9 that maximum positive direct effect on grain yield was for number of days to flowering (3.791) followed by hulling percentage (1.576), whereas maximum negative direct effect was for number of days to harvest (-4.01) followed by L/B ratio (-0.945). The least positive direct effect is shown by alkali spreading value (0.069) followed by amylose content (0.773) and its least negative effect is for height of the plant (-0.26) followed by milling percentage (-0.727).

Highly significant positive correlation was recorded between hulling percentage and grain yield (1.354) which was resulted from high indirect effect of number of days to harvest (2.479) and slightly higher direct effect (1.576) of that character. The high significant positive genotypic correlation of milling percentage and yield (1.253) was mainly due to the high indirect effect of number of days to harvest (2.58). The high significant positive correlation of kernel elongation ratio (1.072) was due to its high indirect effect of number of days to harvest (1.806) and its direct effect of (1.072) of that character.

The residual effect of the path coefficient analysis estimates of Thrissur showed that 99 per cent of the variability in grain yields was contributed by the 12 component traits. It is seen from the Table 10 that maximum positive direct was for volume expansion ratio (4.581) followed by hulling percentage (1.611), whereas maximum negative direct effect was for milling percentage (-4.640) followed by

Table 9. Direct and indirect effects of 10 characters on grain yield at Palghat

| Sl. No. | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ | $X_{10}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| $X_1$ | 3.791 | -4.01 | -0.102 | -0.439 | -0.976 | 0.468 | 0.619 | -0.483 | 0.337 | -0.008 |
| $X_2$ | 3.79 | -4.01 | -0.102 | -0.439 | -0.975 | 0.468 | 0.619 | -0.483 | 0.337 | -0.008 |
| $X_3$ | 1.486 | -1.572 | -0.26 | -0.595 | -0.355 | -0.013 | 0.763 | -0.552 | 0.363 | 0.001 |
| $X_4$ | 1.76 | -1.862 | -0.164 | -0.945 | -1.029 | 0.355 | 1.069 | -0.625 | 0.537 | -0.026 |
| $X_5$ | -2.346 | 2.479 | 0.059 | 0.617 | 1.576 | -0.674 | -0.282 | 0.251 | -0.354 | 0.028 |
| $X_6$ | -2.44 | 2.58 | -0.005 | 0.461 | 1.462 | -0.727 | -0.169 | 0.266 | -0.195 | 0.02 |
| $X_7$ | 2.053 | -2.171 | -0.174 | -0.883 | -0.389 | 0.107 | 1.144 | -0.404 | 0.358 | -0.012 |
| $X_8$ | -1.707 | 1.806 | 0.134 | 0.552 | 0.369 | -0.18 | -0.431 | 1.072 | -0.568 | 0.026 |
| $X_9$ | 1.654 | -1.75 | -0.122 | -0.657 | -0.722 | 0.184 | 0.53 | -0.788 | 0.773 | -0.016 |
| $X_{10}$ | -0.453 | 0.48 | -0.002 | 0.356 | 0.642 | -0.214 | -0.195 | 0.399 | -0.184 | 0.069 |

$X_1$ - No. of days to flowering
$X_2$ - No. of days to harvest
$X_3$ - Height of the plant
$X_4$ - L/B ratio
$X_5$ - Hulling percentage
$X_6$ - Milling percentage
$X_7$ - Volume expansion ratio
$X_8$ - Kernel elongation ratio
$X_9$ - Amylose content
$X_{10}$ - Alkali spreading value

Table 10. Direct and indirect effects of 12 characters on grain yield at Thrissur

| Sl. No. | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ | $X_{10}$ | $X_{11}$ | $X_{12}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X_1$ | 1.454 | -3.329 | -0.046 | -0.265 | 0.22 | -0.016 | 0.043 | 1.05 | 2.881 | -1.818 | -0.181 | -0.134 |
| $X_2$ | 1.456 | -3.325 | -0.047 | -0.326 | 0.313 | 0.017 | -0.021 | 0.978 | 2.7 | -1.476 | -0.178 | -0.136 |
| $X_3$ | 0.776 | -1.829 | -0.086 | -0.605 | 0.789 | 0.212 | -0.148 | 1.089 | 2.051 | -1.656 | -0.154 | -0.043 |
| $X_4$ | 0.461 | -1.294 | -0.062 | -0.838 | 0.993 | 0.055 | -0.643 | 1.04 | 0.589 | 0.506 | -0.18 | -0.024 |
| $X_5$ | 0.241 | -0.783 | -0.051 | -0.626 | 1.328 | 0.07 | -0.45 | 0.746 | -2.508 | 3.192 | -0.137 | -0.028 |
| $X_6$ | -0.097 | -0.232 | -0.076 | -0.195 | 0.39 | 0.239 | -0.442 | -0.262 | 1.205 | -0.103 | 0.005 | 0.048 |
| $X_7$ | -0.107 | -0.117 | -0.022 | -0.924 | 1.026 | 0.181 | -0.583 | 0.02 | -0.545 | 1.837 | -0.054 | 0.058 |
| $X_8$ | 0.948 | -2.02 | -0.058 | -0.541 | 0.615 | -0.039 | -0.007 | 1.611 | 1.728 | -1.911 | -0.199 | -0.115 |
| $X_9$ | -0.903 | 1.935 | 0.038 | 0.106 | 0.718 | -0.062 | -0.069 | -0.6 | -4.64 | 4.142 | 0.086 | 0.044 |
| $X_{10}$ | -0.577 | 1.072 | 0.031 | -0.093 | 0.925 | -0.005 | -0.234 | -0.672 | -4.195 | 4.581 | 0.058 | 0.031 |
| $X_{11}$ | 1.256 | -2.81 | -0.063 | -0.716 | 0.863 | -0.005 | -0.149 | 1.526 | 1.903 | -1.261 | -0.21 | -0.108 |
| $X_{12}$ | 1.199 | -2.766 | -0.023 | -0.125 | 0.231 | -0.07 | 0.206 | 1.136 | 1.264 | -0.87 | -0.14 | -0.163 |

$X_1$ - No. of days to flowering
$X_2$ - No. of days to harvest
$X_3$ - Height of the plant
$X_4$ - Straw yield
$X_5$ - Per plant yield
$X_6$ - Density
$X_7$ - L/B ratio
$X_8$ - Hulling percentage
$X_9$ - Milling percentage
$X_{10}$ - Volume expansion ratio
$X_{11}$ - Amylose content
$X_{12}$ - Alkali spreading value

number of days to harvest (-3.325). The least positive direct effect was shown by density (0.239) followed by per plant yield (1.328) and its least negative effect is for height of the plant (-0.163).

Highly significant positive correlation was recorded between per plant yield and grain yield (0.994) which was resulted from high indirect of volume expansion ratio (3.192) and slightly higher direct of (1.328) that character. The high significant positive correlation of milling percentage and yield was mainly due to high indirect effect of volume expansion ratio (4.142). The high significant positive correlation of volume expansion ratio and yield (0.922) was mainly due to the high direct effect of that character.

At Ernakulam the estimates of path analysis showed that 99 per cent of the variability in grain yield was contributed by the fourteen characters. It is seen from the Table 11 that maximum positive direct effect was for per plant yield (1.001), remaining all characters showed low amount of direct effect on yield.

Highly significant positive correlation was recorded between milling percentage and grain yield (1.17) which was resulted from high indirect effect of per plant yield and yield (1.00) and due to direct effect of (1.00) that character.

**4.4 Stability analysis**

In order to study the performance of genotypes in relation to the environment, stability analysis following the method suggested by Eberhart and Russell was carried out. ANOVA table for stability analysis of 20 characters is presented in Table 12. Among the twenty characters the pooled ANOVA indicated that the characters namely number of days to 50 per cent flowering, number of days to harvest, height of the plant, number of tillers per plant, number of panicles per plant, number of spikelets per panicle, grain yield per hectare, per plant yield, 100 grain weight, L/B ratio, hulling percentage, milling percentage, volume expansion ratio, kernel elongation ratio, amylose content, and alkali spreading value significantly

Table 11. Direct and indirect effects of 14 characters on grain yield at Ernakulam

| Sl. No. | $X_1$ | $X_2$ | $X_3$ | $X_4$ | $X_5$ | $X_6$ | $X_7$ | $X_8$ | $X_9$ | $X_{10}$ | $X_{11}$ | $X_{12}$ | $X_{13}$ | $X_{14}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $X_1$ | 0.044 | -0.044 | 0.004 | 0.005 | 0 | -0.172 | 0 | 0.009 | 0 | -0.001 | 0.002 | -0.016 | -0.004 | 0 |
| $X_2$ | 0.044 | -0.044 | 0.004 | 0.005 | 0 | -0.127 | 0 | 0.009 | 0 | 0 | 0.002 | -0.016 | -0.004 | 0 |
| $X_3$ | 0.03 | -0.03 | 0.005 | 0.004 | 0 | -0.019 | 0 | 0.007 | 0 | 0 | 0.002 | -0.016 | -0.004 | 0 |
| $X_4$ | -0.042 | 0.042 | -0.004 | -0.005 | -0.001 | 0.494 | 0 | -0.009 | 0 | 0.001 | -0.002 | 0.016 | 0.005 | 0 |
| $X_5$ | -0.006 | 0.004 | -0.002 | -0.003 | -0.001 | 0.831 | 0 | -0.003 | 0 | 0.001 | 0.001 | 0.004 | 0.002 | 0 |
| $X_6$ | -0.007 | 0.006 | 0 | -0.003 | -0.001 | 1.001 | 0 | -0.006 | 0 | 0.001 | 0.001 | 0.009 | 0 | -0.001 |
| $X_7$ | 0.044 | -0.044 | 0.004 | 0.005 | 0 | -0.035 | 0 | 0.01 | 0 | 0 | 0.003 | -0.017 | -0.005 | -0.001 |
| $X_8$ | 0.038 | -0.038 | 0.004 | 0.005 | 0 | -0.551 | 0 | 0.01 | 0 | -0.001 | 0.001 | -0.019 | -0.001 | 0 |
| $X_9$ | -0.028 | 0.026 | -0.001 | -0.003 | -0.001 | 0.902 | 0 | -0.007 | 0 | 0.001 | -0.001 | 0.012 | 0.001 | 0.001 |
| $X_{10}$ | -0.02 | 0.018 | -0.001 | -0.003 | -0.001 | 1.175 | 0 | -0.007 | 0 | 0.001 | 0 | 0.011 | 0.001 | 0 |
| $X_{11}$ | 0.032 | -0.032 | 0.003 | 0.003 | 0 | 0.271 | 0 | 0.006 | 0 | 0 | 0.003 | -0.01 | -0.003 | -0.002 |
| $X_{12}$ | -0.037 | 0.036 | -0.004 | -0.005 | 0 | 0.468 | 0 | -0.011 | 0 | 0.001 | -0.001 | 0.019 | 0.002 | 0 |
| $X_{13}$ | 0.027 | -0.028 | 0.003 | 0.004 | 0 | -0.059 | 0 | 0.002 | 0 | 0 | 0.001 | -0.005 | -0.006 | -0.001 |
| $X_{14}$ | -0.007 | 0.007 | -0.003 | 0 | 0 | -0.449 | 0 | 0.002 | 0 | 0 | -0.002 | -0.002 | 0.002 | 0.002 |

$X_1$ - No. of days to flowering
$X_2$ - No. of days to harvest
$X_3$ - Height of the plant
$X_4$ - No. of spikelets
$X_5$ - Straw yield
$X_6$ - Per plant yield
$X_7$ - Pest and disease incidence
$X_8$ - L/B ratio
$X_9$ - Hulling percentage
$X_{10}$ - Milling percentage
$X_{11}$ - Volume expansion ratio
$X_{12}$ - Kernel elongation ratio
$X_{13}$ - Amylose content
$X_{14}$ - Alkali spreading value

Table 12. Pooled analysis of variance for 20 characters at three locations on Kunjukunju rice cultures

| SI.No | Character | MSS of | | | | | |
|---|---|---|---|---|---|---|---|
| | | Varieties | Environment | VxE | ENV (linear) | VxE (linear) | Pooled deviation |
| 1 | No. Of days to flowering | 22.54* | 0.71 | 1.43 | 1.44 | 1.8 | 0.92 |
| 2 | No. Of days to harvest | 22.64* | 0.39 | 2.03 | 0.77 | 2.8* | 1.06 |
| 3 | Ht of the plant | 54.89* | 157.2* | 3.7 | 314.05* | 3.1 | 3.7* |
| 4 | No. Of tillers | 1.76* | 27.9* | 0.4 | 55.9* | 0.29 | 0.44 |
| 5 | No. Of panicles | 0.97* | 25.95* | 0.37 | 51.9* | 0.20 | 0.46 |
| 6 | No. Of spike lets | 1285.8* | 640.38* | 50.08 | 1280.6* | 73.7** | 23.17 |
| 7 | Grain yield per ha | 1071057.1* | 55873742.08 | 197248.30 | 11174744.08 | 9525.7 | 261839.5 |
| 8 | Straw yield per ha | 9860752 | 493002420.0 | 4934355.5 | 986004670* | 4704531.5 | 4518677.7 |
| 9 | Per plant yield | 2.45* | 130.1* | 0.66 | 260.3* | 0.19 | 0.99 |
| 10 | Pest and disease incidence | 108.02 | 776.8* | 110.7 | 1553.6* | 220.3** | 0.96 |
| 11 | 100 grain Wt | 0.013* | 0.013* | 0.002 | 0.02* | 0.004** | 0.0012 |
| 12 | Density | 0.002 | 0.0015 | 0.00089 | 0.00031 | 0.0010 | 0.00061 |
| 13 | L&B ratio | 0.16* | 0.0043 | 0.01 | 0.0087 | 0.0082 | 0.01 |
| 14 | Hulling % | 7.1* | 0.64 | 0.29 | 1.2* | 0.41 | 0.15 |
| 15 | Milling% | 10.43* | 0.60* | 0.11 | 1.21* | 0.05 | 0.15 |
| 16 | Water uptake | 0.00091 | 0.0016 | 0.00068 | 0.0033* | 0.00052 | 0.00073 |
| 17 | Volume expansion ratio | 0.16* | 0.013 | 0.012 | 0.027* | 0.019** | 0.0055 |
| 18 | Kernal elongation ratio | 0.0073* | 0.0087 | 0.0029 | 0.017* | 0.0053** | 0.00041 |
| 19 | Amylose content | 13.16* | 0.10 | 0.23 | 0.212 | 0.179 | 0.24 |
| 20 | Alkali spreading value | 4.8* | 0.092 | 0.076 | 0.19 | 0.056 | 0.083 |

* Significant at p=0.05
** Significant at p=0.01

differed among the genotypes. The influence of environment in respect of characters namely height of the plant, number of tillers per plant, number of panicles per plant, number of spikelets per panicle, per plant yield, pest and disease incidence, 100 grain weight, and milling percentage were differed significantly with respect to location. Eventhough VxE interaction was not significant, environment (linear) was significant with respect to the characters namely height of the plant, number of tillers per plant, number of panicles per plant, number of spikelets per panicle, straw yield per hectare, per plant yield, pest and disease incidence, 100 grain weight, hulling percentage, milling percentage, water uptake, volume expansion ratio and kernel elongation ratio. VxE (linear) was differed significantly with respect to characters namely number of days to harvest, number of spikelets per panicle, pest and disease incidence, 100 grain weight, volume expansion ratio and kernel elongation ratio. The results of the genotypes for each character in response to the environment are given below. The varietal mean, the regression coefficient and the deviation from regression coefficient are presented in Table 13.

**Number of days to 50 per cent flowering**

Kanchana showed the maximum mean value of 90.33 with a regression coefficient of 2.77 and with a deviation of 0.64, whereas local Kunjukunju, recorded the mean value of 82.11 with the regression coefficient of 1.23 and a deviation of 0.05.

**Number of days to harvest**

Kanchana showed the maximum mean value of 116.33 with a regression coefficient of 3.42 and with a deviation of 0.83. Local Kunjukunju recorded the mean value of 108.11 but with the regression coefficient of 1.42 and a deviation of 0.07.

**Height of the plant**

The maximum mean value of 95.78 was shown by Kanchana with a regression coefficient of 0.64 and a deviation of –1.63, whereas K-10-3 showed the mean value of 92.78, the regression coefficient of 1.29 and with a deviation of –1.58.

Table 13. Stability analysis for 20 characters at three locations on Kunjukunju rice cultures

| Characters | Mean | Regression coefficient (b) | Mean square deviation (SD) |
|---|---|---|---|
| No. of days to 50% flowering | | | |
| K-6 | 81.33 | 2.46 | -0.18 |
| K-10-2 | 85.67 | -2.46 | -0.17 |
| K-10-3 | 86.44 | 0.31 | -0.36 |
| K-68-4 | 85.11 | -4.61 | 0.48 |
| K-67-5 | 85.11 | 4.77 | 1.10 |
| K-68-6 | 85.22 | 3.54 | 0.73 |
| Local Kunjukunju | 82.11 | 1.23 | 0.05 |
| Kanchana | 90.33 | 2.77 | 0.64 |
| No. of days to harvest | | | |
| K-6 | 107.33 | 3.13 | -0.10 |
| K-10-2 | 111.67 | -3.15 | -0.11 |
| K-10-3 | 112.44 | 0.56 | -0.43 |
| K-68-4 | 110.67 | -10.01 | 0.45 |
| K-67-5 | 111.00 | 7.13 | 1.24 |
| K-68-6 | 111.11 | 5.42 | 0.97 |
| Local Kunjukunju | 108.11 | 1.42 | 0.07 |
| Kanchana | 116.33 | 3.42 | 0.83 |
| Height of the plant | | | |
| K-6 | 83.78 | 1.38 | 1.50 |
| K-10-2 | 87.22 | 1.31 | -0.17 |
| K-10-3 | 92.78 | 1.29 | -1.58 |
| K-68-4 | 86.33 | 0.85 | -1.59 |
| K-67-5 | 87.67 | 0.93 | 3.32 |
| K-68-6 | 89.11 | 0.83 | 17.28 |
| Local Kunjukunju | 94.67 | 0.76 | 0.08 |
| Kanchana | 95.78 | 0.64 | -1.63 |
| No. of tillers per plant | | | |
| K-6 | 7.18 | 0.83 | -0.68 |
| K-10-2 | 7.24 | 1.04 | 0.10 |
| K-10-3 | 7.46 | 0.74 | -0.45 |
| K-68-4 | 6.78 | 0.90 | -0.40 |
| K-67-5 | 7.00 | 1.04 | -0.60 |
| K-68-6 | 7.28 | 1.34 | -0.66 |
| Local Kunjukunju | 7.60 | 0.88 | -0.67 |
| Kanchana | 9.27 | 1.23 | 1.49 |

Contd.

Table 13 . Continued

| Characters | Mean | Regression coefficient (b) | Mean square deviation (SD) |
|---|---|---|---|
| Number of panicle per plant | | | |
| K-6 | 6.68 | 0.90 | -0.53 |
| K-10-2 | 5.92 | 0.94 | 0.50 |
| K-10-3 | 6.34 | 0.89 | -0.55 |
| K-68-4 | 5.72 | 1.07 | 0.09 |
| K-67-5 | 5.40 | 0.80 | -0.52 |
| K-68-6 | 5.90 | 1.35 | -0.48 |
| Local Kunjukunju | 6.33 | 0.91 | -0.13 |
| Kanchana | 7.19 | 1.14 | 0.93 |
| No. of spikelets per panicle | | | |
| K-6 | 109.22 | 0.51 | -16.16 |
| K-10-2 | 98.67 | 0.42 | 59.65 |
| K-10-3 | 91.67 | 0.99 | -11.55 |
| K-68-4 | 94.89 | 1.49 | -12.35 |
| K-67-5 | 94.78 | 1.21 | 43.37 |
| K-68-6 | 96.56 | 0.34 | -11.98 |
| Local Kunjukunju | 95.22 | 0.69 | -11.41 |
| Kanchana | 86.56 | 2.35 | 14.85 |
| Grain yield per hectare | | | |
| K-6 | 7580.56 | 1.12 | 30118.76 |
| K-10-2 | 6523.22 | 0.89 | -123532.95 |
| K-10-3 | 7059.89 | 1.02 | -71396.87 |
| K-68-4 | 6021.22 | 1.00 | 24354.28 |
| K-67-5 | 5677.78 | 0.96 | -33816.99 |
| K-68-6 | 6252.33 | 1.11 | -154995.62 |
| Local Kunjukunju | 6742.56 | 0.96 | 567727.38 |
| Kanchana | 6442.44 | 0.94 | 211074.52 |
| Straw yield per hectare | | | |
| K-6 | 16319.45 | 1.01 | -2234276.75 |
| K-10-2 | 12821.00 | 0.78 | -2298834.75 |
| K-10-3 | 14159.89 | 0.88 | 11054131.00 |
| K-68-4 | 12548.33 | 0.83 | 2611749.75 |
| K-67-5 | 12405.45 | 0.88 | -912408.00 |
| K-68-6 | 14731.89 | 1.11 | 6847573.50 |
| Local Kunjukunju | 15151.44 | 1.17 | -347331.09 |
| Kanchana | 17349.89 | 1.34 | 3008096.25 |

Contd.

Table 13. Continued

| Characters | Mean | Regression coefficient (b) | Mean square deviation (SD) |
|---|---|---|---|
| Per plant grain yield | | | |
| K-6 | 11.48 | 1.11 | 0.22 |
| K-10-2 | 9.88 | 0.88 | -0.24 |
| K-10-3 | 10.58 | 1.00 | -0.49 |
| K-68-4 | 9.11 | 0.99 | 0.17 |
| K-67-5 | 8.59 | 0.95 | 0.00 |
| K-68-6 | 9.45 | 1.10 | -0.34 |
| Local Kunjukunju | 10.21 | 0.95 | 0.96 |
| Kanchana | 10.26 | 1.03 | 3.44 |
| Pest and disease incidence | | | |
| K-6 | 1.42 | -0.01 | -63.99 |
| K-10-2 | 10.78 | 1.57 | -64.09 |
| K-10-3 | 9.48 | 1.32 | -63.57 |
| K-68-4 | 1.86 | -0.04 | -64.20 |
| K-67-5 | 1.97 | -0.05 | -63.62 |
| K-68-6 | 13.81 | 2.04 | -63.53 |
| Local Kunjukunju | 17.45 | 2.71 | -61.62 |
| Kanchana | 6.72 | 0.46 | -61.25 |
| 100 grain weight | | | |
| K-6 | 2.61 | 0.36 | 0.00 |
| K-10-2 | 2.45 | -0.40 | 0.00 |
| K-10-3 | 2.43 | 2.07 | 0.00 |
| K-68-4 | 2.46 | 1.69 | 0.00 |
| K-67-5 | 2.42 | 2.31 | 0.00 |
| K-68-6 | 4.46 | 1.90 | 0.00 |
| Local Kunjukunju | 2.50 | 0.40 | 0.00 |
| Kanchana | 2.57 | -0.32 | 0.00 |
| Density | | | |
| K-6 | 0.97 | 1.62 | 0.00 |
| K-10-2 | 0.94 | -2.81 | 0.00 |
| K-10-3 | 0.90 | 7.21 | 0.00 |
| K-68-4 | 0.90 | 7.91 | 0.00 |
| K-67-5 | 0.89 | -7.47 | 0.00 |
| K-68-6 | 0.92 | -3.04 | 0.00 |
| Local Kunjukunju | 0.95 | 2.40 | 0.00 |
| Kanchana | 0.92 | 2.17 | 0.00 |

Contd.

Table 13. Continued

| | | | |
|---|---|---|---|
| L/B ratio | | | |
| K-6 | 2.27 | 1.36 | 0.00 |
| K-10-2 | 2.33 | 0.61 | -0.01 |
| K-10-3 | 2.42 | 2.79 | 0.00 |
| K-68-4 | 2.55 | 3.29 | 0.00 |
| K-67-5 | 2.53 | -1.74 | 0.01 |
| K-68-6 | 2.47 | 5.43 | 0.05 |
| Local Kunjukunju | 2.60 | -2.43 | 0.02 |
| Kanchana | 3.03 | -1.33 | 0.00 |
| Hulling (%) | | | |
| K-6 | 78.44 | 0.36 | 0.00 |
| K-10-2 | 75.18 | -1.83 | -0.10 |
| K-10-3 | 76.84 | 1.16 | 0.01 |
| K-68-4 | 75.33 | -0.57 | -0.01 |
| K-67-5 | 74.57 | 2.99 | -0.09 |
| K-68-6 | 73.84 | 2.38 | 0.64 |
| Local Kunjukunju | 76.19 | 2.28 | -0.02 |
| Kanchana | 74.09 | 1.25 | -0.04 |
| Milling (%) | | | |
| K-6 | 68.78 | 1.11 | -0.04 |
| K-10-2 | 65.76 | 1.31 | -0.12 |
| K-10-3 | 66.34 | 1.52 | 0.12 |
| K-68-4 | 63.39 | 1.50 | -0.02 |
| K-67-5 | 63.69 | 1.43 | 0.00 |
| K-68-6 | 63.39 | 0.89 | -0.09 |
| Local Kunjukunju | 65.63 | 0.26 | 0.37 |
| Kanchana | 64.26 | -0.03 | -0.06 |
| Water uptake | | | |
| K-6 | 0.61 | -0.06 | 0.00 |
| K-10-2 | 0.62 | 0.65 | 0.00 |
| K-10-3 | 0.63 | 3.03 | 0.00 |
| K-68-4 | 0.65 | 1.85 | 0.00 |
| K-67-5 | 0.66 | 1.62 | 0.00 |
| K-68-6 | 0.64 | 1.04 | 0.00 |
| Local Kunjukunju | 0.64 | -0.17 | 0.00 |
| Kanchana | 0.61 | 0.04 | 0.00 |

Contd.

Table 13. Continued

| Characters | Mean | Regression coefficient (b) | Mean square deviation (SD) |
|---|---|---|---|
| Volume expansion ratio | | | |
| K-6 | 4.32 | 0.92 | 0.00 |
| K-10-2 | 4.46 | -3.32 | -0.01 |
| K-10-3 | 4.32 | 3.47 | 0.00 |
| K-68-4 | 4.31 | 2.42 | 0.00 |
| K-67-5 | 4.33 | 1.22 | 0.00 |
| K-68-6 | 4.31 | 3.74 | -0.01 |
| Local Kunjukunju | 4.46 | -1.06 | -0.01 |
| Kanchana | 4.99 | 0.65 | 0.00 |
| Kernal elongation ratio | | | |
| K-6 | 1.49 | 2.38 | 0.00 |
| K-10-2 | 1.41 | 0.25 | 0.00 |
| K-10-3 | 1.38 | 0.26 | 0.00 |
| K-68-4 | 1.37 | 0.02 | 0.00 |
| K-67-5 | 1.37 | -0.12 | 0.00 |
| K-68-6 | 1.44 | 4.28 | 0.00 |
| Local Kunjukunju | 1.37 | -0.08 | 0.00 |
| Kanchana | 1.33 | 1.01 | 0.00 |
| Amylase content | | | |
| K-6 | 24.15 | 0.84 | -0.31 |
| K-10-2 | 25.74 | 3.62 | -0.32 |
| K-10-3 | 26.82 | 0.97 | 0.54 |
| K-68-4 | 24.63 | -0.35 | -0.03 |
| K-67-5 | 28.78 | -3.03 | -0.06 |
| K-68-6 | 23.08 | 4.79 | -0.23 |
| Local Kunjukunju | 24.96 | -1.18 | 0.04 |
| Kanchana | 28.73 | 2.51 | -0.25 |
| Alkali spreading value | | | |
| K-6 | 4.78 | -1.71 | -0.05 |
| K-10-2 | 2.33 | 2.86 | -0.03 |
| K-10-3 | 4.44 | 2.86 | 0.26 |
| K-68-4 | 4.67 | 0.57 | 0.16 |
| K-67-5 | 3.78 | 0.57 | 0.01 |
| K-68-6 | 1.11 | 1.14 | -0.01 |
| Local Kunjukunju | 3.22 | 1.71 | -0.05 |
| Kanchana | 4.00 | 0.00 | -0.06 |

**Number of tillers per plant**

The maximum mean value (9.27) was shown by Kanchana with a regression coefficient of 1.23 and with a deviation of 1.49.The genotype K-10-2, recorded the mean value of 7.24, the regression coefficient of 1.04 and with a deviation of 0.10.

**Number of panicles per plant**

Kanchana showed the maximum mean value (7.19) with a regression coefficient of 1.14 and with a deviation of 0.93. K-68-4 recorded the mean value of 5.72, the regression coefficient of 1.07 and with a deviation of 0.09.

**Number of spikelets per panicle**

The maximum mean value was shown by K-6 (109.22) with a regression coefficient of 0.51 and with a deviation of –16.16 whereas genotype K-68-6, recorded the mean value of 96.56, the regression coefficient of 1.21 and with a deviation of 43.37.

**Grain yield per hectare**

The maximum mean value was shown by K-6 (7580.56) with a regression coefficient of 1.12 and with a deviation of 30118.76. K-68-4, which is giving the mean value of 6021.2, showed the regression coefficient of 1.00 and with a deviation of 24354.

**Straw yield per hectare**

The maximum mean value was shown by Kanchana (17349.8) with a regression coefficient of 1.34 and with a deviation of 3008096.25. K-6, which recorded second maximum yield (16319.4) with regression coefficient of 1.01 and a deviation of -2234276.7.

**Per plant yield**

The maximum mean value was shown by K-6 (11.48) with a regression coefficient of 1.11 and with a deviation of 0.22.

**Pest and disease incidence**

The maximum mean value was shown by local Kunjukunju (17.45) with a regression coefficient of 2.71 and with a deviation of –61.62.The genotype K-10-3, which is giving the mean value of 9.48, showed the regression coefficient of 1.32 and with a deviation of –63.57.

**100 Grain weight**

The maximum mean value was shown by K-6 (2.61) with a regression coefficient of 0.36 and with a zero deviation.

**Density**

K-6 showed the maximum mean value (0.97) with a regression coefficient of 1.62 and with a zero deviation.

**L/B ratio**

The maximum mean value was shown by Kanchana (3.03) with a regression coefficient of –1.33 and with zero deviation. K-6, which is giving the mean value of 2.27, recorded the regression coefficient of 1.36 and with no deviation.

**Hulling percentage**

The maximum mean value was shown by K-6 (78.44) with a regression coefficient of 0.36 and with zero deviation. The genotype K-10-3, which is giving the mean value of 76.84, expressed the regression coefficient of 1.16 and with a deviation of 0.01.

**Milling percentage**

The maximum mean value was shown by K-6 (68.78) with a regression coefficient of 1.11 and with a deviation of –0.04.

**Water uptake**

The maximum mean value was shown by K-67-5 (0.66) with a regression coefficient of 1.62 and with zero deviation. K-68-6, which is giving the mean value of 0.64, recorded the regression coefficient of 1.04 and with zero deviation.

**Volume expansion ratio**

The maximum mean value was shown by Kanchana (4.99) with a regression coefficient of 0.65 and with no deviation. K-67-5, which is giving the mean value of 4.33, showed the regression coefficient of 1.22 and with zero deviation.

**Kernel elongation ratio**

The maximum mean value was shown by K-6 (1.49) with a regression coefficient of 2.38 and with zero deviation. Kanchana, which has the mean value of 1.33, recorded the regression coefficient of 1.01 and with zero deviation.

**Amylose content**

The maximum mean value was shown by K-67-5 (28.78) with a regression coefficient of –3.13 and with a deviation of –0.06. Local Kunjukunju, which showed a mean value of 24.96, the regression coefficient of 1.18 and with a deviation of 0.04.

**Alkali spreading value**

The maximum mean value was shown by K-10-3 (6.67) with a regression coefficient of 2.86 and with a deviation of 0.26. K-68-6, which is giving the mean value of 5.00, the regression coefficient of 1.14 and with a deviation of 0.01.

# Discussion

# 5. DISCUSSION

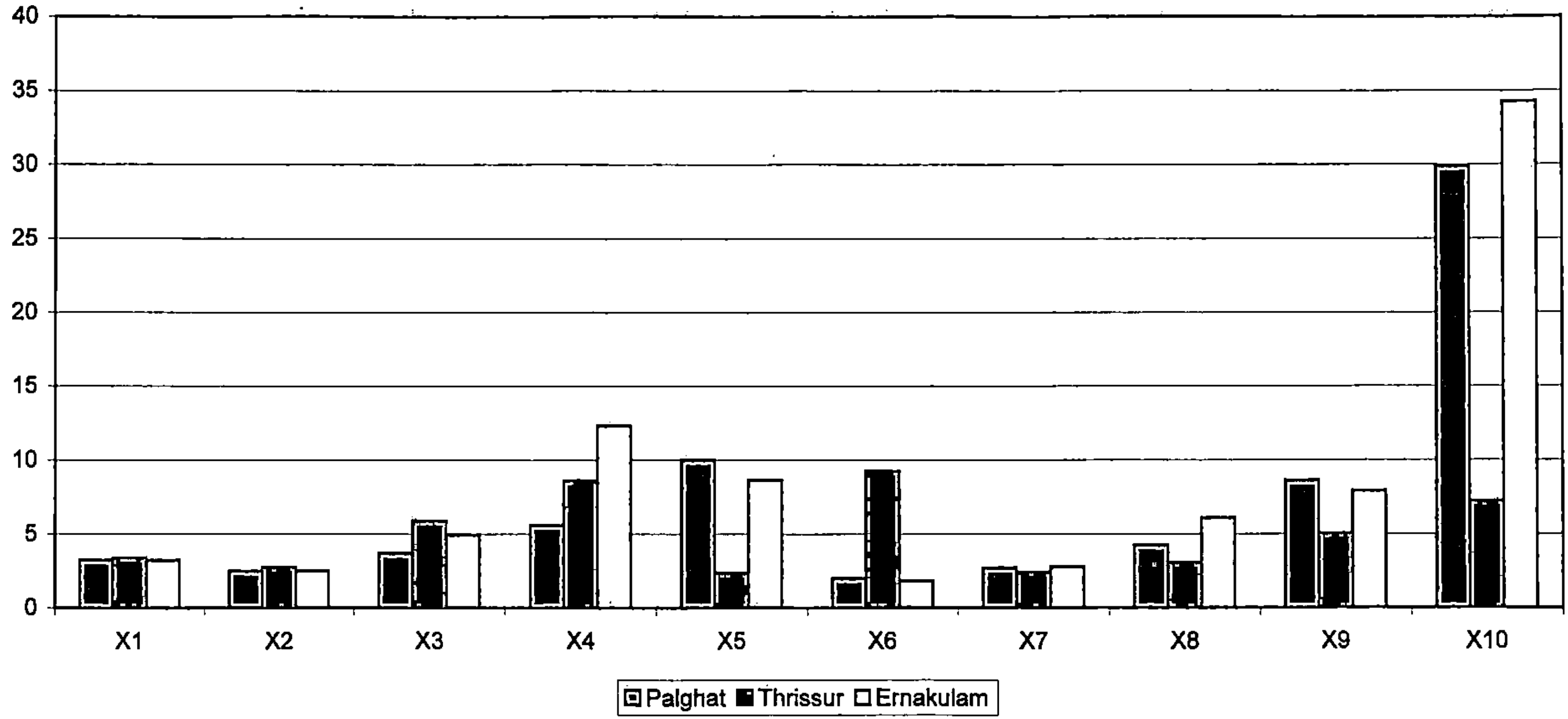
Stability analysis will give various measures of genotype - environment interaction and will provide reliable information about the performance of the genotypes in various environments. With this objective in view an attempt was made to study the performance of six distinct cultures derived from Kunjukunju -a local cultivar of Palghat district, along with standard check Kanchana - a high yielding rice variety, and local Kunjukunju, as local check in three districts of Kerala. The results of the study are discussed below.

## 5.1 Genetic variability

The analysis of variance of three locations namely Palghat, Thrissur and Ernakulam revealed that highly significant differences among the genotypes for many characters studied suggesting the presence of substantial genetic variability among the genotypes. The investigations of De *et al.* (1988), Sarawgi and Soni (1994) and Patra and Dhua (1996) in rice have also shown that wide range of variation was present for most of the characters. These significant differences were not uniform among the locations. At Palghat 11 characters showed significant differences while at Thrissur 13 characters and at Ernakulam 15 characters showed significant differences, showing that these characters are interacting to the environment differentially at each location. It is also giving information that reactions of the genotypes are not uniform to different environments.

Wide range of variations were noticed for all the characters and their differential response to varied environments confirmed that materials selected were genetically different and locations identified were having different environments. The differential range of genetic variability (GCV) estimates for significant characters common to three locations are graphically presented in Fig.1. Not much differences were noticed in the characters like number of days to flowering, number of days to harvest, and milling percentage among the different locations. The character alkali

**Fig. 1. Genotypic coefficient of variation (GCV) for ten characters at three locations**




X1 - No. of days to flowering
X2 - No. of days to harvest
X3 - Height of the plant
X4 - Grain yield $ha^{-1}$
X5 - L/B ratio
X6 - Hulling percentage
X7 - Milling percentage
X8 - Volume expansion ratio
X9 - Kernal elongation ratio
X10 - Amylose content

**PLATE: 1 VARIABILITY OF PANICLES OF KUNJU KUNJU RICE CULTURES**

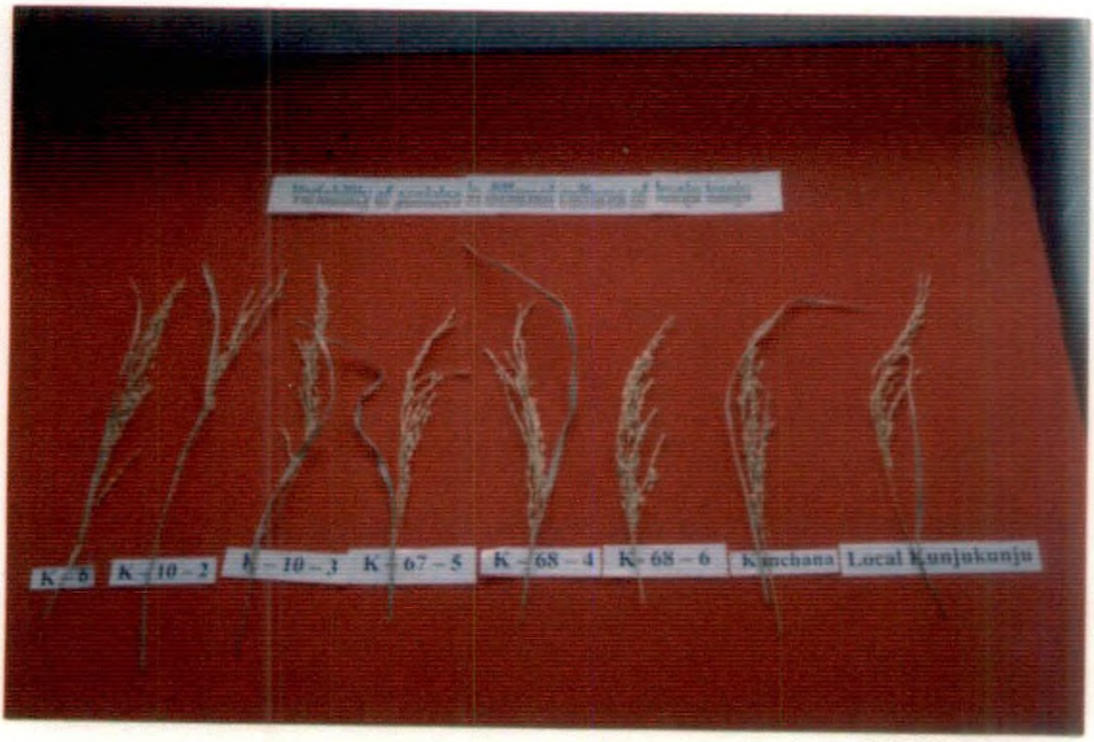



**PLATE: 2 VARIABILITY OFSPIKELETS OF KUNJU KUNJU RICE CULTURES**

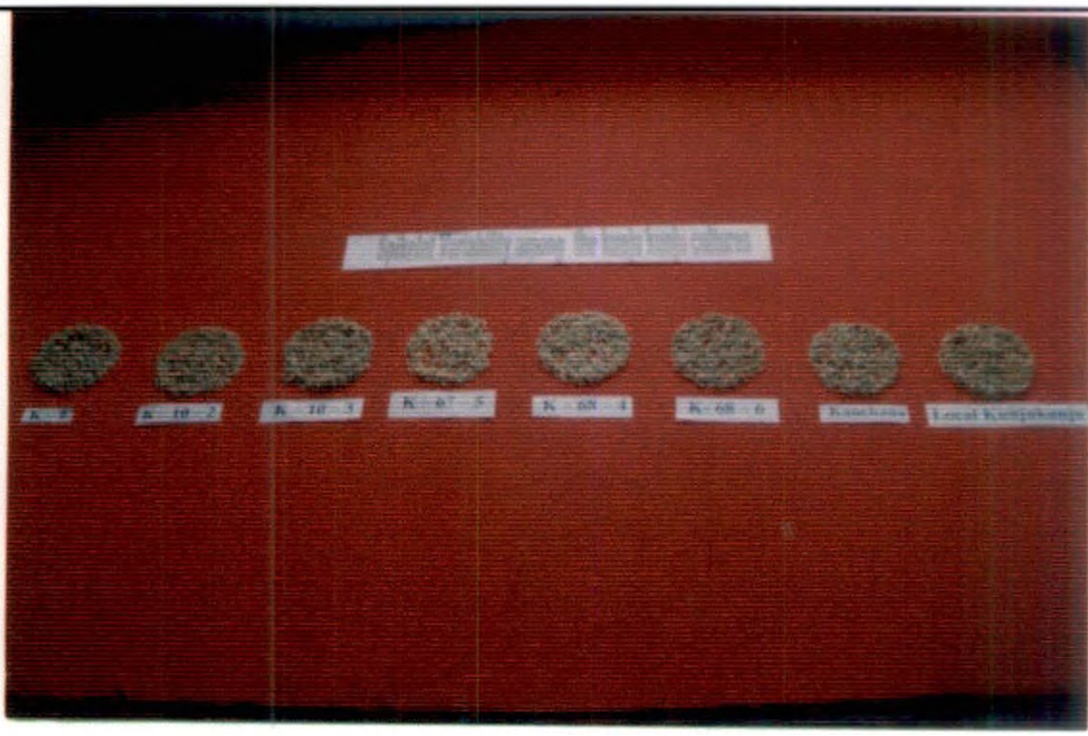


**PLATE:3 VARIABILITY OF PIGMENTATION IN KUNJU KUNJU RICE**

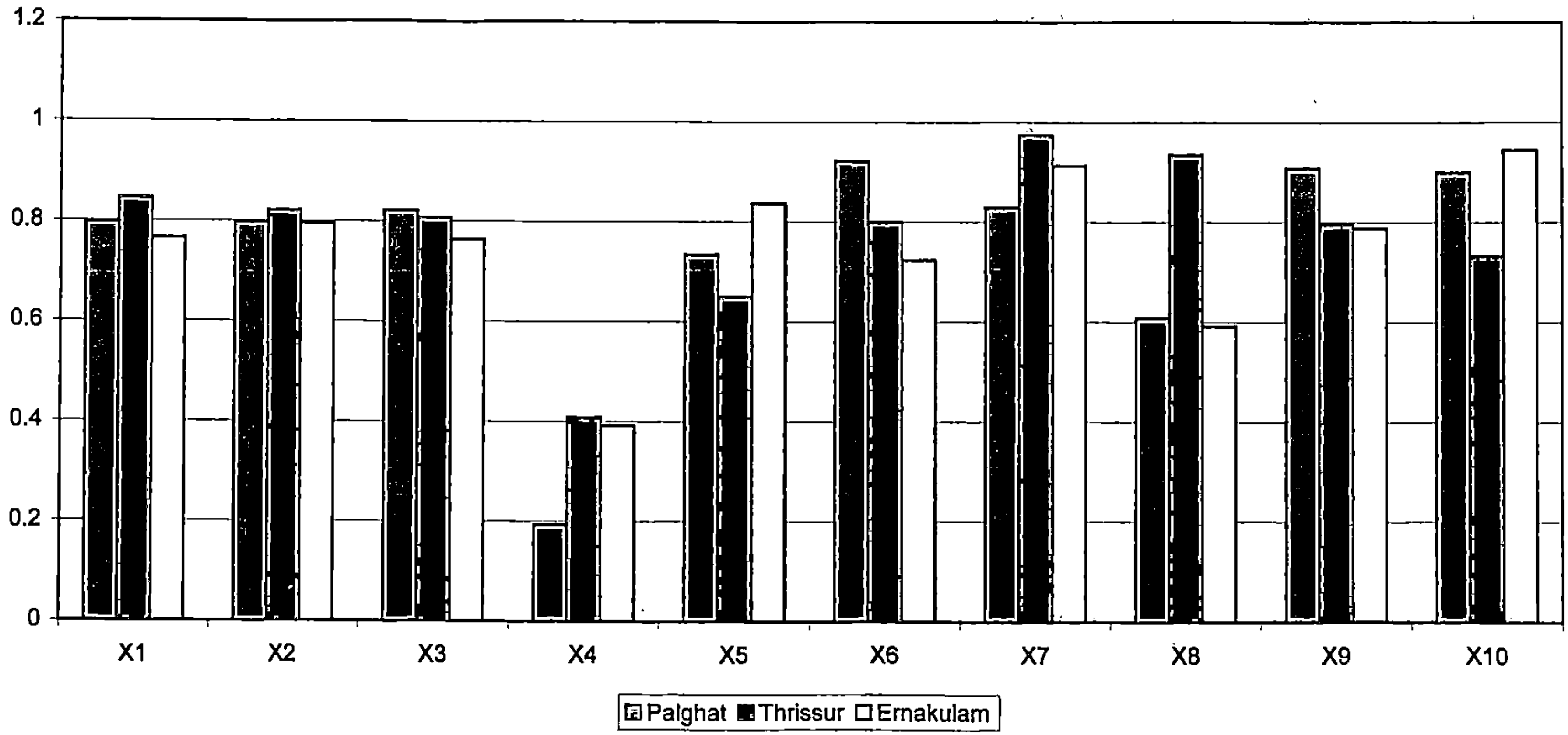
spreading value, L/B ratio, hulling percentage and yield showed differences in the range of variation with respect to locations. The remaining three characters showed moderate differences in the range of variation.

The same trends of variation for heritability were shown for ten characters and it is graphically presented in Fig.2. Except three characters namely number of days to 50 per cent flowering, number of days to harvest and height of the plant, all other characters showed differences in heritability estimates among the three locations, which indicated the differential response of the environment on these characters. Eventhough high differences were there among the heritability estimates for grain yield among the locations, its heritability estimates were low which indicated that considering yield alone for selection is not reliable. Reddy (1992) observed differential response of the environment on heritability estimates for yield and its related traits in rice.

## 5.2 Correlations

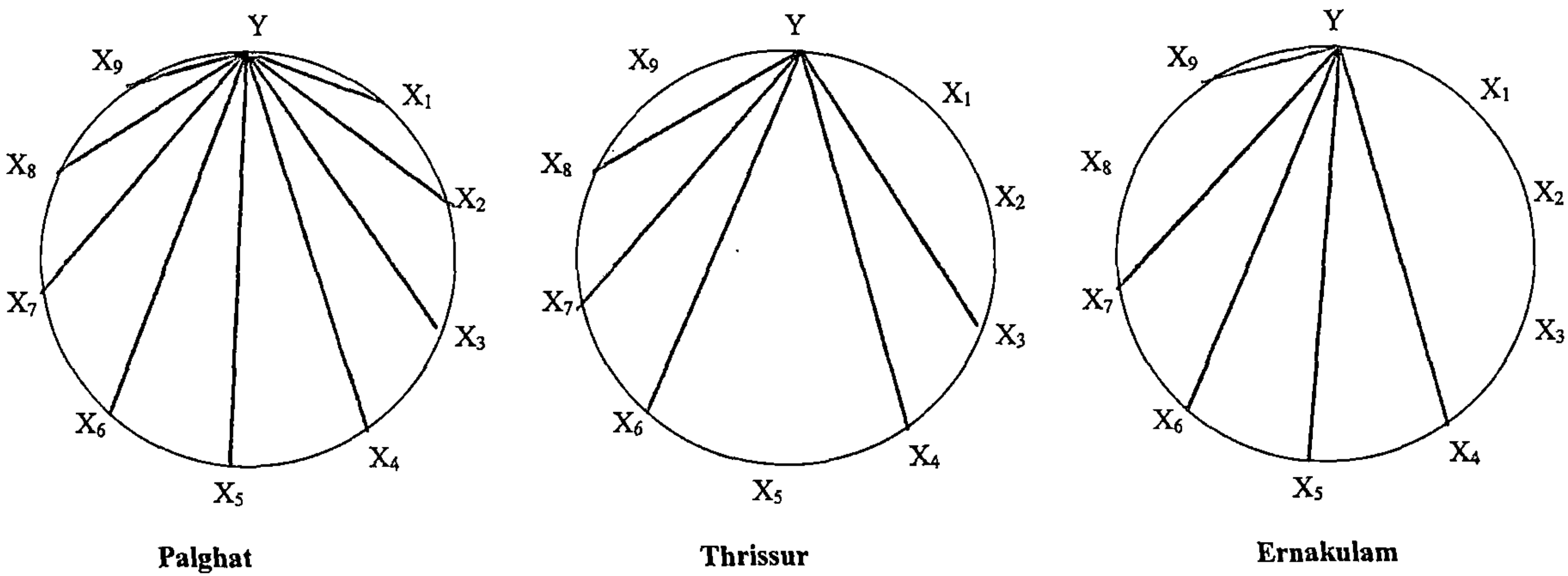
Studies on the association of characters is an important tool in Plant Breeding since it helps in determining the relationship of yield with its components, which in turn helps to select superior genotypes from diverse germ plasm. The estimates of genotypic and phenotypic correlations between various characters help to quantify the intensity and direction of association. Genotypic correlations provided a reliable measure of genetic association between characters helps to differentiate the vital association in breeding from non-vital ones (Falconer, 1981). The expression of quantitative characters to a large extent is influenced by the environment .The changes in the genetic association between characters in different locations also reflect the differential response of environment on the character. Comparative estimates of genetic correlation coefficients between yield and its constituent traits for different locations are presented graphically in Fig.3. In Thrissur and Ernakulam the significantly associated three characters, namely hulling percentage, milling percentage and volume expansion ratio were positively associated, whereas at Palghat

**Fig. 2. Heritability estimates for ten characters at three locations**



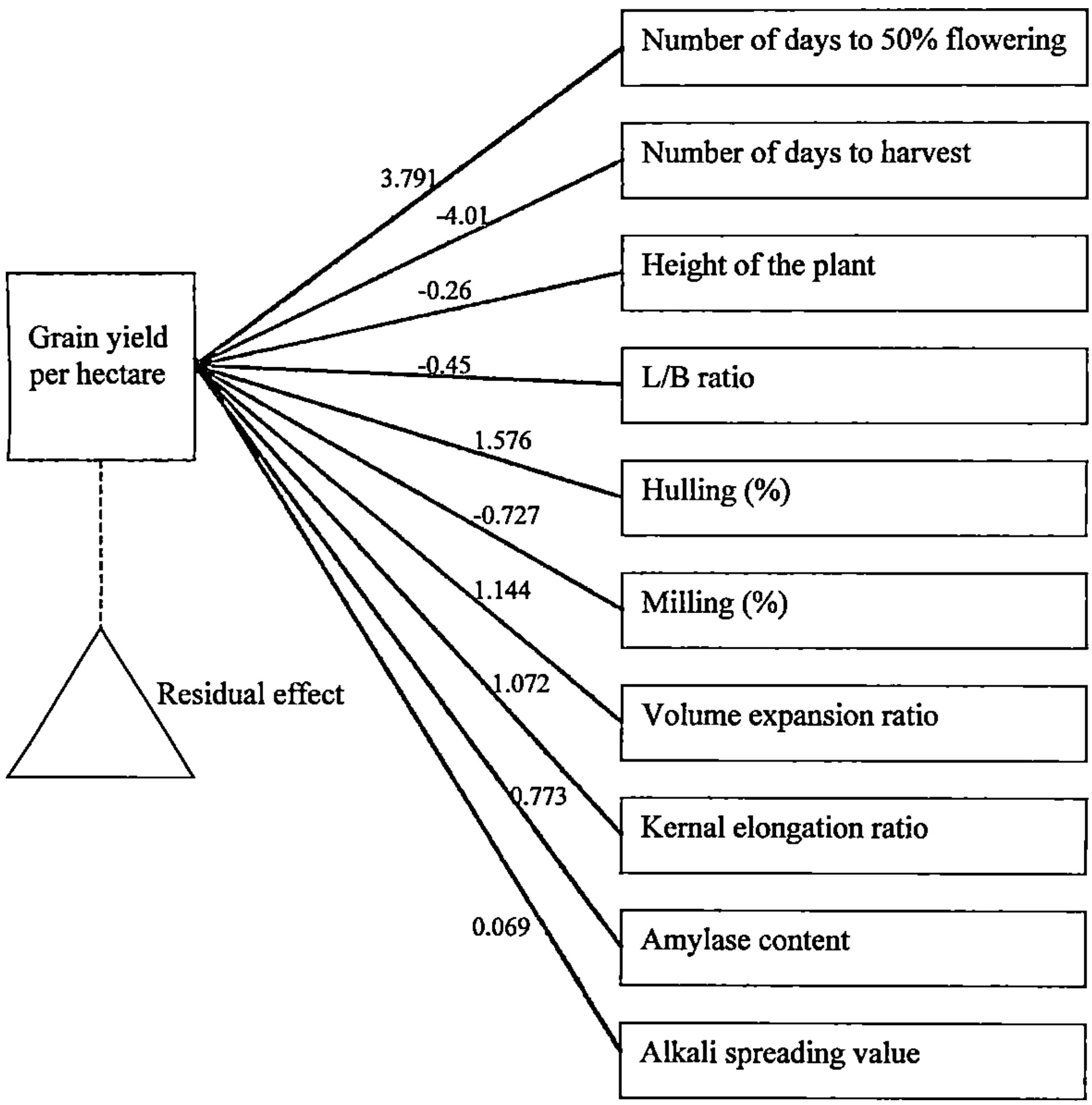

X1 - No. of days to flowering
X2 - No. of days to harvest
X3 - Height of the plant
X4 - Grain yield $ha^{-1}$
X5 - L/B ratio
X6 - Hulling percentage
X7 - Milling percentage
X8 - Volume expansion ratio
X9 - Kernal elongation ratio
X10 - Amylose content

**Fig. 3. Genotypic correlations among different characters in Kunjukunju rice**




$X_1$ = No. of days to 50% flowering
$X_2$ = No. of days to harvest
$X_3$ = Height of the plant
$X_4$ = L/B ratio
$X_5$ = Hulling percentage
$X_6$ = Milling percentage
$X_7$ = Volume expansion ratio
$X_8$ = Amylose content
$X_9$ = Alkali spreading value
Y = Yield

Red - Negative
Blue - Positive

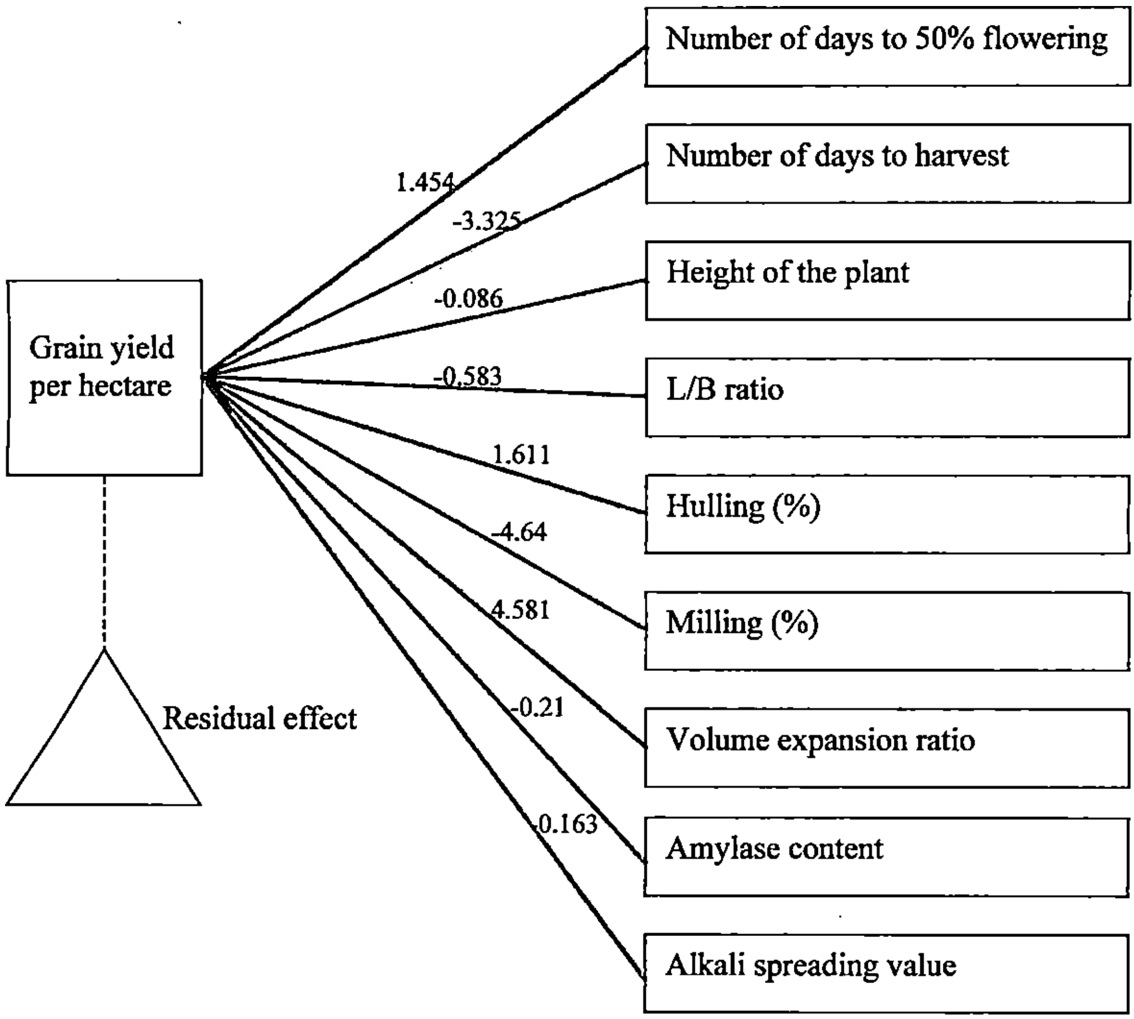



Blue lines - Positive direct effects
Red lines - Negative direct effects

**Fig. 4. Path diagram indicating direct and indirect effects of the component characters on yield at Palghat**

Contd.

Fig. 4. Continued

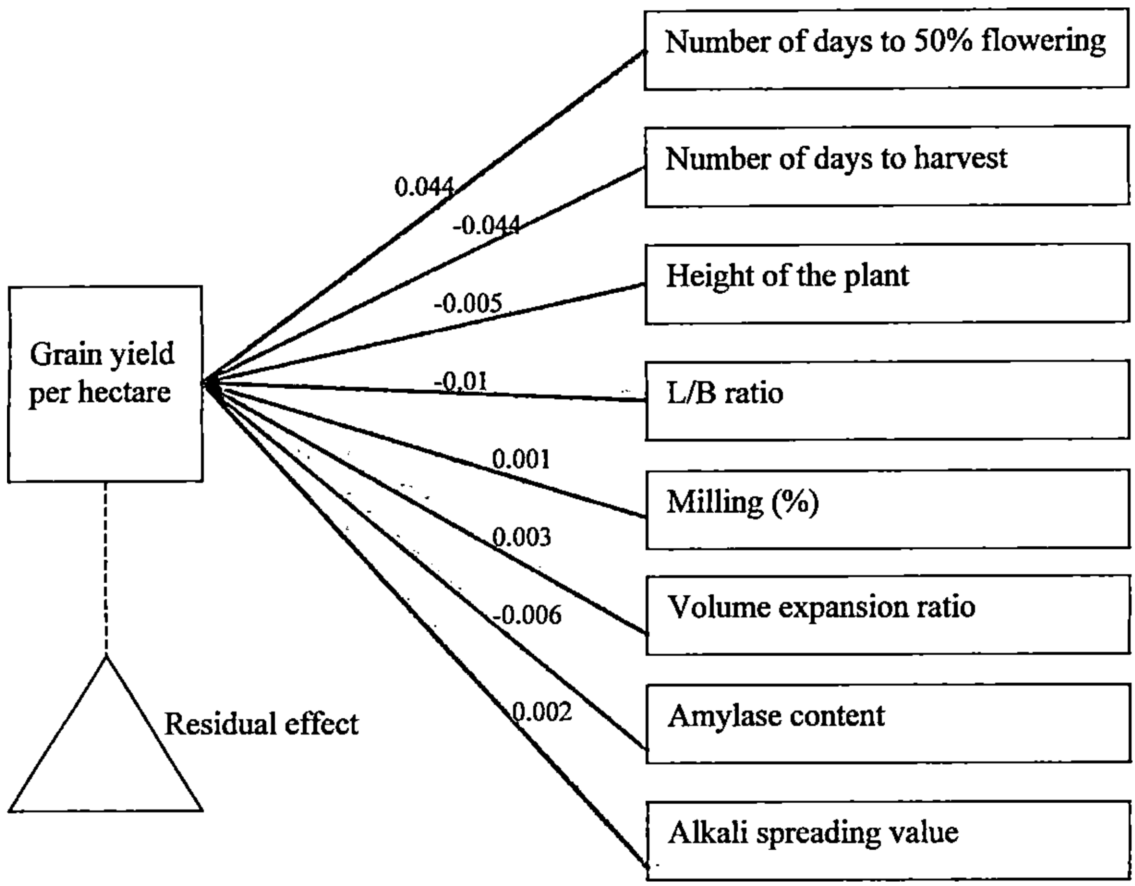



Blue lines - Positive direct effects
Red lines - Negative direct effects

**Fig. 4. Path diagram indicating direct and indirect effects of the component characters on yield at Thrissur**

Contd.

Fig. 4. Continued




Blue lines - Positive direct effects
Red lines - Negative direct effects

**Fig. 4. Path diagram indicating direct and indirect effects of the component characters on yield at Ernakulam**

only two characters hulling percentage and milling percentage were positively associated and the character volume expansion ratio was negatively associated to grain yield, showing differential response of environment in the expression of character. By considering the genotypic correlations between yield and its traits in all the three locations, characters hulling percentage and milling percentage were positively correlated with yield in all the three locations. At Palghat and Ernakulam the character L/B ratio showed significant negative association to yield indicating shorter bold grain can increase the grain yield in these two locations. Malik (1989) supports this study. The height of the plant at Thrissur positively associated to yield where as at Palghat it is negatively associated to yield indicating that an optimum height of the plant is necessary for having a better yield. Amirthadevarathinam (1993), Gravois and Mc New (1993) support the same. So also in the case of alkali spreading value which has positive association towards yield at Palghat and negative association at Ernakulam.

## 5.3 Path Analysis

Correlation studies are helpful in measuring the association of yield and yield components, but they do not provide a clear picture of the direct and indirect effects of associations. However, this can be obtained through path analysis. Path coefficient analysis is very much useful in identifying the important yield formulating selection parameters. Path coefficient analysis was developed by Wright (1923) and applied for first time in plant. Dewey and Lu (1959) furnished a mean for finding out the direct and indirect effects of individual components to final yield. In the present study, path coefficient analysis was performed taking nine yield components, which were significantly correlated with grain yield in any of the location. The cause and effect relationship between yield and its nine components in three locations are illustrated in Fig.4. The residual effect of path analysis of these three locations is ranged from 0.01-1.55 indicating that more than 95 per cent variation in grain yield was contributed genotypically by these selected yield components. Here also the direct and indirect effects of the constituent yield traits on yield differed from location to location, showing the fluctuations in the quantum of its contribution in relation to environment.

The characters number of days to flowering, hulling percentage and volume expansion ratio showed positive direct effect from the three locations towards yield but in different magnitudes. While number of days to harvest showed negative direct effect in all the three locations indicating more number of days for vegetative phase and shorter days for reproductive phase may be prerequisites for higher yield. Amylose content and alkali spreading value showed a positive direct effect towards yield at Ernakulam and Palghat but a negative direct effect at Thrissur indicating that these characters are influenced by environment. Height of the plant at Palghat and Thrissur showing negative direct effect, but with negative and positive genotypic correlations for Palghat and Thrissur respectively, which may be due to its indirect effect through other characters. The same trend was observed for the character L/B ratio and milling percentage also. Singh and Benerjee (1987), Reuben and Katuli (1989), Sardana *et al.* (1989), Ibrahim *et al.* (1990), Sarma and Roy (1993) and Marwat *et al.* (1994) absorbed similar results.

## 5.4 Stability Analysis

The aim of any breeding programme should be to develop genotypes that can withstand unpredictable, transient environmental fluctuations or in other words evolved varieties, which are widely adapted genotypes. All plant types can make a physiological adjustment, which permits them to cope with fluctuations in their immediate environment rather known as adaptations. This phenomenon also known as individual buffering and it is specific to genotype. The individual buffering in response to environment generally termed as GxE interaction. To assess this genotypic environment interaction or varietal adaptations mainly three parameters are used namely mean performance of that character, its regression coefficient and deviation from the regression environmental index. The performances of genotypes for each character in response to environment are discussed below.

**Number of days to 50 per cent flowering and number of days to harvest**

The variety Kanchana showed to be specially adapted to favourable environments, while local Kunjukunju was found to be more stable in different environments.

**Height of the plant**

The variety Kanchana showed to be specially adapted to unfavourable (poor) environments, while genotype K-10-3 was found to be more stable in different environments.

**Number of tillers per plant and number of panicles per plant**

The variety Kanchana showed to be specially adapted to favourable environments, while genotype K-10-2 was found to be more stable in different environments.

**Number of spikelets per panicle**

The genotype K-6 showed to be specially adapted to unfavourable environments, while genotype K-68-5 was found to be specially adapted to favourable environments.

**Grain yield per hectare**

The genotype K-6 has mean yield higher than the overall mean, with a regression coefficient nearer to unity (1.12) and with a minimum deviation showed to be stable and widely adapted. But genotype K-68-4 with lower mean performance than the average of all the varieties with a regression coefficient of 1.00 found to be poorly adapted to all the environments. Rao *et al.* (1996) and Singh *et al.* (1997) showed similar type of results in their studies.

**Straw yield per hectare**

The variety Kanchana showed to be specially adapted to favourable environments, while genotype K-6 was found to be more stable and well adapted to all environments.

**Per plant yield**

Genotype K-6 found to be well adapted to all the environments

**Pest and disease incidence**

The genotype Local Kunjukunju showed to be specially adapted to favourable environments, while genotype K-10-3 was found to be more stable in different environments.

**100 grain weight**

The genotype K-6 showed to be specially adapted to unfavourable environments.

**Density**

Genotype K-6 that recorded mean value higher than the overall mean with a regression coefficient nearer to unity and with zero deviation found to be stable and widely adapted to all the environments.

**L/B ratio**

The variety Kanchana showed to be specially adapted to favourable environments, while genotype K-6 was found to be poorly adapted to all the environments.

**Hulling percentage**

The genotype K-6 showed to be specially adapted to unfavourable environments, while genotype K-10-3 was found to be more stable in different environments.

**Milling percentage**

The genotype K-6 showed to be more stable and well adapted to all the environments.

**Water uptake**

The genotype K-67-5 showed to be specially adapted to favourable environments, while genotype K-68-6 was found to be more stable in different environments.

**Volume expansion ratio**

The variety Kanchana showed to be specially adapted to unfavourable (poor) environments, while genotype K-67-5 was found to be specially adapted to favourable environments.

**Kernel elongation ratio**

The genotype K-6 found to be specially adapted to favourable environments, while genotype Kanchana was found to be poorly adapted to all the environments.

**Amylose content**

The genotype K-67-5 showed to be specially adapted to favourable environments, while Local Kunjukunju was found to be poorly adapted to all the environments.

**PLATE:4 PROMISING KUNJU KUNJU RICE CULTURES**


**Alkali spreading value**

The genotype K-10-3 showed to be specially adapted to favourable environments, while genotype K-68-6 found to be widely adapted and stable to all the environments.

The relative contributions of the stability parameters of 20 characters at all the locations of the eight genotypes are presented in Table 14. Accordingly genotype K-6 which recorded preferentially first ranks in six characters, can be selected as most stable, high yielding and well adapted followed by K-10-3 which has secured first ranks for three characters, followed by K-10-2, local Kunjukunju with two each. Shantakumar *et al.* (1997), Honarnejad *et al.* (1999) and Shadakshari *et al.* (2001) conducted similar studies, which support the above findings.

Table 14. The relative contribution of the stability parameters of 20 characters on eight genotypes

| Genotype | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 | X9 | X10 | X11 | X12 | X13 | X14 | X15 | X16 | X17 | X18 | X19 | X20 | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K-6 | | | | | | | ✓ | ✓ | ✓ | | | ✓ | | | ✓ | | | ✓ | | | 6 |
| K-10-2 | | | | ✓ | ✓ | | | | | | | | | | | | | | | | 2 |
| K-10-3 | | | ✓ | | | | | | | ✓ | | | | ✓ | | | | | | | 3 |
| K-68-4 | | | | | | | | | | | | | | | | | | | | | 0 |
| K-67-5 | | | | | | | | | | | | | | | | | ✓ | | ✓ | | 2 |
| k-68-6 | | | | | | | | | | | | | | | | ✓ | | | | | 1 |
| Local Kunjukunju | ✓ | | | | | | | | | | | | | | | | | | | | 2 |
| Kanchana | | | | | | | | | | | | | | | | | | | | | 0 |

**PLATE:5 FIELD VIEW OF EXPERIMENTS AT PALGHAT,THRISSUR,ERNAKULAM**

# Summary

# 6. SUMMARY

Present study was undertaken to assess the yield stability of Kunjukunju - a popular short duration cultivar over various locations. The study was conducted in the Department of Plant Breeding and Genetics, Vellanikkara during 2001-02. The field experiments were laid out in three districts of Kerala namely Palghat, Thrissur and Ernakulam during Kharif 2001. The salient findings of the study are summarised below.

1. There were significant differences among the Kunjukunju cultures for many of the characters studied. These significant differences were not uniform among the locations.
2. Wide range of variations were noticed for all the characters studied and differential response to various environments indicated that materials selected were genetically different and locations identified were having different environments.
3. Heritability estimates were different in each location for the characters studied. For yield it was low in all the locations indicating that selection considering yield alone is not reliable.
4. Hulling percentage and milling percentage were positively associated with yield in all the locations.
5. Shorter bold grain can increase the grain yield in Palghat and Ernakulam locations.
6. At Palghat the association of height with yield indicated that an optimum height of the plant is necessary for having a better yield.
7. The direct and indirect effects of the constituent yield traits on yield differed from location to location.
8. Days to 50 per cent flowering, hulling percent and volume expansion ratio showed positive direct effect towards yield in all the three locations but in different magnitudes.
9. The variety Kanchana showed to be specially adapted only to favourable environments for the characters number of days to 50 per cent flowering, number of days to harvest, number of tillers per plant, number of panicles per plant, straw

yield per hectare and L/B ratio. It is unfavourable for poor environments for the characters like height of the plant and volume expansion ratio.

10. The Kunjukunju culture K-6 showed to be adapted to unfavourable environments for the characters number of spikelets per panicle, 100 grain weight and hulling percentage. It is found to be stable in different environments for the characters per plant grain yield, straw yield per hectare, density of the grain, hulling percentage, milling percentage and kernel elongation ratio.
11. Based on the relative contribution of stability parameters of 20 characters at all the locations K-6 recorded preferentially first rank in six characters followed by K-10-3 for three characters.
12. K-6 can be selected as most stable high yielding and well adapted Kunjukunju rice culture suitable for Palghat, Thrissur and Ernakulam locations studied.

# References

## REFERENCES


Ali, S.S., Jafri, S.J.H., Khan, T.Z., Mahmood, A. and Butt, M. 2000. Heritability of yield and yield components of rice. *Pakist. J. agric. Res.* 16(2): 89-91

Amirthadevarathinam, A. 1993. Genetic variability, correlation and path analysis of yield components in upland rice. *Madras agric. J.* 70: 781-785

Arumugachamy, S., Giridharan, S., Soundararaj, A.P.M.K., Vivekanandan, P., Anthoniraj, S. and Thiyagarajan, T.M. 1995. Milling characters of raw and parboiled popular rice cultivars. *Int. Rice Res. Newsl.* 20(1): 3

Atroch, A.L., Soares, A.A. and Ramalho, M.A.P. 2000. Adaptability and stability of lineages of upland rice evaluated in Minas Gerais. *Cienciae agrotechnologia* 24: 541-548

Azeez, M.H. and Shafi, M. 1966. *Quality in Rice.* Technical Bulletin No.13. Department of Agriculture, West Pakistan, p.50

Bala, A. 2001. Genetic variability association of characters and path coefficient analysis of saline and alkaline rice genotypes under rainfed conditions. *Madras agric. J.* 88: 356-357

Balan, A., Muthiah, A.R. and Boopathi, S.N.M. 1999. Genetic variability, character association and path coefficient analysis in rainfed rice under alkaline condition. *Madras agric. J.* 86: 122-124

Baruah, D.K., Lalitha, U.C. and Upadhaya, L.P. 1993. Bogabordhan: a stable, high yielding, low-input traditional variety of Assam, India. *Int. Rice Res. Notes.* 18(3): 22

Chaubey, P.K. and Richharia, A.K. 1993. Genetic variability, correlations and path coefficients in indica rices. *Indian J. Genet. Plant Breed.* 53: 356-360

Chaubey, P.K. and Singh, R.P. 1994. Genetic variability, correlation and path analysis of yield components of rice. *Madras agric. J.* 81: 468-470

Chauhan, J.S., Chauhan, V.S., Lodh, S.B. and Dash, A.B. 1992. Environmental influence on genetic parameters of quality components in rainfed upland rice (*Oryza sativa* L.). *Indian J. agric. Sci.* 62: 773-775

Datke, S.B., Kandalkar, H.G., Weginwar, D.H. and Allarwar, A.W. 1997. Study on variability in advanced generations of paddy strains. *J. Soils Crops* 7: 190-195

De, G.C., Modak, R. and Haque, F. 1994. Physical quality of rice grains of different cultivars. *Oryza* 31: 231-233

De, R.N., Rao, A.V.S., Reddy, J.N. and Roy, J.K. 1990. Phenotypic stability in early upland rice. *Crop Improv.* 17: 182-183

De, R.N., Reddy, J.N., Rao, A.V.S., Ramakrishnayya and Pande, K.C. 1992. Stability of rice yield under different low land situations. *Indian J. Genet. Plant Breed.* 52: 139-143

De, R.N., Seetharaman, R., Sinha, M.K. and Banerjee, S.P. 1988. Genetic divergence in rice. *Indian J. Genet.* 48: 189-194

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* 51: 515-518

Directorate of Rice Research (DRR). 1995. *Annual Report for 1994*. Directorate of Rice Research, Hyderabad, India, p.238

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* 6: 36-40

Falconer, D.S. 1981. *Introduction to Quantitative Genetics*. Second edition. Longman, London, p.286

Lokaprakash, R., Shivashankar, G., Mahadevappa, M., Gowda, B.T.S. and Kulkarni, R.S. 1992. Study on genetic variability, heritability and genetic advance in rice. *Indian J. Genet. Plant Breed.* 52: 416-421

Mahajan, C.R., Patil, P.A., Mehetre, S.S. and Hajare, D.N. 1993. Relationship of yield contributing characters to the grain yield in upland rice. *Ann. Plant Physiol.* 7: 266-269

Mahapatra, K.C. and Das, S. 1999. Stability of yield in relation to component traits in rice. *Oryza* 36: 301-305

Malik, S.S. 1989. Grain quality of some promising rice genotypes. *Int. Rice. Res. Newsl.* 14(4): 14-15

Marekar, R. and Siddique, M.A. 1996. Genetic variability and correlation studies in rice. *J. Maharashtra agric. Univ.* 21: 249-251

Marwat, K.B., Tahir, M., Khan, D.R. and Swati, M.S. 1994. Path coefficient analysis in rice (*Oryza sativa* L.). *Sarhad J. Agric.* 10: 547-551

Mirza, M.J., Faiz, F.A. and Majid, A. 1992. Correlation studies and path analysis of plant height, yield and yield components in rice (*Oryza sativa* L.). *Sarhad J. Agric.* 8: 647-653

Mishra, U., Mishra, N.C., Das, G.B. and Patra, G.J. 1996. Genetic variability interrelationship and performance of some scented rice genotypes. *Environment and Ecology* 14: 150-153

Onate, L.U. and Del Mundo, H.M. 1966. Eating quality of some varieties of low land rice. *Philipp. J. Agric.* 47: 208

Pantone, D.J., Baker, J.B. and Jordon, P.W. 1992. Path analysis of red rice (*Oryza sativa* L.) competition with cultivated rice. *Weed Sci.* 40: 313-319

Chaubey, P.K. and Singh, R.P. 1994. Genetic variability, correlation and path analysis of yield components of rice. *Madras agric. J.* 81: 468-470

Chauhan, J.S., Chauhan, V.S., Lodh, S.B. and Dash, A.B. 1992. Environmental influence on genetic parameters of quality components in rainfed upland rice (*Oryza sativa* L.). *Indian J. agric. Sci.* 62: 773-775

Datke, S.B., Kandalkar, H.G., Weginwar, D.H. and Allarwar, A.W. 1997. Study on variability in advanced generations of paddy strains. *J. Soils Crops* 7: 190-195

De, G.C., Modak, R. and Haque, F. 1994. Physical quality of rice grains of different cultivars. *Oryza* 31: 231-233

De, R.N., Rao, A.V.S., Reddy, J.N. and Roy, J.K. 1990. Phenotypic stability in early upland rice. *Crop Improv.* 17: 182-183

De, R.N., Reddy, J.N., Rao, A.V.S., Ramakrishnayya and Pande, K.C. 1992. Stability of rice yield under different low land situations. *Indian J. Genet. Plant Breed.* 52: 139-143

De, R.N., Seetharaman, R., Sinha, M.K. and Banerjee, S.P. 1988. Genetic divergence in rice. *Indian J. Genet.* 48: 189-194

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* 51: 515-518

Directorate of Rice Research (DRR). 1995. *Annual Report for 1994*. Directorate of Rice Research, Hyderabad, India, p.238

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Sci.* 6: 36-40

Falconer, D.S. 1981. *Introduction to Quantitative Genetics*. Second edition. Longman, London, p.286

Finley, K.W. and Wilkinson, G.N. 1963. The analysis of adoption in a plant breeding programme. *Aust. J. agric. Res.* 14: 742-754

Geetha, S., Soundararaj, A.P.M.K., Giridharan, S., Mohandas, S., Thiyagarajan, T.M. and Selvi, B. 1994. Stability analysis of some medium duration rice genotypes over different nitrogen levels. *Ann. agric. Res.* 15: 391-396

Ghosh, A.K. and Govindaswamy, S. 1972. Inheritance of starch iodine blue value and alkali digestion value in rice and their genetic association. *Indian J. agric. Sci.* 11: 423-432

Govindarasu, R. and Natarajan, M. 1995. Analysis of variability and correlation among high density grain characters in rice. *Madras agric. J.* 82: 681-682

Gravois, K.A. and Mc New, R.W. 1993. Genetic relationships among and selection for rice yield and yield components. *Crop Sci.* 33: 249-252

Hedge, S. and Vidyachandra, B. 1998. Yield stability analysis of rice hybrids. *Int. Rice Res. Notes* 23(2): 14

Honarnejad, R., Moin, M.J. and Donosti, H. 1999. Stability analysis of rice cultivars in some locations of Guilan province. *Indian J. agric. Sci.* 29: 723-732

Ibrahim, S.M., Ramalingam, A. and Subramanian, M. 1990. Path analysis of rice grain yield under rainfed lowland conditions. *Int. Rice Res. Newsl.* 15(1): 11

IRRI. 1972. *Annual Report for 1971.* International Rice Research Institute, Los Banos, Philippines, p.238

IRRI. 1980. *Standard Evaluation System for Rice.* International Rice Research Institute, Manila, Philippines, p.44

IRRI. 1995. *Standard Evaluation System for Rice.* International Rice Research Institute, Manila, Philippines, p.44

Janardhanam, V., Nadarajan, N. and Jebaraj, S. 2001. Correlation and path analysis in rice (*Oryza sativa* L.). *Madras agric. J.* 88: 719-720

Kandhola, S.S. and Panwar, D.V.S. 1999. Stability analysis for quality characters in rice. *Ann. agric. Res.* 20: 450-459

Kato, T. 1996. Heritability and genetic correlation for component characters of yield sink capacity in rice. *Int. Rice Res. Notes.* 21(1): 15

Kihupi, L.A. 1998. Inter-relationship between yield and some selected agronomic characters in rice. *Pakist. J. Sci. Res.* 6: 323-328

Kumar, G.S., Mahadevappa, M. and Rudraradhya, A. 1998. Studies on genetic variability, correlation and path analysis in rice during winter across the locations. *Karnataka J. agric. Sci.* 11(1): 73-77

Kumar, R., Krishnapal, Mondal, S.K., Rai, R. and Prasad, S.C. 1994. Genetic study of major characters in upland rice. *Environment and Ecology* 12: 363-365

Kumar, R. and Prasad, S.C. 1991. Stability analysis in upland rice. *Environment and Ecology* 9: 967-970

Lalitha, V.S.P. and Sreedhar, N. 1999. Estimates of genetic parameters for quality traits in rice. *Ann. agric. Res.* 20: 444-449

Lohithaswa, H.C., Bhushana, H.O., Basavarajaiah, D., Prasanna, H.C. and Kulkarni, R.S. 1999. Stability analysis of rice (*Oryza sativa* L.) hybrids. *Karnataka J. agric. Sci.* 12(1): 48-54

Lokanathan, T.R., Sakhare, R.S., Kamble, T.C. and Maheswari, J.J. 1991. Genetic variability and heritability in upland rice (*Oryza sativa* L.). *J. Soils Crops.* 1: 150-153

Lokaprakash, R., Shivashankar, G., Mahadevappa, M., Gowda, B.T.S. and Kulkarni, R.S. 1992. Study on genetic variability, heritability and genetic advance in rice. *Indian J. Genet. Plant Breed.* 52: 416-421

Mahajan, C.R., Patil, P.A., Mehetre, S.S. and Hajare, D.N. 1993. Relationship of yield contributing characters to the grain yield in upland rice. *Ann. Plant Physiol.* 7: 266-269

Mahapatra, K.C. and Das, S. 1999. Stability of yield in relation to component traits in rice. *Oryza* 36: 301-305

Malik, S.S. 1989. Grain quality of some promising rice genotypes. *Int. Rice. Res. Newsl.* 14(4): 14-15

Marekar, R. and Siddique, M.A. 1996. Genetic variability and correlation studies in rice. *J. Maharashtra agric. Univ.* 21: 249-251

Marwat, K.B., Tahir, M., Khan, D.R. and Swati, M.S. 1994. Path coefficient analysis in rice (*Oryza sativa* L.). *Sarhad J. Agric.* 10: 547-551

Mirza, M.J., Faiz, F.A. and Majid, A. 1992. Correlation studies and path analysis of plant height, yield and yield components in rice (*Oryza sativa* L.). *Sarhad J. Agric.* 8: 647-653

Mishra, U., Mishra, N.C., Das, G.B. and Patra, G.J. 1996. Genetic variability interrelationship and performance of some scented rice genotypes. *Environment and Ecology* 14: 150-153

Onate, L.U. and Del Mundo, H.M. 1966. Eating quality of some varieties of low land rice. *Philipp. J. Agric.* 47: 208

Pantone, D.J., Baker, J.B. and Jordon, P.W. 1992. Path analysis of red rice (*Oryza sativa* L.) competition with cultivated rice. *Weed Sci.* 40: 313-319

Panwar, A., Dhaka, R.P.S., Sharma, R.K. and Arya, K.P.S. 1997. Genetic variability and inter relationship in rice (*Oryxa sativa* L.). *Adv. Pl. Sci.* 10(1): 29-32

Patra, B.C. and Dhua, S. 1996. Exploration, collection and characterisation of Basmati rice germplasm in India. *Genetic Resources and Crop Evolution.* 23: 300-305

Paul, C.R. and Nanda, J.S. 1994. Path analysis of yield and yield components and construction of selection indices of direct-seeded rice: first season. *Madras agric. J.* 17:150-154

Priyanka, K., Mishra, S.B. and Thakur, R. 2000. Genetic variability for germination and seedling growth in rice (*Oryza sativa* L.) under cold stress. *Ann. agric. Res.* 21: 331-334

Rajarathinam, S. and Raja, V.D.G. 1992. Correlation and path analysis in some rice varieties under alkaline stress. *Madras agric. J.* 79: 374-378

Rao, K.S., Moorthy, B.T.S., Dash, A.b. and Lodh, S.B. 1996. Effect of time of transplanting on grain yield and quality traits of Basmati - type scented rice (*Oryza sativa*) varieties in coastal Orissa. *Indian J. agric. Sci.* 66: 333-337

Rao, S.S., Bhatnagar, A., Verma, R., Pandey, T.D. and Nandeha, K.L. 1996. Stability analysis of 13 early-duration upland rice genotypes in Bastan Plateau zone, Madhya Pradesh, India. *Int. Rice Res. Notes.* 21(1): 24-25

Reddy, J.N. 1992. Genetic parameters in early upland rice under different environments. *Orissa J. agric. Res.* 5(1-2): 58-62

Reddy, Y.S. and Kumar, P.V.R. 1996. Stability analysis for yield in rice (*Oryza saiva* L.). *New Botanist* 23(1-4): 135-138

Reuben, S.O.W.M. and Katuli, S.D. 1989. Path analysis of yield components and selected agronomic traits of upland rice breeding lines. *Int. Rice Res. Newsl.* 14(4): 11-12

Rosamma, C.A., Elsy, C.R. and Prabhakaran, P.V. 1993. IR 36 - derived lines are stable high yielders in Kerala. *Int. Rice Res. Notes*. 18(3): 20

Roy, A. and Panwar, D.V.S. 1994. The stability of some Indian and exotic genotypes of rice. *Ann. agric. Res.* 15: 147-151

Roy, A., Panwar, D.V.S. and Sharma, R.N. 1995. Genetic variability and causal relationships in rice. *Madras agric. J.* 82: 251-255

Roy, B., Hossain, M. and Hossain, F. 2001. Genetic variability in yield components of rice (*Oryza sativa* L.). *Environment and Ecology* 19: 186-189

Sadananda, A.R., Zaman, F.U. and Siddiq, E.A. 1987. Genetic variability for indices of major cooking and nutritive quality characters in rice (*Oryza sativa* L.) collections from northeast Indian hills. *Indian J. Genet.* 47: 249-255

Sadasivam, S. and Manickam, A. 1992. *Biochemical Methods*. New Age International Limited, Coimbatore, p.250

Sadhukhan, R.N. and Chattopadhyay, P. 2000. Variability and character association between yield attributes and grain quality in aromatic rice. *J. Interacademicia* 4: 494-497

Samonte, S.O. and Hernandez, J.E. 1991. Stability and adaptability analysis. *Philipp. J. Crop Sci.* 16(1): 7-14

Sarawgi, A.K., Rastogi, N.K. and Soni, D.K. 2000. Studies on some quality parameters of indigenous rice in Madhya Pradesh. *Ann. agric. Res.* 21: 258-261

Sarawgi, A.K. and Soni, D.K. 1994. Variability analysis in rice under irrigated and rainfed situations. *Current Res. Univ. agric. Sci. Bangalore* 23(3-4): 33-35

Sardana, S., Sasikumar, B. and Modak, D. 1989. Variability and path analysis in fixed cultures of rice. *Oryza* 26: 250-251

Sarma, R.N. and Roy, A. 1993. Studies on variability and interrelationship of yield attributes in Jhum rice. *Ann. agric. Res*. 14: 311-316

Satyavathi, L.T., Bharadwaj, C. and Subramanyam, D. 2001. Variability correlation and path analysis in rice varieties under different spacings. *Indian J. agric. Res.* 35(2): 79-84

Sawant, D.S. and Patil, S.L. 1995. Genetic variability and heritability in rice. *Ann. agric. Res.* 16: 59-61

Shadakshari, Y.G., Chandrappa, H.M., Kulkarni, R.S. and Shashidhar, H.E. 2001. Genotype x environment interaction in low land rice genotypes of hill zone of Karnataka. *Indian J. Genet. Plant Breed.* 61: 350-352

Shantakumar, G., Kulkarni, R.S. and Jagadeesha, R.C. 1997. Stability analysis in rice. *Karnataka J. agric. Sci.* 10(1): 67-70

Shanthakumar, G., Mahadevappa, M. and Rudraradhya, R. 1998. Studies on genetic variability, correlation and path analysis in rice (*Oryza sativa* L.). *Karnataka J. agric. Sci.* 11(1): 73-77

Shouichi, Y., Douglasa, F., James, H.C. and Kwanchai, A.G. 1976. Physiological Studies of Rice. *Indian J. Genet.* 47:99-103

Singh, A., Chabra, B.S., Sabharwal, P.S. and Singh, A. 1997. Stability analysis for yield and its components in rice (*Oryza sativa* L.). *Indian J. agric. Res.* 31(3): 149-155

Singh, A., Singh, G., Bhutia, D.T. and Awasthi, R.P. 1995. Genotype x environment interaction in rice (*Oryza sativa* L.). *Indian J. agric. Sci.* 65: 832-833

Singh, L., Singh, J.D. and Sachan, N.S. 2002. Intercharacter association and path analysis in paddy (*Oryza sativa* L.). *Ann. Biol.* 18(2): 125-128

Smita, M. and Mahapatra, K.C. 1998. Yield stability of early rice varieties in stratified environments. *Oryza* 35: 109-112

Singh, M.K. and Benerjee, S.P. 1987. Path analysis of yield components in rice. *Kasetsart J. Natural Sci.* 21(1): 86-92

Singh, N.K., Sharma, V.K. and Jha, P.B. 1993. Components of genetic variations in yield traits of rice. *Ann. agric. Res.* 14: 292-296

Singh, R.K. and Chaudhary, B.D. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi, p.182

Singh, S.K., Maurya, D.M. and Singh, R.S. 1990. Character association and path of action in low-land rice cultivars of Uttar Pradesh. *Narendra Deva J. agric. Res.* 5(1): 91-95

Snedecor, G.W. 1961. *Statistical Methods.* The Iowa State University Press, Iowa, USA. p.388

State Planning Board. 1998. *Economic Review.* State Planning Board, Thiruvananthapuram, p.267

Sundaram, T. and Palanisamy, S. 1994. Path analysis in early rice (*Oryza sativa* L.). *Madras agric. J.* 81: 28-29

Thakur, S.K., Choubey, S.K. and Sharma, N.P. 1999. Genetic variability and character association in $F_2$ (Anupama x IR 36) population in rice (*Oryza sativa* L.). *agric. Sci. Digest (Karnal)* 19(3): 187-190

Thakur, S.K., Sharma, N.P. and Sharma, S.N. 2000. Genetic variation and association studies in regregating population of rice (*Oryza sativa* L.). *J. Soils Crops* 10: 316-318

Tripathi, A., Sinha, S.K. and Bhandarkar, S. 1999. Studies on variability, heritability and genetic advance of semi deep water rice. *Adv. Pl. Sci.* 12: 233-235

Vishwakarma, D.N., Lalji, Maurya, D.M. and Maurya, K.N. 1989. Heritability and genetic advance for yield and its components in rice (*Oryza sativa* L.). *Narendra Deva J. agric. Res.* 4(1): 37-39

Witcombe, J.R., Joshi, A., Joshi, K.D. and Sthapit, B.R. 1996. Farmers participatory crop improvement-I. Varietal selection and breeding methods and their impact on biodiversity. *Exp. Agric.* 32: 445-460

Wright, S. 1923. The theory of path coefficients. *Genet.* 8:239-355

Yadav, R.B., Dubey, R.K., Srivastava, M.K. and Sharma, K.K. 1995. Path coefficient analysis under three densities in rice. *J. Soils Crops* 5: 43-45

Yadav, R.K. 2000. Studies on genetic variability for some quantitative characters in rice (*Oryza sativa* L.). *Adv. agric. Res. Ind.* 13: 205-207

# STABILITY ANALYSIS OF KUNJUKUNJU RICE CULTURES (*Oryza sativa* L.)

By

JYOTHI, R.

## ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the requirement for the degree of

# Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Plant Breeding and Genetics
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

2002

# ABSTRACT

Stability analysis for Kunjukunju rice cultures in three locations of Palghat, Thrissur and Ernakulam was conducted at Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara during 2001-2002. Among the eight Kunjukunju rice cultures studied the Kunjukunju rice culture K-6 was found to be stable in different environments for many of the yield and yield traits. It can be selected as the most stable, high yielding and well adapted Kunjukunju rice culture suitable for Palghat, Thrissur and Ernakulam locations. The variety Kanchana showed to be specially adapted only to favourable environments for many of the yield traits and found to be unfavourable for many environments.