STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES

A. SHIVA KUMAR
B.Sc. (Ag.)

MASTER OF SCIENCE IN AGRICULTURE
(GENETICS AND PLANT BREEDING)

2014

STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES

BY

A.SHIVA KUMAR

B.Sc. (Ag.)

THESIS SUBMITTED TO THE ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THEAWARD OF THE DEGREE OF

MASTER OF SCIENCE IN AGRICULTURE
(GENETICS AND PLANT BREEDING)

CHAIRPERSON: Dr. J.SURESH

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE
RAJENDRANAGAR, HYDERABAD-500 030
ACHARYA N. G. RANGA AGRICULTURAL UNIVERSITY

2014

DECLARATION

I, **A. SHIVA KUMAR** hereby declare that the thesis entitled **"STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (O*ryza satva* L.) GENOTYPES"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Science in Agriculture** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

Place: Hyderabad **(A. SHIVA KUMAR)**

Date: **I.D. No. RAM/2012-47**

CERTIFICATE

Mr. A. SHIVA KUMAR has satisfactorily prosecuted the course of research and that the thesis entitled **"STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by him for a degree of any University.

Date:

(Dr. J.SURESH)
Chairperson

CERTIFICATE

This is to certify that the thesis entitled **"STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES "** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** of the Acharya N.G. Ranga Agricultural University, Hyderabad is a record of the bonafide research work carried out by **Mr. A. SHIVA KUMAR** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma or has been published. The published part has been fully acknowledged. All the assistance and help received during the course of investigation have been duly acknowledged by the author of the thesis.

(Dr. J. SURESH)
Chairperson of the Advisory Committee

Thesis approved by the Student's Advisory Committee

Chairperson : **Dr. J.SURESH**
Assistant Professor,
Department of Genetics and Plant Breeding,
College of Agriculture,
Rajendranagar, Hyderabad-500 030. __________________

Member : **Dr. L.V.Subba Rao**
Principal Scientist, Nodal officer(DUS),
Crop Improvement Section,
Directorate of Rice Research,
Rajendranagar, Hyderabad-500 030. __________________

Member : **Dr.Ch. Syam raj Naik**
Associate Professor,
Dept. of Crop physiology
Additional comptroller of Examinations, __________________
Administrative office,
Rajendranagar, Hyderabad-500 030.

LIST OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

LIST OF SYMBOLS AND ABBREVIATIONS

%	:	per cent
<	:	less than
>	:	more than
µ	:	Mean
b_i	:	Regression coefficient
S^2di	:	Deviation from regression
ANOVA	:	Analysis of variance
C.D.	:	Critical difference
C.V.	:	Coefficient of variation
cm	:	centimeter
d.f.	:	degrees of freedom
et al.	:	and others
etc	:	And more
Fig.	:	Figure
G x E	:	Genotype x Environment
g	:	gram
i.e.	:	that is
ml	:	millilitre
PCV	:	Phenotypic Coefficient of Variation
GCV	:	Genotypic Coefficient of Variation
MSS	:	Mean Sum of Squares
No.	:	Number
RBD	:	Randomized Block Design
S.E	:	Standard Error
S.Em	:	Standard Error of mean
viz.	:	namely
Vs.	:	versus

ACKNOWLEDGEMENTS

First and foremost, I offer my obeisance to Lord ***'shiva'*** for his boundless blessing, which accompanied me in all the endeavours.

I am pleased to place my profound etiquette to ***Dr. J. Suresh,*** Assistant Professor, Department of Genetics and Plant Breeding, College of Agriculture, Rajendranagar, Hyderabad and esteemed Chairman of my Advisory Committee for his learned counsel, unstinted attention, arduous and meticulous guidance on the work in all stages. His keen interest, patient hearing and constructive criticism have installed in me the spirit of confidence to successfully complete the task.

I deem it my privilege in expressing my fidelity to ***Dr.L.V. Subba Rao,*** Principal Scientist, Nodal officer(DUS), Crop improvement section, Directorate of Rice Research, Hyderabad and member of my Advisory Committee for her munificent acquiescence and meticulous reasoning to refine this thesis and most explicitly to reckon with set standards. Ineffable in my gratitude and sincere thanks to him for her transcendent suggestions and efforts to embellish the study.

I sincerely extend my profound gratitude and appreciation to the member of my advisory committee to ***Dr. Ch. SyamrajNaik,*** Associate Professor, Department of Crop Physiology, College of Agriculture, Rajendranagar, Hyderabad, for his valuable help and cooperation during the course of my study.

I feel a great privilege in placing on record my profound thanks to ***Dr. M. V. Brahmeshwara Rao,*** Professor and Head (retired), ***Dr. T. Dayakar Reddy*** Professor and Head**,** and it's an immense pleasure to express great, heartfelt respect to my beloved teachers ***Dr. S. Sudheer Kumar, Dr. K. Radhakrishna, Dr. N.A. Ansari, Dr. Kuldeep Singh*** and ***Dr. M., Bharathi ,*** Professors, ***Dr. M. Sujatha, Dr. Farzana Jabeen, Dr.V. Hemalatha Dr. K. Radhika*** and ***Dr.K.B. Eshwari*** Associate Professors and ***Dr.Gopala krishna*** Assistant Professor who have guided me, all the way to reach up to this level.

I owe my special debt of sincere gratitude and appreciation to my beloved teacher ***Dr.P.Saidaiah,*** Assistant Professor, Department of Genetics and Plant Breeding, College of Horticulture, Rajendranagar, Hyderabad.

Words are not enough to express my whole-hearted and affectionate gratitude to my beloved parents ***Sri. A.Mallesh*** and ***Smt. A.Pushpa latha*** for their unbounding love, unparallel affection and unstinted encouragement throughout my educational career and without whose invaluable moral support, the thesis would not have seen the light of the day.

With boundless affection, I would heartly acknowledge the constant encouragement, co-operation and enthusiasm given to me by beloved brothers ***A.Srikanth (chanti), Nivas and*** sister-in-laws ***Bujji*** and ***Nandini.***

No words are enough to express the affection to my special friends ***Tirupathi, Sridhar, Dambadu (Vijay), Sai, Shilpakala, Sravanthi, Saritha, Uma, Shalini, pilli vijay, Ajay*** and ***Puja*** for their help, guidance, constant encouragement and companionship in my personal and professional life.

I express my heartfelt gratitude and thanks to my Divisional Seniors ***Shiva Prasad, Yella goud***, ***Madhukar, Rajesh, Ravikiran, Srikanth, G.P, Prashanth, Prasanna, Parimala, Sumalini, Swarna, Lingaiah, Sukumar, Sadaiah, M.S.Reddy, Rajender, Sravani, Parushuram*** and **Mahadev** for their valuable guidance and encouragement.

It is a great pleasure to acknowledge the affection and inspiration rendered by my junior friends ***J.P, Naveen, Srijan, Kalyan, Mahesh, Sreejan, Shiva, Shankar, Ravindra, Suresh, Santhosh, Rajkumar, Vigneshwari, Nirosha, Ramya, Priyanka*** and ***Susmitha.***

It is a pleasure to acknowledge the affection and inspiration rendered by my department friends, ***Rakesh, Sandeep, Uma Nagesh, Durga Raju, Sriram, R.P, Mahantesh, Meena, Sandeep, Steffi, Vandana, Pragnya, Shruthi, Swapna*** **and** ***Shankar*** for their moral support during research work.

I humbly thank the authorities of ***Acharya N.G. Ranga Agricultural University*** and ***Government of Andhra Pradesh*** for the financial help in the form of stipend during my study period.

Finally, I wish my humble thanks to one and all who have directly or indirectly contributed to the conduct of the study.

(A. SHIVA KUMAR)

Name of the student	:	**A. SHIVA KUMAR**
Title of the thesis	:	**STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES**
Degree to which it is submitted	:	**MASTER OF SCIENCE IN AGRICULTURE**
Faculty	:	**AGRICULTURE**
Department	:	**GENETICS AND PLANT BREEDING**
Major Advisor	:	**DR. J.SURESH**
University	:	**ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY**
Year of submission	:	**2014**

ABSTRACT

The present investigation entitled "Studies on stability analysis of elite medium duration rice (*Oryza sativa* L.) genotypes" was undertaken to study genetic variability parameters and stability of advance varietal trail with medium duration group genotypes for yield and yield attributing characters.

The twenty two rice genotypes including checks were evaluated at three different locations situated at different agro-climatic regions of Andhra Pradesh *viz.*, Directorate of Rice Research farm at ICRISAT, Medak (Central Telangana Zone), Regional Agricultural Research Station, Warangal (Central Telangana Zone) and Regional Agricultural Research Station, Maruteru (Godavari Zone) for studying stability for nine characters *viz.*, days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, total number of grains per panicle, spikelet sterility per cent, 1000- seed weight and grain yield per plant.

The pooled analysis of variance revealed significant difference due to environments for most of the characters indicating significant variation among the environments. Further, partitioning of G x E interaction resulted in significance of both linear and non-linear components for plant height, productive tillers, per cent of sterility and grain yield per plant.

High heritability and genetic advance were recorded for the grain yield per plant. High heritability coupled with high genetic advance for plant height, total number of grains per panicle, 1000-seed weight and grain yield per plant indicated that these traits were chiefly controlled by additive gene action. As such selection to isolate promising pure lines was suggested for their further improvement. High heritability coupled with low genetic advance for panicle length and number of filled grains per panicle suggested

that these traits were under the influence of non-additive gene action, for which heterosis breeding and recurrent selection would be more rewarding.

Based on environmental indices, the location Warangal was best among three locations for yield and most of the yield traits. The same location may used for further studies to expect yield stability in rice in future.

For the character grain yield per plant, among the genotypes 1703 and 1704 were stable in yield performance over all three locations based on Eberhart and Russel (1966) stability criteria. These two genotypes also showed stable performance for the characters *viz.*, days to 50 per cent flowering, productive tillers per plant, number of filled grains per panicle and total number of grains per panicle indicating greater scope of their cultivation under low input management to break the present yield barrier.

CHAPTER I

INTRODUCTION

Rice is one of the most ancient food crops being cultivated in 117 countries, hence called as "Global Grain". It is one of the top five major cereal crop and is a major staple food supporting more than three billion people and represents 50 to 80 per cent of their daily calorie intake in India, rice occupying nearly 43.97 million hectares with an annual production of 104.32 million tonnes and productivity of 2372 kg per hectare. While in Andhra Pradesh, rice is grown in an area of 40.75 lakh hectares with an annual production and productivity of 14.41 lakh tonnes and 3003 kg per hectare respectively (Indiastat, 2013).

Rice farming needs to be made remunerative for farmers and at the same time, the produce should remain competitively priced in global market. Yield improvement is a major target to meet the public demand. Now, the globalization, climate changes, global warming and food security buffers triggered a competitive pricing policy and quality - consumer demand.

Medium duration rice varieties have advantage over the short duration rice varieties due to in short duration rice varieties the crop growth period is reduced so as such yield is also reduced.

India became self sufficient in rice in early1980's mainly due to the development of new plant type based semi dwarf, high yielding varieties coupled with the adoption of improved management practices. But of late, plateauing trend in rice production is observed. To sustain the self sufficiency achieved in rice, in coming decades the production needs to be increased every year by almost two million tonnes. This is a challenging task to meet this demand in the background of shrinking land, dwindling water resources and non availability and sky rocketing costs of labour. This increase in targeted stable production level has to be achieved without disturbing the environmental balance.

The phenotype is the product of the genotype of a particular environment. At times a potential genotype may fail to reach an optimum phenotypic expression due to decrease in correlation between the genotypes, due to the interactions between the genotypes and the environment. It is commonly observed that, even within a season there are fluctuations in the yielding ability of the varieties when planted on different dates. Therefore, it is a long felt need to identify or develop stable genotypes to different environmental conditions.

In static concept, the term stability was used to characterize a genotype which always shows a constant performance whatever the environmental conditions might be. According to the dynamic concept, a stable genotype is one which gives predictable performance over environments without any deviation (Becker and Leon, 1988). Consistent performance in respect to productivity over a wide range of environments is one of the most desirable properties of a genotype to be released as a variety or hybrid. Genotype and Environment interactions are important in developing stable genotypes which interact less with the environment. Rice breeding aims at developing high yielding and stable genotypes.

Yield is a polygenically controlled complex character and highly influenced by genotype and environment interactions. Hence, developing a stable variety with high yield potential and good grain quality is of paramount importance to the plant breeder through selection of varieties that interact less with environment in which they are grown. Evaluation of genotype x environment interaction gives an idea of the buffering capacity of the rice genotypes under different environments, there by enabling plant breeder to recommend appropriate varieties to suit for Andhra Pradesh, particularly for *kharif* season.

Hence keeping in view of the above background, the present study was conducted with the following objectives.

1. To study the genotypic and phenotypic coefficients of variation, genetic advance and heritability.
2. To study the Genotype x Environment interaction for yield and yield components.
3. To identify stable, high yielding genotypes to suit for *kharif* season in Andhra Pradesh.

CHAPTER II

REVIEW OF LITERATURE

The present investigation is aimed at studying mainly the stability of rice genotypes for yield and yield contributing characters during *kharif* season.

A brief review of literature in consonance with the objectives of the present investigation in respect of this crop are reviewed and presented under the following heads.

2.1 To study the Genotypic and Phenotypic coefficients of variation

2.2 To study the heritability and genetic advance

2.3 Stability analysis

2.1 Genetic variability

The nature and extent of variability forms the basis for all crop improvement programmes. According to Allard (1960), yield is polygenically controlled quantitative character and is highly influenced by environment.

Partitioning of observed variability into heritable and non-heritable components is very much essential to get a true indication of the genetic coefficient of variability as a useful measure of the magnitude of genetic variance present in the population.

A brief review of studies on genotypic and phenotypic coefficients of variation in rice is presented in table.

S.No.	Character	Range	Reference
1.	Days to 50 per cent flowering	High	Awasthi and Pandey (2000) Patil and Sarawgi (2005) Rita Bisne *et al.* (2009) Nandan *et al.* (2010) Mulugeta Seyoum *et al.* (2012)
		Moderate	Chikkalingaiagh *et al.* (1999)

S.No.	Character	Range	Reference
			Jaiswal *et al*. (2007) Yadav *et al*. (2010) Selvaraj *et al*. (2011)
		Low	Patil *et al*. (2003) Sinha *et al*. (2004) Krishna *et al*. (2008) Vijayalakshmi *et al*. (2008) Chandra (2009) Khan *et al*. (2009) Ullah *et al*. (2011) Manoj Kumar Prajapate (2011) Rajendar *et al*. (2013) Shiva Prasad *et al*. (2013)
2.	Plant height(cm)	High	Awasthi and Pandey (2000) Sinha *et al*. (2004) Jaiswal *et al*. (2007) Nandan *et al*. (2010) Yadav *et al*. (2010) Akhtar *et al*. (2011) Mulugeta Seyoum *et al*. (2012)
		Moderate	Shiavani and Reddy (2000) Tara Satyavathi *et al*. (2001) Nayak *et al*. (2002) Bisne and Motiramani (2006) Krishna *et al*. (2008) Chandra *et al*. (2009) Jayasudha and Sharma (2010) Selvaraj *et al*. (2011)
		Low	Chikkalingaiah *et al*. (1999)

S.No.	Character	Range	Reference
			Patil *et al*. (2003) Qamar *et al*. (2005) Kole *et al*. (2008) Khan *et al*. (2009) Ullah *et al*. (2011) Rajendar *et al*. (2013)
3.	Number of productive tillers per plant	High	Shivani and Reddy (2000) Sinha *et al*. (2004) Patil and Sarawgi (2005) Jaiswal *et al*. (2007) Nayudu *et al*. (2007) Chandra *et al*. (2009) Ghosal *et al*. (2010) Jayasudha and Sharma(2010) Akhtar *et al*. (2011) Padmaja *et al*. (2011) Rajendar *et al*. (2013) Shiva Prasad *et al*. (2013)
		Moderate	Vange and Ojo (1997) Nagajyothi (2001) Qamar *et al*. (2005) Krishna *et al*. (2008) Chandra et *al*. (2009)
		Low	Niranjana Murthy *et al*. (1999) Tara Satyavathi *et al*. (2001) Surender Raju (2002) Pankaj Garg *et al*. (2010).
4.	Panicle length (cm)	High	Kaw *et al*. (1999) Tripathi *et al*. (1999) Nayudu *et al*. (2007)

S.No.	Character	Range	Reference
		Moderate	Nayak *et al*. (2002) Jaiswal *et al*. (2007) Jayasudha and Sharma (2010) Nandan *et al*. (2010)
		Low	Shivani and Reddy (2000) Tara Satyavathi *et al*. (2001) Patil *et al*. (2003) Bisne and Motiramani (2006) Kole *et al.* (2008) Krishna *et al*. (2008) Chandra *et al*. (2009) Manoj Kumar Prajapate (2011) Serlvaraj *et al*. (2011) Rajendar *et al*. (2013)
5.	Number of filled grains per panicle.	High	Shivani and Reddy (2000) Nayak *et al.* (2002) Patil and Sarawgi (2005) Nayudu *et al*. (2007) Krishna *et al*. (2008) Nandan *et al*. (2010) Pankaj Garg *et al*. (2010) Mulugeta Seyoum *et al*. (2012) Rajendar *et al*. (2013)
		Moderaet	Sarma and Roy (1993) Tara Satyavathi *et al.* (2001) Kole *et al.* (2008) Selvaraj *et al*. (2011)
		Low	Nath and Talukdar (1997) Khan *et al*. (2009)

S.No.	Character	Range	Reference
6.	Total number of grains per panicle	High	Salam *et al*. (2009) Akthar *et al*. (2011) Senthil Kumar *et al*. (2011) Mulugeta Seyoum *et al*. *(*2012)
7.	Spikelet sterility percent	High	Chakraborty *et al*. (2010) Ghosal *et al*. (2010) Parikh *et al*. (2012) Shiva Prasad *et al*. (2013)
8.	1000 grain weight (g)	High	Patil and Sarawgi (2005) Nayudu *et al*. (2007) Chandra *et al*. (2009) Nandan *et al*. (2010) Mulugeta seyoum *et al*. (2012)
		Moderate	Nayak *et al*. (2002) Chandra *et al*. (2009) Selvaraj *et al*. (2011) Ullah *et al*. (2011)
		Low	Chikkalingaiah *et al*. (1999) Vange *et al*. (1999) Tara Satyavathi *et al*. (2001) Yadav *et al*. (2010) Rajendar *et al*. (2013)
9.	Grain yield per plant (g)	High	Shivani and Reddy (2000) Sinha *et al*. (2004) Bisne and Motiramana (2006) Jaiswal *et al*. (2007) Nayudu *et al*. (2007) Anbanandan *et al*. (2009)

S.No.	Character	Range	Reference
			Pankaj Garg *et al*. (2010) Selvaraj *et al*. (2011) Mulugeta seyoum *et al.* (2012) Rajendar *et al*. (2013) Shiva Prasad *et al*. (2013)
		Moderate	Nagajyothi (2001) Tara Satyavathi *et al*. (2001) Qamar *et al*. (2005) Chandra *et al*. (2009) Ullah *et al*. (2011)
		Low	Supriyo Chakraborthy and Hazarika (1994) Khan *et al*. (2009) Rajendar *et al*. (2013)

2.2.1 Heritability

Heritability in broad sense refers to the genetic variation present in the population in relation to the total observed variance. Consistency in the performance of selection in succeeding generations depends on the magnitude of heritable variation present in relation to observed variation. Basic information on heritability is a pre requisite for planning any breeding programme. High heritability indicates that it should be easy to conduct effective selection for the trait

A brief review of studies on heritability in rice is presented in table.

S.No.	Character	Range	Reference
1.	Days to 50 per cent flowering	High	Nayak *et al.* (2002) Sankar *et al.* (2006) Bharadwaj *et al.* (2007) Jaiswal *et al*. (2007)

S.No.	Character	Range	Reference
			Kishore *et al.* (2008) Krishna *et al.* (2008) Jayasudha and sharma (2010) Yadav *et al.* (2010) Selvaraj *et al.* (2011) Ullah *et al.* (2011) Shiva Prasad *et al.* (2013)
		Medium	Sahdev Singh *et al.* (1996) Singh and Choudhary (1996) Rajendar *et al.* (2013)
2.	Plant height (cm)	High	Shivani and Reddy (2000) Bisne and motiramani (2006) Bharadwaj *et al.* (2007) Jaiswal *et al.* (2007) Kumar and Ramesh (2008) Chandra *et al.* (2009) Yadav *et al.* (2010) Akhtar *et al.* (2011) Selvaraj *et al.* (2011) Mulugeta Seyoum *et al.* (2012) Ravindra Babu *et al.* (2012) Shiva Prasad *et al.* (2013)
		Moderate	Sinha *et al.* (2004) Akinwale *et al.* (2011)
		Low	Vijayalakshmi *et al.* (2008) Rajendar *et al.* (2013)

S.No.	Character	Range	Reference
3.	Number of productive tillers per plant	High	Shivani and Reddy (2000) Patil and Sarawgi (2005) Bisne and motiramani (2006) Sankar *et al.* (2006) Nayudu *et al.* (2007) Chandra *et al.* (2009) Anbanandan *et al.* (2009) Nandan and Sweta Singh(2010) selvaraj *et al.* (2011) Shiva Prasad *et al.* (2013)
		Moderate	Satya Priya Lalitha and Sreedhar (1996) Venkata Suresh (2001)
		Low	Ramesh Kumar (1989) Niranjana Murthy *et al.* (1999) Rajendar *et al.* (2013)
4.	Panicle length (cm)	High	Chikkalingaiah *et al.* (1999) Shivani and Reddy (2000) Nayak *et al.* (2002) Patil and Sarawgi (2005) Bisne and Motiramani (2006) Nayudu *et al.* (2007) Jayasudha and Sharma (2010) Mohan and Devendra (2011) Selvaraj *et al.* (2011) Shiva Prasad *et al.* (2013
		Moderate	Satya Priya Lalitha and Sreedhar (1996) Venkata Suresh (2001) Chandra *et al.* (2009)

S.No.	Character	Range	Reference
			Ullah *et al.* (2011)
		Low	Singh and Chaudhary (1996) Chakraborty *et al.* (2010) Nandan *et al.* (2010) Rajendar *et al.* (2013)
5.	Number of filled grains per panicle.	High	Shivani and Reddy (2000) Nagajyothi (2001) Patil *et al.* (2003) Patil and Sarawgi (2005) Bisne and motiramani (2006) Sankar *et al.* (2006) Nayudu *et al.* (2007) Krishna *et al.* (2008) Pankaj Garg *et al.* (2010) Selvaraj *et al.* (2011) Rajendar *et al.* (2013)
		Moderate	Satya Priya Lalitha and Sreedhar (1996) Mulugeta Seyoum *et al.* (2012)
		Low	Nandan *et al.* (2010) Rajendar *et al.* (2013)
6.	Total grains per pnicle	High	Jamal *et al.* (2009) Salam *et al.* (2009) Akhtar *et al.* (2011) Akinwale *et al.* (2011) Mulugeta Seyoum *et al.* (2012)
7.	Spikelet sterility percent	High	Chakraborty *et al.* (2010) Ghosal *et al.* (2010) Shiva Prasad *et al.* (2013)

S.No.	Character	Range	Reference
		Low	Parikh *et al.* (2012)
8.	1000 grain weight (g)	High	Bisne and Motiramani (2006) Bharadwaj *et al.* (2007) Jiaswal *et al.* (2007) Anbanandan *et al.* (2009) Nandan and Sweta Singh (2010) Abdul fiyaz *et al.* (2011) Selvaraj *et al.* (2011) Mulugeta Seyoum *et al.* (2012)
		Moderate	Ramesh kumar (1989) Yadav *et al.* (2010)
		Low	Nandan *et al.* (2010) Rajendar *et al.* (2013)
9.	Grain yield per plant (g)	High	Shivani and Reddy (2000) Patil and Sarawgi (2005) Bisne and Motiramani (2006) Sankar *et al.* (2006) Nayudu *et al.* (2007) Kumar and Ramesh (2008) Anbanandan *et al.* (2009) Pankaj Garg *et al.* (2010) Yadav *et al.* (2010) Selvaraj *et al.* (2011) Rajendar *et al.* (2013) Shiva Prasad *et al.* (2013)
		Moderate	Satya Priya Lalitha and Sreedhar (1999) Chandra et *al.* (2009)

S.No.	Character	Range	Reference
		Low	Bharadwaj *et al.* (2007) Nandan *et al.*(2010)

2.2.2 Genetic advance as per cent of mean

Genetic advance refers to the improvement in the mean genotypic value of the selected plants over the base population**.** Johnson *et al.* (1955) reported that though the heritable estimates give useful indication of relative values of selection based on phenotypic expression, the genetic gain should also be considered to arrive at a more reliable conclusion.

A brief review of studies on genetic advance as per cent of mean in rice is presented in table.

S.No.	Character	Range	Reference
1.	Days to 50 per cent flowering	High	Sankar *et al.* (2006) Bharadwaj *et al.* (2007) Jaiswal *et al*. (2007) Kishore *et al.* (2008) Yadav *et al*. (2010) Selvaraj *et al.* (2011) Shiva Prasad *et al*. (2013)
		Medium	Marimuthu *et al.* (1990) Rao and Shrivastav (1994) Shivani and Reddy (2000) Bisne and Motiramani (2006) Chandra *et al.* (2009) Mulugeta seyoum *et al*. (2012)
		Low	Suman (2003) Madhavi Latha *et al.* (2005) Qamar *et al*. (2005) Krishna *et al.* (2008)

S.No.	Character	Range	Reference
			Vijayalakshmi *et al.* (2008) Jayasudha and Sharma (2010) Ullah *et al.* (2011) Rajendar *et al.* (2013)
2.	Plant height(cm)	High	Kishore *et al.* (2008) Kumar and Ramesh (2008) Chandra *et al.* (2009) Yadav *et al.* (2010) Mohan and Devendra (2011) Selvaraj *et al.* (2011) Shiva Prasad *et al.* (2013)
		Moderate	Patil *et al.* (2003) Sinha *et al.* (2004) Qamar *et al.* (2005) Jayasudha and Sharma (2010)
		Low	Patil and Sarawgi (2005) Vijayalakshmi *et al.* (2008) Ullah *et al.* (2011) Rajendar *et al.* (2013)
3.	Number of productive tillers per plant	High	Suman (2003) Sankar *et al.* (2006) Nayudu *et al.* (2007) Anbanandan *et al.* (2009) Nandan and Sweta Singh (2010) Selvaraj *et al.* (2011) Shiva Prasad *et al.* (2013)
		Moderate	Satya Priya Lalitha and Sreedhar (1996) Venkata Suresh (2001)

S.No.	Character	Range	Reference
			Patra *et al.* (2006)
		Low	Chandra et *al*. (2009) Jayasudha and sharma (2010) Rajendar *et al*. (2013)
4.	Panicle length (cm)	High	Chikkalingaiah *et al.* (1999) Nayak *et al.* (2002) Nayudu *et al.* (2007) Mohan lal and Devendra (2011) Shiva Prasad *et al*. (2013)
		Moderate	Shivani and Reddy (2000) Venkata Suresh (2001) Patil and Sarawgi (2005) Patra *et al*. (2006) Jaiswal *et al*. (2007) Selvaraj *et al*. (2011)
		Low	Nagajyothi (2001) Suman (2003) Chandra *et al*. (2009) Chakraborty *et al*. (2010) Jayasudha and Sharma (2010) Ullah *et al.* (2011) Rajendar *et al*. (2013)
5.	Number of filled grains per panicle.	High	Patil *et al.* (2003) Suman (2003) Sankar *et al.* (2006) Nayudu *et al.* (2007) Krishna *et al.* (2008) Pankaj Garg *et al.* (2010) Rajendar *et al*. (2013)

S.No.	Character	Range	Reference
		Moderate	Satya Priya Lalitha and Sreedhar (1996)
		Low	Mishra *et al*. (1996) Rajendar *et al*. (2013)
6.	Total no.of grains per panicle	High	Akinwale *et al.* (2011) Mulugeta Seyoum *et al.* (2012)
7.	Spikelet sterility percent	High	Chakraborty *et al.* (2010) Ghosal *et al.* (2010) Shiva Prasad *et al.* (2013)
		Low	Parikh *et al.* (2012)
8.	1000 grain weight (g)	High	Bharadwaj *et al.* (2007) Karad and Pol (2008) Anbanandan *et al.* (2009) Nandan and Sweta Singh (2010) Abdul fiyaz *et al*. (2011) Selvaraj *et al*. (2011) Ullah *et al*. (2011)
		Moderate	Shivani and Reddy (2000) Sinha *et al.* (2004) Mulugeta Seyoum *et al.* (2012)
		Low	Chikkalingaiah *et al*. (1999) Nagajyothi (2001) Suman (2003) Vijayalakshmi *et al.* (2008) Chandra *et al*. (2009) Rajendar *et al*. (2013)

S.No.	**Character**	**Range**	**Reference**
9.	Grain yield per plant (g)	High	Madhavi Latha (2002) Sankar *et al.* (2006) Nayudu *et al.* (2007) Kumar and Ramesh (2008) Anbanandan *et al.* (2009) Pankaj Garg *et al.* (2010) Selvaraj *et al*. (2011) Ullah *et al*. (2011) Rajendar *et al.* (2013) Shiva Prasad *et al*. (2013)
		Moderate	Sinha *et al*. (2004) Qamar *et al*. (2005) Patra *et al.* (2006)
		Low	Suman (2003) Sinha *et al.* (2004) Jayasudha and Sharma (2010)

2.3 STABILITY ANALYSIS

2.3.1 Genotype x Environment interaction and stability analysis.

A stable variety is one which has high mean, unit regression coefficient and minimum deviation from regression line. A breeder would usually desire to develop a variety that exhibits high yield performance across many locations and seasons. The genetic effects are not independent of the non–genetic environmental effects. This interplay of genetic and non genetic effects is the G x E interaction (Eberhart and Russell, 1966).

Suman Kumari *et al.* (1999) studied stability of 12 rice genotypes in six environments at different sowing dates and concluded that the genotypes were found to interact significantly with the environments for days to 50 per cent flowering, plant height, number of productive tillers, panicle length, spikelet fertility, 1000 – grain weight, grain density, harvest index and grain yield per plot.

Honarnejad (2000) conducted stability analysis of eight Iranian rice cultivars grown at three locations. Analysis of variance showed significant differences in yield performance and location x year interaction. Stability analysis revealed no significant Cultivar x Environment interaction.

Satya Priya Lalitha and Sreedhar (2000) analyzed the stability parameters of different quality traits in 15 genotypes of rice grown in three environments. Pooled analysis of variance indicated significant differences among genotypes and environments for all the characters suggesting the existence of variation among genotypes and environments.

Chaudahari *et al.* (2002) evaluated seven rice genotypes for the stability of yield and yield components over four years and concluded that both the components of genotype x environment interaction were significant, but the linear component was predominant for number of panicles m^{-2}, grains $panicle^{-1}$, 1000 grain weight, panicle length and grain yield.

Kishore *et al*. (2002) studied genotype x environment interaction for grain yield and some associated traits in eight boro rice genotypes under four environments. The mean sum of squares due to G x E interaction against pooled error was significant, suggesting that the genotypes interacted considerably with environment in expression of the traits in different locations. Both linear and non – linear components were significant for days to 50 % flowering, panicle length, number of fertile grains panicle^{-1} and harvest index.

Nayak *et al*. (2003) conducted stability analysis for grain yield and yield components with 28 scented rice genotypes and a non – scented check in four seasons. Partitioning of mean squares due to G x E interaction revealed that both linear and non – linear components were significant for grain yield and yield components, indicating the importance of both the components in determining the stability of grain yield in scented rice. The linear component was significant when tested against pooled error, suggesting that predicting the performance of genotypes in different seasons would be difficult.

Swamy and Kumar (2003) conducted stability analysis for grain yield and its components in rice with 20 genotypes grown at four locations and concluded that the variance due to environment was significant for all characters except 1000 grain weight. Environment (linear) was significant for plant height, number of effective tillers, panicle length and grain weight per hill. Genotype x Environment (linear) was significant for all characters except days to 50 % flowering, 1000 grain weight and grain yield.

Munisonnappa *et al*. (2004) conducted stability analysis with 11 rice genotypes (seven hybrids and four check varieties) for eleven quantitative traits in six environments and concluded that the variance due to G x E (linear) was significant for days to 50 per cent flowering, plant height, number of spikelets per panicle, 1000 grain weight and grain yield per plant. Non linear component was significant for all characters except number of panicles and grain yield per plant.

Babu *et al*. (2005) studied twenty seven rice hybrids for their stability with respect to yield and its components at three different salt affected environments. Significant genotype x environment interaction (G x E) showed differential behavior of genotypes under different conditions for all the traits studied. Significant linear and non-linear components of G x E interaction for number of grains per panicle and spikelet fertility suggested that the genotypes differed from their linear response to environment.

Shanmuganathan and Ibrahim (2005) evaluated eleven rice hybrids in six different environments for their stability. Significant mean sum of square due to genotypes, environments and G x E interaction was observed. Both linear and non-linear components of G x E interaction were important for the expression of most of the traits; however, linear component was larger in magnitude than the non-linear component. The hybrid CORH 2 was found stable for most of the characters.

Ali *et al*. (2006) evaluated 16 genotypes of rice in nine locations of Punjab and revealed that the combined analysis of variance showed highly significant differences among varieties, environment, variety x environment interaction. Highly significant difference in genotypes may be due to the differences in their genetic makeup and diverse nature of origin. Highly significant differences in locations indicated an existence of variation in the prevailing environments.

Deshpande and Dalvi (2006) evaluated the performance of 12 rice hybrids in respect of grain yield and other characters under five environments in Maharastra and revealed that stability in the yield of the hybrid appeared to differ in respect of level of stability in the component traits. It was found that stability in grain yield was due to stability in yield components only and plasticity in others. The yield behaviour in almost all the genotypes except KRH 2 and DRRH 1 was highly predictable. The hybrid KRH 2 was found to be stable for yield as it has average yield performance; regression coefficient was near to unity and minimum deviation from regression.

Pande *et al*. (2006) studied the stability of 12 high yielding varieties of rice for *boro* season of eastern India. Assessment of varieties based on individual parameters of adaptability ($\bar{X}$, bi, S^2d_i) for grain yield revealed that all the 12 genotypes tested showed significant response to different environments by their significant values of regression coefficient from unity. Ten genotypes exhibited stable performance for grain yield.

Arumugam *et al*. (2007) evaluated 12 rice genotypes for the stability of grain yield and its component characters in six environments. The genotypes were found to interact significantly with the environments for days to 50 per cent flowering, plant height, number of productive tillers, panicle length, spikelet fertility, 1000 – grain weight, grain density, harvest index and grain yield per plot.

Dushyanthakumar and Shadadshari (2007) evaluated 15 rice mutants of PUB local for the stability of yield and yield components across three environments in Karnataka. Significant pooled deviations observed for all the traits, suggested that there is a considerable genotypic differences. Significant linear sensitivity with insignificant non linear sensitivity suggested that the performance of genotypes could be predicted with great precision across the environments.

Sanjay Singh and Singh (2007) evaluated 12 elite low land rice genotypes for stability analysis and concluded that the pooled analysis of variance indicated significant amongest genotypes. Environment variation, its component and genotypes – environment interaction were highly significant for all the traits.

Bhakta and Das (2008) evaluated 26 rice genotypes over eight environments for the assessment of yield and yield stability. Pooled analysis of variance for grain yield over environments showed highly significant differences among genotypes, environments and G x E interaction indicating diverse and variable nature of cropping environments. The difference in performance of genotypes in different environments indicated the presence of significant G x E interaction for the expression of the character.

Panwar *et al*. (2008) studied genotype x environment interaction for grain yield, its components and grain quality traits in 10 parents and their 45 F_1s of scented rice under four environments. Significant genotype x environment interactions were observed for all the eleven characters having homogenous error variance in environments. Among the linear and non – linear components of G x E interaction, linear component was predominant for most of the characters, suggesting variation in the performance of different genotypes grown over environments could be predicted. Mean squares due to environment (linear) was also found significant for all the characters, indicating differences between environments and their influence on genotypes for expression of these characters.

Ramya and Senthilkumar (2008) evaluated 23 rice genotypes in three different environments created by staggering the date of sowing during the year 2006 for their stability. G x E interaction was significant for six characters *viz.*, days to 50 percent flowering, plant height, number of productive tillers per plant, panicle length, number of grains per panicle ansd grain yield per plant. The genotype, MDU 3 was the most stable and consistent one for most of the traits studied in the entire environment.

Saidaiah (2008) studied 115 hybrids and reported that CRMS 32 A x 517, APMS 6A x 118, PUSA x IR 55, PUSA x 124 and APMS 6A x GQ 120 are stable with the desirable *sca* effects, heterosis and *per se* performance for grain yield and important attributes.

Das *et al*. (2009) conducted yield trials on 12 late duration (145-165 days) rice genotypes and revealed that four of the seven genotypes realized above average yield and showed adaptability to all environments, whereas, OR 1901-14-32 and Jagabandhu showed specific adaptaion to poor environments. The G x E interaction was significant for grain yield indicating differential response of genotypes to changes in environments and some genotypes showed stable performance over the range of environments, while many showed unstable performance due to high G x E interaction.

Krishnappa *et al*. (2009) conducted an experiment to evaluate 40 rice genotypes in six environments. Pooled analysis of variance indicated the presence of genetic variability. Linear and non-linear components also revealed that yield and its contributing characters were subjected to environmental changes. The genotypes *viz*., Andrewsal, IET-5784, IET-7191, IET-13870, IET-14211, IMRYT/91/1708, IET-30864, IVT/91(SHW) 10607 and IVT (SHW) 93 /10608 were stable for high mean yield with non-significant bi and S^2di values.

Bhadru (2010) studied stability of hundred rice hybrids and reported that IR-79156A x R-52 and IR-79156A x IR-13419 possessed stability for wider environments & DRR-14A x R-47, IR-79156A x R-49 and IR-80555A x IR-66 exhibited stability for favourable environments with the desirable *sca* effects, heterosis and *per se* performance for grain yield and quality and other important attributes.

Dushyantha kumar *et al.* (2010) studied G x E interaction and stability for grain yield and some associated traits during the year 2002-06 in eight halugidda local rice mutants in the hill zone of Karnataka. Significant G x E interaction was observed for all the traits studied. The pooled deviation was significant for the majority of the traits including grain yield and considerable genotypic difference was observed. Both linear and non-linear components of G x E interaction were significant.

Das *et al*. (2010) conducted multilocation yield trials of 11 mid-early rice genotypes at Bhubaneswar, Chiplima, Jeypore and Ranital over 3 years (2003-05), during *kharif* season. Anova of yield data of the 12 environments revealed significant G x E interaction and indicated differential performance of genotypes over environments. Further partitioning of E+G x E effects revealed that E(linear) component was highly significant. GxE (linear) component was significant and pooled deviation was highly significant, indicating that some genotypes showed linear effects over environments, while others showed significant deviation from linear relationship.

Biswas *et al*.(2011) evaluated 28 rice genotypes for their stability in respect of grain yield and growth duration during *boro* season of 2007-08 over five locations. The G x E interactions were highly significant for growth duration and grain yield, which indicated significant differences among the regression coefficients and that might be extended for stability analysis. The linear components of G x E interactions were insignificant but non-linear component(pooled deviation) were significant for both the traits. Considering both growth duration and grain yield based on stability parameters, the genotypes Ropa and Sera were identified as most stable and could be recommended for release as varieties.

Ahmad Ramezani *et al.* (2011) studied the stability of yield and some phenological parameters with 13 genotypes of rice under various environment conditions. Combined variance analysis of data showed that the genotype and environment at differences were significant relative to days to 50%flowering, plant height and grain yield which indicated a wide range of variability among the genotypes performance. Based on the stability in yield and qualitative parameter genotype 4 was superior to other genotypes so that it was recommended for commercial cultivation in the Isfahan zone of Iran.

Sreedhar *et al.* (2011) studied 82 genotypes including 60 hybrids, 17 parents and 5 checks for eight characters. The pooled analysis of variance revealed that G x E interactions were significant for five characters *viz.*, panicle weight, no. of productive tillers per plant, number of filled grains per panicle and 1000 seed weight and single plant yield implying differential response of genotypes under three locations for these characters. Among the 60 hybrids, superior performing stable hybrids APMS 6 A x IR-24R, APMS6AxBR-827-35-R, IR-80555AxIR-54742R, IR-80559AxIR-54742R, IR-80559AxKMR-3R and IR-80151AxIR-54742R across the three different environmental conditions.

Maji *et al.* (2011) conducted multi-locational rice trials were in 6 locations across Nigeria. G x E analysis of transformed data showed that there was no significant differences in grain yield among varieties and locations. There was however a high interaction of G x E and location x year. Joint regression analysis which gives a measure of stability showed that WAB 96-1-1, IDSA86, M2 and IR47701-6-3-1 were the most stable varieties across the locations.

Subudhi *et al.*(2012) evaluated 20 popular rice varieties of eastern India to study the G x E interaction and stability nature of different yield traits. In pooled analysis the G x E interaction was highly significant and both linear and nonlinear compounds were equally important in determining the stability of different characters. For grain yield, Gouri, IR-8, Jaya and IR-36 was stable varieties and could perform better in all types of environment.

Rasyad *et al*. (2012) studied four locally adapted cultivars and one high yielding cultivar of rice were evaluated at three environments in Riau, Indonesia. There were significant effects of environments on yield and some yield components, except panicle number per plant. The cultivars Cisokan and IR64 were stable for all the environments.

Lal and Singh (2012) studied G x E interaction for grain yield and its components characters in 15 genotypes of rice under six environments during *kharif* 2005-06. Pooled analysis also indicated highly significant differences among the genotypes and environments for all the characters under study. Based on stability parameters, genotypes like Pusa Basumati-1, PR-114 and Sahib-140 were found promising with stable performance for plant height, effective tillers per plant and grain yield per plant.

Somana *et al.*(2013) evaluated the effect of genotype, environment and interaction between genotype and environment on grain anthocyanin content in rice grains and investigated the stability of these black upland rice varieties. Seven genotypes of Thai black indigenous upland rice were laid out in and the Northeast of Thailand. The results indicated that G, E and GX E interaction significantly affected anthocyanin content in rice grains. ULR238 and ULR 046 were desirable in terms of the highest ability and stability for anthocyanin content in rice grains.

Mosavi *et al*. (2013) evaluated five rice promising genotypes and the results obtained showed highly significant yield differences among rice genotypes, environment and genotype by environment interaction. Some rice genotypes were adjudged stable when different yield stability parameters were considered.

Tariku *et al* .(2013) evaluated 16 rice genotypes at three locations of eight environments in north western Ethiopia from 2006 to 2008 to identify stable and high yielding genotypes. The results showed high significant differences among genotypes, environments and genotype by environment interactions for grain yield. The highest grain yield was obtained from genotypes GEN 13, GEN 12 and GEN 9 across environments.

Adesola (2013) evaluated 15 upland rice (*Oryza sativa* L.) varieties cultivated in five environments of South Western Nigeria. Using the additive main effect and multiplicative interaction, AMMI and the genotype and genotype and environment interaction (GGE). WAB (96-1-1) had the highest grain production and appeared to be adaptable to E3 and E5 which were low rainfall environments.

CHAPTER III

MATERIAL AND METHODS

The present investigation on “Studies on stability analysis of elite medium duration rice (*Oryza sativa* L.) genotypes” was undertaken to study the stability of rice genotypes across the three locations and also to identify stable high yielding genotypes for *kharif* season for Telangana and Andhra region of Andhra Pradesh. The materials utilized and the methodologies adopted in the present study are described below.

3.1 MATERIALS

The experimental material comprised of 22 genotypes of rice collected from Directorate of Rice Research Station, Hyderabad. (Table: 3.1).

3.2 EXPERIMENTAL TECHNIQUE

The present investigation was carried out at the following three locations during *kharif* season, 2013.

Location I: Directorate of Rice Research farm at ICRISAT, Hyderabad.
Location II: Regional Agricultural Research Station, Warangal.
Location III: Regional Agricultural Research Station, Maruteru, West Godavari.

3.3 EXPERIMENTAL DESIGN

The experiment was laid out in a Randomized Block Design (RBD) with three replications. The nursery was sown in raised beds and healthy nursery was raised at all the locations following uniform package of practices. Thirty days old seedlings were transplanted following a spacing of 25 x 15 cm with a row length of 4.5 m for each entry.

3.4 CULTURAL OPERATIONS

The package of practices as recommended by Acharya N.G.Ranga Agricultural University was adopted as per schedule throughout the crop growth period with need based plant protection measures. A uniform dose of fertilizers were applied at the rate of 100 kg nitrogen per hectare, 60 kg phosphorus per hectare and 40 kg murate of potash per hectare. Necessary precautions were taken to maintain thirty competitive plants in each entry per replication.

3.5. RECORDING OF OBSERVATIONS

Observations were recorded for yield and yield attributing characters on five randomly selected competitive plants for each entry in each replication. The mean data obtained at each location was considered for final statistical analysis. The method of recording data for each trait is described below character wise.

3.5.1. Days to 50 per cent flowering

The total number of days taken from the date of sowing to complete exersion of the panicle in 50 per cent of the total plants in the net plot.

3.5.2. Plant height (cm)

The plant height was recorded by measuring the total height from the base of the plant to the tip of the top most panicle at the time of harvest and is expressed in centimeters.

3.5.3. Number of productive tillers per plant

The number of ear bearing tillers, which produced healthy panicles were counted on each plant at the time of maturity.

3.5.4. Panicle length (cm)

The length of panicles from each plant was measured in centimeters from neck node to the tip of top most grain in a panicle.

3.5.5. Number of filled grains per panicle

The number of well filled grains were counted in each selected panicle per plant and expressed as filled grains per panicle.

3.5.6. Total Number of grains per panicle

The number of filled grains and unfilled grains were counted in each selected panicle per plant and expressed as total number of grains per panicle.

3.5.7. Spikelet sterility percent

Spikelet sterility was calculated as the ratio of unfilled spikelets per panicle to the total number of spikelets in a panicle and expressed in per cent.

3.5.8. 1000 Seed weight (g)

One thousand well filled grains were counted from a random sample of each entry in each replication and weighed with the help of electronic top pan balance in grams.

3.5.9. Grain yield per plant (g)

Panicles from a single plant were harvested at maturity, threshed, cleaned and sun dried to 12 per cent moisture content and the weight was recorded in grams.

3.6. STATISTICAL ANALYSIS

The data recorded on different traits were subjected to the following statistical analysis.

1. Analysis of variance
2. Genotypic and phenotypic coefficients of variation, heritability and genetic advance.
3. Stability analysis (Eberhart and Russell,1966).

3.6.1 Analysis of variance

3.6.1.1 RBD Analysis

The analysis of variance was carried out as per the method outlined by Panse and Sukhatme (1985).

$$Y_{ij} = \mu + g_i + r_j + e_{ij}$$

Where,

Y_{ij}	=	Phenotypic observation of i^{th} genotype in j^{th} replication
μ	=	General mean
g_i	=	True effect of i^{th} genotype
r_j	=	True effect of j^{th} replication
e_{ij}	=	Random error associated with i^{th} genotype and j^{th} replication

Analysis of variance (ANOVA) was carried out for each character as indicated below :

Source of variation	d.f.	SS	MSS	F-ratio
Replications	r-1	RSS	M'r	M'r/M'e
Treatments	t-1	TSS	M't	M't/M'e
Error	(r-1) (t-1)	ESS	M'e	
Total	rt-1			

Where,

r = Number of replications

t = Number of treatments (genotypes)

M'r = Mean sum of squares of replications

M't = Mean sum of squares of treatments

M'e = Mean sum of squares of error

d.f = Degrees of freedom

MSS = Mean sum of squares

The significance of mean sum of squares for each character was tested against the corresponding error degrees of freedom using 'F' test (Fisher and Yates, 1967).

$$SE(m) = (Me/r)^{1/2}$$

Where,

Me = Error mean of squares

r = Number of replications

C.D = S.E (d) x 't'

Where,

S.E (d) = $(2Me/r)^{1/2}$

't' = t table value at error degrees of freedom

C.V = $(S.D/ \bar{x}) \times 100$

Where,

S.D = Standard deviation of the population

$\bar{X}$ = Population mean

3.6.2.1 Genotypic and phenotypic coefficients of variation

The genotypic and phenotypic coefficients of variation were calculated according to the formula given by Falconer (1981).

$$\text{Genotypic coefficient of variation (GCV)} = \frac{\text{Genotypic standard deviation}}{\text{Mean}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV)} = \frac{\text{Phenotypic standard deviation}}{\text{Mean}} \times 100$$

Categorization of the range of variation was effected as proposed by Sivasubramanian and Madhavamenon (1973).

Less than 10%	:	Low
10-20%	:	Moderate
More than 20%	:	High

3.6.2.2 Heritability

Heritability in the broad sense refers to the proportion of genotypic variance to the total observed variance in the total population. Heritability (h^2) in the broad sense was calculated according to the formula given by Allard (1960).

$$h^2 = \frac{\sigma^2 g}{\sigma^2 p}$$

where,

h^2 = heritability in broad sense

$\sigma^2 g$ = genotypic variance

$\sigma^2 p$ = phenotypic variance ($\sigma^2 g + \sigma^2 e$)

As suggested by Johnson *et al*. (1955) h^2 estimates were categorized as:

Low	:	below 30%
Medium	:	30-60%
High	:	above 60%

3.6.2.3 Genetic advance

Genetic advance refers to the expected gain or improvement in the next generation by selecting the superior individuals under certain amount of selection pressure. From the heritability estimates the genetic advance was estimated by the following formula given by Burton (1952).

$$GA = K \cdot h^2(b) \cdot \sigma_p$$

Where,

GA = expected genetic advance

K = Selection differential, the value of which is 2.06 at 5 per cent selection intensity

σp = phenotypic standard deviation

h^2 (b) = heritability in broad sense

In order to visualize the relative utility of genetic advance among the characters, genetic advance as per cent of mean was computed.

$$\text{Genetic advance as per cent of mean} = \frac{GA}{\text{Grand mean}} \times 100$$

The range of genetic advance as per cent of mean was classified as suggested by Johnson *et al*. (1955).

Low = Less than 10%

Moderate = 10-20 %

High = More than 20%

3.6.3 Stability Analysis

3.6.3.1 Eberhart and Russell's model (1966)

By following the methodology of Eberhart and Russell's model (1966), three parameters namely (i) overall mean of each genotype over a range of environments, (ii) the regression of each genotype on the environmental index and (iii) a function of the squared deviation from the regression were estimated. Eberhart and Russell (1966) used to study the stability of genotypes under different environments.

$$Y_{ij} = \mu_i + b_i I_j + \delta_{ij}$$

Where, Y_{ij} = mean of i^{th} genotype in j^{th} environment.

μ_i = mean of i^{th} genotype over all the environments

b_i = regression coefficient of the i^{th} genotype on the environmental index which measures the response of this genotype to varying environments

I_j = environmental index which is defined as the deviation of the mean of all the genotypes at a given location from overall mean with

$\Sigma_j - I_j = 0$ and

δ_{ij} = The deviation from regression of the i^{th} genotype at j^{th} environment

3.6.3.2 Analysis of variance for stability

The analysis of variance proposed by Eberhart and Russell (1966) is given below.

ANOVA to estimate stability parameters (Eberhart and Russell, 1966)

Source	d. f	S. S	M. S. S
1. Total	(ge -1)	$\sum_i \sum_j Y^2_{ij}$ -C. F.	
2. Genotype	(g-1)	$\frac{1}{e} \sum_I Y^2_i$ -C. F.	MS 1
3. Environment	g(e-1)	$\sum_i \sum_j (Y^2_{ij} - \sum_I Y_i^2 / e)$	
4. Environment (Linear)	1	$\frac{1}{g} \sum_j (Y^2_j I_j / \sum_j I_j^2$	
5. Genotype x Environment (Linear)	(g-1)	$\sum_i (\sum_j Y^2_j I_j / \sum_i I_j^2)$ - Environment (linear) S. S	MS 2
6. Pooled deviation	g(e-2)	$\sum_i \sum_j \square_{ij}^2$	MS 3
7. Deviation due to genotype 1	(e-2)	$\sum_i Y^2_{ij} - \frac{(Y_i)^2}{e} - (\sum_j Y_{ij} I_j)^2 / \sum_j I_j^2 = \sum_j \square_{ij}^2$	
Genotype g	(e-2)	$\sum_j Y^2_{gj} - \frac{(Y_g)^2}{e} - (\sum_j Y_{gj} I_j)^2 / \sum_j I_j^2 = \sum_j \square\dot{o}^2_{gj}$	
8. Pooled error	e(r-1) (g-1)		

g = Number of genotypes = 22

e = Number of environments = 3

r = Number of replications = 3

3.6.3.3 Computation of regression coefficient (bi) for each genotype

$$b_i = \sum_j Y_{ij} I_j / \sum_j I_j^2$$

Where,

b_i = regression coefficient of i^{th} genotype

$\sum_j I_j^2$ = the sum of squares of environmental indices which are common to each value of bi.

$\sum_j Y_{ij}^2$ = (for each genotype) = the sum of products of environmental index (Ij) and the corresponding means (X) of that variety at each location.

These values may be obtained in the following manner.

$$(X)(I_j) = \sum_j Y_{ij} I_j = (S)$$

(I_j) = Vector for environmental index, and

(S) = Vector for sum of products i.e., $\sum Y_{ij} I_j$

3.6.3.4 Computation of mean square deviation S^2di from linear regression

In a regression analysis, it is possible to partition the variance of dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (variance due to regression) and the other which explains the variance due to deviations from linearity symbolically.

$$\sigma Y^2 = \sigma^2 \text{ regression} + \sigma^2 \text{ deviation from regression}$$

The variance of means over different locations with regard to individual genotypes may be obtained in the following way.

$$\sigma^2 gi = \Sigma_j Y_{ij} \text{-} (Y^2{}_i/g)$$

The variance due to deviations from regression ($\sum_i \delta ij^2$) for a genotype being:

$$\Sigma_j \delta ij = [\Sigma_j Y^2 ij - Y^2 i / g] - \frac{(\Sigma Yij\, Ij)^2}{\Sigma_i Ij^2}$$

Where,

$$\Sigma_j Y^2 ij - Y^2 i / g = \text{The variance due to dependent variable}$$

$$(\sum_j Yij - ij)^2 \,/\, (\sum_j ij)^2 = \text{The variance due to regression}$$

Because

$$\frac{(\Sigma_j Yij\, Ij)^2}{\Sigma_j Ij^2} = \frac{(\Sigma_j Yij\, Ij)(\Sigma_j Yij\, Ij)}{\Sigma_j Ij^2} = bi\, \Sigma\, Yij\, Ij$$

From

$$\Sigma_j \delta^2 ij = \text{Values, the stability parameter,}$$

S^2di for each genotype is computed as follows:

$$S^2 di = \Sigma_j \delta^2 ij / (e-2) - (S^2 e / r)$$

$$\text{Mean square} = \frac{\text{Deviation from regression}}{\text{d.f. for environment}} - \frac{\text{Pooled error deviation}}{\text{Number of replications}}$$

The variance due to genotypes, environments and the pooled error were the same as those Calculated in the pooled analysis of the data, except that the total sum of squares was mainly partitioned into three main components.

i. Sum of squares due to genotypes
ii. Sum of squares due to environments + (G x E) and
iii. Pooled error

Again sum of squares due to G x E was further partitioned into two parts namely

i. S.S due to G x E (linear) which is in fact S.S due to regression and

ii. S.S due to deviation from linearity of response (i.e., due to pooled deviation).

The different computational steps involved were as follows.

$$\text{a) S.S. due to environment} + (\text{GxE}) = \sum_i \sum_j Y^2 ij - (\sum_i Y^2 i / e)$$

$$\text{b) S.S. due to environment} + (\text{linear}) = \frac{1}{g} \sum_j YjIj^2 / \sum_j Ij^2$$

$$\text{c) S.S. due to GxE (linear)} = \underset{j}{S} (\underset{j}{S} YjIj^2 / \underset{j}{S} Ij^2) - \text{environment (linear) S.S.}$$

Where,

$$(\sum_j YjIj^2) / \sum_j Ij^2 = bi \sum_j YijIj \text{ for each var iety}$$

3.6.3.5 Test of Significance

The mean sum of squares due to genotypes and environments were tested against G x E interaction. Whereas, mean sum of squares due to G x E interaction was tested against pooled error. Environment (linear) and G x E (linear) were tested against pooled deviation, if pooled deviation is non-significant both these linear components were tested against pooled error. Mean sum of squares due to pooled deviations were tested against pooled error.

The following tests of significance were carried out:

1. To test the significance of the difference among genotype means namely:

Ho = μ1 = μ2 = μ3 = …. μn

F	=	Mean sum of square due to genotype	=	MS_1
		Mean sum of square due to G x E		MS_3

2. To test that the genotypes did not differ for their regression on environmental index i.e.,

Ho = b1 = b2 = b3……… bn

F	=	M.S. due to G x E (linear)	=	MS_2
		M.S. due to pooled deviation		MS_3

F = M.S due to G x E (linear) Ms_2

3. Individual deviation from linear regression was tested as follows:

$$F = [(\sum_j \delta^2 ij) / (S-2)] / \text{pooled error}$$

Against F table value at (e-2)(g-2), at 5% or 1% probability level.

4. The hypothesis that any regression coefficient did not differ from unity or zero was tested by appropriate't' test i.e.,

$$\text{For } (b-0), t = \frac{|b-0|}{SE(bi)} \text{ for } (g-2) \text{ df at 5\% level of probability}$$

$$\text{For } (1-b), t = \frac{|b-1|}{SE(bi)} \text{ for } (g-2) \text{ df at 5\% level of probability}$$

Where,

$$SE\,bi = \sqrt{\sum_j \delta^2 ij / (e-2) / \sum_j Ij^2}$$

3.6.3.6 Stable Genotype

A genotype with unit regression coefficient (b_i=1) and deviation not significantly different from zero (S^2d_i=0) was taken to be a stable genotype with unit response.

Mean and standard error of 'b'

$$\text{Mean of } b = \bar{b} = \sum_i bi / g$$

$$S.E.(b) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\sum_j Ij^2}}$$

3.6.3.7 Population Mean

Population mean (μ) and standard error was calculated as

Population mean (μ) = Grand total / Number of observations

$$S.E.(mean) = \sqrt{\frac{\text{M.S. due to pooled deviation}}{\text{Number of environments} - 1}}$$

Table: 3.1 Details of twenty two genotypes of rice (*Oryza sativa* L.).

S.No.	Name of the genotype	Cross combination	Source
1.	1701	HKR47/IET16076	D.R.R, Hyderabad
2.	1702	NDR359(NC)	D.R.R, Hyderabad
3.	1703	MTU7029/NLR34449	D.R.R, Hyderabad
4.	1704	IR72981-92-1-1-2-2/UPRI 99-1	D.R.R, Hyderabad
5.	1705	------	D.R.R, Hyderabad
6.	1706	ACC-316-1-2/ACC386-2-2-1	D.R.R, Hyderabad
7.	1707	PR116//PAU3075-3-38-PR106P	D.R.R, Hyderabad
8.	1708	NDR8002-AKSHAYADHAN(RC)	D.R.R, Hyderabad
9.	1709	MTU1001/CHAITANYA	D.R.R, Hyderabad
10.	1710	UPRI 2012-17	D.R.R, Hyderabad
11.	1711	OR1206-26-2/IR42221	D.R.R, Hyderabad
12.	1712	RRS/CHINSURAH	D.R.R, Hyderabad
13.	1713	MTU1001/NDLR-8	D.R.R, Hyderabad
14.	1714	WGL14/MEGURI SONA	D.R.R, Hyderabad
15.	1715	IR43581-57-3-3-6/IR 26940-20-3-1	D.R.R, Hyderabad
16.	1716	JAYA(LC)	D.R.R, Hyderabad
17.	1717	MTU1001/ANNADA	D.R.R, Hyderabad
18.	1718	PR116/PAU3075/PR106-P3	D.R.R, Hyderabad
19.	1719	MTU2067/PAU3030-29-2	D.R.R, Hyderabad
20.	1720	IR 73718-1-2-1-3/PSBRC10	D.R.R, Hyderabad
21.	1721	GOURI/IR65629-22-1	D.R.R, Hyderabad
22.	1722	ADT39/TRGUNA	D.R.R, Hyderabad

NC-National check, RC-Regional check and LC-Local check

CHAPTER IV

RESULTS AND DISCUSSION

The present investigation was carried out to evaluate twenty two genotypes in three locations *viz.*, Directorate of Rice Research farm at ICRISAT, Medak for Central Telangana Zone, Regional Agricultural Research Station, Warangal for Central Telangana Zone and Regional Agricultural Research Station, Maruteru for Godavari Zone of Andhra Pradesh for the stability of the genotypes for grain yield and yield related characters *viz.*, days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, total number of grains per panicle, spikelet sterility per cent, thousand seed weight and grain yield per plant. The results obtained are presented below under the following headings.

4.1 Analysis of Variance.

4.2 Mean performance of genotypes, GCV % and PCV %.

4.3 Heritability (broad sense).

4.4 Genetic advance and genetic advance as per cent of mean.

4.5 Stability parameters *viz.*, mean (μ), regression coefficient ($b_{i)}$ and deviation from regression ($S^{-2}di$) as per Eberhart and Russell (1966) model.

4.1 ANALYSIS OF VARIANCE

Twenty two rice genotypes consisting nineteen genotypes from Advance Varietal Trail-1 Medium category and three checks obtained from Directorate of Rice Research, Hyderabad, were subjected to pooled analysis of variance for nine characters *viz.*, days to fifty per cent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, total number of grains per panicle, spikelet sterility per cent, 1000–seed weight and grain yield per plant. The analysis showed significant difference for all the characters among the genotypes studied in all the environments. It indicated that there is lot of variation among genotypes, which can be further studied for their interaction with different environments to identify for their suitability for cultivation. The results are presented in Table: 4.1.

4.2 MEAN PERFORMANCE OF GENOTYPES AND VARIABILITY

The three locations *viz.*, Directorate of Rice Research farm at ICRISAT, Medak for Central Telangana Zone, Regional Agricultural Research Station, Warangal for Central Telangana Zone and Regional Agricultural Research Station, Maruteru for Godavari Zone were utilized to investigate the mean values, genotypic and phenotypic coefficients of variation, heritability (broad sense), genetic advance and genetic advance as per cent of mean for nine characters *viz.*, days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, total number of grains per panicle, spikelet sterility per cent, thousand seed weight and grain yield per plant. The results are presented in Tables 4.2 and 4.3.

4.2.1 Days to 50 per cent flowering

Mean for days to 50 per cent flowering in ICRISAT ranged from 91.00 (1711) to 118.33 (1705), in Warangal it ranged from 90.33 (1705) to 118.00 (1717) and in Maruteru it ranged from 91.00 (1707) to 117.00 (1713) with a mean of 103.16. This character across locations is ranged from 96.88 (1704) to 111.44 (1713), when compared to the best check mean of 100.55 (1702). The one genotype 1704 (96.88) registered a best mean performance than best check which indicated that this character possess less variation, so that improvement is difficult. The genotype 1706 (100.00) showed on par performance with best check. The genotypic (8.03) and phenotypic (8.14) coefficients of variation were low for this trait. Similar kind of reports for low GCV and PCV for days to 50 per cent flowering were reported by Patil *et al.* (2003), Sinha *et al.* (2004), Krishna *et al.* (2008), Vijayalaxmi *et al* . (2008), Chandra *et al.* (2009), Khan *et al*. (2009), Ullah *et al*. (2011), Rajendar *et al.* (2013) and Shiva Prasad *et al.* (2013).

4.2.2 Plant height (cm)

This trait in ICRISAT ranged from 74.81 (1722) to 130.00 (1714), in Warangal it ranged from 77.16 (1717) to 132.80 (1714) and in Maruteru it ranged from 91.20 (1718) to 132.53 (1712) with a mean of 111.37. The plant height pooled analysis of mean performance ranged from 83.02 (1717) to131.68 (1714), compared to the best check 115.11 (1716). The genotypes *viz.,* 1717 (83.02), 1721 (83.37), 1718 (84.84), 1719 (88.43), 1720 (93.97), 1710 (101.70) and 1709 (112.23) registered best performance across three locations. The GCV and PCV were medium *i.e.*, 15.65 and 16.37 respectively. These results are in accordance with the findings of Shiavani and Reddy (2000), Tara Satyavathi *et al.* (2001), Nayak *et al.* (2002), Bisne and Motiramani (2006), Krishna *et al.* (2008), Chandra *et al.* (2009), Jayasudha and Sharma (2010) and Selvaraj *et al.* (2011).

4.2.3 Number of productive tillers per plant

The mean of this character ranged from 7.90 (1722) to 18.31 (1709) at ICRISAT, where as in Warangal from 8.25(1722) to 16.40 (1717) and in Maruteru from 7.46 (1715) to 14.69 (1719) with a mean of 11.22. The pooled mean performance ranged from 8.61 (1722) to 14.29 (1717) compared to the best check 11.31 (1708). The genotypes 1701 (11.47), 1706 (12.24), 1719 (12.88), 1709 (12.97), 1703 (13.26) and 1717 (14.29) recorded at on par mean performance with the check 1708. The GCV (21.24) and PCV (25.74) for this trait were high. Similar kind of results were reported by Shivani and Reddy (2000), Sinha *et al.* (2004), Patil and sarawgi (2005), Jaiswal *et al.*(2007), Nayudu *et al.* (2007), Chandra *et al.* (2009), Jayasudha and Sharma (2010), Ghosal *et al.* (2010), Akhtar *et al.* (2011), Padmaja *et al.* (2011), Rajendar *et al* . (2013) and Shiva Prasad *et al.* (2013).

4.2.4 Panicle length (cm)

The mean panicle length was recorded 24.92, with a minimum of 21.39 (1720) and maximum of 29.20 (1708) in ICRISAT, in Warangal with a minimum of 23.70 (1703) and maximum of 25.79 (1718) and in Maruteru with a minimum of 22.35 (1720) and maximum of 28.22 (1722). The pooled mean performance ranged from 22.76 (1720) to 27.16 (1708). The best check mean performance was 27.16 (1708). The GCV and PCV for this trait were low *i.e.*, 5.90 and 8.67 respectively. These results were in accordance with the findings of Patil *et al.* (2003), Bisne and Motiramani (2006), Kole *et al.* (2008), Krishna *et al.* (2008), Chandra *et al.* (2009), Manojkumar prajapate (2011), Selvaraj *et al.* (2011) and Rajendar *et al.* (2013).

4.2.5 Number of filled grains per panicle

At ICRISAT, number of filled grains per panicle varied from 116.33 (1718) to 210.33 (1701), while it was from 116.13 (1717) to 209.86 (1701) at Warangal and ranged from 119.80 (1717) to 200.73 (1701) at Maruteru, with a mean of 152.7.The mean performance across locations ranged from 118.20 (1717) to 206.97 (1701). Five genotypes 1705 (173.60), 1707 (173.80), 1712 (185.41), 1714 (199.80) and 1701 (206.97) recorded on par mean performance with best check 1702 (170.05).The genotypic (13.77) and phenotypic (23.69) coefficients of variation were moderate to high. Similar results were also reported earlier by Kole *et al.* (2008), Nandan *et al.* (2010), Pankaj Garg *et al*. (2010), Selvaraj *et al*. (2011), Mulugeta seyoum *et al*. (2012) and Rajendar *et al.* (2013)

4.2.6 Total number of grains per panicle

This trait in ICRISAT varied between 104.30 (1715) and 260.03 (1714), while in Warangal it ranged from 136.66 (1717) to 230.86 (1714), where as in Maruteru the range was from 141.00 (1706) to 220.60 (1701), with mean of 166.9.The overall mean performance ranged from 132.11 (1717) to 218.92 (1714). In comparision to the best check 176.65 (1716), one genotype1714 (218.92) recorded superior mean performance and seven genotypes 1711 (177.07), 1707 (177.83), 1703 (187.53), 1705 (188.62), 1712 (190.25), 1701 (198.02) and 1709 (198.85) were with on par mean performance. The genotypic (16.79) and phenotypic (21.88) coefficients of variation were moderate to high for this character. Similar findings were reported by Salam *et al*. (2009), Akhtar *et al*. (2011), Senthil Kumar *et al*. (2011) and Mulugeta *et al. (*2012).

4.2.7 Spikelet sterility percent

For the character spikelet sterility per cent the observed range in ICRISAT was from 8.20 (1707) to 27.02 (1715), in Warangal it ranged from 6.60 (1704) to 18.46 (1716) and in Maruteru it was from 7.16 (1705) to 16.59 (1717) with a mean of 13.05.The pooled mean performance ranged from 8.45 (1705) to 18.16 (1715).The genotypes 1705 (8.45), 1707 (8.79) and 1706 (9.53) were superior in performance over best check 1702 (11.30) and two genotypes 1713 (10.86) and 1711 (10.94) registered on par performance with check. A high genotypic (27.60) and high phenotypic (32.22) coefficients of variation were observed. For this character these results were in accordance with the findings of Chakraborty *et al.* (2010), Ghosal *et al*. (2010), Parikh *et al.* (2012) and Shiva Prasad *et al.* (2013).

4.2.8 1000– seed weight (g)

The trait 1000-seed weight recorded a mean of 26.71. In ICRISAT, this character ranged from 13.56 (1713) to 32.76 (1715), in Warangal it ranged from 21.40 (1707) to 32.53 (1711) and in Maruteru the range was between 19.57 (1714) to 31.50 (1715). The mean performance over the locations ranged from 22.31 (1707) to 32.16 (1715). Two genotypes 1704 (30.98) and 1715 (32.16) revealed on par mean performance with best check 1702 (30.11). The genotypic (14.02) and phenotypic (15.96) coefficients of variation were moderate. These results in similar lines were also reported by Nayak *et al*. (2002), Chandra *et al*. (2009), Selvaraj *et al*. (2011) and Ullah *et al*. (2011).

4.2.9 Grain yield per plant (g)

The grain yield per plant in ICRISAT ranged from 12.53 (1718) to 47.84 (1704), while it ranged from 16.43 (1719) to 65.60 (1705) in Warangal and it ranged from 16.93 (1717) to 83.03 (1709) in Maruteru, with a mean of 34.11. The range of mean performance across locations ranged from 16.87 (1718) to 55.13 (1709). The superior mean performance over best check 1708 (40.05) was reported by five genotypes 1703 (44.08), 1704 (47.64), 1706 (51.02), 1705 (52.48) and 1709 (55.13). The high GCV (41.19) and high PCV (41.55) values were recorded for this trait. As the variability for this character was high, there is lot of scope for improvement of this character by adapting appropriate selection method. Similar kind of results were reported by Pankaj Garg *et al*. (2010), Selvaraj *et al*. (2011), Mulugeta seyoum *et al.* (2012) , Rajendar *et al*. (2013) and Shiva Prasad *et al*. (2013).

GCV and PCV revealed PCV is higher for all the characters, on magnitude basis compared to GCV. The environment playing an important role in the expression of the respective characters. The PCV and GCV relationship showed in fig : 4.1

4.3 Heritability

High heritability estimates were recorded for all characters except panicle length and number of filled grains per panicle. These results were in accordance with findings of Shivani and Reddy (2000), Nayak *et al.* (2002), Patil and Sarawgi (2005), Bisne and Motiramani (2006), Sankar *et al.* (2006), Bharadwaj *et al.* (2007), Anbanandan *et al.*

(2009), Chandra *et al*. (2009), Abdul fiyaz *et al.* (2011), Akinwale *et al*. (2011), Akhtar *et al*. (2011) and Selvaraj *et al.* (2011). The panicle length and number of filled grains per panicle have moderate heritability. Similar kind of results were reported by Satya Priya Lalitha and Sreedhar (1996), Venkata Suresh (2001) and Mulugeta *et al. (*2012). High heritability was recorded for the grain yield per plant character and lowest was recorded for number of filled grain per panicle.

4.4 Genetic advance

The high genetic advance was reported for plant height, productive tillers per plant, number of filled grains per panicle, total number of grains per panicle, sterility percentage and 1000-seed weight and grain yield per plant. Similar kind of results were reported by Patil *et al*. (2003), Suman (2003), Nayudu *et al.* (2007), Kishore *et al*. (2008), Anbandan *et al* .(2009), Yadav *et al.* (2010), Akinwale *et al.* (2011) and Selvaraj *et al.* (2011). Low genetic advance was recorded for days to 50 per cent flowering and panicle length. Similar findings were reported by Nagajyothi (2001), Vijayalaxmi *et al.* (2008), Chandra *et al.* (2009), Ullah *et al.* (2011), Parikh *et al.* (2012), Rajendar *et al.* (2013). The highest genetic advance as per cent of mean was recorded for grain yield per plant and lowest was recorded for 50 per cent flowering.

High heritability coupled with high genetic advance for plant height, total number of grains per panicle, 1000-seed weight and grain yield per plant indicated that these traits were chiefly controlled by additive gene action. As such selection to isolate promising pure lines was suggested for further improvement. High heritability coupled with low genetic advance for panicle length and number of filled grains per panicle suggested that these traits were under the influence of non-additive gene action, for which heterosis breeding and recurrent selection would be more rewarding (Fig: 4.2).

4.5 STABILITY ANALYSIS

Rice is the staple crop and important cereal crop of India, being a thermo and photosensitive in nature, due to its buffering capacity it is being cultivated round the year in different agro-climatic zones of the country. However, the genotypes and breeding material likely to interact differently with different environments. The presently cultivated varieties and hybrids though having high yield potential and erratic in their performance even under less varied conditions of cultivation. Lack of genotypes suitable to specific locations accounts for the decline in the area and productivity in rice, apart from the biotic and abiotic stresses. This warrants the attention of the plant breeders to evolve superior genotypes that would sustain well in the strainful situation. Therefore, assessment of its adaptability is of important concern. Productivity of a population is the function of its adaptation, whereas stability is the statistical measure of genotype x environment interaction (Kandil *et al*. 1990).

4.5.1 Pooled analysis of variance

The results of pooled analysis of variance for stability as devised by Eberhart and Russell (1966) are presented in Table: 4.4. The twenty two genotypes showed significant differences for all the characters except for days to 50 per cent flowering, panicle length and number of filled grains per panicle when tested against mean sum of squares of G x E interaction. It revealed that the selected genotypes are rich in variation for various characters and may not be showing uniform performance in different environments. Significant differences among genotypes for these traits were earlier reported by Satya Priya Lalitha and Sreedhar (2000), Chaudahari *et al* .(2002), Shanmuganathan and Ibrahim (2005), Ali *et al.* (2006), SanjaySingh and Singh (2007), Bhakta and Das (2008), Lal and Singh (2012), Mosavi *et al*. (2013), Somana *et* al. (2013), Tariku *et al.* (2013). Environments showed highly significant differences for all the characters under study except panicle length, number of filled grains per panicle and total number of grains per panicle, indicating wide difference between environments selected. Significant mean sum of squares due to environments were in accordance with the findings of Satya Priya Lalitha and Sreedhar (2000), Swamy and Kumar (2003), Shanmuganathan and Ibrahim (2005), Ali *et al.* (2006), Pande *et al.* (2006), Sanjay Singh and Singh (2007), Bhakta and Das (2008), Ahmad Ramezanil *et al.* (2011), Lal and Singh (2012), Rasyad *et al*. (2012), Mosavi *et al*. (2013) , Somana *et al*. (2013) and Tariku *et al.* (2013). Genotype x Environment interaction components showed highly significant differences for all the characters except days to 50 percent flowering, panicle length, number of filled grains per panicle, total number of grains per panicle and 1000-seed weight, when tested against pooled error. Indicating wide differential behavior of genotypes in changing environments, Suman Kumara *et al.* (1999), Chaudahari *et al.* (2002), Kishore *et al.* (2002),Babu *et al.* (2005), Shanmuganathan and

Ibrahim (2005), Ali *et al.* (2006), Arumugan *et al.* (2007), Sanjay Singh and Singh (2007), Bhakta and Das (2008), Panwar *et al.* (2008), Ramya and Senthilkumar (2008), Das *et al.* (2009), Dushyanth kumar *et al.* (2010), Biswas *et al.* (2011), Sreedhar *et al.* (2011), Mosavi *et al.* (2013), Somana *et al.* (2013) and Tariku *et al* . (2013) also reported the differential response of varieties due to GxE interaction. Significance of Environment (linear) component for all the characters except panicle length, number of filled grains per panicle, total number of grains per plant, when tested against pooled deviation indicated that the genotypes responded linearly for most of the characters under study. The findings of Panwar *et al.* (2008) and Das *et al.* (2010) were in accordance with the present results.

The genotype x environment (linear) interaction was significant for plant height, productive tillers per plant, number of filled grains per panicle, percent of sterility and grain yield per plant when tested against pooled deviation. It suggested that the performance of genotypes across the environments could be predicted with great precision. The similar results confirmed the findings of Munisonnappa *et al.* (2004), Das *et al.* (2010) and Dushyantha Kumar *et al.* (2010); both linear and non-linear components were significant for productive tillers per plant, plant height, sterility percentage indicated the importance of both the components in determining the stability of these traits. These results were confirmed by Nayak *et al.* (2003), Krishnappa *et al.* (2009) and Dushyantha kumar *et al.* (2010), Subudhi *et al.* (2012). The high and significant pooled deviations for days to 50 percent flowering, plant height, panicle length, total number of grains per panicle, 1000-seed weight and grain yield per plant indicated the performance of genotypes is entirely unpredictable in nature. The present results confirmed the earlier findings of Shanmuganathan and Ibrahim (2005), Dushyantha kumar and Shadadshari (2007) and Dushyantha Kumar *et al.* (2010). It also indicated the importance of non-linear component in determining interaction of genotypes with environment.

4.5.2 Environmental indices

Environment index reveals the favourability of an environment at a particular location. Breeze (1969) pointed out that the estimates of environment index can provide the basis for identifying the favourable environment for the expression of maximum potential of the genotype. Based on the positive values of environment indices conclude the favourable environment for genotypes.

Environmental indices of nine characters *viz.*, days to 50 per cent flowering, plant height, number of productive tillers per plant, panicle length, number of filled grains per panicle, total number of grains per panicle, spikelet sterility per cent, 1000–seed weight and grain yield per plant are presented in the table: 4.5.

The location ICRISAT was found to be most favourable location for plant height and productive tillers, while Warangal was the most favourable for number of filled grains per panicle, total number of grains per panicle, per cent of sterility, 1000-seed weight and grain yield per plant. The Maruteru location was the most favourable for days to 50 percent flowering and panicle length.

The location Warangal is best among three locations as it is having good environment index for yield and most of the yield traits. The same location may be used for further studies to expect yield stability in rice in future.

4.5.3 Stability parameters

According to Eberhart and Russel (1966), a stable genotype is one which shows (i) high mean yield (ii) regression coefficient (b_i=1) equal to unity and (iii) a mean square deviation from regression (s^2d_i) near to zero. In interpreting the results of the present investigation,s^2di was considered as the measure of stability as suggested by Breeze (1969), then the type of stability (measure of response or sensitivity to environment changes) was decided on the regression coefficient (bi) and mean values (Finlay and Wilkinson, 1963).If bi is equal to unity , a genotype is considered to posses average stability and widely adaptable to different environments, if b_i is more than unity, it is considered to posses less than average stability and is adaptable to favourable environments, if b_i is less than unity, it is considered to posses more than the average stability and is adaptable to poor environments.

Estimation of stability parameters i.e., mean (μ), regression coefficient (b_i) and a mean square deviation from regression (s^2d_i) for the nine characters are furnished below character- wise. The results are presented in Table: 4.6.

4.5.3.1 Days to 50 per cent flowering

The mean value for this trait varied from 96.88 (1704) to 111.44 (1713). The genotype 1704 was identified as a stable variety having low mean (μ=96.88) with regression coefficient (b_i = 0.98) near 'unity' and non–significant deviation from regression ($S^{-2}d_i$ = -0.3). The genotype 1715 (μ =101.77, b_i =2.67, $S^{-2}d_i$ =-1.16) having low mean, regression coefficient greater than 'unity' and non–significant deviation from regression was suitable for better environment.

For poor environment, the genotype 1709 (μ=108.44, b_i=-1.43, $S^{-2}d_i$ =-1.18) exhibited high mean with regression coefficient less than 'unity' and non–significant deviation from regression was suitable. The genotypes with unpredictable performance having significant deviation from regression values were 1707 (236.60**), 1711 (299.28**), 1720 (152.17**) and 1716 (106.08**).

For days to 50 per cent flowering, both linear and non-linear components of GxE interaction were non-significant but significant for pooled deviation indicated that only non-linear portion contributes for GxE to the considerable extent which is unpredictable in nature in present study. Similar results were reported by Honarnejad (2000), Babu *et al*. (2005), Krishnappa *et al*. (2009) and Biswas *et al.* (2011).

4.5.3.2 Plant height (cm)

The mean values for this trait ranged from 83.02 (1717) to 131.68 (1714). The stable genotype observed for this trait was 1710 having high mean (101.70) with regression coefficient (0.92) near to 'unity' and non–significant deviation from regression (-6.21). For better environment, the genotypes 1716 (μ=115.11, b_i=2.89, s^2d_i=-1.68), 1722(μ=111.26, b_i=2.05, s^2d_i=-2.73) having high mean with regression coefficient greater than 'unity' and non–significant deviation from regression with predictable performance are advised.

The genotypes *viz.*, 1702 (μ=126.00, bi=-0.05, s^2di=-0.06), 1705(μ=123.96, b_i=-0.32, s^2d_i=5.87), 1707 (μ=115.48, b_i=-0.02, s^2d_i=-7.97) and 1714 (μ=131.68, b_i=0.23, s^2d_i=-8.49) recorded high mean with regression coefficient less than 'unity' and non–significant deviation from regression and are suitable for resource scarce environments.

The genotypes *viz.,* 1722(14.15*), 1721(2.93*), 1718(6.09*), 1708(4.98*), 1717(3.47) and 1702(3.90*) with significant deviation from regression were considered to have unpredictable performance.

In respect of plant height in the present investigation, both linear and non-linear components of GxE interaction were found to be significant showed significance for this trait. It indicated significant differences among the genotypes for different environments and linear response to environments. Similar results were observed by Shanmuganathan and Ibrahim (2005), Panwar (2008), Nayak *et al*. (2003), Dushyantha Kumar *et al.* (2010) and Subudhi *et al*. (2012).

4.5.3.3 Productive tillers per plant

Productive tillers per plant are an important yield contributing character in rice. The mean character for this trait varied from 8.61 (1722) to 14.29 (1717). The genotype 1704 have recorded high mean (μ=10.93), regression coefficient (b_i=0.96) 'unity' and non–significant (s^2d_i=-0.89) deviation from regression was considered as stable genotype for this trait.

Four genotypes 1701, 1706, 1709 and 1710 were suitable for favourable environment as they recorded high mean (μ) (11.47, 12.24, 12.97, 11.27) with regression coefficient (b_i) (2.33, 2.00, 3.00, 2.58) greater than 'unity' and non–significant(-0.58, -1.78, -0.54, -1.86) deviation from regression (s^2d_i).

The genotype 1719 with high mean (μ) (12.88), regression coefficient (b_i) (-1.34) less than unity and non–significant (-0.81) deviation from regression (s^2d_i) can perform well under unfavourable environment.

In case of three genotypes *viz.,* 1715(4.72*), 1717(5.21*) and 1718(7.85*), the performance has been found to be highly unpredictable because of their significant deviation from regression values.

Both the linear and non linear components of GxE interaction were found to be significant for number of productive tillers per plant; it demonstrated that the genotypes responded differently to the variation in environmental conditions of locations. Similar results were observed by Shankar *et al*. (2008). Significance of linear component was reported by Munisonnappa *et al*. (2004), Shanmuganathan and Ibrahim (2005). While significance of non linear component was reported by Babu *et al*. (2005).

4.5.3.4 Panicle length (cm)

The mean value for this trait varied from 22.76 (1720) to 27.16 (1708). The stable genotypes identified were 1706 (μ=24.78, b_i= 0.96 and s^2d_i= 0.04).

For better environment, the genotypes 1701 (μ=26.28, b_i=3.69, s^2d_i=-0.68) and 1705 (μ=26.31, b_i=2.57, s^2d_i=0.08), 1707 (μ=25.02, b_i=2.98, s^2d_i=-0.39), 1711(μ=26.33, b_i=2.75, s^2d_i=0.02) and 1715 (μ=26.11, b_i=4.03, s^2d_i=0.08) were having high mean, regression coefficient greater than 'unity' and non–significant deviation from regression. Two genotypes *viz.*, 1709 and 1714 were suitable for poor environments as they recorded high mean (μ) (24.15, 24.48) and non–significant (-0.83, -0.83) deviation from regression (s^2d_i), but regression coefficient (bi) (0.27, 0.44) was less than 'unity'.

The genotypes *viz.*, 1722 (14.15*), 1721 (2.93*), 1718 (6.09*), 1708 (4.98*) and 1702(3.90*) with significant deviation from regression were considered to have unpredictable performance.

In respect of plant height in the present investigation, both linear and non-linear components of GxE interaction were found to be non significant. Similar results were observed by Honarnejad (2000), Babu *et al*.(2005), Krishnappa *et al*.(2009) and Biswas *et al.* (2011).

4.5.3.5 Number of filled grains per panicle

The mean values recorded for this trait was from 118.20 (1717) to 206.97 (1701). The genotype 1704 with high mean (134.40), regression coefficient (1.06) near to 'unity' and non–significant (-225.08) deviation from regression was declared as stable. Six genotypes 1703, 1706, 1710, 1719, 1721 and 1722was suitable for better environment as it had high mean (μ) (169.91, 126.24, 162.75, 122.40, 138.46, 127.51), regression coefficient (b_i) (1.80, 4.15, 4.28, 2.34, 5.07, 1.57) more than 'unity' and non–significant (-206.43, -265.47, -177.75, -295.25, -285.58, -289.31) deviation from regression (s^2d_i).

The genotypes 1702 and 1716 were suitable for poor environments as they recorded high mean (μ) (170.05 and 150.53) and non- significant (-278.09 and -296.36) deviation from regression (s^2d_i) but regression coefficient (b_i) (-6.37 and -1.93) less than unity.

In respect of plant height in the present investigation, linear components of GxE interaction were found to be significant this indicated significant difference among the genotypes for linear response to environments, similar results were observed by Krishnappa *et al*. (2009) and Biswas *et al.* (2011) and non-linear components of GxE interaction were found to be non-significant. Similar results were observed by Nayak *et al*. (2003) and Babu *et al*. (2005).

4.5.3.6 Total number of grains per panicle

The mean values for this trait was from 132.11 (1717) to 218.92 (1714). The genotype 1703 (μ=187.53, b_i= 0.93, s^2d_i=-180.39) was considered stable because it has high mean, regression coefficient near 'unity' and non–significant deviation from regression.

The genotypes 1712 and 1717 with high mean (190.25, 132.11) regression coefficient (2.40, 0.88) greater than 'unity' and non–significant (167.90, 217.82) deviation from regression can perform well under favourable environment. Two genotypes1705 and 1718 with mean (μ) (188.62, 135.11), regression coefficient (b_i) (-5.95, 0.56) less than 'unity' and non-significant (47.46, 14.88) deviation from the regression (s^2d_i), were considered to be suitable for poor environment. The genotypes with unpredictable performance having significant deviation from regression values were 1701 (2374**), 1709 (1169**), 1714 (4099**), 1713 (1314**) and 1711 (1003*).

Both the linear and non-linear components were found non-significant for this trait but significant for pooled deviation which indicated that only non linear portion contributes for GxE to the considerable extent which is unpredictable in nature. Similar results were observed by Honarnejad (2000), Rasyad *et al*. (2012).

4.5.3.7 Percent of sterility

Higher percent of sterility is one of the major constrain in developing high yielding genotypes. The mean values for this trait was from 8.45 (1705) to 18.16 (1715). All the genotypes showed non-significant deviation from regression. The stable genotype 1713 high mean (μ) (10.86) and regression coefficient (b_i) near 'unity' (1.01) and non significant (-1.09) deviation from the regression (s^2d_i) Hence, it can perform well in wider environments. For better environment, three genotypes 1715 (μ=18.16, b_i=3.80, s^2d_i=3.42), 1709 (μ=12.26, b_i=2.87, s^2d_i=3.05), 1704 (μ=11.67, b_i=2.51, s^2d_i=0.30) with high mean, regression coefficient greater than 'unity' and non-significant deviation from regression. The genotype 1716 was suitable for poor environment as they recorded high mean (μ) (15.15) with regression coefficient (b_i) (-1.82) less than 'unity' and non-significant (-1.47) deviation from regression (s^2d_i).

Incase of genotypes *viz.,* 1707 (7.99*) and 1711 (6.73*) the performance has been found to be highly unpredictable because of their significant deviation from regression values.

Both GxE linear and non-linear was significant for this character it demonstrated that the genotypes responded differently to the variation in environmental conditions of locations .Similar results were observed by Nayak *et al*. (2003).

4.5.3.8 1000- seed weight (g)

The mean values for this trait varied from 22.31 (1707) to 32.16 (1715). The genotype 1706 with high mean (μ) (29.58), regression coefficient (b_i) near 'unity' (0.91) and non-significant deviation from regression (s^2d_i) (-1.28) was considered as stable for this trait.

The genotypes which exhibited high mean, regression coefficient more than 'unity' and non–significant deviation from regression and recommended for resource rich environments were 1713 (μ =23.29, b_i=4.84, s^2d_i=1.92) and 1716 (μ =26.81, b_i=2.40, s^2d_i=0.55).

For poor environment, two rice genotypes *viz.,* 1701 and 1715 with high mean (μ) (27.51, 32.16), regression coefficient (bi) (-0.20,-0.23) less than 'unity' and non–significant (-1.36, -0.92) deviation from regression ($S^{-2}d_i$) were suitable.

The performance of genotypes 1702 (5.82*), 1707(29.00**), 1709 (23.19**) and 1714 (39.29**) was unpredictable because of high significant deviation from regression values.

The GE (linear) showed significance for 1000-seed weight which indicated significant difference among the genotypes for linear response to environments. Earlier similar kind of results showed by Sreedhar *et al.* (2011) and Saidaiah *et al.* (2011).

4.5.3.9 Grain yield per plant (g)

High grain yield is the ultimate objective for any breeder to tackle the hunger problem of growing population. The mean values ranged from 16.87 gm/plant (1718) to 55.13 gm/plant (1709). The genotype 1703 was considered stable as it recorded high mean (μ) =44.08 with regression coefficient (b_i) =1.01 near 'unity' and non–significant =0.29 deviation from regression(s^2d_i). The genotype 1704 was also considered stable as it recorded high mean (μ) =47.64 with regression coefficient (b_i) =0.97 near 'unity' and non significant (-1.14) deviation from regression (s^2d_i). The genotypes suitable for better environment with predictable performance were 1712 (μ=37.59, b_i=1.44, d^2s_i=-0.93) and 1715 (μ = 31.79, b_i=2.13, d^2s_i=0.14) having high mean with greater than 'unit' regression and non–significant deviation from linearity.

Two genotypes *viz.*, 1719 and 1720 exhibited high mean (μ) (21.33 and 24.99) with regression coefficient (b_i) (-0.90 and 0.89) less than 'unity' and non–significant (0.70, 2.25) deviation from regression (s^2d_i) were identified for resource scarce environments. All genotypes showed unpredictable performance due to significant deviation from regression (s^2d_i) except six genotypes *viz.*, 1703 (0.29), 1704 (1.14), 1712 (0.93), 1715 (0.14), 1719 (0.70) and 1720 (2.25). The GxE (linear) showed significance for this trait indicated significant differences among the genotypes for linear response to environments. Earlier, Nayak (2008), Biswas *et al.* (2011) and Bhaktha *et al.* (2008) reported similar kind of results and were of the opinion that performance could not predicted, when the location was changed.

Mean performance was high for 1709 and 1705 genotypes but stability analysis showed that 1703 and 1704 were registered stable genotypes. It indicated there is no relationship between mean performance and stability (Fig: 4.3).

Table: 4.1 Pooled analysis of variance for yield and yield contributing traits in rice (*Oryza sativa* L.).

Source of Variation	df	Days to 50 per cent flowering	Plant height (cm)	Productive tillers	Panicle length (cm)	No. of filled grains per panicle	Total no. of grains per panicle	Percent of sterility	1000-seed weight (g)	Grain yield per plant (g)
Replications	2	2.37	56.37	4.53	1.40	2382.98	354.50	1.49	0.32	0.77
Genotypes	65	207.76**	940.80**	19.71**	9.00**	2192.83**	2906.85**	43.69**	46.26**	595.94**
Error	130	1.99	28.78	2.66	2.51	866.63	548.51	4.71	4.16	3.52

* Significant at 5 per cent level of significance   ** Significant at 1 per cent level of significance

Table: 4.2 Mean performance of rice genotypes for yield & yield traits in different locations.

Genotypes		Days to 50% flowering				Plant height (cm)				Productive tellers per plant			
s.no.		ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean
1.	1701	99.33	111.33	91.33	100.66	119.00	121.73	125.76	122.16	15.61	10.53	8.26	11.47
2.	1702	100.00	109.00	92.66	100.55	125.36	128.47	124.20	126.00	12.40	10.13	7.47	10.00
3.	1703	105.66	108.66	101.66	105.33	103.88	120.73	122.53	115.71`	13.51	13.00	13.26	13.26
4.	1704	97.33	100.66	92.66	96.88	111.25	124.13	129.66	121.68	11.68	10.67	10.46	10.93
5.	1705	118.33	90.33	114.66	107.77	124.66	126.86	120.36	123.96	14.18	9.86	9.20	11.08
6.	1706	100.33	104.00	95.66	100.00	111.98	125.46	126.66	125.04	16.13	9.80	10.80	12.24
7.	1707	116.66	99.33	91.00	102.11	123.00	114.40	116.06	115.48	12.10	9.66	8.80	10.18
8.	1708	110.00	100.33	94.00	101.44	116.00	124.30	125.46	124.13	15.21	10.53	8.20	11.31
9.	1709	92.33	105.33	113.00	108.44	97.51	119.60	119.60	112.23	18.31	11.66	8.93	12.97
10.	1710	99.33	112.00	94.33	101.88	95.65	104.06	105.40	101.70	16.21	8.46	9.13	11.27
11.	1711	91.00	115.00	107.66	104.55	122.91	122.93	128.60	124.81	13.51	9.80	8.93	10.75
12.	1712	99.33	112.00	92.00	101.11	124.66	129.26	132.53	128.82	12.33	9.40	7.86	9.86
13.	1713	104.66	112.66	117.00	111.44	114.00	118.20	120.66	117.62	13.48	9.40	9.26	10.71
14.	1714	108.66	110.33	93.00	104.00	130.00	132.80	132.26	131.68	14.66	10.73	8.26	11.22
15.	1715	100.66	113.66	91.66	101.77	116.33	128.20	128.16	124.23	13.23	11.73	7.46	10.81
16.	1716	112.00	102.00	92.67	102.22	98.73	115.46	131.13	115.11	14.16	10.00	8.13	10.76
17.	1717	102.00	118.00	96.00	105.33	78.96	77.16	92.93	83.02	13.31	16.40	13.18	14.29
18.	1718	113.33	102.33	95.33	103.66	80.79	82.53	91.20	84.84	9.05	8.82	13.59	10.48
19.	1719	109.00	100.00	93.66	100.88	75.27	95.80	94.24	88.43	10.50	13.44	14.69	12.88
20.	1720	116.33	104.00	94.00	104.77	87.90	91.82	102.21	93.97	9.92	11.30	11.26	10.83
21.	1721	97.33	105.00	112.66	105.00	75.98	80.54	93.59	83.37	9.32	10.26	13.05	10.88
22.	1722	98.00	110.00	104.33	104.11	74.81	85.98	97.93	111.26	7.90	8.25	9.67	8.61
G.M		104.12	106.63	98.65	103.16	105.42	112.29	116.41	111.37	13.03	10.63	9.99	11.22
C.D 5%		2.78	2.32	1.62	2.28	6.18	5.50	11.88	8.66	3.89	1.76	1.62	2.63
C.V		1.62	1.32	1.00	2.5	3.56	2.97	6.19	4.81	18.13	10.10	9.87	14.53

G.M=Grand Mean; C.D=Critical Difference; C.V=Coefficient of Variation

Table: 4.2 (cont.).

Genotypes		Panicle length (cm)				Number of filled grains per panicle				Total no. of grains per panicle			
S.no		ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean
1.	1701	26.66	24.73	27.46	26.28	210.33	209.86	200.73	206.97	151.73	221.73	220.60	198.02
2.	1702	26.36	24.36	24.00	24.73	179.16	160.40	170.60	170.05	168.60	165.66	157.06	163.77
3.	1703	23.80	23.70	22.76	23.42	148.46	193.33	167.93	169.91	187.86	188.73	186.00	187.53
4.	1704	26.46	24.83	22.90	24.91	121.93	144.66	136.60	134.40	147.16	147.40	147.60	147.38
5.	1705	27.13	24.96	26.83	26.31	171.33	169.93	179.53	173.60	210.00	164.46	191.40	188.62
6.	1706	25.56	24.06	24.73	24.78	118.53	132.20	128.00	126.24	185.30	146.00	141.00	157.43
7.	1707	24.53	24.13	26.40	25.02	175.00	171.00	175.40	173.80	154.10	182.00	197.40	177.83
8.	1708	29.20	24.76	27.53	27.16	136.66	136.66	140.40	137.91	133.16	148.80	156.66	146.21
9.	1709	24.13	24.06	24.26	24.15	176.20	168.86	164.00	169.68	231.16	184.66	180.73	198.85
10.	1710	27.53	25.00	26.40	26.31	165.46	170.86	151.93	162.75	135.56	195.40	175.13	168.70
11.	1711	27.13	24.93	26.93	26.33	159.66	158.00	161.43	159.70	203.83	171.73	155.66	177.07
12.	1712	27.80	24.63	27.86	26.76	193.80	181.00	181.43	185.41	199.83	198.60	172.33	190.25
13.	1713	25.60	23.96	23.40	24.32	160.80	159.86	162.13	160.93	230.47	181.66	177.40	196.51
14.	1714	24.46	24.33	24.66	24.48	200.46	199.80	199.13	199.80	260.03	230.86	165.86	218.92
15.	1715	25.40	24.93	28.00	26.11	131.33	130.46	133.80	131.55	104.30	157.80	151.33	137.81
16.	1716	24.66	23.76	23.60	24.01	152.20	147.40	152.00	150.53	174.33	182.23	173.40	176.65
17.	1717	22.83	25.54	25.22	24.53	118.66	116.13	119.80	118.20	115.93	136.66	143.73	132.11
18.	1718	22.51	25.79	25.69	24.66	116.33	118.40	121.73	118.82	123.86	138.06	143.40	135.11
19.	1719	21.81	23.93	22.83	22.86	119.33	126.00	121.86	122.40	131.26	150.00	145.40	142.22
20.	1720	21.39	24.55	22.35	22.76	117.93	122.20	120.20	120.11	128.46	145.13	144.46	139.35
21.	1721	21.80	24.00	24.33	23.38	135.53	146.93	132.93	138.46	136.33	169.86	153.20	153.13
22.	1722	21.95	24.95	28.22	25.04	127.66	130.33	124.53	127.51	121.40	151.33	144.73	139.15
G.M		24.94	24.54	2.29	24.92	151.67	154.26	152.07	152.7	165.21	170.85	164.75	166.9
C.D 5%		2.34	3.12	2.23	2.55	37.99	57.27	48.87	47.55	20.18	52.11	37.06	37.83
C.V		5.71	7.73	5.36	6.35	15.20	22.53	19.50	14.28	7.41	18.51	13.65	14.02

G.M=Grand Mean; C.D=Critical Difference; C.V=Coefficient of Variation

Table: 4.2 (cont.).

Genotypes		Percent of sterility				1000-seed weight (g)				Grain yield per plant (g)			
		ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean	ICRISAT	Warangal	Maruteru	Pooled mean
1.	1701	18.14	8.97	10.35	12.49	27.93	27.26	27.33	27.51	26.90	36.96	39.86	34.57
2.	1702	16.34	8.74	8.82	11.30	32.36	26.60	31.38	30.11	26.53	47.33	29.32	34.39
3.	1703	16.38	8.58	9.59	11.51	25.77	26.60	26.38	26.25	43.56	45.50	43.20	44.08
4.	1704	16.78	6.60	11.62	11.67	31.83	30.86	30.26	30.98	47.84	47.60	47.50	47.64
5.	1705	11.30	6.89	7.16	8.45	25.53	27.00	24.83	25.78	31.93	65.60	59.93	52.48
6.	1706	10.08	9.42	9.09	9.53	28.06	30.43	30.26	29.58	32.50	58.63	61.93	51.02
7.	1707	8.20	6.96	11.22	8.79	17.90	21.40	27.64	22.31	27.53	41.34	25.57	31.48
8.	1708	17.58	7.99	13.44	13.00	29.23	24.90	27.97	27.36	33.62	52.23	34.30	40.05
9.	1709	19.06	8.46	9.24	12.26	24.53	31.03	23.16	26.24	30.26	53.66	83.03	55.13
10.	1710	18.58	13.63	13.20	15.14	29.06	26.53	29.06	28.22	34.22	45.51	25.65	35.13
11.	1711	10.62	9.04	13.15	10.94	26.13	32.53	31.05	29.90	17.31	42.45	22.80	27.52
12.	1712	15.60	9.52	13.21	12.78	23.36	27.86	25.90	25.71	27.86	46.73	38.18	37.59
13.	1713	13.21	8.50	10.89	10.86	13.56	31.40	24.92	23.29	28.53	44.43	31.89	34.95
14.	1714	13.94	15.25	14.66	14.62	19.66	30.20	19.57	23.14	29.20	51.30	33.53	38.01
15.	1715	27.02	12.81	14.66	18.16	32.76	32.23	31.50	32.16	16.80	44.41	34.16	31.79
16.	1716	11.25	18.46	15.73	15.15	22.06	31.13	27.24	26.81	30.03	27.08	23.56	26.89
17.	1717	14.16	14.97	16.59	15.24	24.72	25.26	26.93	25.64	22.78	29.40	16.93	23.03
18.	1718	18.22	15.76	15.82	16.60	22.31	27.10	26.50	25.30	12.53	16.76	21.33	16.87
19.	1719	15.13	16.24	16.54	15.97	21.74	28.97	27.83	26.18	27.95	16.43	19.61	21.33
20.	1720	14.89	16.10	15.37	15.45	22.64	28.95	28.46	26.68	19.51	31.36	24.09	24.99
21.	1721	13.41	12.59	13.02	13.01	18.62	24.80	24.30	22.57	16.69	20.00	25.63	20.77
22.	1722	15.27	13.76	13.92	14.32	22.16	26.58	29.03	25.92	15.66	21.60	23.42	20.22
G.M		15.23	11.33	12.60	13.05	24.63	28.16	27.34	26.71	27.26	40.29	34.79	34.11
C.D 5%		4.02	3.30	2.67	3.50	4.27	2.84	2.27	3.29	3.58	2.49	2.87	3.03
C.V		16.01	17.67	12.86	16.63	10.51	6.13	5.05	7.64	7.97	3.76	5.00	5.50

G.M=Grand Mean; C.D=Critical Difference; C.V=Coefficient of Variation

Table: 4.3 Genetic parameters for yield & yield contributing characters in Rice (*Oryza sativa* L.)

Character	General mean	Co- efficient of variation		Heritability (%) (bs)	Genetic Advance	Genetic Advance as *per cent* of mean
		GCV (%)	PCV (%)			
Days to 50 per cent flowering	103.16	8.03	8.14	97	16.81	16.30
Plant height (cm)	111.37	15.65	16.37	91	34.32	30.82
Productive tillers per plant	11.22	21.24	25.74	68	4.05	36.12
Panicle length (cm)	24.92	5.90	8.67	46	2.06	8.27
Number of filled grains per panicle	152.7	13.77	23.69	33	25.17	16.48
Total number of grains per panicle	166.9	16.79	21.88	58	44.32	26.55
Percent of sterility	13.05	27.60	32.22	73	6.36	48.69
1000-Seed weight (g)	26.71	14.02	15.96	77	6.77	25.36
Grain yield per plant (g)	34.11	41.19	41.55	98	28.69	84.10

Table: 4.5 Environmental indices for yield components for across the three locations in rice.

Characters	Locations			
		ICRISAT	**Warangal**	**Maruteru**
Days to 50% flowering	Ij	0.98	3.5	-1.48
Plant height (cm)	Ij	-5.95	0.91	5.404
Productive tillers	Ij	1.81	-0.59	-1.22
Panicle length (cm)	Ij	0.01	-0.38	0.36
No. of filled grains per panicle	Ij	-0.99	1.59	-0.59
Total no. of grains per panicle	Ij	-1.72	3.91	-2.18
Per cent of sterility	Ij	2.17	-1.72	-0.45
1000-Seed weight (g)	Ij	-2.08	1.45	0.62
Grain yield per plant (g)	Ij	-1.85	6.17	0.67

Ij – Environmental index

Table: 4.5 Environmental indices for yield components across the three locations in rice.

Characters	Locations			
		ICRISAT	Warangal	Maruteru
Days to 50% flowering	Ij	0.98	3.5	-1.48
Plant height (cm)	Ij	-5.95	0.91	5.404
Productive tillers	Ij	1.81	-0.59	-1.22
Panicle length (cm)	Ij	0.01	-0.38	0.36
No. of filled grains per panicle	Ij	-0.99	1.59	-0.59
Total no. of grains per panicle	Ij	-1.72	3.91	-2.18
Per cent of sterility	Ij	2.17	-1.72	-0.45
1000-Seed weight (g)	Ij	-2.08	1.45	0.62
Grain yield per plant (g)	Ij	-1.85	6.17	0.67

Ij – Environmental index

Table: 4.6 Mean performance and stability for yield & yield traits of rice (*Oryza sativa* L.) genotypes.

s.no.	Genotypes	Days to 50% flowering			Plant height (cm)			Productive tillers per plant		
		Mean	bi	s²di	Mean	Bi	s²di	Mean	bi	s²di
1.	1701	100.66	2.34	20.03**	122.16	0.59	-8.28	11.47	2.33	-0.58
2.	1702	100.55	1.93	8.80**	126.00	-0.05	-0.06	10.00	1.44	0.71
3.	1703	105.33	0.85	-0.27	115.71`	1.77	7.88	13.26	0.12	-0.84
4.	1704	96.88	0.98	-0.3	121.68	1.70	-8.51	10.93	0.96	-0.89
5.	1705	107.77	-2.45	263.00**	123.96	-0.32	5.87	11.08	1.68	-0.81
6.	1706	100.00	1.01	0.02	125.04	0.34	-9.72	12.24	2.00	-1.78
7.	1707	102.11	1.61	236.60**	115.48	-0.02	-7.97	10.18	1.07	-0.88
8.	1708	101.44	1.14	86.03**	124.13	0.25	-9.73	11.31	2.21	-0.45
9.	1709	108.44	-1.43	-1.18	112.23	2.01	35.06*	12.97	3.00	-0.54
10.	1710	101.88	2.00	31.48**	101.70	0.92	-6.21	11.27	2.58	-1.86
11.	1711	104.55	0.28	299.28**	124.81	0.46	-1.58	10.75	1.52	-0.89
12.	1712	101.11	2.32	25.16**	128.82	0.71	-9.67	9.86	1.40	-0.68
13.	1713	111.44	-0.82	55.25**	117.62	0.61	-9.74	10.71	1.47	-0.56
14.	1714	104.00	2.28	8.49**	131.68	0.23	-8.49	11.22	1.98	-0.13
15.	1715	101.77	2.67	-1.16	124.23	1.14	3.32	10.81	1.55	4.72*
16.	1716	102.22	1.55	106.08**	115.11	2.89	-1.68	10.76	1.92	-0.68
17.	1717	105.33	2.49	51.77**	83.02	1.11	62.62*	14.29	-0.32	5.21*
18.	1718	103.66	1.27	110.50**	84.84	0.88	5.09	10.48	-1.06	7.85**
19.	1719	100.88	1.12	76.40**	88.43	1.85	39.38*	12.88	-1.34	-0.81
20.	1720	104.77	1.71	152.17**	93.97	1.23	6.75	10.83	-0.48	-0.83
21.	1721	105.00	-1.26	64.14**	83.37	1.51	17.38	10.88	-1.00	1.53
22.	1722	104.11	0.41	65.86**	111.26	2.05	-2.73	8.61	-0.46	-0.24
Population mean		103.16			111.37			11.22		
C.D 5%		2.28			8.66			2.63		
C.V		2.5			4.81			14.53		
Standard error mean		6.5			2.7			0.87		

*significant at 5 per cent level of significance

** significant at 1 per cent level of significance

Table: 4.6 (cont.).

s.no.	Genotypes	Panicle length (cm)			No. of filled grains per panicle			Total no .of grains per panicle		
		Mean	bi	s²di	Mean	Bi	s²di	Mean	Bi	s²di
1.	1701	26.28	3.69	-0.68	206.97	1.28	-244.32	198.02	5.34	2374.63**
2.	1702	24.73	-0.36	3.90*	170.05	-6.37	-278.09	163.77	0.60	-118.21
3.	1703	23.42	-1.21	-0.59	169.91	1.80	-206.43	187.53	0.93	-180.39
4.	1704	24.91	-2.42	2.38	134.40	1.06	-225.08	147.38	0.00	-181.76
5.	1705	26.31	2.57	0.08	173.60	-1.83	-255.78	188.62	-5.95	47.46
6.	1706	24.78	0.96	0.04	126.24	4.15	-265.47	157.43	-2.46	855.46*
7.	1707	25.02	2.98	-0.39	173.80	-1.70	-295.94	177.83	0.63	772.59*
8.	1708	27.16	3.88	4.98*	137.91	-0.57	-288.52	146.21	0.42	100.19
9.	1709	24.15	0.27	-0.83	169.68	-1.13	-226.11	198.85	-3.10	1169.79**
10.	1710	26.31	1.98	1.29	162.75	4.28	-177.75	168.70	6.39	726.59*
11.	1711	26.33	2.75	0.02	159.70	-0.95	-294.18	177.07	-0.88	1003.31*
12.	1712	26.76	4.41	0.55	185.41	-3.35	-234.49	190.25	2.40	167.90
13.	1713	24.32	-0.64	1.66	160.93	-0.59	-295.28	196.51	-3.24	1314.26**
14.	1714	24.48	0.44	-0.83	199.80	-0.07	-295.67	218.92	3.98	4099.56**
15.	1715	26.11	4.03	0.08	131.55	-0.85	-293.74	137.81	4.61	1032.56*
16.	1716	24.01	-0.16	-0.18	150.53	-1.93	-296.36	176.65	1.43	-181.85
17.	1717	24.53	-0.58	3.47*	118.20	-1.21	-295.20	132.11	0.88	217.82
18.	1718	24.66	-0.34	6.09**	118.82	0.02	-281.69	135.11	0.56	14.88
19.	1719	22.86	-1.57	0.74	122.40	2.34	-295.25	142.22	1.84	-69.10
20.	1720	22.76	-3.07	1.81	120.11	1.40	-295.06	139.35	1.31	-43.35
21.	1721	23.38	0.30	2.93*	138.46	5.07	-285.58	153.13	4.09	-5.14
22.	1722	25.04	2.08	14.15**	127.51	1.57	-289.31	139.15	2.86	123.57
Population mean		24.92			152.7			166.9		
C.D 5%		2.55			47.55			37.83		
C.V		6.35			14.28			14.02		
Standard error mean		1.15			3.7			19.8		

*significant at 5 per cent level of significance ** significant at 1 per cent level of significance

Table: 4.6 (cont.).

s.no.	Genotypes	Per cent of sterility			1000-seed weight (g)			Grain yield per plant (g)		
		Mean	bi	s²di	Mean	Bi	s²di	Mean	Bi	s²di
1.	1701	12.49	2.44	0.11	27.51	-0.20	-1.36	34.57	0.83	32.61**
2.	1702	11.30	2.08	2.16	30.11	-1.32	5.82*	34.39	1.52	55.21**
3.	1703	11.51	2.08	-0.05	26.25	0.23	-1.37	44.08	1.01	0.29
4.	1704	11.67	2.51	0.30	30.98	-0.35	-0.96	47.64	0.97	-1.14
5.	1705	8.45	1.20	-0.68	25.78	0.25	0.66	52.48	2.65	47.00**
6.	1706	9.53	0.20	-1.37	29.58	0.91	-1.28	51.02	2.12	134.50**
7.	1707	8.79	0.10	7.99*	22.31	1.64	29.00**	31.48	0.98	64.21**
8.	1708	13.00	2.32	1.88	27.36	-1.04	1.22	40.05	1.35	66.01**
9.	1709	12.26	2.87	3.05	26.24	1.26	23.19**	55.13	2.11	1016.89**
10.	1710	15.14	1.38	1.12	28.22	-0.54	0.93	35.13	0.75	149.60**
11.	1711	10.94	0.20	6.73*	29.90	1.81	-1.37	27.52	1.86	52.99**
12.	1712	12.78	1.46	0.31	25.71	1.19	-0.86	37.59	1.44	-0.93
13.	1713	10.86	1.01	-1.09	23.29	4.84	1.92	34.95	1.17	21.34**
14.	1714	14.62	-0.32	-1.54	23.14	2.23	39.29*	38.01	1.63	46.00**
15.	1715	18.16	3.80	3.42	32.16	-0.23	-0.92	31.79	2.13	0.14
16.	1716	15.15	-1.82	-1.47	26.81	2.40	0.55	26.89	-0.26	13.84**
17.	1717	15.24	-0.32	0.72	25.64	0.32	0.59	23.03	0.43	60.73**
18.	1718	16.60	0.67	-1.20	25.30	1.40	-1.21	16.87	0.38	25.51*
19.	1719	15.97	-0.32	-1.28	26.18	2.10	-1.19	21.33	-0.90	0.70
20.	1720	15.45	-0.29	-1.48	26.68	1.88	-0.78	24.99	0.89	2.25
21.	1721	13.01	0.20	-1.54	22.57	1.84	-0.84	20.77	0.31	31.49**
22.	1722	14.32	0.40	-1.48	25.92	1.57	6.00*	20.22	0.49	11.19*
Population mean		13.05			26.71			34.11		
C.D 5%		3.50			3.29			3.03		
C.V		16.63			7.64			5.50		
Standard error mean		1.05			1.69			6.49		

*significant at 5 per cent level of significance ** significant at 1 per cent level of significance

Table: 4.7 Classification of rice (*Oryza sativa* L.) genotypes for different characters based on stability parameters

s.no	Character	bi = 1	Bi > 1	Bi < 1
1.	Days to 50 *per cent* flowering	1704	1715	1709
2.	Plant height (cm)	1710	1716 and 1722	1702,1705,1707 and 1714
3.	Productive tillers per plant	1704	1701,1706,1709 and 1710	1719
4.	Panicle length (cm)	1706	1701,1705,1707,1711 and 1715	1709 and 1714
5.	Number of filled grains per panicle	1704	1703,1706,1710,1719,1721 and 1721	1702 and 1716
6.	Total number of grains per panicle	1703	1712 and 1717	1705 and 1718
7.	Per cent of sterility	1713	1704,1709 and 1715	1716
8.	1000-seed weight (g)	1706	1713 and 1716	1701
9.	Grain yield per plant (g)	1703and 1704	1712 and 1715	1719 and 1720

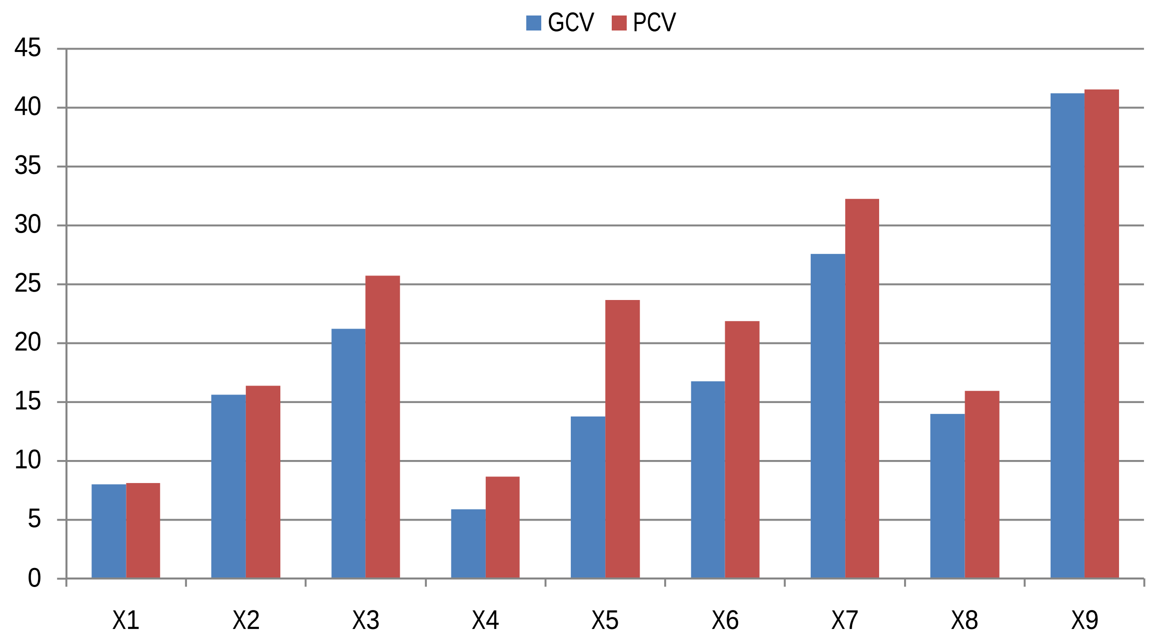

Fig: 4.1 GCV and PCV for yield and yield contributing characters in rice genotypes

X_1= Days to 50 per cent flowering

X_2= Plant height

X_3=Productive tillers

X_4= Panicle length

X_5= Number of filled grains per panicle

X_6= Total number of filled grains per panicle

X_7= Sterility per cent

X_8= 1000-seed weight

X_9= Grain yield per plant

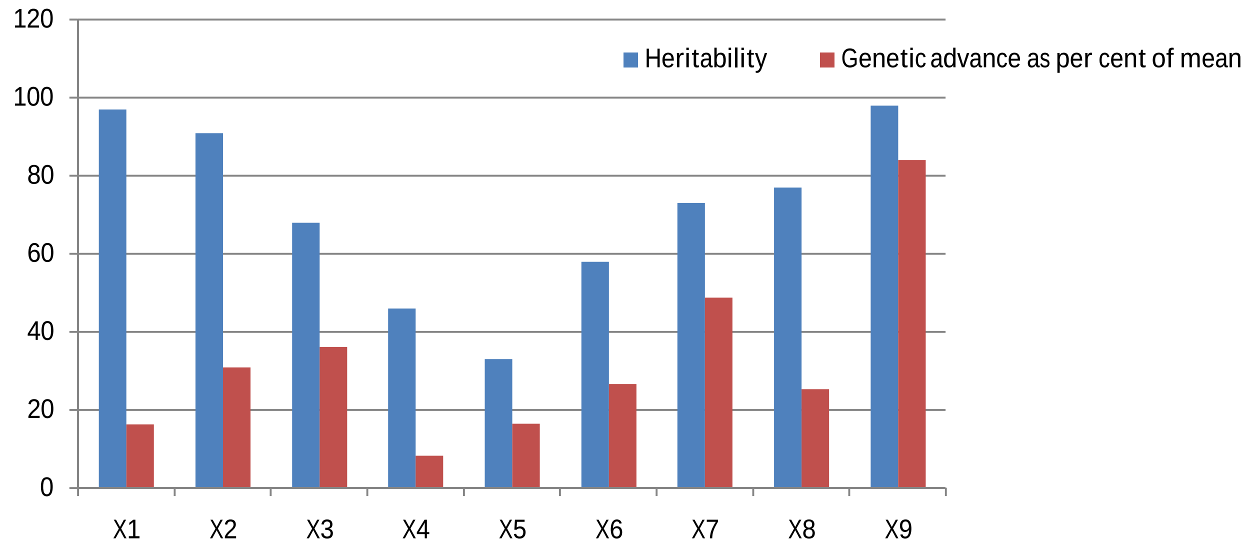

Fig: 4.2 Heritability and Genetic advance as per cent of mean for yield & yield contributing

X_1= Days to 50 per cent flowering

X_2= Plant height

X_3=Productive tillers

X_4= Panicle length

X_5= Number of filled grains per panicle

X_6= Total number of filled grains per panicle

X_7= Sterility per cent

X_8= 1000-seed weight

X_9= Grain yield per plant

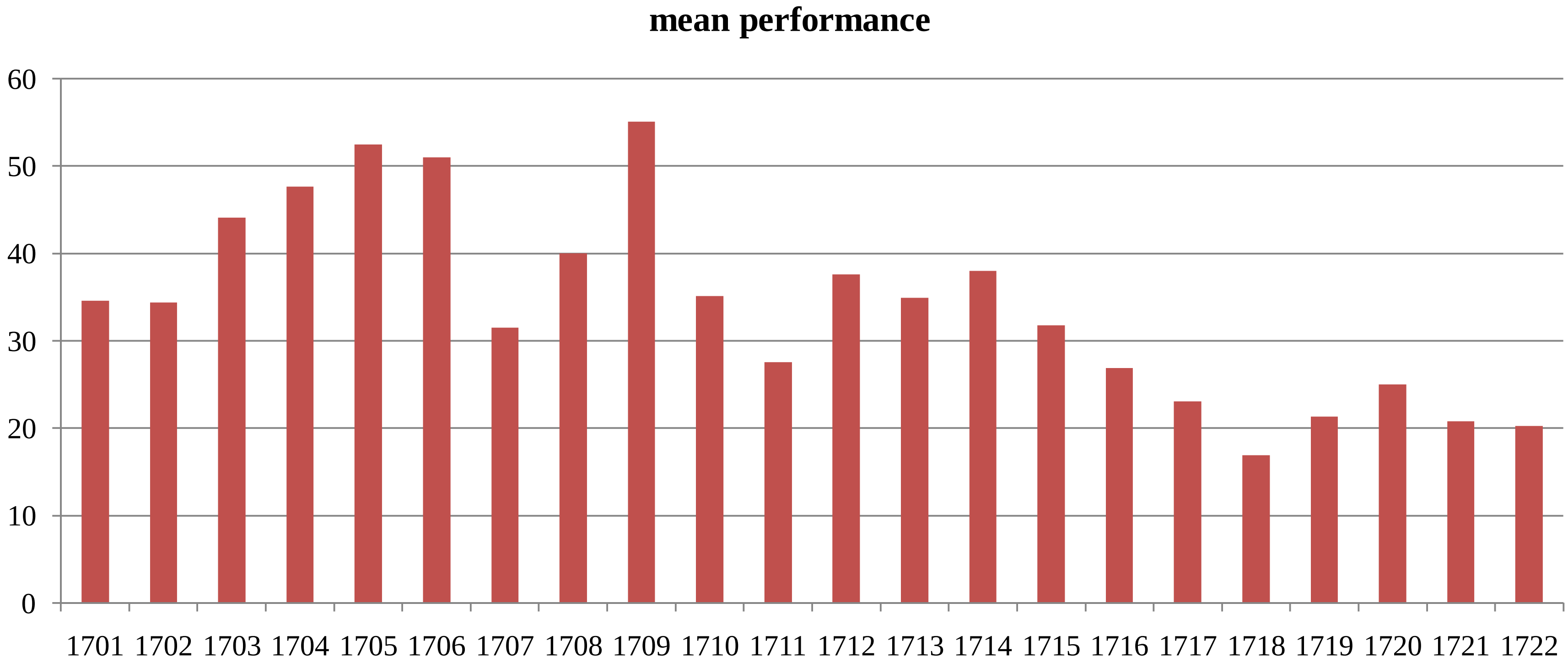

Fig: 4.3 Mean performance of yield charcter in rice genotypes

on X axis genotypes
on Y axis means

CHAPTER VI

SUMMARY AND CONCLUSIONS

The present investigation on "Studies on stability analysis of elite medium duration rice (*Oryza sativa* L.) genotypes" was carried out to study the variability, heritability, genetic advance and stability of twenty two rice genotypes for yield and yield attributes at three locations *viz.*, Directorate of Rice Research farm at ICRISAT (Central Telangana Zone), RARS Warangal (Central Telangana Zone) and RARS Maruteru (Godavari zone) of Andhra Pradesh.

The analysis of variance indicated significant differences among the genotypes for all the characters. Highest GCV and PCV were recorded for plant height, filled grains per panicle, per cent of sterility and grain yield per plant indicating greater variability among the genotypes for these traits. High heritability coupled with high genetic advance for plant height, total number of grains per panicle, 1000-seed weight and grain yield per plant indicated that these traits were chiefly controlled by additive gene action. Hence, selection method by isolating promising pure lines was suggested for their improvement. High heritability coupled with low genetic advance for panicle length and number of filled grains per panicle suggested that these traits were under the influence of non-additive gene action for which heterosis breeding and recurrent selection would be more rewarding.

The pooled analysis of variance for stability indicated significant differences among the environments and genotypes for all the characters except panicle length and number of filled grains per panicle and this was further confirmed by widely differing environmental indices. The genotype x environment interaction was significant for all the characters except days to 50 per cent flowering, panicle length, number of filled grains per panicle, total number of grains per panicle and 1000-seed weight when tested against pooled error indicating differential behaviour of genotypes in changing environments. Significance of environment (linear) component for all the characters except panicle length, number of filled grains per panicle and total number of grains per panicle when tested against pooled deviation indicated that the genotypes responded linearly for most of the characters. Both linear and non-linear components were significant for productive tillers per plant, filled grains per panicle and grain yield per plant indicating the importance of both the components in predicting the stability of genotypes. The high and significant values of pooled deviations for days to 50 per cent flowering, plant height, panicle length and grain yield per plant indicated that performance of genotypes with respect to these traits can not be predicted.

The location Warangal is best among three locations as it is having good environment index for yield and most of the yield traits. The same location may be used for further studies to expect yield stability in rice in future.

Selection of stable and desirable genotypes was made based on the parameters *viz.*, mean (μ), regression coefficient (b_i) and deviation from regression ($S^{-2}d_i$) of Eberhart and Russell (1966) model, since this model is widely adopted and relatively simple. As per this model two genotypes 1703 and 1704 were found to be stable for grain yield per plant and the genotype 1706 was stable for panicle length and 1000- seed weight. The genotype 1704 was stable for days to 50 per cent flowering, productive tillers per plant and number of filled grains per panicle over three locations. The genotype 1715 for days to 50 per cent flowering, panicle length, sterility per cent and grain yield per plant, 1712 for number filled grains per panicle, total number of grains per panicle and grain yield per plant and 1716 for plant height and 1000-seed weight were found to be suitable for favourable environments. The genotypes identified for poor environment were 1719 for productive tillers per plant and grain yield per plant and 1702 for plant height and number of filled grains per panicle.

From the foregoing discussion, it can be concluded that both linear and non-linear components of G × E interaction need to be taken into consideration in prediction of variation in performance of genotypes for yield and yield component traits. The genotypes which exhibited stable performance for yield also showed stability for one or other component characters such as productive tillers per plant or filled grains per panicle.

Grafius (1959) suggested that there would be no separate gene system for yield as yield is an end product of multiplicative interaction between the yield components. Interestingly, in the present study also the genotypes 1703 and 1704 which exhibited stability for yield performance in three locations also showed stability for the yield components especially for 1000-seed weight, total number of grains per panicle and productive tillers. Two genotypes 1705 and 1706 excelled in yielding ability, but they were more adapted to favourable environment, indicating the scope of their cultivation in high input management environments to raise the productivity levels in *kharif* season.

Table: 4.7 showed that different genotypes registered stable performance for different characters. Few genotypes registered b_i is greater than one. These are suitable for better environment and some genotypes registered b_i less than one and these are suitable for resource scarce environments.

LITERATURE CITED

Abdul fiyaz., Ramya, R., Chikkalingaiah, K.T., Ajay, B.C., Gireesh, and Kulkarni, R.S. 2011. Genetic variability, correlation and path coefficient analysis studies in rice (*Oryza sativa* L.) under alkaline soil condition. *Electronic Journal of Plant Breeding*. 2(4):531-537.

Adesola, L. Nassir. 2013. Genotype environment analysis of some yield components of upland Rice (*Oryza sativa* L.) Under Two Ecologies in Nigeria. *International Journal of Plant Breeding and Genetics.* 7:105- 114.

Ahmad ramezani and Masoud torabi. 2011. Stability analysis of grain yield and its components of rice (*Oryza sativa* L.) genotypes. *Electronic Journal of Plant Breeding*. 2(4): 484-487.

Akhtar, N., Nazir, M.F., Rabnawaz, A., Mahmood, T., Safdar, M., Asif, M.E and Rehman, A. 2011. Estimation of Heritability, Correlation and Path Coefficient Analysis in Fine Grain Rice (*Oryza Sativa* L.). *The Journal of Animal & Plant* Sciences. 21(4): 660-664.

Akinwale, M.G., Gregorio, G., Nwilene, F., Akinyele, B.O., Ogunbayo, S and Odiyi, A.C. 2011. Heritability and correlation coefficient analysis for yield and its components in rice (*Oryza sativa* L.). *African Journal of Plant Science*. 5 (3):207-212.

Ali, Y., Sarwar, G., Aslam, Z and Hussain, F. 2006. Genotypic and environmental interaction in advanced lines of rice under salt – affected soils of Punjab. *International Journal of Environmental Science and Technology*. 3(2) : 191 – 195.

Allard, R. W. 1960. Principles of Plant Breeding. Publishers by *John Wiley and Sons Inc*. New York, USA: 485.

Anbanandan, V., Saravonan, K and Sahesan, T. 2009. Variability, heritability and genetic advance in rice. *International Journal of Plant Sciences*. 4 (1): 61-63.

Arumugam, M., Rajanna, M.P and Vidyachandra, B. 2007. Stability of rice genotypes for yield and yield components over extended dates of sowing under Cauvery command area in Karnataka. *Oryza*. 44(2): 104 – 107.

Awasthi, L. P and Pandey, V. K. 2000. Genetic variation in morphological traits of aromatic rice. *Crop Research*, Hisar 19 (2): 361-363.

Babu, S., Anbumalarmathi, J., Sheeba, A., Yogameenakshi, P and Rangasamy, P. 2005. Stability in performance of salt tolerant rice hybrids. *Oryza*. 42(3): 222-224.

Becker, H.C., Leon, J. 1988. Stability analysis in plant breeding. *Plant Breeding.* 101: 1-23.

Bhadru, D. 2010. Genetic analysis for heterosis, combining ability, stability and genetics of fertility restoration in hybrid rice (*Oryza sativa* L.). *ph. D* thesis, Acharya N.G. Ranga Agricultural University, Hyderabad-30.

Bhakta, N and Das, S.R. 2008. Phenotypic stability for grain yield in rice. *Crop Improvement.* 45(1): 115-119.

Bharadwaj, C., Mishra, R., Satyavathi, C.T., Rao, S.K and Kumar, K.S. 2007. Genetic variability, heritability and genetic advance in some new plant type based crosses of rice (*Oryza sativa* L.). *Indian Journal of Agricultural Research.* 41 (3):189-194.

Bisne, R and Motiramani, N.K. 2006. Estimation of heritability, genetic advance and variability for yield contributing characters in rice (*Oryza sativa* L.). *Annals of Agricultural Research.* 27(4):397-400.

Biswas, P.L., Barman, H.N., Ghosal, S., Tohiduzzaan, S and Hazrat Ali, M. 2011. Stability study for growth duration and grain yield of exotic hybrid rice genotypes in Bangladesh. *Bangladesh Journal of Agriculture Resoure.*36 (1): 97-102.

Breeze, E.L. 1969. The measurement and significance of genotype-environment interactions in grasses. *Heredity*. 24:181-200.

*Burton, G.W. 1952. Quantitative inheritance in grasses. Proceeding on 6th *International Grassland Congress Journal*. 1: 277-283.

Chakraborty, R and Chakraborty, S. 2010. Genetic variability and correlation of some morphometric traits with grain yield in bold grained rice (*Oryza sativa* L.) gene pool of Barak valley. *American-Eurasian Journal of Sustainable Agriculture* . 4(1): 26-29.

Chandra, B.S., Reddy, T.D and Kumar, S.S. 2009. Variability parameters for yield, its components and quality traits in rice (*Oryza sativa* L.). *Crop Research*. (1, 2&3): 144-146.

Chaudahari, S.B., Pawar, S.V., Patil, S.C., Jadhav and Waghmode, B.D. 2002. Stability analysis for yield and yield components in rice. *Oryza*. 39: 1 – 4.

Chikkalingaiah Shridhara., Lingaraju, S and Radhakrishna, R.M. 1999. Genetic variability of plant and quality traits in promising genotypes of scented rice (*Oryza sativa* L.). *Mysore Journal of Agricultural Sciences*. 33 (4): 338-431.

Das, S., Misra, R.C., Patnaik, M.C and Das, S.R. 2010.G x E Interaction,adaptability and yield stability of mid-early rice genotypes. *Indian Journal of Agriculture Research.* 44(2): 104-111.

Das, S., Misra, R.C and Patnaik, M.C. 2009. G x E interaction of late duration rice genotypes in different models and evaluation of adaptability and yield stability. *Indian Journal of Crop Science*. 4(1-2): 101-106.

Deshpande, V.N and Dalvi, V.V. 2006. Genotype x Environment interactions in hybrid rice. *Oryza*. 43(4): 318-319.

Dushyanthakumar, B.M., Shadadshari, Y.G and Krishnamurthy, S.L. 2010. Genotype x Environment interaction and stability analysis for grain yield and its components in halugidda local rice mutants. *Electronic Journal of Plant Breeding*. 1(5): 1286-1289.

Dushyanthakumar, B.M and Shadadshari, Y.G. 2007. Stability Analysis of P. U. Belliyappa Local Rice Mutants. *Karnataka Journal of Agricultural Sciences.* 20(4): 724 – 726.

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

*Falconer, D.S. 1981. *Introduction to Quantitative Genetics.* Oliver Boyd, London: 340.

*Fischer, R.A and Yates, F. 1967. *Statistical Tables for Biological Agricultural and Medical Research.* Olive Boyd, Edinburgh.

Ghosal, S., Biswas, P.L., Khatun, M and Khatun, S. 2010. Genetic variability and character Associations in Irrigated rice (*Oryza sativa* L.). *Bangladesh Journal of Plant Breeding Genetics*. 23(2): 23-27.

Grafius, J.E. 1959. Heterosis in barley. *Agronomy Journal.* 51: 551-554.

Honarnejad, R. 2000. Stability and productivity of Iranian rice cultivars. *Tropenlandwirt* .10(1): 3 – 12.

Indiastat. Agriculture production. 30th June 2013. http://www.indiastat.com

Jaiswal, H.K., Srivasthava, A.K and Dey, A. 2007. Variability and association studies in indigenous aromatic rice (*Oryza sativa* L.). *Oryza*. 44(4): 351-353

Jamal., Ifftikhar, H., khali, Abdul Bari, Sajid Khan and Islam Zada. 2009. Genetic variation for yield and yield components in rice. *APRN Journal of Agricultural and Biological Science.* 4(6): 60- 64 .

Jayasudha, S and Sharma, D. 2010. Genetic parameters of variability, Correlation and path-coefficient for grain yield and physiological traits in rice (*Oryza sativa* L.) under shallow lowland situation. *Electronic Journal of Plant Breeding.* 1(5): 1332-1338.

*Johnson, H.W., Robinson, H.F and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agronomy Journal*. 47(7): 314-318.

Kandil, A., Ibrahim, A. F., Marquarld, R and Taha, R. R. 1990. Response of some quality traits of sunflower seeds and oil to different environments. *Journal of Agronomy*.164 (4):22-30.

Karad, S.R and Pol, K.M. 2008. Character association, genetic variability and path coefficient analysis in rice (*Oryza sativa* L.). *International Journal of Agricultural Sciences*. 4 (2): 663-666.

Kaw, R.N., Aquino, R.C., Moon, H.P., Yae, J.D and Haw, N. 1999. Variability and inter-relations in rice under cold stress environments. *Oryza*.36(1):1-4.

Khan, A.S., Imran, M and Ashfaq, M. 2009. Estimation of genetic variability and correlation for grain yield components in rice (*Oryza sativa* L.). *American Eurasian Journal of Agriculture and Environmental Science*. 6(5): 585-590.

Kishore, K., Singh, N.K., Kumar, N and Thakur, R. 2002. Genotype x Environment interaction and stability analysis for grain yield some associated traits in boro rice. *Oryza*. 39: 12 – 14.

Kishore, N.S., Babu, V.R., Ansari, N.A and Prasad, A.R. 2008. Genetic variability, heritability and genetic advance in rice (*Oryza sativa* L.) genotypes of different eco-geographical region. *Research on Crops.* 9(1): 147-150.

Kole, P.C and Hasib, K.M. 2008. Correlation and regression analysis in scented rice. *Madras Agriculture Journal*. 95 (1-6): 178-182.

Krishna, L., Raju, C. H., D and Raju, C. H. S. 2008. Genetic variability and correlation in yield and grain quality characters of rice germplasm. *The Andhra Agricultural Journal*. 55 (3): 276-279.

Krishnappa, M.R., Chandrappa, H.M and Shadakshari, H.G. 2009. Stability analysis of medium duration hill zone rice genotypes of Karnataka. *Crop Research.* 38(1, 2 & 3): 141-143.

Kumar, P and Ramesh, B. 2008. Genetic variability and character association in rice. *Progressive Agriculture.* 8 (2): 260-262.

Lal, M and Pal singh, D. 2012. Genotype x Environment interaction in rice. (*Oryza sativa* L.). *Annals of Biology*. 28(1): 53-55.

Madhavilatha, L., Sekhar, M.R., Suneetha, Y and Srinivas, T. 2005. Genetic variability, correlation and path analysis for yield and quality traits in rice (*Oryza sativa* L.) . *Research on Crops*. 6 (3): 527-537.

Madhavilatha, L. 2002. Studies on genetic divergence and isozyme analysis on rice *(Oryza sativa* L). M.Sc.(Ag.) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.

Maji, A. T., Gana, A.S., Bright, E.O., Ukwungwu, M. NandOchigbo, A.A. 2011. Genotype x Environment analysis of upland medium duration, nationally coordinated rice evaluation trails (CRET) for varietal recommendation. *American Journal of Experimental Agriculture.* 1(4): 486-493.

Manoj Kumar Prajapati., Chandra Mohan Singh., Suresh Babu, G., Roopa, G., Lavanya and Priyadarshini Jadhav. 2011. Genetic parameters for grain yield and its component characters in rice. *Electronic Journal of Plant Breeding*. 2(2): 235-238.

Marimuthu, R., Rajesekharan, S and Soundarapandian, G. 1990. Variability, heritability and genetic advance in rice. *Madras Agricultural Journal.* 77: 443-446.

Mishra, D., Mishra, N.S., Das, G.B and Patra, G.J. 1996. Genetic variability, interrelationship and perforn1ance of some scented rice genotypes. *Environment and Ecology.* 14 (1): 150-153.

Mohan Lal and Devendra K. Chauhan. 2011. Studies of Genetic Variability, Heritability and Genetic Advance In Relation To Yield Traits in Rice. *Agricultural Science Digest*. 31 (3): 220 – 222.

Mosavi, A.A., Jeodar, N.B and Kazemitabar, K. 2013. Environmental responses and Stability analysis grain yield of some rice genotypes. *World Applied Sciences Journal*. 21 (1): 105-108.

Mulugeta Seyoum, Sentayehu Alamerew and Kassahun Bantte. 2012. Genetic Variability, Heritability, Correlation Coefficient And Path Analysis For Yield And Yield Related Traits In Upland Rice (*Oryza sativa* L.). *Journal of Plant Sciences*. 7(1):13-22.

Munisonnappa, S., Vidyachandra, B and Kulkarni, R.S. 2004. Stability analysis in newly developed rice hybrids across dates of sowing during kharif. *Karnataka Journal of Agricultural Sciences.* 17(4): 696 – 700.

Nagajyothi, B. 2001. Studies on performance and heterosis of rice hybrids for yield, yield components and certain grain quality characters. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.

Nandan, R., Sweta and Singh, S.K. 2010. Character Association and Path Analysis in Rice (*Oryza* sativa L.) Genotypes. *World Journal of Agricultural Sciences*. 6 (2): 201-206

Nath, N and Talukdar, P. 1997. Genetic variability and correlation studies in segregating populations of indigenous Scented x High yielding non-scented crosses of rice. *Oryza* .34 (2): 91-93.

Nayak, A.R., Chaudhary, D and Reddy, J.N. 2002. Genetic variability, heritability and genetic advance in scented rice. *Indian Agriculturist*. 46(1&2): 45-47.

Nayak, A.R., Chaudhary, D and Reddy, J.N. 2003. Stability analysis for yield and yield components in scented rice. *Oryza*. 40(1 & 2) : 1 – 4.

Nayudu, K.S.R., Varline, Y.A and Vennila, S. 2007. Studies on variability, heritability and genetic advance for certain yield compounds in rice. *Crop Improvement*. 34 (2): 142-144.

Niranjana Murthy., Kulkarni, R.S and Uday Kumar, M. 1999. Genetic variability, heritability and genetic advance for morpho-physiological traits in rice. *Oryza* .36 (2): 159-160.

Padmaja, D., Radhika, K., Subba Rao, L.V and Padma, V. 2011. Correlation and path analysis in rice germplasm. *Oryza*.48. (1): 69-72.

Pande, K., Singh, S and Singh, O.N. 2006. Stability of rice (Oryza *sativa* L.) varieties for *boro* season of eastern India. *Indian Journal of Genetics*. 66(3): 191 – 195.

Pankaj Garg., Pandey, D.P and Dhirendra singh. 2010. Correlation and Path Analysis for Yield and its Components in Rice (*Oryza Sativa* L.). *Crop Improvement*. 37 (1): 46-51

Panse, V.G and Sukhatme, P.V. 1985. Statistical methods for agricultural workers, Indian Council of Agricultural Research, New Delhi. 187-202.

Panwar, L.L., Joshi, V.N and Ali, M. 2008. Genotype x Environment interaction in scented rice. *Oryza*. 45(1): 103-109.

Parikh, M., Motiramani, N.K., Rastogi, N.K and Sharma, B. 2012. Agro-morphological Characterization and Assessment of variability in Aromatic Rice Germplasm. *Bangladesh Journal of Agricultural Research*. 37(1): 1-8.

Patil, P.V., Sarawgi, A.K and Shrivastava, M.N. 2003. Genetic analysis of yield and quality traits in traditional aromatic accessions of rice. J*ournal of Maharashtra Agricultural Universities*. 28 (3): 255-258.

Patil, P.V and Sarawgi, A.K. 2005. Studies on genetic variability, correlation and path analysis in traditional aromatic rice accessions. *Annals of Plant Physiology*. 19(1):92-95.

Patra, B.C., Pradhan, K.C., Nayak, S.K and Patnaik, S.S.C. 2006. Genetic variability in long awned rice genotypes. *Environment and Ecology*. 24S: 1, 27-31.

Qamar, Z.U., Cheema, A.A., Ashraf, M., Rashid, M and Tahir, G.R. 2005.Association analysis of some yield influencing traits in aromatic and non-aromatic rice. *Pakistan Journal of Botany*. 37(3):613-627.

Rajendar Reddy, M., Surendar Raju, Ch., Dayakar reddy, T and Narender reddy, S. 2013 .Study on genetic parameters in F2 generation involving aromatic rice genotypes (*Oryza sativa* L.). *International Journal of Applied Biology and Pharmacetical Technology*. 4(4): 238-241.

Ramesh Kumar, V.V. 1989. Genetic analysis of yield and its components in four rice crosses. *Journal of Research APAU*. 17 (1): 11.

Ramya, K and Senthilkumar, N. 2008. Genotype x Environment interaction for yield and its component traits in rice (*Oryza sativa* L.). *Crop Improvement.* 35(1): 11-15.

Rao, S.S and Shrivastav, M.N. 1994. Genetic variation and correlation studies in rainfed upland rice. *Oryza*. 31: 288-291.

Rasyad, A., Gulat, M.E and Van Sanford, D.A. 2012. Genotype x Environment interaction and stability of yield components among rice genotypes in riau province, Indonesia. *SABRAO Journal of Breeding and Genetics.* 44(1):102-111.

Ravindra Babu, V., Shreya, K., Kuldeep Singh Dangi, Usharani, G., Siva Shankar, A.2012. Correlation and Path Analysis Studies in Popular Rice Hybrids of India. *International Journal of Scientific and Research Publications*. 2(3).

Rita Bisne, Sarawgi, A.K and Verulkar, S.B. 2009. Study of Heritability, Genetic Advance and Variability for Yield Contributing Characters in Rice. *Bangladesh Journal of Agriculture Research*. 34(2): 175-179.

Sahdev Singh, Dhaka, R.P.S and Malik, S.S. 1996. Heritability and genetic advance in irradiated population of rice. *Crop Research*. 11 (2): 184-188.

Saidaiah, P. 2008. Genetic divergence, combining ability and stability for yield and yield contributing traits in hybrid rice (*Oryza sativa* L). *ph.D* thesis, Acharya N.G. Ranga Agricultural University, Hyderabad-30.

Saidaiah, P., Kumar, S.S and Ramesha, M.S. 2011. Stability analysis of rice (*Oryza sativa* L.) hybrids and their parents. *Journal of Agriculture Science*. 81 (2): 109-115.

Salam, A., Imran, M and Ashfaq, M. 2009. Estimation of genetic variability Correlation for Grain Yield components in rice (Oryza *sativa* L.). *American –Eurasian Journal Agricultural and Environmental Science*. 6 (5):585 -590.

Sanjay Singh and Singh, O.N. 2007. Choice of stable rice genotypes for fragile environment. *Oryza*. 44(2): 154-155.

Sankar, P.D and Anbumalarrnathi, J. 2006. Variability and character association studies in rice (*Oryza sativa* L.). *Agricultural Science Digest.* 26(3): 182-184.

Sarma, R.N and Roy, A. 1993. Studies on variability and inter-relationship of yield attributes in jhum rice. *Annals of Agricultural Research*. 14 (3): 311-316.

Satya Priya Lalitha, V and Sreedhar, N. 2000. Stability parameters for quality characters in rice. *Oryza*. 37(2): 44 – 46.

Satya Priya Lalitha, V and Sreedhar, N. 1996. Heritability and correlation studies in rice. *The Andhra Agricultural Journal*. 43 (2-4): 158-161.

Satya Priya Lalitha, V and Sreedhar, N. 1999. Estimates of genetic parameters for quality traits in rice. *Annals of Agricultural Research.* 20 (1): 18-22.

Selvaraj, C.I., Nagarajan, P., Thinagaran, K., Bharathi, M and Rabindran, R. 2011. Genetic parameters of variability, correlation and path coefficient studies for grain yield and other yield attributes among rice blast disease resistance genotypes of rice(*Oryza sativa* L.). *African Journal of Biotechnology*. 10(17): 3322-3334.

Senthil kumar, N. 2011. Genetics of grain yield and its component characters in rice. *Crop Improvement*. 38 (1): 45 -47.

Shankar, V.G., Ansari, N.A and Ahmed, I. 2008. Stability analysis using thermo-sensitive genic male sterility (TGMS) system in rice (Oryza *sativa* L.). *Research on Crops.* 9(1): 141-146.

Shanmuganathan, M and Ibrahim, S.M. 2005. Stability analysis for yield and its components in hybrid rice (*Oryza sativa* L.). *Crop Research*. 30 (1): 40-45.

Shiva Prasad, G., Sujatha, M., Subba Rao, L.V and Chaithanya, U. 2013. Studies on variability, Heritability and Genetic Advance for Quantitative Character in Rice (*Oryza sativa* L.). *Annals of Biological Research.* 4(6):372-375.

Shivani, D and Reddy, N.S.R. 2000. Variability and genetic advance for morphological and physiological traits in rice hybrids. *Oryza*. 37(3): 231 -233.

Singh, S and Chaudhary, B.S. 1996. Variability, heritability and genetic advance in cultivars of rice (*Oryza sativa* L.). *Crop Research*. 12 (2): 165-167.

Sinha, S.K., Tripathi, A.K and Bisen, U.K. 2004. Study of genetic variability and correlation coefficient analysis in midland land races of rice (Oryza *sativa* L.). *Annals of Agricultural Research*. 25 (1): 1-3.

Sivasubramanian, S and Madhavamenon, P. 1973. Combing ability in rice. *Madras Agricultural Journal*. 60: 419-421.

Somana, P., Wattana, P., Suriharn, B and Sanitchon, J. 2013. Stability and genotype by environment interactions for grain Anthocyanin content of the Thai Black Glutinous Upland Rice (*Oryza sativa* L.).*Sabrao Journal of Breeding and Genetics.* 45(3): 523-532.

Sreedhar, S., Dayakar Reddy, T and Ramesha, M.S. 2011. Genotype x Environment interaction and stability for yield and its components in hybrid rice cultivaters (*Oryza sativa* L.). *International Journal of Plant Breeding and Genetics.* 5 (3): 194-208.

Subudhi, H.N., Bose, L.K., Singh, O.N and Rao, G.J.N. 2012. Genotype x Environment interaction for grain yield and its component traits in irrigated rice. *Madras Agriculture Journal*. 99 (4-6): 178-180.

Suman Kumari, M.R., Kulkarni, R.S and Ramesh, S. 1999. Identification of stable rice genotypes for late planting situations under tankfed areas. *Mysore Journal of Agricultural Science*. 33: 348 – 354.

Suman, A. 2003. Studies on genetic diversity and agro-morphological characterization of rice (*Oryza sativa* L.) germplasm. *M.Sc. (Ag.) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.

Supriyo Chakraborty and Hazarika, M.K. 1994. Estimation of various genetic parameters for yield and yield components in rice. *Oryza.* 31: 226-227.

Surender Raju, C.H. 2002. Study of genetic divergence, variability, stability, gene action and character association for certain physiological quality and yield components in Rice (*Oryza sativa* L.) *Ph.D. Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.

Swamy, M.N and Kumar, B.M.D. 2003. Stability analysis for grain yield and its components in rice. *Karnataka Journal of Agricultural Sciences*. 16(2): 223 – 227.

Tara Satyavathi, C., Bharadwaj, C.H and Subramanyam, D. 2001. Variability, correlation and path analysis in rice varieties under different spacings. *Indian Journal of Agricultural Research*. 35 (2): 79-84.

Tariku, S., Lakew, T., Bitew, M and Asfaw, M. 2013. Genotype by environment interaction and grain yield stability analysis of rice (*Oryza sativa* L.) genotypes evaluated in north western Ethiopia. *Net Journal of Agricultural Science.* 1(1):10-16.

Tripathi, A.K., Sinha, S.K and Bhandarkar, S. 1999. Studies on variability, heritability and genetic advance of semideep water rice. *Advance in Plant Sciences*. 12 (1): 235.

Ullah, M.Z., Bashar, M.K., Bhuiyan, M.S.R., Khalequzzaman, M and Hasan, M.J. 2011. Interrelationship and cause-effective analysis among morphophysiological traits in Biroin rice of Bangladesh. *International Journal of Plant Breeding and Genetics.* 1-9.

Vange, T., OJo, A.A. and Bellow, L.L. 1999. Genetic variability, stability and correlation studies in lowland rice (*Oryza sativa* L.) genotypes. *Indian Journal of Agricultural Sciences*. 69 (1): 30-3.

Vange, T and Ojo, A.A. 1997. Variability and heritability estimates of yield and yield components in some Nigerian low land rice genotypes. *International Rice Research Newsletter*. 6.

Venkata Suresh, A. 2001. Genetic analysis for certain quantitative and qualitative traits in F_2 populations of rice *(Oryza sativa* L). *M.Sc. (Ag) Thesis*, Acharya N.G. Ranga Agricultural University, Hyderabad.

Vijayalakshmi, B., Vijay, D., Raju, P.R.K and Satyanarayana, P.V. 2008. Genetic divergence of qualitative and quantitative characters in low land rice germplasm. *Crop Research*. 36 (1, 2 & 3): 212-214.

Yadav, P., Rangare, N.R., John Anurag, P and Chaurasia, A.K. 2010. Quantitative analysis of rice (*Oryza sativa* L.) in Allahabad agro climate zone. *Journal of Rice Reseach.* 3(10):16-18.

---

*Original not seen

The pattern of “Literature Cited” presented above is in accordance with the Thesis format guidelines, 2010, Acharya N.G. Ranga Agricultural University, Hyderabad.

From:
Dr. T.Dayakar Reddy
Professor & Head,
Dept. of Genetics & Plant Breeding,
College of Agriculture,
Rajendranagar, Hyderabad-30.

To:
The P.G. Dean,
College of Agriculture,
Rajendranagar,
Hyderabad 500 030.

Lr. No: Dt. 16 .05.2012

Sir,

Sub: Submission of M.Sc. thesis of A.SHIVA KUMAR., I.D.No. RAM/12-47 Regarding.

** ***** **

I am herewith forwarding the M.Sc. thesis entitled "**STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES**" submitted by A.SHIVA KUMAR, I.D.No. RAM/12-47 for onward transmission to the Dean of Post-Graduate studies. The student has successfully completed the oral comprehensive examination and the required course work. Kindly acknowledge the receipt of the thesis.

Thanking you sir,

Yours faithfully,

(Dr. T.Dayakar Reddy)

Encl: 1. One copy of the thesis
2. Four passport size photographs
3. No dues certificate
4. Two copies of PG 6
5. Two copy of PG 11
6. Xerox copy of previous degree certificate
7. Convocation form
8. Copy of fee receipts paid
9. Two xerox copies of acknowledgement

From: To:

From:
Dr. T.Dayakar Reddy
Professor & Head,
Dept. of Genetics & Plant Breeding,
College of Agriculture,
Rajendranagar, Hyderabad-30.

To:
The P.G. Dean,
College of Agriculture,
Rajendranagar,
Hyderabad 500 030.

Lr. No: Dt.16 .05.2012

Sir,

Sub: Submission of M.Sc. thesis of A.SHIVA KUMAR., I.D.No. RAM/12-47 Regarding.

** ***** **

I am herewith forwarding the M.Sc. thesis entitled **"STUDIES ON STABILITY ANALYSIS OF ELITE MEDIUM DURATION RICE (*Oryza sativa* L.) GENOTYPES"** submitted by A.SHIVA KUMAR, I.D.No. RAM/12-47 for onward transmission to the Dean of Post-Graduate studies. The student has successfully completed the oral comprehensive examination and the required course work. Kindly acknowledge the receipt of the thesis.

Thanking you sir,

Yours faithfully,

(Dr. T.Dayakar Reddy)

Encl: 1. One copy of the thesis
2. Four passport size photographs
3. No dues certificate
4. Two copies of PG 6
5. Two copy of PG 11
6. Xerox copy of previous degree certificate
7. Convocation form
8. Copy of fee receipts paid
9. Two xerox copies of acknowledgement