

## **QUALITATIVE MORPHOLOGICAL DIVERSITY OF SELECTED RICE (*ORYZA SATIVA* L.) GERMPLASM**

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**DOI: <https://doi.org/10.51193/IJAER.2026.12113>**

Received: 19 Jan. 2026 / Accepted: 05 Feb. 2026 / Published: 25 Feb. 2026

### **ABSTRACT**

Rice (*Oryza sativa* L.) is one of the most important staple foods crops whose demand is increasing mainly due to population growth and urbanization. It is ranked first in most Asian countries and second to maize in Malawi. The aim of the current study was to characterize both local and elite rice germplasm using morphological and grain quality traits in order to identify and document superior germplasm for conservation and use in further breeding programme. The experiment was conducted at Lifuwu Agricultural Research Station during the 2024/2025 rainy season in Alpha Lattice Design (ALD), with three replications and plot dimension of 5 m x 0.4 m. Agglomerative Hierarchical Clustering (AHC) which was done using squared Euclidean distance and (UPGMA) in GenStat (19th Edition) classified 200 rice germplasm into six distinct groups based on morphological and grain quality traits. The germplasm with rare anthocyanin pigmentation such as G81, G83, and G91; diverse awns such as G11, G31, and G76; and variable pubescence such as G1, G2, and G32 serve as valuable donors for resilience and marker-assisted selection. Germplasm with intermediate gelatinization temperature and favorable alkali digestion (G3, G4, G8, G93,

G120) are superior sources for grain quality improvement, while chalk-free germplasm (G1, G2, G75, G190) support the development of premium translucent varieties suited to Malawi's market. The outcomes of this study have a significant contribution to rice improvement goals and objectives in identifying and documenting diverse superior germplasm for adoption by rice growers after advancement or used in further breeding programs.

**Keywords:** Rice Germplasm, Genetic improvement, morphological diversity, breeding programme, grain quality, Gelatinization temperature

**Abbreviations:** IRRI, International Rice Research Institute; CSIR, Council for Scientific and Industrial Research; GT = Gelatinization temperature; ASV, Alkali Spreading Value

## 1. INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important staple food crops for more than half of the world population. The global paddy rice production is approximately 800 million metric tons per year, of which Asia contributes nearly 90% of this volume (FAOSTAT, 2025; Islam et al., 2024). The rice crop has increasing morphological and genetic diversity, and its market demand is growing at 6% per annum in the sub-Saharan Africa due to a shift in food - eating habits, economic growth and increased population; among several factors (Pragnya et al., 2018). In Malawi, rice is grown in three ecologies of rainfed lowland, irrigated lowland and rainfed upland with 80%, 15% and 5% land share, respectively (SES - IRRI, 2013; Ministry of Agriculture, 2024). The cultivars grown in Malawi are bred from different lines which include landraces and elite or improved germplasm introduced from other countries. The rice landraces and old cultivars are vital reservoirs of useful genes and can be used to enrich the improved rice germplasm with desirable traits. The elite rice germplasm consists of different genetic constitution and traits vital for crop improvement, therefore, their availability in Malawi has expanded the genetic pool (Atanda et al., 2021). The high yielding cultivars can be developed through crossing grain quality local land races and introduced superior yielding germplasm, in order to broaden the genetic divergence necessary for exploitation of heterosis (Bakode et al., 2025). Development of rice populations with farmer preferred traits such as grain quality, is a fundamental milestone for adoption and increased productivity of rice cultivars (Efisue et al., 2014; Singh et al., 2020). The knowledge of genetic relationships between local rice and improved genotypes will guide parental selection and the devising of appropriate breeding designs. Genetic diversity analysis differentiates breeding populations and assists in categorizing germplasm into definite classes (Costa-Neto et al., 2020). The morphological studies are vital for characterization of genotypes into hierarchical classes, especially by considering heritable traits (SES - IRRI, 2013). The morphological markers mostly known as qualitative traits, have been used for characterization in order to establish distinctness amongst rice germplasm in several experiments (Pachauri et al., 2020; Sarawgi and Ojha, 2016).

In Malawi, rice development is confronted by a number of constraints including lack of morphological and grain quality information concerning diversity of the native and introduced elite rice germplasm. There was a need to consolidate information of the existing germplasm so that the superior lines could be incorporated in a breeding programme (Roy and Shil, 2020; Demeke et al., 2022). This study was therefore aimed at characterization of some local landraces and elite rice germplasm for qualitative morphological and grain quality traits in order to identify superior germplasm for conservation and use in further breeding programs. The quantitative parameters such as yield and yield-related traits have not been included in the current study because they are appearing on a separate paper that also formed part of a characterization work, entitled “Variability Studies in Landraces and Improved Rice (*Oryza sativa* L.) Germplasm for Yield and Quality Traits”. These studies will enhance our knowledge of genetic diversity within *Oryza glaberrima* and *Oryza sativa*, while promoting the conservation and effective utilization of diverse germplasm in rice breeding programmes in Malawi.

## **2. MATERIALS AND METHODS**

### **2.1 Plant Materials**

The 200-rice germplasm comprising Malawi’s landrace collections, improved varieties, and advanced breeding lines sourced from the International Rice Research Institute (IRRI), Korea-Africa Food and Agriculture Cooperation Initiative (KAFACI) and Africa Rice, were used in the current study (Appendix 2). The local rice varieties such as Faya 14 M 69 and Kilombero released for the past five decades and had been cultivated by farmers in Malawi, were used in the current study as reference varieties.

### **2.2 Experimental site**

The experiment was conducted at Lifuwu Agricultural Research Station in Salima District, during the 2024/2025 rainy season as part of a characterization study of the selected germplasm. The site is located at 500 meters above sea level (masl) within the Katete dambo (13.40°S, 34.35°E), and it received 698 mm of rainfall (56.7% of the annual average), therefore supplementation by irrigation was from Lake Malawi. The mean temperatures ranged from 16 - 28 °C with relative humidity of 65 - 82%, and the soils are vertisols comprising 45% clay, a pH of 7 – 8, low in nitrogen (N) and phosphorus (P) contents.

### **2.3 Experimental design**

The experiment was laid out in Alpha Lattice Design (ALD), as earlier applied by Gomez and Gomez and later adopted by several workers (Gomez and Gomez 1984; Pachauri et al., 2020; Joachim, 2015), with three (3) replications and gross plot size of 5 m x 0.4 m, spacing between plants and rows of 20 cm x 20 cm, respectively, with a space of 1 m between each replicate, and a

band of 40 cm between plots. One (1) seedling of less than 21 days old was transplanted per hill. Fertilizer was applied at 180 kg/ha, consisting of 120 kg/ha NPK6S1.0Zn (23:10:5+6S+1.0Zn) at transplanting and 60 kg/ha urea by broadcasting at 45 after basal application. Weeding was conducted two times using hands and supplementary water was applied as soon as cracks started to form in the trial field. Roguing off-types was conducted routinely to ensure that the grown rice germplasm maintain the purity.

## **2.4 Data collection**

Data were collected from five randomly selected plants per germplasm or per plot, based on the internationally recognized standards for distinctness, uniformity and stability (DUS) stipulated by Bioversity International-IRRI-Africa Rice (2007) and IRRI descriptors (2013). A total of 46 qualitative morphological and grain quality traits were evaluated by observation for genotypic diversity and performance of the 200-rice germplasm (Appendix 1). The qualitative morphological traits and the scoring procedures have been listed in Appendix 1, and they range from ligule shape leaf sence and sterile lemma colour; among others. The selected grain quality traits that were collected include; alkali digestion, seed coat colour and chalkiness. The Alkali Digestion (AlkD) is an indication of gelatinization temperature in the rice grain. In the current study, it was achieved by placing six milled-rice grains in 10 ml of 1.7% potassium hydroxide (KOH) in a shallow container and arrange them so that they did not touch. The containers were left to stand for 23 hours, such that all the samples were soaked at 11: 00 am of the first day at 30°C and scored for spreading, the following day at 10:00 am (SES - IRRI, 2013), (Appendix 1). The Seed Coat (bran) Colour (SCC) of the rice was generally determined by removing the outer coats of rice grains (lemma and palea) during milling to check the seed coat colour and scored as in Appendix 1. The visual rating of the chalky proportion of the grain was used to determine the degree of chalkiness of each rice sample basing on the Standard Evaluation System [SES] scale as described by SES - IRRI (2013), also presented in Appendix 1.

## **2.5 Data Analysis**

The Shannon Weaver diversity index formula was applied for analysis of qualitative morphological and grain quality traits as initially indicated by (Shannon and Weaver, 1949) and later adopted by Berie and Dejene (2025); and was analyzed in the current study using GenStat 19<sup>th</sup> Edition. The Shannon Weaver diversity index formula is as follows:

$$\text{Equation 1: } H' = (\sum (j/J) * \{\log_2 (j/J) * (-1)\}) / \log_2 (k)$$

Where, **H'** stands for the Shannon Weaver diversity index, **k** stands for number of phenotypic classes for a trait, **j** stands for frequency of a phenotypic class of that trait and **J** stands for total number of observations for that trait.

Evenness (E) quantifies whether the rice germplasm in particular are spread evenly across the identified phenotypic groups, or whether some groups dominate. It is derived from the Shannon diversity index ( $H'$ ) and normalized by the maximum possible diversity for the available number of groups (S). In the current study, Evenness (E) was calculated using the following formula;

$$\text{Equation 2: } E = \frac{H'}{\ln(S)}$$

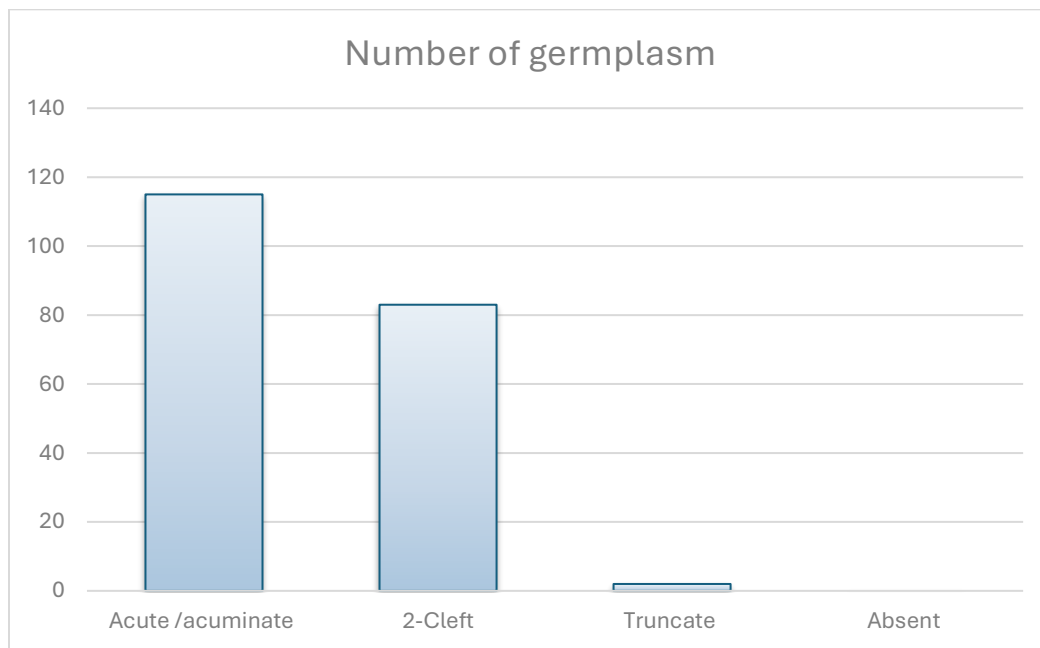
Where, E stands for Evenness index (ranges between 0 and 1),  $H'$  stands for Shannon-Weaver diversity index, S stands for the available total number of distinct rice groups (or species in general), and  $\ln(S)$  stands for the maximum possible Shannon diversity for that richness (or Natural logarithm of species richness), (Appendix). For each trait, the frequency distribution of scores and other statistical graphics were calculated and formulated in Microsoft Excel wherever necessary. The Agglomerative Hierarchical Clustering was performed using squared Euclidean distance and the Average linkage (UPGMA) in GenStat 19<sup>th</sup> Edition to attained natural groupings of the germplasm based on targeted traits.

### **3. RESULTS**

#### **3.1 Qualitative Traits**

##### **3.1.1 Ligule Shape and Colour**

In the present study, there were variations in terms of ligule shape and colour among the 200-rice germplasm. A total of one hundred and fifteen (115) rice germplasm had an acute shape, eighty - three (83) germplasm had the 2-cleft shape and two (2) germplasm had a truncate shape. This represented 57.5%, 41.5% and 1% for the acute, 2-clefted and truncate shaped rice among the studied germplasm (Figure1). Furthermore, a total of one hundred and ninety – three (193), six (6) and one (1) rice germplasm had white, purple lines and purple ligule colour, respectively (Figure 1) and Appendix 2.



**Figure 1: Histogram showing distribution of ligule shape among the 200 studied rice germplasm**



**Ligule presence and colour**



**Ligule presence and colour**

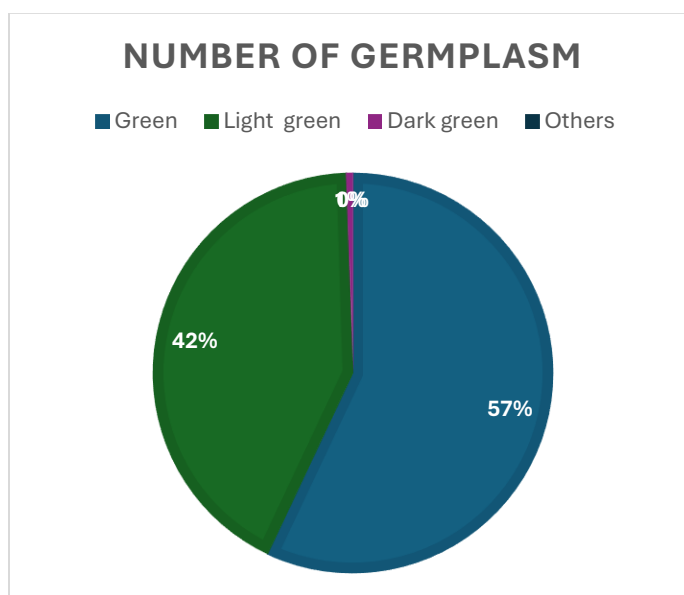
**Figure 2: Rice photos for ligule presence taken from the experiments at LARS, 2024/2025 wet season**

### 3.1.2 Leaf pubescence of blade surface

Among the studied 200 rice germplasm, 187 germplasm exhibited intermediate pubescence, 13 germplasm showed pubescence and none of the germplasm was found to be glabrous.

### 3.1.3 Leaf blade colour

The leaf blade colour varied from green, light green and dark green. These were in the proportions of one hundred and fourteen (114), eighty – five (85) and 1 (one) germplasm, respectively (Figure 3). No other colours were observed on leaf blades of these genotypes.



**Figure 3: Leaf blade colour of the studied 200 rice germplasm**

### 3.1.4 Leaf Collar and colour

All the studied 200 rice genotypes were composed of a leaf collar. In addition, all the genotypes exhibited the light green colour on the leaf collar (Appendix 2).

### 3.1.5 Leaf: anthocyanin colouration of collar

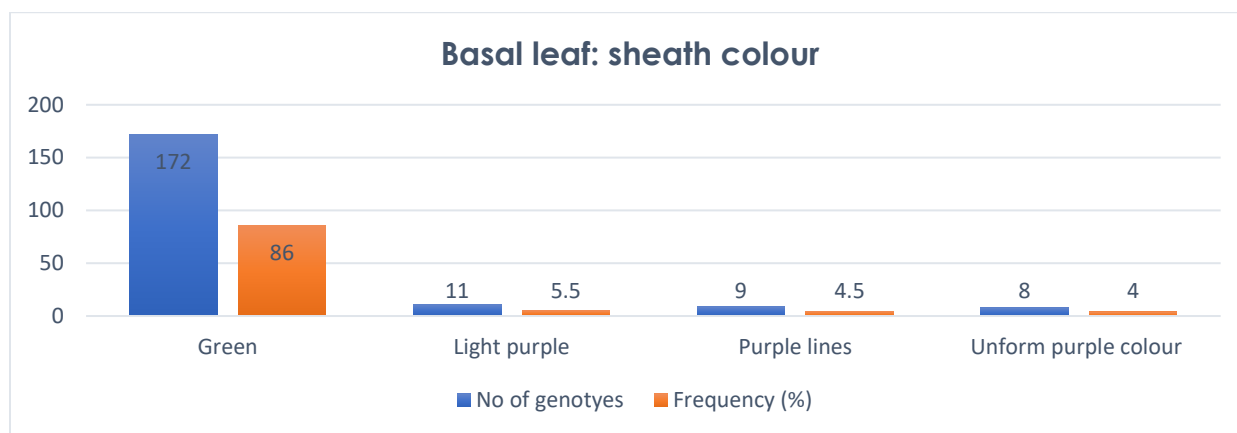
Anthocyanin plays a crucial role in plants such as rice in especially for stress tolerance, metabolic regulation and acting as antioxidants. Among the studied 200 rice germplasm, 182 genotypes expressed absence of anthocyanin in the leaf collar and 18 genotypes had anthocyanin colouration of collar.

### 3.1.6 Coleoptile colour

Out of the studied 200 rice germplasm, 165 genotypes exhibited green coleoptile colour while 35 genotypes consisted of purple coleoptile colour.

**3.1.7 Basal leaf: sheath colour**

One hundred and seventy-two (172) out of the studied 200 rice germplasm showed green basal leaf: sheath colour, eleven (11) genotypes exhibited light purple colour, nine (9) genotypes had purple lines and the remaining eight (8) genotypes showed uniform purple colour (Figure 4).



**Figure 4: Distribution of basal leaf: sheath colour for 200 rice germplasm**

**3.1.8 Leaf: intensity of green colour**

Among the studied 200 rice germplasm, 123 germplasm had dark green colour, 56 germplasm exhibited light green colour, and 21 germplasm revealed medium green colour.

**3.1.9 Leaf: anthocyanin colouration**

Leaf Anthocyanin Colouration refers to the presence and distribution of anthocyanin pigments in the leaf tissues of rice plants and is used as a morphological marker during distinctness, uniformity and stability (DUS) evaluation and germplasm characterization. Among the studied 200 rice genotypes, 197 genotypes were devoid of anthocyanin coloration and 3 genotypes possessed anthocyanin colouration on the leaves.

**3.1.10 Leaf distribution: colouration of anthocyanin**

Among the studied 200 rice germplasm, three (3) genotypes had anthocyanin colouration in the leaf. Of the 3 genotypes, anthocyanin was distributed only on tips for 2 genotypes and for 1 genotype it was present on margins only. Among the studied 200 rice genotypes, there were no genotypes in the category where anthocyanin was neither distributed in blotches nor uniform distribution.

### 3.1.11 Leaf sheath: anthocyanin colouration

Among the evaluated 200 genotypes, anthocyanin colour in leaf sheath was absent for 188 genotypes and present in 12 genotypes.



**Figure 5: Variations in Leaf sheath: anthocyanin colouration among the genotypes**  
Photos taken from the characterization trials at LARS, 2024/2025 rainy season

### 3.1.12 Leaf sheath: intensity of anthocyanin colouration

The 200-rice germplasm exhibited variations in terms of intensity of anthocyanin colouration. A total of 188 rice germplasm expressed absence or very weak intensity of anthocyanin colouration, 3 rice germplasm had weak intensity of anthocyanin colouration, 4 germplasm revealed strong intensity, 4 germplasm exhibited medium intensity and no germplasm had very strong intensity of anthocyanin colouration on leaf sheath.

### 3.1.13 Awn length and colour

Out of the 200 studied rice germplasm, 173 exhibited no awns, 15 were short and partly awned, 11 were long and partly awned and only 1 was long and fully awned. In terms of awn colour, the 173 were described as awnless, 9 had a straw colour whereas 18 comprised a brown colour.

#### **3.1.14 Auricle presence and colour**

The auricles were present in 200 germplasm and all of them were light green in colour suggesting lack of diversity for this trait.

#### **3.1.15 Leaf: anthocyanin colouration of auricles**

Among the evaluated 200 germplasm, 156 genotypes had colourless auricles, 41 genotypes with purple auricles and 3 genotypes exhibited light purple auricles.

#### **3.1.16 Flag leaf: attitude of blade (early observation)**

One hundred and twenty (120) germplasm showed semi-erect flag leaf, 50 genotypes revealed erect flag leaf, 30 genotypes showed horizontal flag leaf and none of the genotypes showed deflexed flag leaf attitude of blade at early observation among the evaluated 200 genotypes.

#### **3.1.17 Flag leaf: attitude of blade (late observation)**

Evaluation of 200 germplasm for flag leaf attitude of blade at late observation stage, 150 genotypes showed horizontal flag leaf, 30 genotypes displayed erect flag leaf, 20 genotypes showed semi erect flag leaf and none of the genotypes had deflexed flag leaf attitude of blade at late observation (Figure 6).



**Erect flag - leaf**

**Horizontal flag - leaf**

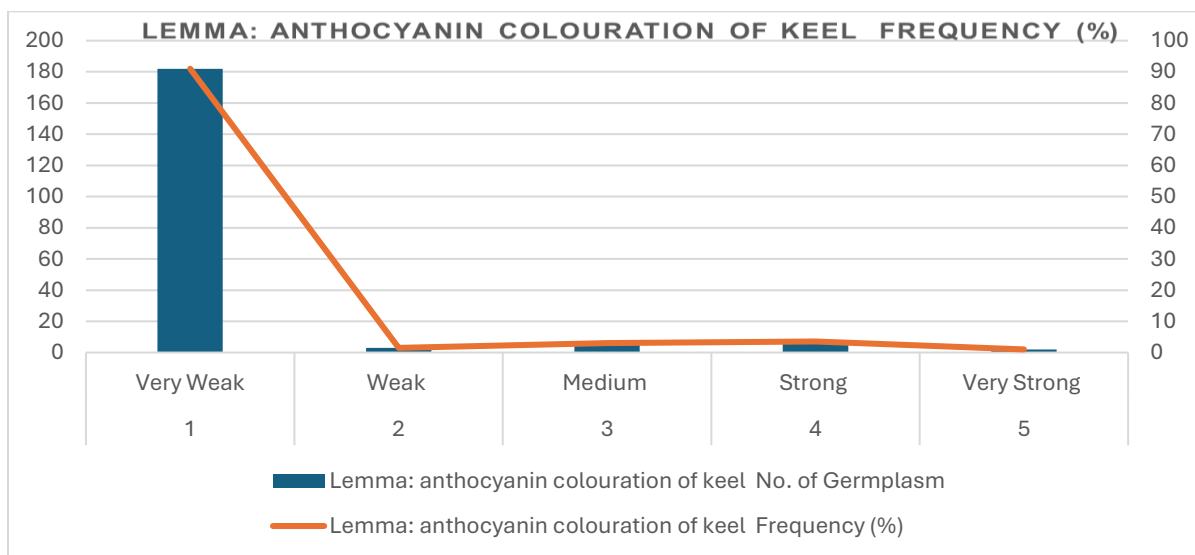
**Figure 6: Photos taken from the characterization trials at LARS, 2024/2025 rainy season, exhibiting flag leaf: attitude**

### **3.1.18 Culm attitude**

Among the 200 germplasm, 150 germplasm had erect attitude of the culm, 37 germplasm were semi-erect followed by 13 which exhibited open type of culm. None of the genotypes had spreading culm attitude.

### **3.1.19 Lemma: anthocyanin colouration of keel**

Among the studied 200 rice germplasm, 182 rice germplasm exhibited very weak anthocyanin colouration, 3 expressed weak anthocyanin colouration of keel, 6 exhibited medium anthocyanin colouration, 7 and 2 germplasm had strong and very strong anthocyanin colouration of keel respectively (Figure 7).



**Figure 7: Lemma: Anthocyanin colouration of keel for the 200-rice germplasm**

**3.1.20 Lemma: Anthocyanin colouration of apex**

Among the 200 germplasms evaluated, 169 genotypes do not have anthocyanin colouration at the apex of lemma, 25 genotypes had weak anthocyanin colouration, 5 genotypes had medium colour, 2 genotypes had strong anthocyanin colouration and 1 genotype with very strong anthocyanin colouration at the apex of lemma.

**3.1.21 Spikelet: colour of stigma**

Of the 200 germplasm, 192 germplasm had white colour stigma, 5 genotypes revealed light green stigma, and 3 genotypes had light purpled stigma.

**3.1.22 Stem: anthocyanin colouration of nodes**

One hundred and seventy – eight (178) germplasm exhibited no anthocyanin colouration of nodes and twenty-two (22) germplasm showed anthocyanin colouration of nodes.

**3.1.23 Stem: intensity of anthocyanin colouration of nodes**

No intensity of anthocyanin colouration of nodes could be indicated for the 178-rice germplasm as they revealed no pigmentation of anthocyanin. However, out of the 22 germplasm which exhibited anthocyanin colouration of nodes, 7 genotypes had weak, 12 germplasm were medium and 3 germplasm showed strong intensity of anthocyanin colouration of nodes.

**3.1.24 Panicle: curvature of main axis**

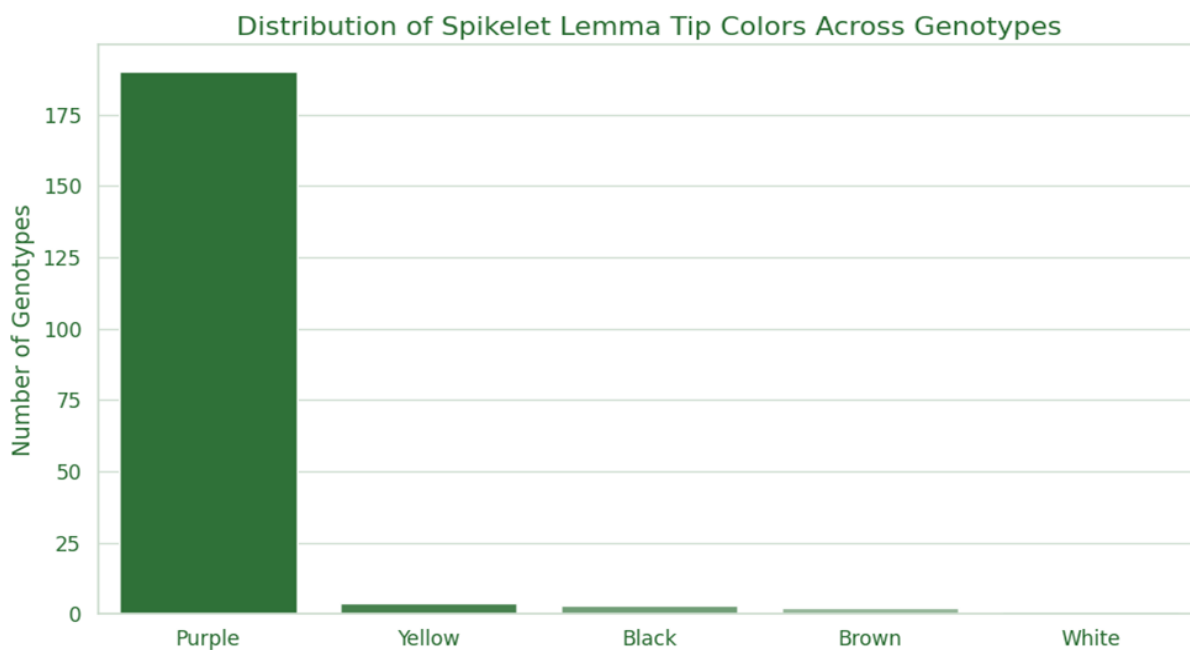
Among the 200 studied germplasm, 65 germplasm possessed straight panicles, 33 genotypes exhibited semi straight panicles, 19 genotypes had deflexed panicles and 83 genotypes had drooping panicle curvature of main axis.

### 3.1.25 Spikelet: density of pubescence of lemma

Out of the studied 200 rice germplasm, one hundred and two (102) genotypes exhibited very strong pubescence of lemma, 59 germplasm had strong pubescence, 28 genotypes showed medium pubescence of lemma, 6 genotypes exhibited weak pubescence of lemma, and 5 genotypes were non pubescent.

### 3.1.26 Spikelet: Lemma tip colour

A total 190 germplasm showed purple lemma tip followed by 4 yellow, 3 showed black lemma tip, 2 had brown tip, and 1 showed white lemma tip. Figure 8 shows the distribution of spikelet lemma tip colours across genotypes.



**Figure 8: Distribution of Lemma Tip Colour**

### 3.1.27 Lemma and palea colour

Out of the 200 germplasm, 199 showed straw colour and only 1 genotype showed gold and gold furrow on straw background.

### 3.1.28 Panicle awns

Of the 200 germplasm, 161 are awnless and 39 had awned panicles.

### **3.1.29 Panicle: colour of awns (late observation)**

Among the 39 germplasm with awns, 16 were yellowish brown, 12 had yellowish white, 7 were purple, 4 had brown, and no genotype had red colour of awns.

### **3.1.30 Panicle: length of awns**

Out of the 39 owned germplasm, 17 genotypes had medium length awns, 11 genotypes showed short awns, 7 were very short, 4 long awns and no genotype had very long length in terms of awns.

### **3.1.31 Panicle: distribution of awns**

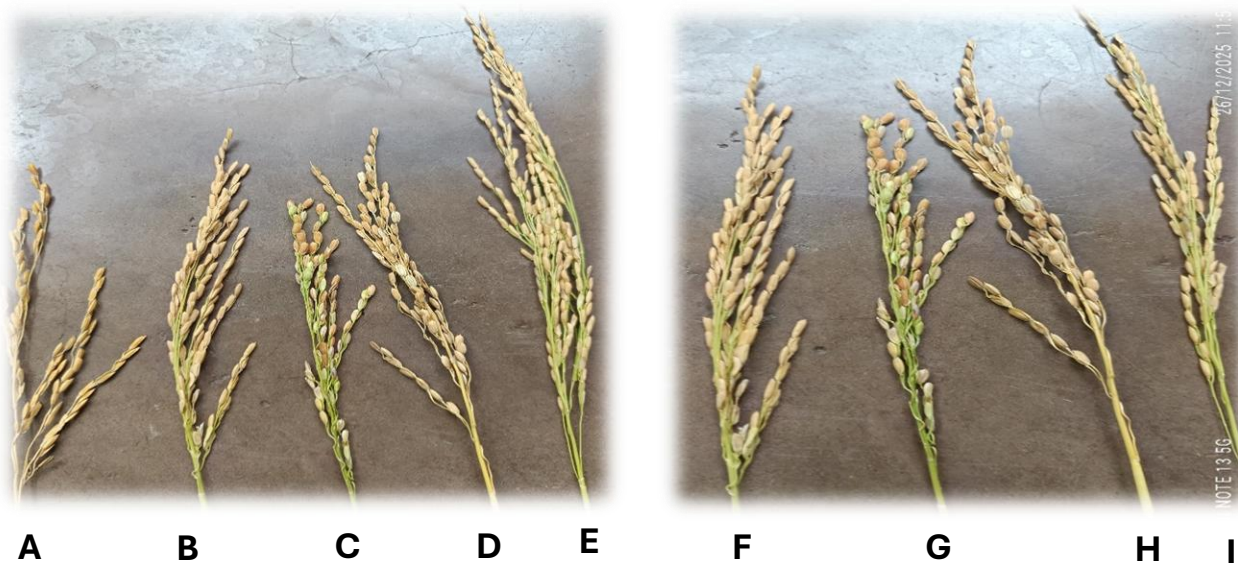
Eighteen (18) germplasm had awns on tips only, 17 had awns only on upper half and 4 genotypes showed awns on whole length of the panicle.

### **3.1.32 Panicle: presence of secondary branching**

All the studied 200 germplasm had secondary branching of the panicles. About 169 genotypes had strong secondary branching, 29 genotypes with weak secondary branching and 2 genotypes showed clustered secondary branching of the panicle.

### **3.1.33 Panicle: attitude of branches**

Out of the studied 200 rice germplasm, a total of 144 genotypes exhibited erect – to semi-erect branches, 22 had semi-erect branches, 30 germplasm showed semi erect to spreading type, 4 were spreading.





**Figure 9: Diverse expression of Panicle: attitude of branches (photos A – P, taken from the characterization trials of 200 rice germplasm at LARS, 2025)**

### **3.1.34 Panicle exertion**

The degree of panicle exertion is of paramount importance in rice breeding as it determines the suitability and success of pollination during crossing. In this study, a total of 6 germplasm exhibited enclosed panicles, 14 germplasm showed a just exerted panicle behaviour, 3 germplasm exhibited partially exerted panicles, 17 germplasm had moderately well exerted panicles and 160 germplasm had well exerted panicles.

### **3.1.35 Panicle type**

A total of 188 rice germplasm exhibited intermediate panicle type, 11 had a compact panicle type and only 1 germplasm had an open panicle type. This represents 94%, 5.5% and 0.5% for the intermediate, compact and open panicle type respectively.

### **3.1.36 Panicle axis**

Out of the studied 200 rice germplasm, 75 germplasm exhibited a droopy type of panicle axis while the remaining 125 germplasm had a straight type of panicle axis.

### **3.1.37 Apiculus colour**

A total of 177 rice germplasm showed brown tawny colour, 22 genotypes had a straw colour and only 1 genotype exhibited the white colour.

### **3.1.38 Culm: Internode colour**

A total of 122 rice genotypes exhibited green internode while the 78 genotypes had light gold internode colour.

### **3.1.39 Leaf sence**

Out of the evaluated 200 rice genotypes, 130 genotypes recorded late leaf sence, 40 genotypes with intermediate leaf sence and 30 genotypes showed early leaf sence.

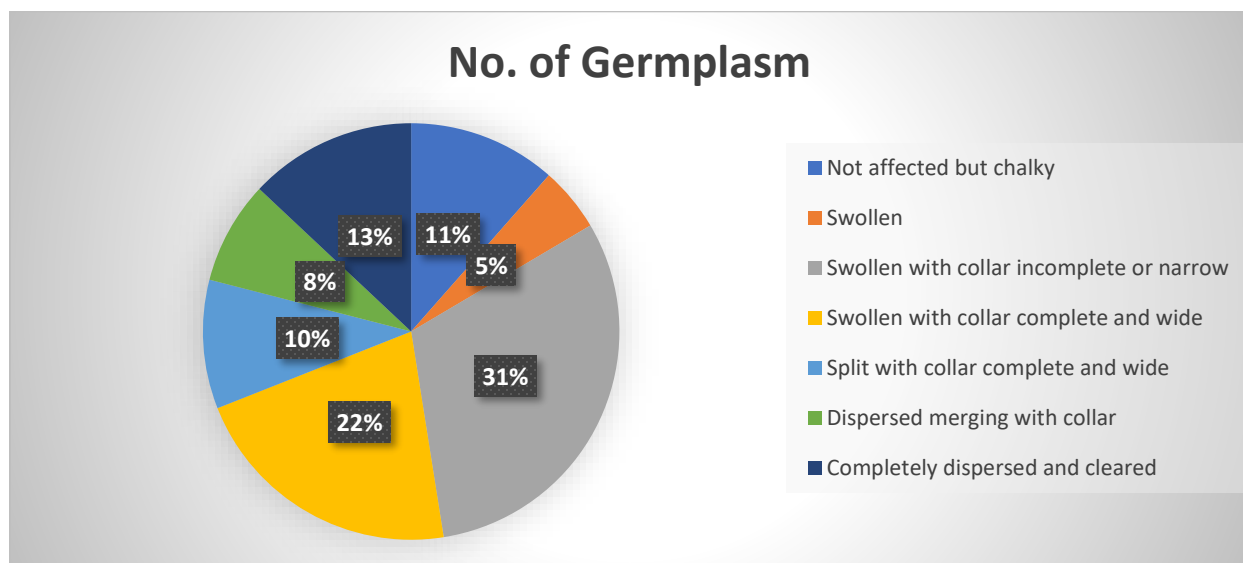
### **3.1.40 Sterile lemma colour**

Out of the studied 200 rice germplasm, 100 genotypes displayed purple colour, 59 genotypes had golden colour, 41 genotypes had straw sterile lemma colour, and none of the genotypes showed red coloured sterile lemma.

## **3.2 Qualitative grain quality traits**

### **3.2.1 Alkali Digestion (AlkD) and Gelatinization Temperature (GT)**

Out of the studied 200 rice germplasm, 125 germplasm had intermediate gelatinization temperature as such the alkali digestion ranged from low to intermediate. Out of 125 germplasm with intermediate group; 62 germplasm were swollen with collar incomplete and narrow; 43 germplasm were swollen with collar complete and wide; and 20 germplasm were split with collar complete and wide. A total of 33 germplasm exhibited high gelatinization temperature, thus low alkali digestion. Out of the 33-rice germplasm with high gelatinization temperature, 10 germplasm were swollen, and 23 germplasm were not affected but chalky. Out of the 200-rice germplasm, the remaining 42 germplasm showed low gelatinization temperature, thus high alkali digestion. Therefore, 16 germplasm out of the 42 germplasm showed dispersed merging with collar, and the remaining 26 germplasm were completely dispersed and cleared.



**Figure 10: Alkali Digestion (AlkD) of the 200-rice germplasm**

### 3.2.2 Seed Coat (bran) Colour (SCC)

Out of the evaluated 200 rice germplasm, 178 germplasm (89%) displayed the white colour while 17 genotypes (8.5%) had light brown colour. The remaining 4 germplasm (2%) and 1 germplasm (0.5%) exhibited brown and speckled brown colour, respectively. The observation did not reveal any rice germplasm with red, variable purple and /or purple colour, among the studied 200 lines.

### 3.2.3 Chalkiness (by observation)

A total of 200 rice germplasm were evaluated for endosperm chalkiness, displaying that 76.5% (n = 153) did not have visible chalkiness, however, a small degree of chalkiness, affecting less than 10% of the kernel area, was revealed in 4.5% (n = 9) of the studied germplasm. The medium chalkiness, defined as 11–20% of the kernel area, was displayed in 10.5% (n = 21) of the germplasm, while large chalkiness, exceeding 20% of the kernel area, affected 8.5% (n = 17) of the entire population (Appendix 1).

## 4.0 DIVERSITY INDEX (H')

The Shannon-Weaver Diversity Index (H') and Evenness (E) were calculated for 47 morphological traits across the rice germplasm. The indices revealed substantial variation in trait diversity, and distribution balance values ranged from 0.00 to 1.81 (Appendix 2). The high diversity traits ( $H' \geq 1.0$ ) were alkali digestion (1.81), panicle curvature (1.29), panicle awn length (1.24), spikelet lemma pubescence density (1.17), panicle awn distribution (1.09), panicle awn colour (1.07), and sterile lemma colour (1.03), Appendix 2. The low diversity traits ( $H' \leq 0.20$ ) were ligule colour

(0.17), spikelet stigma colour (0.17), panicle type (0.17), leaf anthocyanin colouration (0.06), and leaf collar, leaf colour, auricle presence, and lemma and palea colour (0.00). These traits were largely monomorphic, indicating fixation or limited variability, (Appendix 2). The Evenness (E) values ranged from 0.00 to 0.99, indicating variation in the balance of trait state distribution. The high evenness ( $E \geq 0.85$ ) was displayed in alkali digestion (0.93), sterile lemma colour (0.93), panicle curvature of the main axis (0.93), stem anthocyanin intensity (0.85), and leaf senescence (0.85). These traits were both diverse and evenly expressed, reflecting balanced representation across the rice germplasm. On the other hand, the low evenness ( $E \leq 0.20$ ) was revealed in leaf anthocyanin colouration (0.09), ligule colour (0.15), and spikelet lemma tip colour (0.15). The Shannon-Weaver and evenness results show that the studied rice germplasm ranges from highly diverse, balanced traits valuable for breeding to uniform traits with limited variability.

## **5.0 AGGLOMERATIVE HIERARCHICAL CLUSTERING**

Agglomerative Hierarchical Clustering (AHC) was performed using squared Euclidean distance and the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) in GenStat (19th Edition) classified 200 rice germplasm into six distinct groups based on morphological and grain quality traits (Figure 11, Table 1). Cluster 1 (57 germplasm) exhibited uniform ligule shape, consistent sheath colour, and rare anthocyanin expression. Cluster 2 (46 germplasm) was defined by ligule type 2 and heterogeneous anthocyanin distribution. Cluster 3 (35 germplasm) showed strong colour intensity, auricle pigmentation, and pronounced panicle curvature. Cluster 4 (44 germplasm) combined panicle curvature with lemma pubescence and apex anthocyanin deposition. Cluster 5 (10 germplasm) displayed mixed panicle attitudes with lemma pubescence and apex anthocyanin. Cluster 6 (8 germplasm) was distinguished by unique apex anthocyanin, auricle pigmentation, and panicle exertion.

Hierarchical Clustering Dendrogram of 200 Rice Germplasm

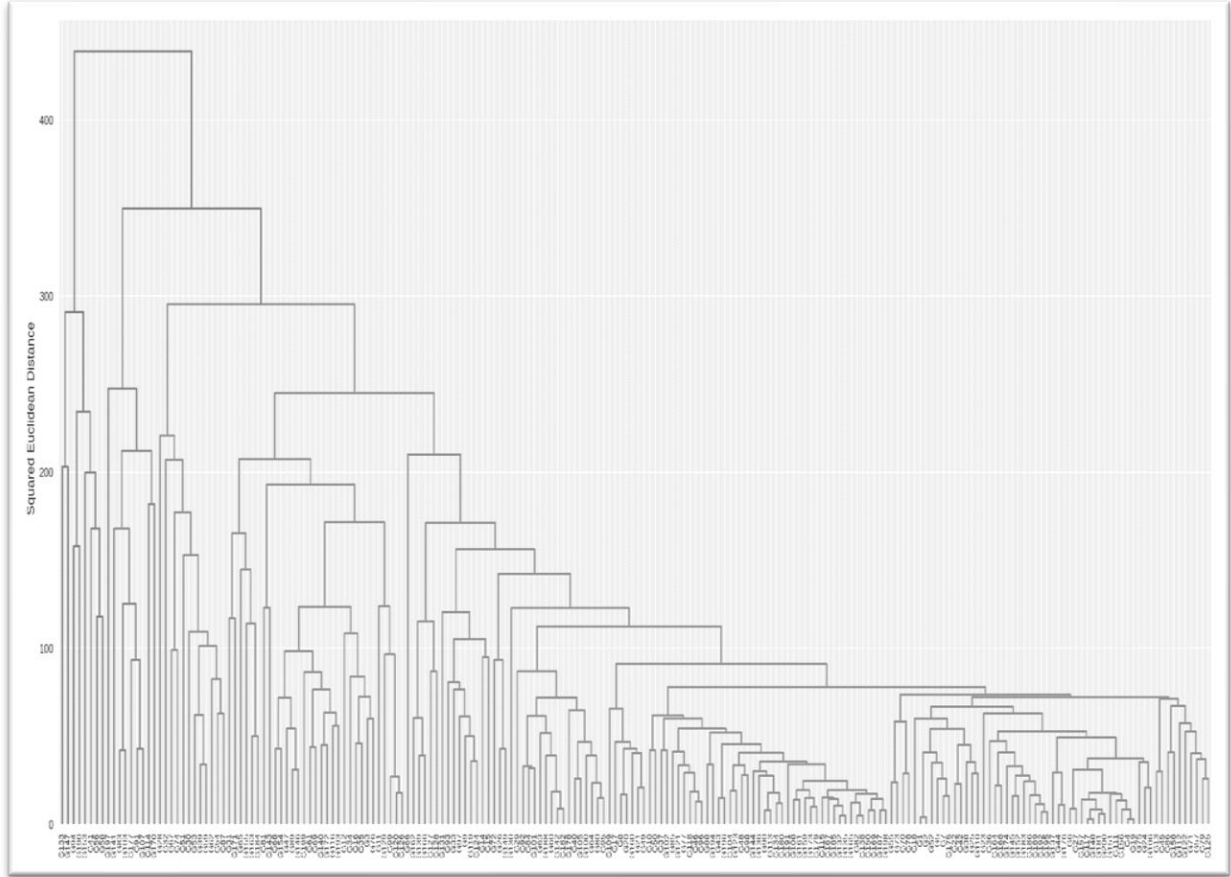


Figure 11: Agglomerative Hierarchical Clustering (AHC) of the 200 rice germplasm

Table 1: Cluster Analysis of Rice Germplasm (G) Traits and Application in Breeding

Cluster (C)	Germplasm (G)	Trait Characteristics	Application in Breeding
C1	G1, G2, G3, G4, G5, G6, G7, G8, G18, G20, G21, G23, G36, G40, G42, G43, G44, G45, G48, G49, G52, G54, G55, G73, G85, G90, G98, G100, G104, G106, G108, G111, G112, G115, G116, G117, G122, G124, G144, G145, G151, G156, G157, G159, G164, G165, G168, G175, G176, G179, G180, G191, G192, G193, G194, G195, G197	Uniform ligule shape, sheath colour variation, low or no anthocyanin	<b>Parent Selection:</b> Stable morphological traits for uniformity. <b>Heterosis:</b> Cross with anthocyanin-rich clusters (C6) to enhance pigment-related traits.
C2	G9, G10, G11, G19, G37, G38, G51, G63, G64, G72, G77, G82, G86, G92, G93, G95, G96, G101, G102, G105, G109, G118, G119, G121, G123, G125, G128, G129, G132, G134, G135, G137,	Ligule shape variation, anthocyanin distribution differences	<b>Parent Selection:</b> Introduces variability in leaf morphology and pigment distribution.

	G138, G140, G141, G142, G148, G150, G154, G161, G173, G181, G182, G183, G185, G200		<b>Heterosis:</b> Cross with uniform clusters (C1) to maximize heterosis in leaf traits.
<b>C3</b>	G12, G13, G24, G25, G31, G39, G47, G58, G62, G74, G83, G87, G89, G97, G99, G107, G114, G126, G127, G131, G133, G136, G147, G153, G155, G160, G162, G166, G170, G171, G177, G178, G188, G22, G27	Distinct colour intensity, panicle curvature	<b>Parent Selection:</b> Pigment enhancement and panicle architecture improvement. <b>Heterosis:</b> Cross with low-anthocyanin clusters (C1) or mixed panicle clusters (C5).
<b>C4</b>	G14, G15, G16, G26, G30, G32, G34, G35, G41, G46, G50, G56, G57, G59, G61, G65, G66, G68, G69, G70, G71, G75, G76, G78, G79, G84, G88, G91, G94, G103, G110, G120, G130, G139, G143, G146, G149, G152, G158, G163, G167, G169, G174, G184,	Panicle curvature, lemma pubescence, anthocyanin apex traits	<b>Parent Selection:</b> Improves panicle traits and lemma pubescence. <b>Heterosis:</b> Cross with uniform clusters (C1) or pigment-rich clusters (C6).
<b>C5</b>	G28, G29, G33, G53, G80, G81, G113, G172, G187, G67	Mixed panicle attitude, lemma pubescence	<b>Parent Selection:</b> Provides variability in panicle attitude and lemma traits. <b>Heterosis:</b> Cross with stable clusters (C1) or pigment-intense clusters (C6).
<b>C6</b>	G17, G60, G189, G190, G196, G186, G198, G199,	Unique anthocyanin apex, auricle traits, panicle exertion	<b>Parent Selection:</b> Introduces rare anthocyanin and auricle traits. <b>Heterosis:</b> Cross with uniform clusters (C1) or mixed panicle clusters (C5).

## 6.0 DISCUSSION

### 6.1 Qualitative morphological traits

The qualitative characterization of 200 rice germplasm revealed both conserved and variable traits, underscoring their importance in genetic improvement, varietal identification, and breeding programs (Pachauri et al., 2020), (Appendix 1 and 2). The ligule morphology showed predominance of acute and two-cleft forms, with white ligules being the most frequent, confirming genetic conservation and that was in corroboration with earlier reports of ligule diversity (Manjunatha et al., 2018). The leaf pubescence was largely intermediate, suggesting genetic dominance and that aligning strongly with previous findings by fellow researchers (Chowdhury et al., 2023; Alam et al., 2025). Leaf blade colour was stable, with most germplasm exhibiting green pigmentation, consistent with chlorophyll concentration and earlier studies linking colour to photosynthetic efficiency in rice plants (Sruthi et al., 2023; Umarani et al., 2024; Ezin et al., 2022).

All the studied 200 rice germplasm were composed of a leaf collar which exhibited the light green colour, confirming trait conservation and that was in agreement with earlier reports (Pragnya et al., 2018). Anthocyanin pigmentation was rare across leaves, sheaths, auricles, lemma, nodes, and stigmas, indicating restricted genetic regulation in cultivated rice compared to wild relatives. These anthocyanin pigmentation-rarity finding of the current study are in great agreement with earlier

reports by several workers (Surya et al., 2024; Thilavech et al., 2025; Jiang et al., 2024; Lv et al., 2024; Subakar et al., 2025; Meng et al., 2021; Avinash et al., 2024; Amudha & Balachandran, 2025).

The coleoptile colour was predominantly green, with purple variants confirming its role as a morphological marker (Muhammad et al., 2020). Basal leaf sheath colour was mainly green and these findings were consistent with earlier reports (Joachim, 2015; Sahoo et al., 2022). The leaf colour intensity varied among the studied 200 rice germplasm, reflecting genetic diversity in chlorophyll content (Gupta et al., 2023; Mwangi et al., 2025).

The awn traits revealed moderate diversity in presence, colour, and distribution among the germplasm, reflecting domestication effects but also retention of wild-type alleles and these findings are supported by earlier researchers (Pachauri et al., 2020; Agata et al., 2023; Kumar et al., 2024; Abdullah et al., 2025). The auricles were universally present and light green, confirming conservation of this traits among rice germplasm (Kumar et al., 2024; Sun et al., 2018).

The flag leaf attitude was mostly horizontal, with erect and semi-erect forms also observed, supporting canopy optimization for yield, and similar results were also reported in earlier studies (Pachauri et al., 2020; Kumar et al., 2024). Among the 200 germplasm, majority exhibited an erect culm attitude, a favorable trait for lodging resistance, efficient plant architecture, and a desirable attribute in breeding programs aimed at improving grain yield. The results agree strongly with previous reports on studies of cereal crops (Zhang et al., 2023). The lemma anthocyanin pigmentation was weak or absent in most germplasm of the current study, and these results are consistent with earlier reports (Singh et al., 2020; Prajuntasan et al., 2022). The stigma colour of the studied 200 rice germplasm was largely white, confirming genetic fixation (Oshima et al., 2019; Meng et al., 2021).

Panicle traits exhibited substantial diversity among the 200 rice germplasm, with curvature being mostly drooping, and straight and semi-straight forms also common (Zhang et al., 2023). The secondary branching was widespread, with strong branching predominating, confirming its role in yield potential, and this corroborated earlier findings (Rachana et al., 2019; Panda et al., 2020; Yadav et al., 2023; Johnny & Anbuselvam, 2025; Gupte et al., 2023). The majority of germplasm revealed well-exserted panicles, consistent with genetic regulation by OsGA20ox and OsEUI1 genes, and this was in tandem with earlier reports (Sun et al., 2025; Mohanty & Parida, 2024). The panicle type was predominantly intermediate, confirming conservation among the 200 rice germplasm, and earlier studies revealed similar findings (Kumar et al., 2024; Surapaneni et al., 2025). The diversity was expressed in panicle axis architecture among the 200 rice germplasm, with majority showing a droopy type and others, straight-type, suggesting a significant genetic effect, corroborating earlier findings (Agata et al., 2023; Pachauri et al., 2020).

The study also revealed a predominance of a light gold culm colour with 84.5% showing this colour, while 12% exhibited green culms and 3.5% had purple lines. The findings are in line with earlier reports that pointed out the dominance of light gold culm colour in rice germplasm (Chigira et al., 2020; Kashiwagi et al., 2022). In the present study, apiculus pigmentation was dominated by brown tawny, with straw and white being rare, also in tandem with earlier reports (Mbanjo et al., 2020; Bhuvanewari et al., 2020). In the present study, internode colour was evaluated across 200 rice genotypes, and majority (60%) revealed white internodes, while the remaining proportion showed light gold pigmentation. This distribution suggests that white internode colour is the predominant phenotype in the studied germplasm, suggesting a genetic preference or selection for this trait in breeding programs agreeing with earlier reports (Ashok, 2015). In the current study, leaf senescence was predominantly late among majority of the germplasm revealing late senescence, suggesting extended photosynthetic activity and yield advantage (Zhou et al., 2024; Sumith et al., 2023; Zhang et al., 2023). The sterile lemma colour was dominated by purple, with golden and straw variants also present, and that is in agreement with findings by Pachauri et al., (2020).

## **6.2 Qualitative grain quality traits**

Among the 200-rice germplasm studied, 125 (62.5%) exhibited intermediate gelatinization temperature with low to intermediate alkali digestion. Within this group, 62 showed swollen grains with incomplete narrow collars, 43 with complete wide collars, and 20 split with complete wide collars. 33 germplasm (16.5%) had high gelatinization temperature, corresponding to low alkali digestion; of these, 10 were swollen and 23 remained chalky. The remaining 42 germplasm (21%) displayed low gelatinization temperature with high alkali digestion, where 16 showed dispersed merging with collars and 26 were completely dispersed and cleared (Appendix 2). These results are in agreement with those reported by fellow workers, where diversity for this trait was revealed (Pragnya et al., 2018; Singh et al., 2020; Devika et al., 2024; Surya et al., 2024). In terms of seed coat colour, majority of the recently evaluated germplasm (89%) exhibited white grain colour, while 8.5%, 2% and 0.5% revealed light brown, brown and speckled brown, respectively (Appendix 1 and 2). Similar findings were reported by Wang et al., (2020) where the white grain colour was dominant.

Of the 200-rice germplasm evaluated, 76.5% showed no visible chalkiness, indicating superior grain translucency. Minor chalkiness (<10% kernel area) was observed in 4.5% of the germplasm, while 10.5% exhibited medium chalkiness (11–20%). Severe chalkiness (>20%) affected 8.5% germplasm (Appendix 1 and 2). Similar findings were reported by previous researchers who confirmed chalkiness as the main grain quality trait and majority of germplasm in that study showed low chalkiness (Li et al., 2025; Pragnya et al., 2018).

### 6.3 Diversity Index (H')

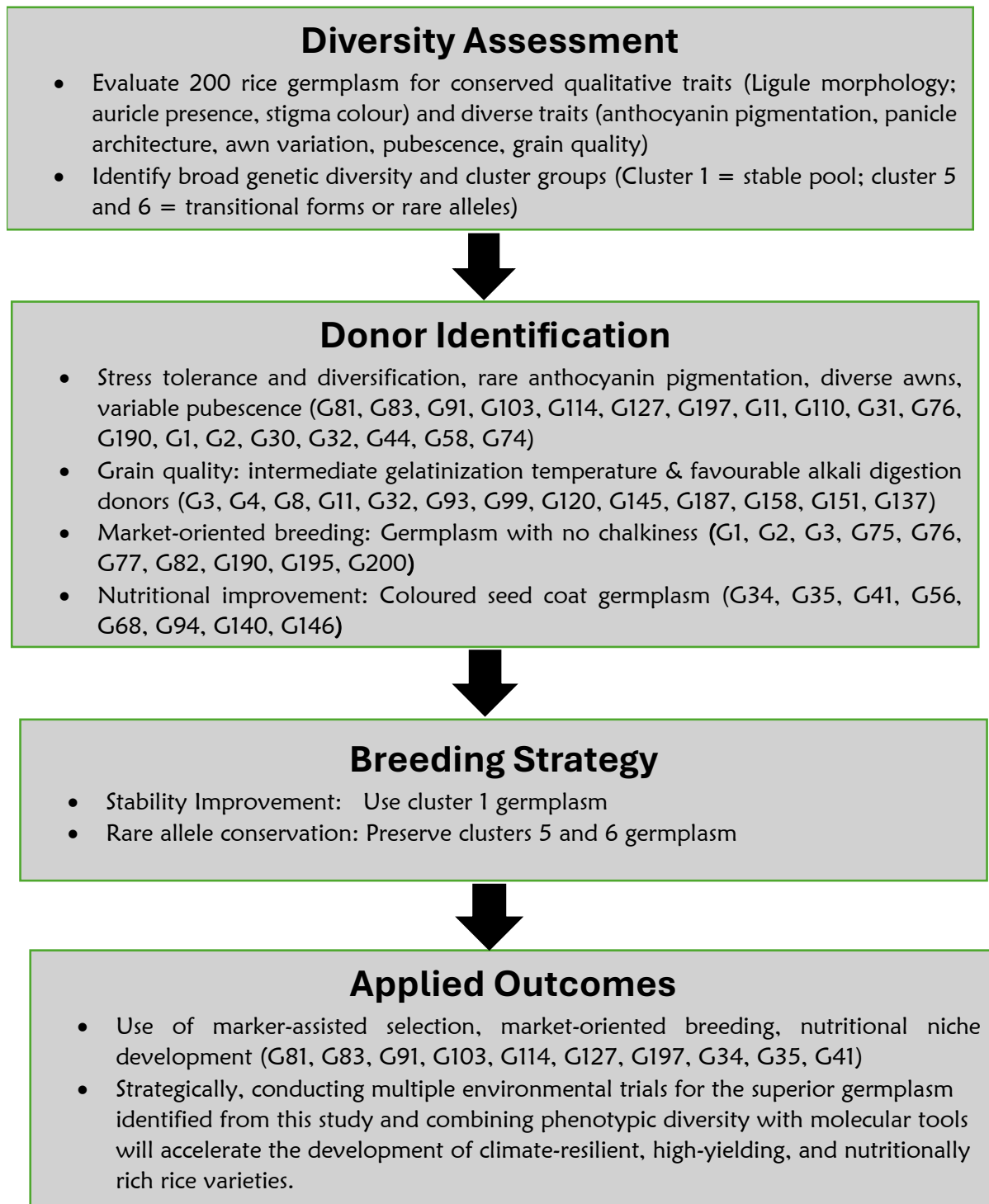
The Shannon-Weaver Diversity Index (H') and Evenness (E) across 46 morphological traits exhibited wide variability (H': 0.00 – 1.81; E: 0.00 – 0.99), (Appendix 2). High diversity was revealed in traits such as alkali digestion, panicle curvature, awn length, lemma pubescence, awn distribution/colour, and sterile lemma colour, while traits such as ligule colour, stigma colour, panicle type, leaf anthocyanin, collar, auricle, and lemma/palea colour were largely monomorphic. High evenness was observed for alkali digestion, sterile lemma colour, panicle curvature, stem anthocyanin intensity, and leaf senescence, while leaf anthocyanin, ligule colour, and lemma tip colour showed low balance. Generally, the germplasm exhibited both highly diverse, evenly distributed traits valuable for breeding and uniform traits with limited variability. These results are in strong agreement with those reported by Umarani et al., (2024), and Berie & Dejene (2025) who found that variable traits showed higher Shannon diversity, while uniform traits had low diversity.

### 6.4 Agglomerative Hierarchical Clustering (AHC)

The Agglomerative Hierarchical Clustering (AHC) using squared Euclidean distance and UPGMA in GenStat categorized 200 rice germplasm into six groups based on morphological and grain quality traits (Figure 11, Table 1). **Cluster 1** displayed uniform ligule shape, consistent sheath colour, and rare anthocyanin expression, indicating stability. **Cluster 2** had ligule type 2 with variable anthocyanin, reflecting pigment diversity. **Cluster 3** exhibited strong colour, auricle pigmentation, and panicle curvature, linked to adaptation of the germplasm. **Cluster 4** combined panicle curvature, lemma pubescence, and apex anthocyanin, suggesting trait linkage. **Cluster 5** showed mixed panicle attitudes with pubescence and apex anthocyanin, representing rare transitional forms. **Cluster 6** was marked by unique apex anthocyanin, auricle pigmentation, and panicle exertion, highlighting rare alleles. Generally, the clustering revealed meaningful associations between pigmentation and structural traits, broad genetic diversity across clusters, and clear breeding potential: suggesting that large clusters as stable pools, while smaller ones as reservoirs of rare alleles for trait improvement and conservation. The present findings corroborate those reported by fellow researchers (Islam et al., 2024; Joachim 2015; Manjunatha et al., 2018).

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

The present study was aimed at characterization of some local landraces and elite rice germplasm for qualitative morphological and grain quality traits in order to identify superior germplasm for conservation and use in further breeding programmes. It highlights the importance of stable germplasm pools and rare allele reservoirs in rice improvement. As concluded and recommended in Figure 12, the framework integrates diversity assessment, donor identification, breeding strategy, and applied outcomes that guide climate-resilient, high-yielding, and nutritionally enriched rice varieties.



**Figure 12: The framework for translating rice germplasm diversity into breeding strategies**

## **8.0 ACKNOWLEDGMENTS**

We are very grateful to the Aqua Fish Center at LUANAR for the financial support when carrying out the field experiments so that this manuscript could be published in a journal. Thanks, are extended to the Department of Crops and Soil Science at LUANAR for allowing authors to undertake this study. Gratitude to fellow scientists and staff from LUANAR and DARS for their tireless support. We are also indebted to the International Rice Research Institute (**IRRI**), Korea - Africa for Food and Agriculture cooperation Initiative (**KAFACI**), Africa Rice and the Department of Agricultural Research Services (DARS) through Lifuwu Agricultural Research Station (LARS) for the provision of plant materials used in the current study.

## **9.0 CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest

## **10.0 SUPPLEMENTALLY MATERIAL**

All the data is available in this document and any additional data can be provided by the corresponding author (E.J), on reasonable request.

## **11.0 FUNDING DECLARATION**

The author (s) acknowledge the financial support received from the Africa Center of Excellence in Aquaculture and Fisheries (**AQUAFISH: ACE AF - II**) of the Lilongwe University of Agriculture and Natural Resources (LUANAR), Bunda Campus, for the implementation and publication of this work.

## **REFERENCES**

- [1]. Abdullah, M., Furtado, A., Masouleh, A.K. *et al.* The genomes of the most diverse AA genome rice species provide a resource for rice improvement and studies of rice evolution and domestication. *BMC Genomics* 26, 54 (2025). <https://doi.org/10.1186/s12864-025-11246-0>
- [2]. Agata A, Ashikari M, Sato Y, Kitano H, Hobo T (2023). Designing rice panicle architecture via developmental regulatory genes. *Breed Sci.* Mar;73(1):86-94. doi:10.1270/jsbbs.22075. Epub 2023 Mar 21. PMID: 37168816; PMCID: PMC10165343
- [3]. Alam, I., Das, B., Tanim, K. M. Y., Zannat, R., Hridoy, A. D., Hossain, H. M. F., Islam, T., & Bhuiyan, M. A. R. (2025). Agro-morphological characterization and diversity studies of local and modern rice genotypes in the coastal region of Bangladesh. *Sarhad Journal of Agriculture*, 41(1), 1–11. Retrieved October 25, 2025, from <https://researcherslinks.com/current-issues/Agro-Morphological-Characterization-and-Diversity/14/1/10386/html>

- [4]. Amudha, R., & Balachandran, S. (2025). Therapeutic potential of anthocyanin-rich deep pigmented rice landraces. *Journal of Phytomedicine and Therapeutics*, 24(1), 282–290. Ukaaz Publications. <https://www.ukaazpublications.com/publications/wpcontent/uploads/2025/01/27-Amudha-282-290>
- [5]. Ashok S (2015). Genetic divergence studies for yield components and grain quality parameters in Rice (*Oryza sativa* L.). M. Sc (Ag.) Thesis. Acharya N.G. Ranga Agricultural University, Guntur, India
- [6]. Atanda SA, Olsen M, Crossa J, Burgueño J, Rincent R, Dzidzienyo D, Beyene Y, Gowda M, Dreher K, Boddupalli PM, Tongoona P, Danquah EY, Olaoye G, Robbins KR (2021) Scalable sparse testing genomic selection strategy for early yield testing stage. *Front Plant Sci.* <https://doi.org/10.3389/fpls.2021.658978>
- [7]. Avinash G, Sharma N, Prasad KR, Kaur R, Singh G, Pagidipala N, Thulasinathan T (2024) Unveiling the distribution of free and bound phenolic acids, flavonoids, anthocyanins, and proanthocyanidins in pigmented and non-pigmented rice genotypes. *Front Plant Sci.* <https://doi.org/10.3389/fpls.2024.1324825>
- [8]. Bakode, Sandhya, Sanjay Kumar Singh, G. K. Koutu, Shailendra Sagar Prajapati, and Pushpa Jharia. 2025. “Phenotypic Characterization and Association Analysis of Morphological Traits in Diverse Rice Genotypes (*Oryza Sativa* L.)”. *International Journal of Plant & Soil Science* 37 (6):548-60. <https://doi.org/10.9734/ijpss/2025/v37i65534>.
- [9]. Berie, A., & Dejene, T. (2025). Morphological characterization and multivariate analysis of rain fed rice (*Oryza sativa* L.) genotypes in Northwest Ethiopia. *Turkish Journal of Agriculture – Food Science and Technology*, 13(2), 423–438. <https://doi.org/10.24925/turjaf.v13i2.423-438.7274>
- [10]. Bhuvanewari S, Gopala Krishnan S, Bollinedi H, Saha S, Ellur RK, Vinod K, Singh IM, Prakash N, Bhowmick PK, Nagarajan M (2020) Genetic architecture and anthocyanin profiling of aromatic rice from Manipur reveals divergence of Chakhao landraces. *Front Genet* 11:570731
- [11]. Costa-Neto G, Fritsche-Neto R, Crossa J (2020) Nonlinear kernels, dominance, and envirotyping data increase the accuracy of genome-based prediction in multi-environment trials. *Heredity* 126(1):92–106. <https://doi.org/10.1038/s41437-020-00353-1>
- [12]. Chigira K, Kojima N, Yamasaki M, Yano K, Adachi S, Nomura T, Jiang M, Katsura K, Ookawa T (2020) Landraces of temperate japonica rice have superior alleles for improving culm strength associated with lodging resistance. *Sci Rep* 10:19855. <https://doi.org/10.1038/s41598-020-76949-8>
- [13]. Chowdhury, N., S. Islam, M.H. Mim, S. Akter, J. Naim, B. Nowicka and M.A. Hossain. 2023. Characterization and genetic analysis of the selected rice mutant populations. *Sabrao*

- J. Breed. Genet., 55(1): 25-37. <https://doi.org/10.54910/sabrao2023.55.1.3>
- [14]. Demeke, B., Dejene, T., & Abebe, D. (2022). Genetic variability, heritability, and genetic advance of morphological, yield related and quality traits in upland rice (*Oryza sativa* L.) genotypes at Pawe, Northwestern Ethiopia. *Cogent Food & Agriculture*, 8(1), 2157099. <https://doi.org/10.1080/23311932.2022.2157099>
- [15]. Devika, S., Anjali Anand, Elangovan A., Pavithra K. S., and Ramesh R. (2024). “Physiochemical Characterization of Rice Genotypes Based on Gel Consistency and Alkali Digestion under Different N Levels.” *International Journal of Agriculture, Environment and Biotechnology*, vol. 7, no. 6e, 2024, Article 857. <https://doi.org/10.33545/2618060X.2024.v7.i6e.857>
- [16]. Efisue AA, Umunna BC, Joseph, Orluchukwu JA (2014). Effects of yield components on yield potential of some lowland rice (*Oyza sativa* L.) in coastal region of Southern Nigeria. *Journal of Plant Breeding and Crop Science* 6(9):119-127. FAOSTAT (2013)
- [17]. Food and Agriculture Organization of the United Nations (2025). FAOSTAT *Statistical Database: Production of primary crops*. FAO, Rome. (Accessed on 21 December, 2025). Available at: <https://www.fao.org>.
- [18]. Gomez KA, Gomez AA (1984). *Statistical procedures for agricultural research* (2 ed.). John Wiley and Sons, New York 680 p.
- [19]. Gupte VP, Manonmani S, Nivedha R, Suresh R, Kumar GS, Raveendran M (2023) Genetic diversity studies and identification of donors for lodging resistance in rice (*Oryza sativa* L.). *Electron. J. Plant Breed.* 14(3):1158–1166
- [20]. Islam, M.A., Hasan, M.M., Hossain, M.A. *et al.* Identification and evaluation of high-performing advanced germplasm of rice through morphological and breeding value analysis. *Discover Agric* 2, 126 (2024). <https://doi.org/10.1007/s44279-024-00143-x>
- [21]. Joachim J (2015). Morphological, molecular and quality characterization of rice varieties and land races from East and Southern Africa. A dissertation submitted in partial fulfillment of the requirements for the degree of Master of science in crop science of Sokoine University of Agriculture. Morogoro, Tanzania.
- [22]. Kashiwagi, T. (2022). Novel QTL for lodging resistance, PRL4, improves physical properties with high non-structural carbohydrate accumulation of basal culms in rice (*Oryza sativa* L.). *Euphytica* 218, 83 (2022). <https://doi.org/10.1007/s10681-022-03036-6>
- [23]. Li, Z., Zhou, L., Ji, K. *et al.* (2025). Genome-wide association study of rice chalky grain rate. *Genet Resour Crop Evol* 72, 9873–9887 (2025). <https://doi.org/10.1007/s10722-025-02545-2>
- [24]. Lv, S., Tang, X., Jiang, L. *et al.* OsLSC6 Regulates Leaf Sheath Color and Cold Tolerance in Rice Revealed by Metabolite Genome Wide Association Study. *Rice* 17, 34 (2024). <https://doi.org/10.1186/s12284-024-00713-z>

- [25]. Manjunatha, G. A., Elsy, C. R., Rajendran, P., Joseph, J. J. R. M. F., & Krishnan, S. (2018). DUS characterization of rice (*Oryza sativa* L.) landraces of Wayanad, Kerala. *Electronic Journal of Plant Breeding*, 9(2), 617–630. <https://doi.org/10.5958/0975-928X.2018.00106.4>
- [26]. Meng, L., Qi, C., Wang, C. et al. Determinant Factors and Regulatory Systems for Anthocyanin Biosynthesis in Rice Apiculi and Stigmas. *Rice* 14, 37 (2021). <https://doi.org/10.1186/s12284-021-00480-1>
- [27]. Ministry of Agriculture. (2024). Malawi's National Rice Development Strategy II (NRDS-II), 2024–2030 (2nd ed.). Government of Malawi. [https://riceforafrica.net/wp-content/uploads/2024/08/malawi\\_nrds2.pdf](https://riceforafrica.net/wp-content/uploads/2024/08/malawi_nrds2.pdf) Accessed December 22, 2025
- [28]. Mohanty, J. K., & Parida, S. K. (2024). Stripping off the rice panicle: Induced genetic variation awakens the sheathed spikelet for a better yield. *Journal of Experimental Botany*, 75(18), 5459–5462. <https://doi.org/10.1093/jxb/erae327>
- [29]. Muhammad, A., Hao, H., Xue, Y. et al. Survey of wheat straw stem characteristics for enhanced resistance to lodging. *Cellulose* 27, 2469–2484 (2020). <https://doi.org/10.1007/s10570-020-02972-7>
- [30]. Mbanjo, E.G.N.; Kretzschmar, T.; Jones, H.; Ereful, N.; Blanchard, C.; Boyd, L.A.; Sreenivasulu, N. (2020). The Genetic basis and nutritional benefits of pigmented rice grain. *Front. Genet.* 2020, 11, 229. [Google Scholar] [CrossRef] [PubMed]
- [31]. Mwangi J.K, Murage H, Ateka E.M and Nyende A. B (2025). Department of Horticulture, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya. <http://ir.jkuat.ac.ke/bitstream/handle/123456789/2885>
- [32]. Oshima M, Taniguchi Y, Akasaka M, Abe K, Ichikawa H, Tabei Y, Tanaka J (2019) Development of a visible marker trait based on leaf sheath-specific anthocyanin pigmentation applicable to various genotypes in rice. *Breed Sci* 69(2):244–254. <https://doi.org/10.1270/jsbbs.18151>
- [33]. Pachauri, K.A., Sarawgi, A.K., Bhandarkar, B., and SK Nair, S. K., (2020). Characterization and variability analysis of rice germplasm accessions for morphological traits. *Journal of Pharmacognosy and Phytochemistry*. E-ISSN: 2278-4136 P-ISSN: 2349-8234 [www.phytojournal.com](http://www.phytojournal.com) JPP 2020; 9(5): 1407-1413
- [34]. Panesar, R., Ramchander, S., & Singh, R. (2024). Assessment of variability parameters and diversity of panicle architectural traits associated with yield in rice (*Oryza sativa* L.). *Plant Science Today*, 11(1), 109–118. <https://doi.org/10.14719/pst.2658>
- [35]. Panda D, Sahu N, Behera PK, Lenka K (2020). Genetic variability of panicle architecture in indigenous rice landraces of Koraput region of Eastern Ghats of India for crop improvement. *Physiol Mol Bio Plants* 26(10):1961–1971
- [36]. Prajuntasana, R.; Ratananikom, K and Payoungkiattikun, W. (2022). Anthocyanin content,

- phenolic content, antioxidant activity and yield in indigenous rice as affected by different fertilizers. *Biodiversitas Journal of Biological Diversity*, 23(8).1156-1198
- [37]. Rachana B, Eswari KB, Jyothi B, Devi LG, Vidhya JL, Bhavani LP, Bharath M, Rao RP, Kumar AJ, Abdul FR, Neeraja CN (2019) Characterization of new plant type core set of rice (*Oryza sativa* L.) using QTL/gene-linked markers. *Oryza* 56(4):352–360
- [38]. Sahoo, B., Bhandarkar, S., Verma, R., & Nair, S. (2022). Study of inheritance pattern for basal leaf sheath colour in rice (*Oryza sativa* L.). *Journal of Research in Agriculture and Animal Science*, 9(7), 8–14. <https://www.questjournals.org/jraas/papers/v9-i7/B09070814.pdf>
- [39]. Sarawgi & Ojha, G.C. (2016). Characterization and correlation analysis for yield and yield contributing traits in medium duration germplasm accessions of rice (*Oryza sativa* L.), *Int. J Cur. Res.*, 8(06), 32382-32389. <https://www.journalcra.com/sites/default/files/issue/pdf/15501.pdf>
- [40]. Singh K.S., Suneetha Y., Kumar G.V., Srinivasa V.R., Raja S.D. and Sriniva (2020). Variability, correlation and path studies in coloured rice. *International Journal of Chemical Studies* 2020; 8(4): 2138-2144 <https://doi.org/10.22271/chemi.2020.v8.i4w.9944>
- [41]. Shannon, C.E. & Weaver, W. (1949). The mathematical theory of communication, The University of Illinois, Chicago, pp. 3 24. <https://raley.english.ucsb.edu/wp-content/Engl800/Shannon-Weaver.pdf>
- [42]. Subakar I., Johnny J., Anbuselvam Y. (2025). DUS Characterization of Tamil Nadu Traditional Rice (*Oryza Sativa* L.) Varieties. *Indian Journal of Agricultural Research*. 59(1): 98-106. doi: 10.18805/IJARE.A-5907
- [43]. Standard Evaluation System for Rice (IRRI, 2013), 5<sup>th</sup> Edition, P.O. Box 933, 1099 Manila, Philippines
- [44]. Sruthi S.R, Ivin. J.J.S, Williams G, Anbuselvam Y (2023). Genetic Variability and Diversity Analysis in Traditional Rice (*Oryza sativa* L.) Varieties of Tamil Nadu. *Environment and Ecology* 41 (2): 746—753, April– June 2023 ISSN 0970-0420 Received 27 October 2022, Accepted 8 February 2023, Published on 24 April 2023
- [45]. Sun XM, Zhang ZY, Chen C, et al., (2018). The C-S-A gene system regulates hull pigmentation and reveals evolution of anthocyanidin biosynthesis pathway in rice. *J Exp Bot.* 2018;69: 1485–98.
- [46]. Sumith de D.A.Z, Athauda M. Prasadika A.A., Priyantha W.S., Jayasinghe Samiduni V. (2023). Influence of Maturity Duration on Grain Yield of Rice under Direct-seeded Condition in the Tropics. *Indian Journal of Agricultural Research*.57(3): 304-311.doi:10.18805/IJARE.A-6031.> <https://arccjournals.com/journal/indian-journal-of-agricultural-research/A-6031>
- [47]. Surapaneni, M., Rao, D.S., Jaldhani, V. et al. Identification of promising genotypes and

- marker-trait associations for panicle traits in rice. *CEREAL RESEARCH COMMUNICATIONS* 53, 807–820 (2025). <https://doi.org/10.1007/s42976-024-00593-5>
- [48]. Surya T, Amudha K, Sivasakthivelan P, Geetha S, Uma D. and Sudha M. (2024). Therapeutic potential of anthocyanin rich deep pigmented rice landraces and its genetic improvement: A review. *Ann. Phytomed.*, 13(2):282-290. <http://dx.doi.org/10.54085/ap.2024.13.2.27>
- [49]. Sun, H., Yao, Q., Hai, M. et al. (2025). Elite Alleles of EPE1 Identified via Genome-wide Association Studies Increase Panicle Elongation Length in Rice. *Rice* 18, 4 (2025). <https://doi.org/10.1186/s12284-025-00759-7>
- [50]. Thilavech, T., Suantawee, T., Chusak, C. *et al.*, (2025). Black rice (*Oryza sativa* L.) and its anthocyanins: mechanisms, food applications, and clinical insights for postprandial glycemic and lipid regulation. *Food Prod Process and Nutr* 7, 15 (2025). <https://doi.org/10.1186/s43014-024-00288-8>
- [51]. Umarani, E., Radhika, K., Padma, V., & Subbarao, L. V. (2024). Agro-morphological characterization of rice (*Oryza sativa* L.) landraces based on DUS descriptors. *International Journal of Agriculture Sciences*, 16(6), 123–129. <https://doi.org/10.18782/2320-7051.2624>
- [52]. Wang, X., Liu, Y., Zhang, Y., & Li, Y. (2022). Field rice panicle detection and counting based on deep learning. *Frontiers in Plant Science*, 13, 966495. <https://doi.org/10.3389/fpls.2022.966495>
- [53]. Yadav, S. P. S., Mehata, D. K., Bhattarai, S., Bhandari, S., Ghimire, N. P., Majhi, S. K., Chaudhary, P., & Bhujel, S. (2023). Genetic variability of panicle architecture traits in different rice accessions under the Eastern Terai conditions of Nepal. *Cogent Food & Agriculture*, 9(1), 2238420. <https://doi.org/10.1080/23311932.2023.2238420>
- [54]. Zheng, H., Sun, S., Bai, L. et al. (2022). Identification of candidate genes for panicle length in *Oryza sativa* L. ssp. japonica via genome-wide association study and linkage mapping. *Euphytica* 218, 16 (2022). <https://doi.org/10.1007/s10681-022-02972-7>
- [55]. Zhang, Y., Liu, Y., Zhang, Y., Wang, Y., Liu, Y., & Li, Y. (2023). Mining the candidate genes of rice panicle traits via a genome-wide association study. *Frontiers in Genetics*, 14, 1239550. <https://doi.org/10.3389/fgene.2023.1239550>
- [56]. Zhou, Y., Wang, Y., Liu, Y., & Wang, Y. (2024). Comprehensive identification of key genes responsible for leaf senescence of rice (*Oryza sativa* L.) by WGCNA using two independent aging datasets. *Plants*, 14(17), 2704. <https://doi.org/10.3390/plants14172704>

**Appendix 1: Qualitative traits descriptions, frequency, diversity index and observation stage of 200 rice germplasm**

ID No	Trait	Scale	Description	No. of germplasm	Frequency (%)	Shannon Weaver Diversity Index (H')	Evenness	Observation stage
1	Ligule shape	0	Absent	0	0	0.73	0.53	Tillering to stem elongation
		1	Acute to acuminate	115	57.5			
		2	2-cleft	83	41.5			
		3	Truncate	2	1			
2	Ligule colour	1	White	193	96.5	0.17	0.15	Stem elongation to booting
		2	Purple lines	6	3			
		3	Purple	1	0.5			
3	Leaf blade pubescence	1	Glabrous	0	0	0.18	0.17	Booting to heading
		2	Intermediate	187	93.5			
		3	Pubescent	13	6.5			
4	Leaf blade colour	1	Light green	85	42.5	0.67	0.49	Seedling to tillering
		2	Green	114	57			
		3	Dark green	1	0.5			
		4	Purple tips	0	0			
		5	Purple margins	0	0			
		6	Purple blotch	0	0			
		7	Purple	0	0			
5	Leaf collar	0	Absent	0	0	0	0	Tillering
		1	Present	200	100			
6	Leaf collar colour	1	Light green	200	100	0	0	Seedling to tillering
		2	Medium green	0	0			
		3	Dark green	0	0			
7	Leaf anthocyanin colouration of collar	1	Absent	182	91	0.33	0.47	Tillering
		9	Present	18	9			
8	Coleoptile colour	1	Green	165	82.5	0.44	0.64	Seedling stage
		2	Purple	35	17.5			
9	Basal leaf sheath colour	1	Green	172	86	0.69	0.5	Tillering to booting
		2	Purple lines	9	4.5			
		3	Light purple	11	5.5			
		4	Purple	8	4			
10		3	Light	56	28	0.86	0.78	

	Leaf intensity of green colour	5	Medium	21	10.5			Seedling to tillering
		7	Dark	123	61.5			
11	Leaf anthocyanin colouration	1	Absent	197	98.5	0.06	0.09	Seedling to tillering
		9	Present	3	1.5			
12	Leaf distribution of anthocyanin	1	Tips only	2	66.7	0.64	0.46	Seedling to tillering
		2	Margins only	1	33.3			
		3	Blotches only	0	0			
		4	Even	0	0			
13	Leaf sheath anthocyanin colouration	1	Absent	188	94	0.22	0.31	Tillering
		9	Present	12	6			
14	Leaf sheath intensity of anthocyanin	1	Absent or very weak	188	94	0.36	0.22	Tillering
		3	Weak	3	1.5			
		5	Medium	5	2.5			
		7	Strong	4	2			
		9	Very strong	0	0			
15	Awning	0	Absent	173	86.5	0.52	0.32	Milk to maturity
		1	Short and partly awned	15	7.5			
		5	Short and fully awned	0	0			
		7	Long and partly awned	11	5.5			
		9	Long and fully awned	1	0.5			
16	Awn colour	0	Awnless	173	86.5	0.4	0.29	Maturity
		1	Straw	9	4.5			
		2	Gold	0	0			
		3	Brown (tawny)	18	9			
		4	Red	0	0			
		5	Purple	0	0			
		6	Black	0	0			
17	Auricle presence and colour	0	Absent (no auricles)	0	0	0	0	Tillering
		1	Light green	200	100			
		2	Purple	0	0			
18	Anthocyanin colouration of auricle	1	Absent	156	78	0.53	0.76	Tillering
		9	Present	44	22			
19		1	Erect	50	25	0.87	0.79	Booting

	Flag leaf attitude (early)	3	Semi-erect	120	60			
		5	Horizontal	30	15			
		7	Recurved	0	0			
20	Flag leaf attitude (late)	1	Erect	30	15	0.73	0.67	Maturity
		3	Semi-erect	20	10			
		5	Horizontal	150	75			
		7	Recurved	0	0			
21	Culm habit	1	Erect	150	75	0.64	0.41	Heading
		3	Semi-erect	37	18.5			
		5	Open	13	6.5			
		7	Spreading	0	0			
		9	Prostrate	0	0			
22	Lemma anthocyanin colouration of keel	1	Absent/very weak	182	91	0.5	0.31	Heading
		3	Weak	3	1.5			
		5	Medium	6	3			
		7	Strong	7	3.5			
		9	Very strong	2	1			
23	Lemma anthocyanin colouration of apex	1	Absent/very weak	169	84.5	0.49	0.31	Heading
		3	Weak	25	12.5			
		5	Medium	3	1.5			
		7	Strong	2	1			
		9	Very strong	1	0.5			
24	Spikelet: Stigma colour	1	White	192	96	0.17	0.11	Heading
		2	Light green	5	2.5			
		3	Yellow	0	0			
		4	Light purple	3	1.5			
		5	Purple	0	0			
25	Stem anthocyanin colouration of nodes	1	Absent	178	89	0.33	0.47	Booting
		9	Present	22	11			
26	Stem: Intensity of anthocyanin colouration of nodes	3	Weak	7	31.8	0.94	0.85	Booting
		5	Medium	12	54.5			
		7	Strong	3	13.7			
27	Panicle: curvature of main axis	1	Straight	65	32.5	1.29	0.93	Maturity
		3	Semi-straight	33	16.5			
		5	Slightly drooping	19	9.5			

		7	Strongly drooping	83	41.5			
28	Spikelet: Lemma pubescence density	0	Absent	5	2.5	1.17	0.73	Maturity
		1	Sparse	6	3			
		3	Medium	28	14			
		5	Dense	59	29.5			
		7	Dense (very strong)	102	51			
29	Spikelet: Lemma tip colour	1	Straw (yellow)	4	2	0.24	0.15	Maturity
		2	Brown	2	1			
		3	White	1	0.5			
		4	Purple	190	95			
		5	Black	3	1.5			
30	Lemma and palea colour	0	Straw	199	99.5	0	0	Maturity
		1	Gold & gold furrows on straw background	1	0.5			
		2	Brown spots on straw					
		3	Brown furrows on straw	0	0			
		4	Brown (tawny)	0	0			
		5	Reddish to light purple	0	0			
		6	Purple spots on straw	0	0			
		7	Purple furrows on straw	0	0			
		8	Purple	0	0			
		9	Black	0	0			
31	Panicle awns	1	Absent	161	80.5	0.44	0.63	Heading to maturity
		9	Present	39	19.5			
32	Panicle: awns colour	1	Light gold	0	0	1.07	0.77	Maturity
		2	Gold	0	0			
		3	Brown	4	10.3			
		4	Reddish brown	16	41			
		5	Light red	12	30.8			
		6	Red	0	0			
		7	Light purple	0	0			
		8	Purple	7	17.9			
9	Black	0	0					

33	Panicle: awns length	1	Very short	7	17.9	1.24	0.77	Maturity
		3	Short	11	28.2			
		5	Medium	17	43.6			
		7	Long	4	10.3			
		9	Very long	0	0			
34	Panicle: distribution of awns	1	Tips only	18	46	1.09	0.99	Maturity
		3	Upper half	17	44			
		5	Whole length	4	10			
35	Panicle: presence of secondary branching	0	Absent	0	0	0.42	0.31	Heading
		1	Light	29	14.5			
		2	Heavy	169	84.5			
		3	Clustered	2	1			
36	Panicle: attitude of branches	1	Erect to semi- erect	144	72	0.78	0.57	Heading
		3	Semi-erect	22	11			
		5	Semi-erect to spreading	30	15			
		7	Spreading	4	2			
37	Panicle exsertion	1	Well exserted	160	80	0.7	0.44	Milk to maturity
		3	Moderately	17	8.5			
		5	Just	14	7			
		7	Partly	3	1.5			
		9	Enclosed	6	3			
38	Panicle type	1	Compact	11	5.5	0.17	0.16	Dough
		5	Intermediate	188	94			
		9	Open	1	0.5			
39	Panicle axis	1	Straight	125	62.5	0.67	0.97	Maturity
		2	Droopy	75	37.5			
40	Apiculus colour	1	White	1	0.5	0.36	0.26	Milk to maturity
		2	Straw	22	11			
		3	Brown	177	88.5			
		4	Red	0	0			
		5	Red apex	0	0			
		6	Purple	0	0			
		7	Purple apex	0	0			
41	Culm: Internode colour	1	Green	122	61	0.67	0.49	Stem elongation
		2	Light gold	78	39			
		3	Purple lines	0	0			
		4	Purple	0	0			
42		1	Slow	130	65	0.93	0.85	Maturity

	Leaf senescence	3	Medium	40	20			
		5	Fast	30	15			
43	Sterile lemma colour	1	Straw (yellow)	41	20.5	1.03	0.93	Maturity
		2	Gold	59	29.5			
		3	Red	0	0			
		4	Purple	100	50			
44	Alkali Digestion	1	Not affected but chalky	23	11.5	1.81	0.93	Maturity (After harvesting)
		2	Swollen	10	5			
		3	Swollen with collar incomplete or narrow	62	31			
		4	Swollen with collar complete & wide	43	21.5			
		5	Split with collar complete and wide	20	10			
		6	Dispersed merging with collar	16	8			
		7	Completely dispersed and cleared	26	13			
45	Seed Coat (bran) Color (SCC)	1	White	178	89	0.36	0.26	Maturity (After harvesting)
		2	Light brown	17	8.5			
		3	Speckled brown	1	0.5			
		4	Brown	4	2			
		5	Red	0	0			
		6	Variable purple	0	0			
		7	Purple	0	0			
46	Chalkiness of Endosperm	0	None	153	76.5	0.95	0.67	Maturity (After harvesting)
		1	Small (less than 10%)	9	4.5			
		5	Medium (11% to 20%)	21	10.5			
		9	Large (more than 20%)	17	8.5			
<b>Source: (IRRI, 2013), UPOV (2007)</b>								

**Appendix 2: Description of qualitative traits for the studied 200 rice germplasm (in relation to Appendix 1)**

GERM PLASM ID	Character number and codes (from Appendix 1)																								
	SOURCE	GERMPASM NAME	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
G1	MALAWI	Kilombero	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G2	MALAWI	Faya 14 M	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G3	KAFACI	KF190232	1	1	2	2	1	1	1	1	1	5	1	0	1	1	9	3	1	1	3	5	1	1	1
G4	MALAWI	Makafaci	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G5	MALAWI	Wachangu	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1
G6	MALAWI	Senga	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G7	MALAWI	Mtupatupa	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	3	1	1
G8	MALAWI	Mpheta	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G9	AfricaRice	Hybrid 001	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	9	3	3	1	5	1
G10	KAFACI	KF190029	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	1	1	3	1	1
G11	KAFACI	KF190023	2	1	2	2	1	1	1	1	1	7	1	0	1	1	7	1	1	9	3	5	1	7	1
G12	KAFACI	KF190202	1	1	2	2	1	1	1	1	1	3	1	0	1	1	7	1	1	1	3	5	5	3	3
G13	KAFACI	KF190242	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	1	1	1	1
G14	AfricaRice	Hybrid 004	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	9	1	5	3	7	1
G15	AfricaRice	Hybrid 002	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	3	3	1	5	5
G16	AfricaRice	KF190028	1	1	2	2	1	1	1	1	1	7	1	0	1	1	7	1	1	1	3	5	1	1	1
G17	AfricaRice	Hybrid 003	2	1	3	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1
G18	KAFACI	15046	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	5	1	1
G19	IRRI	IR18A1908	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G20	MALAWI	NERICA -19 L	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	3	1	1
G21	MALAWI	Kachambo	1	1	2	2	1	1	1	1	2	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G22	KAFACI	SR 35285 – HB3469 – 4	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G23	MALAWI	Sengamfupi	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	5	1	1
G24	KAFACI	SR35300 – HB3467 – 5	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	5	1	1
G25	KAFACI	SR35300 – HB3467 – 10	1	1	3	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	3	1	1
G26	KAFACI	SR34071(#5-16)-5-1-2/NERICA 8	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1
G27	MALAWI	Tambala	2	1	3	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G28	KAFACI	15022	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	3	3	1	7	7
G29	KAFACI	15023	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G30	KAFACI	15024	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	1	5	3	7	1
G31	KAFACI	15025	1	1	2	1	1	1	1	1	1	3	1	0	1	1	7	3	1	1	3	5	1	1	1
G32	KAFACI	15026	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	1	5	5	1	1

G33	KAFACI	15053	2	1	3	1	1	1	1	1	1	5	1	0	1	1	0	0	1	9	1	1	1	1	1	1
G34	KAFACI	15020	2	1	2	1	1	1	1	1	3	7	1	0	1	1	7	3	1	1	3	5	1	1	1	1
G35	MALAWI	Kidney	1	1	2	1	1	1	1	1	1	5	1	0	1	1	7	3	1	1	3	3	1	1	1	1
G36	KAFACI	15002	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	5	1	1	1
G37	KAFACI	15015	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1	1
G38	MALAWI	Nanyondo	2	1	2	2	1	1	1	1	4	7	1	0	1	1	0	0	1	1	1	1	3	1	1	1
G39	MALAWI	Mwenelondo	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	5	5	1	1	1	1
G40	MALAWI	Sengamtali	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1	1
G41	MALAWI	Mangochi	1	1	2	2	1	1	1	1	1	3	1	0	1	1	1	3	1	9	5	5	1	9	1	1
G42	KAFACI	15012	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1	1
G43	KAFACI	Milyang295/SR32037-1-139	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1	1
G44	KAFACI	Milyang296/SR32037-1-114	1	1	3	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1	1
G45	KAFACI	Milyang288/SR32037-1-147	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	1	1	1	1	1
G46	AfricaRice	Nerica8_AC-23	1	1	3	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1	1
G47	KAFACI	KF190153	1	1	2	2	1	1	1	1	4	3	1	0	1	1	1	3	1	1	3	5	3	1	1	1
G48	KAFACI	KF18007	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	5	5	1	3	3	3
G49	KAFACI	Milyang288/SR32037-1-147	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1	1
G50	KAFACI	KF190159	1	1	2	2	1	1	1	2	2	7	1	0	1	1	0	0	1	1	3	5	1	1	1	1
G51	KAFACI	SR35266-2-12-5-1-1	2	1	2	1	1	1	1	2	1	5	1	0	1	1	0	0	1	9	1	1	1	7	7	7
G52	KAFACI	SR35266-2-20-3-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1	1
G53	KAFACI	SR23364-128-1758-1-HV-1-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	5	5	1	1	1	1
G54	KAFACI	SR34598-HB-16-HV-1-1	1	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	9	3	5	1	1	1	1
G55	KAFACI	SR35276-2-4-3-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1	1
G56	KAFACI	SR35276-2-4-3-3-1	1	1	2	1	1	1	1	1	1	3	1	0	1	1	1	3	1	9	3	5	5	1	1	1
G57	KAFACI	SR35276-2-4-3-3-1	1	1	2	2	1	1	1	2	4	3	1	0	1	1	0	0	1	1	3	3	1	1	1	1
G58	KAFACI	SR35266-2-5-2-1-1	1	1	3	2	1	1	1	1	1	3	1	0	1	1	1	3	1	9	1	5	1	1	1	1
G59	KAFACI	SR35266-2-11-4-1-1	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	5	5	1	3	3	3
G60	KAFACI	SR35266-2-18-3-1-1	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1	1
G61	KAFACI	SR34590-HB3433-1-3-1-1	1	1	2	1	1	1	1	2	3	7	1	0	1	1	1	3	1	1	3	5	1	1	1	1
G62	KAFACI	SR34609-HB3483-29-1-1	1	1	2	3	1	1	1	2	1	7	1	0	1	1	0	0	1	9	1	1	1	5	1	1
G63	KAFACI	SR34598-HB-7-HV-1-1	2	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	5	1	1	1

G64	KAFACI	SR33705-HB3381-1-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G65	KAFACI	SR34590-HB3433-1-3-1-1	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G66	KAFACI	SR35266-2-11-4-1-1	1	1	2	2	1	1	1	1	5	1	0	1	1	7	1	1	9	3	5	3	1	1	1
G67	KAFACI	SR35266-2-11-4-1-1	1	1	3	2	1	1	1	1	5	1	0	9	5	0	0	1	9	3	3	1	7	1	1
G68	KAFACI	SR35266-2-11-4-1-1	2	1	2	2	1	1	1	1	7	1	0	1	1	1	1	1	5	5	1	1	1	1	1
G69	KAFACI	SR35266-2-12-5-1-1	2	1	2	2	1	1	1	1	3	1	0	1	1	1	3	1	1	3	5	1	1	1	1
G70	KAFACI	SR35266-2-11-1-1-1	1	1	2	2	1	1	1	2	2	7	1	0	1	1	0	0	1	1	1	5	1	1	1
G71	KAFACI	SR35266-2-11-1-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G72	KAFACI	SR33705-HB3381-1-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	3	1	1
G73	KAFACI	SR35276-2-4-3-3-1	1	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	1	1	1	1	1
G74	KAFACI	SR34590-HB3433-1-1-1-1	1	1	3	2	1	1	1	2	4	7	1	0	9	5	0	0	1	9	3	5	1	1	1
G75	KAFACI	SR35266-2-12-2-1-1	2	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G76	KAFACI	SR34598-HB-16-HV-1-1	1	1	2	2	1	1	1	2	1	3	1	0	1	1	7	1	1	1	3	3	1	1	1
G77	KAFACI	SR35266-2-20-3-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G78	KAFACI	SR35266-2-20-3-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G79	KAFACI	SR35266-2-20-3-1-1	1	1	2	2	1	1	1	1	4	5	1	0	1	1	0	0	1	1	3	5	5	1	1
G80	KAFACI	SR35266-2-12-1-1-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	3	5	3	1	1
G81	KAFACI	SR35266-2-12-1-1-1	2	1	2	2	1	1	9	2	1	7	1	0	1	7	0	0	1	1	5	5	1	1	1
G82	KAFACI	SR35266-2-12-1-1-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	3	5	1	1	1
G83	KAFACI	SR34598-HB-6-HV-1-1	2	1	3	2	1	1	9	2	1	7	9	1	9	7	1	1	1	9	3	5	1	1	1
G84	KAFACI	SR35266-2-5-2-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1
G85	KAFACI	SR35266-2-5-2-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G86	KAFACI	SR35266-2-17-1-1-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	3	5	3	1	3
G87	KAFACI	SR35266-2-17-1-1-1	1	1	2	1	1	1	1	1	1	5	1	0	1	1	0	0	1	9	1	1	3	1	1
G88	KAFACI	SR35266-2-18-3-1-1	2	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	5	5	3	1	3
G89	KAFACI	SR35276-2-4-3-1-1	1	1	2	2	1	1	1	1	1	3	1	0	1	1	1	3	1	1	3	5	1	1	1
G90	KAFACI	SR23364-128-1758-1-HV-1-1-1	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	5	1	1	1
G91	KAFACI	SR34590-HB3433-1-3-1-1	1	1	2	2	1	1	9	2	1	7	1	0	9	7	0	0	1	9	3	5	1	1	1
G92	KAFACI	SR35266-2-18-3-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G93	KAFACI	SR35266-2-11-4-1-1	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	1	5	1	5	5
G94	KAFACI	SR35266-2-11-4-1-1	2	1	2	2	1	1	1	2	3	7	1	0	1	1	0	0	1	9	3	5	1	9	9

G95	KAFACI	SR35266-2-12-5-1-1	2	1	2	2	1	1	1	2	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1
G96	KAFACI	SR35266-2-20-3-1-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	1	1	1	1	1
G97	KAFACI	SR23364-128-1758-1-HV-1-1-1	1	1	2	2	1	1	1	1	4	7	1	0	1	1	0	0	1	9	1	5	5	1	1
G98	KAFACI	SR34598-HB-16-HV-1-1	1	1	2	1	1	1	1	1	1	5	1	0	1	1	0	0	1	1	5	5	1	1	1
G99	KAFACI	SR35276-2-4-3-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	3	5	1	1	3
G100	KAFACI	SR35276-2-4-3-3-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G101	KAFACI	SR34590/SR34071(#5-16)-5-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	1	1	1	1	3	5	3	1	1
G102	KAFACI	SR34071(#5-16)-5-1-2/super	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	5	1	1	3
G103	KAFACI	SR34071(#5-16)-5-1-2/super	2	1	2	2	1	1	9	2	2	3	9	1	9	7	0	0	1	9	3	3	1	1	1
G104	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	3
G105	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G106	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	5	1	1
G107	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	2	2	1	1	9	2	1	7	1	0	9	5	0	0	1	9	3	5	1	1	1
G108	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G109	KAFACI	SR34590/SR34071(#5-16)-5-1	2	1	2	2	1	1	1	2	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G110	IRRI	IR17A1958	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	3	1	3
G111	KAFACI	SR35266-3-2-4-1-1	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G112	KAFACI	SR35300-1-HV-1-1-1	1	1	2	1	1	1	1	1	4	3	1	0	1	1	0	0	1	1	5	5	1	1	1
G113	KAFACI	SR35250-2-4-2-3-1	2	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G114	KAFACI	15053	1	1	2	2	1	1	9	2	1	3	9	2	9	7	0	0	1	9	3	5	3	1	1
G115	KAFACI	TY 34-1	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	5	3	1	1
G116	KAFACI	SR35266-2-7-1-1-1	1	1	2	1	1	1	1	1	1	7	1	0	1	1	1	1	1	1	3	5	3	1	3
G117	KAFACI	15065	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G118	KAFACI	SR34042F3-22-1-1-1-3-1	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	1	1	1	3	1	3
G119	IRRI	IR18A1513	2	1	2	2	1	1	1	1	1	5	1	0	1	1	0	0	1	9	3	5	1	1	1
G120	KAFACI	HR32080-HB3567-4	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	3	5	1	1	1
G121	KAFACI	15002	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G122	KAFACI	HR32083-HB3568-151	1	1	2	1	1	1	1	1	4	3	1	0	1	1	0	0	1	1	3	5	5	1	1
G123	KAFACI	HR32086-HB3569-37	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	3
G124	KAFACI	SR35311-HB3497-4	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	5	5	1	1	1
G125	IRRI	IR18A1706	2	1	2	2	1	1	1	1	3	7	1	0	1	1	0	0	1	1	1	5	3	1	3

G126	KAFACI	SR35329-HB3509-106	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	9	3	5	1	1	1
G127	IRRI	IR18A1882	1	1	2	1	1	1	9	2	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G128	KAFACI	SR35311-HB3497-87	2	1	2	2	1	1	9	2	2	7	1	0	1	1	0	0	1	1	1	1	1	1	1
G129	KAFACI	SR35311-HB3497-88	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	9	1	1	1	1	1
G130	KAFACI	SR35328-HB3508-34	2	1	2	1	1	1	1	2	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G131	KAFACI	SR35329-HB3509-26	2	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	9	3	5	1	1	1
G132	IRRI	IR18A1906	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	1
G133	KAFACI	SR35266-3-2-4-1-1	2	1	2	2	1	1	9	2	3	4	1	0	9	5	0	0	1	9	3	5	1	1	1
G134	KAFACI	SR35300-1-HV-1-1-1	2	1	2	1	1	1	1	1	1	4	1	0	1	1	0	0	1	1	3	5	1	1	1
G135	IRRI	IR17A2077	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G136	KAFACI	SR32037-1-110/SR34590	1	1	2	2	1	1	1	2	1	3	1	0	1	1	0	0	1	1	3	3	1	1	3
G137	IRRI	IR18A1722	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G138	IRRI	IR18A1536	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G139	IRRI	IR17A1141	2	1	2	1	1	1	9	2	2	7	1	0	1	1	0	0	1	1	1	5	3	1	3
G140	IRRI	IR17A2104	2	1	2	2	1	1	1	1	1	7	1	0	1	1	1	3	1	1	3	5	1	1	1
G141	KAFACI	SR32037-1-110/SR34590	2	1	2	1	1	1	1	1	1	3	1	0	9	5	0	0	1	9	1	1	1	1	1
G142	IRRI	IR18A1894	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G143	KAFACI	SR35311-HB3497-87	2	1	2	2	1	1	9	2	3	7	1	0	1	1	1	3	1	1	5	5	1	1	1
G144	KAFACI	SR35311-HB3497-88	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G145	KAFACI	SR35328-HB3508-34	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G146	IRRI	IR18A1032	1	1	2	2	1	1	1	1	1	3	1	0	1	1	1	3	1	1	3	3	3	1	3
G147	KAFACI	SR34590/Nunkeunheugchal	1	1	2	1	1	1	9	2	3	3	1	0	1	1	0	0	1	9	5	5	1	1	1
G148	IRRI	IR17A2863	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G149	KAFACI	SR34590/Nunkeunheugchal	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G150	IRRI	IR18A1891	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G151	IRRI	IR17A1210	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G152	IRRI	IR17A1779	3	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	5	1	1	1
G153	IRRI	IR17A1739	2	1	2	1	1	1	1	1	1	7	1	0	1	1	7	3	1	9	3	5	1	5	3
G154	IRRI	IR17A1695	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G155	IRRI	IR17A1222	1	1	2	1	1	1	9	2	3	3	1	0	1	1	0	0	1	1	5	5	1	1	1
G156	IRRI	IR17A2570	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1

G157	IRRI	IR17A2469	1	1	2	1	1	1	1	2	3	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G158	IRRI	IR17A1583	2	1	2	1	1	1	1	2	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G159	IRRI	IR16A3667	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	3
G160	IRRI	IR17A1425	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1
G161	IRRI	IR20X1008	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G162	IRRI	IR22MD1306	1	1	2	1	1	1	9	2	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G163	IRRI	IR22MD1371	2	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	5	5	1	1	1
G164	IRRI	IR22MD1409	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G165	IRRI	IR22MD1567	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	3	1	1	1
G166	IRRI	IR22MD1702	1	1	2	1	1	1	9	2	1	7	1	0	1	1	0	0	1	1	1	5	1	1	3
G167	IRRI	IR22MD1890	1	1	2	1	1	1	1	1	3	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G168	IRRI	IR22MD1985	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	1	1	1	1
G169	IRRI	IR22MD2076	3	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G170	IRRI	IR22MD2103	1	1	2	1	1	1	9	2	1	3	1	0	9	3	0	0	1	9	3	5	3	1	3
G171	IRRI	IR22MD2110	1	1	2	1	1	1	1	1	1	3	1	0	1	1	7	3	1	1	3	5	1	1	1
G172	IRRI	IR22MD2227	2	1	2	1	1	1	1	1	1	7	1	0	1	1	1	3	1	1	5	5	1	1	1
G173	IRRI	IR22MD2256	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	1	5	1	1	1
G174	IRRI	IR22MD2386	1	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	5	1	1	1
G175	IRRI	IR22MD2407	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G176	IRRI	IR22MD2567	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G177	IRRI	IR22MD2638	2	1	2	2	1	1	9	2	2	3	1	0	9	3	0	0	1	9	1	5	1	1	1
G178	IRRI	IR22MD2664	2	1	3	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	3	1	3
G179	IRRI	IR22MD2715	1	1	2	2	1	1	1	1	3	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G180	IRRI	IR22MD2726	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	5	1	1	1
G181	IRRI	IR22MD2768	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G182	IRRI	IR22MD3015	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G183	IRRI	IR22MD3020	2	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	1	1	1	1	1
G184	IRRI	IR22MD3080	1	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	5	5	1	1	1
G185	IRRI	IR22MD3320	2	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1
G186	IRRI	IR22MD3413	2	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	3	1	3
G187	IRRI	IR22MD3433	1	1	2	1	1	1	1	1	2	7	1	0	1	1	0	0	1	1	1	5	1	1	1

G188	IRRI	IR22MD3630	1	1	2	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G189	IRRI	IR22MD3638	2	3	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	3	1	1	1
G190	IRRI	IR22MD3893	2	1	2	1	1	1	1	1	1	7	1	0	1	1	7	3	1	9	3	5	1	5	5
G191	IRRI	IRRI 154	1	1	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	3	1	3
G192	IRRI	IRRI 174	2	2	2	1	1	1	1	2	1	3	1	0	1	1	0	0	1	1	3	5	3	1	1
G193	IRRI	IR16A3891	2	1	3	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	5	1	1	3
G194	IRRI	IR16A4085	2	1	3	1	1	1	1	1	1	3	1	0	1	1	0	0	1	1	5	5	3	1	3
G195	IRRI	IR16A3838	2	1	2	1	1	1	1	2	1	3	1	0	1	1	0	0	1	1	3	5	1	1	1
G196	IRRI	IRRI 123	2	1	2	2	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	5	1	1
G197	IRRI	IRRI 168	2	1	2	1	1	1	9	2	2	7	1	0	9	3	0	0	1	9	5	5	1	7	1
G198	IRRI	IRRI 156	2	1	2	1	1	1	1	1	1	5	1	0	1	1	0	0	1	1	1	5	1	1	1
G199	IRRI	IR16A4261	2	1	2	2	1	1	1	1	1	3	1	0	1	1	0	0	1	1	3	3	1	1	1
G200	IRRI	IRRI 104	2	2	2	1	1	1	1	1	1	7	1	0	1	1	0	0	1	1	3	5	1	1	1

**NOTE;** G: Germplasm, 1: Ligule shape, 2: Ligule colour, 3: Leaf blade pubescence, 4: Leaf blade colour, 5: Leaf collar, 6: Leaf colour, 7: Leaf anthocyanin colouration of collar, 8: Coleoptile colour, 9: Basal leaf sheath colour, 10: Leaf intensity of green colour, 11: Leaf anthocyanin colouration, 12: Leaf distribution of anthocyanin, 13: Leaf sheath anthocyanin colouration, 14: Leaf sheath intensity of anthocyanin, 15: Awning, 16: Awn colour, 17: Auricle presence and colour, 18: Anthocyanin colouration of auricle, 19: Flag leaf attitude (early), 20: Flag leaf attitude (late), 21: Culm habit, 22: Lemma anthocyanin colouration of keel, 23: Lemma anthocyanin colouration of apex, 24: Spikelet: Stigma colour, 25: Stem anthocyanin colouration of nodes.

Appendix 2: Description of qualitative traits for the studied 200 rice germplasm .....(Continuation

GERMPLASM ID	SOURCE	GERMPASM NAME	Character number and codes (from Appendix 1) .... Continuation																							
			24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	
G1	MALAWI	Kilombero	1	1	0	3	3	1	0	1	0	0	0	3	3	1	5	1	2	1	3	1	2	1	0	
G2	MALAWI	Faya 14 M	1	1	0	3	3	1	0	1	0	0	0	3	3	1	5	1	2	1	1	1	2	1	0	
G3	KAFACI	KF190232	1	1	0	3	7	4	0	9	3	1	3	2	1	1	5	1	3	1	1	1	4	1	0	
G4	MALAWI	Makafaci	1	1	0	3	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	1	4	1	0	
G5	MALAWI	Wachangu	1	1	0	3	1	4	0	1	0	0	0	2	1	3	5	1	2	1	1	1	3	1	0	
G6	MALAWI	Senga	1	1	0	3	7	4	0	1	0	0	0	2	1	1	5	1	3	1	5	1	2	1	0	
G7	MALAWI	Mtupatupa	1	1	0	3	3	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	3	1	0	
G8	MALAWI	Mpheta	1	1	0	3	7	4	0	1	0	0	0	2	1	5	5	1	2	1	5	1	4	1	0	
G9	Africa Rice	Hybrid 001	1	1	0	1	5	4	0	1	0	0	0	2	1	1	5	2	2	2	1	4	3	1	0	
G10	KAFACI	KF190029	1	1	0	7	1	4	0	1	0	0	0	2	1	1	5	1	2	1	3	1	3	1	0	
G11	KAFACI	KF190023	1	1	0	7	7	4	0	9	4	3	3	1	1	1	5	1	2	1	1	1	4	1	0	
G12	KAFACI	KF190202	1	1	0	7	3	4	0	9	3	1	1	2	5	3	5	2	2	1	3	4	4	1	1	
G13	KAFACI	KF190242	2	1	0	1	3	1	0	1	0	0	0	1	1	1	5	1	2	1	1	4	3	1	0	
G14	Africa Rice	Hybrid 004	1	1	0	7	7	4	0	1	0	0	0	2	3	7	5	1	2	2	1	1	4	1	0	
G15	Africa Rice	Hybrid 002	1	1	0	1	5	4	0	1	0	0	0	2	1	7	5	2	2	1	1	1	3	1	0	
G16	MALAWI	KF190028	1	1	0	7	7	4	0	9	8	5	1	2	3	1	5	1	3	1	1	4	3	1	0	
G17	Africa Rice	Hybrid 003	1	1	0	1	1	4	0	1	0	0	0	2	1	7	5	2	2	1	3	1	4	1	0	
G18	KAFACI	15046	1	1	0	3	3	4	0	1	0	0	0	2	7	1	5	1	3	1	1	1	3	1	0	
G19	IRRI	IR18A1908	1	1	0	3	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	1	3	1	0	
G20	MALAWI	NERICA -19 L	2	1	0	1	5	4	0	1	0	0	0	2	1	5	5	1	2	1	3	1	4	1	0	
G21	MALAWI	Kachambo	1	1	0	3	5	4	0	1	0	0	0	2	1	5	5	1	3	1	3	1	2	1	0	
G22	KAFACI	SR 35285 – HB3469 – 4	1	1	0	3	3	4	0	1	0	0	0	2	5	3	5	2	2	1	3	4	3	1	1	
G23	MALAWI	Sengamfupi	1	1	0	3	7	1	0	1	0	0	0	2	1	1	5	1	3	1	5	4	3	1	0	
G24	KAFACI	SR35300 – HB3467 – 5	1	1	0	3	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	1	4	1	0	
G25	KAFACI	SR35300 – HB3467 – 10	1	1	0	3	3	4	0	1	0	0	0	2	3	1	5	1	2	2	3	1	3	1	0	
G26	KAFACI	SR34071(#5-16)-5-1-2/NERICA 8	1	1	0	7	3	4	0	1	0	0	0	2	1	9	5	2	3	2	1	1	3	1	5	
G27	MALAWI	Tambala	1	1	0	1	7	4	0	1	0	0	0	1	1	1	5	1	3	2	5	1	2	1	0	
G28	KAFACI	15022	1	9	3	5	7	4	0	1	0	0	0	2	7	5	5	2	2	1	5	4	7	1	9	
G29	KAFACI	15023	1	1	0	1	5	4	0	1	0	0	0	2	7	1	5	2	3	1	1	2	7	1	9	
G30	KAFACI	15024	1	9	5	7	7	4	0	1	0	0	0	2	1	5	5	2	3	1	1	4	3	1	0	
G31	KAFACI	15025	1	1	0	7	5	3	0	9	4	1	7	1	1	1	5	1	2	1	3	4	7	1	9	
G32	KAFACI	15026	1	9	5	1	1	4	0	1	0	0	0	2	5	9	5	1	3	1	3	2	4	1	5	

G33	KAFACI	15053	1	1	0	5	7	4	0	1	0	0	0	2	5	1	5	2	3	1	1	2	7	1	1
G34	KAFACI	15020	1	1	0	5	7	2	0	9	5	3	1	2	5	1	1	2	2	2	1	2	7	2	0
G35	MALAWI	Kidney	1	1	0	5	5	4	0	9	8	3	1	2	1	1	5	1	3	1	5	4	3	2	0
G36	KAFACI	15002	1	1	0	1	7	4	0	1	0	0	0	2	1	5	5	2	3	1	1	4	3	1	0
G37	KAFACI	15015	1	1	0	7	5	4	0	1	0	0	0	2	1	5	1	2	2	1	3	1	7	1	0
G38	MALAWI	Nanyondo	1	1	0	1	5	4	0	1	0	0	0	2	1	3	5	1	3	1	1	1	1	1	0
G39	MALAWI	Mwenelondo	1	9	3	7	5	4	0	1	0	0	0	1	3	1	5	1	3	1	1	4	3	1	5
G40	MALAWI	Sengamtali	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	3	2	2	1	5
G41	MALAWI	Mangochi	1	9	5	3	7	4	0	9	4	5	3	2	1	1	5	1	2	1	3	4	1	2	5
G42	KAFACI	15012	1	1	0	1	3	4	0	1	0	0	0	1	5	3	5	1	3	2	1	4	3	1	0
G43	KAFACI	Milyang295/SR32037-1-139	1	1	0	7	7	4	0	1	0	0	0	1	1	3	1	2	3	1	1	2	3	1	0
G44	KAFACI	Milyang296/SR32037-1-114	2	1	0	3	7	4	0	1	0	0	0	1	5	1	5	1	2	2	3	4	4	1	0
G45	KAFACI	Milyang288/SR32037-1-147	1	1	0	1	3	4	0	1	0	0	0	2	1	1	5	1	3	1	5	4	4	1	0
G46	Africa Rice	Nerica8_AC-23	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	2	4	1	0
G47	KAFACI	KF190153	1	1	0	1	5	4	0	9	3	1	1	2	5	1	5	2	2	2	1	2	3	2	0
G48	KAFACI	KF18007	1	1	0	7	7	4	0	1	0	0	0	2	5	1	5	2	3	1	1	2	4	1	0
G49	KAFACI	Milyang288/SR32037-1-147	1	1	0	3	5	4	0	1	0	0	0	2	1	5	5	2	3	1	5	4	3	1	0
G50	KAFACI	KF190159	1	1	0	7	3	4	0	1	0	0	0	2	1	1	5	2	3	2	5	1	3	1	0
G51	KAFACI	SR35266-2-12-5-1-1	1	9	3	7	3	4	0	1	0	0	0	2	1	1	1	2	3	2	1	1	7	1	0
G52	KAFACI	SR35266-2-20-3-1-1	1	1	0	7	1	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	3	1	0
G53	KAFACI	SR23364-128-1758-1-HV-1-1-1	1	9	3	5	7	4	0	1	0	0	0	2	5	1	5	2	3	2	1	2	4	1	0
G54	KAFACI	SR34598-HB-16-HV-1-1	1	9	3	1	5	4	0	1	0	0	0	2	1	1	5	1	3	1	5	4	4	1	0
G55	KAFACI	SR35276-2-4-3-1-1	1	1	0	1	5	4	0	1	0	0	0	2	5	1	5	1	3	1	1	2	7	1	0
G56	KAFACI	SR35276-2-4-3-3-1	1	9	5	3	7	4	0	9	4	3	1	2	1	1	5	1	3	1	5	4	7	2	5
G57	KAFACI	SR35276-2-4-3-3-1	1	1	0	3	5	4	0	1	0	0	0	2	1	1	5	1	3	2	5	4	7	1	0
G58	KAFACI	SR35266-2-5-2-1-1	1	9	7	1	7	4	0	9	5	3	7	2	3	5	5	2	3	2	5	2	7	2	0
G59	KAFACI	SR35266-2-11-4-1-1	1	9	5	7	5	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	7	1	5
G60	KAFACI	SR35266-2-18-3-1-1	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	7	1	9
G61	KAFACI	SR34590-HB3433-1-3-1-1	1	1	0	5	5	4	0	9	5	5	1	2	5	1	5	1	3	1	1	2	7	2	0
G62	KAFACI	SR34609-HB3483-29-1-1	1	9	7	1	3	4	0	1	0	0	0	1	1	1	5	1	3	1	1	4	7	1	0
G63	KAFACI	SR34598-HB-7-HV-1-1	1	1	0	5	7	4	0	1	0	0	0	2	3	1	5	2	3	1	1	4	7	1	9

G64	KAFACI	SR33705-HB3381-1-1-1	1	1	0	3	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	2	7	1	5
G65	KAFACI	SR34590-HB3433-1-3-1-1	2	1	0	7	5	4	0	9	4	5	7	2	1	1	5	1	3	1	1	4	7	2	5
G66	KAFACI	SR35266-2-11-4-1-1	1	1	0	7	5	4	0	1	0	0	0	2	5	1	5	2	3	2	1	1	7	1	5
G67	KAFACI	SR35266-2-11-4-1-1	1	9	5	3	7	4	0	1	0	0	0	2	1	1	5	2	3	1	5	2	7	1	0
G68	KAFACI	SR35266-2-11-4-1-1	1	1	0	1	5	5	0	9	4	1	1	2	1	1	5	1	3	1	5	4	7	2	0
G69	KAFACI	SR35266-2-12-5-1-1	1	1	0	3	7	4	0	9	5	7	1	2	3	1	5	1	3	2	1	4	7	2	0
G70	KAFACI	SR35266-2-11-1-1-1	1	1	0	1	3	4	0	1	0	0	0	2	1	5	5	2	3	1	1	4	7	1	0
G71	KAFACI	SR35266-2-11-1-1-1	1	1	0	3	3	4	0	1	0	0	0	2	3	1	5	1	3	1	5	2	7	1	0
G72	KAFACI	SR33705-HB3381-1-1-1	1	1	0	7	7	2	0	1	0	0	0	1	5	5	5	2	3	2	1	2	7	1	5
G73	KAFACI	SR35276-2-4-3-3-1	1	1	0	1	7	4	0	1	0	0	0	2	5	5	5	1	3	1	1	2	7	1	0
G74	KAFACI	SR34590-HB3433-1-1-1-1	1	9	3	3	5	4	0	1	0	0	0	2	5	1	5	2	3	2	5	4	3	1	0
G75	KAFACI	SR35266-2-12-2-1-1	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	1	6	1	0
G76	KAFACI	SR34598-HB-16-HV-1-1	1	1	0	5	5	4	0	9	8	1	3	2	3	1	5	1	3	2	1	1	6	2	0
G77	KAFACI	SR35266-2-20-3-1-1	1	1	0	5	7	4	0	1	0	0	0	2	1	1	5	1	3	1	5	1	6	1	0
G78	KAFACI	SR35266-2-20-3-1-1	1	1	0	1	3	4	0	1	0	0	0	2	3	3	5	1	3	2	1	4	6	1	0
G79	KAFACI	SR35266-2-20-3-1-1	1	1	0	3	3	4	0	1	0	0	0	2	1	1	5	1	3	2	5	4	6	1	0
G80	KAFACI	SR35266-2-12-1-1-1	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	3	2	6	1	5
G81	KAFACI	SR35266-2-12-1-1-1	1	1	0	7	5	4	0	9	4	5	1	1	1	1	5	1	3	1	3	4	6	2	0
G82	KAFACI	SR35266-2-12-1-1-1	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	1	3	2	1	2	6	1	0
G83	KAFACI	SR34598-HB-6-HV-1-1	1	1	0	1	5	4	0	1	0	0	0	2	3	3	5	1	3	1	3	4	6	1	0
G84	KAFACI	SR35266-2-5-2-1-1	1	1	0	7	5	4	0	1	0	0	0	2	3	1	5	2	1	1	1	1	6	1	5
G85	KAFACI	SR35266-2-5-2-1-1	2	1	0	5	5	4	0	1	0	0	0	2	3	1	1	2	3	1	1	2	6	1	0
G86	KAFACI	SR35266-2-17-1-1-1	1	1	0	1	5	4	0	1	0	0	0	2	5	1	1	2	3	1	1	4	6	1	0
G87	KAFACI	SR35266-2-17-1-1-1	1	9	5	5	7	4	0	1	0	0	0	2	1	1	5	2	3	1	3	2	6	1	1
G88	KAFACI	SR35266-2-18-3-1-1	4	1	0	7	7	4	0	1	0	0	0	1	1	1	5	1	3	1	1	4	6	1	0
G89	KAFACI	SR35276-2-4-3-1-1	1	1	0	1	7	4	0	9	5	1	3	1	1	1	5	1	3	2	1	1	6	2	0
G90	KAFACI	SR23364-128-1758-1-HV-1-1-1	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	2	5	1	0
G91	KAFACI	SR34590-HB3433-1-3-1-1	1	1	0	5	5	4	0	1	0	0	0	2	1	3	5	2	3	1	3	2	6	1	5
G92	KAFACI	SR35266-2-18-3-1-1	1	1	0	5	7	4	0	1	0	0	0	1	5	1	5	1	3	2	1	2	3	1	5
G93	KAFACI	SR35266-2-11-4-1-1	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	4	1	0
G94	KAFACI	SR35266-2-11-4-1-1	4	9	3	7	7	4	0	9	4	5	3	2	1	3	5	2	3	2	1	4	3	2	0

G95	KAFACI	SR35266-2-12-5-1-1	1	1	0	1	5	4	0	1	0	0	0	2	1	1	5	1	3	1	3	1	4	1	5
G96	KAFACI	SR35266-2-20-3-1-1	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	5	1	0
G97	KAFACI	SR23364-128-1758-1-HV-1-1-1	1	1	0	3	7	4	0	1	0	0	0	2	1	3	5	2	3	1	1	1	3	1	1
G98	KAFACI	SR34598-HB-16-HV-1-1	1	1	0	7	5	4	0	1	0	0	0	1	3	3	5	2	3	2	1	1	4	1	0
G99	KAFACI	SR35276-2-4-3-1-1	1	1	0	7	5	4	0	9	5	3	1	2	1	3	5	1	3	2	1	2	4	2	0
G100	KAFACI	SR35276-2-4-3-3-1	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	5	1	5
G101	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	0	7	3	4	0	1	0	0	0	2	5	1	5	1	3	2	1	1	4	1	5
G102	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	0	7	7	4	0	1	0	0	0	2	1	5	5	1	3	1	1	1	5	1	0
G103	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	0	1	5	4	0	1	0	0	0	2	1	1	5	1	3	1	3	1	5	1	0
G104	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	0	7	5	4	0	1	0	0	0	2	3	1	5	2	3	2	1	4	5	1	0
G105	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	0	5	5	4	0	1	0	0	0	2	1	1	5	2	3	1	3	4	3	1	5
G106	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	1	3	1	0
G107	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	0	5	7	4	0	1	0	0	0	2	1	1	5	1	3	1	3	1	4	1	0
G108	KAFACI	SR34071(#5-16)-5-1-2/super	1	1	0	7	7	4	0	1	0	0	0	1	1	1	5	1	3	1	3	4	3	1	0
G109	KAFACI	SR34590/SR34071(#5-16)-5-1	1	1	0	7	5	4	0	1	0	0	0	2	3	9	5	1	3	1	3	2	4	1	0
G110	IRRI	IR17A1958	1	1	0	3	5	4	0	1	0	0	0	2	1	1	5	2	3	2	1	4	2	1	0
G111	KAFACI	SR35266-3-2-4-1-1	1	1	0	3	7	4	0	1	0	0	0	2	3	1	5	2	3	1	1	2	3	1	0
G112	KAFACI	SR35300-1-HV-1-1-1	1	1	0	1	1	4	0	1	0	0	0	2	1	1	5	1	3	1	3	1	5	1	0
G113	KAFACI	SR35250-2-4-2-3-1	1	1	0	7	7	4	0	1	0	0	0	1	1	1	5	1	3	2	1	2	5	1	0
G114	KAFACI	15053	1	9	5	1	7	4	0	1	0	0	0	2	5	1	5	1	3	2	1	1	5	1	0
G115	KAFACI	TY 34-1	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	2	3	2	1	2	3	1	0
G116	KAFACI	SR35266-2-7-1-1-1	1	1	0	7	5	4	0	9	8	3	3	2	3	1	5	1	3	2	1	2	5	1	0
G117	KAFACI	15065	1	1	0	1	5	4	0	1	0	0	0	2	1	1	5	2	3	2	1	2	3	1	0
G118	KAFACI	SR34042F3-22-1-1-1-3-1	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	3	2	4	1	0
G119	IRRI	IR18A1513	1	1	0	5	7	4	0	1	0	0	0	2	3	1	5	1	3	2	3	2	4	1	0
G120	KAFACI	HR32080-HB3567-4	1	1	0	5	7	4	0	9	5	5	1	2	1	1	5	1	3	1	3	2	4	2	0
G121	KAFACI	15002	1	1	0	7	5	4	0	1	0	0	0	1	5	1	5	1	3	2	3	2	4	1	0
G122	KAFACI	HR32083-HB3568-151	1	1	0	1	5	4	0	1	0	0	0	1	5	1	5	1	3	2	3	4	5	1	0
G123	KAFACI	HR32086-HB3569-37	1	1	0	7	7	4	0	1	0	0	0	2	5	1	5	1	3	1	1	4	5	1	0
G124	KAFACI	SR35311-HB3497-4	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	1	3	1	0
G125	IRRI	IR18A1706	1	1	0	3	5	4	0	1	0	0	0	2	1	1	5	1	3	2	5	4	4	1	0

G126	KAFACI	SR35329-HB3509-106	1	1	0	7	7	4	0	9	3	5	3	1	1	1	5	1	3	1	1	2	3	2	0
G127	IRRI	IR18A1882	1	1	7	1	7	4	0	1	0	0	0	1	1	1	5	1	3	1	1	4	4	1	5
G128	KAFACI	SR35311-HB3497-87	1	1	7	1	5	4	0	1	0	0	0	1	1	1	5	2	3	2	5	4	3	1	0
G129	KAFACI	SR35311-HB3497-88	1	1	7	7	7	4	0	9	4	3	1	2	1	1	5	2	3	2	5	2	3	1	0
G130	KAFACI	SR35328-HB3508-34	1	1	7	7	3	4	0	1	0	0	0	2	1	1	5	1	3	2	3	4	4	3	0
G131	KAFACI	SR35329-HB3509-26	1	1	7	1	7	4	0	1	0	0	0	2	1	3	5	1	3	1	1	2	1	1	0
G132	IRRI	IR18A1906	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	2	1	0
G133	KAFACI	SR35266-3-2-4-1-1	1	9	5	7	5	4	0	9	4	7	3	2	1	1	5	1	3	2	5	4	3	1	5
G134	KAFACI	SR35300-1-HV-1-1-1	1	1	0	7	5	4	0	1	0	0	0	2	3	1	5	1	3	1	1	4	4	1	0
G135	IRRI	IR17A2077	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	3	1	0
G136	KAFACI	SR32037-1-110/SR34590	1	1	0	7	7	4	0	1	0	0	0	1	1	3	5	1	3	2	3	2	4	1	0
G137	IRRI	IR18A1722	1	1	0	1	7	4	0	1	0	0	0	2	7	1	5	2	3	1	5	4	5	1	0
G138	IRRI	IR18A1536	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	1	3	2	1	2	5	1	0
G139	IRRI	IR17A1141	4	1	0	1	5	4	0	1	0	0	0	2	1	5	5	1	3	2	1	4	3	1	0
G140	IRRI	IR17A2104	1	1	0	7	7	4	0	9	4	3	1	1	1	1	5	1	3	2	1	2	2	4	0
G141	KAFACI	SR32037-1-110/SR34590	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	2	3	4	3	1	0
G142	IRRI	IR18A1894	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	1	3	2	1	2	4	1	9
G143	KAFACI	SR35311-HB3497-87	1	1	0	1	7	5	0	9	5	5	3	2	1	1	1	1	3	1	1	4	4	1	1
G144	KAFACI	SR35311-HB3497-88	1	1	0	7	5	4	0	1	0	0	0	2	1	1	1	1	3	1	1	2	3	1	0
G145	KAFACI	SR35328-HB3508-34	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	5	4	4	1	0
G146	IRRI	IR18A1032	1	1	0	1	7	4	0	9	5	3	3	2	1	1	5	1	3	2	1	2	3	4	0
G147	KAFACI	SR34590/Nunkeunheugchal	1	9	5	7	7	4	0	9	4	5	1	2	1	9	5	2	3	1	3	4	3	4	0
G148	IRRI	IR17A2863	1	1	0	1	5	4	0	1	0	0	0	2	1	1	5	1	3	1	1	2	3	1	0
G149	KAFACI	SR34590/Nunkeunheugchal	1	1	0	5	5	4	0	1	0	0	0	2	1	9	5	2	3	2	3	4	4	1	9
G150	IRRI	IR18A1891	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	2	1	2	3	1	0
G151	IRRI	IR17A1210	1	1	0	3	5	4	0	1	0	0	0	1	1	1	5	2	3	2	3	2	5	1	0
G152	IRRI	IR17A1779	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	2	3	4	3	1	0
G153	IRRI	IR17A1739	1	9	7	7	7	4	0	9	8	5	7	2	1	1	5	2	3	2	5	2	5	1	9
G154	IRRI	IR17A1695	1	1	0	1	7	4	0	9	4	3	1	2	1	1	5	1	3	2	3	2	3	1	0
G155	IRRI	IR17A1222	1	1	0	7	3	4	0	9	4	7	1	2	1	1	5	2	3	1	3	2	3	1	9
G156	IRRI	IR17A2570	1	1	0	5	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	2	5	1	0

G157	IRRI	IR17A2469	1	1	0	1	7	4	0	1	0	0	0	2	1	3	5	1	3	2	1	2	3	1	0
G158	IRRI	IR17A1583	1	1	0	3	3	4	0	1	0	0	0	2	1	1	1	1	3	2	1	4	5	1	0
G159	IRRI	IR16A3667	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	2	1	0
G160	IRRI	IR17A1425	1	1	0	1	7	4	1	1	0	0	0	2	1	9	5	2	3	2	5	2	3	1	1
G161	IRRI	IR20X1008	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	2	1	1	0
G162	IRRI	IR22MD1306	1	1	0	1	5	4	0	1	0	0	0	2	5	1	5	1	3	1	5	4	1	1	0
G163	IRRI	IR22MD1371	1	1	0	7	5	4	1	9	5	5	3	2	1	1	5	2	3	2	1	2	3	1	9
G164	IRRI	IR22MD1409	1	1	0	1	7	4	0	1	0	0	0	2	5	1	5	2	3	1	1	4	4	1	0
G165	IRRI	IR22MD1567	1	1	0	7	5	4	0	1	0	0	0	1	1	1	5	1	3	1	1	2	4	1	0
G166	IRRI	IR22MD1702	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	1	1	0
G167	IRRI	IR22MD1890	1	1	0	7	3	4	0	1	0	0	0	2	1	1	5	2	3	1	1	2	3	1	0
G168	IRRI	IR22MD1985	1	1	0	1	7	4	0	1	0	0	0	2	5	1	5	1	3	2	1	4	4	1	0
G169	IRRI	IR22MD2076	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	4	1	1
G170	IRRI	IR22MD2103	1	9	5	7	3	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	1	1	0
G171	IRRI	IR22MD2110	1	1	0	1	7	4	0	9	5	5	1	2	1	1	5	1	3	2	1	4	3	1	9
G172	IRRI	IR22MD2227	1	1	0	7	7	4	0	9	8	5	3	1	1	1	5	2	3	1	1	4	1	1	0
G173	IRRI	IR22MD2256	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	1	1	0
G174	IRRI	IR22MD2386	1	1	0	1	7	4	0	1	0	0	0	2	1	1	9	1	3	2	1	4	1	1	0
G175	IRRI	IR22MD2407	1	1	0	1	3	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	1	1	0
G176	IRRI	IR22MD2567	1	1	0	3	7	4	0	1	0	0	0	2	5	1	5	1	3	1	1	4	3	1	0
G177	IRRI	IR22MD2638	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	2	1	4	1	1	0
G178	IRRI	IR22MD2664	1	1	0	1	7	4	0	1	0	0	0	1	1	1	5	1	3	1	1	4	1	1	9
G179	IRRI	IR22MD2715	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	1	1	0
G180	IRRI	IR22MD2726	1	1	0	7	5	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	3	1	0
G181	IRRI	IR22MD2768	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	2	3	1	0
G182	IRRI	IR22MD3015	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	4	1	9
G183	IRRI	IR22MD3020	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	2	1	4	1	1	0
G184	IRRI	IR22MD3080	1	1	0	7	7	4	0	9	4	5	3	2	5	1	5	1	3	1	1	4	1	1	9
G185	IRRI	IR22MD3320	1	1	0	7	3	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	4	1	0
G186	IRRI	IR22MD3413	1	1	0	1	7	4	0	1	0	0	0	1	1	1	5	1	3	1	1	4	3	1	0
G187	IRRI	IR22MD3433	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	4	1	0

<b>G188</b>	IRRI	IR22MD3630	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	1	1	9
<b>G189</b>	IRRI	IR22MD3638	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	1	1	0
<b>G190</b>	IRRI	IR22MD3893	1	9	5	7	7	5	0	9	8	7	3	2	5	1	5	2	3	2	1	4	1	4	0
<b>G191</b>	IRRI	IRRI 154	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	5	4	3	1	0
<b>G192</b>	IRRI	IRRI 174	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	2	1	4	1	1	0
<b>G193</b>	IRRI	IR16A3891	1	1	0	7	7	4	0	9	5	5	3	2	5	1	5	1	3	1	1	4	3	1	1
<b>G194</b>	IRRI	IR16A4085	1	1	0	7	3	4	0	1	0	0	0	2	1	3	5	2	3	2	1	4	5	1	0
<b>G195</b>	IRRI	IR16A3838	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	2	3	1	1	4	1	1	0
<b>G196</b>	IRRI	IRRI 123	1	1	0	7	7	4	0	1	0	0	0	2	1	1	1	1	3	1	1	4	3	1	0
<b>G197</b>	IRRI	IRRI 168	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	2	5	4	1	1	9
<b>G198</b>	IRRI	IRRI 156	1	1	0	7	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	5	1	0
<b>G199</b>	IRRI	IR16A4261	1	1	0	7	3	4	0	9	4	5	3	2	1	1	1	2	3	1	1	4	3	1	0
<b>G200</b>	IRRI	IRRI 104	1	1	0	1	7	4	0	1	0	0	0	2	1	1	5	1	3	1	1	4	3	1	0

**NOTE:** G: Germplasm, 26: Stem: Intensity of anthocyanin colouration of nodes, 27: Panicle: curvature of main axis, 28: Spikelet: Lemma pubescence density, 29: Spikelet: Lemma tip colour, 30: Lemma and palea colour, 31: Panicle awns, 32: Panicle: awns colour, 33: Panicle: awns length, 34: Panicle: distribution of awns, 35: Panicle: presence of secondary branching, 36: Panicle: attitude of branches, 37: Panicle exertion, 38: Panicle type, 39: Panicle axis , 40: Apiculus colour, 41: Culm: Internode colour, 42: Leaf senescence, 43: Sterile lemma colour, 44: Alkali Digestion, 45: Seed Coat (bran) Color (SCC), 46 : Chalkiness of Endosperm.