Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes

By

MAQSOODULLAH

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THESIS

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KERALA, INDIA

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DECLARATION

I, hereby declare that the thesis entitled **"Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

Date: 09/09/2020

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CERTIFICATE

Certified that the thesis entitled **"Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes"** is a record of research work done independently by **Mr. Maqsoodullah** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship to him.

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CERTIFICATE

We, the undersigned members of the advisory committee of **Mr. Maqsoodullah** a candidate for the degree of **Master of Science in Agriculture** with major field in **Plant Breeding and Genetics,** agree that the thesis entitled **"Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes"** may be submitted by **Mr. Maqsoodullah** in partial fulfilment of the requirement for the degree.

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Dedicated to My

Beloved Brothers and My

Wife…!

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LIST OF ABBREVIATED TERMS

Abbreviation	Full Name
DUS	Distinctness, Uniformity and Stability
PPV&FR	Protection of Plant Varieties and Farmers' Rights
UPOV	International Union for the Protection of New Varieties of Plants
NBPGR	National Bureau of Plant Genetic Resources
ABD	Augmented block design
ANOVA	Analysis of variance
TCR No.	Thrissur collection ID
Coll. No.	Collection number
ACC No.	Accession number
EC No.	Exotic collection number
ICAR	Indian Council of Agricultural Research
IRRI	International Rice Research Institute
KAU	Kerala Agriculture University
TS	Total score
CD	Critical difference
SPSS	Statistical package for social science
mm	Milimeter
cm	Centimeter
m	Meter
m^2	Square meter
^oC	Degree celcius
%	Per cent
g	Gram

Introduction

1. INTRODUCTION

Rice (*Oryza sativa* L. 2n = 24) the most ancient and major food crop of the world, is being cultivated over 10,000 years. It is a staple food crop, feeding more than 60 per cent of the world's population. Other edible uses of rice include, rice flakes, puffed rice, rice wafers, canned rice *etc*. It is also used in starch and brewing industries. The by-product of rice milling *i.e*. rice husk and bran are also used as cattle and poultry feed. Rice is a nutritional cereal crop, providing 20 per cent of the calories and 15 per cent of proteins consumed by world's population. Although, it is a chief source of carbohydrates and protein in Asia, it also supply minerals and fibres (Sajid *et al*. 2015).

Genetic diversity in *Oryza* species far exceeds that in any other crops. There are thousands of rice varieties, genotypes, land races and wild species which vary based on plant and grain characteristics such as plant type, height, nature of leaves, grain size, texture, glutinous nature, aroma, cooking and nutritious quality. Accurate type of cultivar selection is the most essential feature for elevating rice production. Morphological characterization is the main step in the classification and assessment of the germplasm. In order to provide information for plant breeding programmes, agro-morphological characterization of germplasm accessions is one of the most essential aspects.Evaluation of germplasm collections is essential for maintenance of the diversity and identification of valuable genes.

Numerous morphological features acts as the crucial aspect of rice grain yield. Plant height, tillering and panicle morphology are very significant for identification of grain production of rice. Genetic diversity of rice is an insurance against crop failure. The only way to ensure food security for future generations is to exploit the present day genetic diversity and to identify the promising genotypes for future breeding programmes.

With the enactment of Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001 by Government of India, morphological characterization based on DUS (Distinctness, Uniformity and Stability) is the requisite for registering varieties under PPV&FR Act. This is essential for the IP protection over crop varieties including farmers' rights.

Exotic cultivars are the most important resources which, may offer desirable genes for new biotic and abiotic stresses, and may represent unique alleles for productivity that are not available in the indigenous germplasm of rice. The limited genetic variation within the indigenous germplasm of rice can be expanded by incorporating variability from exotic germplasm.

Therefore, the present study was taken up with the following objectives:

1. To characterize exotic germplasm of rice according to guided descriptor.
2. To find out rice genotypes with their diverse growth parameters and yield contributing characters for yield and quality attributes.
3. To find out the genotypes which have potential characters for using in further breeding programmes.

Review of literature

2. REVIEW OF LITERATURE

The literature relevant to the present study entitled "Characterization of exotic germplasm of rice (*Oryza sativa* L.), for yield and quality attributes" through morphological characters and quality attributes has been reviewed here.

Characterization and identification of genetic diversity in crops especially in rice is one of the most important achievements in evolutionary biology to obtain exact information in respect to the extent of genetic divergence. It allows identification, enhancement of core collection, grouping of accessions and retrieval of valuable germplasm for breeding programmes, resulting in better insight about the composition of the collection and its genetic diversity.

Evaluation of genetic diversity is an integral part of any successful and productive breeding program. Breeders are using morphological markers to estimate genetic diversity and a range of morphological descriptors in different crops for identification target trait have been identified (Rana and Bhat, 2004). Morphological traits such as seed color and shape, grain length and width, kernel length, breadth and shape, awn, thousand grain weight etc. and plant characters such as culm length, heading time, maturity time, number of primary branches, number of secondary branches, length of panicle, number of effective tillers per plant, seed in panicle and so on, can be used in identifying of rice genotypes. Genetic studies have shown that these traits are highly heritable and therefore, can be easily used in distinguishing varieties.

2.1. Morphological characterization

Characterization and description of germplasm is very important to obtain information regarding the characters of accessions which are collected for the final users to assure the maximum use of germplasm. It helps and determine the manifestation of highly heritable traits differing from morphological or agronomical aspect to molecular marker. The accurate collection and recording data is a very essential aspect to distinguish accessions within a species among phenotypes. Collection and identification of the valuable germplasm allows grouping of accessions for better breeding programmes.

Seventy-one aromatic rice collected from all over Japan, were cultivated along with twenty-one aromatic cultivars collected from 7 countries and 18 non-aromatic cultivars of Japan. They were evaluated for their aromatic features and agronomic characteristics. The local Japanese aromatic cultivars had greater height, fewer and larger panicles, high straw weight, lower yield, less tolerance to lodging and more awns than the varieties. The local Japanese aromatic cultivars were categorized into eastern and western groups morphologically (Itani, 2002).

Nabeela *et al.* (2004) conducted an experiment with one hundred-twenty-four landraces of rice for 7 quantitative and 8 qualitative traits. The landraces were late in flowering and maturity compared to the modern cultivars, but had lower values for panicle and grain length. Finally seven accessions were identified and recorded with high performance for individual traits.

Doebley *et al.* (2006) characterized wild and cultivated species of rice based on morphological and physiological characteristics viz. seed shattering, stem growth habit, awn length, and or seed colour.

Hien *et al.* (2007) worked with sixty-six aromatic rice cultivars collected from Asia for determination of range of diversity between them. Twenty-two morphological traits with 101 morphometric descriptors were found in the germplasm. All traits except ligule color, grain size, grain shape, culm strength; plant height and secondary branching contributed the mean diversity indices.

Rice cultivars exhibited wide variations on the basis of morphological traits like, length of awn, length of panicle, leaf blade color and leaf sheath colour. These were the most important morphological traits in identification of rice. Thus, other morphological traits such as node base colour, awning, distribution of awns, anthocyanin colouration of stem nodes, internodes and stigma colour were the secondary important traits which, can be used for identification of rice cultivars (Mehla and Kumar, 2008).

Thirty-two aromatic rice accessions of Chhattisgar germplasm was characterized by Bisne and Sarawgi (2008) and these germplasm accessions were observed for twenty-two morphological, six agronomical and eight quality traits. The specific genotypes B: 1340, B: 2039, B: 2495, B: 2816, B: 16930, B: Z354, B: 1163, B: 2094 were recognized for quality and agronomical features. Hence, these accessions may be utilized in hybridization program to obtain desired segregate for good grain quality with better yield.

Sarhadi *et al.* (2008) evaluated rice germplasm for most essential agronomic attributes and aroma in twenty-six cultivars from Afghanistan, Iran, and Uzbekistan, along with varieties from Japan, Thailand and India. The plant height detected among countries was diverse. Afghan cultivars were classified as tall, and Iranian and Uzbek intermediate and short, respectively. Variation in panicle, grain, leaf, basal internodes, and culm dimension was observed among rice cultivars, indicating rice diversity in Central Asia. Six out of ten, two out of seven and zero out of six of Afghan, Iranian, and Uzbek rice cultivars, respectively, were aromatic indicating Afghan cultivars as good source of aromatic rice germplasm for Central Asia.

Mathure *et al.* (2011) evaluated sixty-nine genotypes for various traits and found thirty six exquisite genotypes to have one or more desirable characters, like early flowering, dwarf stature, long panicles, higher number of productive tillers per plant and strong aroma.

Forty-six aromatic rice accessions of Dubraj group from Chhattisgarh and Madhya Pradesh were evaluated for twenty morphological, six agronomical and eight quality characters. They identified accession 10190 with good quality and agronomical characteristics which can be used as a potential donor in hybridization programme to obtain anticipated segregates for grain quality with higher yield (Sarawgi *et al.* 2012).

A wide range of variability for all the morphological characters were observed in seventy-one aromatic rice accessions by Parikh *et al*. (2012) on the basis of characters such as basal leaf sheath colour, leaf blade colour, ligule colour, plant habit, apiculus colour and awning exhibited more variation among the accessions. Majority of the genotypes were observed to have green leaf blade colour, green tip colour and green leaf margin.

Subba *et al*. (2013) worked with sixty-five landraces of rice using forty-three agro-morphological characters following Distinctiveness, Uniformity, Stabilty (DUS) descriptor. Out of sixty-five varieties evaluated, thirty-two were observed to be distinguishing on the basis of twenty-two important traits.

Saini *et al.* (2013) observed wide variability with respect to plant height, culm length, days to heading, spikelets per panicle and grains per panicle. They observed moderate variability for length of leaf blade, total tillers per plant, productive tillers per plant, panicle length, straw and grain yield. Range of variability with respect to grain width, test weight of grain, grain length and stem thickness was narrow.

Singh *et al.* (2014) evaluated forty-eight upland rice germplasm accessions and they categorized them for fourteen quantitative and fifteen qualitative characters. The most promising accessions identified for yield were PKSLGR-16, PKSLGR-23, PKSLGR-43 and PKSLGR-45.

According to Sarawgi *et al.* (2014), 87.25 and 89.70 per cent of genotypes showed green basal leaf sheath color and green leaf blade color, respectively in the germplasm they evaluated. Percentage of other traits were like well panicle exertion (57.10 per cent), white stigma color (65.93 per cent), straw coloured apiculus (78.18 per cent), awnlessness (88.48 per cent), straw coloured hull (70.34 per cent), intermediate threshability (47.30 per cent), erect flag leaf angle (57.59 per cent), medium leaf senescence (67.15 per cent) and straw coloured sterile lemma (97.05 per cent) when they observed for eighteen qualitative characters in 408 rice germplasm accessions.

Sinha *et al*. (2015) reported wide range of variation for grain size and shape, anthocyanin colouration of lemma, palea and kernel, presence or absence of aroma and awning characteristics in fifty-five traditional rice varieties.

Sixty-four aromatic rice germplasm were characterized by Kumar *et al.* (2016) for 35 agro morphological and quality characters and all the sixty four accessions were found to be dissimilar on the basis of thirty one agro-morphological and quality characteristics. They suggested that the accessions having very long panicle, short stem length, large number of panicle per plant, and extra-long slender grain can be used as potential donor in hybridization programs.

Singh *et al*. (2016) studied twenty (ten mega varieties and ten landraces) varieties of rice by using twenty-three morphological characters according to guided descriptors. Among the 23 DUS traits utilized in the characterization of 20 rice genotypes, 6 traits viz., the basal leaf sheath color, color of ligule, shape of ligule, auricles, anthocyanin coloration of auricles and anthocyanin coloration of nodes exhibited no difference among the cultivars.

Umarani *et al.* (2017) characterized seventy landraces of rice on the basis of fourteen traits as per DUS guidelines. They reported that out of fourteen traits studied, stem anthocyanin colouration of node was dimorphic, while three characters (colour of stigma, stem length and panicle exsertion) were trimorphic. Basal leaf sheath colour, time of flowering (50per cent plants with panicles), flag leaf attitude , panicle length, decorticated grain length and shape were tetramorphic and lemma anthocyanin colouration of apex and amylose content exhibited five classes and decorticated grain colour exhibited six groups.

Rawte and Saxena, (2018) worked with hundred landraces of rice collected from different parts of Chhattisgarh. The data were recorded on 30 different agro-morphological characters (19 qualitative and 11 quantitative). The germplasm of rice showed high genetic variation for majority of qualitative and quantitative traits. High variability was observed with time to 50 per cent flowering, time to maturity, 1000 grains weight, stem length, grain length and width. Out of 30 different agro-morphological traits, five characteristics observed monomorphic and the rest of the traits showed variation among the accessions.

Manjunatha, *et al.* (2018) conducted an experiment on sixty landraces of rice along with aromatic genotypes which were collected from various regions of Wayanad of Kerala. They studied both qualitative and quantitative traits based on International Union for the Protection of New Varieties of Plants (UPOV) and Protection of Plant Varieties and Farmers Right Authority (PPV&FRA) guidelines. They reported that out of 24 characters, five characteristics were monomorphic, thirteen were dimorphic, four were trimorphic, one trait (basal leaf sheath colour) was tetramorphic and stem length including panicle was having five groups.

2.2 Clustering of genotypes

Nascimento *et al.* (2011) characterized 146 accessions of upland rice based on qualitative and quantitative agro-morphological descriptor. Based on cluster analysis for qualitative traits the accessions were classified in two groups. Grouping based on quantitative traits resultd in three clusters. The most divergent group of accessions included the genotypes Mitsukasane, Mie, Tomoe mochi, Ooba kirishima and Nourin mochi 6, which showed a higher number of spicklets per plant.

Sahu *et al.* (2014) studied five rice germplasm accessions namely, Amajhopa, Koudidhul, Chhindguchhi, Nariyal phool and Amaruthi. UPGMA cluster analysis performed using SM similarity coefficient matrices grouped the genotypes into two clusters with similarity coefficient ranging from 0.29 to 0.91. In pair-wise comparison, the maximum similarity was obtained between Ama Jhopa and Nariyal

Phool with a similarity index of 0.91, whereas Ama Ruthi showed least similarity with other genotypes (similarity index 0.29).

Elyasi *et al.* (2014) studied 24 different genotypes of modified native rice and clustering was done based on Ward's method. Results showed that genotypes were divided in to three clusters. Nemat genotypes, 203 and 416 fall in to cluster I, while Gharib and Khezr belong to cluster II. Cluster III consisted of Saleh, Sallari, Hasan Sarai, Binam and Hassani. Comparing clustering average based on Duncan test showed genotypes having high yield was in cluster I.

Mondal *et al*. (2014), did DUS characterization for 21 rice varieties based on 46 qualitative and 14 quantitative characters. Varieties were clustered following the eight grouping characteristics recommended by PPV & FRA. Improved landrace and conventionally bred varieties fall in to separate clusters.

Ahmed *et al.* (2015), studied ten similar or duplicate named Dhaliboro rice germplasm of Bangladesh for twenty-one qualitative characters. The dendrogram based on UPGMA clustering method, distributed the Dhaliboro genotypes along with BRRI dhan 28 and BRRI dhan 29 into three clusters for the nineteen qualitative agro-morphological traits. Cluster III was the major one with maximum genotypes (9), while cluster I consisted with BRRI dhan 28 and BRRI dhan 29 and cluster II consisted only DB5. It was revealed that the genotype DB2 and DB6 were found duplicate, which indicated that they were 100 per cent similar.The genetic distance, ranging from 0.000 to 9.646, also revealed the existence of significant differences among the duplicate named Dhaliboro rice. The highest distances (9.646) was recorded between genotype DB1 and DB4. Finally, duplicate named Dhaliboro rice germplasm showed exclusive variability and unique features for utilization in future breeding programme.

Alia *et al.* (2016) characterized indigenous rice accessions on the basis of twenty four qualitative traits. Cluster analysis for qualitative traits, identified four clusters at a dissimilarity level of 2.31. It is seen that rice genotype 007664 showed much variation for qualitative traits.

Kumar (2016) characterized 65 indigenous accessions of rice for 48 qualitative and quantitative characters. On the basis of Divergence analysis genotypes were grouped into five clusters. The highest numbers of genotypes (39 nos) were present in cluster III. Cluster II had maximum intra-cluster distance and maximum inter-cluster distance was observed between cluster II and cluster IV.

Ahmed *et al*. (2018) evaluated fifty-four T. Aman rice landraces for 11 morphological and yield contributing characters. Based on D2 values, the genotypes were grouped into 15 clusters. Seven genotypes were grouped into the clusters IV and VI, whereas clusters III and XIII contained only one genotype each. Highest intra-cluster distance (1.0) was found in cluster II and the lowest (0.0) in clusters III and XIII. Range for inter-cluster D2 values was 19.2 to 0.6, indicating wide range of diversity among the germplasm. Highest leaf length and culm diameter was observed in cluster XIII. Highest effective tillers per hill were seen in cluster IX. Genotypes of cluster II had lowest days to maturity, while cluster XV had highest grain length of 6.1 mm and cluster I had highest grain LB ratio (2.97). Cluster VIII showed the highest yield per hill (22.0 g), panicle length and 1000 grain weight. Hence, genotypes belonging to cluster VIII may be selected for crossing with the germplasm from clusters XIII, IX, II, XV and I for developing high yielding varieties with improved panicle length, effective tillers per hill, growth duration and grain type.

Islam et al. (2018a) characterized 113 accessions of aromatic rice germplasm based on qualitative descriptors. No duplicates were identified among the accessions for qualitative traits in the cluster analysis. UPGMA cluster analysis, grouped 113 accessions of aromatic germplasm in to ten distinct clusters. The highest numbers of germplasm (96) were found in cluster IXd, two each were found in cluster III, IV and VI, 3 were found in IXc and only one genotype each was observed in cluster I, II,V, VII, VIII, IX a, IXb and X

2.2 Correlation coefficient analysis

The statistical method which measure the degree and direction of association or relationship among two or more variables is called correlation. It represent the degree of linear combination between pairs of traits and can form as a basis of selection. The available of literature on correlation in rice is reviewed here.

Highly positive correlation of grain yield per plant was observed with biological yield, total and productive tillers per plant, 1000 grain weight and panicle length by (Verma and Srivastava, 2004).

Nabeela *et al.* (2004) based on their study with one hundred-twenty-four landraces of rice found that time to flowering was positively associated with maturity (r=0.833) and grain length (r=0452). Plant height displayed positive and significant correlation with panicle length (r=0.452), signifying the importance of plant height in enhancing of panicle length.

The grain yield per plant had positive correlation with spikelet fertility, panicle length, number of grains per panicle and number of effective tillers per plant (Satyanarayana *et al*., 2005).

Xu *et al.* (2005) indicated that panicle length was negatively associated to grain insertion density, grain quality, and seed-setting ability because of extreme length of panicle is not advantageous for erect positioning and thus disadvantageous for photosynthesis.

The positive correlation of spikelet yield with plant height, number of production tillers hill-^{1}, and dry matter plant-^{1} and harvest index at fifteen phenotypic and genotypic level reported by (Shashidhar *et al.,* 2005).

The significant positive association of grain yield per plant with the characters viz., plant height, number of effective tillers per plant, panicle length, number of grains per panicle, spikelet fertility per cent and 1000 grain weight has been observed by (Muthuswamy and Kumar, 2006).

Girish *et al.* (2006) observed positive and high correlation of grain yield per plant with plant height, panicle length, number of spikelets per panicle, number of tillers per plant, biological yield, harvest index and grain breadth.

According to Agahi *et al.* (2007), grain yield was positively associated with days to flowering, number of productive tillers per plant, time to maturity, number of grain per panicle and plant height.

Positive correlation with grain yield was observed for panicle length, panicles/plant, plant height, filled grains/panicle and harvest index (Akter *et al.,* 2007).

Khan *et al.* (2009) reported significant and positive correlation of grain yield per plant with plant height, panicle length, flag leaf width and number of grains per panicle.

Akhtar *et al.* (2011) observed genotypic and phenotypic correlation for yield contributing traits in ten rice genotypes. They reported that yield had high genetic correlation with number of grains per panicle, days to maturity and 1000 grain weight.

Sadeghi, (2011) also found that grain yield had significant and positive association with grains per panicle, days to maturity, number of productive tillers and days to flowering.

According to Ashfaq *et al*. (2012), there was positive relationship of plant yield with panicle length, productive tillers per plant, number of grain per panicle, and grain weight per panicle. The yield component characters like, panicle length was associated with flag leaf area, number of primary branches per panicle, number of spikelets per panicle, number of seeds per panicle and grain weight per panicle. These component characters also had a great contribution to the enhancement of yield.

Satheesh and Saravanam, (2012) calculated association in fifty-three genotypes of rice for 15 characters and observed that grain yield per plant showed significant and positive genotypic association with the number of productive tillers per plant, total number of grain and filled grains per panicle.

Mamun *et al.* (2012) worked with fifty exotic rice genotypes for yield and yield contributing characters. The highest significant positive correlation of grain yield was with days to first flowering, days to harvesting, filled grains per panicle followed by grain length at genotypic and phenotypic level.

Forty exotic and Indian germplasm involving one local standard variety were evaluated by Rangare *et al*. (2012). They reported that an enhancement in grain yield, can be achieved by intensive selection for biological yield per plant, number of spikelet per panicle, number of fertile tillers per plant, test weight, panicle length and days to maturity as these traits exhibited highly positive correlation with grain yield. However, days to initial flowering, days to 50 per cent flowering, harvest index and plant height had positive but non-significant correlation with grain yield.

Chakravorty *et al*. (2013) studied fifty-one landraces of rice to work out the interrelationship among 18 agro-morphological traits and found all the traits except ligule length, culm length, number of grains per panicle and number of primary branches per panicle were significantly and positively correlated with kernel weight.

The significant correlation of days to flowering, number of effective tillers, 1000 grain weight with grain yield per plant were observed in rice by Rashid *et al.*

(2014), while the flag leaf area, plant height and panicle length displayed significant negative association with grain yield per plant.

Evaluation of seventy genotypes of rice (*Oryza sativa* L.) by Lakshmi *et al.* (2014) showed that grain yield per plant was significantly and positively associated with days to maturity, number of productive tillers per plant, plant height and kernel length.

Correlation studies were conducted for fourteen morphological characters in six advanced lines of basmati rice along with check variety BRRI Dhan 29 by Ratna *et al.* (2015). They observed significant positive correlation between plant height and panicle length and number of filled spikelets per panicle and yield. However, plant height had significant negative correlation with yield. Number of effective tillers per plant had negative correlation with panicle length and with number of unfilled spikelets per panicle. Number of ineffective tillers/plant had significant negative correlation with 1000-seed weight.

Anis *et al.* (2016) evaluated eleven hybrid combinations and two check varieties to find out interrelationships of yield and yield components of rice. Study showed significant and positive correlations in most of the cases. The highest value of correlation was found between flag leaf area and panicle length (0.788). Grain yield showed significant positive correlation with number of panicles per plant.

A study of Kumar *et al.* (2018) showed that, biological yield per plant, harvest index, spikelet fertility, 1000-grain weight, L/B ratio, plant height and panicle length showed significant and positive correlation with grain yield per plant.

Prakash *et al.* (2018) have done correlation analysis in rice for sodicity tolerance. They observed highly significant and positive correlation of grain yield per plant with plant height, flag leaf area, panicle bearing tillers per plant, panicle length, grains per panicle, 1000 grain weight and biological yield per plant.

According to Shrestha *et al.* (2018), grain yield had positive and significant association with 1000 grain weight, flag leaf area and SPAD reading.

Li *et al*. (2019) have done an extensive study on relationship between yield and other agronomic traits using traits of 7686 rice varieties, released in China from 1978 to 2017. They assessed the association between yield and other agronomic traits for four different rice ecotypes, i.e., indica inbred, indica hybrid, japonica inbred, and japonica hybrid. They observed that the associations between agronomic traits and yield were ecotype-dependent. For indica inbred and indica hybrid ecotypes, greater values of filled grain number per panicle, 1000-grain-weight, plant height, panicle length, grains per panicle, seed setting rate, long growth period, low panicle number per unit area, and low seed length/width ratio, resulted in high grain yield. In the japonica inbred and japonica hybrid ecotypes, only high panicle number per unit area and long growth period led to high grain yield. Duration of crop consistently had a positive effect on yield in all ecotypes, and plant height had a positive effect on yield for the indicas and japonica inbred only. Plant height had a negative effect for japonica hybrid.

Materials and methods

3. MATERIALS AND METHODS

3.1 Experimental site

Study on **"Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes"** was conducted in the Department of Plant Breeding and Genetics, College of Horticulture, Kerala Agricultural University and at the experimental farm of NBPGR (National Bureau of Plant Genetic Resources) Regional station, Velannikkarra, Thrissur, during June 2019 to October 2019. The site lies between 10^o 10' and 10^o46' North latitude and 75^o 57' and 76^o 54' East longitude.

3.2 Planting materials

Hundred exotic accessions of rice along with five check varieties (Jyothi, Jaya, Thulasi, Vaiashak and Manurathna) were used in the study. The seeds of accessions were collected from NBPGR (National Bureau of Plant Genetic Resources), Regional station, Velannikkara, Thrissur. Descriptions of the accessions are given in the Table 1.

3.3 Design and layout

The experiment was set in augmented completely randomized design (Augmented design I) as proposed by Federer 1956. It is an experimental design which is used to test a large number of germplasm lines in limited area is known as augmented design (Singh and Narayanan, 2017).

The field was divided into 5 blocks; each block contained 25 lines of rice genotypes including check varieties and the germplasm are allotted in each line randomly. Each plot size was $5m^2$ with 1m boarder maintained surrounding the field and every block. Spacing followed was row to row distance of 20 cm and plant to plant distance of 15 cm. The twenty-five genotypes each were distributed to every block randomly along with check varieties. List of accessions with TCR number and check varieties in experiment layout presented inTable 2.

Table 1. Details of exotic rice germplasm used in the study

No	TCR No	Coll. No.	ACC No.	No	TCR No	Coll. No.	ACC No.	No	TCR No	Coll. No.	ACC No.
1	2036	AC-720	EC 182353A	36	6627	IRRI 0001	EC 415392	71	6670	IRRI 0044	EC 415435
2	3724	ACC-04056	EC 207737	37	6628	IRRI 0002	EC 415393	72	6671	IRRI 0045	EC 415436
3	3734	ACC-04066	EC 207747	38	6629	IRRI 0003	EC 415394	73	6672	IRRI 0046	EC 415437
4	3793	ACC-04125	EC 204847	39	6631	IRRI 0005	EC 415396	74	6673	IRRI 0047	EC 415438
5	3809	ACC-06280	EC 204863	40	6632	IRRI 0006	EC 415397	75	6674	IRRI 0048	EC 415439
6	3810		EC 204864	41	6634	IRRI 0008	EC 415399	76	6676	IRRI 0050	EC 415441
7	3811	ACC-06331	EC 204865	42	6636	IRRI 0010	EC 415401	77	6677	IRRI 0051	EC 415442
8	3814	ACC-06393	EC 204868	43	6637	IRRI 0011	EC 415402	78	6679	IRRI 0053	EC 415444
9	3832		EC 204885	44	6638	IRRI 0012	EC 415403	79	6680	IRRI 0054	EC 415445
10	3874	ACC-11726	EC 204928	45	6639	IRRI 0013	EC 415404	80	6681	IRRI 0055	EC 415446
11	3916	ACC-16353	EC 204970	46	6640	IRRI 0014	EC 415405	81	6682	IRRI 0056	EC 415447
12	3936	ACC-19492	EC 204991	47	6641	IRRI 0015	EC 415406	82	6683	IRRI 0057	EC 415448
13	3943	ACC-19928	EC 204999	48	6642	IRRI 0016	EC 415407	83	6684	IRRI 0058	EC 415449
14	3945	ACC-20461	EC 205001	49	6643	IRRI 0017	EC 415408	84	6685	IRRI 0059	EC 415450
15	3985A	ACC-26530	EC 205042	50	6644	IRRI 0018	EC 415409	85	6686	IRRI 0060	EC 415451
16	3990	ACC-26803	EC 205047	51	6645	IRRI 0019	EC 415410	86	6687	IRRI 0061	EC 415452
17	4011A	ACC-27782A	EC 205070	52	6646	IRRI 0020	EC 415411	87	6689	IRRI 0063	EC 415454
18	4013	ACC-28505	EC 205072	53	6647	IRRI 0021	EC 415412	88	6690	IRRI 0064	EC 415455

19	4067	ACC-39188	EC 205128	54	6648	IRRI 0022	EC 415413	89	6691	IRRI 0065	EC 415456
20	4104	ACC-50355	EC 205166A	55	6649	IRRI 0023	EC 415414	90	6692	IRRI 0066	EC 415457
21	4130	ACC-55958	EC 205192	56	6650	IRRI 0024	EC 415415	91	6693	IRRI 0067	EC 415458
22	4132	ACC-55969	EC 205194	57	6651	IRRI 0025	EC 415416	92	6694	IRRI 0068	EC 415459
23	4133	ACC-55981	EC 205195	58	6652	IRRI 0026	EC 415417	93	6695	IRRI 0069	EC 415460
24	4142	ACC-31715	EC 205204	59	6655	IRRI 0029	EC 415420	94	6696	IRRI 0070	EC 415461
25	4143	ACC-37799	EC 205205	60	6656	IRRI 0030	EC 415421	95	6697	IRRI 0071	EC 415462
26	4161	ACC-25491	EC 205223	61	6657	IRRI 0031	EC 415422	96	6698	IRRI 0072	EC 415463
27	4190	ACC-27789	EC 205252	62	6658	IRRI 0032	EC 415423	97	6699	IRRI 0073	EC 415464
28	4202	ACC-27803	EC 205264	63	6660	IRRI 0034	EC 415425	98	6700	IRRI 0074	EC 415465
29	4207	ACC-27809	EC 205269	64	6661	IRRI 0035	EC 415426	99	6703	IRRI 0077	EC 415468
30	4212	ACC-27818	EC 205275	65	6662	IRRI 0036	EC 415427	100	6705	IRRI 0079	EC 415470
31	4232	ACC-38652	EC 205295	66	6663	IRRI 0037	EC 415428		**Check varieties**	Jyothi	
32	4242	ACC-40792	EC 205305	67	6664	IRRI 0038	EC 415429			Jaya	
33	4251	ACC-05159	EC 205314	68	6666	IRRI 0040	EC 415431			Thulasi	
34	4257	ACC-32291	EC 205321	69	6668	IRRI 0042	EC 415433			Vaiashak	
35	4268	ACC-03033	EC 205333	70	6669	IRRI 0043	EC 415434			Manurathna	

Table 2. List of accessions with EC number and check varieties in experiment layout

Block- 1		Block- 2		Block- 3		Block- 4		Block- 5	
No	**ACC No.**	**No**	**ACC No.**	**No**	**ACC No.**	**No**	**ACC No.**	**No**	**ACC No.**
1	EC 415451		Manurathna	41	EC 205314	61	EC 415409		Jyothi
2	EC 207737	21	EC 415458	42	EC 205321	62	EC 415410	81	EC 204864
3	EC 415452	22	EC 415459	43	EC 205333	63	EC 415411	82	EC 415431
	Jyothi	23	EC 205192	44	EC 415392		Thulasi	83	EC 204865
4	EC 415454	24	EC 205194	45	EC 415393	64	EC 415412	84	EC 415433
5	EC 207747	25	EC 205195	46	EC 415394	65	EC 415413		Manurathna
6	EC 415455		Vaiashak		Jyothi	66	EC 415414	85	EC 415434
7	EC 204863	26	EC 205204	47	EC 415468	67	EC 415415	86	EC 415435
8	EC 415456	27	EC 205205	48	EC 415396		Vaiashak	87	EC 415436
9	EC 204928	28	EC 205223	49	EC 415397	68	EC 415416	88	EC 415437
10	EC 204970	29	EC 415460	50	EC 204885	69	EC 415417	89	EC 415438
11	EC 204991	30	EC 415461		Thulasi	70	EC 182353A		Thulasi
	Manurathna	31	EC 205252		Manurathna		Jyothi	90	EC 415439
12	EC 204999	32	EC 205264	51	EC 415399	71	EC 204847	91	EC 204868
13	EC 205001		Jyothi	52	EC 415470	72	EC 415420	92	EC 415441
14	EC 205042	33	EC 205269	53	EC 415401	73	EC 415421	93	EC 415442
15	EC 415457		Jaya	54	EC 415402	74	EC 415422		Vaiashak
16	EC 205047	34	EC 415462		Vaiashak	75	EC 415423		Jaya
	Jaya	35	EC 205275	55	EC 415403	76	EC 415425	94	EC 415444
17	EC 205070	36	EC 415463	56	EC 415404		Jaya	95	EC 415445
18	EC 205072		Thulasi	57	EC 415405	77	EC 415426	96	EC 415446
	Thulasi	37	EC 205295	58	EC 415406	78	EC 415427	97	EC 415447
19	EC 205128	38	EC 415464	59	EC 415407	79	EC 415428	98	EC 415448
20	EC 205166A	39	EC 415465		Jaya	80	EC 415429	99	EC 415449
	Vaiashak	40	EC 205305	60	EC 415408		Manurathna	100	EC 415450

3.4 Preparation of main field

The field was ploughed using tractor driven disk plough followed by tilling two times using a cultivator. Weeds and stubbles were removed and the plot was levelled. Then, five raised beds (each block prepared with 5 cm high) of size of 25 x 3 m^2 were prepared as shown in Plate 1.

Plate 1. Preparation of main field

3.5 Seed sowing

Seeds of accessions were sown on 21 July 2019 directly on the field in five block randomly and labeled correctly (Plate 2).

Plate 2. Sowing of seed

3.6 Weed control

After three weeks all the weeds were removed carefully. Also thinning has been done and in each line sufficient plants maintained for taking observations (Plate 3).

Plate 3. Weeds control and thinning of the lines

3.7 Application of fertilizers

Sufficient fertility of soil was ensured by applying of fertilizers as per KAU (2010) as shown in (Plate 4).

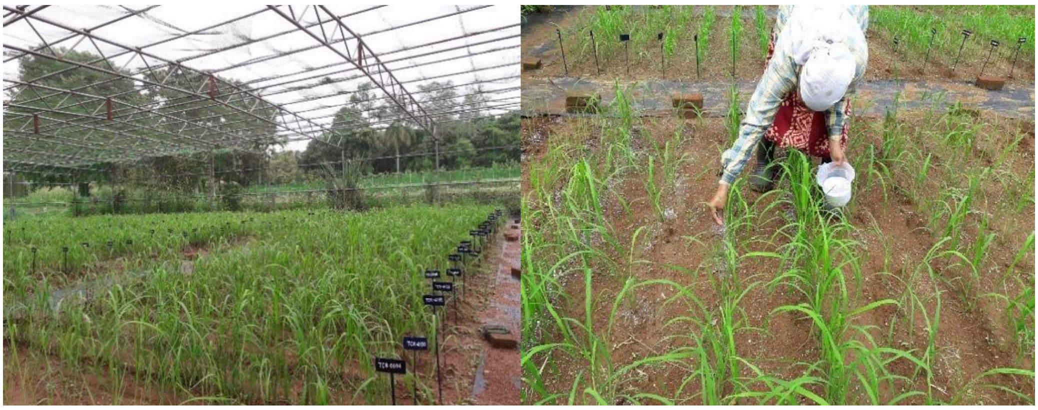


Plate 4. Application of fertilizer

3.8 Plant protection measure

Proper management measures were taken against rice stem borer throughout tillering and heading stage of rice. Insecticide of Reeva-5, 3mg per liter was applied at active tillering stage and panicle initiation stage of rice for controlling rice ear bug (*Leptocorisa acuta*) as show in (Plate 5).

Plate 5. Application of insecticide

3.9 Methods of recording of observations

Among the 100 accessions sown, eleven were not germinated. Hence, observations were recorded from 89 accessions and five check varieties. Observations on morphological characters were collected from 5 randomly selected plants from every line of block. The plants were selected from the middle of line to avoid border impact and the mean was calculated. Twenty-five qualitative and fifteen quantitative characters were recorded using the descriptor (Rani *et al.*2006) DUS (Distinctiveness, Uniformity and Stability) guidelines. The observations for characterization were recorded at field condition as follows:

3.9.1 Evaluation of qualitative characters

The experimental field and block were visited daily as per schedule and data at each stage were collected according to descriptor. A data record book was used for keeping records of data related to identification of the accessions. The image of specific character of the accession was taken from experiment field at suitable stages to compare among the genotypes of rice.

3.9.1.1 Coleoptile colour

Coleoptile colour was recorded at the emergence of first leaf through coleoptile as shown in figure 1. Accessions can be categorized into three groups with codes in line with guided descriptor as follows:

- ✓ Coleoptile colour
    - Colourless : 1
    - Green : 2
    - Purple : 3

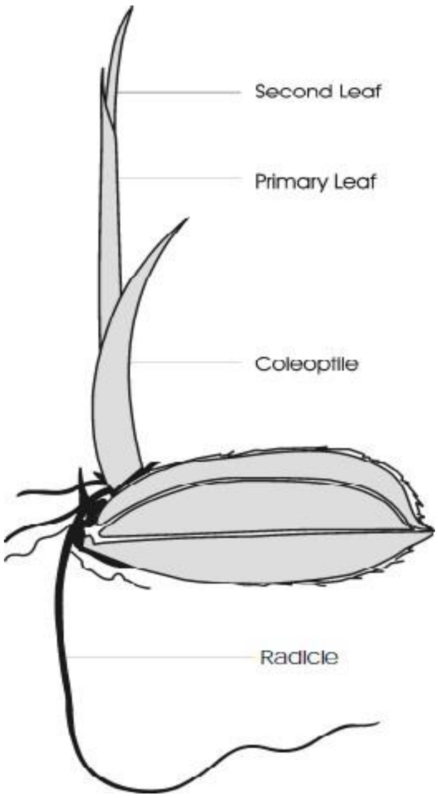


Fig 1. Radicle and coleoptile of seed

3.9.1.2 Basal leaf sheath color

The colour of basal leaf sheath, which is covered around the culm above the basal node, was noted visually at booting stage and the accessions can be grouped into four groups with their codes according to descriptors as follows.

- ✓ Basal leaf sheath color
  - Green : 1
  - Light purple : 2
  - Purple lines : 3
  - Uniform purple : 4

3.9.1.3 Leaf sheath anthocyanin colouration

The observation of leaf sheath anthocyanin colouration was recorded at booting stage and the genotypes can be categorized into two groups with codes based on descriptor as follows:

- ✓ Leaf sheath anthocyanin colouration
  - Absent : 1
  - Present : 9

3.9.1.4 Leaf blade distribution of anthocyanin colouration

Observation recorded in respect to the distribution of anthocyanin colouration on the leaf blade at booting stage and the accessions can be classified into four groups with codes following rice descriptor as per follows:

- ✓ Leaf blade distribution of anthocyanin coloutation
  - On tips only : 1
  - On margins only : 2
  - In blotches only : 3
  - Uniform : 4

3.9.1.5 Leaf blade attitude

Leaf blade attitude is the position of the tip of the blade and it was recorded at anthesis half way visually and the genotype can be grouped into four parts with codes based on guided descriptors as follows:

- ✓ Leaf blade attitude
  - Erect : 1
  - Semi-erect : 3
  - Horizontal : 5
  - Deflexed : 7

3.9.1.6 Auricle colour

Auricle colour was visually observed at booting stage and can be classified into three groups with codes following the descriptor.

- ✓ Auricle colour
  - Colourless : 1
  - Light purple : 2
  - Purple : 3

3.9.1.7 Collar colour

Plants were observed for presence of colour on the collar of rice crop visually at booting stage and can be categorized into two groups with codes as per follows:

- ✓ Collar colour
  - Absent : 1
  - Present : 9

3.9.1.8 Ligule shape

Shape of leaf ligule was observed visually at booting stage and recorded. Thus, the genotypes can be classified as following as shown in Figure 2.

- ✓ Ligule shape
  - Truncate : 1
  - Acute : 2
  - Split : 3

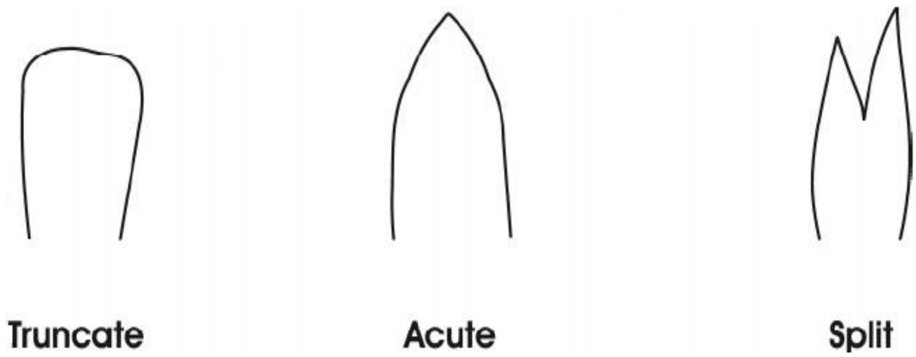


Fig 2. Ligule shape

3.9.1.9 Ligule color

The colour of ligule was noted at booting stage by visual observation of individual genotypes and can be divided into six groups according descriptor as follows:

- ✓ Ligule colour
  - White : 1
  - Purple : 2
  - Light purple : 3

3.9.1.10 Flag leaf attitude

Flag leaf attitude refers to the angle of attachment between the flag leaf and the main panicle axis. It was recorded visually at ripening stage and can be categorized into four groups that are presented in Figure 3.

- ✓ Flag leaf attitude
  - Erect : 1
  - Semi-erect : 3
  - Horizontal : 5
  - Deflexed : 7

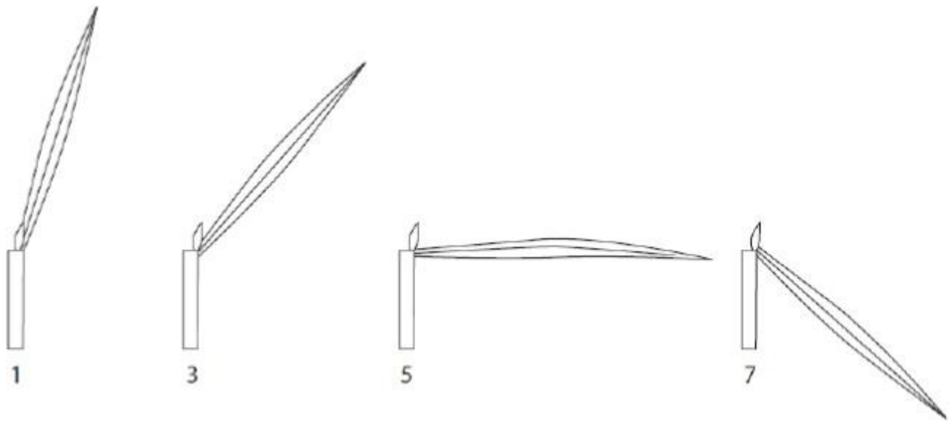


Fig 3. Flag leaf attitude

3.9.1.11 Culm habit

Culm habit was estimated by the average angle of tendency of the base of the main culm from vertical. It was observed visually at booting stage and can be categorized into following groups as seen in Figure 4.

- ✓ Culm habit
  - Erect : 1
  - Semi-erect : 3

- Open : 5
- Spreading : 7

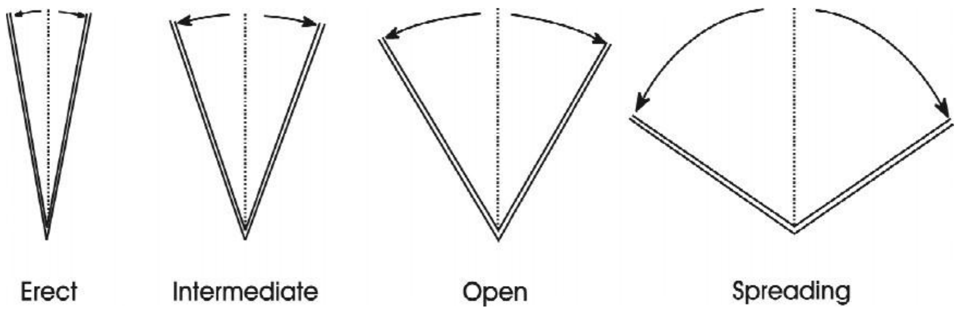


Fig 4. Culm habit

3.9.1.12 Culm: lodging resistance

Culm lodging resistance observed according to the degree of lodging at maturity stage and the genotypes can be grouped as follows:

✓ Culm: lodging resistance

- Very weak : 1 (all plants flat)
- Weak : 3 (most plants nearly flat)
- Intermediate : 5 (most plants leaning about 45°)
- Strong : 7 (most plants leaning 20° from vertical)
- Very strong : 9 (all plants vertical)

3.9.1.13 Stigma colour

Stigma colour was visually observed at flowering stage and the genotypes can be divided by the subsequent groups.

✓ Stigma colour

- White : 1
- Light green : 2
- Yellow : 3

- Light purple : 4
- Purple : 5

3.9.1.14 Lemma and palea colour

Lemma and palea colour observed in presence of sufficient sun light at ripening stage and the genotypes can be classified into the following groups:

- ✓ Lemma and palea colour
  - Straw : 1
  - Golden : 2
  - Gold straw : 3
  - Brown spots on straw : 4
  - Purple spots : 5
  - Purple : 6
  - Black : 7

3.9.1.15 Lemma-colour of apiculus

Colour of lemma at apiculus was assessed visually at anthesis half way stage and genotypes can be classified to the subsequent groups according to descriptor as follows:

- ✓ Lemma - colour of apiculus
  - Absent : 1
  - Weak : 3
  - Medium : 5
  - Strong : 7
  - Very strong : 9

3.9.1.16 Sterile lemma colour

Sterile lemma colour was observed at ripening stage and the accessions were categorized into the subsequent groups:

- ✓ Sterile lemma colour
    - Straw : 1
    - Gold : 2
    - Red : 3
    - Purple : 4

3.9.1.17 Presence of awns

The presence of awns was recorded at ripening stage. It was normally a character of exotic species of rice and categorized as per descriptor.

- ✓ Presence of awns
    - Absent : 1
    - Present : 9

3.9.1.18 Distribution of awns

The observation was recorded according to descriptor at ripening stage and the genotypes are classified into three groups as follows:

- ✓ Distribution of awns
    - Tip only : 1
    - Upper half only : 3
    - Whole length : 5

3.9.1.19 Colour of awns

The colour of awn recorded at ripening stage and the genotypes are categorized into the following groups based on descriptor:

- ✓ Colour of awns
  - Yellow white : 1
  - Yellow brown : 2
  - Brown : 3
  - Reddish brown : 4
  - Light red : 5
  - Red : 6
  - Light purple : 7
  - Purple : 8
  - Black : 9

3.9.1.20 Panicle - attitude of main axis

The panicle attitude of main axis was determined by curvature position of panicle base according to descriptor at ripening stage and classified into groups as follows and is shown in Figure 5.

- ✓ Panicle: attitude main axis
  - Straight : 1
  - Semi-straight : 3
  - Drooping deflexed : 5
  - Deflexed drooping : 7

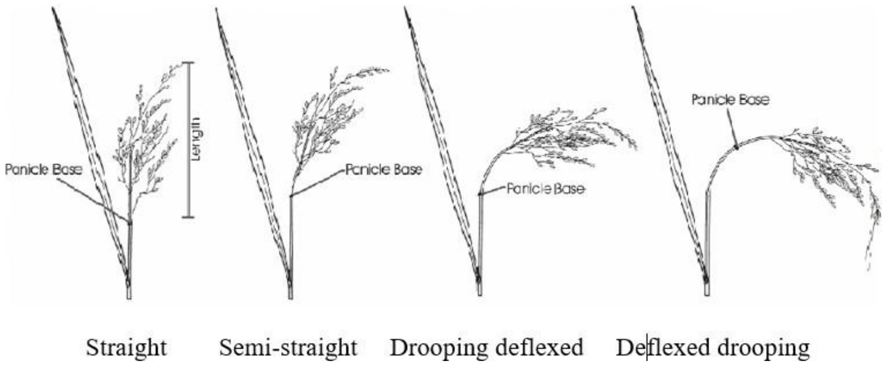


Fig 5. Panicle: attitude main axis

3.9.1.21 Panicle - attitude of branches

Attitude of panicle branches was characterized by the compactness of the panicle at ripening stage and classified in respect to its mode of branching, angle of primary branches and spikelet density. It has shown as per follow in the figure 6.

- ✓ Panicle: attitude of branches
    - Erect : 1
    - Erect to semi-erect : 3
    - Semi-erect : 5
    - Semi-erect to spreading : 7
    - Spreading : 9

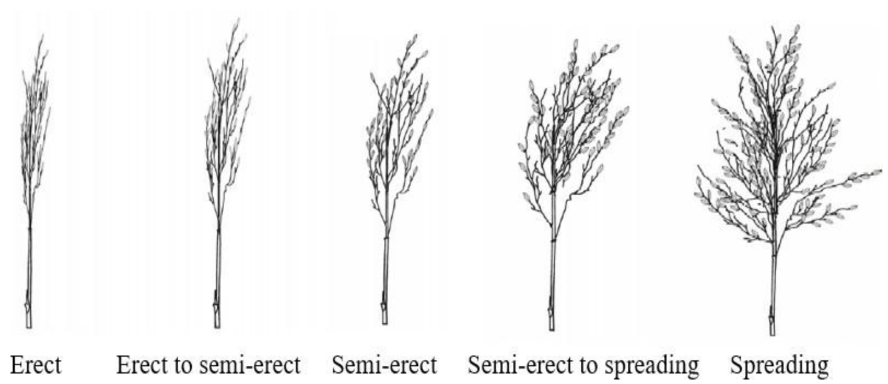
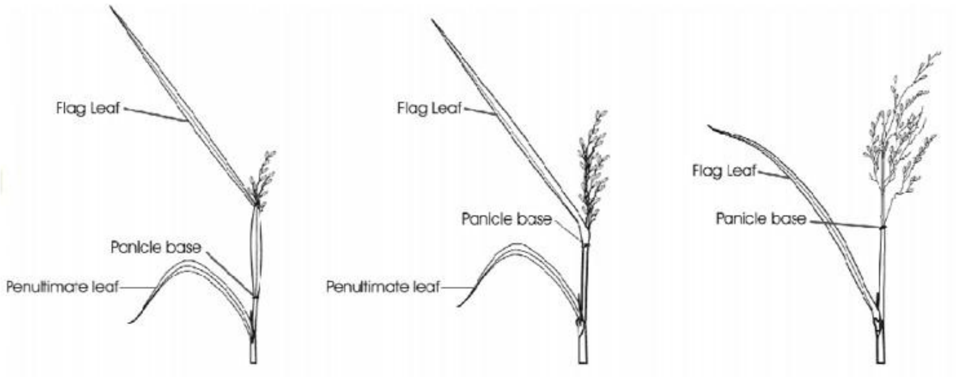


Fig 6. Attitude of panicle branches

3.9.1.22 Panicle exertion

Panicle exertion was recorded at ripening stage and the accessions are categorized into the following groups that are shown in Figure 7.

- ✓ Panicle excertion
  - Partly excerted : 3
  - Mostly exceted : 5
  - Well excerted : 7



Partly excerted (< 80%) | Mostly exceted (81- 99%) | Well excerted (100%)

Figure 7. Panicle exsertion

3.9.1.23 Panicle threshability

The observation recorded after harvesting stage during the removal of grain from the panicle and the genotypes are classified into three groups as per follow:

- ✓ Panicle: threshability
  - Easy : 1
  - Intermediate: 2
  - Difficult : 3

3.9.1.24 Caryopsis - pericarp colour

The pericarp colour recorded visually after removing the husk from the grain based on the hard caryopsis stage. It can be categorized according to descriptor into the following groups:

- ✓ Caryopsis: pericarp colour
    - White : 1
    - Light brown : 2
    - Variegated brown : 3
    - Dark brown : 4
    - Light red : 5
    - Red : 6
    - Variegated purple : 7
    - Purple : 8
    - Dark purple : 9

3.9.1.25 Caryopsis - shape

The observation recorded based on the length and width of grain and it can be classified into the following groups according to descriptor:

- ✓ Caryopsis shape
    - Short slender : 1
    - Short bold : 2
    - Medium slender : 3
    - Long bold : 4
    - Long slender : 5
    - Extra-long slender: 6

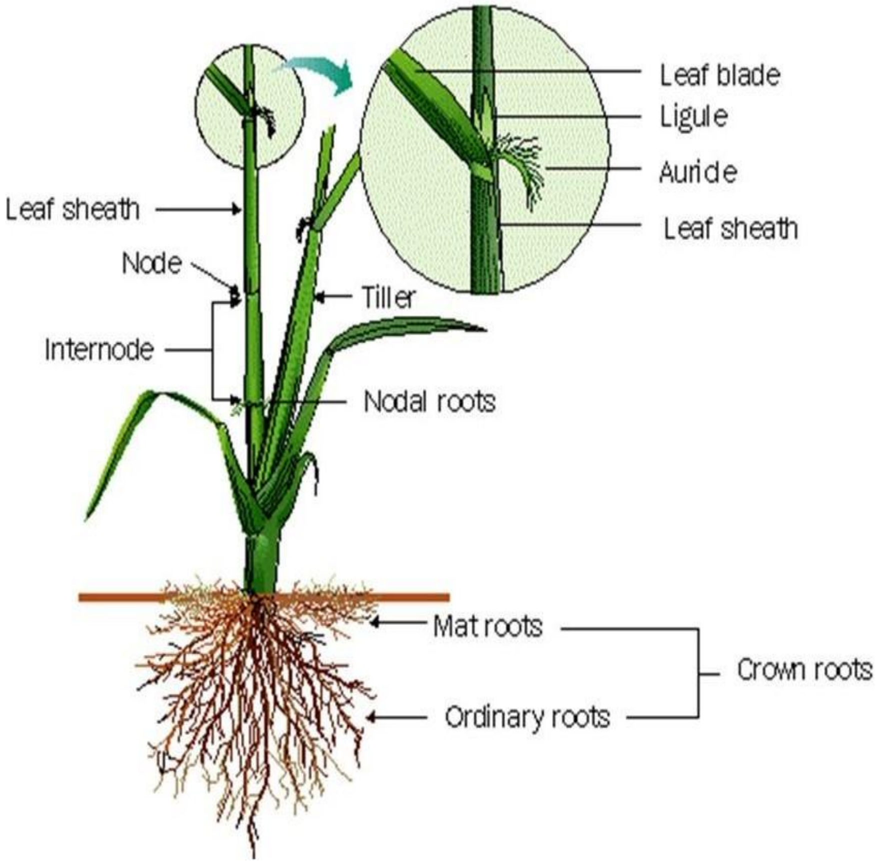


Fig 8. Morphology of a rice plant (vegetative stage)

3.9.2 Evaluation of quantitative characters

3.9.2.1 Plant height (cm)

The average height of the five plants from the ground level to the tip of the panicle (main culm) was measured randomly at maturity and genotypes can be categorized into five different classes as per descriptor.

Plant height = Stem length + Panicle length

- ✓ Plant height
  - Very short (<91 cm)
  - Short (91-110 cm)
  - Medium (111-130 cm)
  - Long (131-150 cm)
  - Very long (>150 cm)

3.9.2.3 Ligule length (mm)

The length of ligule was measured from the junction point of ligule between the leaf sheath and blade to the tip from five random plants at maturity and recorded in millimeters.

- ✓ Ligule length
  - Short (<5 mm)
  - Medium (5- 10 mm)
  - Long (>10 mm)

3.9.2.2 Leaf blade length (cm)

The leaf length was measured from the joining point of leaf to the tip point of leaf from five plants randomly in centimeter scale at booting stage according to DUS guidelines and the accession can be categorized into following groups:

- ✓ Leaf blade length
  - o Short (<30 cm)
  - o Medium (30-45 cm)
  - o Long (>45 cm)

3.9.2.5 Leaf blade width (cm)

The width of leaf blade measured at the middle of leaf at booting stage and was recorded in centimeter randomly from individual plants. The genotypes can be categorized based on descriptor as follows:

- ✓ Leaf blade width
  - o Narrow (<1 cm)
  - o Medium (1-2 cm)
  - o Broad (>2 cm)

3.9.2.6 Days to 50 per cent flowering

Number of days was recorded when 50 per cent of primary panicle emerged and the genotypes classified into the following groups:

- ✓ Days to 50 per cent flowering
  - o Very early (<71)
  - o Early (71-90)
  - o Medium (91-110)
  - o Late (111-130)
  - o Very late (>131)

3.9.2.7 Days to maturity

The number of days required to reach plant to the harvestable maturity from date of sowing that was recorded at ripening stage and the genotypes can be grouped as follows:

- ✓ Days to maturity
  - Very early (<100)
  - Early (101- 120)
  - Medium (121- 140)
  - Late (140- 160)
  - Very late (>160)

3.9.2.8 Number of tillers per plant

The total number of tillers was recorded from five plants randomly at maturity and average was calculated. The genotypes can be divided into the following groups:

- ✓ Number of tillers per plant
  - Low (<5 culms)
  - Intermediate (5- 10 culms)
  - High (>10 culms)

3.9.2.9 Number of productive tillers per plant

The number of tillers bearing panicle were counted from the plants at maturity and average has taken. The genotypes can be grouped as follows:

- ✓ Number of productive tillers per plant
  - Low (<7 culms)
  - Intermediate (8- 12culms)
  - High (>15 culms)

3.9.2.10 Panicle length (cm)

The panicle length was recorded randomly from five plants at the time of prior to harvesting and measured from the neck of panicle to the tip of main tillers in centimeters. The genotypes can be classified into the following groups according to their length.

- ✓ Panicle length
    - Very short (<11 cm)
    - Short (12-15 cm)
    - Medium (16-25 cm)
    - Long (26-35 cm),
    - Very long (>35cm)

3.9.2.11 Number of spikelets per panicle

Number of spikelets per panicle include all the filled and unfilled spikelets and it's measured from random five plants of each genotypes at harvest and average was taken. The genotypes were categorized as per follow:

- ✓ Number of spikelets per panicle
    - Few (<150)
    - Medium (151-200),
    - Many (201-300)
    - So Many (>301)

3.9.2.12 Number of grains per panicle

The number of grains from individual plants was taken randomly after harvest and mean value was recorded. Based on the observed value genotypes can be classified into the following classes:

- ✓ Number of grains per panicle

- Few (<150)
- Medium (151-200),
- Many (201-300)
- So Many (>301)

3.9.2.13 Grain length (mm)

The grain has taken from individual plants randomly and measured in millimeters after harvest. Vernier caliper was used to take the observation. Average length was recorded from five grain. The genotypes were categorized into different groups as per follow:

- ✓ Grain length
  - Very short (<6.0 mm)
  - Short (6.1- 8.5)
  - Medium (8.6- 10.5 mm)
  - Long (10.6- 12.5 mm)
  - Extra Long (>12.51 mm)

3.9.2.14 Grain width (mm)

The grain width has taken by vernier caliper in millimeters after harvest and the mean value of five grain from each genotype was recorded randomly. The genotypes can be classified in to the following groups:

- ✓ Grain width
  - Very narrow (<2.0 mm)
  - Narrow (2.1- 2.5 mm)
  - Medium (2.6- 3.0 mm)
  - Broad (3.1- 3.5 mm)
  - Very broad (>3.5 mm)

3.9.2.15 100 grain weight (g)

After threshing 100 grain weight was measured and recorded after harvest. The genotypes can be classified into five groups based on test weight as follows:

- ✓ 100 grain weight
  - Very low (<15 g)
  - Low (15- 20 g)
  - Medium (21- 25 g)
  - High (26- 30 g)
  - Very high (>30 g)

3.9.2.16 Grain yield (g)

The grain yield was recorded by weighing all the grains of an accession individually in gram as per descriptor. Genotypes were classified as follows:

- ✓ Grain yield per plant
  - Low (<10 g)
  - Medium (10- 20 g)
  - High (>20 g)

3.9.2.18 Incidence of pests and diseases

Each genotype was observed visually for incidence of pests and diseases.

3.10 Statistical analysis

Hierarchical clustering based on qualitative and quantitative data and correlation between the characters were done using the statstical package SPSS. Analysis of variance of the augmented design was done using Plant breeding Package of R.

3.11. Scoring accessions based on qualitative and quantitative traits

Accessions were scored for yield contributing qualitative traits like erect leaf, flag leaf, erect and strong culm and exserted panicle and quantitative traits better than check varieties to find out superior accessions.

Results and discussion

4. RESULTS AND DISCUSSION

The study was conducted with a view to characterize hundred exotic germplasm of rice according to the DUS guidelines (Rani *et al*., 2006). Twenty-five qualitative and fifteen quantitative characters were observed. Results have been compiled in tabular form and described below:

- Qualitative Characteristics
- Quantitative Characteristics

4.1 Evaluation of qualitative characters

Observations were recorded on twenty-five qualitative characters of the accessions and presented in Table 4 to 19.

Characterization of exotic rice germplasm based on qualitative parameters was recorded on the field according to DUS (Distinctiveness, Uniformity and stability guidelines from five plants randomly as presented in Table 3.

Table 3. Characterization of exotic rice germplasm based on qualitative parameters

SL. No.	Genotype	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
1	EC 207747	1	1	1	0	3	1	1	3	1	3	3	1	1	1	5	1	1	0	0	7	5	7	2	5	3
2	EC 204847	1	1	1	0	3	1	1	3	1	3	3	1	5	4	5	1	9	1	4	5	5	7	2	1	3
3	EC 204863	1	1	1	0	3	1	1	3	1	3	3	1	1	4	7	1	9	5	4	5	5	5	2	5	3
4	EC 204865	1	1	1	0	3	1	1	3	1	3	1	1	5	4	1	1	9	1	4	5	5	5	2	5	1
5	EC 204868	1	1	1	0	1	1	1	3	1	3	1	1	5	1	5	1	9	5	4	5	5	5	2	5	1
6	EC 204928	1	1	1	0	3	1	1	3	1	1	1	1	5	1	5	1	9	1	1	5	5	7	2	6	1
7	EC 204970	1	1	1	0	3	1	1	3	1	1	3	1	5	3	1	1	9	1	1	5	5	7	2	5	1
8	EC 204991	1	1	1	0	3	1	1	3	1	3	3	3	1	3	1	1	1	0	0	2	5	5	2	5	3
9	EC 204999	1	1	1	0	3	1	1	3	1	1	3	1	1	1	5	1	1	0	0	2	5	7	2	5	1
10	EC 205001	1	1	1	0	3	1	1	3	1	5	3	1	1	3	5	1	9	5	4	5	5	7	2	1	3
11	EC 205042	1	1	1	0	3	1	1	3	1	3	3	1	1	3	1	1	9	3	4	5	5	7	2	5	3
12	EC 205047	1	1	1	0	1	1	1	3	1	1	2	1	1	3	1	1	9	5	4	5	5	5	2	1	1
13	EC 205070	1	1	1	0	3	1	1	3	1	5	3	1	1	3	5	1	9	5	1	7	5	7	2	5	3
14	EC 205072	1	1	1	0	3	1	1	3	1	3	1	1	1	3	1	1	9	5	1	5	5	7	2	5	3
15	EC 205128	1	3	1	0	1	1	1	3	1	3	1	1	1	3	1	1	1	0	0	2	5	5	2	6	3
16	EC 205192	1	1	1	0	3	1	1	3	1	1	1	1	1	3	1	1	9	5	1	5	9	7	2	5	2
17	EC 205205	1	1	1	0	1	1	1	3	1	1	1	1	1	1	5	1	1	0	0	5	5	5	2	5	2
18	EC 205223	1	1	1	0	1	1	1	3	1	1	3	1	1	3	1	1	1	0	0	5	5	7	2	6	1
19	EC 205252	1	1	1	0	1	1	1	3	1	1	3	1	1	3	1	1	9	1	1	2	9	7	2	6	1
20	EC 205264	1	1	1	0	3	1	1	3	1	5	3	1	5	1	1	1	9	1	1	2	5	7	2	5	3
21	EC 205269	1	1	1	0	1	1	1	3	1	1	3	1	1	3	1	1	1	0	0	5	5	5	2	6	1
22	EC 205275	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	5	5	5	2	5	1
23	EC 205305	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	5	5	5	2	6	2

24	EC 205314	1	1	1	0	1	1	1	3	1	3	1	1	1	4	1	1	1	0	0	5	5	5	2	1	3
25	EC 205321	1	3	1	0	1	1	1	3	1	5	1	1	5	1	1	1	9	1	4	5	9	7	2	1	3
26	EC 205333	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	9	1	1	5	5	7	2	6	3
27	EC 415392	1	1	1	0	1	1	1	3	1	1	1	1	1	1	5	1	1	0	0	5	5	5	2	1	4
28	EC 415393	1	1	1	0	1	1	1	3	1	3	1	1	1	3	1	1	9	5	1	5	5	5	2	1	3
29	EC 415394	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	1	1	5	5	5	2	1	4
30	EC 415396	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	1	1	5	5	5	2	1	4
31	EC 415397	1	3	1	0	1	1	1	3	1	3	3	1	5	1	1	1	9	1	4	5	5	7	2	1	3
32	EC 415399	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	5	2	1	3
33	EC 415401	1	1	1	0	1	1	1	3	1	3	1	1	1	3	1	1	9	1	1	5	5	5	2	6	3
34	EC 415402	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	5	1	5	5	5	2	1	3
35	EC 415403	1	1	1	0	1	1	1	3	1	1	1	1	1	1	5	1	9	5	1	5	5	7	2	1	3
36	EC 415404	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	7	2	1	3
37	EC 415405	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	1	0	0	5	5	7	2	1	4
38	EC 415406	1	1	1	0	1	1	1	3	1	1	1	1	1	1	1	1	1	0	0	5	5	5	2	1	3
39	EC 415407	1	1	1	0	1	1	1	3	1	1	1	1	1	1	5	1	1	0	0	5	5	7	2	1	3
40	EC 415408	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	1	1	5	5	5	2	1	3
41	EC 415409	1	1	1	0	1	1	1	3	1	5	3	1	1	4	5	1	1	0	0	5	5	5	2	1	3
42	EC 415410	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	5	2	1	3
43	EC 415411	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	9	5	1	5	5	7	2	1	3
44	EC 415412	1	1	1	0	1	1	1	3	1	3	3	1	1	1	1	1	1	0	0	5	5	7	2	1	4
45	EC 415413	1	1	1	0	1	1	1	3	1	1	1	1	1	1	5	1	9	3	1	5	5	7	2	1	3
46	EC 415414	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	9	1	1	5	5	5	2	5	3
47	EC 415415	1	1	1	0	1	1	1	3	1	3	3	1	1	1	1	1	1	0	0	5	5	7	2	5	3
48	EC 415416	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	5	5	5	2	1	3
49	EC 415417	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	1	1	2	5	5	2	1	3
50	EC 415420	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	5	5	7	2	1	3

51	EC 415421	1	1	1	0	1	1	1	3	1	1	1	1	1	4	5	1	9	1	1	5	5	7	2	1	3
52	EC 415422	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	7	2	1	3
53	EC 415423	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	7	5	5	2	1	3
54	EC 415425	1	1	1	0	1	1	1	3	1	3	3	1	1	1	1	1	1	0	0	5	5	5	2	1	3
55	EC 415426	1	3	1	0	1	1	1	3	1	1	1	1	1	1	1	1	1	0	0	7	5	7	2	1	3
56	EC 415427	1	1	1	0	1	1	1	3	1	3	1	1	5	1	1	1	9	1	4	5	5	5	2	1	3
57	EC 415428	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	7	2	1	1
58	EC 415429	1	3	1	0	1	1	1	3	1	3	3	1	5	1	1	1	1	0	0	5	5	7	2	1	3
59	EC 415431	1	1	1	0	1	1	1	3	1	3	3	1	1	1	1	1	1	0	0	5	5	5	2	1	4
60	EC 415433	1	3	1	0	1	1	1	3	1	3	3	1	5	1	1	1	9	3	4	5	5	5	2	1	3
61	EC 415434	1	3	1	0	1	1	1	3	1	3	3	3	5	1	1	1	9	5	1	5	5	5	2	1	3
62	EC 415435	1	3	1	0	1	1	1	3	1	3	3	3	1	1	1	1	1	0	0	5	5	5	2	1	3
63	EC 415436	1	1	1	0	1	1	1	3	1	3	3	3	1	1	5	1	1	0	0	5	5	3	2	1	4
64	EC 415437	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	1	0	0	5	5	5	2	1	3
65	EC 415438	1	3	1	0	1	1	1	3	1	3	1	1	5	1	5	1	1	0	0	5	5	5	2	1	3
66	EC 415439	1	3	1	0	1	1	1	3	1	3	1	1	5	1	1	1	9	5	4	7	9	5	2	1	4
67	EC 415441	1	1	1	0	1	1	1	3	1	3	3	1	1	4	5	1	9	3	1	5	5	5	2	1	3
68	EC 415442	1	1	1	0	3	1	1	3	1	3	1	1	1	1	5	1	9	5	1	7	5	5	2	1	1
69	EC 415444	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	9	5	1	5	5	5	2	1	3
70	EC 415445	1	1	1	0	1	1	1	3	1	3	1	1	1	1	5	1	9	5	1	5	5	5	2	1	4
71	EC 415446	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	9	1	1	5	5	5	2	1	3
72	EC 415448	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	5	2	1	3
73	EC 415449	1	1	1	0	1	1	1	3	1	3	1	1	1	4	5	1	9	1	1	2	5	5	2	1	4
74	EC 415450	1	1	1	0	1	1	1	3	1	3	3	1	1	1	5	1	1	0	0	5	5	5	2	1	4
75	EC 415451	1	1	1	0	3	1	1	3	1	3	1	1	1	4	1	1	1	0	0	5	5	5	2	1	3
76	EC 415452	1	3	1	0	1	1	1	3	1	1	1	1	1	3	1	1	1	0	0	5	5	5	2	1	4
77	EC 415454	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	1	0	0	5	5	7	1	1	3

78	EC 415455	1	1	1	0	1	1	1	3	1	3	1	1	1	3	1	1	9	3	1	5	5	7	1	1	3
79	EC 415456	1	1	1	0	3	1	1	3	1	3	3	1	1	3	1	1	1	0	0	5	5	7	1	1	3
80	EC 415458	1	1	1	0	1	1	1	3	1	1	1	1	1	1	1	1	1	0	0	5	5	7	1	1	3
81	EC 415459	1	1	1	0	1	1	1	3	1	1	1	1	1	4	5	1	9	3	2	7	5	5	1	1	2
82	EC 415460	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	1	0	0	5	5	7	1	1	1
83	EC 415461	1	1	1	0	1	1	1	3	1	3	1	1	1	1	1	1	9	1	1	7	5	7	1	1	4
84	EC 415462	1	1	1	0	1	1	1	3	1	1	3	1	1	3	1	1	1	0	0	5	5	5	1	1	3
85	EC 415463	1	1	1	0	1	1	1	3	1	3	1	1	1	3	1	1	1	0	0	5	5	5	1	1	3
86	EC 415464	1	1	1	0	3	1	1	3	1	3	1	1	1	3	1	1	1	0	0	5	5	7	1	1	3
87	EC 415465	1	1	1	0	1	1	1	3	1	3	3	1	1	3	1	1	1	0	0	5	5	7	1	1	3
87	EC 415468	1	1	1	0	1	1	1	3	1	3	1	1	1	3	1	1	9	1	1	5	5	5	1	1	3
89	EC 415470	1	1	1	0	1	1	1	3	1	3	3	1	1	3	1	1	1	0	0	5	5	7	1	1	3
Check varieties																										
	Jyothi	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1	1	9	5	1	5	5	5	1	6	3
	Jaya	1	1	1	1	2	1	1	3	1	3	1	1	5	1	5	1	9	3	1	4	3	5	1	1	3
	Thulasi	1	1	1	1	1	1	1	3	1	1	1	1	5	1	1	1	9	5	1	5	5	5	1	5	3
	Vaisakh	1	1	1	1	1	1	1	3	1	3	1	1	1	1	1	1	1	0	0	5	5	7	1	5	3
	Manurathna	1	1	1	1	1	1	1	3	1	3	1	1	1	1	5	1	1	0	0	5	5	5	1	6	3

(**A-** Coleoptile colour; **B-** Basal leaf sheath colour; **C-** Leaf sheath anothocyanin colouration; **D-** Leaf blade distribution of anthocyanin; **E-** Leaf blade attitude; **F-** Auricle colour; **G-** Colour of collar; **H-** Ligule shape; **I-** Ligule colour; **J-** Flag leaf attitude; **K-** Culm habit; **L-** culm lodging resistance; **M-** Stigma colour; **N-** Lemma and palea colour; **O-** Lemma colour of apiculus; **P-** Sterile lemma colour; **Q-** Presence of awns; **R-** Distribution of awns; **S-** Colour of awns; **T-** Panicle attitude of main axis; **U-** Panicle attitude of branches; **V-** Panicle exsertion; **W-** Panicle threshability; **X-** Pericarp colour of kernel; **Y-** Caryopsis shape).

4.1.1 Coleoptile color

Based on the recorded observations all genotypes (100 per cent) exhibited colourless coleoptile and there no green and purple colour among them. Subba*et al.* (2013) have done DUS charecterisation of 64 farmer varieties of rice based on 43 characters. Among the 64 farmer varieties they have studied, two varieties were having green coleoptile, while, one variety had purple coleoptile. Roy and Sharma (2014) characterized 84 landraces of rice collected from various agro-ecological regions of West Bengal and adjoining areas. They observed that 83 accessions had colourless coleoptile and only one had purple coleoptile. Komala *et al.* (2017) characterised of eight rice genotypes and observed coleoptile colour was purple in Intan and Asha, while it was green in case of Abhilash, Hemavathi, MGD 101, Mugad suganda, SIRI 1253 and PSB 6. All these studies indicate that rice genotypes in general possess colourless coleoptiles and purple coloured coleoptiles is a rare occurrence and hence, can be used in identification of genotypes.

4.1.2 Basal leaf sheath color

As per the basal leaf sheath colour observed, accessions were categorized as green and purple. Out of 89 accessions, eleven (11.70 per cent) accessions exhibited purple colour and the rest seventy-eight (83.0 per cent) accessions and check varieties had green coloured basal leaf Table 4. Subba*et al*. (2013) observed 55 out of 65 farmer varieties they studied were having green basal leaf sheath, while one variety each had light purple, and purple lines. Ten varieties were having uniform purple basal leaf sheath. Roy and Sharma, (2014) observed that 81 out of 84 landraces of rice collected from various agro-ecological regions of West Bengal and adjoining areas were having green basal leaf colour , while, three genotypes had uniform purple basal leaf . Islam et al. (2018a) characterised 113 accessions of aromatic germplasm and observed that 95.58 per cent of the accessions had green basal leaf and only 4.42 per cent of accessions had coloured basal leaf. Based on these studies it can be assumed that purple colour of basal leaf is a trait which is present only in a few genotypes and hence, can be used for identification of genotypes.

Table 4. Categorization of accessions based on basal leaf sheath colour

State	Code	Accessions	Percentage of accessions
Green	1	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415427, EC 415428, EC 415431, EC 415436, EC 415437, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	83.0
Purple	3	EC 205128, EC 205321, EC 415397, EC 415429, EC 415426, EC 415452, EC 415433, EC 415434, EC 415435, EC 415438, EC 415439	11.70

4.1.3 Leaf sheath - anthocyanin colouration

The observation of leaf sheath anthocyanin showed that all the accessions including check varieties does not have leaf sheath anthocyanin colouration. According to Subba*et al.* (2013), 56 out of 65 farmer varieties were having no anthocyanin colouration on leaf sheath, while nine genotypes had anthocyanin colouration. Roy and Sharma, (2014) observed very weak intensity of anthocyanin colouration in leaf sheath in 96.43 per cent of genotypes they have studied. They observed medium intensity of anthocyanin colouration in two genotypes (2.38 per cent) and strong anthocyanin colouration in one genotype. Ahmed *et al*. (2015) observed that, out of 10 genotypes, the anthocyanin coloration in leaf sheath was present in three duplicate named Dhaliboro rice germplasm (DB5, DB9 and DB10). The rest seven genotypes had no anthocyanin coloration in leaf sheath.Islam et al. (2018a) observed that leaf sheath anthocyanin colouration was absent in 108 genotypes accounting to 95.58 per cent of total genotypes, while it was present in 5 genotypes. Islam et al. (2018a) observed absence of leaf sheath anthocyanin colouration in all the 36 similar named aromatic rice landraces of Bangladesh**.** Hence, it is clear that leaf anthocyanin colouration also can be used as distinguishing feature to identify a genotype.

4.1.4 Leaf blade - distribution of anthocyanin colouration

Observation recorded on distribution of anthocyanin colouration on the leaf blade, showed that none of the accessions had anthocyanin coloration on the leaf. Subba*et al.* (2013) observed that 54 out of 65 famer varieties were having no anthocyanin colouration on leaf while eleven varieties had anthocyanin coloration on leaf. Mondal *et al*. (2014) observed no variation between varieties for leaf anthocyanin coloration and distribution of anthocyanin coloration in leaf based on their study on DUS characterization using morphological descriptors for 21 rice varieties. Ahmed *et al*. (2015) reported maximum number (90per cent per cent) of the germplasm showed green leaf blade, while only 10 per cent of germplasm had purple margin in leaf blade out of 10 Dhaliboro genotypes they studied. Roy *et al.* (2016) observed no variation in leaf anthocyanin colouration based on their study on 126 indigenous short grain aromatic rice genotypes.

4.1.5 Leaf blade - attitude

On the basis of leaf blade attitude eighteen accessions and check variety Jaya (20.21 per cent) were having semi-erect leaf blade attitude and the rest seventy-one accessions and other four check varieties (79.80 per cent) were having erect leaf blade attitude as presented in Table 5. Islam et al. (2018a) observed that 96.46 per cent of 113 accessions of aromatic germplasm of rice had horizontal leaf angle.Reduced susceptibility to photo inhibition and reduced risk of overheating was observed with erect leaf stature Burgess *et al. (*2015).

According to Tafere and Irie (2019), erect leaf angles lead to improvement in whole day carbon gain by enhancing light absorption at low solar angles under dense canopies. Hence, majority of the tested accessions can be considered as photosynthetically more efficient.

Table 5. Categorization of accessions based on leaf blade attitude

State	**Code**	**Accessions**	**Percentage of accessions**
Erect	1	EC 204868, EC 205047, EC 205128, EC 205205, EC 205223, EC 205252, EC 205269, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415452, EC 415454, EC 415455, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415465, EC 415468, EC 415470, Jyothi, Thulasi, Vaisakh and Manurathna	79.80
Semi-erect	2	EC 207747, EC 204847, EC 204863, EC 204865, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205070, EC 205072, EC 205192, EC 205264, EC 415442, EC 415451, EC 415456, EC 415464, Jaya	20.21

4.1.6 Auricle color

Observation on the auricle color of accessions showed that all the accessions were having colourless auricle.Subba*et al*. (2013) observed three classes of auricle colouration with majority being colourless (83.07 per cent). Five out of 65 famers variety they evaluated had light purple auricle, while 6 varieties had purple auricle. According to Mondal *et al*. (2014), anthocyanin coloration of auricles was dimorphic. Roy and Sharma, (2014) reported that 98.8 per cent of the genotypes they evaluated had colourless auricle, while 1.19 per cent had purple auricle. Sahu *et al*. (2014) observed, genotypes Koudi Dhul, Chhind Guchhi, Ama Jhopa and Nariyal Phool had green auricle while it was purple in Ama Ruthi.

Ahmed *et al*. (2015) reported that anthocyanin coloration of auricles was present only in DB5 (10 per cent) genotype, while rest (90 per cent) of the germplasm had no anthocyanin coloration in auricles. Alia *et al*. (2016). Islam *et al*. (2018a) and Islam *et al*. (2018b) observed all rice genotypes they tested had colourless auricle. Similar to colouration of other parts of rice plant colourless auricle is the predominant trait. Light purple or purple is a rare occurrence and can be used to distinguish genotypes.

4.1.7 Collar colour

There was no variation among the observed accessions for collar colour. All the accessions had colourless collar. Modal *et al.* (2014); Ahmed*et al.* (2015) and Alia *et al.* (2016) also did not notice anthocyanin coloration of collar in the genotypes they evaluated. However, Sahu *et al.* (2014) observed one genotype having purple collar colour among five genotypes they tested. Islam et al. (2018a) observed pale green collar colour in 95.58 per cent of the tested genotypes among the 113 aromatic germplasm. Islam et al. (2018a) studied 36 similar named aromatic rice landraces of Bangladesh and observed all genotypes having pale green collar colour. Hence, collar colour also being a rare occurrence in rice genotypes can be used for identifying genotypes.

4.1.8 Ligule shape

Ligule in all the accessions were in split shape and there was no visible variation among them.Subba*et al.* (2013); Modal *et al.* (2014); Ahmed*et al*. (2015); Alia *et al.* 2016; Roy *et al.* (2016) and Islam et al. (2018a) reported ligule shape as monomorphic with cleft ligule. Lipi *et al.* (2018) evaluated nineteen maintainer lines of hybrid rice and observed 63.15 per cent of accessions had two - cleft ligule and the rest 36.85 had acuminate ligule. As per these studies majority of accessions have two cleft ligule and other less frequently appearing phenotypes can be used to distinguish genotypes.

4.1.9 Ligule colour

Observation on ligule colour showed no difference among the accessions. All the accessions possessed white ligule. Subba*et al.* (2013) observed three classes of ligule colour in 65 farmer's varieties they studied. Fifty six varieties had white ligule, while four had light purple and five had purple ligule. Mondal *et al.* (2014) observed two classes in ligule colour when they evaluated five land races along with 16 released varieties. Eight duplicate named *Dhaliboro* rice germplasm had colorless ligule while, two had ligules with green with purple lines among ten germplasm lines as observed by Ahmed *et al.* (2015). Roy *et al.* (2016) and Islam et al. (2018a) could not observe any difference in ligule colour among the rice germplasm they studied. Nineteen maintainer lines of three line hybrid rice were characterized by Lipi *et al.* (2018). They observed colourless ligule in 87. 47 per cent of genotypes while it was shades of purple in 10.25 per cent of lines they studied. These studies also indicate that majority of rice accessions possess colourless or white ligule. Hence, other classes can be a trait of specific genotypes and can be used in distinguishing genotypes.

4.1.10 Flag leaf attitude

According to the current study twenty accessions and one check variety (22.34 per cent) exhibited erect flag leaf attitude, five accessions (5.31 per cent) showed

horizontal type flag leaf attitude and the rest sixty-four accessions along with four check varieties (72.34 per cent) were having semi-erect flag leaf attitude as indicated in Table 6.Subba*et al*. (2013) observed that out of 65 farmer varieties 58 possessed horizontal flag leaf blade attitude. Only seven genotypes had erect flag leaf. According to Mondal *et al*. (2015) flag leaf attitude of blade was polymorphic. Ahmed *et al*. (2015) observed sixty per cent of *Dhaliboro* germplasm were having erect attitude of flag leafblade, while forty per centof the germplasm had semi-erect flag leaf blade. Roy *et al*. (2016) observed that erect flag leaf attitude of blade (44 per cent) was predominant among 126 short grained aromatic rice varieties. Alia *et al.* (2016) observed intermediate flag leaf angle in 23 genotypes among 24 genotypes they evaluated. Only one genotype had erect flag leaf. Islam et al. (2018a) observed flag leaf angle in 72.22 per cent of the accessions were semi erect while, in 27.7 per cent it was horizontal. Lipi *et al.* (2018) observed semi-erect angle of flag leaf in
68.42 per cent of maintainer lines they studied in hybrid rice while it was 15.75 per cent for erect flag leaf and 15.83 per cent for horizontal attitude of flag leaf. Islam et al. (2018a) observed 72.22 per cent of the 36 aromatic land races they studied possessed semi erect flag leaf while, in 27.78 per cent it was horizontal.

There was a positive correlation between flag leaf angle and photosynthesis material translocation which increases spikelets fertility and grain yield in rice. For this effect flag leaf must be wide and vertical (Dutta *et al.* 2002). Jennings *et al.* (2003) reported that modifications of leaf angle and flag leaf angle have been emphasized by many investigators as a means to obtain better light utilization. More upright leaves will permit penetration of solar energy in to the lower levels of the aerial structure of plants and help in enhanced photosynthesis. Hence, the accessions with erect flag leaf may have yield advantage over other accessions.

Table 6. Categorization of accessions based on flag leaf attitude

State	Code	Accessions	Percentage of accessions
Erect	1	EC 204928, EC 204970, EC 204999, EC 205047, EC 205192, EC 205205, EC 205223, EC 205252, EC 205269, EC 415392, EC 415403, EC 415406, EC 415407, EC 415413, EC 415421, EC 415426, EC 415452 EC 415458, EC 415459, EC 415462, Thulasi	22.34
Semi-erect	3	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204991, EC 205042, EC 205072, EC 205128, EC 205275, EC 205305, EC 205314, EC 205333, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415404, EC 415405, EC 415408, EC 415410, EC 415411, EC 415412, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415422, EC 415423, EC 415425, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415454, EC 415455, EC 415456, EC 415460, EC 415461, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	72.34
Horizontal	5	EC 205001, EC 205070, EC 205264, EC 205321, EC 415409	5.31

4.1.11 Culm habit

Observation on culm habit showed that thirty-nine (41.48 per cent) accessions were having semi-erect and the rest fifty accessions and five check varieties (53.20 per cent) were having erect culm habit. There was no open and spreading culm habit among the accessions as presented in Table 7. Roy and Sharma, (2014) reported that culm angle among 84 land races they have evaluated was erect in 17.85 per cent, semi erect in 76.19 per cent and spreading in 5.95 per cent. Komala *et al*. (2017) studied culm attitude in eight popular varieties of Karnataka state and observed that culm was semi erect in Intan, Hemavathi and Asha, while it was open in Abhilash, MGD 101, Mugad suganda, SIRI 1253 and PSB 6. Islam et al. (2018a) observed culm angle as erect in 29.21 per cent of the genotypes, while intermediate types of culm was seen in 60.18 per cent and open types in 10.62 per cent of the genotypes they studied.

Tafere and Irie, (2019) reported that short culm erect (SC-E) cultivar produced significantly higher photosynthesis rate, poor stomatal conductance, maximum PAR, higher canopy photosynthesis and grain yield than short culm open (SC-O) cultivar for planting density treatments. Hence, accessions with erect stem may have these advantages over other accessions.

Table 7. Categorization of accessions based on culm habit

State	**Code**	**Accessions**	**Percentage of accessions**
Erect	1	EC 204865, EC 204868, EC 204928, EC 205072, EC 205128, EC 205192, EC 205205, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415401, EC 415402, EC 415403, EC 415405, EC 415406, EC 415407, EC 415408, EC 415411, EC 415413, EC 415416, EC 415417, EC 415420, EC 415421, EC 415423, EC 415426, EC 415427, EC 415437, EC 415438, EC 415439, EC 415441, EC 415444, EC 415445, EC 415449, EC 415451, EC 415452, EC 415454, EC 415455, EC 415458, EC 415459, EC 415460, EC 415461, EC 415463, EC 415464, EC 415468, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	53.20
Semi-erect	3	EC 207747, EC 204847, EC 204863, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205223, EC 205252, EC 205264, EC 205269, EC 415397, EC 415399, EC 415404, EC 415409, EC 415410, EC 415412, EC 415414, EC 415415, EC 415422, EC 415425, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415442, EC 415446, EC 415448, EC 415450, EC 415456, EC 415462, EC 415465, EC 415470	41.48

4.1.12 Culm lodging resistance

Observation on culm lodging resistance in the tested accessions showed that four accessions (4.25 per cent) had weak culm and the rest 85 accessions and five check varieties (95.74 per cent) were recorded with strong culm as indicated in Table 8. Nascimento *et al.* (2011) based on their studies with 146 up land rice accessions observed that 37.5 per cent of accessions were having no lodging while 37.5 per cent had few plants lodged and 25 per cent had moderate lodging. According to Girija *et al*. (2017), lodging of the rice crop is the major limiting factor to rice productivity. Lodging not only reduces the yield but also it deteriorates grain quality impedes mechanical harvesting, increases harvesting and drying costs. Lodging resistance is complex trait influenced by environment and structural properties of the stem. Hence, the accessions showing lodging resistance can be used in breeding programme.

Table 8. Categorization of accessions based on culm lodging resistance

State	Code	Accessions	Percentage of accessions
Weak	3	EC 204991, EC 415434, EC 415435, EC 415436	4.25
Strong	7	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462,	95.74

		EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	

4.1.13 Stigma colour

Visual observation of stigma colour showed that fourteen accessions and two check varieties (17.02 5) possessed purple stigma and the rest seventy-five accessions and three check varieties had (82.98 per cent) had white stigma colour as specified in Table 9. Komala *et al.* (2017) observed colour of stigma was purple in Intan and Asha genotypes and remaining genotypes (Abhilash, Hemavathi, MGD 101, Mugad suganda, SIRI 1253 and PSB 6) it was white. Manjunatha *et al.* (2018) observed purple stigma in 62 per cent of land races, while in three per cent of landraces it was light green and in 35 per cent of cultivars it was white when they evaluated 60 landraces of rice.

Islam et al. (2018a) based on their studies in 113 aromatic rice varieties observed that 88.49 per cent of genotypes had white stigma and 5.31, 6.19 per cent of accessions had light purple and purple coloured stigma, respectively. Islam et al. (2018a) based on their study on 36 aromatic land races of rice observed that all genotypes possessed white coloured stigma. All these studies points to the fact that majority of rice germplasm exhibits white stigma while, light purple and purple coloured stigma occurs rarely. Hence, this feature can be used to morphologically distinguish between genotypes.

Table 9. Categorization of accessions based on stigma colour

State	**Code**	**Accessions**	**Percentage of accessions**
White	1	EC 207747, EC 204863, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205269, EC 205275, EC 205305, EC 205314, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399,	82.98

		EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415428, EC 415431, EC 415435, EC 415436, EC 415437, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Vaisakh and Manurathna.	
Purple	5	EC 204847, EC 204865, EC 204868, EC 204928, EC 204970, EC 205264, EC 205321, EC 415397, EC 415427, EC 415429, EC 415433, EC 415434, EC 415438, EC 415439, Jaya and Thulasi	17.02

4.1.14 Lemma and palea colour

Eleven accessions (11.70 per cent) exhibited brown spots on lemma and palea, twenty-two accessions (23.40 per cent) had golden straw colour and the rest fifty-six accessions and five check varieties (64.90 per cent) had straw colour for lemma and palea as presented in Table 10. Alia *et al.* (2016) observed lemma and palea color of accessions number EC 415418, EC 415415, EC 415406, EC 415405 and EC 415403 were brown spot on straw, while, gold and straw colour lemma and palea were observed in the remaining genotypes when they evaluated 24 rice accessions. Manjunatha *et al.* (2018) observed six states of expression for lemma and palea colour among 60 landraces they evaluated. Seventeen per cent of land races had straw coloured lemma and palea, while in three per cent of the accessions it was gold and gold furrows on straw background, in 15 per cent of accessions it was of brown spots on straw, in 30 per cent of landraces it was brown furrows on straw, in 22 per cent of landraces were of brown (tawny) and 13 per cent of landraces it was purple black.

Islam et al. (2018a) observed nine different types for lemma and palea colour. They were gold, brown furrows on straw, brown, reddish to light purple, purple spots on straw, purple furrows on straw, purple and black. Gour *et al*. (2019) also observed wide variation in lemma and pealea colour. It was straw colour in 54 lines, brown spots on straw in 13 lines, brown furrows on straw in six lines, reddish to light purple in four lines, gold and gold furrows on straw background in three lines, black colour in two lines and brown (tawny) in one line. Being a qualitative trait showing wide variability and not influenced by environment this can be used for identification of specific genotype.

Table 10. Categorization of accessions based on lemma and palea colour

State	**Code**	**Accessions**	**Percentage of accessions**
Straw	1	EC 207747, EC 204868, EC 204928, EC 204999, EC 205205, EC 205264, EC 205275, EC 205305, EC 205321, EC 205333, EC 415392, EC 415394, EC 415396, EC 415397, EC 415399, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415450, EC 415454, EC 415458, EC 415460, EC 415461, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	64.90
Gold straw	3	EC 204970, EC 204991, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205223, EC 205252, EC 205269, EC 415401, EC 415452, EC 415455, EC 415456, EC 415459, EC 415462, EC 415463, EC 415464, EC 415465, EC 415470	23.40
Brown spots on straw	4	EC 204847, EC 204865, EC 204863, EC 205314, EC 415393, EC 415409, EC 415421, EC 415441, EC 415449, EC 415451, EC 415468	11.70

4.1.15 Lemma - colour of apiculus

According to the observations recorded, two accessions (2.13 per cent) possessed strong colour for apiculus, thirty-nine accessions along with two check varieties (43.62 per cent) exhibited medium colour and the rest forty-eight accessions and three check varieties (51.20 per cent) did not have any colour as indicated in Table 11. Alia *et al.* (2016) observed apiculus colour of the rice genotypes as brown except accession number EC 415403, EC 415407, EC 415409, EC 415410, EC 415411,EC 415413, 7649, EC 415415, and EC 415418 which were white. Islam et al. (2018a) observed five classes in colour of apiculus. Out of 113 aromatic rice lines they evaluated 11 had white, 49 had straw, 19 had brown, two had red and 33 had purple apiculus. Islam et al. (2018a), based on their studies on 36 aromatic rice's observed that most of the tested landraces possessed straw coloured apiculus (63.89 per cent), while, brown, red and purple were observed among other genotypes they evaluated. This polymorphic trait also can be used in identification of rice genotypes.

Table 11. Categorization of accessions based on lemma colour of apiculus

State	Code	Accessions	Percentage of accessions
Absent	1	EC 204865, EC 204970, EC 204991, EC 205042, EC 205047, EC 205072, EC 205128, EC 205192, EC 205223, EC 205252, EC 205264, EC 205269, EC 205314, EC 205321, EC 205333, EC 415393, EC 415397, EC 415401, EC 415405, EC 415406, EC 415411, EC 415412, EC 415415, EC 415425, EC 415426, EC 415427, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415437, EC 415439, EC 415444, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Thulasi and Vaisakh.	54.25
Medium	3	EC 207747, EC 204847, EC 204868, EC 204928, EC 204999, EC 205001, EC 205070, EC 205205, EC 205275, EC 205305, EC 415392, EC 415394, EC 415396, EC 415399, EC 415402, EC 415403, EC 415404, EC 415407, EC 415409, EC 415410, EC 415413, EC 415414, EC 415416, EC 415417,	43.62

		EC 415420, EC 415421, EC 415422, EC 415423, EC 415428, EC 415436, EC 415438, EC 415441, EC 415442, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415459, Jaya and Manurathna.	
Strong	4	EC 204863, EC 415408	2.13

4.1.16 Sterile lemma colour

On the basis of sterile lemma colour all the accessions along with five check varieties (100 per cent) observed with straw colour and among these accessions there was no variation. Subba *et al.* (2013) observed 53 cultivars were of straw sterile lemma colour, 8 were of red, 2 were of gold and purple, among 65 farmer varieties they have evaluated. According to Mondal *et al*. (2014), sterile lemma colour was polymorphic among 21 rice genotypes they have evaluated. As per the report of Alia *et al.* (2016), sterile lemma and palea colour was red, straw or gold. Komala *et al.* (2017) observed sterile lemma colour as straw in all eight genotypesthey evaluated. Manjunatha *et al.* (2018) reported that all the 60 land races of rice they have evaluated were having straw coloured sterile lemma, except for one landrace (Kayama) which had purple colour for sterile lemma. Colour of sterile lemma being a qualitative trait showing polymorphism and not influenced by environment can also be used as a means to identify genotypes.

4.1.17 Presence of awns

Based on the recorded data, forty-six accessions along with two check varieties (51.06 per cent) were without awns and the other forty-three accessions with three check varieties (48.93 per cent) exhibited the presence of awns as presented in Table 12. Nascimento *et al.* (2011) evaluated one hundred and forty-six accessions of upland rice and observed that awns were absent in 55 per cent of the genotypes they studied. Roy and Sharma, (2014) based on their study on 84 land races reported that twenty-one cultivars were with awn and others did not have awns. Islam et al. (2018a) observed 78 genotypes without awn and 35 genotypes with awn among 113

Bangladeshi aromatic rice they characterized. According to Guo and Schnurbusch, (2016), awns, which are derived from floral structures in grasses, are known to be critically important for photosynthesis and transpiration. However, domestication and human selection resulted in absence of awns to facilitate grain harvesting, handling and storage Mach, (2015). Hence awns can be considered as a primitive trait saving the plants from bird and animal damage.

Table 12. Categorization of accessions based on presence of awns

State	Code	Accessions	Percentage of accessions
Absent	1	EC 207747, EC 204991, EC 204999, EC 205128, EC 205205, EC 205223, EC 205269, EC 205275, EC 205305, EC 205314, EC 415392, EC 415399, EC 415404, EC 415405, EC 415406, EC 415407, EC 415409, EC 415410, EC 415412, EC 415415, EC 415416, EC 415420, EC 415422, EC 415423, EC 415425, EC 415426, EC 415428, EC 415429, EC 415431, EC 415435, EC 415436, EC 415437, EC 415438, EC 415448, EC 415450, EC 415451, EC 415452, EC 415454, EC 415456, EC 415458, EC 415460, EC 415462, EC 415463, EC 415464, EC 415465, EC 415470, Vaisakh and Manurathna.	52.12
Present	9	EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205192, EC 205252, EC 205264, EC 205321, EC 205333, EC 415393, EC 415396, EC 415397, EC 415394, EC 415401, EC 415402, EC 415403, EC 415408, EC 415411, EC 415413, EC 415414, EC 415417, EC 415421, EC 415427, EC 415433, EC 415434, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415449, EC 415455, EC 415459, EC 415461, EC 415468, Jyothi, Jaya and Thulasi	47.87

4.1.18 Distribution of awns

In the present study, twenty-one accessions along with two check varieties (24.46 per cent) had awns on the tip only, six accessions and one check variety (7.44 per cent) possessed awns on the upper half only, sixteen genotypes (17.02 per cent) exhibited awns on whole length of panicle and the rest forty-six accessions with two check varieties (51.06 per cent) were observed without awns as presented in Table 13.Nascimento *et al.* (2011) evaluated one hundred and forty-six accessions of upland rice for distribution of awn per panicle and they observed that it was absent in 55 per cent of genotypes. Among 45 per cent of genotypes having awns, in 23 per cent of the genotypes awns were present only at the tip of the panicle and in 22 per cent of the genotypes it was present on whole panicle. Morphological characterization of popular rice varieties of Karnataka by Komala *et al.* (2017) showed that among eight varieties awns were present only in Mugad suganda and its distribution was observed on tip only. Islam et al. (2018a) characterized 36 aromatic rice germplasm of Bangaladesh and found that among 13 genotypes having awn, in nine genotypes awns were present only in the tip and in remaining four it was present in the upper half of panicle. With domestication awns become eliminated from the genotypes or became restricted to a limited portion of the panicle facilitating easy harvest and threshing. Hence, accessions having awns in the full length of the panicle might not have undergone selection by man. Also these accessions can be tried to deter animals and birds feeding on rice.

Table 13. Categorization of accessions based on distribution of awns

State	Code	Accessions	Percentage of accessions
Tip only	1	EC 204847, EC 204865, EC 204928, EC 204970, EC 415461, EC 205252, EC 205264, EC 205321, EC 205333, EC 415394, EC 415396, EC 415397, EC 415401, EC 415408, EC 415414, EC 415417, EC 415421, EC 415427, EC 415446, EC 415449, EC 415468, Jyothi and Thulasi,	24.46
Upper half only	3	EC 205042, EC 415413, EC 415433, EC 415441, EC 415455, EC 415459, Jaya	7.44

Whole length	5	EC 204863, EC 204868, EC 205001, EC 205047, EC 205070, EC 205072, EC 205192, EC 415393, EC 415402, EC 415403, EC 415410, EC 415434, EC 415439, EC 415442, EC 415444, EC 415445	17.02
Absent	7	EC 207747, EC 204991, EC 204999, EC 205128, EC 205205, EC 205223, EC 205269, EC 205275, EC 205305, EC 205314, EC 415392, EC 415399, EC 415404, EC 415405, EC 415406, EC 415407, EC 415409, EC 415411, EC 415412, EC 415415, EC 415416, EC 415420, EC 415422, EC 415423, EC 415425, EC 415426, EC 415428, EC 415429, EC 415431, EC 415435, EC 415436, EC 415437, EC 415438, EC 415448, EC 415450, EC 415451, EC 415452, EC 415454, EC 415456, EC 415458, EC 415460, EC 415462, EC 415463, EC 415464, EC 415465, EC 415470, Vaisakh and Manurathna.	51.06

4.1.19 Colour of awns

The colour of awn recorded at ripening stage showed that thirty accessions and three check varieties (35.10 per cent) had yellowish white awns, only one genotype (1.06 per cent) showed yellowish awn, twelve accessions had (12.76 per cent) reddish brown and the rest forty-six accessions with two check varieties (51.06 per cent) had yellowish white awns colour as indicated in Table 14. Mondal *et al.* (2014) observed colour of awn as a polymorphic trait. Roy *et al*. (2016) observed that 91 per cent of the 126 short grain aromatic rice lines they characterized do not possess awn. Among rest the nine per cent, 64 per cent of genotypes hadyellowish white awns. Islam et al. (2018a) observed 13 out of 36 aromatic rice lines had awns. Among these awned 13 lines 10 were having straw coloured awns while one had brown and two had black owns. Being a polymorphic qualitative trait awn colour can be used as a specific feature to distinguish rice genotypes.

Table 14. Categorization of accessions based on colour of awns

State	Code	Accessions	Percentage of accessions
Yellowish white	1	EC 204928, EC 204970, EC 205070, EC 205072, EC 205192, EC 205252, EC 205264, EC 205333, EC 415393, EC 415394, EC 415396, EC 415401, EC 415402, EC 415403, EC 415408, EC 415411, EC 415413, EC 415414, EC 415417, EC 415421, EC 415434, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415449, EC 415455, EC 415461, EC 415468Jyothi, Jaya and Thulasi	35.10
Yellowish brown	2	EC 415459	1.06
Reddish brown	4	EC 204847, EC 204865, EC 204868, EC 204863, EC 205001, EC 205042, EC 205047, EC 205321, EC 415397, EC 415427, EC 415433, EC 415439	12.76
Absesnt	10	EC 207747, EC 204991, EC 204999, EC 205128, EC 205205, EC 205223, EC 205269, EC 205275, EC 205305, EC 205314, EC 415392, EC 415399, EC 415404, EC 415405, EC 415406, EC 415407, EC 415409, EC 415410, EC 415412, EC 415415, EC 415416, EC 415420, EC 415422, EC 415423, EC 415425, EC 415426, EC 415428, EC 415429, EC 415431, EC 415435, EC 415436, EC 415437, EC 415438, EC 415448, EC 415450, EC 415451, EC 415452, EC 415454, EC 415456, EC 415458, EC 415460, EC 415462, EC 415463, EC 415464, EC 415465, EC 415470, Vaisakh and Manurathna.	51.06

4.1.20 Panicle attitude of main axis

The panicle attitude of main axis was determined by curvature of panicle base. Seven accessions (7.44 per cent) had semi-straight panicle, while, eight accessions (8.51 per cent) had deflexed drooping and seventy-four accessions along with check varieties (84.04 per cent) had drooping deflexed panicle attitude of main axis as indicated in Table 15. According to Xu *et al.* (2005) one of the parameters of rice ideal panicle type for Liaoning province of China was neck-panicle curvature <40°. In the present study majority of the accessions had this more than 40 an ideal character.

Alia *et al.* (2016) observed all the three panicle types as intermediate, compact, open in 24 different rice genotypes they characterised. Panicle axis of accession number EC 415415, EC 415410, EC 415413, EC 415407, EC 415408 and EC 415403 were straight, rest of the accessions displayed droopy panicle axis. Manjunatha *et al.* (2018) also reported majority of 60 landraces they evaluated (88 per cent) were of drooping type of panicle curvature of main axis and others were of deflexed.

In contrast to this Liang *et al.* (2017) suggested erect panicle type is an important characteristic for japonica super rice and plays a significant role in enhancing yield. The erect panicle type can be considered as a genetic ideotype resource to japonica super rice group by virtue of its agronomic advantages such as grain number per panicle and biomass. Also erect panicle optimizes canopy structure (Xu *et al*. 1990). Rice plants with drooping panicle can be lodged easily Gao *et al*. (1999). However, when the panicle is heavy there will always be a tendency for drooping. Hence, the axis of panicle suitable for different types and situation may vary and breeder has to choose the best type.

Table 15. Categorization of accessions based on panicle attitude of main axis

State	**Code**	**Accessions**	**Percentage of accessions**
Semi-straight	3	EC 204991, EC 204999, EC 205128, EC 205252, EC 205264, EC 415417, EC 415449	7.44
Drooping deflexed	5	EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 205001, EC 205042, EC 205047, EC 205072, EC 205192, EC 205205, EC 205223, EC 205269, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415420, EC 415421, EC 415422, EC 415425, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415444, EC 415445, EC 415446, EC 415448,	84.04

		EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415460, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	
Deflexed drooping	7	EC 207747, EC 205070, EC 415423, EC 415426, EC 415439, EC 415442, EC 415459, EC 415461	8.51

4.1.21 Panicle - attitude of branches

Attitude of panicle branches was characterized by the compactness of the panicle and was classified with respect to its mode of branching, angle of primary branches and spikelet density. Only two accessions (2.12 per cent) were observed to have spreading panicle and the rest eighty-eight accessions along with check varieties (97.87 per cent) showed semi-erect type of panicle attitude of branches as presented in Table 16. According to Manjunatha *et al.* (2018), out of sixty landraces they evaluated, erect to semi-erect was observed in 10 per cent, 7 per cent were of semi erect, 27 per cent were of semi-erect to spreading type and 57 per cent were of spreading type. Crop breeders selectively breed for compact panicle type and open panicle type is selected against, for maximizing crop grain production and harvest (Fageria, 2017). Semi erect panicle observed in the present study is an indication that some amount of improvement might have happened in the accessions with respect to branching attitude of panicle.

Table 16. Categorization of accessions based on panicle attitude of branches

State	Code	Accessions	Percentage of accessions
Semi-erect	5	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405,	97.87

		EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	
Spreading	9	EC 205321, EC 415439	2.12

4.1.22 Panicle exsertion

Panicle exertion was recorded at near ripening stage. On the basis of observations recorded there was only one accession (1.06 per cent) having partly exserted panicle, thirty-nine accessions along with one check variety (42.55 per cent) exhibited well exserted panicle, the rest forty-nine accessions and four check varieties (56.38 per cent) were having mostly exserted panicle as presented in Table 17. Variation was observed among tested genotypes for panicle exsertion by Alia *et al.* (2016). Manjunatha *et al.* (2018) reported that 93 per cent of cultivars were having exserted panicle, while only 7 per cent had mostly exserted panicle when they evaluated 60 landraces of Wyanad. Islam et al. (2018a) observed that 94.69 per cent of 113 aromatic land races exhibited well exserted panicle. Lipi *et al.* (2018) observed well exserted panicle in 52.63 per cent, moderately exserted in 31.57 per cent, and just exserted in 15.74 per cent among 19 maintainer lines of three line hybrid rice.

Panicles should emerge completely from the flag leaf sheath, and part of internode below the panicle base should be exposed. If upper internode is short lower panicle branches remain enclosed, spikelets in that branches become sterile or partially filled and are often blackened by secondary pathogens, resulting in yield losses Jennings *et al.* (1979). Hasan *et al*. (2018) reported that out crossing rate had significant positive correlation with panicle exertion (0.986**). So for better yield in varieties and for enhancing crossing in hybrid rice programme well exserted panicle is essential.

Table 17. Categorization of accessions based on panicle exsertion

State	Code	Accessions	Percentage of accessions
Partly exserted	3	EC 415436	1.06
Mostly exceted	5	EC 204863, EC 204865, EC 204868, EC 204991, EC 205047, EC 205128, EC 205205, EC 205269, EC 205275, EC 205305, EC 205314, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399, EC 415401, EC 415402, EC 415406, EC 415408, EC 415409, EC 415410, EC 415414, EC 415416, EC 415417, EC 415423, EC 415425, EC 415427, EC 415431, EC 415433, EC 415434, EC 415435, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415459, EC 415462, EC 415463, EC 415468, Jyothi, Jaya, Thulasi and Manurathna.	56.38
Well exserted	7	EC 207747, EC 204847, EC 204928, EC 204970, EC 204999, EC 205001, EC 205042, EC 205070, EC 205072, EC 415458, EC 205192, EC 205223, EC 415460, EC 415461, EC 205252, EC 205264, EC 205321, EC 205333, EC 415397, EC 415470, EC 415403, EC 415404, EC 415405, EC 415407, EC 415411, EC 415412, EC 415413, EC 415415, EC 415420, EC 415421, EC 415422, EC 415426, EC 415428, EC 415429, EC 415454, EC 415455, EC 415456 EC 415464, EC 415465 and Vaisakh.	42.55

4.1.23 Panicle threshability

The observation recorded after harvest during the removal of grain from the panicle. Based the data noted, all the accessions along with five check varieties were intermediate to remove the grain from the panicle.This trait isof great economic importance. If spikelet attachment to its pedicel is too loose it will lead to grain shattering which can cause serious yield loss. Too tight attachment reduces effectiveness of machine harvesting Jennings *et al*. (1979); Okubo *et al.* (2012). There have been many efforts to develop rice varieties with an intermediate panicle threshability to stabilize rice yields. Hence based on the present study all the accessions were superior with respect to panicle threshability.

4.1.24 Caryopsis - pericarp colour

The pericarp colour recorded visually after removing the husk from the grain. According to the observation recorded, ten accessions along with two check varieties (10.63 per cent) exhibited red pericarp colour, eighteen accessions with two check varieties (19.14 per cent) showed light red colour and the rest of sixty-five accessions and one check varieties (70.21 per cent) were found with white pericarp colour as presented in Table 18. As per the study of Manjunatha *et al.* (2018), colour of the decorticated grain was white in 28 per cent of landraces, light red in 22 per cent and red in 50 per cent of landraces. Islam et al. (2018a) observed white pericarp colour in 79 out of 113 aromatic genotypes they studied. They observed light brown pericarp in 32 genotypes and red in two genotypes. Colour of pericarp is considered as a commercial grain quality. In Kerala, people prefer red kernelled rice and that might have resulted in rice germplasm rich in red pericarp colour as observed by Manjunatha *et al.* (2018). However, as the present study utilised exotic germplasm we could observe more white kernelled accessions.

Table 18. Categorization of accessions based on pericarp colour of kernel

State	**Code**	**Accessions**	**Percentage of accessions**
White	1	EC 204847, EC 205001, EC 205047, EC 205314, EC 205321, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422,	70.21

		EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470 and Jaya	
Light red	5	EC 207747, EC 204863, EC 204865, EC 204868, EC 204970, EC 204991, EC 204999, EC 205042, EC 205070, EC 205072, EC 205192, EC 205205, EC 205264, EC 205275, EC 415414, EC 415415, Thulasi and Vaiasakh	19.14
Red	6	EC 204928, EC 205128, EC 205223, EC 205252, EC 205269, EC 205305, EC 205333, EC 415401, Jyothi and Manurathna.	10.63

4.1.25 Caryopsis shape

The observations recorded based on the length and width of grain showed that out of 89 accessions, ten (10.63 per cent) were short slender, four accessions (4.25 per cent) had short bold grains, six accessions (6.38 per cent) were long bold and rest sixty-nine along with five check varieties (78.72 per cent) were medium slender as indicated in Table 19. High level of variation was reported for grain shape in Brazilian and Pakistan rice collections Nascimento *et al.* (2011) and Siddiqui *et al.* (2007). Mondal *et al.* (2014) observed highest polymorphism for decorticated grain shape. Komala *et al.* (2017) observed decorticated grain shape as short slender in SIRI 1253, medium slender in Intan, Abhilash, Hemavathi, SIRI 1253, Asha, PSB 68 and long slender in Mugad suganda. Manjunatha *et al.* (2018) observed five states of expression for decorticated grain shape. Being highly polymorphic, this trait also can be used in identification of genotypes

Table 19. Categorization of accessions based on shape of kernel

State	Code	Accessions	Percentage of accessions
Short slender	1	EC 204928, EC 204970, EC 204999, EC 205047, EC 205223, EC 205252, EC 205269, EC 205275, EC 415428, EC 415460	10.63
Short bold	2	EC 205192, EC 205205, EC 205305, EC 415459	4.25
Medium slender	3	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204991, EC 205001, EC 205042, EC 205070, EC 205072, EC 205128, EC 205264, EC 205314, EC 205321, EC 205333, EC 415393, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415454, EC 415455, EC 415456, EC 415458, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	78.72
Long bold	4	EC 415392, EC 415394, EC 415396, EC 415405, EC 415412,EC 415452	6.38

Characterisation of 89 exotic accessions and five check varieties showed that out of 25 qualitative traits evaluated eight, namely, coleoptiles colour, leaf anthocyanin coloration, leaf distribution of anthocyanin coloration, auricle colour, collar colour, ligule shape, ligule colour and threshability were monomorphic. Eight qualitative traits viz, basal leaf colour, leaf blade attitude, culm habit, culm lodging resistance, stigma colour colour of sterile lemma, presence of awns and panicle attitude of branches were dimorphic. Qualitative traits like, flag leaf attitude, lemma and palea colour, colour of apiculus, distribution of awns, panicle attitude of main axis, panicle exsertion, and pericarp colour were trimorphic. Colour of awns and caryopsis shape had four classes. Qualitative traits less affected by the environment can be used as a marker for identifying genotypes, also if it is associated with a breeding objective it can be selected directly or can be used in breeding programme.

The frequency distribution of important qualitative characters presented in Fig 9 in the below:

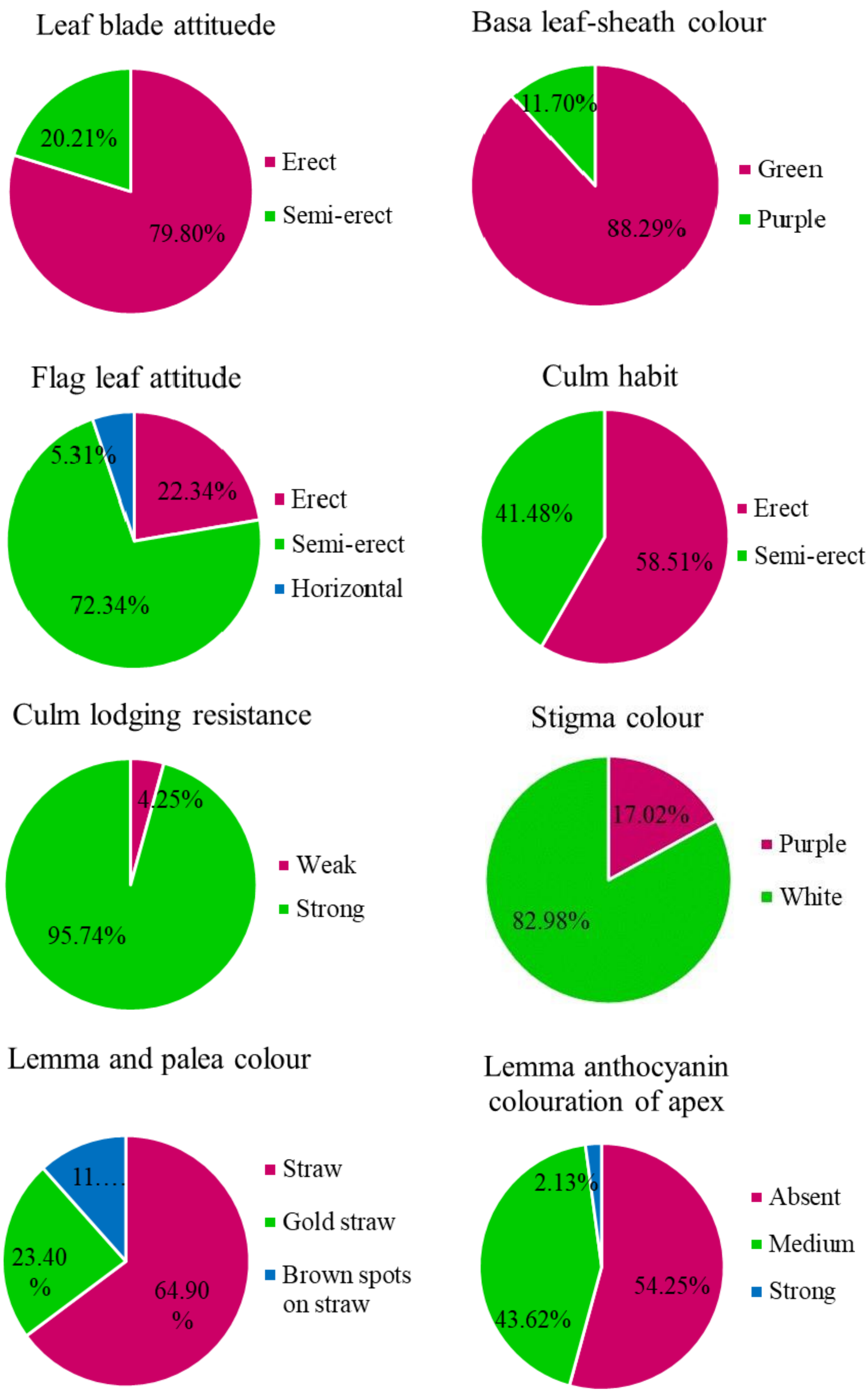


Fig 9. Frequency distribution of qualitative characters

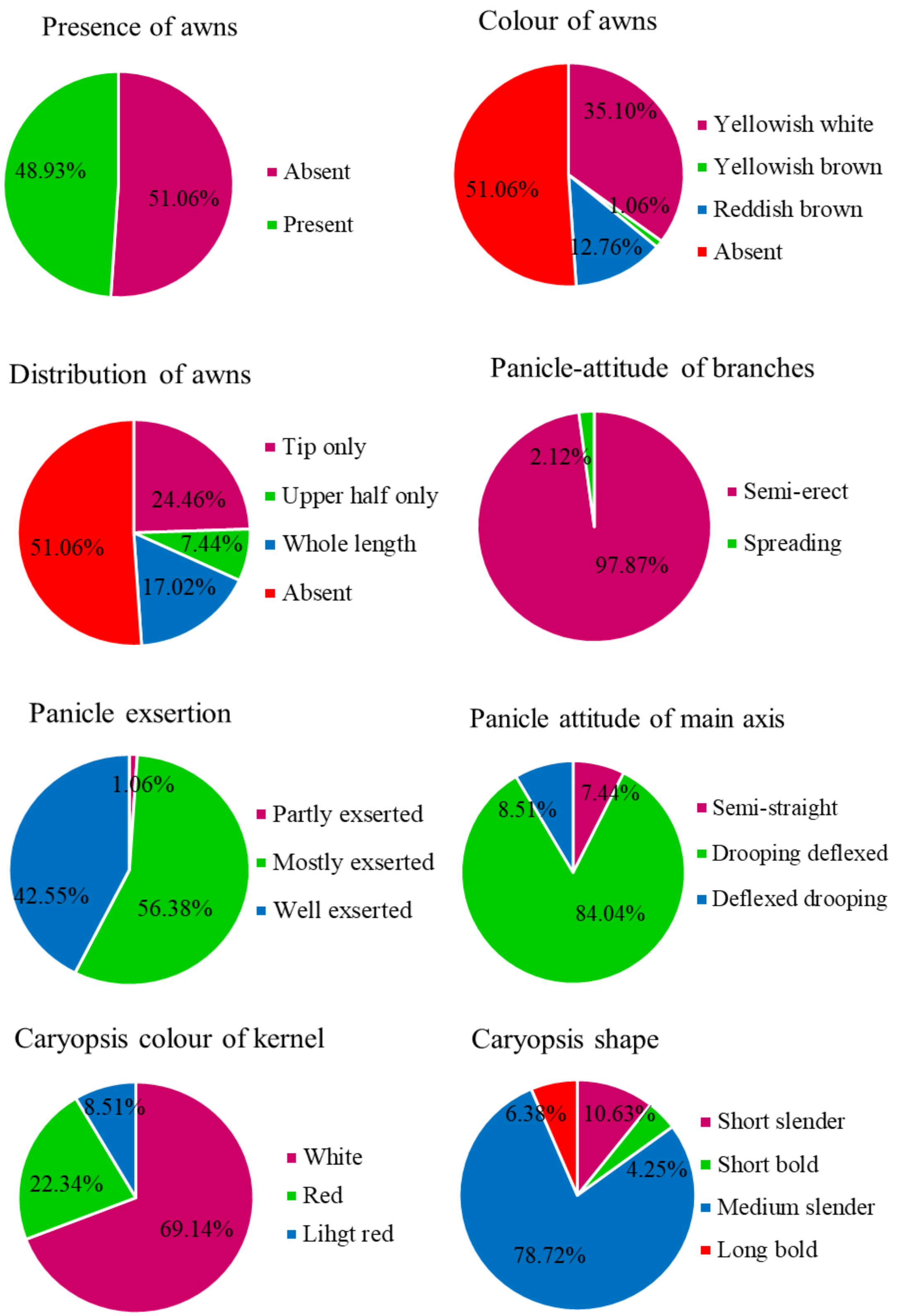


Fig 9. Frequency distribution of qualitative characters

Grouping of accessions based on superior qualitative characters

According to Tafere and Irie, (2019), erect leaf angles enhance light absorption at low solar angles under dense canopies. They also reported that short culm, erect cultivar produced significantly higher photosynthesis rate, poor stomatal conductance, maximum PAR, higher canopy photosynthesis and grain yield than short culm open cultivar for planting density treatments.

According to Jennings *et al.* (2003), more upright leaves will permit penetration of solar energy in to the lower levels of the aerial structure of plants and help in enhanced photosynthesis. According to Girija *et al.* (2017), lodging of the rice crop is the major limiting factor to rice productivity. Lodging not only reduces the yield but also it deteriorates grain quality impedes mechanical harvesting, increases harvesting and drying costs. Hence, strong culm is an important trait for higher productivity. Panicles should emerge completely from the flag leaf sheath, and part of internode below the panicle base should be exposed. If upper internode is short and lower panicle branches remain enclosed, spikelets in that branches become sterile or partially filled and are often blackened by secondary pathogens, resulting in yield losses (Jennings *et al*. 1979). Considering all these, accessions were grouped based on erect angle of leaf and flag leaf and strong and erect culm with well exserted panicle and the total score was calculated and given in Table 20.

Table 20. Grouping the accessions based on the qualitative traits having effect on yield

S.L No.	Accessions	Erect Leaf	Erect flag leaf	Erect culm	Strong culm	Well exserted panicle	Total score
1	EC 207747				√	√	2
2	EC 204847				√	√	2
3	EC 204863				√		1
4	EC 204865			√	√		2
5	EC 204868	√		√	√		3
6	EC 204928		√	√	√	√	4
7	EC 204970		√	√		√	3
8	EC 204991						0
9	EC 204999		√		√	√	3
10	EC 205001				√	√	2

11	EC 205042				√	√	2
12	EC 205047	√	√		√		3
13	EC 205070				√	√	2
14	EC 205072			√	√		2
15	EC 205128	√		√	√		3
16	EC 205192		√	√	√	√	4
17	EC 205205	√	√	√	√	√	5
18	EC 205223	√	√		√	√	4
19	EC 205252	√	√		√	√	4
20	EC 205264				√	√	2
21	EC 205269	√	√		√		3
22	EC 205275	√		√	√		3
23	EC 205305	√		√	√		3
24	EC 205314	√		√	√		3
25	EC 205321	√		√	√	√	3
26	EC 205333	√		√	√	√	4
27	EC 415392	√	√	√	√		4
28	EC 415393	√		√	√		3
29	EC 415394	√		√	√		3
30	EC 415396	√		√	√		3
31	EC 415397	√		√		√	3
32	EC 415399	√		√			2
33	EC 415401	√		√	√		3
34	EC 415402	√		√	√		3
35	EC 415403	√	√	√	√	√	4
36	EC 415404	√		√		√	3
37	EC 415405	√		√	√	√	4
38	EC 415406	√	√	√	√		4
39	EC 415407	√	√	√	√	√	5
40	EC 415408	√		√	√		3
41	EC 415409	√		√			2
42	EC 415410	√		√			2
43	EC 415411	√		√	√	√	4
44	EC 415412	√		√		√	3
45	EC 415413	√	√	√	√	√	5
46	EC 415414	√			√		2
47	EC 415415	√			√	√	3
48	EC 415416	√		√	√		3
49	EC 415417	√		√	√		3
50	EC 415420	√		√	√	√	4
51	EC 415421	√	√	√	√	√	5
52	EC 415422	√			√	√	2
53	EC 415423	√		√	√		3
54	EC 415425	√			√		2

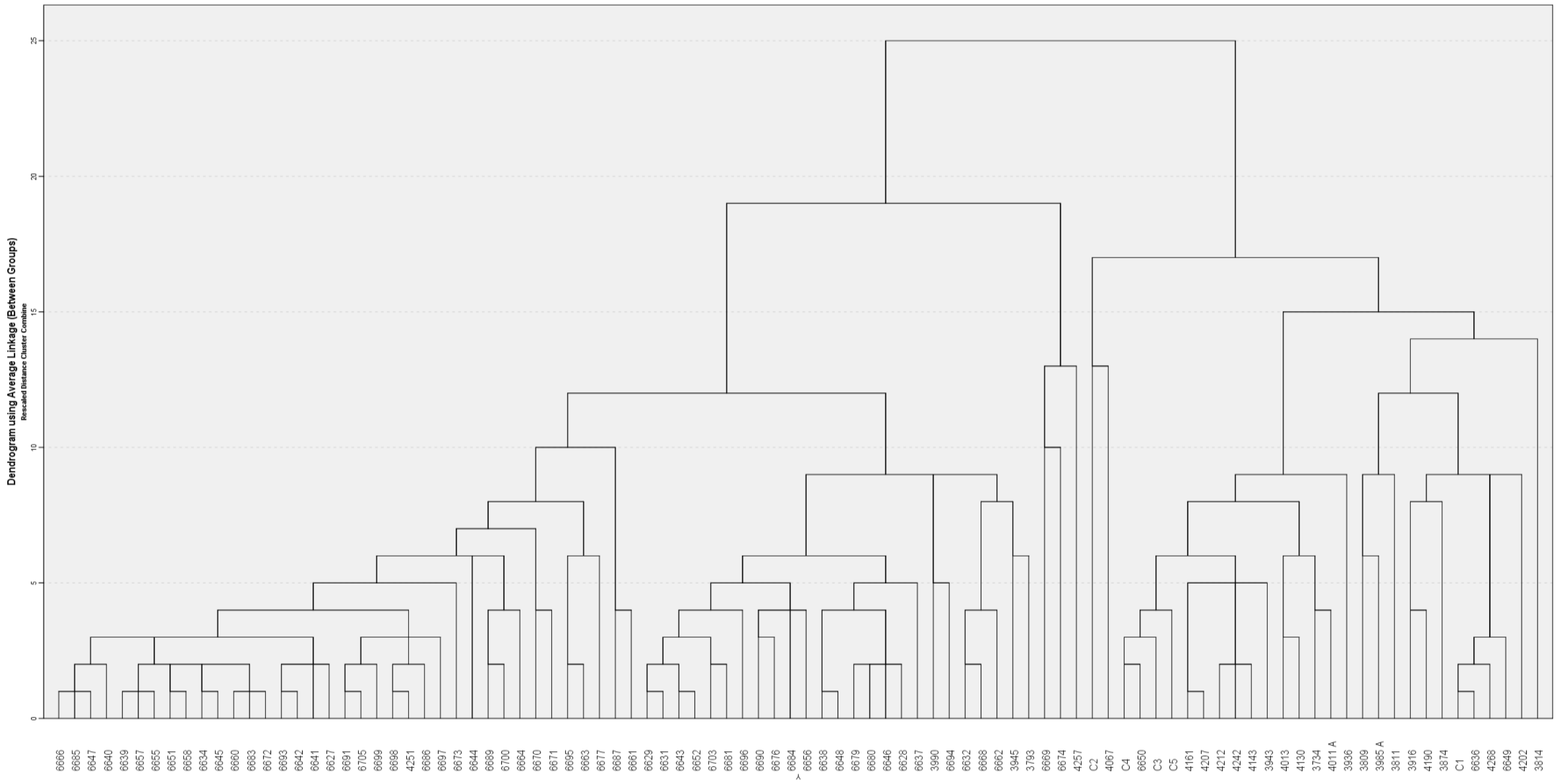
55	EC 415426	√	√	√	√	√	5
56	EC 415427	√		√	√		3
57	EC 415428	√			√	√	3
58	EC 415429	√			√	√	3
59	EC 415431	√			√		2
60	EC 415433	√			√		2
61	EC 415434	√					1
62	EC 415435	√					1
63	EC 415436	√					1
64	EC 415437	√		√	√		3
65	EC 415438	√		√	√		3
66	EC 415439	√		√	√		3
67	EC 415441	√		√	√		3
68	EC 415442				√		1
69	EC 415444	√			√		2
70	EC 415445	√		√	√		3
71	EC 415446	√			√		2
72	EC 415448	√			√		2
73	EC 415449	√		√	√		3
74	EC 415450	√			√		2
75	EC 415451			√	√		2
76	EC 415452	√	√	√	√		4
77	EC 415454	√		√	√	√	4
78	EC 415455	√		√	√	√	4
79	EC 415456				√	√	2
80	EC 415458	√	√	√	√	√	5
81	EC 415459	√	√		√		3
82	EC 415460	√		√	√	√	4
83	EC 415461	√		√	√	√	4
84	EC 415462	√	√		√		3
85	EC 415463	√		√	√		3
86	EC 415464			√	√	√	3
87	EC 415465	√			√	√	3
88	EC 415468	√		√	√		3
89	EC 415470	√			√	√	3

Accessions EC 204928, EC 205192, EC 205205, EC 205223, EC 205252, EC 205333, EC 415392, EC 415403, EC 415405, EC 415406, EC 415407, EC 415411, EC 415413, EC 415420, EC 415421, EC 415426, EC 415452, EC 415454, EC 415455, EC 415458, EC 415460 andEC 415461 were identified as superior with respect to five superior qualitative characters.

Table 21. Selected accessions based on superior qualitative traits

Sl. N.	Accessions	Erect Leaf	Erect flag leaf	Erect culm	Strong culm	Well exsetred panicle	Total score
1	EC 204928		√	√	√	√	4
2	EC 205192		√	√	√	√	4
3	EC 205205	√	√	√	√	√	5
4	EC 205223	√	√		√	√	4
5	EC 205252	√	√		√	√	4
6	EC 205333	√		√	√	√	4
7	EC 415392	√	√	√	√		4
8	EC 415403	√	√	√	√	√	4
9	EC 415405	√		√	√	√	4
10	EC 415406	√	√	√	√		4
11	EC 415407	√	√	√	√	√	5
12	EC 415411	√		√	√	√	4
13	EC 415413	√	√	√	√	√	5
14	EC 415420	√		√	√	√	4
15	EC 415421	√	√	√	√	√	5
16	EC 415426	√	√	√	√	√	5
17	EC 415452	√	√	√	√		4
18	EC 415454	√		√	√	√	4
19	EC 415455	√		√	√	√	4
20	EC 415458	√	√	√	√	√	5
21	EC 415460	√		√	√	√	4
22	EC 415461	√		√	√	√	4

Fig 10. Hierarchical clustering of exotic rice accessions based on qualitative traits



Dendrogram using average linkage (between groups)

Clustering of the accessions based on qualitative characters showed that the accessions grouped into 12 clusters. Among the clusters, cluster one had highest number of accessions. Thirty five accessions belonged to the first cluster (Figure 14 and Table 22). Next big cluster was cluster 3 containing 25 accessions. Clusters 4, 5, 6, 7, 8 and 12 had only one accession each. Second cluster included only two accessions, while cluster 10 had four accessions. Cluster 9 had 11 accessions and cluster 11 also consisted of 11 accessions. Alia *et al.* (2016) identified four clusters on the basis of cluster analysis for qualitative traits, at a dissimilarity level of 2.31.

Check variety Jaya formed a separate cluster (cluster 7), while, Thulasi, Vaisakh and Manurathna fall in to cluster 9 along with eight exotic accessions. Check variety Jyothi fall into cluster 11 along with teen exotic accessions. Ahmed *et al*. (2015) constructed a dendrogram using UPGMA clustering method distributed the 10 genotypes with two popular BRRI rice varieties namely BRRI dhan28 and BRRI dhan29 into three major clusters. Out of three clusters, Cluster III was the major one with maximum genotypes (9), while cluster I consisted with BRRI dhan28 and BRRI dhan29 and cluster II consisted with only DB5, respectively.Roy and Sharma, (2014) constructed a Dendrogram based on agro-morpho-quality characters of 84 local landraces of rice which showed five clusters with genetic variation. More number of clusters observed in the present study indicates the wide variability present in the exotic germplasm.

Table 22. Hierarchical clustering of the of exotic rice accessions based on qualitative traits

Cluster No.	Accessions	Percentage of accessions
1	EC 205314, EC 415392, EC 415399, EC 415404, EC 415405, EC 415406, EC 415407, EC 415409, EC 415410, EC 415412, EC 415416, EC 415420, EC 415422, EC 415423, EC 415425, EC 415428, EC 415429, EC 415431, EC 415435, EC 415436, EC 415437, EC 415438, EC 415442, EC 415448, EC 415450, EC 415451, EC 415454, EC 415456, EC 415458, EC 415460, EC 415462, EC 415463,	37.23

	EC 415464, EC 415465, EC 415470	
2	EC 415426, EC 415452	2.12
3	EC 204847, EC 205001, EC 205047, EC 415393, EC 415394, EC 415396, EC 415397, EC 415402, EC 415403, EC 415408, EC 415411, EC 415413, EC 415417, EC 415421, EC 415427, EC 415433, EC 415441, EC 415444, EC 415445, EC 415446, EC 415449, EC 415455, EC 415459, EC 415461, EC 415468	26.59
4	EC 415434	1.06
5	EC 415439	1.06
6	EC 205321	1.06
7	Jaya	1.06
8	EC 205128	1.06
9	EC 204999, EC 205072, EC 205205, EC 205223, EC 205269, EC 205275, EC 205305, EC 415415, Thulasi, Vaisakh and Manurathna	11.70
10	EC 207747, EC 204991 EC 205070, EC 205192	4.25
11	EC 204863, EC 204865, EC 204928, EC 204970, EC 205042, EC 205252, EC 205264, EC 205333, EC 415401, EC 415414, Jyothi	11.70
12	EC 204868	1.06

4.2 Evaluation of quantitative characters

Observations were recorded on the quantitative characters of germplasm and statistical analysis was done using plant breeding package in R and ANOVA is presented in Table 23, and data along with value of crtitical difference and categorization of quantitative data is presented in Table 24.

Table 23. ANOVA for augmented design

	Mean sum of square															
Source	**DF**	**PH**	**LL**	**LBL**	**LBW**	**TF**	**TM**	**NTP**	**NPTP**	**PL**	**NSP**	**NGP**	**GL**	**GW**	**TGW**	**GY**
Genotypes	4	2050.50	6.00	261.40	0.01	1253.01	1325.60	4.93	6.77	7.83	595.0	1271.63	1.60	0.10	0.23	32.78
Block	4	210.99	0.20	109.42	0.08	185.30	95.63	2.56	0.38	1.94	170.02	180.97	0.26	0.14	0.11	11.24
Residual	16	146.47	0.68	19.56	0.01	256.30	265.30	2.01	0.24	2.58	262.30	242.82	0.26	0.22	0.03	9.97

PH- Plant height; **LL-** Ligule length; **LBL-** Leaf blade length; **LBW-** Leaf blade width; **TF-** Days to 50 per cent flowering; **TM-** Days to maturity; **NTP-** Number of tillers per plant; **NPTP-** Number of productive tillers per plant; **PL-** Panicle length; **NSP-** Number of spikelets per panicle; **NGP-** Number of grains per panicle; **GL-** Grain length; **GW-** Grain width; **TGW-** 100 grain weight; **GY-** Grain yield

Table 24. Mean performance of exotic accessions of rice based on quantitative parameters

SL. No.	Accessions	PH (cm)	LL (mm)	LBL (cm)	LBW (cm)	TF days	TM days	NTP (no)	NPTP (no)	PL (cm)	NSP (no)	NGP (no)	GL (no)	GW (mm)	TGW (g)	GY(g)
1	EC 207747	130.00	12.00	69.00	1.00	83.00	113.00	9.00	8.00	22.00	119.00	97.00	8.00	2.90	1.62	9.65
2	EC 204847	97.00	4.20	64.00	0.60	102.00	131.00	3.40	3.40	16.00	136.00	114.00	9.12	2.40	1.21	6.05
3	EC 204863	133.00	5.00	70.00	1.14	84.00	112.00	9.00	6.00	21.00	100.00	78.00	7.86	2.90	1.91	10.80
4	EC 204865	85.00	4.00	47.00	0.60	98.00	131.00	4.00	3.00	15.00	99.00	75.00	8.00	3.00	1.50	7.50
5	EC 204868	78.00	3.00	39.00	0.50	102.00	131.00	3.00	3.00	17.00	107.00	89.00	8.20	3.12	2.01	5.95
6	EC 204928	124.00	7.00	52.00	1.00	76.00	103.00	8.00	5.00	18.00	97.00	79.00	6.86	2.20	2.05	5.90
7	EC 204970	118.00	5.00	70.00	1.00	80.00	108.00	6.00	4.00	21.00	112.00	90.00	6.84	2.18	1.91	8.73
8	EC 204991	120.00	4.00	57.00	0.98	79.00	107.00	6.00	3.00	21.00	81.00	67.00	8.26	2.82	1.98	9.90
9	EC 204999	153.00	8.00	59.00	1.04	79.00	105.00	8.00	4.00	23.00	90.00	70.00	7.00	1.58	1.78	9.53
10	EC 205001	84.00	5.00	55.00	1.10	81.00	109.00	7.00	4.00	16.00	143.00	127.00	8.86	2.96	2.08	7.52
11	EC 205042	111.00	11.00	63.00	0.96	76.00	101.00	9.00	4.00	20.00	85.00	71.00	6.94	3.00	2.24	11.20
12	EC 205047	126.00	6.00	67.00	0.94	79.00	111.00	6.00	5.00	24.00	95.00	77.00	8.52	2.78	1.79	5.61
13	EC 205070	129.00	4.00	65.00	0.96	87.00	121.00	5.00	6.00	20.00	115.00	95.00	8.72	2.96	1.95	9.65
14	EC 205072	119.00	5.00	61.00	0.82	98.00	130.00	7.00	3.00	18.00	92.00	68.00	8.46	3.12	1.69	8.45
15	EC 205128	132.00	5.00	63.00	0.94	106.00	131.00	9.00	4.00	21.00	84.00	62.00	8.22	2.66	1.71	8.71
16	EC 205192	128.00	8.00	65.00	1.00	81.00	111.00	5.00	3.00	20.00	105.00	81.00	8.46	3.10	2.17	10.80
17	EC 205205	87.00	6.00	49.00	1.20	75.00	108.00	4.00	3.00	20.00	85.00	71.00	7.70	3.18	2.19	7.07
18	EC 205223	116.00	12.00	58.00	0.90	81.00	112.00	8.00	4.00	22.00	193.00	171.00	6.12	2.38	2.08	16.20
19	EC 205252	124.00	6.00	55.00	0.70	74.00	104.00	8.00	6.00	21.00	109.00	91.00	7.26	2.20	2.02	15.30
20	EC 205264	106.00	5.00	67.00	0.90	80.00	111.00	6.00	4.00	20.00	79.00	59.00	8.18	3.26	1.95	5.74
21	EC 205269	118.00	4.00	59.00	0.90	78.00	110.00	5.00	4.00	22.00	93.00	75.00	7.04	2.44	2.25	15.60
22	EC 205275	97.00	3.00	67.00	0.80	81.00	111.00	8.00	4.00	17.00	129.00	107.00	8.26	2.88	2.09	9.10
23	EC 205305	108.00	4.00	59.00	1.00	79.00	109.00	5.00	3.00	23.00	71.00	49.00	7.00	3.00	1.35	6.41
24	EC 205314	139.00	5.00	58.00	1.10	101.00	128.00	5.00	4.00	21.00	212.00	186.00	8.44	2.94	1.55	6.62
25	EC 205321	133.00	6.00	69.00	1.10	81.00	111.00	4.00	4.00	22.00	116.00	94.00	9.44	2.96	1.93	13.90
26	EC 205333	132.00	5.00	62.00	0.70	79.00	109.00	5.00	4.00	21.00	94.00	74.00	8.04	1.66	2.19	10.60
27	EC 415392	74.00	6.00	45.00	0.90	82.00	111.00	4.00	4.00	16.00	88.00	70.00	10.76	2.32	2.06	12.40
28	EC 415393	87.00	8.00	54.00	0.70	82.00	111.00	4.00	4.00	19.00	91.00	71.00	8.72	1.88	2.43	9.24

29	EC 415394	82.00	6.00	43.00	0.70	80.00	110.00	4.00	3.00	16.00	75.00	53.00	10.94	1.96	1.25	8.90
30	EC 415396	87.00	7.00	44.00	0.90	71.00	101.00	5.00	3.00	11.00	86.00	70.00	10.74	2.28	2.38	16.40
31	EC 415397	84.00	11.00	50.00	0.70	101.00	131.00	5.00	4.00	20.00	98.00	76.00	8.78	1.50	1.85	10.10
32	EC 415399	80.00	10.00	44.00	1.00	80.00	111.00	6.00	3.00	15.00	86.00	70.00	8.88	2.12	2.28	15.90
33	EC 415401	129.00	8.00	58.00	0.90	93.00	121.00	8.00	8.00	22.00	94.00	72.00	10.04	2.90	2.45	17.60
34	EC 415402	88.00	6.00	47.00	0.80	83.00	115.00	5.00	4.00	16.00	83.00	63.00	10.54	2.18	1.94	8.74
35	EC 415403	89.00	10.00	46.00	1.00	77.00	108.00	5.00	4.00	17.00	89.00	71.00	9.38	2.46	1.88	9.04
36	EC 415404	104.00	5.00	43.00	1.00	81.00	111.00	4.00	4.00	16.00	55.00	50.00	8.92	1.78	2.13	10.60
37	EC 415405	93.00	9.00	43.00	1.00	88.00	118.00	7.00	4.00	21.00	75.00	57.00	10.90	2.30	2.19	17.40
38	EC 415406	94.00	10.00	42.00	1.00	88.00	117.00	5.00	3.00	20.00	70.00	54.00	9.04	1.82	2.44	11.40
39	EC 415407	94.00	7.00	50.00	1.00	78.00	108.00	6.00	4.00	19.00	91.00	73.00	9.44	1.72	2.48	9.08
40	EC 415408	93.00	9.00	54.00	1.00	83.00	111.00	4.00	3.00	20.00	86.00	72.00	10.38	2.58	2.36	14.10
41	EC 415409	73.00	8,8	41.00	0.80	87.00	117.00	5.00	3.00	20.00	83.00	65.00	9.50	2.64	2.09	7.23
42	EC 415410	77.00	7.00	38.00	0.70	79.00	111.00	5.00	3.00	21.00	67.00	57.00	9.04	1.54	2.25	10.80
43	EC 415411	79.00	6.00	41.00	0.90	76.00	105.00	6.00	4.00	17.00	90.00	70.00	10.20	2.34	1.77	10.40
44	EC 415412	90.00	11.00	42.00	0.80	80.00	110.00	4.80	3.80	17.00	97.00	77.00	10.76	2.38	1.80	6.75
45	EC 415413	77.00	5.80	45.00	0.86	74.00	102.00	4.40	3.60	22.00	112.00	88.00	10.42	2.40	2.07	10.30
46	EC 415414	66.00	6.40	43.00	0.80	75.00	106.00	4.80	4.20	17.00	85.00	61.00	9.74	2.84	2.01	10.50
47	EC 415415	105.00	9.00	47.00	0.70	71.00	101.00	6.00	4.00	22.00	119.00	99.00	9.08	3.04	1.87	7.47
48	EC 415416	75.00	11.00	42.00	1.00	81.00	111.00	4.20	3.20	18.00	100.00	80.00	9.46	2.52	2.09	10.40
49	EC 415417	87.00	6.40	47.00	1.10	78.00	109.00	5.80	3.80	19.00	101.00	79.00	8.64	1.74	2.16	7.65
50	EC 415420	77.00	10.00	49.00	0.50	78.00	106.00	4.80	4.40	17.00	99.00	83.00	10.50	2.20	2.32	12.70
51	EC 415421	82.00	10.00	45.00	0.80	80.00	110.00	5.40	4.60	21.00	71.00	53.00	9.06	1.80	2.10	6.59
52	EC 415422	103.00	12.00	51.00	1.00	78.00	106.00	5.90	5.10	24.00	88.00	66.00	10.85	2.10	2.62	7.75
53	EC 415423	84.00	4.20	40.00	0.60	78.00	107.00	4.20	3.80	16.00	128.00	106.00	10.12	2.20	2.13	10.60
54	EC 415425	80.00	7.00	50.00	1.00	88.00	116.00	4.00	4.00	18.00	80.00	64.00	9.92	2.50	2.04	6.44
55	EC 415426	96.00	9.00	43.00	1.00	103.00	128.00	5.00	5.00	21.00	103.00	83.00	8.64	1.70	1.88	13.90
56	EC 415427	75.00	6.80	41.00	0.70	99.00	118.00	4.60	3.80	21.00	114.00	94.00	10.22	2.22	1.58	16.00
57	EC 415428	85.00	9.00	36.00	1.00	81.00	111.00	5.00	4.00	17.00	84.00	62.00	8.22	1.60	1.84	7.62
58	EC 415429	82.00	10.00	43.00	1.00	77.00	106.00	5.00	4.00	17.00	85.00	67.00	10.00	2.50	1.74	7.60
59	EC 415431	78.00	8.00	41.00	0.50	78.00	109.00	5.00	4.00	17.00	87.00	69.00	10.60	2.40	1.65	11.20
60	EC 415433	91.00	8.00	48.00	0.50	78.00	108.00	4.00	4.00	19.00	126.00	106.00	10.56	2.16	1.79	15.00
61	EC 415434	87.00	8.00	42.00	0.60	73.00	101.00	4.00	4.00	19.00	95.00	73.00	10.44	2.38	1.50	9.36

62	EC 415435	79.00	8.00	35.00	0.50	77.00	106.00	6.00	4.00	15.00	94.00	76.00	10.00	2.20	1.51	7.67
63	EC 415436	92.00	10.00	35.00	0.50	77.00	106.00	5.00	4.00	20.00	123.00	105.00	10.16	2.14	1.40	9.91
64	EC 415437	79.00	8.00	39.00	0.50	78.00	108.00	4.00	4.00	15.00	104.00	84.00	9.76	2.30	1.65	7.25
65	EC 415438	77.00	10.00	36.00	0.60	103.00	131.00	5.00	3.00	20.00	118.00	100.00	10.14	2.20	1.36	4.79
66	EC 415439	86.00	11.00	46.00	0.50	98.00	131.00	6.00	5.00	25.00	114.00	94.00	10.28	2.26	1.67	12.80
67	EC 415441	78.00	3.00	39.00	0.50	102.00	131.00	3.00	3.00	17.00	57.00	49.00	8.20	3.12	2.01	5.95
68	EC 415442	70.00	7.00	45.00	0.40	79.00	111.00	6.00	4.00	17.00	96.00	78.00	9.16	2.26	1.53	7.65
69	EC 415444	76.00	10.00	47.00	1.00	99.00	131.00	5.00	4.00	19.00	105.00	85.00	9.46	1.90	1.25	8.90
70	EC 415445	85.00	11.00	52.00	1.00	76.00	105.00	5.00	3.00	16.00	93.00	73.00	10.62	2.30	1.77	7.06
71	EC 415446	73.00	9.00	43.00	0.40	80.00	111.00	5.00	5.00	18.00	81.00	63.00	8.78	1.68	1.68	7.35
72	EC 415448	80.00	9.00	53.00	1.00	81.00	111.00	6.00	5.00	19.00	156.00	134.00	9.72	3.16	2.27	6.23
73	EC 415449	82.00	7.00	41.00	1.00	81.00	111.00	5.00	4.00	18.00	97.00	79.00	10.66	2.38	1.92	7.35
74	EC 415450	85.00	5.00	46.00	1.00	83.00	111.00	6.00	6.00	17.00	98.00	78.00	10.52	2.22	2.29	6.19
75	EC 415451	74.00	3.00	72.00	1.00	97.00	137.00	7.00	3.00	21.00	89.00	71.00	10.00	2.54	1.81	12.60
76	EC 415452	83.00	10.00	42.00	0.86	102.00	138.00	4.00	4.00	20.00	133.00	113.00	10.42	2.38	2.00	9.50
77	EC 415454	83.00	7.00	46.00	0.80	79.00	104.00	3.00	3.00	23.00	94.00	78.00	9.44	2.36	1.67	8.95
78	EC 415455	84.00	7.00	43.00	1.00	78.00	106.00	3.00	3.00	20.00	75.00	61.00	9.00	2.30	1.92	8.45
79	EC 415456	70.00	6.00	36.00	0.76	87.00	113.00	4.00	3.00	19.00	107.00	91.00	9.68	2.24	1.76	4.82
80	EC 415458	92.00	6.00	53.00	0.90	99.00	131.00	5.00	4.00	25.00	110.00	88.00	9.38	2.30	1.83	13.80
81	EC 415459	120.00	7.00	69.00	1.30	93.00	121.00	7.00	5.00	26.00	117.00	95.00	12.00	2.86	2.17	14.10
82	EC 415460	79.00	4.00	46.00	0.50	106.00	131.00	4.00	3.00	20.00	99.00	81.00	8.46	2.08	2.11	15.40
83	EC 415461	94.00	7.00	42.00	0.70	98.00	131.00	4.00	3.00	23.00	83.00	63.00	9.78	2.18	2.04	6.10
84	EC 415462	80.00	4.00	41.00	0.70	92.00	125.00	3.00	3.00	16.00	74.00	58.00	9.56	2.64	2.01	7.13
85	EC 415463	79.00	5.00	42.00	0.68	93.00	122.00	3.00	2.00	17.00	127.00	107.00	9.90	2.14	1.45	7.25
86	EC 415464	81.00	3.00	50.00	1.00	80.00	111.00	4.00	3.00	22.00	100.00	82.00	9.00	2.00	1.74	9.98
87	EC 415465	90.00	11.00	46.00	1.00	103.00	131.00	4.00	3.00	14.00	83.00	63.00	10.00	2.00	2.02	14.20
87	EC 415468	79.00	6.00	44.00	0.70	96.00	127.00	3.00	2.00	22.00	29.00	111.00	9.66	2.46	2.04	10.80

89	EC 415470	88.00	6.00	52.00	0.50	90.00	128.00	3.00	3.00	19.00	82.00	62.00	10.18	2.06	1.56	10.50
90	Jyothi	80.16	5.04	44.72	0.85	98.00	126.00	7.20	6.44	19.60	108.84	89.40	9.29	3.00	2.10	15.20
91	Jaya	114.60	5.14	52.68	0.96	96.40	130.00	6.08	5.16	18.70	89.04	67.84	8.49	2.86	1.92	10.44
92	Thulasi	110.10	6.60	53.28	0.86	78.00	107.00	4.96	3.32	17.90	82.12	63.56	8.42	2.99	2.22	9.34
93	Vaisakh	127.40	3.80	59.08	0.90	78.00	108.00	4.76	4.00	19.00	110.88	90.40	8.28	3.17	2.41	11.96
94	Manurathna	84.24	6.22	41.72	0.86	83.00	131.00	6.24	4.40	16.30	70.08	54.72	7.72	2.81	2.33	11.30
	Over all mean	94.07	7.07	49.75	0.84	85.01	114.72	5.23	3.91	19.25	98.43	80.48	9.25	2.38	1.92	9.80
	Minimum	66.00	3.00	35.00	0.40	71.00	102.00	3.00	2.00	11.00	29.00	49.00	6.12	1.50	1.21	4.82
	Maximum	153.00	12.00	72.00	1.30	106.00	138.00	9.00	8.00	26.00	212.00	186.00	12.00	3.26	2.62	17.40
	Mean of check vars	103.30	5.36	50.53	0.89	86.68	120.40	5.84	4.66	18.3	92.18	73.18	8.44	2.97	2.20	11.65
	CD	25.55	1.72	9.32	0.22	7.76	9.51	3.00	1.04	3.40	37.65	32.91	1.69	0.98	0.38	6.67

(**PH-** Plant height; **LL-** Ligule length; **LBL-** Leaf blade length; **LBW-** Leaf blade width; **TF-** Days to 50 per cent flowering; **TM-** Days to maturity; **NTP-** Number of tillers per plant; **NPTP-** Number of productive tillers per plant; **PL-** Panicle length; **NSP-** Number of spikelets per panicle; **NGP-** Number of grains per panicle; **GL-** Grain length; **GW-** Grain width; **TGW-** 100 grain weight; **GY-** Grain yield**).**

Evaluation of eighty nine exotic rice accessions along with five check varieties in augmented design showed that there was high variability present in the population for all quantitative traits tested. The data is presented in Table 25 and 39.

4.2.1 Plant height (cm)

Plant height of the accessions was observed between 66 cm of accession EC 415414 and 153 cm of accession EC 204999 with an overall mean of 94.07 cm indicating wide variability between the accessions for the trait. Plant height of the check varieties were observed between 80.16 cm of Jyothi to 127.40 cm of Jaya with mean value of 103.00 cm. The accessions EC 207747, EC 204863, EC 204999, EC 205070, EC 205314, EC 205321, EC 205128, EC 205333 and EC 415401 were significantly taller than the check varieties while, EC 204868, EC 415392, EC 415409, EC 415410, EC 415413, EC 415414, EC 415416, EC 415420, EC 415427, EC 415431, EC 415438, EC 415441, EC 415442, EC 415444, EC 415446, EC 415451 and EC 415456 were shorter than the check varieties.

Plant height is an important agronomic trait that directly affects the yield in rice. The dwarf phenotype will not lodge, but if the plants are too short, it will lead to insufficient growth and affect the yield. Hence, semi dwarf genotypes will be more useful to minimize lodging with good yield. It is influenced by soil type, irrigation, application of fertilizer etc. Categorization of the accessions by DUS criteria based on the plant height showed that fifty-four accessions along with two check varieties (59.57 per cent) were very short (<91 cm), sixteen accessions (17.02 per cent) were short (91- 110 cm), fourteen accessions and three check varieties (18.08 per cent) were medium (110- 130 cm), four accessions (4.25 per cent) were long (131-150 cm) and only one accession (1.06 per cent) was very long (>150 cm) as presented in Table 25. Fourteen accessions which are observed to be medium in height can be used for crop improvement programmes in rice after considering other traits.

Table 25. Categorization of the accessions based on plant height

State	Code	Accessions	Percentage of accessions
Very short (<91 cm)	1	EC 204865, EC 204868, EC 205001, EC 205205, EC 205314, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415402, EC 415403, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415416, EC 415417, EC 415420, EC 415421, EC 415423, EC 415425, EC 415427, EC 415428, EC 415429, EC 415431, EC 415434, EC 415435, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415460, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi and Manurathna.	59.57
Short (91-110 cm)	3	EC 204847, EC 205264, EC 205275, EC 205305, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415415, EC 415422, EC 415426, EC 415433, EC 415436, EC 415458, EC 415461	17.02
Medium (111-130 cm)	5	EC 207747, EC 204928, EC 204970, EC 204991, EC 205042, EC 205047, EC 205070, EC 205072, EC 205192, EC 205223, EC 205252, EC 205269, EC 415401, EC 415459 Jaya, Thulasi and Vaisakh	18.08
Long (131-150 cm)	7	EC 204863, EC 205128, EC 205321, EC 205333	4.25
Very long (>150 cm)	9	EC 204999	1.06

4.2.2 Ligule length (mm)

Ligule is a thin outgrowth at the joint of leaf and leafstalk in family Poaceae and is present in all most all varieties of rice. The length, color, and shape of the ligule differ according to variety. Observation on ligule length in 89 accessions showed wide variability. Length of ligule varied between 3.00 mm of accessions EC 204868, EC 205275, EC 415441, EC 415451 and EC 415464 to 12 cm of accessions EC 207747, EC 205223 and EC 415422 with a mean value of 7.07mm. Among the check varieties it varied between 3.80 mm of Vaisakh to 6.60mm of Thulasi with a mean value of 5.36mm. Thirty six accessions were having longer ligule compared to the mean of the check varieties. The accessions EC 204868, EC 205275, EC 415441, EC 415451 and EC 415464 were having shorter ligule.

Categorization of accessions based on ligule length showed that twenty-four accessions along with three check varieties (28.72 per cent) had short (<5 mm) ligule length, fifty-six genotypes with two check varieties (61.70 per cent) possessed medium (5- 10 mm) and nine accessions (9.57 per cent) had long (>10 mm) ligule length as indicated in Table 26. According to Chaffey (1985, and 2000), ligule is photosynthetic, and based on its position on the leaf, it could act passively to prevent ingression of water. By considering its structure and ultrastructure, it may also play a more active role in the life of the plant. He observed it has been assumed to act in protecting the culm and leaves that it encloses from the entry of water, dust and harmful spores. Variability showed in the length of ligule indicate that it must be having specific role. Abraham *et al.* (2017) reported that the ligule length was a good indicator to distinguish between the two established yield patterns in the selected landraces based on their study on 37 accessions from four land races in Obafemi Awolowo University, Nigeria. They classified the accessions in to two groups as intermediate or late maturing with high tillering, dense panicle with low test weight and early maturing and, low tillering, less dense or sparse panicle with high test weight. They concluded that plants with longer ligules are likely to produce more spikelets or grains but low 1000-grain weight. They also suggested that being an outgrowth of the leaf sheath, ligule form a kind of support system for internodes at the node, and helps the culm to bear the weight of the panicle. Being a character which can be observed at seedling phase of the plant they proposed to consider ligule length as a selection criteria for early selection of high yielding plants. Hence, based on this criteria the accessions EC 207747, EC 205042, EC 205223, EC 415397, EC 415412, EC 415416, EC 415422, EC 415439, and EC 415465 can be considered as high yielding.

Table 26. Categorization of accessions based on ligule length

State	**Code**	**Accessions**	**Percentage of accessions**
Short (<5 mm)	1	EC 204847, EC 204863, EC 204865, EC 204868, EC 204970, EC 204991, EC 205001, EC 205070, EC 205072, EC 205128, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205333, EC 415404, EC 415423, EC 415450, EC 415451, EC 415460, EC 415462, EC 415463, EC 415464, Jyothi, Jaya and Vaisakh.	28.72
Medium (5- 10 mm)	2	EC 204928, EC 204999, EC 205047, EC 205192, EC 205205, EC 205252, EC 205321, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399, EC 415401, EC 415402, EC 415403, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415413, EC 415414, EC 415415, EC 415417, EC 415420, EC 415421, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415461, EC 415468, EC 415470, Thulasi and Manurathna.	61.70
Long (<10 mm)	3	EC 207747, EC 205042, EC 205223, EC 415397, EC 415412, EC 415416, EC 415422, EC 415439, EC 415465	9.57

4.2.3 Leaf blade length (cm)

According to Tafere and Irie (2019), the photosynthetic rate of plant is a function of canopy architecture and leaf area is one of the major canopy feature. Leaf area is determined by the length and breadth of the leaf. The leaf length of the tested accessions showed wide variability. It was found between 35 cm of accessions EC 415435, EC 415436, to 72 cm of EC 415451 with a mean value of 49.75cm. Among the check varieties it were observed between 41.72 cm to 59.08 cm of Vaisakh with a mean value of 50.53cm. The exotic accessions namely, EC 207747, EC 204847, EC 204863, EC 204970, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205264, EC 205275, EC 205321, EC 205333 and EC 415451 were having longer leaf in comparison with the mean leaf length of check varieties. These accessions with an increased leaf area might be having high photosynthetic efficiency compared to short leaves. Accessions EC 415409, EC 415410, EC 415411, EC 415423, EC 415427, EC 415428, EC 415431, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415449, EC 415456 and EC 415462 were having shorter leaf blade.

According the DUS criteria thirty-two accessions along with two check varieties (36.17 per cent) were found to have medium leaf length (30- 45 cm), while, fifty-seven accessions with three check varieties (63.82 per cent) recorded long leaf (>45 cm). There was no short leaf blade in the tested accessions as indicated in Table 27. Long leaf observed in majority of the accessions indicates that these accessions may be photosynthetically more efficient. Similar to the present study, Manjunatha *et al*. (2018b) also observed long leaves in 63 per cent of land races they studied. They observed medium long leaves in 33 per cent of the genotypes and only three per cent of landraces were having short leaf.

Table 27. Categorization of the accessions based on leaf blade length

State	Code	Accessions	Percentage of accessions
Medium (30- 45 cm)	5	EC 204868, EC 415394, EC 415396, EC 415399, EC 415404, EC 415405, EC 415406, EC 415409, EC 415410, EC 415411, EC 415412, EC 415416, EC 415423, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415446, EC 415449, EC 415452, EC 415455, EC 415456, EC 415461, EC 415462, EC 415463, EC 415468, Jyothi and Manurathna.	36.17
Long (>45 cm)	7	EC 207747, EC 204847, EC 204863, EC 204865, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415397, EC 415401, EC 415402, EC 415403, EC 415407, EC 415408, EC 415413, EC 415414, EC 415415, EC 415417, EC 415420, EC 415421, EC 415422, EC 415425, EC 415433, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415448, EC 415450, EC 415451, EC 415454, EC 415458, EC 415459, EC 415460, EC 415464, EC 415465, EC 415470 Jaya, Thulasi and Vaisakh	63.82

4.2.4 Leaf blade width (cm)

Observation on leaf width also showed wide variability among the accessions evaluated. It varied from 0.40cm of accession EC 415442 to 1.30 cm of EC 415459 with a mean value of 0.84. Among the check varieties range was observed between 0.85 cm of Jyothi to 0.96 cm of Jaya with a mean of 0.89cm. Being an important part of canopy architecture leaf blade width also contribute to photosynthesis and yield. In the case of leaf blade width only one accession EC 204863 had significantly broader leaves compared to check varieties, while, 45 accessions had narrow leaf. Hence, even though many accessions had longer leaves as they were narrow the expected advantage for photosynthesis might not have reached because of low leaf area. The accession EC 204863 had long and broad leaves, however, number of leaves and orientation of leaf also has to be considered while assessing the photosynthetic efficacy.

Categorization of accessions on the basis of leaf blade width showed that fifty-five accessions along with four check varieties (62.76 per cent) were having narrow (<1 cm) leaf blade. Thirty-four accessions with one check variety (37.23 per cent) had medium (1- 2 cm) leaf blade width. There was no accession with broad leaf (Table 28). Studies by Manjunatha *et al.* (2018b) based on 60 land races of Kerala showed that majority of the genotypes (77 per cent) had medium leaf width and rest 23 per cent of the land races had broad leaf. Hence, it can be assumed that based on leaf area traditional land races of Kerala could be more photosynthetically efficient compared to exotic accessions.

Table 28. Categorization of the accessions based on leaf blade width

State	**Code**	**Accessions**	**Percentage of accessions**
Narrow (<1 cm)	3	EC 204847, EC 204865, EC 204868, EC 204991, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415401, EC 415402, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415420, EC 415421, EC 415423, EC 415427, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415446, EC 415452, EC 415454, EC 415456, EC 415458, EC 415460, EC 415461, EC 415462, EC 415463, EC 415468, EC 415470, Jyothi, Thulasi, Vaisakh and Manurathna.	62.76
Medium (1-2 cm)	5	EC 207747, EC 204863, EC 204928, EC 204970, EC 204999, EC 205001, EC 205192, EC 205205, EC 205305, EC 205314, EC 205321, EC 415399, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415417, EC 415422,	37.23

		EC 415425, EC 415426, EC 415428, EC 415429, EC 415444, EC 415445, EC 415448, EC 415449, EC 415450, EC 415451, EC 415455, EC 415459, EC 415464, EC 415465 Jaya	

4.2.5 Days to 50 per cent flowering

Duration of a crop is determined by the days to flowering and days to maturity. Early flowering crop will help the plants to escape biotic and abiotic stress and also allow the farmer for multiple cropping. The accessions was found between for days to flowering from 71 days of accession EC 415396 and EC 415415 to 106 days of EC 415460 with a mean value of 85.01 days. Among the check varieties range was observed between 78 days of Thulasi and Vaisakh to 98 days of Jyothi with mean of 86.68 days. Twenty accessions were late to initiate flower, while 33 accessions were early to flower compared to the mean value of the check varieties.

Grouping of the accessions based on days to flowering showed that sixty-five accessions along with three check varieties (72.34 per cent) were early to flower (71-90 days), while, twenty-four accessions and two check varieties (27.65 per cent) took medium number of days to flower (91- 110 days). There was no very early, late and very late flowering accessions as showed in Table 29. Majority of accessions evaluated were early to flower and these early flowering accessions can be used in breeding programme considering other important traits. According to Manjunath *et al.* (2018b), 17 per cent landraces were of late type (111-130 days) and 83 per cent of landraces were of very late indicating late flowering nature of traditional rice cultivars of Kerala.

Table 29. Categorization of the accessions based on Days to 50 per cent flowering

State	**Code**	**Accessions**	**Percentage of accessions**
Early (71- 90 days)	3	EC 207747, EC 204863, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415439, EC 415441, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415454, EC 415455, EC 415456, EC 415464, Thulasi, Vaisakh and Manurathna.	72.34
Medium (91- 110 days)	5	EC 204847, EC 204865, EC 204868, EC 415397, EC 415401, EC 205072, EC 205128, EC 205314, EC 415426, EC 415427, EC 415438, EC 415442, EC 415444, EC 415451, EC 415452, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415465, EC 415468, EC 415470, Jyothi and Jaya	27.65

4.2.6 Days to maturity

Days to flowering and days to maturity follows same pattern. Accessions flower early will come to maturity early. There was wide variability observed in total duration of 89 exotic accessions evaluated. It was found between 101 days of EC 205042 to 138 days of EC 415452 with a mean value of 114.72. Duration of check varieties was observed between 107 days of Thulasi to 130 days of Jaya with a mean maturity duration of 120.40 days. Results showed that thirty four accessions were significantly early compared to mean value of the checks and 14 accessions were late to reach maturity.

On basis of categorization, majority of the accessions (70.21 per cent) along with Thualasi and Vaisakh showed early maturity of (101- 120 days) and 25 accessions along with three check varieties (29.78 per cent) exhibited medium duration of maturity (121- 140 days) as indicated in Table 30. Manjunatha *et al.* (2018b) observed that 15 per cent of landraces were of late type (141-160 days) and 85 per cent landraces were very late (>160) to mature indicating the earliness of exotic accessions. Hence, these lines can be used in breeding programmes considering other important traits also.

Table 30. Categorization of the accessions based on days to maturity

State	**Code**	**Accessions**	**Percentage of accessions**
Early (101- 120 days)	3	EC 207747, EC 204863, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415399, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415435, EC 415436, EC 415437, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415454, EC 415455, EC 415456, EC 415464, Thulasi and Vaisakh	70.21
Medium (121- 140 days)	5	EC 204847, EC 204865, EC 204868, EC 205070, EC 205072, EC 205128, EC 205314, EC 415397, EC 415401, EC 415426, EC 415438, EC 415439, EC 415441, EC 415434, EC 415451, EC 415452, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415465, EC 415468, EC 415470, Jyothi, Jaya and Manurathna.	29.78

4.2.7 Number of tillers per plant

Number of tillers per plant is an important agronomic trait which contributes to yield in rice. The variability observed for this trait in the 89 exotic rice germplasm tested was less compared to other characters. Among the tested accessions range was observed between three to nine with an average of 5.23. Among the five check varieties range was observed between 4.96 of Thulasi to 7.20 of Jyothi and the mean value for check variety was 5.94. Only four accessions had significantly high number of tillers per plant (9) compared to check varieties and they are EC 207747, EC 204863, EC 205042 and EC 205128. All other accessions were on par with check varieties for this character. Saini *et al.* (2013) observed high number of tillers per plant ranging from 9.5 to 29.6 among 160 short duration rice germplasm they evaluated. Compared to that work in the present study variability with respect to total number of tillers was less.

Categorization of the accessions based on number of tillers per plant showed that , fifty-nine genotypes along with two check varieties (64.89 per cent) recorded low (<5 tillers) and thirty accessions with three check varieties (35.10per cent) had medium (5- 10 tillers) number of tillers as presented in Table 31.

Table 31. Categorization of the accessions based on number of tillers per plant

State	**Code**	**Accessions**	**Percentage of accessions**
Low (<5)	1	EC 204847, EC 204865, EC 204868, EC 205070, EC 205192, EC 205205, EC 205269, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415402, EC 415403, EC 415404, EC 415406, EC 415408, EC 415409, EC 415410, EC 415412, EC 415413, EC 415414, EC 415416, EC 415420, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415436, EC 415437, EC 415438, EC 415442, EC 415444, EC 415445, EC 415446, EC 415449, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415460,	64.89

		EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Thulasi and Vaisakh	
Medium (5- 10)	2	EC 207747, EC 204863, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205072, EC 205128, EC 205223, EC 205252, EC 205264, EC 205275, EC 415399, EC 415401, EC 415405, EC 415407, EC 415411, EC 415415, EC 415417, EC 415421, EC 415422, EC 415435, EC 415439, EC 415441, EC 415448, EC 415450, EC 415459, Jyothi, Jaya and Manurathna.	35.10

4.2.8 Number of productive tillers per plant

Number of productive tillers per plant is an important character contributing directly to yield. It range was observed between two in accession EC 415468 to eight in accessions EC 207747 and EC 415401. Mean value among the accessions was 3.91. Among the check varieties it varied between 3.2 of Thulasi to 6.44 of Jyothi with a mean value of 4.66. Only four accessions namely,EC 207747, EC 204863, EC 205070 and EC 415401 had significantly higher number of productive tillers per plant compared to mean value of check varieties.Thirty six accessions had low number of productive tillers while others were on par with check varieties. Saini *et al.* (2013) observed a wider range for number of productive tillers per plant. In their studies range was observed between 5.5 to 25.60.

Classification of the number of productive tillers per plant as per DUS criteria showed that eighty-seven accessions along with five check varieties (97.87 per cent) had low (<7) number of productive tillers, while, two accessions (2.12 per cent) were found to have intermediate number of productive tillers (8-12 culms) as indicated in Table 32. Similar to our studies Manjunatha *et al.* (2018) also observed 88 per cent of landraces having few number of panicle which is otherwise the number of tillers bearing panicle, and only 12 per cent landraces were of medium type.

Table 32. Categorization of the accessions based on number of productive tillers per plant

State	**Code**	**Accessions**	**Percentage of accessions**
Low (<7 culms)	1	EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	97.87
Intermediate (8- 12culms)	2	EC 207747, EC 415401	2.12

4.2.9 Panicle length (cm)

Length of the panicles is also an important character contributing to yield. Among the 89 exotic accessions evaluated and observed between 11 cm of the accession EC 415396 to 26 cm of the accession EC 415459.The mean value for panicle length among the accessions was 19.25 cm. Panicle length in the check varieties was found between 17.90 cm of Thulasi to 19.60 cm of Jyothi and the mean value was 18.30 cm. Eighteen accessions namely, EC 207747, EC 204999, EC 205047, EC 205223, EC 205269, EC 205305, EC 205321, EC 415401, EC 415413, EC 415415, EC 415422, EC 415439, EC 415454, EC 415458, EC 415459, EC

415461, EC 415464 and EC 415468 were having longer panicles compared to check varieties, while only two accessions had short panicles. They were accessions, EC 415396 and EC 415465. The accessions with longer panicle can be used in breeding programme to improve yield.

Categorization based on panicle length showed that six accessions (6.38 per cent) had very short (<16 cm) panicle while, thirty-seven accessions along with five check varieties (44.68 per cent) had short (16- 20 cm) panicle and forty-six accessions (48.93 per cent) had medium long panicle (21- 25 cm) as presented in Table 33.However, Manjunatha *et al.* (2018) observed short panicles in 3 per cent of the landraces they studied while medim long panicles were observed in 32 per cent, long panicles in 57 per cent and very long panicles in 8 per cent of landraces they evaluated. This indicate that in general exotic germplasm had short panicles.

Table 33. Categorization of the accessions based on panicle length

State	Code	Accessions	Percentage of accessions
Very short (<16 cm)	1	EC 204865, EC 415396, EC 415399, EC 415435, EC 415437, EC 415465	6.38
Short (16- 20cm)	3	EC 204847, EC 204868, EC 204928, EC 205001, EC 205072, EC 205275, EC 415392, EC 415393, EC 415394, EC 415411, EC 415412, EC 415414, EC 415420, EC 415428, EC 415429, EC 415403, EC 415404, EC 415407, EC 415416, EC 415417, EC 415423, EC 415425, EC 415431, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415456, EC 415462, EC 415463, EC 415470, EC 415433, EC 415434, Jyothi, Jaya, Thulasi,Vaisakh and Manurathna.	44.68
Medium (21-25 cm)	5	EC 207747, EC 204863, EC 204970, EC 204991, EC 204999, EC 205042, EC 205047, EC 205070, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205305, EC 205314, EC 205321, EC 205333, EC 415397, EC 415401, EC 415402, EC 415405, EC 415406, EC 415408, EC 415409, EC 415410, EC 415413, EC 415415, EC 415421, EC 415422, EC 415426, EC 415427, EC 415436, EC 415438, EC 415439,	48.93

		EC 415451, EC 415452, EC 415454, EC 415455, EC 415458, EC 415459, EC 415460, EC 415461, EC 415464, EC 415468	

4.2.10 Number of spikelets per panicle

Spikelets per panicle determines the grain number and ultimately yield. In the tested 89 exotic accessions the number of spikelets per panicle was observed between 29 (accession, EC 415468) to 212 (accession, EC 205314) with a mean value of 98.43. Number of spikelets in check varieties was observed between 70.08 of Manurathna to 110.88 of Vaisakh with a mean value of 92.19. Accessions EC 204847, EC 205001, EC 205223, EC 205314, EC 415448 and EC 415452 had more number of spikelets compared to check varieties and all other accessions were on par with check varieties. According to Saini *et al.* (2013), number of spikelets panicle was observed between 73 to 281.60 indicating wide variability of the rice short duration germplasm they evaluated. Compared to their study range of variation was less in the present study. Categorisation of accessions on the basis of number of spikelets per panicle showed that 85 accessions and all check varieties (96.80 per cent) recorded few (<150) spikelets per panicle and two accessions (2.12per cent) had medium (150- 200) spikelets per panicle and one accession had many number of spikelets per panicles as presented in Table 34.

Table 34. Categorization of the accessions based on number of spikelets per panicle

State	Code	Accessions	Percentage of accessions
Few (<150)	3	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410,	96.80

		EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	
Medium (150-200)	5	EC 205223, EC 415448	2.12
Many (>200)		EC 205314	1.06

4.2.11 Number of grain per panicle

Number of grains per panicle in rice is an important trait contributing directly to grain yield. The trait was showing high variability in the 89 exotic accessions evaluated. It was found between 49 numbers (accession, EC 415441) to 186 (accession, EC 205314) with a mean value of 80.48. Among the check varieties range was observed between 54.72 of Manurathna to 90.40 of Vaisakh. Eight accessions had grain number more than that of check varieties. They were EC 204847, EC 205001, EC 205223, EC 205275, EC 205314, EC 415448, EC 415452 and EC 415463. Only six accessions had low number of grains per panicle compared to check varieties and they were EC 204863, EC 204863, EC 204868, EC 415407 and, EC 415407. Saini *et al.* (2013) observed the range for number of grains per panicle as 9.42 to 223.20 indicating wide variability in the germplasm.On the basis of number of grain per panicle, two accessions (2.12 per cent) exhibited medium (151-200) number of grain and the rest eighty-seven accessions along with check varieties (97.87 per cent) showed low (<150) grain per panicle as indicated in Table 35.

Table 35. Categorization of the accessions based on number of grains per panicle

State	Code	Accessions	Percentage of accessions
Low (<150)	1	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205205, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205321, EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415460, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna.	97.87
Medium (151-200)	3	EC 205223, EC 205314	2.12

4.2.12 Grain length (mm)

Grain length is an important trait which determines the commercial quality of the rice grain. It was observed between6.12 mm (accession, EC 205223) to 12.00 mm (accession, EC 415459) with a mean value of 9.25mm. Among the check varieties it varied from 7.72 mm of Manurathna to 8.29 mm of Jyothi. Average value for grain length of check varieties was 8.44 mm. Only one accession EC 205223 was shorter than the check varieties, while nineteen accessions had long grains. All other entries were on par with check varieties with respect to grain length. Grain length of 160 short duration rice germplasm was found between 4.29 mm to 9.25mm (Saini *et al.*

2013). However, in the present study grains were longer with a range of 6.12 mm to12.00 mm.

Based on grain length, twenty-four accessions along with four check varieties (29.78 per cent) were grouped as short (6.1- 8.5 mm), fifty-five accessions and one check variety (59.57 per cent) as medium (8.6- 10.5 mm) and ten accessions (10.63 per cent) as long (10.6- 12.5 mm) as presented in Table 36. Manjunatha *et al.* (2018) classified land races based on grain length as very short (6.67 per cent), short (75 per cent), medium (16.67 per cent) and long (1.67 per cent) among the 60 landraces of Kerala. This indicate that majority of Kerala landraces are shorter compared to exotic accessions where we could get more of medium long grains.

Table 36. Categorization of the accessions based on grain length

State	Code	Accessions	Percentage of accessions
Short (6.1-8.5 mm)	3	EC 207747, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205042, EC 205072, EC 205128, EC 205192, EC 205205, EC 205223, EC 205252, EC 205264, EC 205269, EC 205275, EC 205305, EC 205314, EC 205333, EC 415428, EC 415442, EC 415460, Jaya, Thulasi, Vaisakh and Manurathna.	29.78
Medium (8.6- 10.5 mm)		EC 204847, EC 205001, EC 205047, EC 205070, EC 205321, EC 415393, EC 415397, EC 415399, EC 415401, EC 415403, EC 415404, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415423, EC 415425, EC 415426, EC 415427, EC 415429, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415439, EC 415441, EC 415444, EC 415446, EC 415448, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415461, EC 415462, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470, Jyothi	59.57
Long (10.6- 12.5 mm)	5	EC 415392, EC 415394, EC 415396, EC 415402, EC 415405, EC 415412, EC 415422, EC 415431, EC 415445, EC 415449	10.63

4.2.12 Grain width (mm)

Width of grain in rice also determines the shape of grain which is an important commercial aspect. Among the exotic accessions grain width was found between 1.50 mm (accession, EC 415397) to 3.26mm (accession, EC 205264) and the mean value was 2.38. Among the check varieties it varied from 2.81 mm of Manurathna to 3.17mm of Vaisakh with a mean of 2.97mm. Fifteen accessions had narrow grain compared to check varieties and none of the exotic accession had significantly broader grain. Saini *et al.* (2013) observed grain width of the rice gremplasm they evaluated as ranging from 0.22mm to 2.48mm indicating wide variability in the germplasm they evaluated. Grain width of fifteen accessions (15.95per cent) were grouped as very narrow (<2.0 mm), while forty-eight accessions (51.06 per cent) had narrow (2.1- 2.5 mm), twenty-one accessions along with four check varieties (26.59 per cent) had medium (2.6- 3.0 mm) and five accessions with one check variety (5.31 per cent) had broad (3.1- 3.5 mm) grain as indicated in Table 37. Compared to the studies of Manjunatha *et al.* (2018) where they could get more of broader grains, in the present study majority of accessions had narrow grains. They observed 1.67 per cent as very narrow, 6.67 per cent as medium, 70 per cent as broad and 21.67 per cent as very broad. This indicate that exotic accessions have long and narrow grains whereas land races of Kerala are short and broad.

Table 37. Categorization and grouping based on grain width

State	Code	Accessions	Percentage of accessions
Very narrow (<2.0 mm)	1	EC 204999, EC 205333, EC 415393, EC 415394, EC 415397, EC 415404, EC 415406, EC 415407, EC 415410, EC 415417, EC 415421, EC 415426, EC 415428, EC 415444, EC 415446	15.95
Narrow (2.1- 2.5 mm)	3	EC 204847, EC 204865, EC 204868, EC 204928, EC 204970, EC 205042, EC 205223, EC 205252, EC 205269, EC 415392, EC 415396, EC 415399, EC 415402, EC 415403, EC 415405, EC 415411, EC 415412, EC 415413, EC 415414, EC 415420, EC 415422, EC 415423, EC 415427, EC 415431, EC 415433, EC 415434, EC 415435, EC 415436,	51.06

		EC 415437, EC 415438, EC 415439, EC 415441, EC 415442, EC 415445, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415460, EC 415461, EC 415463, EC 415464, EC 415465, EC 415468, EC 415470	
Medium (2.6- 3.0 mm)	5	EC 207747, EC 204863, EC 204991, EC 205001, EC 205047, EC 205070, EC 205128, EC 205275, EC 205305, EC 205314, EC 205321, EC 415401, EC 415408, EC 415409, EC 415416, EC 415425, EC 415429, EC 415448, EC 415449, EC 415459, EC 415462, Jyothi, Jaya, Thulasi and Manurathna	26.59
Broad (3.1- 3.5 mm)	7	EC 205072, EC 205192, EC 205205, EC 205264, EC 415415, Vaisakh	5.31

4.2.13 100 grain weight (g)

Test weight or hundred grain weight is determined by the boldness of grain and is a determinant of grain yield in rice. Among the exotic accessions range was observed between 1.21g to 2.62g with a mean value of 1.92. Among the check varieties range was observed between 1.2 g of Jaya to 2.41 g of Vaisakh with a mean value of 2.20g. None of the accessions had high test weight compared to check varieties, while 29 accessions had low test weight. Other sixty accessions were on par with check varieties for test weight. Saini *et al.* (2013) observed that the 100 grain weight of the genotypes they studied was observed between 2.14 g to 2.36 g showing a narrow range for the trait. However, in the present study the accessions showed a wider range of 1.21g to 2.62 g.

Categorization of accessions were found that nine accessions (9.57) had low (> 1.5 g) grain weight and thirty eight accessions (41.48 per cent) along with check variety Jaya possessed medium (1.5 - 2.0 g) grain weight as presented in Table 38. Forty one accessions (47.87 per cent) and check varieties, Jyothi, Thulasi, Vaisakh and Manurathna had high test weight ranging between 20.5 to 3 g. One accession EC 415422 had very high test weight of more than 3 g. Manjunatha *et al.* (2018) observed low test weight in 10 per cent of land races they evaluated. And the other classes were

18.33 per cent medium, 28.33 per cent were high and 43.33 per cent were very high test weight of more than 3 g for 100 seeds. This also is a clear indication of the difference in the grain type of the exotic lines and land races of Kerala which are shorter, broader and heavier compared to exotic accessions.

Table 38. Categorization of accessions based on 100 grain weight

State	Code	Accessions	Percentage of accessions
Low (<1.5 g)	1	EC 204847, EC 204865, EC 205305, EC 415394, EC 415434, EC 415436, EC 415438, EC 415444, EC 415463	9.57
Medium (1.5- 2 g)	2	EC 207747, EC 204863, EC 204970, EC 204991, EC 204999, EC 205047, EC 205070, EC 205072, EC 205128, EC 205264, EC 205314, EC 205321, EC 415397, EC 415402, EC 415403, EC 415411, EC 415412, EC 415415, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415433, EC 415435, EC 415437, EC 415439, EC 415442, EC 415445, EC 415446, EC 415449, EC 415451, EC 415454, EC 415455, EC 415456, EC 415458, EC 415464, EC 415470, Jaya	41.48
High (2.1- 2.5g)	3	EC 204868, EC 204928, EC 205001, EC 205042, EC 205192, EC 205205, EC 205223, EC 205252, EC 205269, EC 205275, EC 205333, EC 415392, EC 415393, EC 415396, EC 415399, EC 415401, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415413, EC 415414, EC 415416, EC 415417, EC 415420, EC 415421, EC 415423, EC 415425, EC 415441, EC 415448, EC 415450, EC 415452, EC 415459, EC 415460, EC 415461, EC 415462, EC 415465, EC 415468, Jyothi, Thulasi, Vaisakh and Manurathna.	47.87
Very high (2.6- 3 g)	4	EC 415422	1.06

4.2.14 Grain yield (g)

Grain yield is the most important aspect of any plant of commercial interest. It is highly influenced by many factors most important being its genetic potential. Being exotic collections which are not exposed to their natural environment the exact potential of the plant might not have expressed here. Grain yield of the accession raged between 4.79g (accession, EC 415438) to 17.40g (accession, EC 415405) with a mean value of 9.80 g. Among the check varieties range was observed between 9.34g of Thulasi to 15.20g of Jyothi with a mean value of 11.65 g. None of the genotypes were having better yield than check varieties and only two accessions were having lower yield than check varieties indicating that other 87 accessions were having grain yield on par with check varieties. As per the study of Saini *et al.* (2013) the grain yield per plant was observed between 8 g to 46.96 g. indicating a wide range for the trait which was not observed in the present study. Based on grain yield fifty-four accessions along with two check varieties (59.57per cent) had low (<10 g) and thirty-five genotypes with three check varieties (40.42per cent) obtained medium (10- 20 g) grain yield as indicated in Table 39.

Table 39. Categorization of accessions based on grain yield

State	Code	Accessions	Percentage of accessions
Low (<10 g)	1	EC 207747, EC 204847, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205047, EC 205070, EC 205072, EC 205128, EC 205205, EC 205264, EC 205275, EC 205305, EC 205314, EC 415393, EC 415394, EC 415402, EC 415403, EC 415407, EC 415409, EC 415412, EC 415415, EC 415417, EC 415421, EC 415422, EC 415425, EC 415428, EC 415429, EC 415433, EC 415434, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415452, EC 415454, EC 415455, EC 415456, EC 415461, EC 415462, EC 415463, EC 415464 , Jaya and Thulasi	59.57
Medium (10-20 g)	2	EC 204863, EC 205042, EC 205192, EC 205223, EC 205252, EC 205269, EC 205321, EC 205333,	40.42

		EC 415392, EC 415396, EC 415397, EC 415399, EC 415401, EC 415404, EC 415405, EC 415406, EC 415408, EC 415410, EC 415411, EC 415413, EC 415414, EC 415416, EC 415420, EC 415423, EC 415426, EC 415427, EC 415431, EC 415439, EC 415451, EC 415458, EC 415459, EC 415460, EC 415465, EC 415468, EC 415470, Jyothi, Vaisakh and Manurathna	

The variation of important quantitative characters presented in Fig 10 in the below:

Fig 11. Variation of accessions based on quantitative characters

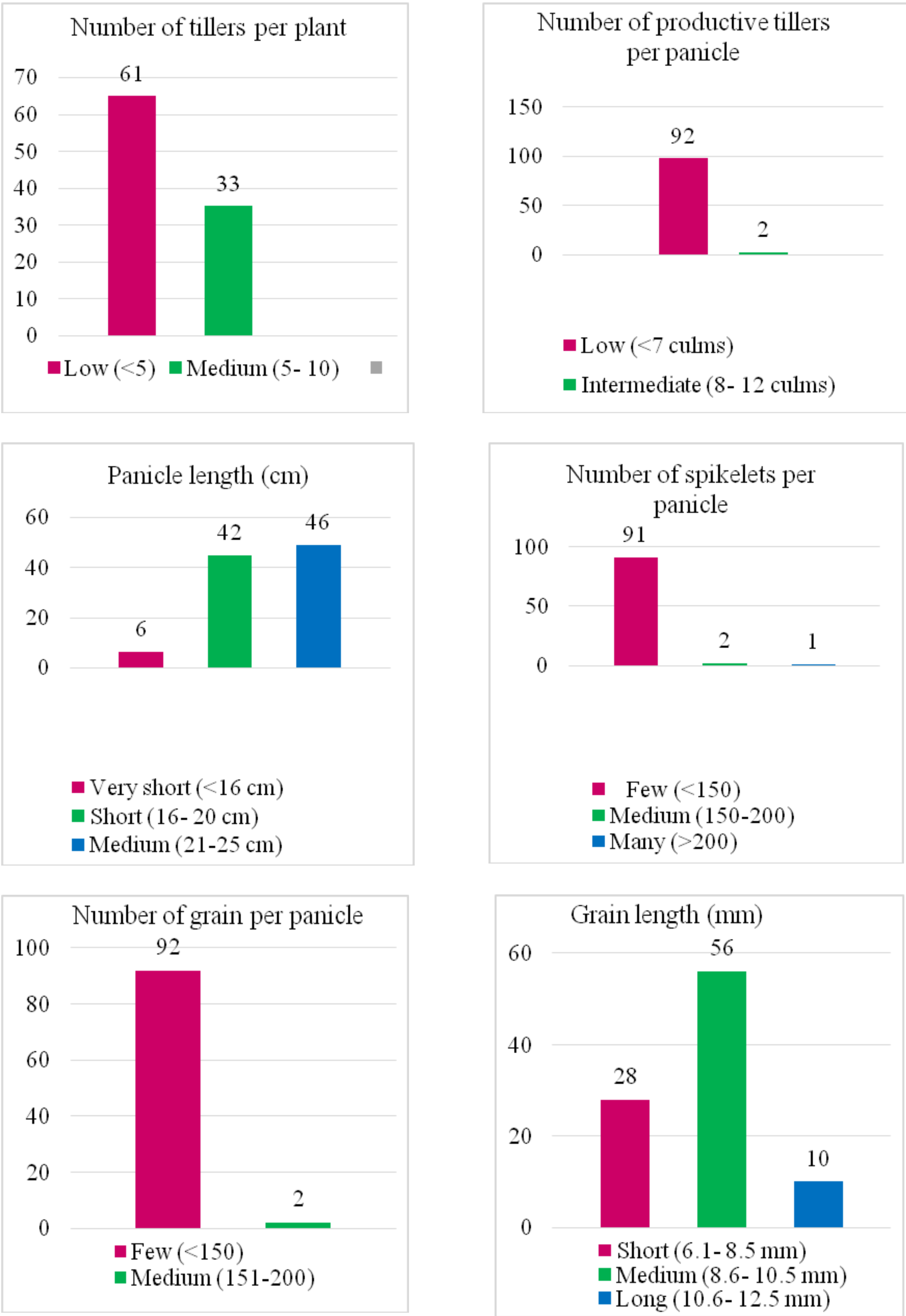


Fig 11. Variation of accessions based on quantitative characters

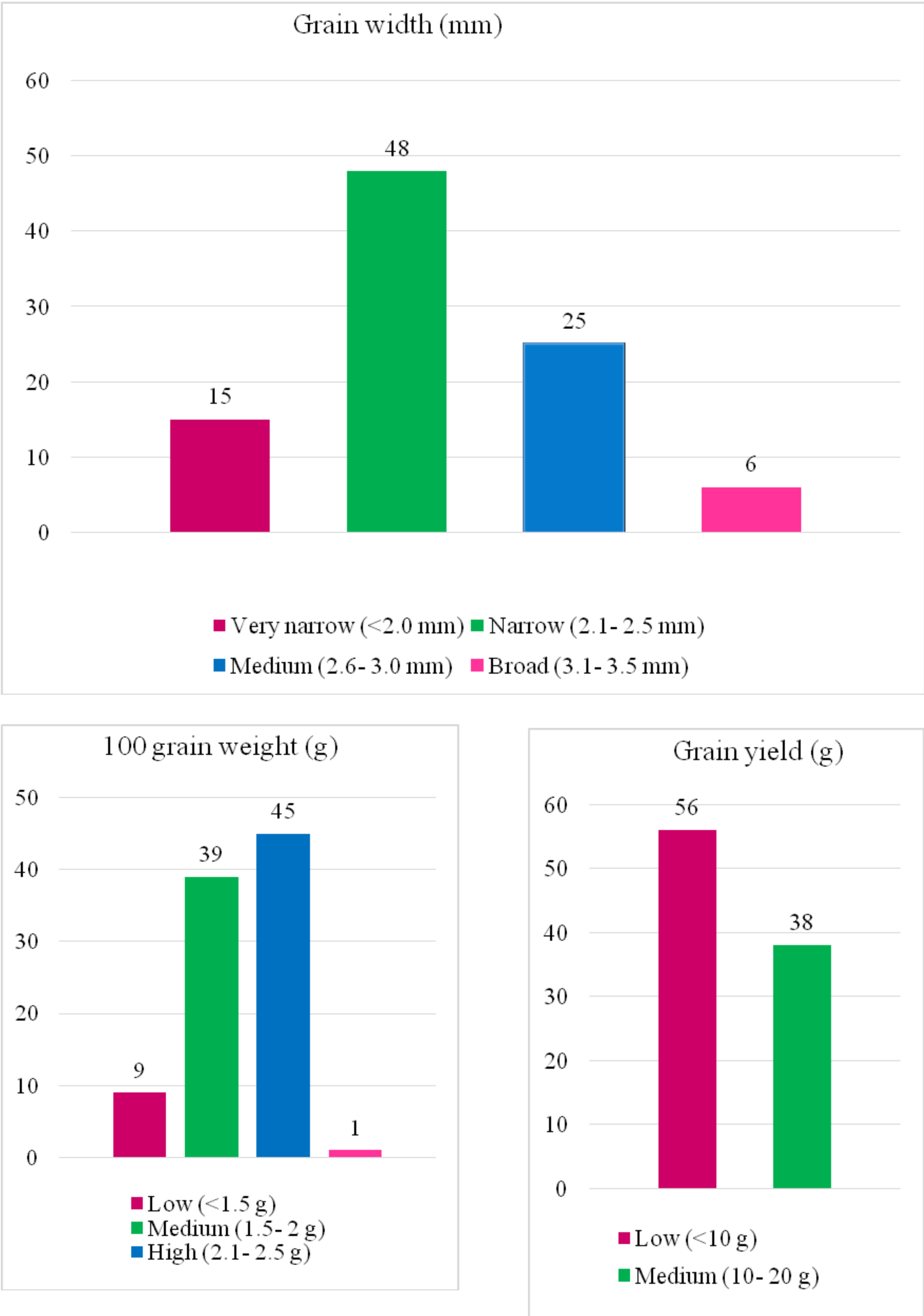


Fig 11. Variation of accessions based on quantitative characters

Table 40. Correlation between traits in exotic accessions of rice

	PH	LL	LBL	LBW	DF	DM	NTP	NPT	PL	NSP	NGP	GL	GW	TW	GY
PH	**1.00**														
LL	-0.14	**1.00**													
LBL	0.75**	-0.29**	**1.00**												
LBW	0.42**	-0.01	0.44**	**1.00**											
DF	-0.06	-0.12	0.02	-0.14	**1.00**										
DM	0.11	-0.17	0.08	0.04	0.03	**1.00**									
NTP	0.51**	0.11	0.51**	0.32**	-0.10	0.02	**1.00**								
NPT	0.37**	0.20	0.31**	0.18	-0.07	-0.17	0.63**	**1.00**							
PL	0.41**	0.03	0.40**	0.22*	0.16	0.0	0.24*	0.24*	**1.00**						
NSP	0.11	-0.06	0.13	-0.04	-0.04	0.03	0.07	-0.07	0.10	**1.00**					
NGP	0.15	0.12	0.14	-0.03	0.10	-0.07	0.12	0.17	0.08	0.21*	**1.00**				
GL	-0.52**	0.20	-0.45**	-0.18	0.02	-0.09	-0.39**	-0.09	-0.19	-0.31**	-0.05	**1.00**			
GW	0.22*	-0.26*	0.40**	0.23*	-0.04	0.05	0.25*	0.10	0.05	0.09	0.2	-0.13	**1.00**		
TW	0.12	0.09	0.11	0.40**	-0.30**	-0.18	0.17	0.11	0.04	0.06	-0.18	-0.01	0.06	**1.00**	
GY	0.14	0.13	0.11	0.09	0.00	-0.05	0.14	0.12	0.12	0.19	0	0.13	-0.09	0.37**	**1.00**

(PH- Plant height; **LL-** Ligule length; **LBL-** Leaf blade length; **LBW-** Leaf blade width; **DF-** Days to 50 per cent flowering; **DM-** Days to maturity; **NTP-** Number of tillers per plant; **NPT-** Number of productive tillers per plant; **PL-** Panicle length; **NSP-** Number of spikelets per panicle; **NGP-** Number of grains per panicle; **GL-** Grain length; **GW-** Grain width; **TW-** 100 grain weight; **GY-** Grain yield**)**.

4.3 Correlation between quantitative traits

4.3.1 Plant height

Correlation studies between plant height and other traits showed that plant height had highly significant and positive correlation with leaf blade length, leaf blade width, number of total tillers, number of productive tillers, and panicle length. It had significant and positive correlation with grain width. However, plant height was negatively correlated to grain length. Anis *et al.* (2016) based on their studies with 11 rice hybrids observed that plant height had highly significant and positive correlation with panicle length alone. Prakash *et al*. (2018) also found positive and highly significant correlation of plant height with panicle length. They observed negative correlation of plant height with grains per panicle. Kumar *et al.* (2018) reported positive correlation of plant height with 1000 grain weight and grain yield per plant.

4.3.2 Ligule length

Correlation of ligule length with none of the characters studied was positive. However, it had negative and highly significant association with length of leaf blade and significant negative association with width of grain. Abraham *et al.* (2017) reported strong positive correlation of ligule length with number of spikelets per panicle, number of grains per panicle and negative correlation with 100 grain weight.

4.3.3 Leaf blade length

Highly significant and positive association was observed between leaf blade length and plant height, leaf blade width, number of total tillers, and grain width. It exhibited highly significant and negative association with length of ligule and length of grain.

4.3.4 Leaf blade width

Width of leaf blade exhibited highly significant and positive association with plant height, length of leaf blade, number of total tillers, and hundred seed weight. It had significant positive correlation with length of panicle and width of grain. It did not exhibit negative association with any traits studied.

4.3.5 Days to 50 per cent flowering

Correlation studies between quantitative traits in exotic germplasm of rice showed that days to fifty per cent flowering does not have positive association with any of the traits studied. However, it had highly significant and negative association with hundred grain weight. Prakash *et al.* (2018) observed negative correlation of days to flowering with grains per panicle. Anis *et al.* (2016) did not observe correlation of days to flowering with any other character they studied. Kumar *et al.* (2018) observed negative correlation of days to flowering to plant height, length of panicle, 1000 grain weight and grain yield per plant.

4.3.6 Days to maturity

Number of days to taken to maturity does not have any association with any of the traits studied. As per the study of Kumar *et al.* (2018) days to maturity had negative correlation with plant height, panicle length, 1000 grain weight, and grain yield per plant.

4.3.7 Number of tillers per plant

Plant height, length of leaf blade, breadth of leaf blade and number of productive tillers had highly significant and positive association with total number of tillers, while it had significant positive association with length of panicle and width of grain. It also exhibited negative and highly significant correlation with grain length. Kumar *et al.* (2011) observed significant and positive correlation of grain yield per plant with tillers per plant.

4.3.8 Number of productive tillers

Number of productive tillers had highly significant and positive correlation with plant height, length of leaf blade and number of total tillers. It also had positive correlation with length of panicle. However, studies by Anis *et al.* (2016) in 11 rice hybrids revealed negative correlation of number of productive tillers to panicle length. As per the study of Prakash *et al.* (2018) productive tillers per plant exhibited highly significant and positive correlation with length of panicle, grains per panicle, 100 grain weight and grain yield per plant. According to the study of Kumar *et al.* (2018) productive tillers were negatively correlated with 1000 grain weight and grain yield per plant.

4.3.9 Panicle length

Length of panicle exhibited highly significant and positive association with height of plant and length of leaf blade. It also had significant and positive correlation with width of leaf blade and number of total and productive tillers. Anis *et al.* (2016) observed negative correlation of panicle length to number of productive tillers in hybrid rice. Prakask *et al.* (2018) observed positive correlation of length of panicle to grains per plant and 100 grain weight. Kumar *et al.* (2018) observed positive correlation of panicle length with grain yield per plant.

4.3.10 Spikelets per panicle

Number of spikelets per panicle had significant and positive correlation with grains per panicle. It also exhibited highly significant negative association with length of grain. According to Ranawake and Amarasinghe, (2014) number of spikelets per panicle was significantly and positively correlated with the grain yield per plant.

4.3.11 Grains per panicle

Number of grains per panicle had positive association with number of spike lets per panicle. It did not exhibit correlation with any other trait. Ranawake and

Amarasinghe, (2014) reported that number of grains per panicle and grain weight have significant and positive correlations with grain yield.

4.3.12 Grain length

Plant height, length of leaf blade and total number of tillers and number of spikelets per panicle had highly significant negative correlation with length of grain.

4.3.13 Grain width

Length of leaf blade had highly significant and positive correlation with grain width. It also had significant had positive association with plant height, leaf blade width and number of total tillers. Grain width also exhibited negative association with ligule length.

4.3.14 Hundred grain weight

Width of leaf blade had highly significant and positive correlation with hundred grain weight. Positive and significant association was also observed between 100 grain weight and grain yield**.** It had negative association with days to flowering. Ranawake and Amarasinghe, (2014) also reported positive correlation of 100 grain weight with single plant yield in rice.

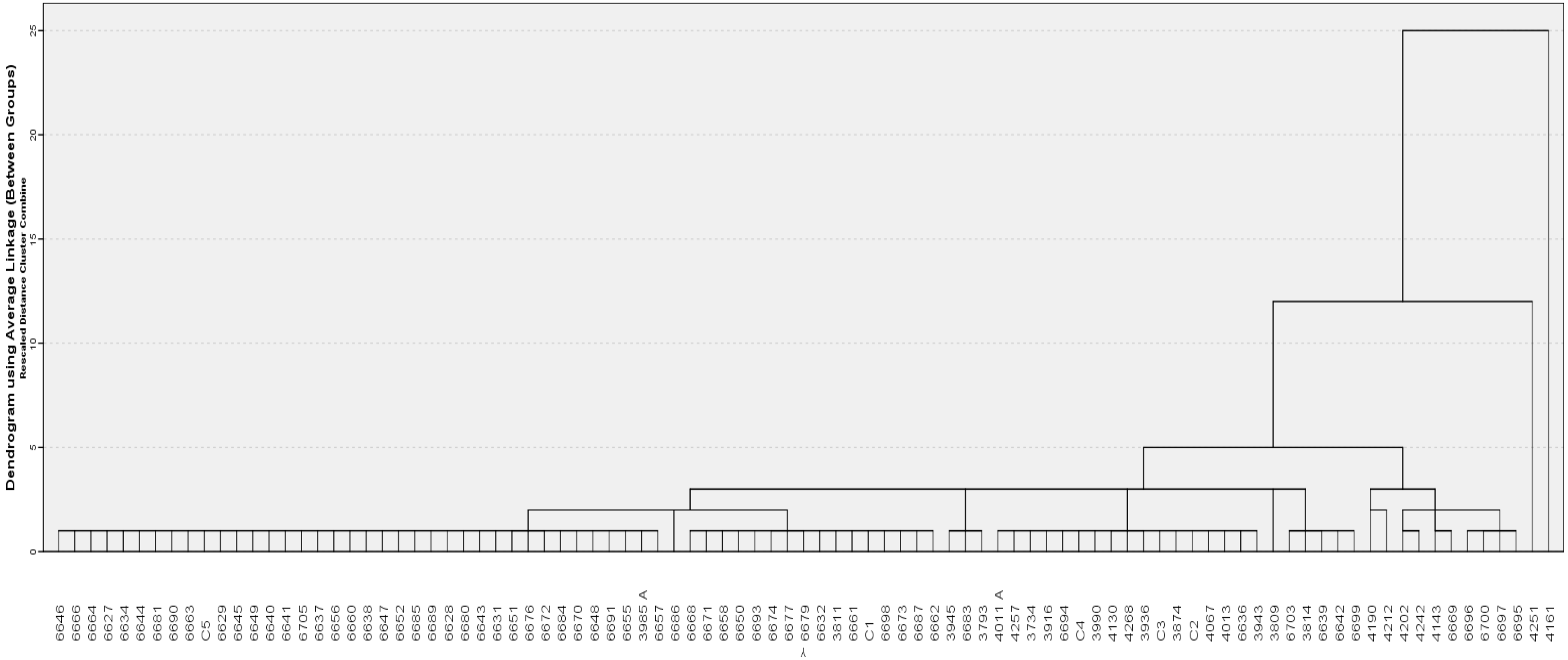
4.3.15 Grain yield per plant

Grain yield per plant exhibited highly significant and positive correlation with hundred grain weight only. According to Anis *et al.* (2016) grain yield had positive association with number of productive tillers only. Kumar *et al.* (2018) observed 1000-grain weight, plant height and panicle length having significant and positive correlation with grain yield per plant. According to Ratna *et al.* (2015), grain per plant was negatively correlated with plant height and length of panicle. They also reported positive correlation of grain yield per plant with number of productive tillers and number of grains per panicle. Hence, high test weight of the accessions can be an indication of higher yield in the accessions. Hundred grain weight was found to be positively correlated with leaf width hence, leaf width also can be considered while selecting for grain yield in rice.

4.4 Clustering of exotic rice accessions based on quantitative traits

Dendrogram constructed using average linkage distance resulted in four clusters at average distance five (Figure 15 and Table 41). Majority of the accessions evaluated (88.31 per cent) fall in to the cluster 1. Second cluster consisted of nine accessions viz, EC 205252, EC 205275, EC 205264, EC 205205, EC 415434, EC 415461, EC 415465, EC 415462 and EC 415460. Third cluster had only one accession EC 205314 and fourth cluster also consisted of only one accession EC 205223.

Fig 12. Hierarchical clustering of exotic rice accessions based on quantitative traits



Dendrogram using average linkage (between groups)

Table 41. Grouping of accessions based on quantitative traits

Cluster No.	Accessions	Percentage of accessions
1	EC 207747, EC 204847, EC 204863, EC 204865, EC 204868, EC 204928, EC 204970, EC 204991, EC 204999, EC 205001, EC 205042, EC 205047, EC 205070, EC 205072, EC 205128, EC 205192, EC 205269, EC 205305, EC 205321 EC 205333, EC 415392, EC 415393, EC 415394, EC 415396, EC 415397, EC 415399, EC 415401, EC 415402, EC 415403, EC 415404, EC 415405, EC 415406, EC 415407, EC 415408, EC 415409, EC 415410, EC 415411, EC 415412, EC 415413, EC 415414, EC 415415, EC 415416, EC 415417, EC 415420, EC 415421, EC 415422, EC 415423, EC 415425, EC 415426, EC 415427, EC 415428, EC 415429, EC 415431, EC 415452 EC 415433, EC 415435, EC 415436, EC 415437, EC 415438, EC 415441, EC 415442, EC 415444, EC 415445, EC 415446, EC 415448, EC 415449, EC 415450, EC 415451, EC 415452, EC 415454, EC 415455, EC 415456, EC 415458, EC 415459, EC 415463, EC 415464, EC 415468, EC 415470, EC 415439, Jyothi, Jaya, Thulasi, Vaisakh and Manurathna,	88.31 per cent
2	EC 205205,EC 205252, EC 205264, EC 205275, EC 415434, EC 415460, EC 415461, EC 415462 and EC 415465	9.57 per cent
3	EC 205314	1.06 per cent
4	EC 205223	1.06 per cent

Similar to the present study Alia *et al.* (2016), also observed less number of clusters (3no) when they have done cluster analysis for quantitative traits, at dissimilarity level of 5.36. Presence of less number of clusters and presence of majority of the accessions in a single cluster (cluster 1) indicate the similarity among the exotic accessions with respect to quantitative traits.

Scoring of accessions based on quantitative characters in comparison with check varieties

Accessions were scored for each character in comparison with check varieties. Number of characters better than the check varieties was noted for each accession as given in Table 42.

Table 42. Scoring the accessions in comparison with check varieties

Accessions	PH	LL	LBL	LBW	DF	DM	NTP	NPT	PL	NSP	NGP	GL	GW	TW	GY	TS
EC 207747		√	√			√	√	√	√							6
EC 204847			√							√	√					3
EC 204863			√	√		√	√	√								5
EC 204865																0
EC 204868	√			√				√								3
EC 204928					√	√										2
EC 204970			√		√	√			√							4
EC 204991					√	√										2
EC 204999		√			√	√			√							4
EC 205001											√					1
EC 205042		√	√		√	√	√									5
EC 205047			√		√	√			√							4
EC 205070			√					√								2
EC 205072			√													1
EC 205128			√													1
EC 205192		√	√			√										3
EC 205205					√	√										2
EC 205223		√				√					√					3
EC 205252					√	√										2
EC 205264			√			√										2
EC 205269					√	√										2
EC 205275			√			√					√					3
EC 205305					√	√										2
EC 205314											√					1
EC 205321			√			√										2
EC 205333			√		√	√										3
EC 415392	√					√						√				3
EC 415393		√			√											2
EC 415394												√				1
EC 415396					√	√						√				3
EC 415397		√														1
EC 415399		√			√											2
EC 415401		√														1
EC 415402						√						√				2
EC 415403		√			√	√										3

EC 415404						√										1
EC 415405		√				√										2
EC 415406		√				√										2
EC 415407					√	√										2
EC 415408		√				√						√				3
EC 415409	√	√				√										3
EC 415410	√				√	√										3
EC 415411					√	√										2
EC 415412		√				√						√				3
EC 415413	√				√	√			√			√				5
EC 415414	√				√	√										3
EC 415415		√			√	√										3
EC 415416	√	√				√										3
EC 415417					√	√										2
EC 415420	√	√			√	√										4
EC 415421		√				√										2
EC 415422		√			√	√						√				4
EC 415423					√	√										2
EC 415425						√										1
EC 415426		√														1
EC 415427	√				√							√				3
EC 415428		√				√										2
EC 415429		√			√	√										3
EC 415431	√	√			√	√										4
EC 415433		√			√	√						√				4
EC 415434		√			√	√						√				4
EC 415435		√			√	√										3
EC 415436		√			√	√						√				4
EC 415437		√			√	√										3
EC 415438	√	√										√				3
EC 415439		√										√				2
EC 415441	√															1
EC 415442	√				√	√										3
EC 415444	√	√														2
EC 415445		√			√	√						√				4
EC 415446	√	√			√											3
EC 415448		√				√					√					3
EC 415449						√						√				2
EC 415450						√						√				2
EC 415451	√		√													2
EC 415452		√									√	√				3
EC 415454					√	√										2
EC 415455					√	√										2
EC 415456	√					√										2
EC 415458																0
EC 415459																0
EC 415460																0

EC 415461																0
EC 415462																0
EC 415463											√					1
EC 415464						√										1
EC 415465		√														1
EC 415468																0
EC 415470												√				1

Accessions EC 207747, EC 204863, EC 204970, EC 204999, EC 205042, EC 205047, EC 415413, EC 415420, EC 415422, EC 415431, EC 415433, EC 415434, EC 415436 and EC 415445, having total score more than 4 in comparison with check varieties were identified as superior with respect to quantitative traits as given in Table 43.

Table 43. Exotic rice accessions identified as superior with respect to quantitative characters

Accessions	PH	LL	LBL	LBW	DF	DM	NTP	NPT	PL	NSP	GP	GL	GW	TW	GY	TS
EC 207747		√	√			√	√	√	√							6
EC 204863			√	√		√	√	√								5
EC 204970			√		√	√			√							4
EC 204999		√			√	√			√							4
EC 205042		√	√		√	√	√									5
EC 205047			√		√	√			√							4
EC 415413	√				√	√			√			√				5
EC 415420	√	√			√	√										4
EC 415422		√			√	√						√				4
EC 415431	√	√			√	√										4
EC 415433		√			√	√						√				4
EC 415434		√			√	√						√				4
EC 415436		√			√	√						√				4
EC 415445		√			√	√						√				4

These accessions which are superior with respect to quantitative characters can be further studied to confirm their superiority to use in breeding programmes. Accessions were grouped based on quantitative and qualitative traits and is presented in Table 44. Accessions EC 207747, EC 204970, EC 204999, EC 205042, EC 205047, EC 205192, EC 205205, EC 205223, EC 205333, EC 415392EC 415403, EC 415407, EC 415413, EC 415420, EC 415421, EC 415422, EC 415445 and EC 415452 were identified as superior.

Table 44. Scoring of accessions based on quantitative and superior qualitative traits

Accessions	PH	LL	BL	BW	DF	DM	TT	PT	PL	SP	GP	GL	GW	TW	GY	Erect Leaf	Erect Flag Leaf	Erect culm	Strong culm	Well exsertion panicle	TS
EC 207747		√	√			√	√	√	√										√	√	8
EC 204847			√							√	√								√	√	5
EC 204863			√	√		√	√	√											√		6
EC 204865																		√	√		2
EC 204868	√			√				√								√		√	√		6
EC 204928					√	√											√	√	√	√	6
EC 204970			√		√	√			√								√	√		√	7
EC 204991					√	√															2
EC 204999		√			√	√			√								√		√	√	7
EC 205001											√								√	√	3
EC 205042		√	√		√	√	√												√	√	7
EC 205047			√		√	√			√							√	√		√		7
EC 205070			√					√											√	√	4
EC 205072			√															√	√		3
EC 205128			√													√		√	√		4
EC 205192		√	√			√											√	√	√	√	7
EC 205205					√	√										√	√	√	√	√	7
EC 205223		√				√					√					√	√		√	√	7
EC 205252					√	√										√	√		√	√	6
EC 205264			√			√													√	√	4
EC 205269					√	√										√	√		√		5
EC 205275			√			√					√					√		√	√		6

EC 205305					√	√										√		√	√		5
EC 205314											√					√		√	√		4
EC 205321			√			√										√		√	√	√	6
EC 205333			√		√	√										√		√	√	√	7
EC 415392	√					√						√				√	√	√	√		7
EC 415393		√			√											√		√	√		5
EC 415394												√				√		√	√		4
EC 415396					√	√						√				√		√	√		6
EC 415397		√														√		√		√	4
EC 415399		√			√											√		√			4
EC 415401		√														√		√	√		4
EC 415402						√						√				√		√	√		5
EC 415403		√			√	√										√	√	√	√	√	8
EC 415404						√										√		√		√	4
EC 415405		√				√										√		√	√	√	6
EC 415406		√				√										√	√	√	√		6
EC 415407					√	√										√	√	√	√	√	7
EC 415408		√				√						√				√		√	√		6
EC 415409	√	√				√										√		√			5
EC 415410	√				√	√										√		√			5
EC 415411					√	√										√		√	√	√	6
EC 415412		√				√						√				√		√		√	6
EC 415413	√				√	√			√			√				√	√	√	√	√	10
EC 415414	√				√	√										√			√		5
EC 415415		√			√	√										√			√	√	6

EC 415416	√	√				√										√		√	√		6
EC 415417					√	√										√		√	√		5
EC 415420	√	√			√	√										√		√	√	√	8
EC 415421		√				√										√	√	√	√	√	7
EC 415422		√			√	√						√				√			√	√	7
EC 415423					√	√										√		√	√		5
EC 415425						√										√			√		3
EC 415426		√														√	√	√	√	√	5
EC 415427	√				√							√				√		√	√		6
EC 415428		√				√										√			√	√	5
EC 415429		√			√	√										√			√	√	6
EC 415431	√	√			√	√										√			√		6
EC 415433		√			√	√						√				√			√		6
EC 415434		√			√	√						√				√					5
EC 415435		√			√	√										√					4
EC 415436		√			√	√						√				√					5
EC 415437		√			√	√										√		√	√		6
EC 415438	√	√										√				√		√	√		6
EC 415439		√										√				√		√	√		5
EC 415441	√															√		√	√		4
EC 415442	√				√	√													√		4
EC 415444	√	√														√			√		4
EC 415445		√			√	√						√				√		√	√		7
EC 415446	√	√			√											√			√		5
EC 415448		√				√					√					√			√		5

EC 415449						√						√				√		√	√		5
EC 415450						√						√				√			√		4
EC 415451	√		√															√	√		4
EC 415452		√									√	√				√	√	√	√		7
EC 415454					√	√										√		√	√	√	6
EC 415455					√	√										√		√	√	√	6
EC 415456	√					√													√	√	4
EC 415458																√	√	√	√	√	5
EC 415459																√	√		√		3
EC 415460																√		√	√	√	4
EC 415461																√		√	√	√	4
EC 415462																√	√		√		3
EC 415463											√					√		√	√		4
EC 415464						√												√	√	√	4
EC 415465		√														√			√	√	4
EC 415468																√		√	√		3
EC 415470												√				√			√	√	4

Table 45. Exotic rice accessions identified based on qualitative and quantitative traits

Accessions	PH	LL	BL	BW	DF	DM	TT	PT	PL	SP	GP	GL	GW	TW	GY	Erect L	Erect F L	Erect culm	Strong culm	Panicle exsertion	TS
EC 207747		√	√			√	√	√	√										√	√	8
EC 204970			√		√	√			√								√	√		√	7
EC 204999		√			√	√			√								√		√	√	7
EC 205042		√	√		√	√	√												√	√	7
EC 205047			√		√	√			√							√	√		√		7
EC 205192		√	√			√											√	√	√	√	7
EC 205205					√	√										√	√	√	√	√	7
EC 205223		√				√					√					√	√		√	√	7
EC 205333			√		√	√										√		√	√	√	7
EC 415392	√					√						√				√	√	√	√		7
EC 415403		√			√	√										√	√	√	√	√	8
EC 415407					√	√										√	√	√	√	√	7
EC 415413	√				√	√			√			√				√	√	√	√	√	10
EC 415420	√	√			√	√										√		√	√	√	8
EC 415421		√				√										√	√	√	√	√	7
EC 415422		√			√	√						√				√			√	√	7
EC 415445		√			√	√						√				√		√	√		7
EC 415452		√									√	√				√	√	√	√		7

Accessions EC 207747, EC 204970, EC 204999, EC 205042, EC 205047, EC 205192, EC 205205, EC 205223, EC 205333, EC 415392EC 415403, EC 415407, 6648, EC 415420, EC 415421, EC 415422, EC 415445 and EC 415452 were identified as superior with respect to qualitative and quantitative traits. These can be utilized in further rice improvement programmes.

Summary

5. SUMMARY

The present research study on **"Characterization of exotic germplasm of rice (Oryza sativa L.) for yield and quality attributes"** was conducted in the Department of Plant Breeding and Genetics, College of Horticulture, Kerala Agricultural University and at the experimental farm of NBPGR (National Bureau of Plant Genetic Resources) Regional station, Velannikkarra, Thrissur, during June 2019 to October 2019. The study aimed to characterize the exotic germplasm of rice based on morphological traits according to DUS descriptor.

The experiment was set in augmented block design (ABD) and hundred germplasms of rice along with five check varieties (Jyothi, Jaya, Thulasi, Vaiashak and Manurathna) was used in the study. The field was divided into 5 blocks; each block comprised 25 lines of rice genotypes including check varieties and the germplasm are allotted in each line randomly. The results of study summarized as below:

Observations recorded on qualitative characters showed that all accessions were having colourless coleoptiles, auricle and collar, split shape white ligule, intermediate threshability and does not have leaf sheath and leaf anthocyanin colouration.

Basal leaf sheath colour in eleven accessions was purple, while, it was green in seventy-eight accessions and check varieties

Eighteen accessions and check variety Jaya were having semi-erect leaf blade and 71 accessions and four check varieties were having erect leaf blade.

Twenty accessions and one check variety had erect flag leaf, five accessions had horizontal flag leaf and 64 accessions and four check varieties had semi-erect flag leaf.

Thirty-nine accessions were having semi-erect culm while it was erect in 50 accessions and five check varieties.

Four accessions had weak culm and 85 accessions and five check varieties had strong culm.

Stigma colour in 14 accessions and two check varieties was purple and it was white in 75 accessions and three check varieties.

Eleven accessions had brown spots on lemma and palea, 22 accessions had golden straw and the rest 56 accessions and five check varieties had straw colour for lemma and palea.

Strong colour for anthocyanin pigmentation of apiculus was present in two accessions while it was medium in 39 accessions and two check varieties and 48 accessions and three check varieties did not have any colour.

Nine accessions had white sterile lemma and 80 accessions and five check varieties had straw coloured sterile lemma.

Forty three accessions and three check varieties had awns, while it was absent in the rest 41 and two check varieties

Twenty-one accessions and two check varieties had tip awns only, while, six accessions and one check variety had awns on the upper half and 16 accessions had awns on whole length of panicle.

Colour of awn in 30 accessions and three check varieties was yellowish white, one accession had yellowish awn and 12 accessions had reddish brown.

Seven accessions had semi-straight panicle, while, it was deflexed drooping in eight accessions and drooping deflexed in 74 accessions and check varieties.

Two accessions had spreading panicle and the rest 88 accessions and check varieties had semi-erect panicle.

One accession had partly exserted panicle, 39 accessions and one check variety had well exserted panicle, 49 accessions and four check varieties had mostly exserted panicle.

Pericarp colour was red in eight accessions, light red in 16 accessions and five check varieties and white in 65 accessions.

Grain shape in 10 accessions was short slender, four accessions short bold, six accessions long bold and in 69 accessions and five check varieties it was medium slender.

Accessions EC 204928, EC 205192, EC 205205, EC 205223, EC 205252, EC 205333, EC 415392, EC 415403, EC 415405, EC 415406, EC 415407, EC 415411, EC 415413, EC 415420, EC 415421, EC 415426, EC 415452, EC 415454, EC 415455, EC 415458, EC 415460 and EC 415461 were identified as superior with respect to five qualitative characters which was associated with grain yield.

Clustering of the accessions based on qualitative characters showed that the accessions grouped into 12 clusters. Thirty five accessions belonged to the first cluster. Cluster 3 contained 25 accessions, clusters 4, 5, 6, 7, 8 and 12 had only one accession each. Second cluster included two accessions, while cluster 10 had four accessions. Cluster 9 had 11 accessions and cluster 11 also consisted of 11 accessions.

Plant height of the accessions was observed between 66.cm of accession EC 415414 and 153 cm of accession EC 204999 with an overall mean of 94.07. Nine accessions were taller than the check varieties while, 17 were shorter than the check varieties.

Length of ligule varied between 3.00 mm of accessions EC 204868, EC 205275, EC 415441, EC 415451 and EC 415464 to 12 cm of accessions EC 207747, EC 205223 and EC 415422 with a mean value of 7.07 mm. Thirty six accessions were having longer ligule while, accessions EC 204868, EC 205275, EC 415441, EC 415451 and EC 415464 were having shorter ligule.

The leaf length of the tested accessions were observed between 35 cm of accessions EC 415435, EC 415436, to 72 cm of EC 415451 with a mean value of 49.75cm. Fifteen accessions had longer leaf.

Leaf width varied from 0.40cm of accession EC 415442 to 1.30 cm of EC 415459 with a mean value of 0.84. Accession EC 204863 had significantly broader leaves, while, 45 accessions had narrow leaf.

Days to flowering was observed between 71 days of accession EC 415396 and EC 415415 to 106 days of EC 415460 with a mean value of 85.01 days. Twenty accessions were late to initiate flower, while 33 accessions were early to flower.

Maturity duration were found between 101 days of EC 205042 to 138 days of EC 415452 with a mean value of 114.72. Thirty four accessions were early and 14 accessions were late to reach maturity.

Number of tillers per plant was observed between three to nine with an average of 5.23. Accessions EC 207747, EC 204863, EC 205042 and EC 205128 had high number of tillers.

Number of productive tillers per plant were found between two in accession EC 415468 to eight in accessions EC 207747 and EC 415401. Mean value among the accessions was 3.91. Accessions EC 207747, EC 204863, EC 205070 and EC 415401 had higher number of productive tillers per plant.

Length of the panicles was observed between 14 cm of the accession EC 415465 to 26 cm of the accession EC 415459.The man value for panicle length among the accessions was 19.25 cm. Eighteen accessions had longer panicles, while, two accessions had short panicle.

Number of spikelets per panicle was observed between 55 of accession EC 415404 to 212 of accession EC 205314 with a mean value of 98.43. Accessions EC 204847, EC 205001, EC 205223, EC 205314, EC 415448 and EC 415452 had more number of spikelets.

Number of grains per panicle was observed between 49 numbers in accession EC 415441 to 186 in accession EC 205314 with a mean value of 80.48. Eight accessions had more grain number.

Grain length was between 6.12 mm of the accession EC 205223 to 12.00 mm of accession EC 415459 with a mean value of 9.25mm. Accession EC 205223 had short grains, and 19 accessions had long grains.

Grain width was observed between 1.50 mm of accession EC 415397 to 3.26mm of EC 205264 with a mean value of 2.38mm. Fifteen accessions had narrow grains.

Test weight was observed between 1.21g to 2.62 g, with a mean value of 1.92. Twenty-nine accessions had low test weight.

Grain yield of the accessions on par with check varieties were found between 4.79 g of EC 415438 to 17.40g of EC 415405 with a mean value of 9.80g. None of the genotypes had high yield and only two accessions had lower yield.

Plant height had highly significant and positive correlation with leaf blade length and width, number of total and productive tillers and panicle length. It also had positive and significant correlation with grain width.

Correlation of ligule length with length of leaf blade was highly significant and negative and it was negative with width of grain.

Highly significant and Positive association was observed between leaf blade length with plant height, leaf blade width, number of total tillers, and grain width. It exhibited highly significant and negative association with length of ligule and length of grain.

Width of leaf blade had highly significant and positive association with plant height, length of leaf blade, number of total tillers, and hundred seed weight. It had significant positive correlation with length of panicle and width of grain.

Days to fifty per cent flowering had highly significant and negative association with test weight.

Number of days to taken to maturity does not have any association with any of the traits.

Total number of tillers had highly significant and positive association with plant height, length and breadth of leaf blade and number of productive tillers, while it had significant positive association with length of panicle and width of grain. It also exhibited negative and highly significant correlation with grain length.

Number of productive tillers had highly significant and positive correlation with plant height, length of leaf blade and number of total tillers. It also had positive correlation with length of panicle.

Length of panicle exhibited highly significant and positive association with plant height and length of leaf blade. It also had significant and positive correlation with width of leaf blade, number of total and productive tillers.

Number of spikelets per panicle had significant and positive correlation with grains per panicle. It also exhibited highly significant negative association with length of grain. Number of grains per panicle had positive association with number of spikelets per panicle.

Plant height, length of leaf blade and total number of tillers and number of spikelets per panicle had highly significant negative correlation with length of grain.

Length of leaf blade had highly significant and positive correlation with grain width. It also had significant had positive association with plant height, leaf blade width and number of total tillers. Grain width also exhibited negative association with ligule length.

Hundred grain weight had highly significant and positive correlation with width of leaf blade. Positive and significant association was also observed between 100 grain weight and grain yield**.**

Grain yield per plant exhibited highly significant and positive correlation with hundred grain weight only.

Dendrogram constructed using average linkage distance resulted in four clusters at average with majority of the accessions falling in to the cluster 1.

Accessions EC 207747, EC 204863, EC 204970, EC 204999, EC 205042, EC 205047, EC 415413, EC 415420, EC 415422, EC 415431, EC 415433, EC 415434, EC 415436 and EC 415445, having total score more than 4 in comparison with check varieties were identified as superior with respect to quantitative traits.

Accessions EC 207747, EC 204970, EC 204999, EC 205042, EC 205047, EC 205192, EC 205205, EC 205223, EC 205333, EC 415392, EC 415403, EC 415407, EC 415413, EC 415420, EC 415421, EC 415422, EC 415445 and EC 415452 were identified as superior when quantitative and qualitative traits considered together.

References

6. REFERENCES

Abraham, O. G., Chinyere, C. N., Richard, O. A. and Julius, O. F. 2017. Screening for yield related characters in some landrace accessions of Oryza sativa linn. *J. Plant Sci.* 12(2): 52-58.

Agahi, K., Fotokian, M. H. and Farshadfar, E. 2007. Correlation and path analysis of some yield related traits in rice genotypes (*Oryza sativa* L.). *Asian J. Plant Sci.* 6(3): 513- 517.

Ahmed, M. S., Parveen, S., Baktiaari, MHK. and Siddique, M. A. 2015. Study of qualitative agro-morphological characters of Dhaliboro rice (*Oryza sativa* L.) germpalasm of Bangaladesh. *Eco-friendly Agric. J.* 8(08): 91- 96.

Ahmed, M.S., Rashid, E. S. M. H., Akter, N. and Khalequzzaman, M., 2018. Morphological Characterization and Diversity of T. Aman Rice Germplasm of Bangladesh. *Bangladesh Rice J. 22*(2): 13- 22.

Akhtar, N., Nazir, M. F., Rabnawaz, A., Mahomod, T., Safdar, M. E., Asif, M. and Rehman, A. 2011. Estimation of heritability, correlation and path coefficient analysis in fine grain rice (*Oryza sativa* L.). *J. Plant Sci.* 21(4): 60- 64.

Akter, K., Habib, S. H., Bashar, M. K. and Nurummabi, A. M. 2007. Genetic analysis and selection criteria in advanced breeding lines of deep water rice. *Bangladesh J. Plant Breed. Genet.* 20(1): 39-45.

Alia, Khalil, A. I. H., Ali-Shah, S. M. A. and Durrishahwar, N. M. 2016. Grouping rice genotypes in different clusters based on their similarity index. *Pure and Appl. Biol*. 5(3): 386- 391.

Anis, G. B., EL-Namaky, R. A., AL-Ashkar, I. M., Barutçular, C. and El Sabagh, A. 2016. Yield potential and correlation analysis of some rice hybrids for yield and its component traits. *J. of Anim. and Plant Sci*. 30(2): 4748- 4757.

Ashfaq, M., Khan, A. S., Khan, S. H. U. and Ahmad, R. 2012. Association of various morphological traits with yield and genetic divergence in rice (*Oryza sativa* L.). *Int. J. Agric. Biol.* 14: 55- 62.

Bisne, R. and Sarawagi, A. K. 2008. Agro-morphological and quality characterization of Badshah Bhog group from aromatic rice germplasm of Chhattisgarh. *Bangladesh J. Agril. Res.* 33(3): 479- 492.

Burgess, A. J., Retkute, R., Pound, M. P., Foulkes, J., Preston, S. P., Jensen, O. E., Pridmore, T. P. and Murchie, E. H. 2015. High-resolution three-dimensional structural data quantify the impact of photoinhibition on long-term carbon gain in wheat canopies in the field. *Plant Physiology*, 169(2): 1192- 1204.

Chaffey, N. J. 1985. Structure and function in the grass ligule: presence of veined and membranous ligules on the same culm of British grasses. *New phytologist*, 101(4): 613- 621.

Chaffey, N. 2000. Physiological anatomy and function of the membranous grass ligule. *New Phytologist*, 146(1): 5- 21.

Chakravorty, A., Ghosh, P. D. and Sahu, P. K. 2013. Multivariate analysis of landraces of rice of West Bengal. *Am. J. Exp. Agric.* 3(1): 110- 123.

Dutta, R. K., Baset, M. A. and Khanam, S. 2002. Plant architecture and growth characteristics of fine grain and aromatic rices and their relation with grain yield. *Int. Rice Commission Newsletter*. *51*: 51-55.

Doebley, J.F., Gaut, B. S. and Smith, B. D. 2006. The molecular genetics of crop domestication. *Cell*. 127(7): 1309- 1321.

Elyasi, S., Abdollahi, S. and Mollasadeghi, V. 2014. Cluster analysis of 24 genotypes of modified rice according to qualitative and quantitative traits. *Bulletin of Environ. Pharmacology and Life Sci*. 3(8): 109- 111.

Fageria, N. K., He, Z. and Baligar, V. C. 2017. Phosphorus management in crop production. *CRC Press. Boca Raton London, New York*. 45.

Federer, W. T. 1956. Augmented (or hoonuiaku) designs. Hawaiian Planters' Record LV (2):191-208.

Girija, R. M., Satyanarayana, P. V., Lal-Ahmed, M., Ashok, R. Y., Srinivasa, R. V. and Jhansirani, P. 2017. Breeding strategies for lodging resistance in rice. *Int. J. Bio-resource and Stress Manag.* 8(6): 895- 903.

Gao, S. J., Chen, W. F. and Zhang, B. L. 1999. Studies of erect panicle in rice. *J Jilin Agric Sci*. *24*: 12-15.

Girish, T. N., Gireesha, T. M., Vaishali, M. G., Hanamareddy, B. G. and Hittalmani, S. 2006. Response of a new IR50/ Moroberekan recombinant inbred population of rice (*Oryza sativa* L.) from an indica x japonica cross for growth and yield traits under aerobic conditions. *Euphytica.* 152 (2): 149- 161.

Gour, L., Koutu, G.K., Singh, Y. and Singh, S.K., 2019. Characterization and grouping of indigenous rice lines based on Dus test for different qualitative differentials. *The Pharma Innovation J.* 8(4): 1162- 1168.

Hasan, M. J., Kulsum, M. U., Paul, A. K., Biswas, P. L., Rahman, M. H., Ansari, A., Akter, A., Lipi, L. F., Mohiuddin, S. J. and Al Rafiq, M. Z. 2018. Assessment of Variability for Floral Characteristics and Out-Crossing Rate in CMS Lines of Hybrid Rice. Bangladesh Rice J. 22(2): 31- 39.

Hien, N. L., Sarhadi, W. A., Oikawa, Y. and Hirata, Y. 2007. Genetic diversity of morphological responses and the relationships among Asian aromatic rice (*Oryza sativa* L.) cultivars. *Tropics.* 16(4): 343-355.

Islam, M. Z., Akter, N., Chakrabarty, T., Bhuiya, A., Siddique, M. A., and Khalequzzaman, M. 2018a. Agro-morphological Characterization and Genetic Diversity of Similar Named Aromatic Rice (*Oryza sativa* L.) Landraces of Bangladesh. *Bangladesh Rice J.* 22(1): 45-56.

Islam, M. Z., Khalequzzaman, M., Bashar, M. K., Ivy, N. A., Haque, M. M., Mian, M. A. K. and Tomita, M. 2018b. Agro-morphological Characterization of

Bangladeshi Aromatic Rice (*Oryza sativa* L.) Germplasm Based on Qualitative Traits. *Bangladesh Rice J. 22*(2): 41-54.

Jennings, P. R., Coffman, W. R. and Kauffman, H.E. 1979. Rice improvement, Grain quality. *Int. Rice Res. Ins*. 186p.

Itani, T. 2002. Agronomic characteristics of aromatic rice cultivars collected from Japan and other countries. *Jpn J. Crop Sci.* 71(1): 68-75.

Jennings, P. R., Berrio, L. E., Torres, E. and Corredor, E. 2003. A breeding strategy to increase rice yield potential. *Webapp. Ciat. cigiar. Org/biotechnology/pdf/Jennings/pdf Accessed on 20th August*.

Khan, A. S., Imran, M. and Asfaq, M. 2009. Estimation of genetic variability and correlation for grain yield components in rice (*Oryza sativa* L.). American European *J. Agric. Environ. Sci.* 6(5): 585- 590.

Komala, N.T., Gurumurthy, R. and Surendra, P., 2017. Morphological characterization of popular rice varietiesof Zone VIII and Zone IX of Karnataka State. *Bulletin of Environ. Pharmacology and Life Sci.* 6(3): 515- 519.

Kumar, A., Kumar, H., Gupta, V., Khosla, G. and Sharma, P. K. 2011. Correlation and path coefficient analysis for yield and yield component traits in rice (Oryza sativa L.). *Agric. Sci. Digest-A Res. J. 31*(4): 275- 279.

Kumar, V., Rastogi, N. K., Sarawgi, A. K., Chandrakar, Pratibha, Singh, P. K. and Jena, B. K. 2016. Agro-morphological and quality characterization of indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm. *J. Appl. Nat. Sci.* 8 (1): 314-320.

Kumar, R. 2016. Diversity analysis in indigenous landraces of rice (*Oryza sativa* L.). MSc (Ag) thesis, Indira Gandhi Krishi Vishwaviadyalaya, Raipur (Chhattisgarh), 171p.

Kumar, S., Chauhan, M. P., Tomar, A., Kasana, R. K. and Kumar, N. 2018. Correlation and path coefficient analysis in rice (*Oryza sativa* L.). *Phama innovation J.* 7(6): 20- 26.

Lakshmi, M. V., Suneetha, Y., Yugandhar, G. and Lakshmi, N. V. 2014. Correlation studies in rice (*Oryza sativa* L.). *Int. J. Genet. Eng. and Biotech*. *5*(2): 121- 126.

Li, R., Li, M., Ashraf, U., Liu, S. and Zhang, J. 2019. Exploring the relationships between yield and yield-related traits for rice varieties released in China from 1978 to 2017. *Frontiers in plant sci*. 10: 1- 12.

Liang, T., Hong, G. A. O., Yoshihiro, H., Koki, H., Tetsuya, N., LIU, T. S., Tatsuhiko, S. and XU, Z. J. 2017. Erect panicle super rice varieties enhance yield by harvest index advantages in high nitrogen and density conditions. *J. integrative agric. 16*(7): 1467- 1473.

Lipi, L. F., Hassan, M. J., Akter, A., Biswas, P. L., Kulsum, M. U., Ansari, A. and Islam, M. Z. 2018. Variability Assessment of Different Maintainer Lines for Hybrid Rice Development Based on Qualitative Traits. *Bangladesh Rice J. 22*(2): 79- 87.

Mach, J. 2015. Domesticated versus wild rice? Bring it awn!. *The Plant cell.* 27: 1818.

Mehla, B. S. and Kumar, S. 2008. Use of Morphological traits as descriptors for identification of rice genotype. *Agric. Sci. Digest*. 28(2): 104.

Mamun, A. A., Ivy, N. A., Rasul, M. G., Mian, M. A. K. and Hossain, M. M. 2012. Genetic diversity, character association and path coefficient analysis of exotic rice genotypes (*Oryza sativa* L.). *Bangladesh J. Plant Breed. and Genet.* 25(1): 25- 29.

Manjunatha, G. A. 2018. Diversity analysis in landraces of rice (*Oryza sative* L.) in wayanad through morphological and molecular polymorphism study. MSc (Ag) thesis, Kerala agricultural university, Vellanikkar, Thrissur. 251p.

Manjunatha, G. A., Elsy, C. R., Rajendran, P., Joseph, J., Francies, R. M., and Krishnan, S. 2018a. Agro-morphological characterization of rice (*Oryza sativa* L.) landraces of Wayanad, Kerala. *J. Pharmacognosy and Phytochemistry,* 7(2): 1409-1414.

Manjunatha, G. A., Elsy, C. R., Rajendran, P., Joseph, J., Francies, R. M. and Krishnan, S., 2018b. DUS Characterization of rice (*Oryza sativa* L.) landraces of wayanad, kerala. *Elec. J. Plant Breed*. *9*(2): 617- 630.

Mathure, S., Shaikh, A., Renuka, N., Wakte, K., Jawali T. N. R. and Nadaf, A. 2011. Characterisation of aromatic rice (*Oryza sativa* L.) germplasm and correlation between their agronomic and quality traits. *Euphytica*. 179: 237- 246.

Mondal, B., Singh, S. P. and Joshi, D. C. 2014. DUS characterization of rice (*Oryza sativa* L.) using morphological descriptors and quality parameters. *Outlook on agric.* 43(2): 131- 137.

Muthuswamy, A. and Ananda Kumar, C. R. 2006. Variability studies in drought resistant cultures of rice. *Res. Crops.* 7(1): 130- 132.

Nabeela, Z., Aziz, S. and Masood, S. 2004. Phenotypic divergence for agromorphological traits among landrace genotypes of rice (*Oryza sativa* L.) from Pakistan. *Int. J. Agric. Biol.* 6(2): 335- 339.

Nascimento, W. F. D., Silva, E. F. D. and Veasey, E. A. 2011. Agro-morphological characterization of upland rice accessions. *Scientia Agricola*, 68(6): 652- 660.

Okubo, K., Watanabe, T., Miyatake, N., Maeda, S. and Inoue, T. 2012. Evaluation method for threshability of rice varieties by grasping the panicle with hand. *Jpn. J. Crop Sci.* 81(2): 201- 206.

Parikh, M., Motiramani, N. K., Rastogi, N. K. and Sharma, B. 2012. Agro-morphological characterization and assessment of variability in aromatic rice germplasm. *Bangladesh J. Agric. Res.* 37(1): 1- 8.

Prakash, H. P., Verma, O. P., Chaudhary, A. K. and Amir, M. 2018. Correlation and Path Coefficient Analysis in Rice (*Oryza sativa* L.) for Sodicity Tolerance. *Int. J. Curr. Microbiol. Appl. Sci.* 7(7): 177- 187.

Rana, M.K. and Bhat, K.V. 2004. A comparison of AFLP and RAPD markers for genetic diversity and cultivar identification in cotton. *J. Plant Biochem and Biotech*. *13*(1): 19-24.

Ranawake, A. L. and Amarasinghe, U. G. S. 2014. Relationship of yield and yield related traits of some traditional rice cultivars in Sri Lanka as described by correlation analysis. *J. Sci. Res. and Rep.* 3(18): 2395- 2403.

Rangare, N. R., Krupakar, A., Ravichandra, K., Shukla, A. K. and Mishra, A. K. 2012. Estimation of characters association and direct and indirect effects of yield contributing traits on grain yield in exotic Indian rice (*Oryza sativa* L.) germplasm. *Int. J. Agric. Sci*. 2(1): 54- 61.

Rani, N. S., Rao, L. S. and Viraktamath, B. C. 2006. National guidelines for the conduct of tests for distinctness, uniformity and stability: rice (Oryza sativa L)–zero draft. *Directorate of Rice Res*. 8-15.

Rashid, K., Kahlia, I., Farooq, O. and Ahsan, M. Z. 2014. Correlation and cluster analysis of some yield and yield related traits in rice (*Oryza sativa* L.). *J. Recent Adv. Agric.* 2 (6): 271- 276.

Ratna, M., Begum, S., Husna, A., Dey, S.R. and Hossain, M. S. 2015. Correlation and path coefficients analyses in basmati rice. *Bangladesh J. Agric Res.* 40(1): 153-161.

Rawte, S. and Saxena, R. R., 2018. Morphological Characterization of Selected Rice (*Oryza sativa* L.) from Core Germplasm Group of Chhattisgarh Using DUS Descriptors. *Int. J. Curr. Microbiol. Appl. Sci*. *7*(10): 350- 357.

Roy, S. C. and Sharma, B. D. 2014. Assessment of genetic diversity in rice (Oryza sativa L.) germplasm based on agro-morphology traits and zinc-iron content for crop improvement. *Physiology and Molecular Biol. of Plants*. *20*(2): 209-224.

Roy, P. S., Samal, R., Rao, G. J. N., Patnaik, S. S. C., Jambhulkar, N. N., Patnaik, A. and Mohapatra, T. 2016. Differentiation and description of aromatic short grain rice landraces of eastern Indian state of Odisha based on qualitative phenotypic descriptors. *BMC ecol. 16*(1): 36.

Sadeghi, S. M. 2011. Heritability, phenotypic correlation and path coefficient studies for some agronomic characters in landrace rice varieties. *World Appl. Sci. J.* 13(5): 1229- 1233.

Sahu, G. R., Rao, R. K., Tiwari, J. K. and Sarawgi, A. K. 2014. Clustering pattern of some indigenous rice (*Oryza sativa* L.) accessions from Chhattisgarh. *Indian J. Plant Genet. Resour. 27*(3): 225- 229.

Saini, P., Francies, R. M., Joseph, J., Bastian, D. and Vigneshwaran, V. 2013. Genetic assessment of core set developed from short duration rice accessions held by Kerala Agricultural University. *J. Trop. Agric. 51*(1): 126- 131.

Sajid, M., Khan, S.A., Khurshid, H., Iqbal, J., Muhammad, A., Saleem, N. and Ali Shah, S.M. 2015. Characterization of Rice (*Oryza Sativa* L.) Germplasm through Various Agro-Morphological Traits. *Sci Agric.* 9(2): 83-88.

Sarawgi, A. K., Parikh, M. and Sharma, B. 2012. Agro-Morphological and quality characterization of Dubraj group from aromatic rice germplasm of Chhattisgarh and Madhya Pradesh. *Int. J. Pl. Res.* 25(2): 387- 394.

Sarawgi, A.K., Parikh, M., Sharma, B. and Sharma, D., 2014. Phenotypic divergence for agro-morphological traits among dwarf and medium duration rice germplasm and inter-relationship between their quantitative traits. *Int. quarterly J. life sci. 9*(4): 1677- 1681.

Sarhadi, W.A., Hien, N., Zanjani, L., Yosofzai, W., Yoshihashi, T. and Hirata. Y. 2008. Comparative analyses for aroma and agronomic traits of native rice cultivars from Central Asia. *J. Crop Sci. Biotech*. 11(1): 17- 22.

Satheesh K. P. and Saravanam, K. 2012. Genetic variability, correlation and path analysis in rice (*oryza sativa* L.). *Int. J. Curr. Res*. 4(9): 82- 85.

Satyanarayana, P. V., Srinivas, T., Reddy, P. R., Madhavilatha, L. and Suneetha, Y. 2005. Studies on variability, correlation and path coefficient analysis for restorer lines in rice (*Oryza sativa* L.). *Res. Crops*. 6(1): 80- 84.

Shashidhar, H. E., Pasha. F., Nanjunath, J., Vinlod, M. S. and Kanbar, A. 2005. Correlation and path co-efficient analysis in traditional cultivars and doubled haploid lines of rain fed lowland rice (*Oryza sativa* L.). *Bangladesh J. Agril. Sci*. 42(2): 156- 159.

Shrestha, N., Poudel, A., Sharma, S., Parajuli, A., Budhathoki, S. and Shrestha, K., 2018. Correlation Coefficient and Path Analysis of Advance Rice Genotypes in Central Mid-hills of Nepal. *Int. J. Re. Agric. Sci*. 5:150- 154.

Siddiqui, S. U., Kumamaru, T. and Satoh, H. 2007. Pakistan rice genetic resources-I: Grain morphological diversity and its distribution. *Pakistan J. Botany*. *39*(3): 841- 848.

Sinha, A. K., Mallick, G. K. and Mishra, P. K. 2015. Diversity of grain morphology on traditional rice varieties of lateritic regions of West Bengal. *World J. Agric. Sci.* 11(1): 48- 54.

Singh, A., Singh A. K., Sharma, P and Singh, P. K. 2014. Characterization and assessment of variability in upland rice collections. *Electr. J. Plant. Breed.* 5(3): 504- 510.

Singh V. J., Gampala, S., Singh A. K. and Chakraborti. (2016). DUST characterization of mega rice varieties and landraces of India. *Annals Plant and Soil Res*. 17 (2): 156- 159.

Singh, P. and Narayanam, S. S. 2017. Biometical techniques in plant breeding (6th Ed.). Kalyani publishers. 22p.

Kumar, V., Rastogi, N. K., Sarawgi, A. K., Chandrakar, Pratibha, Singh, P. K. and Jena, B. K. 2016. Agro-morphological and quality characterization of indigenous and exotic aromatic rice (*Oryza sativa* L.) germplasm. *J. Appl. Nat. Sci.* 8 (1): 314-320.

Subba R. L.V., Shiva Prasad, G., Chiranjivi, M., Chaitanya, U. and Surender, R. 2013. DUS characterization for farmer varieties of rice. *IOSR J. Agric. Vet. Sci.* 4(5): 35- 43.

Tafere, C. and Irie, K. 2019. Photosynthesis Efficiency of Culm Habit Near-Isogenic Lines Rice (*Oryza sativa* L.) to Different Planting Densities. *Int. J. Res. Agric. Sci.* 6:219- 229.

Umarani, E., Radhika, K., Padma, V., and Rao, S. L. V. 2017. Agro-morphological characterization of rice (*Oryza sativa* L.) landraces based on DUS descriptors. *Int. J. Pure Appl. Biosci.* 5: 466- 475.

Verma, O. P. and Srivastava, H. K. 2004. Productive association of quantitative traits in diverse ecotypes of rice (*Oryza sativa* L.). *J. Sustainable Agric*. 25 (2): 75-91.

Xu, Z. J., Chen, W. F., Zhang, L. B. and Yang, S. R. 1990. Comparative study on light distribution in rice canopy of different panicle types. *Scientia Agricultura Sinica*, *23*(4): 10- 16.

Xu, Z., Chen, W., Zhang, L. and Yang, S. 2005. Design principles and parameters of rice ideal panicle type. *Chinese Science Bulletin*. *50*(19): 2253- 2256.

ABSTRACT

Genetic diversity in rice, one of the most ancient and major food crop of the world, far exceeds that in any other crop. The present study on "Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes" was done in the Department of Plant Breeding and Genetics, College of Horticulture, and at the experimental farm of NBPGR Regional station, Thrissur, during June 2019 to October 2019. Hundred exotic accessions of rice received from IRRI, Philippines were evaluated along with five checks varieties viz., PTB 39 (Jyothi), Jaya, Thulasi, PTB 60 (Vaisakh) and Manurathna. The experiment was set in augmented block design with 5 blocks; each block comprising of 20 exotic accessions and five check varieties. Each entry was planted in plots of $5m^2$ at a spacing of 15 x 20 cm^2. Out of hundred accessions, eighty-nine germinated and were evaluated for qualitative and quantitative traits at appropriate stages as per DUS descriptor (2006).

Out of the 25 qualitative traits observed, eight each were monomorphic and dimorphic. The traits flag leaf attitude, lemma and palea colour, colour of apiculus, distribution of awns, panicle attitude of main axis, panicle exsertion, and pericarp colour were found to be trimorphic. Colour of awns and caryopsis shape had four classes. Qualitative traits were less affected by the environment and they can be used as robust morphological markers for identifying genotypes. Twenty-two accessions were identified as superior with erect leaf, erect flag leaf, erect and strong culm and well exserted panicle.

Based on qualitative characters accessions grouped into 12 clusters. Thirty-five accessions belonged to the first cluster. Cluster 3 comprised 25 accessions, Cluster 9 and 11 consisted of 11 accessions each. Second cluster included two accessions, while cluster 10 had three accessions. Other six clusters were composed of single accessions.

Observation on quantitative characters showed that seventeen accessions were having low height than the check varieties. Thirty-six accessions were having longer ligule, while, fifteen accessions were having longer leaf and accession EC 204863 had broader leaves. Thirty-three accessions were early to flower and 34 accessions were

early to mature. Accessions EC 207747, EC 204863, EC 205042 and EC 205128 had high number of tillers. Accessions EC 207747, EC 204863, EC 205070 and EC 415401 had high number of productive tillers per plant. Accessions EC 204847, EC 205001, EC 205223, EC 205314, EC 415448 and EC 415452 had more number of spikelets. While, comparing with check varieties, eighteen accessions had longer panicles. Eight accessions had more grain number and nineteen accessions had longer grains. Majority of the accessions had grain yield on par with check varieties.

Correlation studies showed that plant height had positive correlation with leaf length and width, number of total and productive tillers, panicle length and grain width. Correlation of ligule length with leaf length and grain width was negative. Leaf length was correlated with leaf width, number of total tillers and grain width. Leaf width exhibited positive association with plant height, length of leaf blade, number of total tillers, hundred seed weight, panicle length and grain width. Days to fifty per cent flowering expressed negative association with test weight. Total number of tillers was positively associated with plant height, length and breadth of leaf, number of productive tillers, panicle length and grain width, whereas, it was negatively correlated with grain length. Number of spikelets per panicle had positive correlation with grains per panicle and negative association with grain length. Positive and significant association was observed between 100 grain weight and grain yield**.**

Dendrogram constructed using average linkage distance resulted in four clusters with majority of the accessions falling in the cluster 1.

Accessions EC 207747, EC 204970, EC 204999, EC 205042, EC 205047, EC 205192, EC 2052015, EC 205223, EC 205333, EC 415392, EC 415403, EC 415407, EC 415413, EC 415420, EC415421, EC 415422, EC 415445, EC 415452 were identified as superior when quantitative and qualitative traits considered together and these exotic accessions can be used in breeding programmes after further confirmation studies.

Characterization of exotic germplasm of rice (*Oryza sativa* L.) for yield and quality attributes

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ABSTRACT OF THE THESIS

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