

**ASSESSMENT OF MORPHOLOGICAL CHARACTERISTICS
AND GENETIC VARIABILITY STUDIES IN
LANDRACES OF RICE (*Oryza sativa* L.)**

**SUJATA
MA1TAG0233**

***DEPARTMENT OF GENETICS AND PLANT BREEDING
UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL
SCIENCES, SHIVAMOGGA
COLLEGE OF AGRICULTURE, SHIVAMOGGA
August, 2019***

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**DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, SHIVAMOGGA
UNIVERSITY OF AGRICULTURAL AND HORTICULTURAL
SCIENCES SHIVAMOGGA**

C E R T I F I C A T E

This is to certify that the thesis entitled 'ASSESSMENT OF MORPHOLOGICAL CHARACTERISTICS AND GENETIC VARIABILITY STUDIES IN LANDRACES OF RICE (*Oryza sativa* L.)' submitted in partial fulfillment of the requirements for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **GENETICS AND PLANT BREEDING** to the College of Agriculture, Shivamogga. University of Agricultural and Horticultural Sciences, Shivamogga is a bonafide record of research work carried out by **Miss. SUJATA, ID No. MA1TAG0233** (sujatarugan459@gmail.com) during the period of study in this university under my guidance and supervision and no part of this thesis has previously formed the basis for the award of any other degree, diploma, associateship, fellowship or any other similar titles.

**Shivamogga
August, 2019**



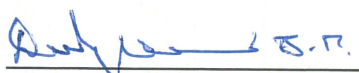

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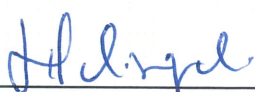
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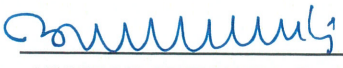


(SHRIDEVI, A. JAKKERAL)

Members:

1. 

(B. M. DUSHYANTHA KUMAR)
2. 

(BASAVARAJ, I. HALINGALI)
3. 

(GURUMURTHY, B. R.)

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*Shivamogga,
August, 2019*


(Sujata)

**Assessment of morphological characteristics and genetic variability studies in
landraces of rice (*Oryza sativa* L.)**

(SUJATA)

ABSTRACT

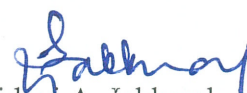
Present investigation was carried out to characterize 51 landraces of rice at Zonal Agricultural and Horticultural Research Station, Shivamogga, during the *Kharif* 2018, Shivamogga using Randomized complete block Design. Forty one qualitative and thirteen quantitative characters were evaluated as per DUS guidelines given by PPV and FRA, 2001. Five characters such as the presence of leaf ligule, split shape of leaf ligule, absence of male sterility and presence of secondary branching characters were common in all the 51 landraces of rice. Remaining 36 characters were unique and distinct among the landraces of rice. Analysis of variance revealed a significant difference for all the characters. The high GCV, PCV and heritability with maximum genetic advance per cent mean was recorded for days to 50 per cent flowering, days to maturity, leaf length, stem thickness, plant height, total number of tillers per plant, number of productive tillers per plant and test weight. Correlation analysis revealed that traits *viz.*, total number of tillers per plant, number of productive tillers per plant, test weight, panicle length and panicle fertility showed significant positive correlation with grain yield per plant. Path analysis revealed that days to 50 per cent flowering, leaf width, the total number of tillers per plant, number of productive tillers per plant, panicle length and test weight showed a direct and positive effect on grain yield. Mahalanobis' D^2 clustered the landraces of rice into eight clusters, cluster IV and cluster V showed highest inter-cluster distance. The study will be useful for breeders, researchers and farmers to identify and choose the restoration and conservation of beneficial genes for crop improvement and also to seek protection under Protection of Plant Varieties and Farmer's Rights Act, 2001.

Department of Genetics and Plant Breeding
JAHS, Shivamogga
August, 2019



Sujata

(sujatarugan459@gmail.com)



Shridevi A. Jakkeral

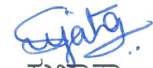
(gowrishrigpb@gmail.com)

ಸ್ಥಳೀಯ ಭತ್ತದ ತಳಿಗಳಲ್ಲಿ ರೂಪಕ ವಿಜ್ಞಾನದ ಗುಣಲಕ್ಷಣಗಳು ಮತ್ತು ಅನುವಂಶೀಯ ವ್ಯತ್ಯಾಸದ
ಮೌಲ್ಯಮಾಪನದ ಅಧ್ಯಯನ
(ಸುಜಾತಾ)
ಸಾರಾಂಶ

ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ೫೧ ವಂಶವಾಹಿ ರೂಪಕಗಳ ಗುಣಾತ್ಮಕ ಹಾಗೂ ಪರಿಮಾಣಾತ್ಮಕ ಗುಣಗಳನ್ನು ವಿಶ್ಲೇಷಿಸುವ ಸಲುವಾಗಿ ವಲಯ ಕೃಷಿ ಮತ್ತು ತೋಟಗಾರಿಕಾ ಸಂಶೋಧನಾ ಕೇಂದ್ರ, ಶಿವಮೊಗ್ಗದಲ್ಲಿ ೨೦೧೮ ರ ಮುಂಗಾರು ಹಂಗಾಮಿನಲ್ಲಿ ಯಾದ್ಯಚ್ಚಿಕ ಬ್ಲಾಕ್ ವಿನ್ಯಾಸ ಬಳಸಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ೪೧ ಗುಣಾತ್ಮಕ ಹಾಗೂ ೧೩ ಪರಿಮಾಣಾತ್ಮಕ ಗುಣಗಳ ಅಧ್ಯಯನವನ್ನು ಪಿಪಿವಿ ಮತ್ತು ಎಫ್‌ಆರ್‌ಎ, ೨೦೦೧ ರ ಮಾರ್ಗದರ್ಶನದ ಪ್ರಕಾರ ಕೈಗೊಳ್ಳಲಾಯಿತು. ೫ ಗುಣಲಕ್ಷಣಗಳಾದ ಎಲೆ ಲಿಗುಲ್ ಇರುವಿಕೆ, ಎಲೆ ಲಿಗುಲ್ ವಿಭಜಿತ ಆಕಾರ, ಗಿಡದಲ್ಲಿ ಪರಾಗಗಳು ಇರುವಿಕೆ ಮತ್ತು ದ್ವಿತೀಯ ಕವಲೊಡೆಯುವ ಪಾತ್ರಗಳ ಉಪಸ್ಥಿತಿ ಎಲ್ಲಾ ೫೧ ವಂಶವಾಹಿಗಳಲ್ಲಿ ಕಂಡುಬಂದಿದೆ. ಉಳಿದ ೩೬ ಗುಣಲಕ್ಷಣಗಳು ಭತ್ತದ ತಳಿಗಳಲ್ಲಿ ವಿಶಿಷ್ಟ ಮತ್ತು ವಿಭಿನ್ನವಾಗಿವೆ. ವಂಶವಾಹಿ ರೂಪಕಗಳ ಎಲ್ಲಾ ಗುಣಲಕ್ಷಣಗಳಲ್ಲೂ ಗಮನಾರ್ಹ ವ್ಯತ್ಯಾಸ ತಿಳಿದುಬಂದಿದೆ. ಶೇಕಡ ೫೦ ರಷ್ಟು ಹೂಬಿಡಲು ಬೇಕಾದ ದಿನಗಳು, ಬೆಳೆ ಪ್ರಬುದ್ಧತೆಗೆ ಬೇಕಾದ ದಿನಗಳು, ಎಲೆಯ ಉದ್ದ, ಕಾಂಡದ ಸುತ್ತಳತೆ, ಗಿಡದ ಎತ್ತರ, ಪ್ರತಿ ಗಿಡದ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಗಿಡದ ಫಲದಾಯಕ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ ಹಾಗೂ ೧೦೦೦ ಕಾಳುಗಳ ತೂಕವು ಅಧಿಕ ವ್ಯತ್ಯಾಸದ ವಿಭಿನ್ನಾರ್ಥ ಗುಣಾಂಕ (ಪಿಸಿವಿ) ಹಾಗೂ ವ್ಯತ್ಯಾಸದ ವಂಶವಾಹಿ ಗುಣಾಂಕ (ಜಿಸಿವಿ) ಜೊತೆಗೆ ಅಧಿಕ ವಂಶಾನುಗತ ಹಾಗೂ ಅನುವಂಶೀಯ ಮುಂಚಿತತೆ ದಾಖಲಾಗಿದೆ. ಪರಸ್ಪರ ಸಂಬಂಧದ ವಿಶೇಷಣೆಯ ಪ್ರಕಾರ ಪ್ರತಿ ಗಿಡದ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಗಿಡದ ಫಲದಾಯಕ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ, ೧೦೦೦ ಕಾಳುಗಳ ತೂಕ, ತೆನೆಯ ಉದ್ದ ಹಾಗೂ ತೆನೆಯ ಫಲವತ್ತತೆಯು ಗಿಡದ ಧಾನ್ಯದ ಇಳುವರಿಯೊಂದಿಗೆ ಗಮನಾರ್ಹವಾದ ಸಕಾರಾತ್ಮಕ ಸಂಬಂಧವನ್ನು ತೋರಿಸಿದೆ. ಶೇಕಡ ೫೦ ರಷ್ಟು ಹೂಬಿಡಲು ಬೇಕಾದ ದಿನಗಳು, ಎಲೆಗಳ ಅಗಲ, ಪ್ರತಿ ಗಿಡದ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ, ಪ್ರತಿ ಗಿಡದ ಫಲದಾಯಕ ತೆಂಡೆಗಳ ಸಂಖ್ಯೆ, ತೆನೆಯ ಉದ್ದ ಹಾಗೂ ೧೦೦೦ ಕಾಳುಗಳ ತೂಕವು ಇಳುವರಿಯ ಮೇಲೆ ನೇರ ಮತ್ತು ಸಕಾರಾತ್ಮಕ ಪರಿಣಾಮವನ್ನು ತೋರಿಸಿದೆ. ಮಹಾಲನೋಬಿಸ್ ಡಿ^೨ ಸಂಖ್ಯಾಶಾಸ್ತ್ರವು ವೈವಿಧ್ಯತೆಯ ಆಧಾರದ ಮೇಲೆ ವಂಶವಾಹಿ ರೂಪಕ ಸಾಲುಗಳನ್ನು ಎಂಟು ಗುಂಪುಗಳಾಗಿ ವಿಂಗಡಿಸಿತು. ಅಧಿಕ ಅಂತರ ಗುಂಪುಗಳ ದೂರವು ಗುಂಪು ೪ ಮತ್ತು ೫ ರ ನಡುವೆ ಕಂಡುಬಂದಿದೆ. ಸಸ್ಯ ತಳಿಗಳ ಸಂರಕ್ಷಣೆ ಮತ್ತು ರೈತರ ಹಕ್ಕುಗಳ ಪ್ರಾಧಿಕಾರದ, ೨೦೦೧ ಕಾಯ್ದೆಯಡಿ ರಕ್ಷಣೆ ಪಡೆಯಲು ಈ ಅಧ್ಯಯನವು ತಳಿಗಾರರು, ಸಂಶೋಧಕರು ಮತ್ತು ರೈತರಿಗೆ ಉಪಯುಕ್ತವಾಗಿದೆ.

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ಆಗಸ್ಟ್, ೨೦೧೯


ಸುಜಾತಾ

(sujatarugan459@gmail.com)


ಶ್ರೀದೇವಿ ಎ. ಜಕ್ಕರಲ್

(gowrishrigpb@gmail.com)

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INTRODUCTION

I INTRODUCTION

Rice (*Oryza sativa* L.) is an important source of energy as well as a staple food for more than half of the world's population. More than 90 per cent of global rice is consumed and produced in Asia. China stands first in the production of rice followed by India which produces nearly one fourth (22 %) of the rice in the world. Worldwide rice is grown in 163.3 mha with the production of 758.9 million tonnes of having productivity 4,448 kg per ha. In India rice is grown over 43.77 mha of area with the production of 112.75 million tonnes of having the productivity of 2576 kg per ha. In Karnataka rice occupies 0.93 mha area with 3.01 million tonnes of production and 3030 kg per ha of productivity (Anon. 2017-18).

Rice stands as important source of energy and carbohydrate. Calories from rice are particularly important for the poor accounting for 50 to 80 per cent of the daily caloric intake. Seed protein content in rice is one of the important nutritional parameter. The average content of protein in rice grains is 8 per cent, iron is 1.2 mg / 100 g and zinc is 0.5 mg / 100 g and supplies 21 per cent of global energy (Wang *et al.*, 2018). Therefore, considerable effort has been directed at improving the protein content by identification of high protein rice sources and development of modern rice varieties.

Landraces are cultivated and maintained by the farmers which are not only having a major source for resistance to biotic and abiotic stresses but also having useful traits that provide an opportunity to the breeder for further improvement in grain quality as well as the grain yield. Landraces have broad genetic variability of complex quantitative traits with respect to growth, maturity and also into physiochemical properties. India being one of the centers for the origin of rice, a large number of landraces and native cultivars are available and cultivated at different agro-climatic zones. India has a germplasm collection of more than 60,000 accessions, whereas 4,25,500 rice accessions were conserved in world gene bank which provides a genetic resource for rice improvement. The incorporation of adaptability genes from landraces could ensure optimum grain yield for the region (Vijaykumar *et al.*, 2012).

Due to an increase in the need for varietal improvement in rice crop, characterization and evaluation of existing landraces plays a significant role and helps in estimating phenotypic diversity as well as identifying elite genotype through agro-morphological traits. Characterization of accessions is used to evaluate the phenotypic diversity through agro-morphological traits that are essential for the gene bank management to protect the unique rice (Bajracharya *et al.*, 2006).

Characterization of a particular genotype or variety plays an important role in the identification of variety and avoid duplication. Characterization of the variety will help in recording and storing the useful data that helps in planning the breeding program and also essential for the protection of new plant varieties. Qualitative traits are being more stable over generations are reliable for the characterization of varieties (Raut, 2003).

For initiating any crop improvement program and selection techniques analysis of variability in crop species is important. The success of plant breeding program depends on the extent of genetic variability present in a crop. Hence for crop genetic improvement, it is essential for the breeder to know the nature and magnitude of genetic variation governing the inheritance of quantitative characters like yield and its components.

The variability present in the crop is difficult to judge whether it is heritable or non-heritable. Heritability is the transmission of the character from one generation to the next generation. It plays an important role in yield improvement through the selection of component traits. The genetic parameters like, genotypic coefficient of variability and phenotypic coefficient of variability helps to estimate the amount of variability present in the given experimental material. Instead of single estimates of heritability analysis of genetic advance will be more helpful in predicting genetic gain under selection.

To study the variability among the population and species morphological and agronomical traits have been used which helps in determining the suitability for local agronomic conditions, yield potential and ability to tolerate against pests and diseases. Estimation of the degree of diversity helps in identifying the genetically divergence genotypes to create new variability and for further use in the hybridization program. Diversity analysis provides information on the genetic distances among local genotypes and genetic similarities or distinctness among populations of the same named local genotypes in a different niche of environments (Kumar *et al.*, 2008).

Evaluation of genetic diversity among the plant material is important to know the source of genes of or a particular trait within the available germplasm. The nature and extent of the degree of genetic divergence of the parents is a pre-requisite for the selection of diverse parents for their potential use in a rice breeding program for the improvement of rice production. Parents identified on the basis of divergence for any breeding program would be more promising (Known *et al.*, 2002).

The protection of Plant Varieties and Farmers Right (PPV and FR) Act 2001, New Delhi, has mandates like protection of breeder's varieties, farmers' rights and growth of seed industry in making available the seed of protected varieties to the

farmer. Distinctness, Uniqueness and Stability (DUS) test guidelines developed by the Plant Varieties and Farmers Right (PPV and FR) Act 2001, New Delhi are followed in characterizing and assessing the stability in rice landraces or local rice genotypes or farmers rice varieties may be grouped as distinct or stable and such genotypes may be protected under the act.

Yield is the complex trait that is contributed by the direct and indirect effect of each trait. Analysis of correlation provides information on the relationship between the different traits and measures the mutual relationship between two variables and also helps the breeder for simultaneous improvement in the characters. Correlation between yield and other traits helps in identifying the desirable genotype.

With the above information, the present experiment was carried out with the following objectives

1. Morphological characterization landraces of rice
2. Estimation of genetic variability for yield and yield related traits
3. Study of correlation and path coefficient analysis for yield and yield related traits
4. To study genetic diversity for yield and yield related traits

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Rice is an important and primary food source of the world's population. The development of high yielding varieties is essential to feed the growing population. Genetic variability is the basic requirement for a successful plant breeding program. Hence, better understanding of the nature and magnitude of genetic variability is important along with the association of different yield and quality attributing traits.

The literature relevant to the experiment is reviewed and presented under the following headings.

2.1 Morphological characterization landraces of rice

2.2 Estimation of genetic variability for yield and yield related traits

2.3 Study on correlation and path coefficient analysis for yield and yield related traits

2.4 To study genetic diversity for yield and yield related traits

2.1 Morphological characterization of rice landraces.

Characterization of a variety is helpful to identify and to avoid duplication and also provides information for plant breeding program which leads to a system of storing and recording useful data which can be retrieved and made available to others and in planning a breeding program.

Patra (2000) studied that 22 accessions of rice are having purple basal leaf sheath among the rice varieties of Orissa. Leaf length shows the statistically significant difference and some other distinguishable characters were also found like panicle curvature of the main axis, panicle type, awning, the color of the tip of lemma, density of pubescence of lemma and color of stigma.

Thimmanna *et al.* (2000) described that the morphological characteristics of parent of Karnataka hybrid rice could be used to differentiate the parental lines and the traits studied were flag leaf angle, auricle color, ligule length, colour and shape, inter node color, panicle type, secondary branching and exertion percentage, leaf length, width, pubescence and color, awning, test weight and seed length, width and L/B ratio.

Rao *et al.* (2001) characterized 123 landraces of rice and native cultivars using agro-morphic descriptors and also estimated variability. For 11 morphological characters, the frequency distribution was given and it was found that traits like white stigma, light green collar and green basal sheath contains the highest frequency.

Suman (2003) studied germplasm of rice and grouped them based on awning and anthocyanin pigmentation. Eight plant parts of the rice germplasm were grouped into three groups by using awning traits whereas based on pigmentation distribution grouped into nine groups.

Sharma *et al.* (2004) studied 142 Ahu rice genotypes of Assam and characterized them based on 21 agro-morphic traits and most of them are having the characters like low tillering, intermediate plant height, erect growing, early maturing, flag leaf angle and intermediate panicle type.

Bajracharya *et al.* (2006) characterized 147 landraces of rice for agro-morphological variability. Variability was in the traits like color sterile lemma, seed coat and lemma and palea also estimated high correlation in secondary branching, panicle type, culm angle, and strength.

Subbarao *et al.* (2006) studied one thousand and fifty-six rice accessions to estimate variability for 21 agro-morphological characters based on agro-morphological descriptors (IRRI,1996) and concluded that 54 per cent of landraces were having early plant vigor, 41 per cent were intermediate and four per cent were with poor plant vigor and also estimated that 57 per cent of them possessed green basal leaf sheath color, 12 per cent were light purple color, 18 per cent having purple color and 13 per cent having purple lines.

Joshi *et al.* (2007) characterized nineteen varieties of basmati and non-basmati rice at different growth stage for 52 morphological characteristics and concluded that the cultivars possessed an overlapping expression of combination traits but the identity still existed in the individual cultivars hence they were used in registration.

Padmaja (2007) characterized one hundred and fifty germplasms of rice for eleven morphological characters using morpho-agronomic descriptors (IRRI,1996) and concluded that all studied characters showed variability like, basal leaf sheath color, leaf pubescence, leaf blade color, early plant vigor, ligule shape and color, panicle type and exertion, awning, stigma color and threshability.

Bisne and Sarawagi (2008) carried out an experiment to characterize 32 rice accessions for six agronomical, eight quality traits and twenty-two morphological traits. Highest variability was observed among 22 morphological traits *viz.*, color of lemma and palea, apiculus color, lemma and palae pubescence and leaf blade color, whereas L/B ratio, kernel length, breadth, head rice recovery percentage, alkali spreading value, hulling and milling percentage and aroma.

Bora *et al.* (2008) conducted an experiment to evaluate eleven rice landraces of Assam and characterized them based on hulled and unhulled grain characters *viz.*,

grain length and width, L / B ratio, color of grain, test weight, dehusked grain color, shape, length and width.

Qadir *et al.* (2008) carried out an experiment for the characterization of rice varieties based on 16 plant morphological characters. Rice genotypes for each trait were characterized three classes were made for each character which includes, stigma color, ligule shape, leaf pubescence and leaf color. For each plant traits like secondary branching, panicle exertion, panicle type, auricle color, leaf sheath color, plant habit, flag leaf angle and apiculus color were characterized into two different classes.

Das and Ghosh (2010) carried out an experiment to characterize four hundred and 31 traditional rice cultivars on thirty-one traits. Grains per panicle exhibit the highest variability whereas leaf blade color, stigma color and panicle exertion exhibited moderate variability.

Joshi and Chawla (2010) evaluated twenty indigenous rice cultivars on the basis of 46 visually assessed DUS descriptors and described that 44 were monomorphic, 17 were dimorphic and six were polymorphic whereas fourteen measurable descriptors were found in that one was monomorphic, six were dimorphic and seven were found polymorphic. Based on six characteristics, the varieties were grouped like, stem length, time of heading, amylase content decorticated grain color, length and shape.

Patra and Chawla (2010) studied 18 traditional and improved basmati rice for DUS testing and concluded that panicle characteristics followed by grain characteristics exhibited maximum polymorphism. Leaf and stem characters showed a low level of polymorphism.

Nascimento *et al.* (2011) studied 146 upland rice accessions by using qualitative and quantitative agro-morphological descriptors (IRRI,1980) and concluded that out of 14 qualitative traits 12 traits showed high polymorphism and out of 11 quantitative traits 14 showed significant differences.

Njavara rice varieties were evaluated by Sreejayan *et al.* (2011) for 24 morphological traits and concluded that in Njavara genotypes four morphologically distinct types were found by using different multivariate methods.

Bhartiya *et al.* (2012) evaluated nineteen varieties of rice by following the standard procedure of DUS guidelines for 60 morphological traits and described that variation was not seen for 17 traits whereas 23 traits showed dimorphic and 20 were polymorphic. Six varieties showed distinct physio-morphological features. In DUS test guidelines eight grouping characters were estimated they are the time of heading, stem length, amylase content, decorticated grain color, length, shape, and aroma.

Chakrabarty *et al.* (2012) carried out an experiment to characterize 91 farmers' grown rice varieties for 44 qualitative traits. The varieties showed distinct visual differences for lemma and palea color (ranging from purple to tawny), grain width varying from 1.9 mm to 2.4 mm and grain length ranging from 5.2 mm to 11.3 mm. The majority of the varieties had long bold (41 varieties) and extra long slender (40 varieties) grains. Remaining varieties had short bold (3), medium slender (2) and long slender (5) grains.

Chakravorty and Ghosh (2012) had characterized 51 landraces of rice for forty-six characters following standard Distinctiveness, Uniformity and Stability (DUS) testing guidelines for three seasons. Out of 51 varieties studied, they were found 27 to be distinctive on the basis of 22 essential and 24 additional characters. Regarding the qualitative traits studied a remarkable variation has been found in significant amount specially among the traits like basal leaf sheath colour, leaf blade pubescence, panicle exertion, ligule colour, auricle colour, leaf senescence, flag leaf attitude, stem length, panicle length, tip colouration in lemma and awn distribution.

Parikh *et al.* (2012) carried out an experiment to characterize 71 aromatic rice germplasm and grouped them based on plant habit, awning and anthocyanin pigmentation. Plant habit and awning forms three groups of each whereas anthocyanin pigmentation forms twelve groups. Genetic parameters for the ten agronomic characters indicated that the selection of landraces may be done for fertile spikelets per panicle, spikelet density, spikelet sterility per cent and hundred seed weight.

Patra and Marndi (2012) characterized and evaluated medicinal rice accession germplasm by following the standard procedure of IRRI-IPGRI descriptor for morpho-agronomic characters at vegetative as well as reproductive stages and described that high variability was found for the seedling height of 21 days old seedling.

Vijaykumar *et al.* (2012) evaluated milled rice of sixty farmer's varieties for morphological and physiochemical properties and estimated the existence of significant differences among them. The varieties were grouped into seven classes based on length and breadth ratio and the milled raw rice showed variability ranging from 3.99 to 7.65 mm for length and from 1.43 mm to 3.09 mm for breadth.

Sarawgi *et al.* (2013) carried out an experiment to characterize 782 germplasm of rice for twenty-nine morphological and eight agronomical traits. They described that except leaf: collar, leaf: ligule and leaf: shape of ligule, most of the morphological characters showed variation in different accessions.

Sinha and Mishra (2013) done an investigation for characterization for 20 qualitative and 13 quantitative morphological characters with 82 agro-morphic descriptors. The results of PCA suggested that characters such as leaf length and width ratio, plant height, grain width, decorticated grain width, 50 per cent flowering and maturity time were the principal discriminatory characteristics of landraces of rice variety.

Krishna and Nidhi (2014) conducted an experiment to characterize the landraces of rice on the basis of pigmentation on 12 plant parts and the hundred genotypes were classified into 26 groups. On the basis of plant habit the rice germplasm was divided into three groups and three groups were also made on the basis of awning character.

Semwal *et al.* (2014) evaluated 23 landraces of rice for seed morphology in West Bengal and concluded that variability was found in qualitative traits like seed coat color, presence or absence of awns and aroma, kernel color and type.

Kalyan *et al.* (2017) had done characterization of thirty-five landraces of rice was done using twenty-nine agro-morphological traits following Distinctiveness, Uniformity and stability (DUS) test. Twenty-two were found to be distinctive out of thirty-five varieties, on the basis of twenty-nine essential characters.

Manjunatha *et al.* (2018) conducted an experiment to characterize sixty landraces of rice which include aromatic genotypes for both qualitative and quantitative traits and estimated that among the 24 descriptors, five traits were monomorphic, 13 traits were found to be dimorphic, and four were trimorphic.

Sharma and Singh (2018) carried out an experiment to characterize 136 farmer's varieties of rice by using 55 agro-morphological traits following the DUS test and concluded 55 genotypes exhibit distinctive based on the 55 essential characters studied out of one thirty-six varieties.

Avinash *et al.* (2019) conducted an experiment in a set of 542 Nagina 22 rice mutants from M₄ generation for morphological characterization under DUS test guidelines and compared with Nagina 22 as a check variety. Characterization has confirmed the existence of Distinctness, Uniqueness and Stability for the traits studied as given in the guidelines. Out of 542 mutant lines, majority of the mutant lines had purple lines as basal leaf sheath color with 68.45 per cent, leaf auricle was absent for all mutants, 97 per cent of mutants were colorless with respect to leaf anthocyanin and white color of ligule was more prominent with 99.36 per cent, light purple in 13.09 per cent and purple in 0.36 per cent.

Lokesh *et al.* (2019) characterized 83 indigenous rice germplasm for 31 morphological characters. Basal leaf sheath colour, colour of tip of lemma, lemma & palea colour found highest variation in germplasm. On the basis of pigment distribution in 13 plant parts, the entire germplasm was classified into 23 groups as per DUS guideline.

Monica *et al.* (2019) conducted an experiment to characterize 261 farmers' variety of rice from Madhya Pradesh for 21 qualitative traits and estimated that most of the traits were polymorphic except coleoptiles color, presence of leaf collar, presence of leaf ligule and shape of ligule.

2.2 Estimation of genetic variability for yield and yield related traits

The existence of nature and the magnitude of genetic variability is the fundamental basis for any crop improvement programs. To get a true indication of the genetic coefficient of variability partitioning of the variability into a heritable and non-heritable component is very much essential as a useful measure of the magnitude of genetic variance present in the population.

Bidhan *et al.* (2001) estimated that high GCV and PCV was recorded in rice for grain breadth, yield and number of grains per panicle, whereas heritability was found between 50 per cent and 90 per cent (grain yield and grain breadth). Highest genetic advance as per cent mean was observed for number of filled grain per panicle followed by grain yield. High heritability coupled with moderate genetic advance and the less environmental effect was observed in traits like, grain length and breadth, the number of filled grains per panicle and test weight.

Sankar *et al.* (2006) reported that high heritability coupled with high genetic advance was recorded in rice for the time of heading, plant height and number of productive tillers per plant. Whereas spikelet fertility exhibits high heritability with moderate genetic advance.

Sharma and Sharma (2007) described high GCV for rice grain L/B ratio and yield per plant whereas days to 50 per cent flowering, grains per panicle, L/B ratio and test weight exhibit a high level of heritability.

Amudha and Thiyagarajan (2008) reported a high level of broad sense heritability along with high genetic variability for gel consistency and amylase content in rice. Veerabhadiran *et al.* (2009) reported that gel consistency in rice crop showed high GCV and PCV whereas decorticated grain width, L/B ratio followed by amylase content exhibit moderate GCV and PCV. The traits like, decorticated grain width, L/B ratio, and amylose content showed high heritability coupled with high genetic advance.

Hilal *et al.* (2010) estimated high genotypic coefficient of variation in rice for the traits like grain yield, test weight, flag leaf area, harvest index and amylase content. Pandey and Anurag (2010) described a high level of heritability for decorticated grain color and width with low genetic advance in rice.

Sreeparvathy *et al.* (2010) reported high heritability coupled with high genetic advance in rice for the number of productive tillers per plant, whereas decorticated grain length, L/B ratio and amylase content showed high heritability with moderate genetic advance.

Yadav *et al.* (2010) described high GCV and PCV for traits like the total number of tillers per plant, the total number of grains per panicle whereas, moderate GCV and PCV were recorded for panicle length in rice. High heritability was estimated for the traits like single plant yield with maximum genetic advance, whereas the time of heading showed high heritability coupled with low genetic advance.

Manoj *et al.* (2011) estimated high heritability in rice for harvest index and spikelet per panicle along with maximum genetic advance whereas flag leaf width exhibits moderate genetic advance with a high level of heritability.

Sangam *et al.* (2011) carried out an experiment in rice to estimate genetic parameters like variability, heritability and genetic advance in thirty one rice genotypes on the basis of thirteen quantitative traits and concluded that high level of GCV and PCV estimated for number of spikelet per panicle followed by grain yield per hill, number of panicles per hill and harvest index. High heritability coupled with high genetic advance was reported for the number of spikelets per panicle.

Mohanty *et al.* (2012) estimated a high amount of GCV and PCV was recorded in rice for single plant yield followed by the number of productive tillers per plant and time of 50 per cent flowering recorded moderate GCV and PCV whereas lowest GCV and PCV were recorded for panicle length. The maximum genetic advance was found for plant height followed by a single plant yield with high heritability.

Singh *et al.* (2012) described high GCV and PCV in rice for the time of heading, the total number of tillers per plant, number of productive tillers per plant, the total number of grains per panicle single plant yield, decorticated grain length, width and L/B ratio. Plant height and the total number of grains per panicle exhibit high heritability coupled with high genetic advance, whereas the time of heading and single plant yield showed high heritability coupled with moderate genetic advance.

Sravan *et al.* (2012) described high GCV and PCV for single plant yield followed by plant height, flag leaf length and time of heading in rice. Plant height and the total number of grains per panicle possess maximum genetic advance with a high level of heritability. The significant positive correlation of rice grain yield was with biological yield per plant, harvest index, panicles per plant, plant height, spikelets per panicle, panicle length, test weight, spikelet fertility and flag leaf length.

Dhanwani *et al.* (2013) reported high GCV and PCV in rice for single plant yield (30.52 % :31.18 %), filled grains per panicle (26.05 % :26.86 %) followed by gel consistency (42.72 % : 43.67 %), alkali spreading value (49.55 % :49.90 %) whereas moderate GCV and PCV for the total number of tillers per plant, number of productive tillers per plant, panicle length, decorticated grain L/B ratio. High heritability coupled with high genetic advance was described for single plant yield followed by gel consistency whereas high heritability coupled with low genetic advance was observed for time of heading. The characters having high GCV and PCV with high genetic advance was found to be highly heritable governed by additive gene action.

Gangashetty *et al.* (2013) conducted an experiment to estimate the extent of genetic variability in the 42 local non-basmati aromatic genotypes of rice. It was described that analysis of variance showed significant for all the traits under studied and the magnitude of high GCV and PCV was observed for panicle weight, grain length, test weight, number of productive tillers per plant, plant height, number of tillers per plant, iron and zinc content and grain yield per plant whereas, panicle length, grain breadth and L/B ratio showed moderate genotypic and phenotypic coefficients of variance while, days to 50 per cent flowering showed lower values of genotypic and phenotypic variance. High heritability coupled with high genetic advance was observed for all traits except days to 50 per cent flowering.

Vanisree *et al.* (2013) studied the genetic parameters, correlation and path analysis in 21 rice genotypes for 12 yield and quality traits. High magnitude of GCV and PCV for the traits like the number of productive tillers per plant, single plant yield and L/B ratio, while panicle length, time of heading and decorticated grain width possess low GCV and PCV. Whereas the triats like number of productive tillers per plant, panicle density, number of filled grains per panicle, 1000-grain weight, grain yield per plant and kernel length exhibited high heritability coupled with high genetic advance.

Parikhomba *et al.* (2011) conducted an experiment to study thirty F₁ rice hybrids for variability, heritability and genetic advance along with parents and checks and concluded that the number of filled grains per plant, pollen fertility, yield per

plant and harvest index showed a high level of heritability along with moderate genetic advance.

Varthini *et al.* (2014) estimated that number of productive tillers in rice shows the largest variation with the coefficient of variation of 28.03 per cent followed by leaf length, grain length-width ratio, single plant yield and number of filled grains per panicle, whereas least variation was shown by days to maturity with the CV of 9.74 per cent.

Nirmaladevi *et al.* (2015) estimated that high GCV and PCV was recorded in rice for water uptake, gel consistency, alkali spreading value and head rice recovery (%), whereas head rice recovery (89 % and 29 %), milling (84 % and 21 %), water uptake (90 % and 24 %), amylose content (93 % and 29 %) and gel consistency (90 % and 31 %) exhibits highest broad sense heritability and genetic advance.

Shivayogayya *et al.* (2016) were carried out an experiment to assess the genetic advance genetic, genetic variability, heritability, for yield and yield component characters in four hundred mutant lines of rice. Genetic variability parameters showed that heritability is high for most of the characters and (PCV) was higher than the respective GCV. The high and low genetic advance was estimated in the number of grains per panicle and per cent of chaffyness respectively.

Umarani (2016) carried out an experiment to estimate the variability, heritability and genetic advance in seventy landraces of rice for sixteen agromorphological and grain quality parameters. Total number of grains per panicle recorded highest PCV (35.94) and GCV (35.85), whereas spikelet fertility exhibits lowest PCV (4.59) and GCV (4.28) among all the characters under study. High heritability coupled with high genetic advance as a per cent of mean recorded in all the characters under study except spikelet fertility and panicle length.

Abebe *et al.* (2017) conducted an experiment to estimate genetic variability parameters in 36 rice genotypes and concluded that plant height, number of unfilled grains per panicle, culm length, grain yield and biomass yield showed high level of GCV and PCV and also observed high heritability for culm length, plant height, biomass yield and plant height. Maximum genetic advance with high to moderate heritability showed for plant height, grain yield, biomass yield and number of unfilled grains per panicle.

Basavaraj *et al.* (2017) estimated that high range of GCV and PCV was found in rice for days to 50 per cent flowering and unfilled grain number per panicle, whereas shoot biomass, root biomass, panicle number per plant, flag leaf length, grain

filling duration (80.83 and 24.39), tiller number per plant and test weight exhibit high heritability coupled with high genetic advance as per cent of mean.

Rashid *et al.* (2017) conducted an experiment to estimate the genetic variability for ten rice genotypes. Yield and yield contributing traits showed significant variation among the genotypes through analysis of variance. The higher estimates of PCV and GCV were observed for number of unfilled grains per panicle, number of filled grains per panicle and plant height while panicle length, number of effective tillers per plant, days to 50 per cent flowering, days to maturity, fertility (%), 1000 Seed weight and yield per panicle showed low PCV and GCV values.

Sahu *et al.* (2017) described that high values of heritability along with genetic advance were observed for biological yield and harvest index in rice. The PCV values were greater than GCV. Plant height followed by biological yield recorded high PCV values and second leaf length and harvest index exhibited moderate to high PCV values in both the situations.

Gaurav *et al.* (2018) described that grains per panicle, spikelet's per panicle and flag leaf area in rice show higher estimates of PCV and GCV. And also reported that high heritability coupled with high genetic advance for grains per panicle, flag leaf area, test weight, spikelets per panicle and plant height.

Manjunath *et al.* (2018) described that in rice the traits of grains per panicle and grain yield per plant shows high GCV and PCV. Also explained that high heritability coupled with high genetic gain as a percentage of mean was observed for the number of grains per panicle followed by 1000 grain weight.

Iqbal *et al.* (2018) evaluated fourteen elite rice genotypes on nature and magnitude of genetic variability and described that except physiological maturity, the traits panicle emergence, flag leaf area, effective tillers per plant, panicle length, primary branches and grains per panicle, 1000-grain weight and paddy yield per plot, exhibit high magnitude GCV and PCV (> 20 %).

2.3 Study of correlation and path coefficient analysis for yield and yield related traits

Yield is the complex character depends on the interaction of a number of component traits hence understanding the relationship between yield and its component is of paramount importance for making the best use of these relationships in selection. Direct and indirect character association forms the basis for selecting a desirable plant and also helps in evaluating the influence of various component characters on grain yield.

Priya and Joel (2009) worked on correlation, path analysis and drought indices in rice and reported that the correlation studies revealed that the single plant yield (SPY) was significantly positively correlated with number of primary branches per panicle, number of tillers, number of leaves, number of productive tillers, number of secondary branches per panicle, number of grains per panicle, number of chaffs per panicle and boot leaf breadth when evaluated under controlled irrigation condition. In the path analysis, it was found out that the number of productive tillers per plant has a high positive direct effect and most of the other traits showed negligible or low direct effect in lowland condition.

Sabesan *et al.* (2009) described that grain yield per plant in rice showed positive significant association with plant height and productive tillers per plant at both genotypic and phenotypic levels. The 1000 grain weight was positively significantly correlated with plant height, grains per panicle and grain breadth.

Chakraborty and Chakraborty (2010) conducted an experiment to estimate correlation and path coefficient analysis in 47 bold grain rice. The results revealed that positive significant correlation with grain yield per hill was manifested in characters like sterility percentage, effective branch tiller per hill and panicle length.

Nandan *et al.* (2010) estimated that plant height, days to 50 per cent flowering, number of spikelets per panicle, number of grains per panicle and spikelet fertility in rice exhibited a strong positive association with rice grain yield, whereas the high direct effect on grain yield per plant was observed for the number of grains per panicle.

Sarika *et al.* (2010) described that aroma in rice was found to be negatively associated with days to 50 per cent flowering as well as with filled grains per panicle. However, the correlation between panicle length and effective tillers with aroma was not observed.

Yadav *et al.* (2010) estimated correlation coefficient in rice for the traits number tillers per hill, number of panicles per plant, number of spikelets per panicle, harvest index and test weight were significantly and positively associated with grain yield per plant at both genotypic and phenotypic level whereas path coefficient analysis revealed a direct positive effect on seed yield per hill at genotypic level for the traits like plant height, number of spikelets per panicle, number tillers per hill, biological yield, test weight and harvest index.

Akhtar *et al.* (2011) studied ten rice genotypes for yield contributing traits. Described that the number of grains per panicle, days to maturity and 1000-grain weight had a strong genetic correlation with paddy yield. It was revealed that paddy

yield had significant positive correlation with number of grains per panicle ($b = 0.0164$) and 1000-grain weight ($b = 0.1356$).

Fiyaz *et al.* (2011) described that significant positive association in rice was found for the trait days to 50 per cent flowering, total biomass, Number of productive tillers, total spikelet per panicle and plant height with grain yield. Path analysis revealed that their direct effects on grain yield through total biomass and harvest index were also very high.

Rajamadhan *et al.* (2011) studied correlation and path analysis for the association between quantitative traits on the yield of rice. A positive and significant association was found for the traits panicle length, the number of grains per panicle, grain breadth number of productive tillers and the number of productive tillers with grain yield per plant. The secondary trait panicle length showed a significant positive association with the number of grains per panicle, 1000-grain weight and grain yield.

Babu *et al.* (2012) conducted an experiment to estimate correlation and path analysis in 21 hybrid rice and described the number of productive tillers per plant showed positive and significant association with yield per plant, whereas path analysis exhibited a positive direct effect on yield for the traits number of productive tillers per plant and panicle length.

Khalid *et al.* (2012) described a significant and positive correlation in rice for the number of tillers per panicle, panicle length, the number of filled grains per panicle and test weight with grain yield whereas per cent grains per panicle showed a negative correlation with yield. Path analysis reported direct effects for grain yield with panicle length, test weight, number of tillers per plant and filled grains per panicle.

Ramya *et al.* (2012) described a highly significant and positive association in rice for the total number of grains per panicle and the number of productive tillers per plant with grain yield per plant whereas the direct effect on grain yield was observed for the total number of tillers per plant.

Seyoum *et al.* (2012) described that the maximum positive direct effect and highly significant genotypic correlation coefficient was found in rice for grains per panicle with grain yield. From the path analysis, it was revealed that grains per panicle exhibited a maximum positive direct effect on grain yield followed by days to 50 per cent flowering, panicle length, total spikelet fertility and plant height.

Sohrabhi *et al.* (2012) studied 50 upland rice accessions for 12 growth traits, yield and its related components in Malaysia and concluded that all traits under the

study were highly significant among the accessions, among those plant height exhibit highly significant and positive correlation with most of the traits studied.

Berhanu *et al.* (2013) carried out an experiment in rice to estimate the correlation and path coefficient for grain zinc concentration and yield contributing traits. The results revealed that a highly positive and significant correlation observed for number tillers per plant with productive tillers per plant (0.906), plant height (0.379) and grain zinc concentration with 1000 grain weight (0.2668) with grain yield per plant whereas path analysis described positive and direct effect of plant height, productive tillers per plant and grain breadth while, zinc concentration of grain had a negative direct effect on grain yield.

Bian *et al.* (2013) described that phenotypic correlation analysis in rice showed that there was no significant correlation between 1000-grain weight (TGW) and the percentage of grains with chalkiness (PGWC) in both environments, which indicated that the linkage of TGW and PGWC traits could be broken via suitable population.

Prakash *et al.* (2013) evaluated 42 nonbasmati rice genotypes and estimated that panicle weight, grain breadth, number of tillers per plant and number of productive tillers per plant exhibit significant and positive association with grain yield per plant whereas days to 50 per cent flowering and plant height showed negative and significant correlation at both genotypic and phenotypic level. Path coefficient analysis revealed high direct effect for panicle weight, number tillers per plant, number of productive tillers per plant and test weight with grain yield per plant at both genotypic and phenotypic level.

Rashid *et al.* (2013) described that a highly significant positive correlation was found in rice for days to maturity, days to heading, number of productive tillers, 1000-grain weight with grain yield per plant. A highly significant negative correlation found in plant height, panicle length and flag leaf area with grain yield per plant.

Singh *et al.* (2014) carried out an experiment to evaluate 38 rice germplasm for association studies for 12 different yield and yield related traits and concluded that significant and positive association was observed with yield per plot at both genotypic and phenotypic level for the traits like days to maturity, total number of tillers per plant, days to maturity, total grain per panicle, biological yield per plant and spikelet fertility.

Allam *et al.* (2015) conducted an experiment to estimate correlation and path analysis in 23 genotypes of basmati rice for grain yield and its components. High significant positive genotypic and phenotypic correlation for grain yield was observed

in days to maturity, effective panicles, spikelets per panicle and amylase content. Effective panicles per plant imparted the highest positive direct effect on yield followed by test weight, spikelets per panicle, kernel length and spikelet fertility for path analysis.

Tulasi *et al.* (2016) indicated that highly significant and positive association showed in rice for the traits panicle number, panicle length, panicle weight, total dry matter at flowering and harvesting stage, number of grains per panicle, number of filled grains per panicle, grain filling and harvest index with grain yield per plant. In path coefficient analysis, the main yield component traits which recorded maximum positive direct effect on grain yield were total dry matter at harvesting stage, harvest index, panicle weight, grain filling, total dry matter at flowering and number of grains per panicle.

Kar *et al.* (2018) described that in rice grain yield was positively correlated with plant height, fertile grain number, fertility percentage and days to flowering whereas days to 50 per cent flowering exhibited a maximum positive direct effect on grain yield followed by plant height fertility percentage, 1000-grain weight and grain yield per plant.

Kumar and Singh (2018) described that a significant positive correlation in rice was found for the traits like grains per panicle, fertility per cent and spikelet per panicle with grain yield per plant. Grain length had a positive and significant correlation with grain length after cooking, grain breadth and L/B ratio. Path analysis revealed that grains per panicle had a maximum direct effect on grain yield per plant followed by tillers per plant and 1000-grain weight.

Kumar *et al.* (2018) described that positive and significant correlation showed in rice for spikelet fertility, 1000-grain weight, L/B ratio, plant height, biological yield per plant, harvest index and panicle length with grain yield per plant to emerge as most important associates of grain yield in rice. Path analysis identified biological yield per plant followed by harvest-index as most important direct yield contributing traits and biological yield per plant followed by 1000-grain weight and panicle length exhibited a high order of positive indirect effect.

Meena *et al.* (2018) conducted an experiment to estimate correlation and path coefficient analysis in 38 rice genotypes for yield and its related traits. Correlation analysis revealed positive and direct association with yield per plant for panicle length, the number of effective tillers, filled grains per panicle and days to 50 per cent flowering, whereas path analysis exhibited maximum direct contribution for 50 per cent flowering with grain yield per plant.

Neeta *et al.* (2018) estimated that the positive and significant correlation was described for spikelet fertility, flag leaf area, panicle bearing tillers per plant, panicle length, spikelets per panicle, grains per panicle, biological yield per plant, harvest index and 1000-grains weight with grain yield per plant. Path analysis identified in most important direct yield contributing traits like biological yield and harvest-index. The residual effect under path analysis was very low and negligible.

Rasel *et al.* (2018) assessed 28 local rice landraces for eleven morphological traits for the improvement of salt tolerance ability of rice genotypes. Correlation study revealed that significant negative correlations at both phenotypic and genotypic level exist between standard evaluation score (SES) and survival rate (%), root length, shoot length, root fresh weight, root dry weight and shoot dry weight at the seedling stage. The root length (0.487), root dry weight (0.394) and shoot dry weight (0.047) had direct positive effect on standard evaluation score at genotypic level where live leaves (%) per plant (0.168), total number of roots (0.006), chlorophyll content (0.243) and shoot fresh weight (0.102) had a direct positive effect on standard evaluation score at phenotypic level can be revealed by studying path analysis.

Vennkatesh and Govindarasu (2018) described that the highest positive correlation in rice with grain yield was recorded by root number at 15 cm. Path analysis revealed that a very high magnitude of positive direct effect with grain yield was registered by root length. Very high to high magnitudes of negative direct effects were exhibited by root volume.

Mutturaj *et al.* (2019) conducted an experiment to evaluate the degree of association between grain yield and its related traits in 27 advanced breeding lines of rice with four checks and the results revealed positive and direct effect on grain yield per plant for days to 50 per cent flowering, panicle length, days to maturity, number of productive tillers per plant, number of filled grains per panicle, straw yield, test weight and harvest index.

2.4 To study genetic diversity for yield and yield related traits

Genetic distance plays an important role to obtain the superior genotypes in the segregating population as parental diversity is the optimum magnitude. Genetic diversity determines the inherent potential of genotype and frequency of desirable recombinants in segregating populations.

Bhutia *et al.* (2005) conducted an experiment to estimate genetic divergence in 41 local genotype of rice by using Mahalanobis' D^2 and grouped them into six clusters.

Bose and Pradhan (2005) estimated genetic diversity in 35 deep water rice genotypes using Mahalanobis' D^2 statistics and grouped the genotypes into ten clusters. Genotypes under clusters IX and cluster X recorded the highest inter-cluster distance whereas Cluster IV recorded maximum intra-cluster distance.

Naik *et al.* (2006) described the nature and magnitude of genetic diversity in 50 aromatic rice, which was grouped into seven clusters. Cluster VI shows the highest mean for grain yield per plant and biological yield per plant, whereas cluster I and cluster V records the least distance. Between cluster three and four highest inter-cluster distance was recorded.

The study was conducted to estimate genetic diversity in 50 genotypes of rice by Ramya and Kumar (2008) and grouped them into 11 clusters. The results revealed that cluster I having largest with 35 genotypes and maximum cluster distance were recorded between cluster IV and cluster VIII. The traits like the number of productive tillers per plant, number of grains per panicle and grain yield per plant contribute maximum towards divergence.

Dushyanthkumar and Anand (2010) classified rice genotypes into eight clusters and described that cluster VI was the largest among all includes 21 genotypes whereas clusters I, II, II, IV and V contained two genotypes each and cluster VI and VIII includes four genotypes each which records high degree of divergence.

Rajesh *et al.* (2010) described that the characters like single plant yield and days to fifty per cent flowering contributed maximum towards the genetic divergence. Between cluster IV and V exhibit maximum inter-cluster distance.

Ali *et al.* (2012) carried out an experiment to estimate Genetic diversity 66 local aromatic rice genotypes by following Mahalanobis' D^2 statistic method. The genotypes fell into ten clusters. Cluster X comprises only single genotype whereas the maximum number (11) of landraces consisted of clusters III and VII. Shortest inter-cluster distance found between clusters VII and IX while the highest observed between clusters I and V.

An experiment was carried out by Chamundeshwari *et al.* (2012) to estimate genetic diversity in 31 rice genotypes using Mahalanobis' D^2 statistics and grouped them into eight clusters. The largest number of landraces with 23 consisted of cluster I. The traits like days to 50 per cent flowering followed by grain yield, iron content, test weight and gel consistency contribute maximum towards genetic divergence

Mahalingam *et al.* (2012) studied 31 rice germplasms to estimate genetic diversity using Mahalanobis' D^2 values and grouped them into 13 clusters. 1000-grain weight and single plant yield contributed maximum towards total genetic divergence.

Neha and Gabriel (2012) studied 69 genotypes of rice using D^2 values and the genotypes were grouped into nine clusters. The highest inter-cluster distance was recorded between clusters II and VII. Cluster I, V and VIII were the largest clusters which include 12 genotypes followed by cluster III with nine genotypes.

Ovung *et al.* (2012) grouped seventy rice genotypes using Mahalanobis' D^2 values into nine clusters. The maximum inter-cluster distance was recorded between cluster VI and cluster VII whereas the minimum was recorded between cluster III and cluster IV.

Patil *et al.* (2012) conducted an experiment to estimate D^2 values for twenty-four aromatic rice genotypes and grouped them into six clusters. The results revealed that between the cluster III and cluster IV recorded maximum divergence, whereas between cluster I and cluster III recorded minimum divergence.

Yadav and Soni (2012) conducted an experiment to estimate the degree and magnitude of genetic divergence among 48 newly developed rice hybrids and described that highest inter-cluster distance was found between clusters II and IV, II and IX and II and V, whereas highest intracluster distance was found between clusters VII, I and IV.

Estimation for genetic diversity based on D^2 values for twenty-four rice landraces of Goa was studied by Manohara and Singh (2013) and grouped them into six clusters. Among the different traits studied, plant height, days to 50 per cent flowering, grain breadth and test weight contributes maximum towards the total divergence.

Kar *et al.* (2013) studied 65 indigenous aromatic rice genotypes to estimate genetic diversity and grouped them into thirteen clusters. The results revealed that maximum genetic distance was recorded between clusters IV and V and clusters IV and XI.

Kumar *et al.* (2013) studied 73 rice genotypes using the magnitude of D^2 statistics and grouped them into nine clusters. The highest intra-cluster distance was exhibited by cluster V and lowest for cluster III.

Tirkey *et al.* (2013) conducted an experiment to estimate genetic diversity for 195 rice accessions and grouped them into ten clusters. The highest intercluster distance was recorded between cluster VI and cluster VII followed by cluster IV and cluster VII, whereas the highest intra-cluster distance was recorded for cluster I and cluster IX and concluded that presence of high inter-cluster distance than intra-cluster distance indicate wide genetic diversity among the genotypes.

Sandhya *et al.* (2014) conducted an experiment to estimate genetic diversity for 32 elite rice genotypes using Mahalanobis' D^2 values and the genotypes were grouped into six clusters. The results revealed that maximum inter-cluster distance was recorded between cluster V and cluster VI, whereas the maximum intra-cluster was recorded in cluster IV. Cluster I and cluster VI were the largest having eight genotypes each, followed by cluster IV with six genotypes. The characters contributed maximum towards genetic divergence are biological yield per plant, number of spikelets per plant, test weight, days to 50 per cent flowering and harvest index.

Umrani (2014) studied seventy rice landraces for genetic diversity and grouped into nine clusters using Tocher's method based on D^2 value. Out of nine clusters, cluster I was the largest comprising of fifty landraces, followed by cluster III consists of eight, cluster VI consists of four and cluster VII consists of three landraces. The existence of a high degree of heterogeneity was among the genotypes of monogenotypic clusters II, IV, V, VIII and IX.

Prafull *et al.* (2015) conducted an experiment to estimate genetic diversity in 18 IRRI and Raipur originated rice genotypes and grouped them into five clusters. Cluster II and cluster III consist of five genotypes while cluster V consist of two IRRI genotypes assuring comparative diversity of exotic material.

Ibrahim *et al.* (2019) conducted an experiment to estimate genetic diversity in 87 rice accessions, were grouped into seven clusters and concluded morphological markers are effective in assessing rice genetic diversity.

MATERIAL AND METHODS

III MATERIAL AND METHODS

The details of the material and methods followed during the present investigation are mentioned in the following section. It also consists of information on the statistical tools used in drawing inferences on the characters considered in the investigation.

3.1 Experiment I: Characterization of landraces of rice

3.1.1 Experimental material

The materials comprised of fifty-one landraces of rice collected from Zonal Agricultural and Horticultural Research Station (ZAHRS), Brahmavar. The study was conducted at College of Agriculture, Shivamogga, during the *Kharif* 2018. The list of landraces of rice along with their respective codes included in this study was mentioned in Table 1.

3.1.2 Experimental layout

The experimental design used was a Randomized Complete Block Design with two replications. All 51 landraces were arranged in eleven columns and four rows. The spacing maintained was 20 cm between rows and 15 cm between plants within the row. The recommended agronomic practices were followed to raise a good crop.

3.1.3 Cultural operations

Seeds of all landraces of rice genotypes were sown on raised nursery beds of one m² each on 21st June 2018, on the eighth block, at COA, UAHS, Shivamogga. Twenty three days age old seedlings of each entry were transplanted in the main plot at the rate of two seedlings per hill on 13th July 2018, by following a Randomized Complete Block Design. The spacing was maintained with the plant to plant spacing of 15 cm within a row and row to row spacing of 20 cm. The recommended cultural operations were done to ensure uniform and healthy crop stands as per standard package of practice.

3.1.4 Method of sampling and recording observation

The following observations were recorded at appropriate growth stages

3.1.4.1 Agro-morphological characters

The observations on various agro-morphological characters including qualitative and quantitative characters were recorded. List of morphological characters based on DUS guidelines given by PPV and FRA, 2001 for characterization of landraces of rice presented in Table 2.

Table.1 List of landraces of rice along with their respective codes

Code	Genotype	Code	Genotype	Code	Genotype	Code	Genotype	Code	Genotype
BMRG-1	ANEKOMBIN ABHATTA	BMRG-14	SEETHMOG	BMRG-27	KAYAME	BMRG-40	NATTIJADDU		
BMRG-2	ARJUNA	BMRG-15	GIDDABASUMATI	BMRG-28	KEMPURAJESH	BMRG-41	NEERAMBADE		
BMRG-3	ATIRE	BMRG-16	GIDDABHATTA	BMRG-29	TULASIMOG	BMRG-42	BASUMATI		
BMRG-4	BHAGYODAY A	BMRG-17	GULVADISANNA	BMRG-30	HALINGA	BMRG-43	PEETASALE		
BMRG-5	BEGANBEAC H	BMRG-18	HALAGA	BMRG-31	KURUVA	BMRG-44	METERBHATTA		
BMRG-6	BHARMA	BMRG-19	INTAAN	BMRG-32	LALNETH	BMRG-45	ANDANOORSANNA		
BMRG-7	BILINELLU	BMRG-20	IRGA	BMRG-33	PRATIKSHA	BMRG-46	ANDRABASUMATI		
BMRG-8	BMR-US	BMRG-21	JULI	BMRG-34	BMR-MS-1-2-1	BMRG-47	DASARAPATTI		
BMRG-9	CHARE	BMRG-22	KALAME	BMRG-35	MALABAR	BMRG-48	PARLAN		
BMRG-10	CHICKSALE	BMRG-23	KANAKACHUDI	BMRG-36	MASKAT	BMRG-49	SHANKARAKEMPAKKI		
BMRG-11	PINGARA	BMRG-24	SOMASALE	BMRG-37	MEESEBHATTA	BMRG-50	BPT-5204		
BMRG-12	IR-8	BMRG-25	KAVADARI	BMRG-38	MYSORESANNA	BMRG-51	JGL-1798		
BMRG-13	RATAN	BMRG-26	KAVALAKANNU	BMRG-39	NADDANTARAS ALE	Treatment no.50 and 51 was taken as check varieties.			

Table.2 List of morphological characters based on DUS guidelines given by PPV and FRA for characterization of landraces of rice

Sl. No	Characteristics	Status	Stage of observation (in days)	Type of assessment
1	Coleoptile: Color	Green	10	VS
		Purple		
2	Basal leaf: Sheath color	Green	40	VS
		Light purple		
		Purple lines		
		Uniform purple		
3	Leaf: Intensity of green color	Light	40	VG
		Medium		
		Dark		
4	Leaf: Anthocyanin coloration	Absent	40	VG
		Present		
5	Leaf: Distribution of anthocyanin coloration	On tips only	40	VG
		On margins only		
6	Leaf sheath: Anthocyanin coloration	Present	40	VG
		Absent		
7	Leaf sheath: Intensity of anthocyanin coloration	Weak	40	VG
		Medium		
		Very strong		
8	Leaf: Pubescence of blade surface	Weak	40	VS
		Medium		
		Strong		
		Very strong		
9	Leaf: Auricles	Present	40	VS
		Absent		
10	Leaf: Anthocyanin coloration of auricles	Colorless	40	VS
		Purple		
11	Leaf: Collar	Absent	40	VS
		Present		
12	Leaf: Anthocyanin coloration of collar	Absent		
		Present		
13	Leaf: Ligule	Present	40	VS
14	Leaf: Shape of ligule	Split	40	VS
15	Leaf:Color of ligule	White		
		Light purple		
		Purple		
16	Leaf: Length of blade	Short (<30cm)	40	MS
		Medium (30-45cm)		
		Long (>45cm)		
17	Leaf: Width of blade	Narrow (<1cm)	40	MS
		Medium (1-2cm)		
		Broad (<2cm)		

Contd....

18	Culm: Attitude	Erect	40	VS
		Semi-erect		
		Open		
		Spreading		
19	Time of heading (50 per cent of plants with panicles)	very early(>71 days)	55	VG
		early(71-90 days)		
		medium(91-110 days)		
		late(111-130 days)		
		very late(>131 days)		
20	Flag leaf: Attitude of blade (early observation)	Erect	60	VG
		semi-erect		
		Horizontal		
		Drooping		
21	Spikelet: Density of pubescence of lemma	Weak	60-80	VS
		Medium		
		Strong		
		Very strong		
22	Male sterility	Absent	65	VG
23	Lemma: Anthocynin coloration of keel	Absent or very weak	65	VS
		Weak		
		Medium		
		Strong		
		Very strong		
24	Lemma: Anthocynin coloration of below Apex	Absent	65	VS
		Weak		
		Medium		
		Strong		
		Very strong		
25	Lemma: Anthocynin coloration of apex	Absent	65	VS
		Strong		
		Very strong		
26	Spikelet: Color of stigma	White		
		Yellow		
		Light purple		
		Purple		
27	Stem: Thickness	Thin (<0.40cm)	70	MS
		Medium (0.40-0.55cm)		
		Thick (>0.55cm)		

28	Stem: Length	Very short(>91cm)	70	MS
		Short (91-110cm)		
		Medium (111-130cm)		
		long(131-150cm)		
29	Stem: Anthocynin coloration of nodes	Absent	70	VS
		Present		
30	Stem: Intensity of anthocynin coloration of nodes	Weak	70	VS
		Medium		
		Strong		
31	Stem: Anthocynin coloration of internodes	Absent	70	VS
		Present		
32	Panicle: Length of main axis	Very hort(<16cm)	70-90	MS
		Short (16-20cm)		
		Medium (21-25cm)		
		Long (26-30cm)		
		Very ong(>30cm)		
33	Flag leaf: Attitude of blade (late observation)	Semi-erect	90	VG
		Horizatal		
		Deflexed		
34	Panicle: Curvature of main axis	Semi-straight	90	VG
		Deflexed		
		Drooping		
35	Panicle: Number per plant	Few(<11)	80-90	MS
		Medium(11-20)		
		Many(>20)		
36	Spikelet: Color of tip of lemma	Yellowish	80-90	VG
		Red		
		Purple		
		Black		
37	Lemma and palea: Color	Straw	80-90	VG
		Gold and gold furrows on straw background		
		Brown spots on straw		
		Brown furrows on straw		
		Brown reddish to light purple		
		Purple		
		Black		

Contd....

38	Panicle: Awns	Absent	90	VG
		Present		
39	Panicle:Color of awns (late observation)	Yellowish white	90	VS
		Light purple		
		Purple		
40	Panicle:Length of longest awn	Very short	90	VG-MS
		Short		
		Medium		
		Very long		
41	Panicle:Distribution of awns	Tips only	90	VS
		Whole length		
42	Panicle:Presence of secondary branching	Present	90	VG
43	Panicle:Secondary branching	Weak	90	VG
		Strong		
		Clustered		
44	Panicle:Attitude of branches	Erect	90	VG
		Erect to semi-erect		
		Semi-erect		
		Semi-erect to spreading		
45	Panicle:Exertion	Spreading	90	VG
		Partly exerted		
		Mostly exerted		
		Well exerted		
46	Time of maturity (days)	Very early(<100)	90	VG
		Early(101-120)		
		Medium(121-140)		
		Late(141-160)		
		Very late(>160)		
47	Leaf:Senescence	Early	92	VG
		Medium		
		Late		
48	Sterile lemma: Color	Straw	92	VS
		Gold		
		Purple		
49	Grain: Weight of 1000 fully developed grains	Very low(>15g)	92	MG
		Low(15-20g)		
		Medium(21-25g)		
		High(26-30g)		
		Very high(>30g)		

Contd....

50	Grain: Length	Short(6.1-8.5mm)	92	MS
		Medium(8.6-10.5mm)		
51	Grain: Width	Very narrow(>2mm)	92	MS
		Narrow(2.1-2.5mm)		
		Medium(2.6-3mm)		
52	Decorticated grain:Length	Short	92	MS
		Medium		
		Long		
		Extra long		
53	Decorticated grain:Width	Narrow	92	MS
		Medium(2.0-2.5mm)		
		Broad(>2.5mm)		
54	Decorticated grain:Color	White	92	VG
		Light brown		
		Variegated brown		
		Dark purple		
		Dark brown		

MG: Measurement by a single observation of a group of plants or parts of plants

MS: Measurement by a number of individual plants or parts of plants

VG: Visual assessment by a single observation of a group of plants or parts of plants

VS: Visual assessment by observation of individual plant or parts of plants

3.1.4.1.1 Coleoptiles color

The color of coleoptiles was visually recorded at 10 days old seedling stage.

3.1.4.1.2 Basal leaf: sheath color

The color of the leaf sheath, which is wrapped around the culms above the basal node, was visually recorded at the late vegetative stage.

3.1.4.1.3 Leaf: Intensity of green color

The intensity of green color on the leaf was visually recorded at the early boot stage by observing a group of the plant. The major categories recorded were light, medium and dark green color.

3.1.4.1.4 Leaf: Anthocynin coloration

The presence or absence of anthocynin coloration on the leaf was recorded at the early boot stage by visual assessment in a group of the plant.

3.1.4.1.5 Leaf: Distribution of anthocynin coloration

The distribution of anthocynin coloration on the leaf was recorded at the early boot stage by visual assessment in a group of the plant.

3.1.4.1.6 Leaf sheath: Anthocynin coloration

The presence or absence of leaf sheath anthocynin coloration was recorded at the early boot stage by visual assessment in a group of the plant.

3.1.4.1.7 Leaf sheath: Intensity of anthocynin coloration

The intensity of anthocynin coloration on leaf sheath was recorded at the early boot stage by visual assessment of the group of the plant. The major groups were weak, medium and strong anthocynin coloration.

3.1.4.1.8 Leaf: Pubescence of blade surface

The leaf blade pubescence was recorded at the late vegetative stage by visual assessment of individual plants.

3.1.4.1.9 Leaf auricles

Most of the leaves possess small paired hairy appendages on either side of the base of the leaf blade. These appendages are called auricles. The presence or absence of auricles was visually assessed at early boot stage by observation of individual plant.

3.1.4.1.10 Leaf: Anthocynin coloration of auricles

The anthocynin coloration of auricles *i.e.*, yellowish green, purple and purple line color in was recorded at the early boot stage with visual assessment by observation of individual plant.

3.1.4.1.11 Leaf: Collar

The presence or absence of anthocynin coloration at the collar was recorded at the early boot stage by visual assessment of the individual plant.

3.1.4.1.12 Leaf: Anthocynin coloration of the collar

The presence or absence of anthocynin coloration at the collar was recorded at the early boot stage by visual assessment of the individual plant.

3.1.4.1.13 Leaf: Ligule

The presence or absence of papery membrane at the inside juncture between the leaf sheath and blade called ligule was visually recorded at the early boot stage by observation of individual plant or parts of the plant.

3.1.4.1.14 Leaf: Shape of ligule

The shape of ligule *i.e.*, acute to acuminate, cleft and truncate shapes were recorded at the late vegetative stage by visual assessment of the individual plant.

3.1.4.1.15 Leaf: Color of ligule

The color of the papery membrane at the inside junction between the leaf sheath and blade was visually recorded.

3.1.4.1.16 Leaf : Length of the blade (cm)

The length of the blade was measured in centimeter and categorized in to very short, short, medium, long and very long leaves.

3.1.4.1.17 Leaf: Width of the blade (cm)

The width of the blade was measured in centimeter and categorized in to narrow and medium leaves.

3.1.4.1.18 Culm: Attitude

The culm attitude was recorded at the early boot stage by visual assessment and grouped into erect, semi-erect, open or spreading culm attitude by observation of individual plant.

3.1.4.1.19 Time of heading (50 per cent plants with panicle)

The number of days was recorded from the date of sowing to the days when primary panicles in 50 per cent of plants have emerged.

3.1.4.1.20 Flag leaf: Attitude of blade

The attitude of flag leaf was recorded at the ripening stage through visual observation and grouped into erect, semi-erect and horizontal classes according to the features of the majority of plants of the landraces.

3.1.4.1.21. Spikelet :Density of pubescence of lemma

The density of pubescence of lemma recorded visually at dough development stage as weak, medium, strong and very strong.

3.1.4.1.22 Male sterility

The presence or absence of male sterility was observed visually.

3.1.4.1.23 Lemma : Anthocynin coloration of keel

Anthocynin coloration of keel recorded visually during anthesis stage as absent or very weak, weak, medium, strong and very strong.

3.1.4.1.24 Lemma: Anthocynin coloration of the area below apex

The anthocynin coloration of the area below the apex of lemma was recorded at halfway of anthesis by visual observation and grouped into absent, weak, medium and very strong.

3.1.4.1.25 Lemma: Anthocynin coloration of apex

The anthocynin coloration of apex was recorded at halfway of anthesis by visual observation and grouped into the green, red, purple, white and purple apex.

3.1.4.1.26 Spikelet: Color of stigma

The color of stigma *i.e.*, the female reproductive part of the rice plant was recorded visually. Stigma color is determined from blooming spikelets (between 9 am to 2 pm).

3.1.4.1.27 Stem: Thickness (cm)

The stem thickness was recorded at the grain development stage. Thickness was measured in centimeter and categorized into thin, medium and thick stem classes.

3.1.4.1.28 Stem: Length (cm)

The length of the stem was measured in centimeter excluding panicle and categorized into very short, short, medium, long and very long.

3.1.4.1.29 Stem: Anthocynin coloration of nodes

The presence or absence of anthocyanin coloration of nodes was recorded at the grain filling stage through visual assessment of individual plant nodes.

3.1.4.1.30 Stem: Intensity of anthocynin coloration of nodes

Visual observation recorded on intensity of anthocyanin coloration of nodes during milk development stage as weak, medium and strong.

3.1.4.1.31 Stem: Anthocynin coloration of internodes

The presence or absence of anthocyanin coloration of nodes was recorded at the grain development stage through visual assessment of each landrace.

3.1.4.1.32 Panicle: Length of main axis (cm)

Panicle length of the main axis was measured in centimeters at the time of plant maturity from the base of panicle to the tip of the last spikelet prior to harvesting.

3.1.4.1.33 Flag leaf: Attitude of blade (late observation)

The late observation of flag leaf attitude recorded visually as semi-erect, horizontal and deflexed.

3.1.4.1.34 Panicle : Curvature of main axis

The panicle curvature of main axis recorded visually during ripening stage as semi-straight, deflexed and drooping.

3.1.4.1.35 Panicle: Number per plant

The number of panicles of the plants were counted in five random plants and averaged. Then categorized into medium and few.

3.1.4.1.36 Spikelet: Color of tip of lemma

Color of tip of lemma recorded visually as yellowish, red, purple and black.

3.1.4.1.37 Lemma and palea: Color

Covering of kernel per rice grain is known as lemma and palea. Its color was recorded visually.

3.1.4.1.38 Panicle: Awns

An awning is a thorn like an extension from the keel of the lemma. The presence or absence of awns was recorded at the ripening stage and assessed through visual observation of a group of plants.

3.1.4.1.39 Panicle: Color of awns (late observation)

Extension of the keel of the lemma is called awn and late observation of color of awns was recorded visually.

3.1.4.1.40 Panicle: Length of longest awn

Length of longest awn was recorded at ripening stage through centimeter measurement of awn of individual panicle and grouped into very short, short, medium and long awn length.

3.1.4.1.41 Panicle: Distribution of awn

The distribution of awns was recorded at the ripening stage through visual assessment of individual plants and grouped into the presence of awns at whole length, upper half only and upper quarter only.

3.1.4.1.42 Panicle: Presence of secondary branching

The presence or absence of secondary branching was recorded at the ripening stage through visual observation of a group of plants.

3.1.4.1.43 Panicle: Secondary branching

Based on the intensity of secondary branching genotypes were classified into three groups namely weak, strong and clustered.

3.1.4.1.44 Panicle: Attitude of branches

The attitude of branches of panicle was recorded visually at the ripening stage, which was classified into open, compact and semi-compact.

3.1.4.1.45 Panicle: Exertion

The panicle exertion was recorded visually at the ripening stage, which were classified into partly exerted, mostly exerted and well-exerted classes. The classes were recorded through visual assessment of a group of plants.

3.1.4.1.46 Time of maturity (days)

This was recorded in days from sowing to maturity. This character is categorized into very early, early, medium, late and very late duration.

3.1.4.1.47 Leaf: Senescence

Leaf senescence was recorded visually during caryopsis hardening stage and grouped into early, medium and late.

3.1.4.1.48 Sterile lemma: Color

Color of sterile lemma was recorded visually and classified them into straw color, gold color and purple color.

3.1.4.1.49 Grain: Weight of 1000 fully developed grains

Thousand well-developed, whole grains dried to 13 per cent moisture content of each of the entries were taken randomly and weighed in gram on a precision balance.

3.1.4.1.50 Grain: length

More than 100 grains were taken randomly without removing the hull and the average length was recorded in millimeters using rice analyzer and categorized into long, medium and short.

3.1.4.1.51 Grain: Width

Ten grains were taken randomly without removing the hull and average width was recorded in millimeters using rice analyzer and categorized into very narrow, narrow, medium, broad and very broad.

3.1.4.1.52 Decorticated grain: Length

Decorticated grain length was measured using graph sheet and categorized into short, medium, long and extra long.

3.1.4.1.53 Decorticated grain:Width

Decorticated grain width was measured using graph sheet and categorized into narrow, medium and broad.

3.1.4.1.54 Decorticated grain color

The color of the seed coat was recorded visually after hulling characterized into white, light brown, variegated brown, dark brown, light red, variegated purple, purple and dark purple.

3.2 Experiment II: Genetic variability, diversity and character association studies

3.2.1 Observations recorded

Five randomly selected plants from each genotype were labeled for recording the observations. The average observations were recorded on these five plants was considered for statistical analysis. The characters on which observations were recorded are described below.

3.2.1.1 Days to 50 per cent flowering

The number of days was recorded from the date of sowing to the days when the primary panicle in 50 per cent plants was emerged.

3.2.1.2 Days to maturity

The total number of days taken by each genotype from sowing to physiological maturity was observed and measured.

3.2.1.3 Leaf length (cm)

The length of leaf was measured in centimeter.

3.2.1.4 Leaf width (cm)

The width of leaf was measured in centimeter.

3.2.1.4 Plant height (cm)

The height of the plant at maturity from the base of the plant to the tip of panicle excluding awn was measured and recorded in centimeters.

3.2.1.6 Stem: Thickness (cm)

The stem thickness was recorded at the grain development stage. Thickness was measured in centimeter.

3.2.1.7 Total number of tillers per plant

The number of tillers per plant was recorded by counting both the productive and unproductive tillers.

3.2.1.8 Number of productive tillers per plant

The number of productive tillers bearing panicles per plant was recorded by excluding the tillers which do not bear panicles.

3.2.1.9 Panicle length (cm)

Panicle length or main axis was measured in centimeters at the time of plant maturity from the base of panicle to the tip of last spikelet prior to harvesting.

3.2.1.10 L/B ratio

The average of the ratio of the length to the breadth of few randomly selected grains was used for recording grain length and breadth using rice analyzer.

3.2.1.11 Spikelet fertility (%)

The number of filled grains was counted in randomly selected five panicles and averaged to obtain the number of filled grains per panicle. Spikelet fertility per panicle was calculated by dividing the average number of filled grains of five panicles by an average number of spikelets of five panicles and expressed in percentage.

3.2.1.12 Test weight (g)

Weight of one thousand randomly selected filled grains was measured using electronic balance and expressed in grams.

3.2.1.13 Yield per plant (g)

It was recorded by weighing all the grains of the individual plant in gram.

3.3 Statistical analysis

3.3.1 Analysis of Variance (ANOVA)

The data of mean value for all the characters were analyzed for their variance following Randomized Complete Block Design outlined by Cochran and Cox (1975).

Analysis was done using software WINDOSTAT version 9.2 at Department of Genetics and Plant Breeding, UAHS, Shivamogga.

Source of variation	Degrees of freedom	Sum of squares	Mean sum of square	F Ratio
Replication	(r – 1)	SSR	SSR/(r-1)=MSSR	MSSR/MSSE
Genotypes	(t – 1)	SSG	SSG/(t-1)=MSSG	MSSG/MSSE
Error	(r-1) (t-1)	SSE	SSG/(t-1)=MSSG	
Total	(rt-1)	TSS		

Where ,

r = Number of replications

t = Number of genotypes

MSSR = Replication mean sum of square

MSSG = Genotype mean sum of square

MSSE = Error mean sum of square

3.3.1.1 Mean

Mean is the sum of all observations in a sample divided by the number of observations (n).

$$\text{Mean} = \frac{\sum x_i}{n}$$

Where,

x_i = i^{th} observation of a population

n = Number of observations

3.3.1.2 Range

Range is the minimum and maximum values of the observations in a sample of a genotype.

3.3.1.3 Standard error

It is the measure of uncontrolled variation present in a sample which is estimated by dividing the standard deviation (SD) by the square root of number of observations (n) in the sample and is denoted by SE.

$$SE = \frac{SD}{\sqrt{n}}$$

3.3.1.4 Standard error difference between two means

It is calculated with the help of error mean sum of square from ANOVA table.

$$SEd, m = \sqrt{\frac{2MSSE}{r}}$$

Where,

r = number of replications

MSSE = error mean sum of square

3.3.1.5 Critical difference (CD)

It is calculated to judge whether the difference between two particular treatments was significant or not.

$$CD \text{ at 1\% or 5\% probability level} = \sqrt{\frac{2MSSE}{r}} \times t^*$$

t*(value) at 1 per cent probability level (for error probability level)

3.3.1.6 Coefficient of Variation (CV)

It is the ratio of standard deviation of a sample to its mean and expressed in percentage.

$$CV(\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

3.3.2 Estimation of genetic parameters

Phenotypic and genotypic variances were estimated using the formula given by Weber and Murthy (1952).

$$\text{Genotypic variance } (\sigma_g^2) = \frac{MSS(\text{genotypes}) - MSS(\text{error})}{\text{Number of replications}}$$

$$\text{Phenotypic variance } (\sigma_p^2) = \sigma_g^2 + MSS(\text{error})$$

Where,

σ_p^2 = Phenotypic variance

σ_g^2 = Genotypic variance

3.3.3 Coefficient of Variability

Both genotypic and phenotypic coefficients of variability were estimated as per the method suggested by Burton and De vane (1953).

3.3.3.1 Genotypic Coefficient of Variation (GCV)

$$GCV = \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

Where,

$$\sigma_g^2 = \text{Genotypic variance}$$

$$\bar{X} = \text{Mean of the characters}$$

3.3.3.2 Phenotypic Coefficient of Variation (PCV)

$$PCV = \frac{\sqrt{\sigma_p^2}}{\bar{X}} \times 100$$

Where,

$$\sigma_p^2 = \text{Phenotypic variance}$$

$$\bar{X} = \text{Mean of the characters}$$

The GCV and PCV values were classified as described by Sivasubramanian and Menon (1973).

GCV and PCV values	Classification
0-10	Low
10-20	Medium
20 and above	High

3.3.4 Heritability (h^2 in broad sense)

Heritability in broad sense was computed as the ratio of genetic variance to the total phenotypic variance as suggested by Hanson *et al.* (1956) and expressed as percentage.

$$h^2 = \frac{\sigma_g^2}{\sigma_p^2} \times 100$$

Where,

$$\sigma_g^2 = \text{Genotypic variance}$$

$$\sigma_p^2 = \text{Phenotypic variance}$$

Heritability (broad sense) estimates were categorized into high, moderate and low by Robinson *et al.* (1949).

Heritability (%)	Classification
5-10	Low
10-30	Medium
30-60	High
>60	Very high

3.3.5 Genetic advance (GA)

Genetic advance was estimated by using the formula given by Johnson *et al.* (1955).

$$GA = h^2 \times k \times \sigma_p$$

Where,

h^2 = Heritability estimate

σ_p^2 = Phenotypic standard deviation

K = Selection differential at 5 per cent is equal to 2.06 of selection (Lush, 1949)

3.3.5.1 Genetic advance as per cent of mean (GAM)

$$GAM = \frac{GA}{\bar{X}} \times 100$$

Where,

\bar{X} = Grand mean of the trait

GA = Genetic advance

The Genetic Advance as per cent of Mean (GAM) was categorized by Johnson *et al.* (1955).

GAM (%)	Classification
0-10	Low
10-20	Medium
20 and above	High

3.3.6 Correlation coefficient (r)

The correlation coefficient was calculated to determine the degree of association of the characters with yield and also among the different yield components.

Both genotypic and phenotypic coefficients of correlation between all pairs of characters were determined by using variance and covariance components. The analysis was done by using the WINDOSTAT 9.2 software.

$$r_{g(x,y)} = \frac{c_{ov}(x,y)_g}{\sqrt{\sigma_{gx}^2 \sigma_{gy}^2}}$$

$$r_{p(x,y)} = \frac{C_{ov}(x,y)_p}{\sqrt{\sigma_{px}^2 \sigma_{py}^2}}$$

Where,

r_p = Phenotypic correlation

r_g = Genotypic correlation

$C_{ov}(x,y)_g$ and $C_{ov}(x,y)_p$ are phenotypic and genotypic correlation between the characters x and y are the genotypic variances of the characters x and y.

σ_{px}^2 and σ_{py}^2 are the phenotypic variances of the characters x and y.

σ_{gx}^2 and σ_{gy}^2 are the genotypic variances of the characters x and y.

The calculated values of r was compared with 'r' table value with (n-2) degrees of freedom at 5 and 1 per cent level of significance, where n refers to number of pairs of observation.

3.3.7 Path coefficient analysis

Path coefficient analysis was done using the correlation coefficients to ascertain the direct and indirect effects of the yield components on yield as suggested by Wright (1921) and illustrated by Dewey and Lu (1959). The data was analyzed by using WINDOSTAT 9.2 software.

$$P_{01} + P_{02} r_{12} + \dots + P_{0p} r_{1p} = r_{01}$$

$$P_{01} r_{21} + P_{02} r_{22} + \dots + P_{0p} r_{2p} = r_{02}$$

$$P_{0p} r_{1p} + P_{0p} r_{2p} + \dots + P_{0p} = r_{0p}$$

Where,

P_{01}, P_{02}, P_{0p} are the direct path coefficients of variables 1,2,3..... p on the dependent variable 0. $r_{12}, r_{13}, \dots, r_{1p}, \dots, r_{(p-1)}$ are the possible correlation coefficients between various independent variables and $r_{01}, r_{02}, \dots, r_{0p}$ are the correlations between

dependent and independent variables. The indirect effects of the i^{th} variable via j^{th} variable were obtained $p_{0j} \times r^{ij}$.

The contribution of the remaining unknown factors was measured as the residual factor and calculated as,

$$P^2_{0X} = 1 - (P^2_{01} + 2P_{01} + P_{02}r^{12} + 2P_0 P_{03}r_{13} + \dots + P^2_{02} + P_{02} P_{03}r_{13} + \dots + P^2_{0p})$$

$$\text{Residual factor } (R^2) = \sqrt{P^2_{0X}}$$

0.00 - 0.09 : Negligible

0.10 - 0.19 : Low

0.20 - 0.29 : Moderate

0.30 - 0.99 : High

>1.00 : Very high

3.3.8 Genetic diversity

3.3.8.1 Mahalanobis' D^2 analysis

Mahalanobis' (1936) D^2 statistics was used for assessing the genetic divergence between populations. The D^2 analysis was done by using WINDOSTAT 9.2 version software installed at Department of Genetics and Plant Breeding, UAHS, Shivamogga. The generalized distance between any two populations is given by formula,

$$D^2 = \sum \sum \lambda_{ij} \sigma_{ai} \sigma_{aj}$$

Where,

D^2 = Square of generalized distance

λ_{ij} = Reciprocal of the common dispersal matrix

$\sigma_{ai} = (\mu_{i1} - \mu_{i2})$

$\sigma_{aj} = (\mu_{j1} - \mu_{j2})$

μ = General mean

Since, the formula for computation requires inversion of higher order determinant, transformation of the original correlated unstandardized character mean (Xs) to standardized uncorrelated variable (Ys) was done to simplify the computational procedure. The D^2 values were obtained as the corresponding uncorrelated (Ys) values of any two uncorrelated genotypes (Rao, 1952).

3.3.8.2 Clustering of D^2 values

All the $(n-1)/2$ D^2 values were clustered using Tocher method as described by Rao (1952).

Intra cluster distance:

The intra cluster distances were calculated by the formula given by Singh and Chaudhary (1977).

$$\text{Square of intra cluster distance} = \frac{\sum D_i^2}{n}$$

Where,

$\sum D_i^2$ = Sum of distance between all possible combinations of the entries included in a cluster

n = Number of all possible combinations.

Inter cluster distance:

The inter cluster distances were calculated by the formula described by Singh and Chaudhary (1977).

$$\text{Square of inter cluster distance} = \frac{\sum D_{ij}^2}{n_i n_j}$$

Where,

$\sum D_{ij}^2$ = sum of distance between all possible combinations of the $(n_i n_j)$ number of entries included in a cluster.

n_i = number of lines in cluster i.

n_j = number of lines in cluster j.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

The results of the present investigation on morphological characterization, genetic variability and diversity studies for yield in landraces of rice (*Oryza sativa* L.) are presented under the following sub headings.

4.1 Morphological characterization of landraces of rice

4.2 Estimation of genetic variability for yield and yield related traits

4.3 Study of correlation analysis for yield and yield related traits

4.4 Path coefficient analysis among yield and its related characters

4.5 Genetic diversity for yield and yield related traits

4.1 Morphological characterization of landraces of rice

Fifty-one landraces of rice were characterized based on fifty-four morphological characters by following DUS test guidelines given by PPV and FRA, 2001 and the following results were obtained. Diversity in landraces of rice were presented in Plate 1. Frequency distribution, number of landraces of rice and code names of each landraces of rice characterized according to DUS test guidelines is presented in Table 3.

4.1.1 Coleoptiles color

Coleoptile color (1) have been observed in ten days old seedlings of all the landraces of rice (Plate 2). Among 51 landraces of rice studied, 46 (90.19 %) landraces of rice had green coleoptile color (Arjuna, Atire, Bhagyodaya, and Beganbeach) and five (9.80 %) landraces of rice had purple coleoptile color (Shankarakempakki, Seethmog, Kavalakannu, Kuruva and Meesebhatta).

4.1.2 Basal leaf: sheath color

Basal leaf sheath color (2) was recorded as green color in 46 (90.19 %) landraces of rice (Arjuna, Atire, Bhagyodaya, Bharna, Bilinellu and Beganbeach), uniform purple color in two (3.92 %) landraces of rice (Kanankachudi and Meesebhatta), purple lines in two (3.92 %) landraces of rice (Kavalakannu and Kuruva) and light purple color in only one (1.96 %) rice landrace (Seethmog).

Table.3. Frequency distribution, number of landraces of rice and code names of each landraces of rice characterized according to DUS test guidelines

Sl.No	Characters	Status	No. of Genotypes	Frequency (%)	Genotype
1	Coleoptile: Color	Green	46	90.19	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51
2	Basal leaf: Sheath color	Purple	5	9.80	BMRG-14, 26, 31, 37 and 49
		Green	46	90.19	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
3		Light purple	1	1.96	BMRG-14
		Purple lines	2	3.92	BMRG-26 and 31
		Uniform purple	2	3.92	BMRG-23 and 37
		Light	14	27.45	BMRG-6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 18, 19, 21, 29 and 38
		Medium	16	31.37	BMRG-5, 22, 23, 26, 31, 36, 36, 37, 40, 41, 43, 45, 47, 48, 49 and 51
4	Leaf: Intensity of green color	Dark	21	41.17	BMRG-1, 2, 3, 4, 15, 17, 20, 24, 25, 27, 28, 30, 32, 33, 34, 35, 39, 42, 44, 46 and 50
		Absent	43	84.37	BMRG-1, 2, 3, 4, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
5	Leaf: Distribution of anthocynin coloration	Present	8	15.66	BMRG-5, 7, 14, 21, 23, 26, 31 and 37
		On tips only	3	5.88	BMRG-5, 7 and 31
6	Leaf sheath: Anthocynin coloration	On margins only	5	9.80	BMRG-14, 21, 24, 26 and 37
		Present	7	13.72	BMRG-14, 21, 23, 26, 31, 37 and 49
		Absent	44	86.27	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50 and 51



Halinga



Nattijaddu



Peetasale



Chare



Kalama



Meesebhatta



Kavalakannu



Chicksale



Beganbeach



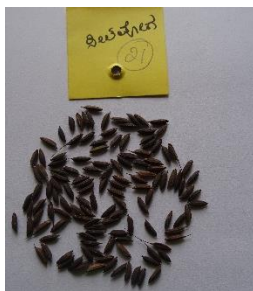
Somasale



Bharna



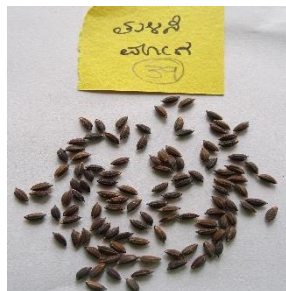
Giddabasmati



Seethmog



Lalneth



Tulasimog

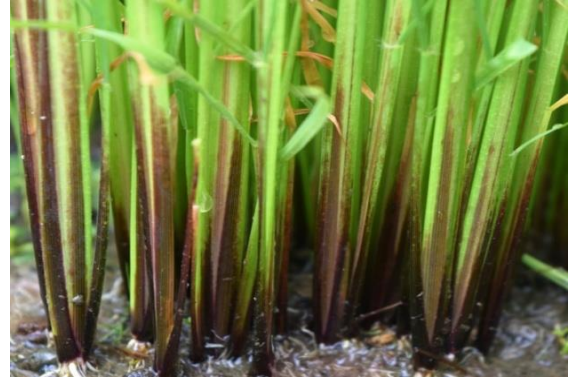


Ratan

Plate 1: Diversity in landraces of rice



Green (Atire)



Purple (Shankarakempaki)

Plate 2: Character No 01: Variation in coleoptiles color



Light (Bharma)



Medium (Juli)



Dark (Irga)

Plate 3: Character No 03: Intensity of green color of leaf

Contd.

7	Leaf sheath: Intensity of anthocyanin coloration	Weak	34	66.66	BMRG-2, 3, 5, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 49, 50 and 51
		Medium	3	5.88	BMRG-14, 26 and 31
		Very strong	1	1.96	BMRG-37
8	Leaf: Pubescence of blade surface	Weak	25	49.01	BMRG-1, 2, 3, 4, 5, 6, 7, 12, 16, 20, 21, 23, 24, 28, 34, 35, 36, 38, 39, 42, 45, 46, 47, 48, 49, 50 and 51
		Medium	18	35.29	BMRG-8, 9, 10, 11, 14, 15, 17, 18, 19, 22, 25, 26, 27, 29, 30, 31, 32 and 33
		Strong	6	11.76	BMRG-37, 40, 41, 42, 43 and 44
		Very strong	2	3.92	BMRG -13 and 45
9	Leaf: Auricles	Present	48	94.11	BMRG-1, 2, 3, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 49, 50 and 51
		Absent	3	5.88	BMRG-4,6 and 7
10	Leaf: Anthocyanin coloration of auricles	Colorless	48	94.11	BMRG-1, 2, 3, 5, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 49, 50 and 51
		Purple	3	5.88	BMRG- 23,31 and 49
11	Leaf: Collar	Present	51	100	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
12	Leaf: Anthocyanin coloration of collar	Absent	45	88.23	BMRG-1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
		Present	6	11.76	BMRG-5, 14, 26, 27, 31 and 37
13	Leaf:legule	Present	51	100	BMRG1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51

14	Leaf: Shape of ligule	Split	51	100	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
15	Leaf: color of ligule	White	48	94.11	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
		Light purple	2	3.92	BMRG-14 and 37
		Purple	1	1.96	BMRG-31
16	Leaf: Length of blade	Short (<30cm)	19	37.25	BMRG-1, 2, 3, 4, 5, 7, 8, 12, 13, 17, 19, 20, 21, 22, 24, 33, 34, 50 and 51
		Medium (30-45cm)	30	58.82	BMRG-6, 9, 10, 11, 14, 15, 16, 18, 23, 25, 26, 27, 28, 29, 30, 31, 32, 35, 36, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48 and 49
		Long (>45cm)	2	3.92	BMRG-37 and 38
17	Leaf: width of blade	Narrow (<1cm)	33	64.70	BMRG-6, 7, 8, 9, 10, 12, 14, 16, 17, 18, 19, 20, 21, 22, 23, 24, 28, 29, 30, 31, 32, 34, 35, 36, 37, 38, 41, 42, 47, 48, 49, 50 and 51
		Medium (1-2cm)	12	23.52	BMRG-11, 13, 15, 25, 26, 27, 33, 39, 40, 43, 45 and 46
		Broad (<2cm)	6	11.76	BMRG-1, 2, 3, 4, 5 and 44
18	Culm: attitude	Erect	15	29.41	BMRG-1, 2, 3, 5, 7, 12, 13, 16, 20, 21, 24, 42, 45, 50 and 51
		Semi-erect	19	37.25	BMRG-4, 6, 8, 9, 10, 11, 14, 15, 17, 19, 22, 27, 33, 35, 37, 39, 43, 44 and 46,
		Open	14	27.45	BMRG-18, 23, 25, 26, 30, 31, 32, 34, 36, 40, 41, 47, 48 and 49
		Spreading	3	5.88	BMRG-28, 29 and 38
19	Time of heading (50 per cent of plants with panicles)	very early(>71 days)	11	21.56	BMRG-15, 22, 24, 26, 27, 30, 31, 32, 36, 42 and 49
		early(71-90 days)	4	7.84	BMRG-2, 9, 19 and 47
		medium(91-110 days)	9	17.64	BMRG-5, 10, 13, 18, 23, 33, 35, 46 and 48
		late(111-130 days)	11	21.56	BMRG-4, 11, 14, 17, 34, 38, 39, 43, 44, 45 and 51
		very late(>131 days)	16	31.37	BMRG-1, 3, 6, 7, 8, 12, 16, 20, 21, 25, 28, 29, 37, 40, 41 and 50

Contd....

20	Flag leaf: Attitude of blade (early observation)	Erect	36	70.58	BMRG-1, 3, 4, 5, 7, 8, 9, 10, 12, 13, 14, 16, 18, 19, 20, 21, 22, 25, 28, 29, 31, 32, 33, 34, 37, 38, 39, 40, 41, 42, 43, 45, 46, 49, 50 and 51
		semi-erect	11	21.56	BMRG-2, 6, 15, 23, 26, 27, 30, 35, 44, 47 and 48
		Horizontal	3	5.88	BMRG-11, 24 and 36
		Drooping	1	1.96	BMRG-17
21	Spikelet: Density of pubescence of lemma	Weak	18	35.29	BMRG-2, 6, 7, 9, 11, 16, 25, 26, 27, 29, 34, 38, 42, 46, 47, 48, 50 and 51
		Medium	17	33.33	BMRG-1, 3, 4, 5, 8, 10, 13, 17, 19, 24, 32, 33, 36, 37, 41, 43 and 49
		Strong	10	19.60	BMRG-20, 21, 22, 23, 28, 30, 39, 40, 44 and 45
		Very strong	6	11.76	BMRG-12, 14, 15, 18, 31 and 35
22	Male sterility	Absent	51	100	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
23	Lemma: Anthocyanin coloration of keel	Absent or very weak	37	72.54	BMRG-1, 3, 6, 7, 8, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 24, 25, 27, 28, 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 45, 46, 47, 48, 50 and 51
		Weak	1	1.96	BMRG-5
		Medium	4	7.84	BMRG-4, 9, 23, and 44
		Strong	6	11.76	BMRG-2, 22, 26, 37, 43 and 49
		Very strong	3	5.88	BMRG-14, 21 and 29
24	Lemma: Anthocyanin coloration of below Apex	Absent	36	70.58	BMRG-1, 3, 4, 6, 7, 8, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 27, 28, 31, 32, 33, 34, 36, 38, 39, 41, 42, 43, 45, 46, 47, 48, 50 and 51
		Weak	1	1.96	BMRG-35
		Medium	4	7.84	BMRG-21, 26, 30, and 44
		Strong	5	9.80	BMRG-2, 5, 10, 22 and 40
		Very strong	5	9.80	BMRG-9, 14, 29, 37 and 49
25	Lemma: Anthocyanin coloration of apex	Absent	35	68.62	BMRG-1, 3, 4, 6, 8, 11, 12, 13, 15, 16, 17, 18, 19, 20, 24, 25, 31, 32, 33, 34, 35, 36, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 50 and 51
		Strong	4	7.84	BMRG-2, 7, 9 and 22
		Very strong	12	23.52	BMRG-5, 10, 14, 21, 23, 26, 27, 28, 29, 30, 37 and 49

26	Spikelet: Color of stigma	White	29	56.86	BMRG-1, 4, 6, 7, 8, 13, 15, 16, 20, 21, 22, 26, 29, 30, 32, 33, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 48, 50 and 51
		Yellow	5	9.80	BMRG-9, 11, 19, 24 and 47
		Light purple	6	11.76	BMRG-12, 17, 18, 25, 34 and 35
		Purple	11	21.56	BMRG-2, 3, 5, 10, 14, 23, 27, 28, 31, 36 and 49
27	Stem:thickness	Thin (<0.40cm)	12	23.52	BMRG-16, 32, 34, 35, 36, 37, 40, 41, 43, 44, 45 and 49
		Medium (0.40-0.55cm)	15	29.41	BMRG-2, 3, 4, 6, 7, 8, 14, 15, 17, 22, 23, 24, 30, 31 and 51
		Thick (>0.55cm)	24	47.05	BMRG-1, 5, 9, 10, 11, 12, 13, 18, 19, 20, 21, 25, 26, 27, 28, 29, 33, 38, 39, 42, 46, 47, 48 and 50
28	Stem:length	Very short(>91cm)	22	43.13	BMRG-1, 3, 6, 8, 11, 13, 16, 19, 30, 32, 33, 34, 36, 39, 42, 44, 46, 47, 48, 49, 50 and 51
		Short (91-110cm)	18	35.29	BMRG-2, 4, 10, 15, 17, 18, 20, 21, 23, 24, 26, 28, 29, 31, 40, 41, 43 and 45
		Medium (111-130cm)	7	13.72	BMRG-9, 14, 22, 25, 27, 35 and 37
		long(131-150cm)	4	7.84	BMRG-5, 7, 12 and 38
29	Stem: Anthocynin	Absent	47	92.15	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
		Present	4	7.84	BMRG-14, 21, 28 and 31
30	Stem: intensity of anthocynin coloration of nodes	Weak	47	92.15	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
		Medium	1	1.96	BMRG-28
		Strong	3	5.88	BMRG-14, 21 and 31
31	Stem: anthocynin coloration of internodes	Absent	44	86.27	BMRG-1, 2, 3, 4, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 26, 29, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
		Present	7	13.72	BMRG-5, 6, 21, 25, 27, 28 and 31
32	Panicle:length of main axis	Very short(<16cm)	1	1.96	BMRG-16
		Short (16-20cm)	12	23.52	BMRG-1, 3, 5, 7, 10, 25, 33, 34, 35, 42, 44, 46 and 50
		Medium (21-25cm)	22	43.13	BMRG-2, 4, 8, 9, 11, 13, 17, 18, 19, 22, 26, 30, 31, 32, 36, 38, 39, 40, 43, 45, and 51
		Long (26-30cm)	15	29.41	BMRG-6, 12, 14, 15, 20, 21, 23, 24, 27, 28, 29, 37, 41, 47 and 48
		Very long(>30cm)	1	1.96	BMRG-49

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33	Flag leaf:Attitude of blade (late observation)	Semi-erect	36	70.58	BMRG-1,2,3,4,5,6,9,10,12,13,14,15,17,18,19,22,23,24,25,26,27,28,35,37,40, 41,42,43,44,46,47,48, 50 and 51
		Horizontal	11	21.56	BMRG-7,8,11,16,20,21,24,29,36,37 and 38
		Deflexed	4	7.84	BMRG-17, 39,45 and 49
34	Panicle: Curvature of main axis	Semi-straight	33	64.70	BMRG-1,3,5,6,9,10,11,12,13,14,15,17,18,19,22,23,24,25,27,28, 29,30,33,35,37,40,41,42,43,44,46,47,48 and 51
		Deflexed	3	5.88	BMRG-4,16 and 21
		Drooping	15	29.41	BMRG-2,7,8,16,20,26,31,32,34,36,38,39,45,49 and 50
35	Panicle: Number per plant	Few(<11)	8	15.68	BMRG-9,10,16,18,21,25,29 and 30
		Medium(11-20)	41	80.39	BMRG-1,2,3,4,5,6,7,8,11,12,13,14,15,17,19,20,22,23,24,26,27, 28,31,32,33,35,36,37,38,39, 40,41,42,43,45,46,47,48,49, 50 and 51
		Many(>20)	2	3.92	BMRG-34 and 44
36	Spikelet: Color of tip of lemma	Yellowish	5	9.80	BMRG-15,20, 32,36 and 41
		Red	3	5.88	BMRG-10, 23, 35
		Purple	11	21.56	BMRG-2,5, 7,21, 22, 26,27, 28, 30,40 and 49
		Black	4	7.84	BMRG-9,14, 29 and 37
37	Lemma and palea: Color	Straw	35	68.62	BMRG-1, 2, 3, 6,7, 8,10,11,12,13,15,16,17,18,19,20, 24,25, 27,28, 31, 32,33,34,35, 38,39,41,42,44,45,46,47,48,50 and 51
		Gold and gold furrows on straw background	6	11.76	BMRG-4, 21,22, 40, 43 and 49
		Brown furrows on straw	7	13.72	BMRG-9, 23, 26, 30, 36,37and 43
		Brown reddish to light purple	1	1.96	BMRG-5
		Black	2	3.92	BMRG-14 and 29
38	Panicle: Awns	Absent	42	82.35	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30, 31, 33, 34, 35, 36, 38, 39, 43, 45, 46, 47,48, 49, 50 and 51
		Present	9	17.64	BMRG-14, 15,23,32,37, 40, 41, 42 and 44
39	Panicle: Color of awns (late observation)	Yellowish white	6	11.76	BMRG-15, 32, 40,41, 42, and 44
		Light purple	1	1.96	BMRG-23
		Purple	2	3.92	BMRG-14, 37

40	Panicle: Length of longest awn	Very short Short Medium Very long Tips only Whole length Present	1 2 1 4 8 1 51	1.96 3.92 1.96 7.84 15.68 1.96 100	BMRG-32 BMRG-14 and 42 BMRG-41 BMRG-23,37,15 and 40 BMRG-13,23,32,37,40,41,42 and 44 BMRG-15 BMRG-1,2,3,4,5,6,7,8,11,12,13,14,15,17,19,20,22,23,24,26,27,28,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50 and 51 BMRG-1,2,3,4,6,8,9,10,11,16,17,18,19,22,23,28,30,31,32,33,34,35,36,38,41,42,44,46,49 and 50 BMRG-5,7,14,20,21,25,27,29,37,39,40,45,48 and 51 BMRG-12,13,15,24,26,43 and 47 BMRG-1,2,7,8,9,19,20,21,22,24,33,36,42,49 and 50 BMRG-3,5,13,26 and 28 BMRG-6,10,14,30,31,34,43,44,45,46 and 47 BMRG-4,11,15,27,29,32,37,38,39,40,48 and 51
41	Panicle: Distribution of awns	Weak	30	58.82	BMRG-12,16,17,18,23,25,35 and 41 BMRG-1,2,4,6,7,12,13,28,31,32,34,38,39,47,48,50 and 51 BMRG-19,25,29,33,35,36,37,40,41,44,45 and 46 BMRG-3,5,8,9,10,11,14,15,16,17,18,20,21,22,23,24,26,27,30,42,43 and 49
42	Panicle: Presence of secondary branching	Strong	14	27.45	BMRG-23,26,27,32 and 42 BMRG-9,15,19,30 and 31 BMRG-2,5,17,18,20,33,34,46,48 and 49
43	Panicle: Secondary branching	Clustered	7	13.72	BMRG-4,10,11,12,13,14,21,22,24,35,36,38,39,43,44,45,47,50 and 51 BMRG-1,3,6,7,8,16,25,28,29,37,40 and 41 BMRG-19,26,27,30,31,42,49 and 51 BMRG-1,2,9,10,18,21,35,44 and 46 BMRG-3,4,5,6,7,8,11,12,13,14,15,16,17,20,22,23,24,25,28,29,32,33,34,35,36,37,38,39,40,41,43,45,47,48 and 50
44	Panicle: Attitude of branches	Erect Erect to semi-erect Semi-erect Semi-erect to spreading Spreading Partly exerted Mostly exerted Well exerted	15 5 11 12 8 17 12 22	29.41 9.80 21.56 23.52 15.86 33.33 23.52 43.13	BMRG-12,16,17,18,23,25,35 and 41 BMRG-1,2,4,6,7,12,13,28,31,32,34,38,39,47,48,50 and 51 BMRG-19,25,29,33,35,36,37,40,41,44,45 and 46 BMRG-3,5,8,9,10,11,14,15,16,17,18,20,21,22,23,24,26,27,30,42,43 and 49
45	Panicle: Exertion	Very early(<100) Early(101-120) Medium(121-140) Late(141-160) Very late(>160)	5 5 10 19 12	9.80 9.80 19.60 37.25 23.52	BMRG-23,26,27,32 and 42 BMRG-9,15,19,30 and 31 BMRG-2,5,17,18,20,33,34,46,48 and 49 BMRG-4,10,11,12,13,14,21,22,24,35,36,38,39,43,44,45,47,50 and 51 BMRG-1,3,6,7,8,16,25,28,29,37,40 and 41 BMRG-19,26,27,30,31,42,49 and 51 BMRG-1,2,9,10,18,21,35,44 and 46 BMRG-3,4,5,6,7,8,11,12,13,14,15,16,17,20,22,23,24,25,28,29,32,33,34,35,36,37,38,39,40,41,43,45,47,48 and 50
46	Time of maturity(days)	Early Medium Late	8 9 34	17.64 66.66	
47	Leaf: Senescence				

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48	Sterile lemma: Color	Straw	47	92.15	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 23, 24, 25, 27, 26, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50 and 51
49	Grain: Weight of 1,000 fully developed grains	Gold	2	3.92	BMRG-10 and 22
		Purple	2	3.92	BMRG-14 and 29
		Very low(>15g)	4	7.84	BMRG-1, 3, 4 and 34
		Low(15-20g)	5	9.80	BMRG-15, 16, 17, 22 and 27
		Medium(21-25g)	21	41.17	BMRG-7, 8, 10, 13, 14, 21, 23, 25, 26, 30, 31, 37, 41, 42, 43, 44, 46, 47, 49, 50 and 51
50	Grain: Length	High(26-30g)	7	13.72	BMRG-5, 6, 11, 19, 23, 39 and 40
		Very high(>30g)	14	27.45	BMRG-2, 9, 12, 18, 20, 24, 28, 29, 33, 35, 36, 38, 45 and 48
		Short (6.1-8.5mm)	39	76.47	BMRG-1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 37, 40, 43, 44, 46, 49, 50 and 51
		Medium(8.6-10.5mm)	12	23.52	BMRG-2, 13, 19, 35, 36, 38, 39, 41, 42, 45, 47 and 48
51	Grain: Width	Very narrow(>2mm)	2	3.92	BMRG-9 and 24
		Narrow(2.1-2.5mm)	12	23.52	BMRG-1, 2, 4, 10, 13, 28, 36, 42, 43, 46, 50 and 51
		Medium(2.6-3mm)	26	50.98	BMRG-3, 6, 7, 12, 14, 15, 18, 19, 20, 21, 22, 23, 25, 26, 27, 30, 31, 33, 34, 39, 40, 41, 44, 47, 48 and 49
		Broad(3.1-3.5mm)	11	21.56	BMRG-5, 8, 11, 16, 17, 29, 32, 35, 37, 38 and 45
52	Decorticated grain:Length	Short	22	43.13	BMRG-1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 21, 22, 24, 25, 27, 32, 33, 34, 35, 36, 37 and 50
		Medium	13	25.49	BMRG-17, 28, 29, 30, 31, 39, 40, 43, 44, 45, 46, 49 and 51
		Long	3	5.88	BMRG-7, 13 and 20
		Extra long	6	11.76	BMRG-19, 23, 38, 42, 47 and 48
53	Decorticated grain:Width	Narrow	9	17.64	BMRG-7, 20, 28, 29, 30, 31, 39, 40 and 43
		Medium(2.0-2.5mm)	13	25.49	BMRG-17, 32, 33, 34, 35, 36, 37, 44, 45, 46, 49, 50 and 51
		Broad(>2.5mm)	29	56.86	BMRG-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 21, 22, 23, 24, 25, 26, 27, 38, 41, 42, 47 and 48
54	Decorticated grain:Color	White	40	78.43	BMRG-1, 3, 4, 5, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 24, 25, 26, 33, 34, 35, 37, 38, 39, 41, 40, 42, 43, 44, 45, 46, 47, 48, 50 and 51
		Light brown	7	13.72	BMRG-9, 23, 28, 29, 30, 32, and 36
		Variogated brown	2	3.92	BMRG-2 and 27
		Dark purple	1	1.96	BMRG- 31
		Dark brown	1	1.96	BMRG-49

4.1.3 Leaf: Intensity of green color

Intensity of green color (3) in leaves was recorded (Plate 3) as light green color in 14 (27.45%) landraces of rice (Bharma, Bilinellu, Chare, Chicksale and Pingara), medium green color in 16 (31.37%) landraces of rice (Juli, Beganbeach, Kalame, Kanakachudi and Kavalakannu) and dark green color in 21 (41.17%) landraces of rice (Irga, Anekombinabhata, Arjuna, Atire, Bhagyodaya and Juli).

4.1.4 Leaf: Anthocynin coloration

Anthocynin coloration on leaves (4) was recorded as (Plate 4) absent in 43 (84.37 %) landraces of rice (Anekombinabhata, Arjuna, Atire, Bhagyodaya, Pingara and Ratan) and present in eight (15.66%) landraces of rice (Beganbeach, Bilinellu, Seethmog, Juli, Kanakachudi, Kavalakannu, Kuruva and Meesebhata).

4.1.5 Leaf: Distribution of anthocynin coloration

Distribution of anthocynin coloration of on leaves (5) was recorded only on tips in three (5.88 %) landraces of rice (Beganbeach, Bilinellu, and Kuruva) and on margins in five (9.80%) landraces of rice (Seethmog, Juli, Somasale, Kavalakannu and Meesebhata).

4.1.6 Leaf sheath: Anthocynin coloration

Anthocynin coloration on leaf sheath (6) was (Plate 5) present in six (11.76%) landraces of rice (Shankarakempakki, Seethmog, Juli, Kanakachudi, Kavalakannu, Kuruva and Meesebhata) and absent in 45 (88.23%) landraces of rice (Arjuna, Atire, Beganbeach, Malabar, Maskat, Parlan, Dasarapatti and Shankarakempakki).

4.1.7 Leaf sheath: Intensity of anthocynin coloration

Intensity of anthocynin color (7) was weak in 34 (66.66%) landraces of rice (Nattijaddu, Neerambade, Peetasale, Meterbhata and Andanoorsanna), medium in three (5.88%) and very strong in only one (1.96%) rice landrace (Meesebhata).

4.1.8 Leaf: Pubescence of blade surface

Pubescence on leaf blade surface (8) was recorded as weak in 25 (49.01%) landraces of rice (Giddabhata, Irga, Juli, Kanakachudi and Kempurajesh), medium in 18 (35.29%) landraces of rice (Kayame, Kempurajesh, Kuruva and Lalneth), strong in six (11.76%) landraces of rice (Meesebhata, Nattijaddu, Neerambade, Peetasale and Meterbhata) and very strong in only two (3.92%) landraces of rice (Ratan and Andanoorsanna)



Absent (Ratan)



Present (Kavalakannu)

Plate 4: Character No 04: Anthocyanin coloration of leaves



Absent (Maskat)



Present (Shankarakempaki)

Plate 5 : Character No 06 : Leaf sheath anthocyanin



Absent (Bhagyodaya)



Present (Kanakachudi)

Plate 6 : Character No10 : Anthocyanin coloration of auricle

4.1.9 Leaf :auricles

Auricles of leaves (9) were present in 48 (94.11%) landraces of rice (Giddabhatta, Irga, Juli, Kanakachudi and Kempurajesh) and absent in only three (5.88 %) landraces of rice (Bhagyodaya, Bharma and Bilinellu).

4.1.10 Leaf: Anthocynin coloration of auricles

Anthocynin coloration of auricles (10) was recorded (Plate 6) as colorless in 48 (94.11%) landraces of rice (Atire, Bhagyodaya, Beganbeach, Kavadadi, Kayame, Tulasimog, Lalneth, Malabar and Maskat) and purple color in three (5.88%) landraces of rice (Kanakachudi, Kuruva and Shankarakempakki).

4.1.11 Leaf: Collar

Leaf collar (11) was present in all 51 (100%) landraces of rice (Anekombinabhata, Atire, Bhagyodaya, Chicksale, Pingara, Juli and Kalame).

4.1.12 Leaf: Anthocynin coloration of the collar

Anthocynin coloration of collar (12) was absent in 45 (88.23 %) landraces of rice (Bhagyodaya, Chicksale, Pingara) and present in six (11.74%) landraces of rice (Beganbeach, Seethmog, Kavalakannu, Kayame, Kuruva and Meesebhata).

4.1.13 Leaf: Ligule

All the 51 (100%) landraces of rice (Chicksale, Pingara, Kayame and Kuruva) had leaf ligule (13).

4.1.14 Leaf: Shape of ligule

Shape of the leaf ligule (14) is split shape present in all the 51 landraces of rice (Atire, Bhagyodaya, Kavalakannu and Kuruva).

4.1.15 Leaf: Color of ligule

The color of the ligule (15) was white in 48 (94.11%) landraces of rice (Neerambade, Peetasale, Meterbhata, Andanoorsanna, Parlan and Shankarakempakki), light purple in two (3.92%) landraces of rice (Seethmog and Meesebhata) and purple in only one (1.96%) rice landrace (Kuruva).

4.1.16 Leaf: Length of the blade (cm)

Length of leaf blade (16) was recorded as short in 19 (37.25%) landraces of rice (Gulvadisanna, Intaan and Irga), medium in 30 (58.82%) landraces of rice

(Kavadari, Kavalakannu and Kayame) and long in only two (3.92%) landraces of rice (Meesebhatta and Mysoresanna).

4.1.17 Leaf: Width of the blade (cm)

Width of leaf (17) was narrow in 33 (64.70%) landraces of rice (Malabar, Maskat and Mysoresanna), medium in 12 (23.52%) landraces of rice (Naddantarasale, Nattijaddu and Peetasale) and broad in six (11.76%) landraces of rice (Atire, Bhagyodaya and Meterbhatta).

4.1.18 Culm: Attitude

Culm attitude (18) was recorded and 15 (29.41%) landraces of rice showed erect (Beganbeach, Bilinellu Somasale and Andanoorsanna), 19 (37.25%) landraces of rice were semi-erect (Bhagyodaya, Bharma, Chare, Kalame, Kayame and Malabar), 14 (27.45%) landraces of rice were open (Kuruva, Lalneth, Maskat, Nattijaddu and Neerambade) and three (5.88%) landraces of rice were having spreading culm attitude (Kempurajesh, Tulasimog and Halinga).

4.1.19 Time of heading (50 per cent plants with panicle)

Time of heading (19) was recorded as very early in 11 (21.56%) landraces of rice (Seethmog, Kalame and Somasale), early in four (7.84%) landraces of rice (Arjuna, Intaan and Dasarapatti), medium in nine (17.64 %) landraces of rice (Chicksale, Ratan and Halaga), late in 11 (21.56%) landraces of rice (Peetasale, Meterbhatta and Andanoorsanna) and very late in 16 (31.37%) landraces of rice (Meesebhatta, Nattijaddu and Neerambade).

4.1.20 Flag leaf: Attitude of blade (early observation)

Early observation of flag leaf attitude of blade (20) was recorded and categorized into erect in 36 (70.58%) landraces of rice (Anekombinabhatta, Atire and Bhagyodaya), semi-erect in 11 (21.56%) landraces of rice (Bharma, Giddabasumati and Kanakachudi), horizontal in three (5.88%) landraces of rice (Pingara, Somasale and Maskat) and drooping in only one (1.96%) rice landrace (Gulvadisanna).

4.1.21 Spikelet :Density of pubescence of lemma

Density of pubescence of lemma (21) was weak in 18 (35.29 %) landraces of rice (Arjuna, Bharma, Bilinellu, Giddabhatta and Kavadari), medium in 17 (33.33 %) landraces of rice (Anekombinabhatta, Gulvadisanna, Intaan and Somasale), strong in ten (19.60 %) landraces of rice (Irga, Juli, Kalame, Kanakachudi and Kempurajesh) and very strong in six (11.76 %) landraces of rice (IR-8, Seethmog, Giddabasumati, Halaga, Kuruva, Malabar, Nattijaddu and Peetasale).

4.1.22 Male sterility

All the 51 (100%) landraces of rice (Atire, Kavalakannu and Beganbeach) showed absence of male sterility (22).

4.1.23 Lemma : Anthocynin coloration of keel

During anthesis stage lemma characters were observed, anthocynin coloration of keel (23) was very strong in three (5.88 %) landraces of rice (Seethmog, Juli and Tulasimog), strong in six (11.76 %) landraces of rice (Arjuna, Bhagyodaya, Kalame, and Meesebhatta), medium in four (7.84 %) landraces of rice (Chare, Kanachudi and Kavalakannu), weak in only one (1.96 %) rice landrace (Beganbeach) and absent in 37 (72.54 %) landraces of rice (Anekombinabhatta, Atire, Bharma and Bilinellu).

4.1.24 Lemma: Anthocynin coloration of the area below the apex

Similarly anthocynin coloration of below apex (24) was recorded (Plate 7) as very strong in three (5.88%) landraces of rice (Seethmog, Tulasimog, and Shankarakempakki), strong in four (7.84 %) landraces of rice (Arjuna, Kavalakannu and Meesebhatta), medium in five (9.80 %) landraces of rice (Chare, Kanakachudi and Meterbhatta), weak in only one (1.96%) rice landrace (Beganbeach) and absent in 38 (74.50 %) landraces of rice (Gulvadisanna, Mysoresanna, Naddantarasale and Neerambade).

4.1.25 Lemma: Anthocynin coloration of apex

Anthocynin coloration of apex (25) was recorded as very strong in 12 (23.52 %) landraces of rice (Beganbeach, Chicksale, Seethmog and Tulasimog), strong in only four (7.84 %) landraces of rice (Arjuna, Bilinellu, and Kalame) and absent in 37 (72.54%) landraces of rice (Anekombinabhatta, Bhagyodaya, IR-8 and Ratan).

4.1.26 Spikelet: Color of stigma

Color of stigma (26) was white in 29 (56.86 %) rice landraces (Lalneth, Meesebhatta, Mysoresanna, Naddantarasale and Peetasale), yellow in five (9.80%) landraces of rice (Chare, Pingara, Intaan, Somasale and Dasarapatti), light purple in six (11.76%) landraces of rice (IR-8, Halaga, Intaan and Kavadari) and purple in eleven (21.56 %) landraces of rice (Arjuna, Atire, Beganbeach and Chicksale).

4.1.27 Stem: Thickness (cm)

Thickness of stem (27) recorded as thin in 12 (23.52%) landraces of rice (Malabar, Maskat and Neerambade), medium in 15 (29.41%) landraces of rice (Somasale, Meesebhatta and Nattijaddu) and thick in 24 (47.05%) landraces of rice (Anekombinabhatta, Beganbeach, Chare, Chicksale and Pingara).

4.1.28 Stem: Length (cm)

Stem length (28) was also recorded (Plate 8) as very short in 22 (43.13%) landraces of rice (Bharma, Pingara and Ratan), short in 18 (35.29 %) landraces of rice (Arjuna, Bhagyodaya and Chicksale), medium in seven (13.72 %) landraces of rice (Chare, Kalame, Seethmog and Kavadari) and long in four (7.84%) landraces of rice (Beganbeach, Bilinellu and Mysoresanna).

4.1.29 Stem: Anthocynin coloration of nodes

Stem characters were noted down during milk development stage. Anthocynin coloration of nodes (29) was recorded as absent in 47 (92.15%) landraces of rice (Atire, Arjuna, Bhagyodaya, Beganbeach, Bharma and Bilinellu) and present in four (7.84%) landraces of rice (Seethmog, Juli, Kempurajesh and Kuruva).

4.1.30 Stem: Intensity of anthocynin coloration of nodes

Intensity of anthocynin coloration of nodes (30) was recorded as weak in 47 (92.15%) landraces of rice (Lalneth, Malabar, Meesebhatta, Myosresanna and Naddantarasale), medium in only one (1.96%) landraces of rice (Kempurajesh) and strong in three (5.88%) landraces of rice (Seethmog, Juli and Kuruva).

4.1.31 Stem: Anthocynin coloration of internodes

Anthocynin coloration of internodes (31) was recorded as absent in 44 (86.27%) landraces of rice (Seethmog, Giddabasumati, Gulvadisanna, Halaga and Intaan) and present in seven (13.72%) landraces of rice (Beganbeach, Bharma, Juli and Kavadari).

4.1.32 Panicle: Length of main axis (cm)

The panicle length of main axis (32) was recorded in (Plate 9) as very long in only one (1.96%) landraces of rice (Shankarakempakki), long in 15 (29.41%) landraces of rice (Bharma, Seethmog and Irga), medium in 22 (43.13%) landraces of rice (Pingara, Gulvadisanna, Halaga and Intaan), short in 12 (23.52%) landraces of rice (Kavadari, Kuruva, Beganbeach and Lalneth) and very short in only one (1.96%) rice landrace (Giddabhatta).

4.1.33 Flag leaf: Attitude of blade (late observation)

The late observation of flag leaf attitude (33) was (Plate 10) recorded as semi-erect in 36 (70.58%) landraces of rice (Anekombinabhata, Arjuna, Atire, Beganbeach and Bharma.), horizontal in 11 (21.56%) landraces of rice (Maskat, Bilinellu, Pingara, Giddabhata, Irga and Juli) and deflexed in four (7.84%) landraces of rice (Gulvadisanna, Naddantarasale nad Andanoorsanna).



Strong (Kavalakannu)



Absent (Somasale)



Very strong anthocyanin coloration of apex (tulasimog)

Plate7: Character No 24 : Anthocynin coloration of area below apex

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Plate 8 : Character No 28: Stem length



Very short (Giddabhatta) Short (Beganbeach) Medium (Pingara) Long (seethmog)

Plate 9: Character No 32 : Panicle length of main axis



Semi-erect (Arjuna) Horizontal (Maskat) Deflexed (Gulvadisanna)

Plate 10 : Character No 33 : Flag leaf attitude of blade (late observation)

4.1.34 Panicle : Curvature of main axis

Panicle characters were observed during ripening stage and noted as curvature of panicle axis (34) was semi-straight in 33 (64.70%) landraces of rice (Anekombinabhata, Atire and Beganbeach), deflexed in three (5.88%) landraces of rice (Bhagyodaya, Giddabhata and Juli), drooping in 15 (29.41%) landraces of rice (Giddabhata, Irga, Kavalakannu and Kuruva).

4.1.35 Panicle: Number per plant

Number of panicles per plant (35) was recorded as few in eight (15.68%) landraces of rice (Juli, Kavadari and Tulasimog), medium in 41 (80.39%) landraces (Malabar, Maskat and Meesebhata), many in two (3.92%) landraces of rice (BMRG-MS-1-2-1 and Meterbhata).

4.1.36 Spikelet: Color of tip of lemma

Color of tip of lemma (36) was recorded as yellowish, red, purple and black in five (9.80 %) landraces of rice (Lalneth, Maskat and Neerambade), three (5.88 %) landraces of rice (Chicksale and Kanachudi), 11 (21.56 %) landraces of rice (Kempurajesh, Nattijaddu and Shankarakempakki) and four (7.84 %) landraces of rice (Chare, Seethmog, and Tulasimog) respectively.

4.1.37 Lemma and palea: Color

The lemma and palea color (37) was also recorded (Plate 11) as straw in 35 (68.62 %) landraces of rice (Lalneth, Atire, Halaga and Intaan), gold and gold furrows on straw background in six (11.76 %) landraces of rice (Juli, Kalame, and Shankarakempakki), brown furrows on straw in seven (13.72 %) landraces of rice (Chare and Kanakachudi), brown reddish to light purple in only one (1.96%) landraces of rice (Beganbeach) and black in two (3.92 %) landraces of rice (Seethmog and Tulasimog).

4.1.38 Panicle: Awns

Panicle awns (38) were also recorded as present in nine (17.64 %) landraces of rice (Seethmog Neerambade and Giddabasumati) and absent in 42 (82.35 %) landraces of rice (Gulvadisanna, Anekombinabhata, Arjuna, Atire, Malabar and Maskat,).

4.1.39 Panicle: Color of awns(late observation)

Color of awns was recorded (Plate 12) as yellowish white in six (11.76%) landraces of rice (Giddabasumati and Neerambade), light purple in only one (1.96%)

landraces of rice (Kanakachudi) and purple in only two (3.92 %) rice landrace (Seethmog and Meesebhatta).

4.1.40 Panicle: Length of longest awn

The length of longest awn (40) was recorded (Plate 13) as very short in only one (1.96%) landraces of rice (Lalneth), short in two (3.92%) landraces of rice (Seethmog and Basumati), medium in one (1.96%) landraces of rice (Neerambade) and very long in four (7.84 %) landraces of rice (Kanakachudi, Meesebhatta and Giddabasumati).

4.1.41 Panicle: Distribution of awn

Distribution of awns (41) was also recorded as distribution of awns on tips only in eight (15.68 %) landraces of rice (Kanakachudi, Neerambade and Nattijaddu) and whole length in only one (1.96%) landraces of rice (Giddabasumati).

4.1.42 Panicle: Presence of secondary branching

Secondary branching (42) in panicle was present in all 51 (100%) landraces of rice (Atire, Bharma, Beganbeach and Kavalakannu).

4.1.43 Panicle: Secondary branching

Secondary branching (43) was recorded as weak in 30 (58.82%) landraces of rice (Chicksale, Arjuna, Atire, Bhagyodaya and Bharma), strong secondary branching in 14 (27.45 %) landraces of rice (Tulasimog, Beganbeach and Bilinellu) and clustered secondary branching in seven (13.72%) landraces of rice (Kavalakannu, Ratan, Giddabasumati and Somasale).

4.1.44 Panicle: Attitude of branches

Attitude of panicle branching (44) was recorded as erect in 15 (29.41%) landraces of rice (Anekombinabhata, Arjuna and Bilinellu), erect to semi-erect in five (9.80%) landraces of rice (Atire, Beganbeach and Ratan), semi-erect in 11 (21.56%) landraces of rice (Bharma, Chicksale and Seethmog), semi-erect to spreading in 12 (23.52%) landraces of rice (Kayame, Tulasimog and Lalneth) and spreading in eight (15.86%) landraces of rice (Kavadari, Malabar and Neerambade).

4.1.45 Panicle: Exertion

Type panicle exertion (45) was recorded as partly exerted in 17 (33.33%) landraces of rice (Naddantarasale, Dasarapatti and Parlan), mostly exerted in 12 (23.52%) landraces of rice (Kavadari, Tulasimog and Malabar) and well exerted in 22 (43.13%) landraces of rice (Giddabhata, Gulvadisanna and Halaga).



Gold and gold furrows
on straw (Juli)



Purple (Seethmog)



Straw (Lalneth)

Plate 11 : Character No 37 : Lemma and palea color



Light purple (Kanakachudi)



Yellowish white (Neerambade)



Purple (Seethmog)

Plate 12: Character No 39 : Color of awns



Long (Kanakachudi)



Medium (Neerambade)



Short (Seethmog)



Very short (Lalneth)

Plate 13: Character No 40: Length of longest awns



Early (Pratiksha)



Medium (Irga)



Late (Pingara)

Plate 14 : Character No : 46 Time of maturity (days)

4.1.46 Time of maturity (days)

Time of maturity (46) was recorded (Plate 14) based on days required to crop harvest the fifty-one landraces of rice are grouped into very late found in 13 (25.49%) landraces of rice (Meesebhata, Nattijaddu and Neerambade), late in 19 (37.25%) landraces of rice (Seethmog, Peetasale, Meterbhata and Andanoorsanna), medium in eight (15.68%) landraces of rice (Irga, Halaga, Parlan and Shankarakempakki), early in six (11.76%) landraces (Kanakachudi, Intaan and Kuruva) and very early in four (11.76%) landraces of rice (Pratiksha, Kavalakannu, Kayame and Lalneth).

4.1.47 Leaf : Senescence

During caryopsis hardening stage the leaf senescence (47) was recorded as early in eight (15.68%) landraces of rice (Kavalakannu, Kayame and Lalneth), medium in nine (17.67%) landraces of rice (Beganbeach, Gulvadisanna and Halaga), late in 34 (66.66%) landraces of rice (Juli, Kalame and Somasale) and very late in 13 (25.49%) landraces of rice (Kempurajesh, Tulasimog and Meesebhata).

4.1.48 Sterile lemma: Color

Sterile lemma color (48) was observed as straw in 47 (92.15%) landraces of rice (Maskat, Mysoresanna and Naddantarasale), gold in only two (3.92 %) landraces of rice (Chicksale and Kalame) and purple in two (3.92 %) landraces of rice (Seethmog and Tulasimog).

4.1.49 Grain: Weight of 1000 fully developed grains

Test weight (49) of each genotype was recorded as very high in 14 (27.45%) landraces of rice (Arjuna ,Chare and Halaga), high in seven (13.72%) landraces of rice (Beganbeach, Bharma and Pingara), medium in 21 (41.17%) landraces of rice (Bilinellu, Chicksale and Juli), low in five (9.80%) landraces of rice (Giddabhata, Gulvadisanna and Kalame) and very low in four (7.84%) landraces of rice (Anekombinabhata and Bhagyodaya).

4.1.50 Grain: length

Grain length (50) was recorded as medium in 12 (23.52%) landraces of rice (Ratan, Intaan and Malabar) and short in 39 (76.47%) landraces of rice (Anekombinabhata, Atire and Bharma).

4.1.51 Grain: Width

Grain width (51) was recorded as (Plate 15) very narrow in two (3.92%) landraces of rice (Chare and Somasale) narrow in 10 (19.60%) landraces of rice (Ratan, Chicksale, Arjuna and Peetasale), medium in 19 (37.25%) landraces (Juli,

Atire, Bharna and Ratan), and broad in 11 (21.56%) landraces of rice (Tulasimog, Pingara, Giddabhata and Gulvadisanna).

4.1.52 Decorticated grain:Length

Decorticated grain length (52) was recorded as (Plate 16) short in 22 (43.13%) landraces of rice (Chicksale, Juli, Kalame and Somasale), medium in 12 (23.52%) landraces of rice (Kuruva, Gulvadisanna, Kempurajesh and Tulasimog), long in three (5.88%) landraces of rice (Ratan, Bilinellu, Irga and Kuruva) and extra-long in six (11.76%) landraces of rice (Mysoresanna, Dasarapatti and Parlan).

4.1.53 Decorticated grain:Width

Decorticated grain width (55) was recorded as narrow in nine or 17.64 per cent of landraces (Nattijaddu and Peetasale), medium in 13 (25.49%) landraces (Andanoorsanna, Shankarakempakki) and broad in 29 (56.86%) landraces of rice (Dasarapatti and Parlan).

4.1.54 Decorticated grain color

Decorticated grain color (54) was recorded as (Plate 17) white in 40 (78.43 %) landraces of rice (Chicksale, Giddabhata, Halaga and Intaan), light brown in seven (13.72 %) landraces of rice (Lalneth and Tulasimog), variegated brown in two (3.92 %) landraces of rice (Arjuna and Kayame), dark purple in one (1.96 %) landraces of rice (Kuruva) and dark brown in one (1.96 %) landraces of rice (Shankarakempakki).

4.2 Estimation of genetic variability for yield and yield related traits

The mean values of all the thirteen characters of 51 landraces of rice studied are given in Appendix I and the analysis of variance for yield and yield related characters in landraces of rice is presented in Table 4. The analysis of variance for various morphological characters were statistically tested and found to be significant for all the characters evaluated. Estimates of range, mean, variability, heritability and genetic advance as per cent mean for yield and its contributing characters in landraces of rice are furnished in the Table.5 (Fig.1 and 2).

4.2.1 Days to 50 per cent flowering

The mean values of days to 50 per cent flowering was 124.59 with a range of 70.50 to 146.26 days. The Giddabasumati (BMRG-15) was the earliest to flower (70.50 days) while Meesebhata (BMRG-37) took as many as 146.26 days to flower. The phenotypic and genotypic coefficient of variability were 14.07 and 13.90 per cent respectively. Very high heritability estimates of 97.60 per cent coupled with a high expected genetic advance per cent mean of 28.30 per cent, was observed for this trait.

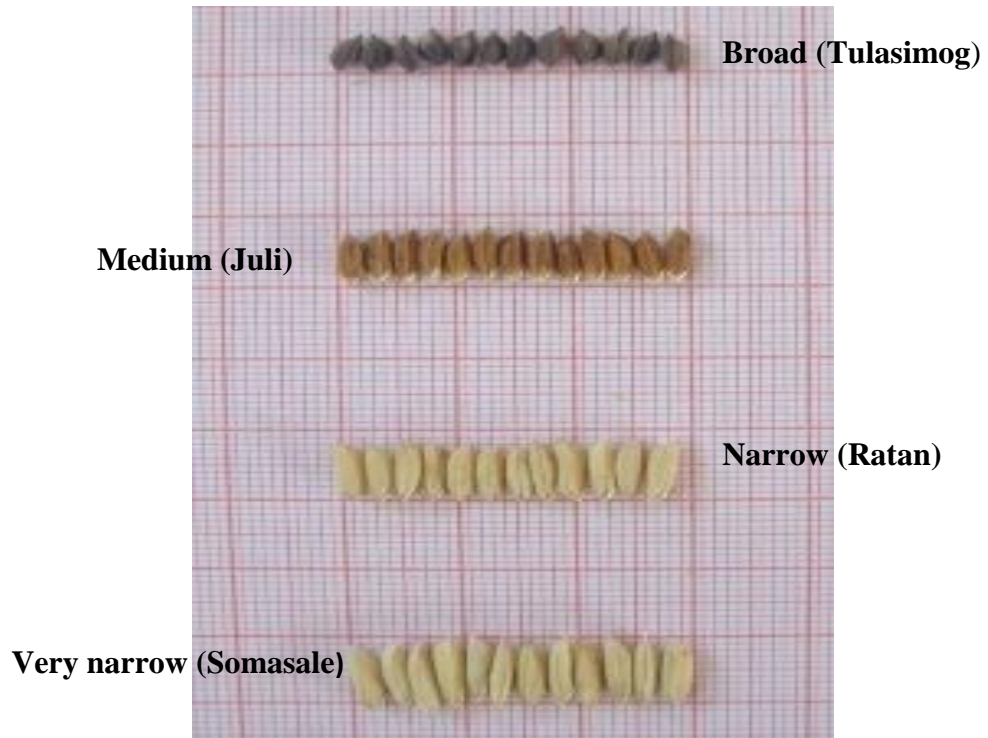


Plate 15 : Character No 51 : Grain width

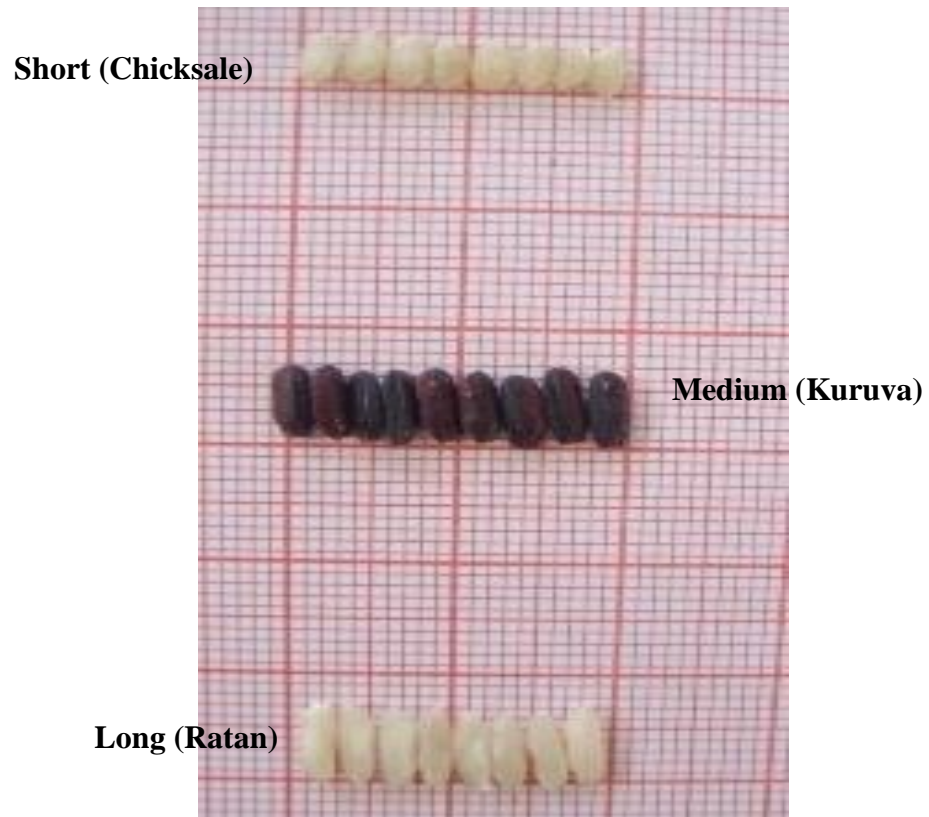


Plate 16: Character 52 : Decorticated grain length



Variegated brown (Kayame)



White (Chicksale)



Light brown (Tulasimog)



Dark purple (Kuruva)

Plate 17: Character No 54 : Decorticated grain color

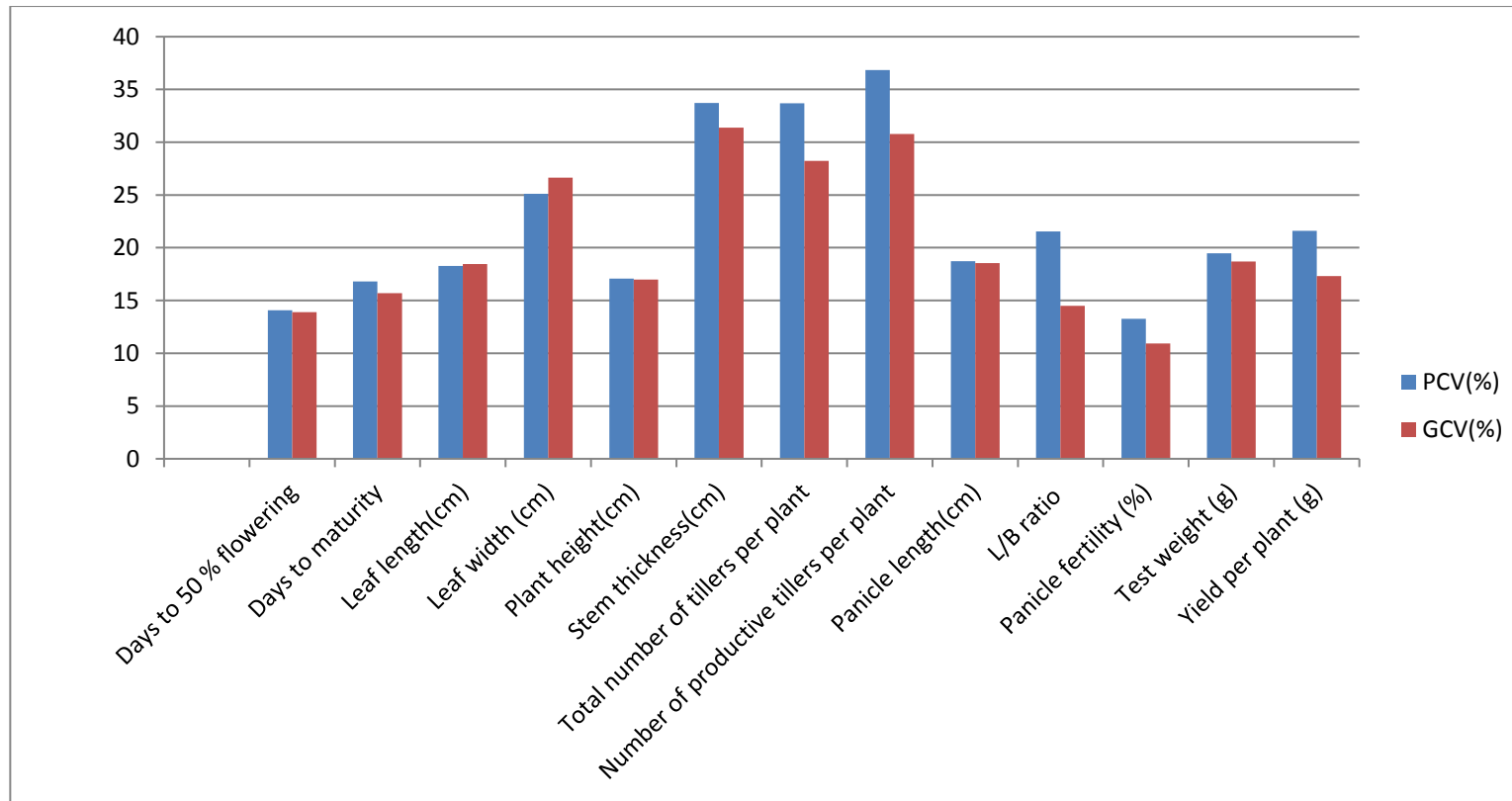


Fig.1 Phenotypic and genotypic coefficient of variation for grain yield and its component characters

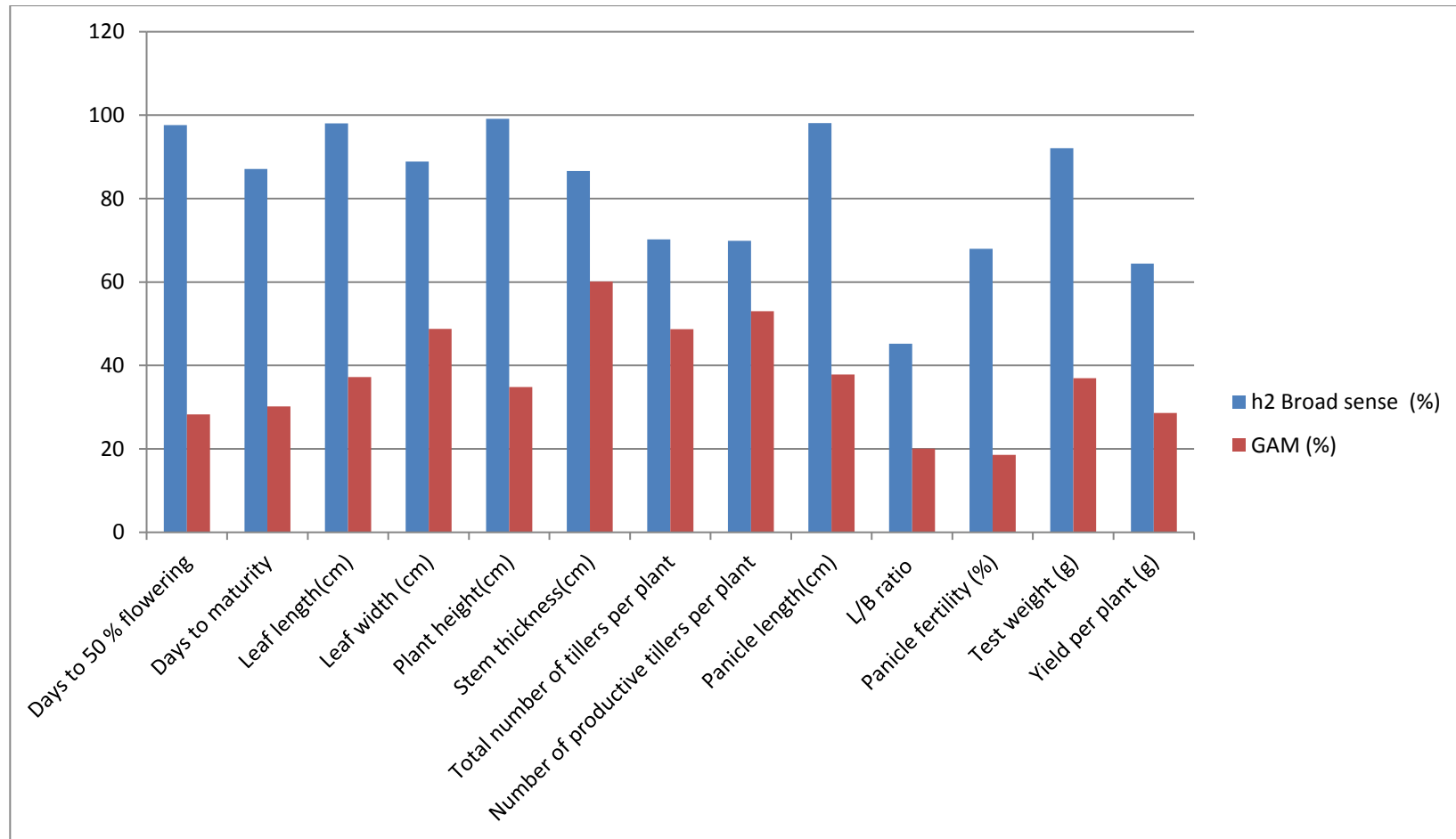


Fig.2 Heritability and genetic advancement as per cent mean for grain yield and its component characters

Table.4 Analysis of variance for yield and yield related characters in landraces of rice.

Sl. No.	MSS	df	Days to 50% flowering	Days to maturity	Leaf length	Leaf width	Plant height	Stem thickness	Total no. of tillers per plant
1	Replication	1	21.8878	261.184	0.4283	0.01060	6.4602	0.0024	2.5349
2	Treatments	50	607.8730**	1050.3470**	64.9649**	0.06141**	566.2439**	0.0583**	67.6340**
3	Error	50	7.4716	72.5779	0.64755	0.003602	2.66058	0.0042	11.8625
4	CV		2.1865	6.0466	2.5920	8.8642	1.6505	12.3573	18.4097
5	LSD (5%)		5.4719	17.1115	1.6163	0.1205	3.2762	0.1302	6.9179
6	LSD (1%)		7.2950	22.8128	2.1548	0.1607	4.3678	0.1736	9.2229

Sl. No.	MSS	df	No. of productive tillers per plant	Panicle length	L/B ratio	Panicle fertility	Test weight	Yield per plant
1	Replication	1	3.0645	1.6289	0.3878	44.2203	0.8011	1.3192
2	Treatments	50	61.2154**	45.2900**	0.4051**	156.7044**	45.6279**	42.5182**
3	Error	50	10.8544	0.4329	0.1527	29.8913	1.8803	9.2202
4	CV		16.2214	2.5912	15.9460	7.5014	5.4829	12.8911
5	LSD (5%)		6.6175	1.3293	0.7850	10.9814	2.7543	6.0990
6	LSD (1%)		8.8223	1.7721	1.0465	14.6403	3.6720	8.1311

** Significance at 1% level, * Significance at 5% level

Table.5 Estimates of range, mean, variability, heritability and genetic advance as per cent mean for yield and its contributing characters in landraces of rice

Sl. No	Characters	Mean	Range		PCV (%)	GCV (%)	h ² Broad sense (%)	GAM (%)
			Min.	Max.				
1.	Days to 50 % flowering	124.59	70.50	146.26	14.07	13.90	97.60	28.30
2.	Days to maturity	140.89	86.60	179.49	16.81	15.69	87.10	30.16
3.	Leaf length(cm)	31.04	16.75	41.75	18.44	18.26	98.03	37.25
4.	Leaf width (cm)	0.67	0.34	0.98	26.63	25.11	88.90	48.78
5.	Plant height(cm)	98.82	70.00	142.00	17.06	16.98	99.10	34.82
6.	Stem thickness(cm)	0.52	0.27	0.85	33.72	31.37	86.60	60.13
7.	Total number of tillers per plant	18.70	8.17	29.12	33.69	28.22	70.20	48.70
8.	Number of productive tillers per plant	16.29	7.46	27.00	36.84	30.79	69.90	53.03
9.	Panicle length(cm)	25.54	17.25	35.56	18.72	18.54	98.10	37.82
10.	L/B ratio	2.45	1.54	3.42	21.54	14.49	45.20	20.08
11.	Panicle fertility (%)	72.88	44.71	88.43	13.25	10.92	68.00	18.55
12.	Test weight (g)	25.00	16.75	35.01	19.48	18.70	92.10	36.96
13.	Yield per plant (g)	23.55	14.98	33.00	21.59	17.32	64.40	28.62

4.2.2 Time of maturity

The mean number of days to maturity was 140.89 with a range of 86.60 to 179.49 days. The Kayame (BMRG-27) was the earliest (86.60 days) to mature while Tulasimog (BMRG-29) was late (179.49 days) to mature. Moderate phenotypic and genotypic coefficient of variability were 16.81 and 15.69 per cent, respectively was noted for this trait. Very high heritability estimates of 87.10 per cent coupled with a very high expected genetic advance per cent mean of 30.16 per cent, was observed for this trait.

4.2.3 Leaf length (cm)

Leaf length showed the mean value of 31.04 cm with a range of 16.75 cm to 41.75 cm. Highest leaf length of 41.75 cm shown by Mysoresanna (BMRG-38) and the lowest leaf length of 16.75 cm shown by Arjuna (BMRG-2). The phenotypic and genotypic coefficient of variability was 18.44 and 18.26 per cent, respectively. High heritability estimates of 98.03 per cent coupled with a high expected genetic advance per cent mean of 37.25 per cent, was observed for this trait.

4.2.4 Leaf width (cm)

The mean value of leaf width recorded was 0.67 cm with a range of 0.34 cm to 0.98 cm. Highest leaf width of 0.98 cm Nattijaddu (BMRG-40) and the lowest leaf width of 0.34 cm by Chicksale (BMRG-10). Very high phenotypic and genotypic coefficients variability were 25.11 and 26.63 per cent, respectively was noted for this trait. High heritability estimates of 88.90 per cent coupled with a high expected genetic advance of 48.78 per cent, was observed for this trait.

4.2.5 Plant height (cm)

The plant height was recorded the mean value of 98.82 cm with a range of 142.00 cm to 70.00 cm. Highest plant height of 142.00 cm was associated with Bilinellu (BMRG-7) and the lowest plant height of 70.00 cm by Ratan (BMRG-13). Moderate phenotypic and genotypic coefficient of variability was 17.06 and 16.98 per cent, respectively was noted for this trait. Very high heritability estimates of 99.10 per cent coupled with very high genetic advance of 34.82 per cent, was observed for this trait.

4.2.6 Stem thickness (cm)

The mean value of stem thickness was recorded was 0.52 cm with a range of 0.27 cm to 0.85cm. Highest stem thickness of 0.85cm was associated with IR-8 (BMRG-12) and the lowest stem thickness of 0.27cm by Neerambade (BMRG-41). Very high phenotypic and genotypic of coefficient of variability were 33.72 and 31.37

per cent respectively, was noted for this trait. Very high heritability estimates of 86.60 per cent coupled with a high expected genetic advance of 60.13 per cent, was observed for this trait.

4.2.7 Total number of tillers per plant

Total number of panicles per plant recorded the mean value of 18.70 with a range of 8.17 to 29.12 days. High number of tillers 29.12 was observed in Tulasimog (BMRG-29) and low number of tillers 8.17 was found in Arjuna (BMRG-37). High phenotypic and genotypic coefficient of variability were 33.69 and 28.22 per cent respectively. Very high heritability estimates of 70.20 per cent coupled with a high expected genetic advance per cent mean of 48.70 per cent, was observed for this trait.

4.2.8 Number of productive tillers per plant

Significant difference among the genotypes for number of productive tillers per plant was noticed. It was ranged from 7.46 to 27.00 with a mean value of 16.29. Highest number of productive tillers was recorded by Shankarakempakki (BMRG-49) while Bilinellu (BMRG-7) showed the lowest number of productive tillers. Very high phenotypic and genotypic coefficient of variability observed were 36.84 and 30.79 per cent, respectively. Very high heritability estimates of 69.90 per cent coupled with a high expected genetic advance per cent mean of 53.03 per cent, was observed for this trait.

4.2.9. Panicle length (cm)

The mean panicle length recorded was 25.54 cm with a range of 17.25 to 35.56 cm. Highest panicle length of 35.56 cm was observed in Mysoresanna (BMRG-38) and the lowest panicle length of 17.25 cm by BPT-5204 (BMRG-50). The phenotypic and genotypic coefficient of variability were 18.72 and 18.54 per cent, respectively. Very high heritability estimates of 98.10 per cent coupled with a high expected genetic advance per cent eman of 37.82 per cent, was observed for this trait.

4.2.10. L/B ratio

The mean value of L/B ratio was recorded was 2.45 with a range of 1.54 mm to 3.42 mm. Highest L/B ratio was 3.42 observed in Gulvadisanna (BMRG-17) and lowest was 1.54 in Kalame (BMRG-22). The phenotypic and genotypic coefficient of variability were 21.54 and 14.49 per cent, respectively. High heritability estimates of 45.20 per cent coupled with a moderate expected genetic advance per cent mean of 20.08 per cent, was observed for this trait.

4.2.11 Panicle fertility (%)

The per cent panicle fertility ranged from 44.71 to 88.43 with a mean value of 72.88. Highest panicle fertility was recorded by BMRG-MS-1-2-1 (BMRG-34) and Nattijaddu (BMRG-40). Moderate phenotypic and genotypic coefficient of variability were 13.25 and 10.92 per cent, respectively was noted for this trait. Very high heritability of 68.00 per cent coupled with a moderate expected genetic advance as per cent mean of 18.55 per cent, was observed for this trait.

4.2.12 Test weight (g)

Test weight ranged from 16.75 g to 35.01 g with a mean of 25.00 g. The coefficient of variability for phenotypic and genotypic were 19.48 and 18.70 per cent, respectively. The maximum test weight of 35.01g was observed in Somasale (BMRG-24) and the minimum test weight of 16.75g was observed in Bhagyodaya (BMRG-4). Very high heritability estimates of 92.10 per cent coupled with a high expected genetic advance per cent mean of 36.96 per cent, was observed for this trait.

4.2.13 Yield per plant (g)

Grain yield per plant varied significantly from 14.98 g to 33.00 g with a mean of 23.55 g. The lowest grain yield was recorded by Dasarapatti (BMRG-47) and Somasale (BMRG-24) recorded the highest grain yield per plant. The phenotypic and genotypic coefficient of variability for this trait were 21.59 and 17.32 per cent respectively. Very high heritability estimates of 64.40 per cent coupled with a high expected genetic advance per cent mean of 28.62 per cent, was observed for this trait.

4.3 Study of correlation analysis for yield and yield related traits

Phenotypic correlation was worked out among 13 characters to know the nature of association existing among the characters. The results of phenotypic correlation analysis for yield and yield related traits in landraces of rice were presented in Table 6. The result pertaining to correlation at phenotypic level between grain yield and other related characters are presented first followed by correlation among the characters.

4.3.1 Correlation of grain yield with other characters

Significant and positive association at phenotypic level was observed between grain yield with total number of tillers per plant (0.7898), number of productive tillers per plant (0.7791), test weight (0.7485), panicle length (0.2624) and panicle fertility (0.2270). The traits like days to 50 per cent flowering (0.1883), leaf length (0.1220), leaf width (0.0210) and stem thickness (0.0417) exhibited a non-significant but positive association with grain yield. Whereas, days to maturity (-0.0408), plant height (-0.0473) and L/B ratio (-0.0643) has shown negative and non-significant association with grain yield.

Table.6 Phenotypic correlation analysis for yield and yield related traits in landraces of rice

Traits	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃
X ₁	1.0000	0.3067**	0.1559	0.0344	-0.1168	-0.0207	0.2376*	0.1896	0.1392	0.1372	-0.0193	0.0414	0.1883
X ₂		1.0000	-0.0155	-0.0908	0.2306*	-0.1882	-0.0933	-0.0873	0.1901	0.0559	-0.1333	-0.0987	-0.0408
X ₃			1.0000	0.1491	0.2854**	0.0359	0.2874**	0.2539*	0.4216**	-0.0004	0.0802	0.1392	0.1220
X ₄				1.0000	-0.2981**	0.1137	0.0431	0.0293	-0.1069	-0.0484	-0.0529	-0.1308	0.0210
X ₅					1.0000	-0.0382	-0.0276	-0.0490	0.1844	0.0023	-0.0553	0.1444	-0.0473
X ₆						1.0000	0.2079*	0.2340*	0.1665	0.1506	0.0650	0.1676	0.0417
X ₇							1.0000	0.9605**	0.3230**	-0.0336	0.3556**	0.7366**	0.7898**
X ₈								1.0000	0.2920**	-0.0525	0.3204**	0.7254**	0.7791**
X ₉									1.0000	0.0972	-0.0053	0.2421*	0.2624**
X ₁₀										1.0000	-0.0735	-0.0052	-0.0643
X ₁₁											1.0000	0.2841**	0.2270*
X ₁₂												1.0000	0.7485**
X ₁₃													1.0000

** Significance at 1% level, * Significance at 5% level

X₁- Days to 50 per cent flowering, X₂- Number of productive tillers per plant, X₃- Leaf length (cm), X₄- Leaf width(cm), X₅- Plant height(cm), X₆- Stem thickness(cm), X₇- Total number of tillers per plant, X₈- Panicle length(cm), X₉- Panicle L/B ratio, X₁₀- Panicle fertility (%), X₁₁- Test weight (g), X₁₂- Yield per plant (g), X₁₃- Yield per plant (g).

4.3.2 Correlation among yield components

4.3.2.1 Days to 50 per cent flowering

Days to 50 per cent flowering showed positive correlation at phenotypic level with days to maturity (0.3067) and total number of tillers per plant (0.2376). Non-significant positive association was observed for leaf length (0.1559), leaf width (0.0344), number of productive tillers per plant (0.1896), panicle length (0.1372) and test weight (0.0414). Whereas non-significant negative association was found with plant height (-0.1168), stem thickness (-0.0207) and panicle fertility (-0.0193)

4.3.2.2 Days to maturity

Days to maturity showed positive correlation at phenotypic level with plant height (0.2306). Positive non-significant association was found with panicle length (0.1901) and L/B ratio (0.0559). Whereas negative non-significant association was found with leaf length (-0.0155), leaf width (-0.0908), stem thickness (-0.1882), total number of tillers per plant (-0.0933), number of productive tillers per plant (-0.0873), panicle fertility (-0.1333) and test weight (-0.0987).

4.3.2.3 Leaf length (cm)

Leaf length showed positive significant correlation at phenotypic level with plant height (0.2854), total number of tillers per plant (0.2874), number of productive tillers per plant (0.2539) and panicle length (0.4216). Non-significant positive correlation was found with leaf width (0.1491), stem thickness (0.0359), panicle fertility (0.0802), test weight (0.1392) and yield per plant (0.1220). While non-significant negative correlation was found with L/B ratio (-0.0004).

4.3.2.4 Leaf width (cm)

Leaf width showed positive non-significant correlation at phenotypic level with stem thickness (0.1137), total number of tillers per plant (0.0431), number of productive tillers per plant (0.0293) and yield per plant (0.0210). While negative significant association was found with plant height (-0.2981). A negative non-significant association was found with panicle length (-0.1069), L/B ratio (-0.0484), panicle fertility (-0.0529) and test weight (-0.1308).

4.3.2.5 Plant height (cm)

Plant height showed positive non-significant correlation at phenotypic level with panicle length (0.1665), L/B ratio (0.1506) and plant height (0.1676) whereas negative non-significant association was found with stem thickness (-0.0382), total

number of tillers per plant (-0.0276), number of productive tillers per plant (-0.0490), panicle fertility (-0.0529) and yield per plant (-0.0473).

4.3.2.6 Stem thickness (cm)

Stem thickness recorded a positive significant correlation at phenotypic level with total number of tillers per plant (0.2079) and number of productive tillers per plant (0.2340) whereas positive non-significant association was found with test weight (0.1676), panicle length (0.1665), L/B ratio (0.1506), yield per plant (0.0417) and panicle fertility (0.0650).

4.3.2.7 Total number of tillers per plant

Total number of tillers per plant exhibited positive significant correlation at phenotypic level with number of productive tillers per plant (0.9605), yield per plant (0.7898), test weight (0.7366), panicle fertility (0.3556) and panicle length (0.3230). While L/B ratio (-0.0525) exhibited negative non-significant association.

4.3.2.8 Number of productive tillers per plant

Number of productive tillers per plant was found to be significantly positively correlated at phenotypic level with panicle length (0.2920), panicle fertility (0.3204), test weight (0.7254) and yield per plant (0.7898). L/B ratio (-0.0525) exhibited negative non-significant association.

4.3.2.9 Panicle length (cm)

Test weight (0.2421) and yield per plant (0.2624) recorded positive and significant association at phenotypic level. L/B ratio (0.0972) exhibit positive non-significant association whereas panicle fertility (-0.0053) showed negative non-significant association.

4.3.2.10 L/B ratio (cm)

Panicle fertility (-0.0735), test weight (-0.0052) and yield per plant (-0.0643) showed negative non-significant association at phenotypic level.

4.3.2.11 Panicle fertility (per cent)

Test weight (0.2841) and yield per plant (0.2270) showed positive significant correlation association at phenotypic level.

4.3.2.12 Test weight (g)

Test weight showed positive significant correlation association at phenotypic level with yield per plant (0.7485).

4.4 Path coefficient analysis among yield and yield related traits

Path coefficient analysis was carried out at phenotypic level for grain yield as a dependent character and the characters found significantly correlated with grain yield as independent. Estimates of direct and indirect effects of yield components on grain yield in landraces of rice were shown in Table 7.

4.4.1 Days to 50 per cent flowering

The direct contribution of days to 50 per cent flowering on grain yield was positive (0.0533) at phenotypic level.

The positive significant correlation of days to 50 per cent flowering (0.1883) with grain yield was mainly due to indirect and positive effect of this through days to maturity (0.0164), leaf length (0.0083), leaf width (0.0018), total number of tillers per plant (0.0127), number of productive tillers per plant (0.0101), panicle length (0.0074), L/B ratio (0.0073) and test weight (0.0022).

However, it showed negative effect on yield through plant height (-0.0062), stem thickness (-0.0011) and panicle fertility (-0.0010).

4.4.2 Days to maturity

Days to maturity showed negative (-0.0025) direct effect on grain yield at phenotypic level.

The negative and non-significant association with grain yield due to indirect and positive effect *via.*, leaf width (0.0002), stem thickness (0.0005), total number of tillers per plant (0.0002), number of productive tillers per plant (0.0002), panicle fertility (0.0003) and test weight (0.0002).

Whereas as it showed negative effect on yield through days to 50 per cent flowering (-0.0008), days to maturity (-0.0025), plant height (-0.0006), panicle length (-0.0005) and L/B ratio (-0.0001).

4.4.3 Leaf length (cm)

Leaf length showed negative direct effect on grain yield (-0.1130) at phenotypic level.

This trait recorded non- significant but positive (0.1220) association with grain yield due to indirect and positive effect on yield was exhibited by leaf length on yield through days to maturity (0.0018) and L/B ratio (0.0000).

Table.7 Estimates of direct and indirect effects of yield components on grain yield in landraces of rice

Traits	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃
X ₁	0.05333	0.0164	0.0083	0.0018	-0.0062	-0.0011	0.0127	0.0101	0.0074	0.0073	-0.0010	0.0022	0.1883
X ₂	-0.0008	-0.0025	0.0000	0.0002	-0.0006	0.0005	0.0002	0.0002	-0.0005	-0.0001	0.0003	0.0002	-0.0408
X ₃	-0.0176	0.0018	-0.1130	-0.0168	-0.0322	-0.0041	-0.0325	-0.0287	-0.0476	0.0000	-0.0091	-0.0157	0.1220
X ₄	0.0026	-0.0070	0.0115	0.0768	-0.0229	0.0087	0.0033	0.0022	-0.0082	-0.0037	-0.0041	-0.0101	0.0210
X ₅	0.0057	-0.0112	-0.0138	0.0144	-0.0485	0.0019	0.0013	0.0024	-0.0089	-0.0001	0.0027	-0.0070	-0.0473
X ₆	0.0032	0.0293	-0.0056	-0.0177	0.0060	-0.1558	-0.0324	-0.0365	-0.0259	-0.0235	-0.0101	-0.0261	0.0417
X ₇	0.0728	-0.0286	0.0880	0.0132	-0.0085	0.0637	0.3063	0.2942	0.0990	-0.0103	0.1089	0.2256	0.7898
X ₈	0.0438	-0.0202	0.0587	0.0068	-0.0113	0.0541	0.2221	0.2312	0.0675	-0.0121	0.0741	0.1677	0.7791
X ₉	0.0117	0.0160	0.0355	-0.0090	0.0155	0.0140	0.0272	0.0246	0.0843	0.0082	-0.0004	0.0204	0.2624
X ₁₀	-0.0044	-0.0018	0.0000	0.0015	-0.0001	-0.0048	0.0011	0.0017	-0.0031	-0.0317	0.0023	0.0002	-0.0643
X ₁₁	0.0010	0.0069	-0.0042	0.0027	0.0029	-0.0034	-0.0185	-0.0166	0.0003	0.0038	-0.0519	-0.0148	0.2270
X ₁₂	0.0168	-0.0401	0.0565	-0.0531	0.0586	0.0680	0.2989	0.2943	0.0982	-0.0021	0.1153	0.4058	0.7485

Residual effect- 0.5178

X₁- Days to 50 per cent flowering , X₂- Days to maturity , X₃- Leaf length (cm), X₄- Leaf width(cm), X₅- Plant height(cm), X₆- Stem thickness(cm), X₇- Total number of tillers per plant , X₈- Number of productive tillers per plant, X₉- Panicle length(cm), X₁₀- L/B ratio, X₁₁- Panicle fertility (%), X₁₂- Test weight (g), X₁₃- Yield per plant (g).

However it showed negative effect on yield through days to 50 per cent flowering (-0.0176), leaf width (-0.0168), plant height (-0.0322), stem thickness (-0.0041), total number of tillers per plant (-0.0325), number of productive tillers per plant (-0.0287), panicle length (-0.0476), panicle fertility (-0.0091) and test weight (-0.0157).

4.4.4 Leaf width (cm)

Leaf length showed positive and direct leaf width (0.0768) effect on grain yield at phenotypic level.

Leaf width recorded non- significant but positive (0.0210) association with grain yield due to indirect and positive effect through days to 50 per cent flowering (0.0026), leaf length (0.0115), stem thickness (0.0087), total number of tillers per plant (0.0033) and number of productive tillers per plant (0.0022).

Whereas it showed negative effect on yield through days to maturity (-0.0070), plant height (-0.0229), panicle length (-0.0082), L/B ratio (-0.0037), panicle fertility (-0.0041) and test weight (-0.0101).

4.4.5 Plant height (cm)

Plant height exhibited negative and direct (-0.0485) effect on grain yield at phenotypic level.

Plant height showed negative non-significant (-0.0473) association with grain yield due to indirect and positive effect on yield *via.*, days to 50 per cent flowering (0.0057), leaf width (0.0144), stem thickness (0.0019), total number of tillers per plant (0.0013), number of productive tillers per plant (0.0024), panicle fertility (0.0027) and negative effect through days to maturity (-0.0112), leaf length(-0.0138), panicle length (-0.0089), L/B ratio (-0.0001) and test weight (-0.0070).

4.4.6 Stem thickness (cm)

Stem thickness showed negative direct (-0.1558) effect on grain yield at phenotypic level.

This trait exhibited positive and non-significant (0.0417) association on grain yield due to indirect and positive effect through days to 50 per cent flowering (0.0032), days to maturity (0.0293) and plant height (0.0060). It showed negative indirect effect on yield through leaf length (-0.0056), leaf width (-0.0177), total number of tillers per plant (-0.0324), number of productive tillers per plant (-0.0365), panicle length (-0.0259), L/B ratio (-0.0235), panicle fertility (-0.0101) and test weight (-0.0261).

4.4.7 Total number of tillers per plant

Total number of tillers per plant showed positive and direct (0.3063) effect on grain yield at phenotypic level.

This trait showed positive and significant (0.7898) association on grain yield due to indirect and positive effect through number of productive tillers per plant (0.2942), test weight (0.2256), panicle fertility (0.1089), panicle length (0.0900), leaf length (0.0880), days to 50 per cent flowering (0.0728), stem thickness (0.0637) and leaf width (0.0132). However, it showed negative effect on yield through days to maturity (-0.0286), plant height (-0.0085) and L/B ratio (-0.0103).

4.4.8 Number of productive tillers per plant

Number of productive tillers per plant showed positive and direct (0.2312) on grain yield at phenotypic level.

This trait recorded positive and significant (0.7791) association on grain yield due to indirect and positive effect on yield *via.*, total number of tillers per plant (0.2221), test weight (0.1677), days to 50 per cent flowering (0.0438), leaf length (0.0587), leaf width (0.0068), stem thickness (0.0541), panicle length (0.0675), and panicle fertility (0.0741) and exhibited negative effect through days to maturity (-0.0202), plant height (-0.0113) and L/B ratio (-0.0121).

4.4.9 Panicle length (cm)

Panicle length exhibited positive and direct (0.0843) effect on grain yield at phenotypic level.

It also showed positive and non-significant (0.2624) association with grain yield due to indirect and positive effect on grain yield through days to 50 per cent flowering (0.0117), days to maturity (0.0160), leaf length (0.0355), plant height (0.0155), stem thickness (0.0140), total number of tillers per plant (0.0272), number of productive tillers per plant (0.0246), L/B ratio (0.0082) and test weight (0.0204) and showed negative effect on yield through leaf width (-0.0090) and panicle fertility (-0.0004).

4.4.10 L/B ratio

L/B ratio exhibited negative and direct (-0.0317) effect on grain yield at phenotypic level.

This trait recorded negative and non-significant (-0.0643) association with grain yield due to indirect and positive effect on grain yield through leaf width

(0.0015), total number of tillers per plant (0.0011), number of productive tillers per plant (0.0017), panicle fertility (0.0023) and test weight (0.0002).

However it showed negative effect on yield through days to 50 per cent flowering (-0.0044), days to maturity (-0.0018), plant height (-0.0001), stem thickness (-0.0048) and panicle length (-0.0031).

4.4.11 Panicle fertility (%)

The negative and direct (-0.0519) effect on grain yield at phenotypic level was exhibited by panicle fertility.

Panicle fertility showed positive and non-significant (0.2270) association with grain yield due to indirect and positive effect on grain yield through days to 50 per cent flowering (0.0010), days to maturity (0.0069), leaf width (0.0027), plant height (0.0029), panicle length (0.0003), L/B ratio (0.0038) and showed negative effect through leaf length (-0.0042), stem thickness (-0.0034), total number of tillers per plant (-0.0185), number of productive tillers per plant (-0.0166) and test weight (-0.0148).

4.4.12 Test weight (g)

Positive and direct (0.4058) effect on grain yield at phenotypic level was recorded by test weight.

Test weight exhibited positive and significant (0.7485) association with grain yield due to indirect and positive effect on grain yield through days to 50 per cent flowering (0.0168), leaf length (0.0565), plant height (0.0586), stem thickness (0.0680), total number of tillers per plant (0.2989), number of productive tillers per plant (0.2943), L/B ratio (0.0982) and panicle fertility (0.1153).

However, it showed negative effect on grain yield through days to maturity (-0.0401), leaf width (-0.0531) and L/B ratio (-0.0021).

4.5 Genetic diversity for yield and yield related traits

Genetic diversity analysis helps in assessing the nature and magnitude of diversity among the genotypes. In order to identify the genetically diverse genotypes for their uses in recombination breeding program. Mahalanobils' generalized distance (D^2) analysis was carried out using 13 characters studied.

4.5.1 Group constellation

The clustering pattern of landraces of rice into eight clusters are presented in Table 8. These clusters were formed by grouping all fifty-one rice landraces in such a way that genotypes within each cluster had smaller D^2 statistics than in other cluster.

Cluster pattern revealed that twenty landraces of rice were present in cluster I, seventeen landraces of rice were present in cluster II, six rice genotypes were present in cluster III, four landraces of rice were present in cluster V, only one rice landrace was present in clusters IV, VI, VII and VIII respectively.

4.5.2 Intra and inter cluster distance

The average D^2 values of intra and inter clusters distances are given in Table 9. The maximum difference among the landraces of rice within the same clusters ranged from 0.00 to 280.47. The maximum intra cluster distance was shown by cluster V (280.47) followed by cluster III (210.38), cluster II (160.16) and cluster I (153.71).

When diversity among the clusters (intercluster) was studied, it showed a range of 255.57 to 1355.55. Cluster IV and cluster V showed maximum intercluster distance (1355.55) followed by cluster V and cluster VI (1077.79), whereas the lowest inter-cluster distance was noticed between cluster VI and cluster VIII (255.57) followed by cluster II and cluster IV (269.07).

4.5.3 Cluster means of different characters under study

The cluster means of thirteen characters across eight clusters are presented in Table 10.

4.5.3.1 Days to 50 per cent flowering

The landraces of rice in cluster IV (134.50) followed by cluster III (133.25) showed the highest mean value whereas, cluster VII (70.50) followed by cluster VIII (74.78) comprised of landraces of rice with lowest mean values for days to 50 per cent flowering.

4.5.3.2 Days to maturity

The highest cluster mean values for days to maturity was recorded by cluster IV (157.50) followed by cluster VI (148.00) whereas cluster VII (112.00) followed by cluster VIII (117.50) comprised of landraces with lowest mean values for days to maturity.

Table .8 Clustering pattern of 51 landraces of rice

Clusters	No. of entries	Genotypes
I	20	Bhagyodaya, IR-8, Seethmog, Giddabhata, Gulvadisanna, Halaga, Kalame, Kavadari, Kavalakannu, Kayame, Tulasimog, Kuruva, Malabar, Maskat, Nattijaddu, Peetasale, Meterbhata, Andanoorsanna, Dasarapatti, Parlan.
II	17	Atire, BMR-US, Pingara, Intaan, Irga, Juli, Kanakachudi, Somasale, Halinga, Pratiksha, BMR-MS-1-2-1, Basumati, Andrabasumati, Shankarakempakki, BPT-5204, JGL-1798.
III	6	Kempurajesh, Lalneth, Meesebhata, Mysoresanna, Naddantarasale.
IV	1	Anekombinabhata
V	4	Beganbeach, Bilinellu, Chare, Chicksale.
VI	1	Ratan
VII	1	Giddabasumati
VIII	1	Arjuna

Table .9 Intra and inter cluster distances for yield and its component characters in landraces of rice

Clusters	I	II	III	IV	V	VI	VII	VIII
I	153.71	360.54	293.99	814.84	348.23	695.24	433.89	658.27
II		160.16	479.75	269.07	787.10	291.79	449.14	436.54
III			210.38	1016.90	557.64	775.04	551.22	919.97
IV				0.00	1355.55	256.87	768.19	458.36
V					280.47	1077.79	522.13	723.50
VI						0.00	272.56	255.57
VII							0.00	300.80
VIII								0.00

*Diagonal values indicate intra cluster distances

*Above diagonal values indicate inter cluster distances

Table .10 Cluster means for yield and its component characters in landraces of rice

Clusters	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃
I	127.78	146.30	33.38	0.70	109.05	0.49	19.65	16.86	25.16	2.44	73.77	24.94	23.77
II	131.82	134.47	27.77	0.69	84.12	0.52	18.45	16.03	23.82	2.45	73.01	24.64	24.06
III	133.25	146.67	38.05	0.66	99.94	0.59	22.37	19.87	34.05	2.54	74.38	26.83	25.71
IV	134.50	157.50	17.98	0.55	71.00	0.66	8.18	7.57	19.50	2.83	56.72	17.18	15.96
V	95.75	139.63	30.28	0.43	126.50	0.59	12.02	10.46	24.69	2.36	66.76	25.61	18.46
VI	95.50	148.00	25.68	0.92	70.00	0.65	24.24	23.62	24.80	2.59	75.98	25.36	25.25
VII	70.50	112.00	33.78	0.99	91.50	0.48	15.32	12.88	26.50	1.90	71.60	20.54	19.62
VIII	74.78	117.50	16.75	0.48	91.00	0.39	17.40	16.11	20.78	2.49	31.32	31.32	28.03

X₁- Days to 50 per cent flowering , X₂- Days to maturity , X₃- Leaf length (cm), X₄- Leaf width(cm), X₅- Plant height(cm), X₆- Stem thickness(cm), X₇- Total number of tillers per plant , X₈- Number of productive tillers per plant, X₉- Panicle length(cm), X₁₀- L/B ratio, X₁₁- Panicle fertility (%), X₁₂- Test weight (g), X₁₃- Yield per plant (g).

4.5.3.3 Leaf length (cm)

Highest mean values for leaf length was recorded by cluster VII (33.78) followed by cluster I (33.38) and the lowest mean was recorded by cluster IV (17.98) followed by cluster VIII (16.75).

4.5.3.4 Leaf width (cm)

The highest cluster mean values for leaf width was recorded by cluster VII (0.99) followed by cluster VI (0.92) and the lowest mean value recorded by cluster V () followed by cluster VIII () for leaf width.

4.5.3.5 Plant height (cm)

The landraces of rice in cluster V (126.50) followed by cluster I (109.05) showed the highest mean value whereas, cluster IV (71.00) followed by cluster VI (70.00) showed lowest mean value for plant height.

4.5.3.6 Stem thickness (cm)

The highest mean value for stem thickness was recorded by cluster IV (0.66) followed by cluster VI (0.65) whereas cluster VIII followed by cluster VII showed lowest mean value for stem thickness.

4.5.3.7 Total number of tillers per plant

The highest mean value for total number of tillers per plant was recorded by cluster VI (24.24) followed cluster III (22.37) while lowest mean value was recorded by cluster IV (8.18) followed by cluster V (12.02).

4.5.3.8 Number of productive tillers per plant

The landraces of rice in cluster VI (23.62) followed by cluster III (19.87) showed highest mean value for number of productive tillers per plant while, the landraces of rice in clusters IV (7.57) followed by cluster V (10.46) showed lowest value of mean for this trait.

4.5.3.9 Panicle length (cm)

The highest mean value for panicle length was recorded by cluster III (34.05) followed by cluster VII (26.50). The lowest mean value recorded by cluster IV (19.50) followed by cluster VIII (20.78).

4.5.3.10 L/B ratio

The cluster IV (2.83) followed by cluster VI (2.59) exhibited highest mean values, whereas cluster VII (1.90) followed by cluster V (2.36) recorded lowest mean value for the trait L/B ratio.

4.5.3.11 Panicle fertility (%)

The highest mean value for panicle fertility was recorded by cluster VIII (82.71) followed by cluster III (74.38) while lowest mean value was recorded by cluster IV (56.72) followed by cluster V (66.79) for the trait panicle fertility.

4.5.3.12 Test weight (g)

The highest mean value for test weight was recorded by cluster VIII (31.32) followed by cluster III (26.83) while lowest mean value was recorded by cluster VII (20.54) followed by cluster IV (17.18) for the trait test weight.

4.5.3.13 Yield per plant (g)

The highest mean value for yield per plant was recorded by cluster VIII (28.03) followed by cluster III (25.71) while lowest mean value was recorded by cluster V (18.46) followed by cluster IV (15.96) for the trait test weight.

4.5.4 Contribution of different characters towards divergence

The per cent contribution of each trait towards total divergence was observed and presented in Table 11. The maximum contribution towards divergence was contributed by plant height (45.88 %) followed by panicle length (19.14 %), leaf length (16.55 %), days to 50 per cent flowering (10.82 %), test weight (4.71 %), stem thickness (0.86 %) and days to maturity (0.71 %). Least contribution to divergence was made by yield per plant (0.08 %) and total number of tillers per plant (0.08 %).

Table.11. Contribution of yield and yield character towards divergence in landraces of rice

Character	Per cent contribution
Plant height	45.88
Panicle length	19.14
Leaf length	16.55
Days to 50% flowering	10.82
Test weight	4.71
Stem thickness	0.86
Leaf width	0.71
Days to maturity	0.55
Panicle fertility	0.47
Yield per plant	0.08
Number of productive tillers per plant	0.08
Total number of tillers per plant	0.08

DISCUSSION

V DISCUSSION

Rice is having genetically diverse germplasm collection, Conservation and evaluation of landraces of rice plays an important role in crop improvement and development program. Across the world, thousands of rice germplasm accessions has been collected, documented, conserved and also utilized in breeding programs that are having good traits.

Screening of germplasm accessions of rice and local landraces of rice for desirable alleles can help in identifying genotypes suitable for specific breeding programs. The utilization of such genetic material in further improvement depends on the knowledge on the extent of variability and character association. Germplasm resources is a very wide term that includes all the allelic resources spread in types ranging from most primitive wild progenitors to highly bred cultivars and strains. Utilization of entire germplasm resources in a breeding program is needed to enhance the diversity of cultivars.

The presence of genetic variability in the plant material plays an important role in any crop improvement through a breeding program. Hence, the utility of such germplasm in the breeding program can be judged based on the knowledge of extent and magnitude of genetic variability, character association and direct and indirect effect of influencing the different character and genetic divergence in the material.

The present investigation was carried out to assess the variability parameter, character association, direct and indirect effect character and genetic divergence for thirteen quantitative characters along with morphological characterization. In 51 landraces of rice the information obtained regarding morphological characterization, variability parameters, correlation coefficient, path coefficient and genetic diversity are discussed under the following sub-headings.

5.1 Morphological characterization of landraces of rice

5.2 Estimation of genetic variability for yield and yield related traits

5.3 Study of correlation analysis for yield and yield related traits

5.4 Path coefficient analysis among yield and yield related traits

5.5 Study of genetic diversity for yield and yield related traits

The analysis of variance revealed a highly significant difference among the rice genotypes for all the traits. All the genotypes mentioned in the study exhibited a considerable amount of differences in their mean performance with respect to all the characters studied. This has been exemplified by the highly significant mean sum of

squares for these traits, which indicated that the genotypes under study were genetically diverse. The similar findings were noted by Gangashetty *et al.* (2013).

5.1 Morphological characterization of landraces of rice

Qualitative characters are considered as the morphological markers in the identification of landraces of rice and also they are less influenced by environmental fluctuations.

In order to characterize the landraces of rice according to DUS test guidelines fifty-four characters were evaluated. In ten days old seedlings coleoptiles color has been recorded through visual assessment on individual plants. Of the fifty-one landraces of rice studied, 46 landraces of rice showed green coleoptiles color (Arjuna, Atire and Bhagyodaya), five landraces of rice showed purple color of coleoptiles color (Shankarakempakki, Kavalakannu and Kuruva). Basal leaf sheath color observed during booting stage of the crop was recorded as 46 rice landraces were green color (Atire, Bharma and Bilinellu), only one rice landrace showed light purple color (Seethmog), two landraces of rice showed purple lines (Kavalakannu and Kuruva) and uniform purple color (Kanakachudi and meesebhata) each. Rao *et al.* (2001) and Subbarao *et al.* (2006) recorded the similar results for these traits.

Regarding leaf characters, intensity of green color leaves have been recorded during the booting stage through visual assessment of group of plants into three classes light green color in 14 landraces of rice, medium green color in 16 landraces of rice and dark green color in 21 landraces of rice, whereas anthocyanin coloration of leaves was absent in 86.27 per cent of landraces of rice and present in 13.72 per cent of landraces of rice. Similar results were reported by Quadir *et al.* (2008).

With respect to anthocyanin color of leaf sheath, it was absent in 45 landraces of rice and present in only six landraces of rice. Intensity of anthocyanin color on leaves was very weak in 49.001 per cent of landraces of rice, medium in 35.29 per cent of landraces of rice, strong in 11.76 per cent of landraces of rice and very strong in 3.92 per cent of landraces of rice. A low level of polymorphism with respect to anthocyanin coloration of leaf and stem characters was observed by Patra and Chawla (2010) in molecular characterization of Basmati rice according to DUS test guidelines.

Leaf auricles were present in 48 landraces of rice and absent in three landraces of rice. Parikh *et al.* (2012) reported the similar results in characterization of aromatic rice varieties of Bangladesh. Anthocyanin coloration of auricles was observed in 5.88 per cent of landraces of rice and absent in 94.11 per cent of landraces of rice. Leaf collar was present in all the landraces of rice. Similarly

anthocynin coloration of collar was found in 11.76 per cent of landraces of rice and absent in 88.23 per cent of landraces of rice. Similarly anthocynin coloration of collar was found in 6 of landraces of rice and absent in 45 landraces of rice. Similar results were reported by Quadir *et al.* (2006).

Color of stigma was recorded as white in 29 landraces of rice, yellow in five landraces of rice, light purple in six landraces of rice and purple in six landraces of rice. Padmaja (2007) studied the stigma color during characterization of one hundred and fifty germplasms for eleven morphological characters using morpho-agronomic descriptors (IRRI,1996). Das and Ghosh (2010) carried out an experiment to characterize 130 traditional rice cultivars based on 31 traits and found that stigma color and leaf blade color exhibited the highest variability.

Common characters in all the 51 landraces of rice have been observed with respect to presence of leaf ligule with split shape in all the 51 landraces of rice, whereas Subbarao *et al.* (2013) noted farmer's varieties having acute shape of leaf ligule. Chakravorty and Ghosh (2012) have reported acute, split and truncate shape of leaf ligule in farmer's varieties of rice. Whereas color of the ligule was recorded as white in 48 landraces of rice, light purple in two landraces of rice and purple in one rice landrace. Similar observation of ligule color was recorded by Krishna and Nidhi (2014). Padmaja (2007) recorded ligule shape and color while characterizing 150 germplasms for 11 morphological characters using morpho-agronomic descriptors (IRRI,1996).

Spikelet characters were recorded during beginning of anthesis to dough development stage. Density of pubescence of lemma was recorded by visual assessment of single spikelet recorded as weak in 35.29 per cent of landraces of rice, medium in 33.33 per cent of landraces of rice, strong in 19.60 per cent of landraces of rice and very strong in 11.76 per cent of landraces of rice respectively. Similar result with respect to pubescence of lemma and palea was also recorded by Bisne and Sarawagi (2008). Landraces of rice were also recorded for male sterility and found absent in all 51 landraces of rice, similar results were reported by Subbarao *et al.* (2006).

Lemma characters had been observed during half stage of anthesis and recorded that anthocynin coloration of keel was absent or very weak in 72.54 per cent landraces of rice, weak in 1.96 per cent landrace of rice, medium in 7.84 per cent landraces of rice, strong in 11.76 per cent landraces of rice and very strong in 5.88 per cent landraces of rice. Similarly anthocynin coloration of area below apex was observed as absent in 38 landraces of rice, weak in only one landraces of rice, medium in five landraces of rice, strong in four landraces of rice and very strong in three landraces of rice. Patra and Marndi (2012) reported the similar results.

Intensity of anthocyanin coloration of nodes has been observed as weak in 47 landraces of rice , medium in only one landrace of rice and strong in three landraces of rice . The intensity of anthocyanin coloration of the internodes was recorded as absent in 44 landraces of rice and present seven landraces of rice . Krishna and Nidhi (2014) recorded the internode color as green, purple line and purple white, node color as green and purple.

During seed development stage a late observation of flag leaf attitude was recorded visually as semi-erect in 36 landraces of rice , horizontal in 11 landraces of rice , and deflexed in four landraces of rice . The curvature of main axis of panicle was recorded as semi-straight in 33 landraces of rice , deflexed in three landraces of rice and drooping in 15 landraces of rice . Patra (2000) studied panicle curvature of main axis in 22 accessions rice varieties of Orissa.

Lemma and palea color was observed as straw in 35 landraces of rice , gold and gold furrows on straw background in six landraces of rice , brown furrows on straw in seven landraces of rice , brown reddish to light purple in only one landrace of rice and black in two landraces of rice . Bajracharya *et al.* (2006) observed the lemma and palea color during characterization of 147 landraces of rice for agromorphological variability.

At ripening stage panicle was observed and recorded for presence or absence of awns and was found to be present in nine landraces of rice and absent in 42 landraces of rice . Krishna and Nidhi (2014) and Semwal *et al.* (2014) also recorded for presence or absence of awns.

Secondary branching of panicle was found in all 51 landraces of rice . Also observed for type of secondary branching and recorded as weak in 30 landraces of rice , strong in 14 landraces of rice and clustered in seven landraces of rice . Qadir *et al.* (2008) also observed secondary branching ten rice varieties based on sixteen plant morphological characters.

Leaf senescence was recorded during caryopsis hardening stage and recorded as early senescence in eight landraces of rice , medium senescence in nine landraces of rice and late senescence in 34 landraces of rice . Chakravorty and Ghosh (2012) recorded similar results while characterizing landraces of rice in West Bengal.

At the boot leaf stage, the length of leaf blade was measured by taking individual leaf and recorded as short in 19 landraces of rice , medium in 30 landraces of rice and long in two landraces of rice . Similarly, width of leaf blade also measured and recorded as narrow in 33 landraces of rice , medium in 12 landraces of rice and broad in six landraces of rice . Similar observations were also made by Chakravorty

and Ghosh (2012) in characterizing the local paddy landraces of rice on 15 quantitative characters. Sinha and Mishra (2013) also reported similar results.

Stem thickness measured at milk development stage as thin in 12 landraces of rice, medium in 15 landraces of rice and thick in 24 landraces of rice. Similarly stem length was measured as very short in 22 landraces of rice, short in 19 landraces of rice, medium in six landraces of rice and long in four landraces of rice. Manjunatha *et al.* (2018) recorded stem length during characterization of sixty landraces of rice which include aromatic genotypes for both qualitative and quantitative traits.

Decorticated grain length was observed and recorded as short in 22 landraces of rice, medium in 12 landraces of rice and long in three landraces of rice and extra-long in six landraces of rice, whereas decorticated grain width was recorded as narrow in nine landraces of rice, medium in 13 landraces of rice and broad in 29 landraces of rice. Similarly decorticated grain color was observed and recorded as white color in 40 landraces of rice, light brown color in seven landraces of rice, variegated brown color in two landraces of rice, dark purple color in only one landrace of rice and dark brown color in one landrace of rice. Bhartiya *et al.* (2012) recorded decorticated grain color and length in nineteen rice varieties by following the standard procedure of DUS guidelines for 60 morphological traits. Joshi and Chawla (2010) recorded decorticated grain color and length in twenty indigenous rice cultivars on the basis of forty six visually assessed DUS descriptors.

The characters like anthocyanin coloration of different parts of plant, presence of awns, lemma and palae color and decorticated grain color could be used as morphological markers in breeding programs. Whereas, characters like high leaf pubescence (Meesebhata, Neerambade, Andanoorsanna and Ratan), strong thick stem (Anekombinabhata, Beganbeach, Chiksale and Pingara), purple stigma (Atire,) and presence of awns (Meesebhata, Seethmog and Neerambade) were known to impart resistance against insect pest so genotypes with these characters could be used in developing varieties to tolerant to insect pests.

5.2. Estimation of genetic variability for yield and yield related traits

Genetic variability is most essential for crop improvement and development programs in any crop. The genetic variability is partitioned into heritable and non-heritable components with suitable genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance as per cent mean. The estimation of these genetic parameters enables the breeder for crop improvement by selection.

The landraces of rice showed a wide range of variation, which provides scope for the selection of superior and desired genotypes for further improvement in rice. The heritable and non-heritable portion of total variability observed is indispensable in adopting the suitable breeding procedure.

The moderate GCV and PCV values were observed for days to 50 per cent flowering, time of maturity, leaf length, plant height, panicle length, L/B ratio, panicle fertility, test weight and yield per plant. Similar results were reported by Rashid *et al.* (2017) for the traits like days to 50 per cent flowering, days to maturity, fertility (%), panicle length, 1000 Seed weight and yield panicle panicle. Mohanty *et al.* (2012) reported similar results of the presence of moderate GCV and PCV for days to 50 per cent flowering. Iqbal *et al.* (2018) reported a high magnitude of GCV and PCV for the traits like panicle length and 1000-grain weight. Sravan *et al.* (2012) reported high GCV and PCV for single plant yield, plant height flag leaf length and time of heading. Hilal *et al.* (2010) reported a high magnitude of PCV and GCV for traits like grain yield per plant, flag leaf area and test weight. The occurrence of moderate estimates of PCV and GCV indicated that these traits allow a reasonable scope for the yield improvement through selection owing to their moderate genetic variability.

High GCV and PCV values were noticed for the traits like leaf width, stem thickness, the total number of tillers per plant and number of productive tillers per plant. Similar results were recorded by Yadav *et al.* (2010) reported high GCV and PCV for the total number of tillers per plant. Gangashetty *et al.* (2013) reported high GCV and PCV for traits like the number of productive tillers per plant, number of tillers per plant, and grain yield per plant. Dhanwani *et al.* (2013) reported moderate GCV and PCV for traits like the total number of tillers per plant, number of productive tillers per plant. Varthini *et al.* (2014) reported that the number of productive tillers shows the largest variation with a coefficient of variation. Singh *et al.* (2012) reported high GCV and PCV for the total number of tillers per plant, number of productive tillers per plant. High GCV and PCV values indicating that there is a greater scope for selection of these traits due to the occurrence of high genetic variability during yield improvement.

Estimates of PCV were higher than the corresponding GCV for all the traits under study. Vanisree *et al.* (2013) and Sahu *et al.* (2017) also reported higher estimates of PCV than their respective GCV for all the traits studied. However, the difference between PCV and GCV was less for these traits indicating the low environmental influence and predominance of genetic factors controlling variability in these traits.

Heritability in broad sense coupled with high genetic advance as per mean act as direct selection parameters that provide the index of transmissibility of the traits

and these traits are mostly controlled by additive gene action which gives an indication about the effectiveness of selection in improving the character (Johnosn *et al.*,1995).

The traits like days to 50 per cent flowering, days to maturity, leaf length, leaf width, plant height, stem thickness, the total number of tillers per plant, number of productive tillers per plant, panicle length, test weight and yield per plant recorded high level of heritability. Basavaraj *et al.* (2017) reported high heritability for the traits like panicle number per plant, flag leaf length, tiller number per plant and test weight. Manoj *et al.* (2011) reported high heritability for flag leaf width. Vanishree *et al.* (2013) also reported high heritability for days to 50 per cent flowering, days to maturity, test weight, the total number of tillers per plant, number of productive tillers per plant, panicle length and L/B ratio. Sharma and Sharma (2007) reported high heritability for the traits like days to 50 per cent flowering, L/B ratio and test weight. Gaurav *et al.* (2018) reported high heritability coupled with high genetic advance for grains per panicle, flag leaf area, test weight, spikelets per panicle and plant height. Sravan *et al.* (2012) reported plant height and the total number of grains per panicle possess maximum genetic advance with a high level of heritability. High heritability estimates for a character indicates that these characters are less influenced by environment and hence is a wide scope for genetic improvement of these traits through selection.

Genetic advance as per cent mean (GAM) was high for the traits like days to 50 per cent flowering, days to maturity, leaf length, leaf width, plant height, stem thickness, total number of panicles per plant, number of productive tillers per plant, panicle length, test weight and yield per plant. These results were in accordance with the results of Gangashetty *et al.* (2013) for the number of tillers per plant, the number of productive tillers per plant, plant height and grain yield per plant. Genetic advance as per cent mean was moderate for the traits like L/B ratio and panicle fertility. Sreeparvathy *et al.* (2010) reported moderate genetic advance as per cent mean for L/B ratio. Sankar *et al.* (2006) reported a similar result of moderate genetic advance as per cent mean for the trait panicle fertility. Basavaraj *et al.* (2017) reported high heritability coupled with high genetic advance as per cent of the mean for panicle number per plant, flag leaf length, grain filling duration (80.83 and 24.39), tiller number per plant and test weight.

Hence, the traits like stem thickness, total number of panicles per plant, number of productive tillers per plant, plant height, days to 50 per cent flowering, days to maturity, leaf length, leaf width, panicle length, test weight and yield per plant showed high heritability with high GAM emerged as the ideal traits for improvement through the selection. These traits also showed moderate to high GCV and PCV

indicates that the landraces of rice with these traits provide a higher response to selection due to their transmissibility to the next generation.

5.3 Study of correlation analysis for yield and yield related traits

Knowledge of the correlation between yield and its contributing characters is important to find out guidelines for plant selection. Partitioning of total correlation into direct and indirect effect by path coefficient analysis helps in making the selection more effective (Priya and Joel, 2009). The existing relationships between the traits are generally determined by the genotypic, phenotypic and environmental correlation

5.3.1 Correlation of grain yield with other characters

In the present study grain yield had significant positive association at phenotypic level with total number of tillers per plant, number of productive tillers per plant, panicle length, panicle fertility and test weight whereas, non-significant but positive association with days to 50 per cent flowering, leaf length, leaf width, plant height and stem thickness. These results were in accordance with the results obtained by Nandan *et al.* (2010) for the traits like plant height, days to 50 per cent flowering and spikelet fertility, Yadav *et al.* (2010) for the traits like number tillers per hill, number of panicles per plant, number of spikelets per panicle and test weight, Khalid *et al.* (2012) for the traits like number of tillers per panicle, panicle length, number of filled grains per panicle and test weight. Fiyaz *et al.* (2011) for days to 50 per cent flowering, Number of productive tillers, total spikelet per panicle and plant height. Sabesan *et al.* (2009) for traits like plant height and productive tillers per plant.

5.3.2 Correlation among yield component

Days to 50 per cent flowering showed a positive correlation at phenotypic level with days to maturity and the total number of tillers per plant, which is on par with Nandan *et al.* (2010). Days to maturity showed a positive correlation with plant height, a positive non-significant association was found with panicle length and L/B ratio. Whereas negative non-significant association was found with leaf length, leaf width, stem thickness, the total number of tillers per plant, number of productive tillers per plant, panicle fertility and test weight.

Leaf length showed positive significant correlation with plant height, the total number of tillers per plant, number of productive tillers per plant and panicle length. Leaf width showed positive non-significant correlation with stem thickness, the total number of tillers per plant, number of productive tillers per plant and yield per plant.

Plant height showed positive non-significant correlation at phenotypic level with panicle length, L/B ratio and plant height. Sohrabhi *et al.* (2012) reported that plant height exhibit highly significant and positive correlation with most of the traits studied.

The total number of tillers per plant exhibit positive significant correlation at phenotypic level with the number of productive tillers per plant, panicle length, panicle fertility, test weight and yield per plant. Berhanu *et al.* (2013) reported a positive and significant correlation of the total number of tillers per plant with productive tillers per plant, plant height, 1000 grain weight and grain yield per plant.

The number of productive tillers per plant was found to be a significant correlation association at phenotypic level with panicle length, panicle fertility, test weight and yield per plant. Vanishree *et al.* (2013) reported similar results where the number of productive tillers per plant showed a significant and positive association with panicle length, panicle fertility, test weight and yield per plant. Babu *et al.* (2012) reported that the number of productive tillers per plant showed a significant and positive association with grain yield per plant.

Panicle length recorded positive and significant association with test weight and yield per plant. Rajamadhan *et al.* (2011) reported similar results for the traits like panicle length showed a significant positive association with the number of grains per panicle, hundred-grain weight and grain yield.

Panicle fertility recorded positive and significant association with test weight and yield per plant. Test weight showed a positive significant correlation association with yield per plant. Similar results were reported by Akhtar *et al.* (2011).

The findings of the present research revealed that grain yield showed positive significant association with total number of tillers per plant, number of productive tillers per plant, panicle length, panicle fertility and test weight indicating that increase in these traits would also increase grain yield. Hence direct selection for these yield-attributing characters would help in improving the yield.

5.4. Path coefficient analysis for yield related traits

The path analysis suggested by Dewey and Lu (1959) specified the effective measure of direct and indirect causes of association and also depicts the relative importance of each factor involved in contributing to the final product that is yield. In the present study, the path coefficient analysis was done at the phenotypic level and the results were discussed below.

Path analysis revealed that days to 50 per cent flowering, leaf width, the total number of tillers per plant, number of productive tillers per plant, panicle length and test weight showed a direct and positive effect on grain yield. This indicates that the yield improvement program will be effective by selecting these traits. Similar results were obtained by Seyoum *et al.* (2012) for days to 50 per cent flowering, panicle length, total spikelet fertility and plant height. Khalid *et al.* (2012) described Similar results panicle length, test weight, number of tillers per plant and filled grains per panicle. Babu *et al.* (2012) reported similar results with the number of productive tillers per plant and panicle length. The traits like leaf length and stem thickness showed a negative direct effect on grain yield.

The highest positive indirect effect on grain yield was recorded by panicle length via the total number of tillers per plant followed by leaf length, leaf width and days to 50 per cent flowering.

The traits which have a direct effect on yield indicating that the selection for these characters was likely to bring about an overall improvement in single plant yield directly. Therefore, it is suggested that preference should be given to these characters in the selection programme to isolate superior lines with genetic potentiality for yield in rice genotypes. The traits which have an indirect effect *via.*, another component also aid in an indirect selection of such trait to improve the yield.

5.5 Study of genetic diversity for yield and yield related traits

Estimation of nature and magnitude of genetic diversity within and among the landraces of rice will be helpful in the selection of desirable parents to exploit high heterosis and useful recombination. Mahalanobis' D^2 statistics is the most appropriate method for estimating the degree of divergence present among the landraces of rice. In order to estimate the diversity in 51 landraces of rice, thirteen characters were considered and diversity was assessed by using Mahalanobis' D^2 statistics.

Based on D^2 values all 51 landraces of rice were grouped into eight clusters. Clustering pattern revealed that twenty landraces of rice present in cluster I forming the largest cluster, followed by seventeen landraces of rice present in cluster II, six landraces of rice present in cluster III, four landraces of rice present in cluster V, only one genotype was present in the clusters IV, VI, VII and VIII respectively. Similar results were shown by Dushyanthkumar and Anand (2010), classified the landraces of rice into eight clusters, also Chamundeshwari *et al.* (2012) classified 31 landraces of rice using Mahalanobis D^2 statistics and grouped them into eight clusters.

5.5.1. Average inter and intra-cluster distances

Cluster V (280.47) recorded maximum intra-cluster distance. Hence, the landraces of rice included under cluster V can be used as parents in the recombination breeding program owing to the presence of greater diversity within these landraces of rice .

Cluster V and cluster VI showed maximum inter-cluster distance (1077.79) followed by cluster IV and cluster V (1355.55). Whereas the lowest inter-cluster distance was noticed between cluster VI and cluster VIII (255.57) followed by cluster II and cluster IV (269.07). Similar results were recorded by Sandhya *et al.* (2014) reported that maximum inter-cluster distance was recorded between cluster V and VI. The presence of maximum genetic distance among such landraces of rice indicates the presence of wide genetic diversity such landraces of rice can be utilized in the recombination breeding program. Greater the distance between the two clusters (intercluster) than within the cluster (intracluster) wider the genetic diversity among the landraces of rice (Tirkey *et al.*, 2013). Presence of minimum intercluster distance indicates that such landraces of rice are closely related or close genetic base hence the least heterosis is exploited from such landraces of rice ,Whereas from the clusters showing high inter cluster distance in breeding programs for developing varieties and hybrids with wider variability and desirable quality.

5.5.2. Cluster means analysis

Indirect selection for yield improvement in any crop depends upon the selection of yield attributing traits, which have direct positive effect on yield. Selection for these traits should be done in the clusters which show highest cluster mean values for the characters. Cluster IV had showed highest mean values for days to 50 per cent flowering, days to maturity, stem thickness and L/B ratio. Cluster III had showed highest mean values for leaf length and panicle length. Highest mean for leaf width was exhibited by cluster VII. Cluster V had showed highest mean for plant height. Cluster VI had showed highest mean values for total number of tillers plant, number of productive tillers per plant and panicle fertility. Highest mean value for test weight and yield per plant was shown by cluster VIII.

5.5.3. Contribution of different clusters towards divergence

The maximum contribution towards divergence was made by plant height followed by panicle length, leaf length, days to 50 per cent flowering, test weight, stem thickness and time of maturity. Least contribution to divergence was made by yield per plant and the total number of tillers per plant. Plant height contributed forty-five per cent of total divergence indicates that landraces of rice differ significantly with respect to their different plant height. Manohara and Singh (2013) reported that plant height, days to 50 per cent flowering, grain breadth and test weight contributes

maximum towards the total divergence. Sandhya *et al.* (2014) reported that the number of spikelets per plant, test weight, days to 50 per cent flowering contributed maximum towards genetic divergence.

Conclusion

- 51 landraces of rice studied under the present investigation were exhibited distinctiveness, uniformity and stability for most of the characters studied.
- Some of the landraces of rice like Giddabasumati, Kuruva, Kavalakannu, Atire and Kanakachudi were found to be having unique for the characters like anthocynin coloration of the leaf, auricle, ligule, presence of awn lemma and palea color and decorticated grain color.
- The landraces of rice exhibited a wide range of variation, which provides scope for the selection of desired genotypes for further improvement in rice .
- Correlation studies revealed that grain yield exhibited significant and positive association at phenotypic level with the total number of tillers per plant, number of productive tillers per plant, panicle length, panicle fertility and test weight.
- D² analysis revealed that cluster IV and cluster V showed maximum intercluster distance indicates the presence of wide genetic diversity such landraces of rice (Anekombinabhata, Beganbeach, Bilinellu, Chare and Chicksale) can be utilized in the hybridization program for the development of high yielding varieties that combine desirable grain traits.

Future line of work

- The landraces of rice are genetically diverse and possess potential variation for economic traits and can be evaluated under different environments for greater exploitation in the breeding program.
- These landraces of rice can further be screened for molecular characterization by the screening of a large set of primers.
- The landraces of rice can also be utilized for evaluating quality parameters like amylase content and gelatinization temperature.
- The landraces of rice falling under cluster IV and cluster V found to be more divergent. Hence these landraces of rice can be utilized in hybridization to identify desirable recombinants to increase both the quality and quantity of grain.
- The landraces of rice studied can be registered under PPV and FRA, 2001 for protection.

SUMMARY

VI SUMMARY

In the present investigation, the assessment of morphological characteristics and genetic variability studies was done in 51 landraces of rice. The experiment was conducted at College of Agriculture, Shivamogga, during *kharif* 2018. The experimental design used was a Randomized Complete Block Design with two replications. The spacing maintained was 20 cm between rows and 15 cm between plants within the row. The objectives were, morphological characterization according to DUS test guidelines given by PPV and FRA, 2001 and to assess the relative performance, estimation of genetic variability, heritability, genetic advance as per cent mean, character association and genetic divergence among the landraces of rice for grain yield and some yield attributing traits. The results of the study and conclusion drawn from the experiment are summarized below.

Fifty-one landraces of rice were evaluated for fifty-four agro-morphological characters by following DUS test guidelines of PPV and FRA, 2001. Among them 41 qualitative characters studied in the morphological characterization of landraces of rice, five characters such as the presence of leaf ligule, split shape of leaf ligule, absence of male sterility and presence of secondary branching characters were common in all the 51 landraces of rice. Remaining 36 characters were unique and distinct among the landraces of rice. Landraces of rice *viz.*, Beganbeach, Bilinellu, Seethmog, Juli, Kanakachudi, Kavalakannu, Kuruva and Meesebhata had recorded anthocyanin coloration only on leaves. Landraces of rice such as Beganbeach, Bilinellu, and Kuruva recorded the distribution of anthocyanin coloration of leaf on tips only whereas, landraces of rice *viz.*, Seethmog, Juli, Somasale, Kavalakannu and Meesebhata recorded the distribution of anthocyanin coloration of leaf on margins only. Seethmog, Juli, Kanakachudi, Kavalakannu, Kuruva and Meesebhata landraces of rice showed anthocyanin coloration on leaf sheath.

Anthocyanin coloration of auricles was recorded in the landraces of rice Seethmog, Kavalakannu and Kuruva. The anthocyanin coloration of collar was recorded in Beganbeach, Seethmog, Kavalakannu, Kayame, Kuruva and Meesebhata.

The density of pubescence of lemma was recorded as strong in landraces of rice Irga, Juli, Kalame, Kanakachudi and Kempurajesh, very strong density of pubescence of lemma was exhibited by the landraces of rice Seethmog, Giddabasumati, Halaga, Kuruva, Malabar, Nattijaddu and Peetasale. These characters are useful in varietal identification and could be used as morphological markers in the hybridization program.

Analysis of variance revealed a significant difference among 51 landraces of rice for all the characters. High GCV, PCV and heritability with maximum genetic advance per cent mean was recorded for days to 50 per cent flowering, days to maturity, leaf length, stem thickness, plant height, total number of tillers per plant, number of productive tillers per plant and test weight. The landraces of rice with these traits having high GCV and PCV would provide a higher response to selection due to their high transmissibility to the next generation. There is less difference between the GCV and PCV revealed that less influence of environmental factor and traits are under the control of additive genes. Hence, a simple and early generation selection scheme would be effective for grain yield improvement.

The grain yield had a significant and positive association at phenotypic level with the total number of tillers per plant, number of productive tillers per plant, test weight, panicle length and panicle fertility. Path analysis revealed that days to 50 per cent flowering, leaf width, the total number of tillers per plant, number of productive tillers per plant, panicle length and test weight showed a direct and positive effect on yield. This revealed that selection of these characters will help in grain yield improvement.

51 landraces of rice were grouped into eight clusters on the basis of Mahalanobis' D^2 values. The maximum number of landraces of rice were present in cluster I (20 landraces of rice) followed by cluster II (17 landraces of rice). The highest intra cluster distance was shown by cluster V (280.47) whereas cluster I showed lowest intra cluster distance. This revealed that presence of diverse landraces of rice in different clusters.

The cluster IV and cluster V showed highest inter-cluster distance (1355.55) followed by cluster V and cluster VI (1077.79), this emphasizes the possibilities of getting high heterotic F_1 hybrid as well as transgressive segregants in the advanced generation for different traits, when hybridization is carried out involving landraces of rice between these two divergent clusters contributed largely for total divergence in genotypes revealing ample scope for improvement of the traits.

The per cent contribution of thirteen characters towards total divergence was studied. The maximum contribution towards divergence was made by plant height, followed by panicle length, leaf length, days to 50 per cent flowering, test weight, stem thickness and days to maturity. These traits contributed maximum towards total divergence in the landraces of rice revealing ample scope for improvement of these traits.

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APPENDICES

VIII APPENDIX

Appendix I : Mean values of all the thirteen characters of 51 landraces of rice

Sl. No.	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁	X ₁₂	X ₁₃
1	134.50	157.50	17.97	0.55	71.00	0.66	8.17	7.56	19.50	2.83	56.72	17.17	15.95
2	74.77	117.50	16.75	0.47	91.00	0.38	17.40	16.10	20.77	2.48	82.71	31.31	28.03
3	135.00	171.50	24.98	0.67	82.50	0.38	13.34	12.34	19.50	2.46	62.33	17.52	21.85
4	115.00	140.50	29.78	0.42	108.00	0.35	11.50	10.63	27.75	2.65	58.95	16.75	21.80
5	94.00	132.50	29.50	0.54	133.00	0.56	10.87	9.47	22.00	2.30	67.99	27.50	16.88
6	129.00	175.00	19.94	0.50	90.50	0.32	17.36	15.81	29.50	2.31	63.66	25.30	27.05
7	119.50	176.50	27.99	0.35	142.00	0.41	9.12	7.46	19.50	3.01	58.00	23.56	16.88
8	141.50	158.50	25.58	0.55	87.25	0.45	13.27	12.51	24.50	2.36	65.12	24.29	20.82
9	75.50	111.00	30.89	0.49	111.00	0.70	12.87	11.01	22.75	1.60	74.26	27.64	18.87
10	94.00	138.50	32.75	0.34	120.00	0.69	15.22	13.90	34.50	2.52	66.91	23.74	21.19
11	129.00	136.50	22.99	0.85	85.00	0.75	15.45	14.26	24.50	2.64	60.34	24.52	22.27
12	141.50	159.00	29.57	0.78	124.50	0.85	19.75	18.77	26.75	2.92	69.33	27.25	24.52
13	95.50	148.00	25.68	0.92	70.00	0.65	24.23	23.61	24.79	2.59	75.98	25.35	25.25
14	128.50	158.50	31.83	0.74	118.00	0.55	18.28	15.25	29.25	2.18	72.64	25.33	21.23
15	70.50	112.00	33.78	0.98	91.50	0.47	15.32	12.87	26.50	1.89	71.60	20.54	19.62
16	134.50	169.50	39.57	0.87	104.00	0.29	14.00	11.35	24.00	2.49	81.73	17.75	18.20
17	122.00	159.50	27.58	0.67	110.00	0.45	19.40	11.69	26.24	3.42	82.27	20.29	19.32
18	124.00	161.00	33.25	0.84	105.50	0.58	11.97	9.92	23.04	2.08	79.12	18.50	18.96
19	124.00	122.00	27.25	0.67	85.50	0.67	24.43	21.44	20.49	2.77	74.03	28.46	26.16
20	135.50	138.50	20.50	0.89	93.00	0.47	12.99	9.50	25.75	2.55	74.38	23.50	22.45
21	136.76	135.00	30.25	0.62	89.50	0.64	13.35	9.30	28.24	2.65	70.30	22.15	21.48
22	124.00	159.00	29.97	0.82	111.00	0.55	15.00	14.34	24.75	1.54	74.14	17.98	17.85
23	134.00	118.00	25.97	0.35	93.00	0.72	25.11	21.58	30.50	2.44	79.81	27.14	27.00
24	140.50	142.50	27.10	0.74	92.00	0.45	27.95	22.50	27.78	2.56	80.79	35.01	33.00
25	116.00	169.00	30.59	0.75	123.50	0.35	16.13	16.03	22.00	3.06	81.29	23.25	23.40
26	115.50	93.50	34.58	0.85	106.50	0.70	19.57	17.49	20.00	2.24	73.12	24.57	24.79

27	124.50	86.60	31.06	0.84	115.50	0.65	19.66	16.87	19.50	2.10	66.70	21.04	21.75
28	133.70	163.49	39.75	0.72	98.50	0.82	24.34	21.53	31.77	2.23	75.98	32.10	29.50
29	146.00	179.49	31.62	0.58	106.00	0.54	29.12	24.44	26.50	1.70	82.72	32.57	31.24
30	135.50	118.00	31.79	0.71	85.50	0.36	15.25	12.69	22.50	2.27	77.38	25.19	24.92
31	124.50	116.00	32.82	0.77	96.50	0.47	19.09	12.22	21.500	2.70	73.44	26.48	25.02
32	131.50	96.50	36.14	0.69	90.00	0.31	24.00	21.62	34.78	2.30	76.78	27.97	25.03
33	145.00	122.50	26.50	0.91	81.75	0.74	27.13	25.50	19.50	2.15	82.80	30.54	29.74
34	126.50	130.50	24.90	0.59	74.00	0.35	10.52	8.96	18.50	2.30	88.43	17.50	17.57
35	128.50	146.50	33.25	0.44	123.50	0.29	26.90	23.95	23.25	1.88	83.00	32.60	30.60
36	127.50	157.50	33.00	0.65	106.50	0.37	26.99	25.49	27.77	2.47	83.91	30.05	30.22
37	146.26	169.00	41.50	0.65	94.10	0.62	19.38	17.14	32.77	2.20	76.21	21.90	22.50
38	122.00	141.50	41.75	0.55	115.50	0.70	27.17	24.27	35.56	3.22	77.40	30.54	29.69
39	121.25	151.00	34.99	0.88	86.00	0.81	25.68	24.47	34.75	3.03	76.50	29.53	29.25
40	136.50	162.00	38.88	0.98	98.50	0.36	15.10	12.36	27.24	3.19	44.71	26.10	24.99
41	144.78	158.50	34.17	0.49	115.55	0.27	13.66	10.16	34.63	2.25	63.40	18.89	18.28
42	134.50	92.50	34.57	0.61	78.50	0.67	18.32	16.63	21.79	2.91	75.84	22.86	22.71
43	120.28	142.00	37.00	0.97	105.82	0.42	18.18	15.99	28.04	1.96	56.35	24.31	23.55
44	122.76	150.00	33.53	0.50	92.00	0.27	15.78	13.65	22.06	1.95	72.95	24.67	22.64
45	128.56	141.50	34.95	0.49	115.60	0.40	27.23	24.75	27.95	1.86	77.92	32.30	30.99
46	115.50	127.50	31.70	0.87	76.01	0.74	18.77	15.63	27.79	2.67	77.39	22.56	22.15
47	135.00	141.50	35.53	0.49	99.00	0.76	21.76	19.66	26.00	3.35	82.85	27.41	14.98
48	140.50	133.50	39.50	0.60	111.00	0.64	27.61	22.38	29.50	3.08	78.00	29.68	29.21
49	132.50	127.00	33.78	0.69	84.00	0.31	28.71	27.00	24.00	2.44	62.50	31.25	29.81
50	121.75	133.50	34.78	0.76	78.50	0.31	14.97	13.10	17.25	2.39	75.50	20.57	20.17
51	124.50	137.00	29.78	0.79	73.49	0.44	16.66	13.66	22.75	1.73	70.54	20.39	19.87
Mean	124.59	140.89	31.04	0.67	98.82	0.52	18.70	16.29	25.54	2.45	72.88	25.00	23.55

X₁- Days to 50 per cent flowering, X₂- Days to maturity, X₃- Leaf length (cm), X₄- Leaf width (cm), X₅- Plant height (cm), X₆- Stem thickness (cm), X₇- Total number of tillers per plant, X₈- Number of productive tillers per plant, X₉- Panicle length (cm), X₁₀- L/B ratio, X₁₁- Panicle fertility (%), X₁₂- Test weight (g), X₁₃- Yield per plant (g).