The Variability of Qualitative Traits in Promising Rice Lines

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Abstract. Rice is one of the world's oldest important crops. Qualitative traits can be useful for the identification of promising rice lines. In this study, seventeen advance rice lines were evaluated for qualitative traits. This assessment was carried out to analyse the variability in genotypes, based on 49 important qualitative traits of rice. Data on morphological parameters was collected from each line at suitable phase of growth to check variation. Findings were recorded according to descriptors for rice. Dendrogram was constructed which divided all the genotypes into seventeen major clusters, each subdivided into smaller sub-clusters. The pattern of cluster based on qualitative traits revealed the wide genetic variation. A high level of genetic variability based on qualitative traits was observed in this study. The genetic improvement of the rice needs the availability of genetic variability in promising lines. Significant phenotypic information and these variability has potential to develop quality rice for future breeding programs.

Keywords: rice, lines, qualitative traits, genetic, variability.

1. Introduction

Rice has been one of the world’s most important food crops [1]. Rice species in the genus Oryza have been extensively studied because of their agronomically useful traits in genetic improvement as part of cuisine and forage [2]. Rice is a self-pollinated crop and most varieties released are pure lines. Consequently, in breeding programs, variability within lines is nil, while that between lines can be quite limited if only few number of cultivar are tested [3]. In highly self-pollinated crops, where populations often exist as a composite of various homozygous individuals [4].

The evaluation of the nature and extent of genetic diversity within the lines is necessary for assisting plant breeders in selecting appropriate materials for further genetic improvement of lines [5]. Qualitative traits are essential for the description of rice. These traits are expressed into different categories from quantitative traits [6].

Genetic variability in rice is necessary to sustain level of productivity. The breeding program needs evaluated traits based on morphological descriptors. Qualitative characteristic is one of based studies on genetic diversity. This knowledge will help in the breeding of good quality lines [7].

Characterization of overall genetic diversity can be considered as a valuable gene pool for superior lines breeding programs [8]. The aim of this present study was obtained the information on genetic variability based on qualitative traits among seventeen rice lines.
2. Material and Methods

Seventeen rice lines (*Oryza sativa* L.) were evaluated in February-July 2019 (Table 1) at Magelang, Central Java, Indonesia (7°27′51″ N latitude and 110°11′34″ E longitude), altitude of 430 m above sea level. The type of soil in field trials is Alluvial (48.79% clay, 30.08% silt and 21.14% sand) with a pH 6.06. Average temperature, humidity and air pressure during the growing season are 26.72°C, 56.81% and 1009.81 mbar, respectively. Annual average rainfall in this region 27.45% (ranges 0-2.12 mm).

The study was laid out in a randomized complete block design with three replications. Each plot has a size of 5 m × 5 m, plot to plot distance was kept as 0.5 m. Row to row and plant to plant spacing were maintained at 20 cm × 20 cm. The experiment begins with land clearing, and continues by hand tractor order to receive sunlight. Organic fertilizer was spread thoroughly before harrowing. Each rice lines sowed in the nursery, transplanted at the age of 15 days, two plants per holes. Planting is done after the soil is watered until wet to create loose soil. The agronomical practices and pest/diseases controls in fields in provision of habitat were followed to raise a good crop [9;10;11;12].

Seventeen promising lines were characterized by 49 descriptors according to the methodology Descriptors for Wild and Cultivated Rice (*Oryza spp.*) [13]. For each qualitative trait, high varied extensively were taken for data analysis. The data were first standardized to eliminate the effects of different measurement following Pandey et al. [14]. Clustering is processed using SAS software facility [15]. For all qualitative descriptors presented descriptively.

| Lines | Name                      | Lines | Name                           |
|-------|---------------------------|-------|--------------------------------|
| L1    | GM 11                     | L10   | Mutan Rojolele 30 Pendek       |
| L2    | V11                       | L11   | Mutan Rojolele 30 Tinggi       |
| L3    | V12                       | L12   | Mutan V12T                     |
| L4    | V12 Inpari                | L13   | Mutan Mayangsari               |
| L5    | GM 28                     | L14   | Mutan Lakatesan                |
| L6    | GM 2                      | L15   | Mutan Batan                    |
| L7    | GM 8                      | L16   | Inpari 33 (variety)            |
| L8    | Inpago 6 Mayangsari       | L17   | Inpari 30 Ciherang Sub 1 (variety) |
| L9    | Mutan Lampung Kuning      |       |                                |

3. Results and Discussion

Morphological variability for qualitative traits in seventeen lines of rice is presented in Table 2. The experimental material of rice characterization studies indicates wide diversity in qualitative traits vary among lines. Morphological variations among lines were affected mostly by its genotypes than environmental factors. The results in the present study revealed a high degree of morphologically recognizable polymorphism for almost all the qualitative variables.

Across genotypes, factor analysis summarized the phenotypic traits main factors and morphological traits. One of the unique trait in rice plants is the color of the auricle. Observation at the late vegetative stage shows the diversity of characters consisting of whitish (Lines 2, 4, 8, 10, 13), yellowish green (Lines 1, 3, 5, 6, 7, 9, 11, 12, 15, 16, 17) and purple lines (line 14). The results on all rice lines at the late vegetative stage show that the qualitative ligule shape is 2-cleft (Figure 1).

Culm anthocyanin coloration on nodes in all Lines is absent after flowering to near maturity. The presence and distribution of purple color from anthocyanin, observed on the outer surface of the nodes on the culm. This study estimated underlying node color of culm is no underlying color visible due to anthocyanin. The underlying color of the outer surface of the nodes on the culm, ignoring any anthocyanin coloration. Stage: after flowering to near maturity.

Characters of internode anthocyanin culm is absent in stage near coloration maturity. The presence and distribution of purple color from anthocyanin, observed on the outer surface of the internodes on the culm. Underlying internode coloration of culm all genotypes is no underlying color visible due to
anthocyanin. The underlying color of the outer surface of the internodes on the culm, ignoring any anthocyanin coloration at near maturity stage.

The range of variation observed among the lines for the flag leaf attitude descriptors are presented in Figure 2. The flag leaf attitude of rice lines was observed in both early and late observation, showed erect (Lines 1,2,3,4, 5,7,8,9,11,14,15,16,17), semi-erect/intermediate (Lines 10, 13), horizontal (Lines 6, 12).

![Colour of auricle and ligule shape](image)

**Figure 1.** Colour of auricle and ligule shape

![Flag leaf attitude](image)

**Figure 2.** The flag leaf attitude

The other qualitative character that is always the main concern is the culm habit type. The estimated average angle of inclination of the base of the main culm from vertical. Plant characteristics of rice lines indicate the nature after flowering stage of the plant habit type is erect (Figure 3).

The pattern of inheritance for a qualitative trait is typically monogenetic, which means that the trait is only influenced by a single gene. The flag leaf attitudes and culm habit type are good examples of qualitative traits. The environment has very little influence on the phenotype of these traits.

The characteristic color of apiculus lemma is observed at early observation or after anthesis to hard dough stage (pre ripening stage) it was that all Lines showed brown (tawny) except Line 9 with straw properties (Figure 4). Seed characteristics is the most important to be observed. Observations in rice lines indicate the nature of caryopsis pericarp colors are white (Lines 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 13, 15, 16, 17) and red (Lines 2, 12, 14) (Figure 5). Khan *et al* [16] argued that rice caryopsis pericarp shape, color, and aroma can influence to consumer preference, breeders must take all these parameters into consideration when developing a new line.

Endosperm type all Lines is non-glutinous/non-waxy. By visual observation, two types of endosperm of polished rice are distinguishable. In glutinous rice, which does not have amylose, the endosperm appears a waxy white. In non-glutinous rice, which contains amylose, the endosperm appears cloudy and translucent.
Figure 3. Culm habit (1= Erect/<15°)

Figure 4. Lemma colour of apiculus

Figure 5. Caryopsis pericarp colour
| No. | Qualitative traits                                      | Description of the traits                                      | Lines |
|-----|--------------------------------------------------------|---------------------------------------------------------------|-------|
| 1   | Coleoptile anthocyanin colouration                     | 0=Absent; 1=Very weak; 3=Weak                                 | L1 L2 L3 L4 L5 L6 L7 L8 L9 L10 L11 L12 L13 L14 L15 L16 L17 |
| 2   | Basal leaf sheath colour                              | 1=Green; 2=Green with purple lines                           |       |
| 3   | Leaf sheath anthocyanin colouration                   | 0=Absent; 3=Weak; 5=Medium                                   |       |
| 4   | Leaf blade presence/absence of anthocyanin colouration| 0=Absent; 1=Present                                          |       |
| 5   | Leaf blade intensity of green                          | 0=No green colour visible due to anthocyanin; 3=Light; 5=Medium|       |
| 6   | Leaf blade attitude                                   | 1=Erect; 3=Semi-erect                                        |       |
| 7   | Leaf blade pubescence                                 | 1=Glabrous (smooth); 2=Intermediate                          |       |
| 8   | Leaf blade pubescence on blade surface                | 1=Glabrous; 2=Hairy on upper surface                         |       |
| 9   | Leaf margin pubescence                               | 1=Absent; 1=Present                                          |       |
| 10  | Auricle colour                                        | 1=Absent; 2=Yellowish green; 5=Purple lines                  |       |
| 11  | Collar colour                                         | 1=Erect; 3=Semi-erect                                        |       |
| 12  | Little leaf anthocyanin                              | 0=Absent; 1=Present                                          |       |
| 13  | Flag leaf attitude (early observation)                | 1=Erect; 3=Semi-erect                                        |       |
| 14  | Colum such as anthocyanin colouration on nodes        | 0=Absent; 1=Present                                          |       |
| No  | Qualitative traits                          | Lines | Description of the traits                                                                 |
|-----|--------------------------------------------|-------|-------------------------------------------------------------------------------------------|
| 18  | Culm: underlying node colour               | L1    | 0=No underlying colour visible due to anthocyanin                                         |
| 19  | Culm: internode anthocyanin               | L2    | 0=Absent                                                                                  |
| 20  | Culm: underlying internode colouration     | L3    | 0=No underlying colour visible due to anthocyanin                                         |
| 21  | Culm: lodging resistance                   | L4    | 5=Intermediate (most plants leaning about 45°); 7=Strong (most plants leaning about 20° from vertical); 9=Very strong (all plants vertical) |
| 22  | Culm: strength                             | L5    | 7=Strong                                                                                  |
| 23  | Flag leaf: attitude (late observation)     | L6    | 1=Erect; 3=Semi-erect; 5=Horizontal                                                        |
| 24  | Leaf: senescence                          | L7    | 5=Intermediate (one leaf still green at harvest); 7=Late (two or more leaves still green at harvest) |
| 25  | Male sterility (Stage at anthesis)         | L8    | 1=Effectively absent: <25% sterile pollen                                                  |
| 26  | Stigma: colour                            | L9    | 1=White                                                                                   |
| 27  | Anther: colour                            | L10   | 1=Yellow                                                                                   |
| 28  | Lemma and palea: colour (early observation)| L11   | 3=Gold and gold furrows; 4=Brown (tawny)                                                   |
| 29  | Lemma: colour of apiculus (late observation)| L12  | 2=Straw; 3=Brown (tawny)                                                                  |
| 30  | Lemma: anthocyanin colourisation of area below apiculus | L13 | 0=Absent; 3=Weak                                                                          |
| 31  | Awns: distribution                        | L14   | 0=None (awnless); 2=Upper quarter only                                                     |
| 32  | Awns: colour (early observation)           | L15   | 4=Brown (tawny)                                                                           |
| 33  | Panicle: attitude of main axis             | L16   | 2=Semi-upright                                                                             |
| 34  |                                           | L17   |                                                                                           |
| No | Qualitative traits | Lines |
|----|-------------------|-------|
| 34 | Panicles: panicle branching (semi-compact panelle) | 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 |
| 35 | Panicles: secondary branching | 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 |
| 36 | Panicles: exertion | 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 |
| 37 | Panicles: shattering | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| 38 | Panicles: threshability (Cultivated species) | 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 |
| 39 | Awns: colour (late observation) | 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 |
| 40 | Lemma and palea pubescence | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| 41 | Lemma and palea: colour (late observation) | 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 |
| 42 | Lemma: anthocyanin colouration of keel | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| 43 | Lemma: anthocyanin colouration of area below apiculus (late observation) | 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| 44 | Lemma: shape of apiculus. Stage: after harvest | 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 |
| 45 | Sterile lemma: colour | 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| 46 | Caryopsis: shape | 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 |
| 47 | Caryopsis: pericarp colour | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |
| 48 | Endosperm type | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 |

Description of the traits:
- **Panicles: panicle branching (semi-compact panelle)**: 1 = Semi-compact; 2 = Dense (~2-3 secondary branches per primary branch, ~50% of spikelet borne directly on primary branch); 3 = Parry exerted (panicle base is slightly beneath the collar of the flag leaf blade); 4 = Just exerted (panicle base coincides with the collar of the flag leaf blade).
- **Panicles: secondary branching**: 1 = 1; 2 = 2; 3 = 3; 4 = 4; 5 = 5; 6 = 6; 7 = 7; 8 = 8; 9 = 9; 10 = 10; 11 = 11; 12 = 12; 13 = 13; 14 = 14; 15 = 15; 16 = 16; 17 = 17.
- **Panicles: exertion**: 1 = Semi-erect (semi-compact panicle); 2 = Dense (~2-3 secondary branches per primary branch, ~50% of spikelet borne directly on primary branch); 3 = Parry exerted (panicle base is slightly beneath the collar of the flag leaf blade); 4 = Just exerted (panicle base coincides with the collar of the flag leaf blade).
- **Panicles: shattering**: 1 = Very low (<1%); 2 = Low (~1-5%); 3 = Moderate (~5-50%); 4 = High (~50-90%); 5 = Very high (~90-100%).
- **Panicles: threshability (Cultivated species)**: 1 = Trichomes are short (not visible); 2 = Trichomes are long (visible); 3 = Easy (>50% of grains removed).
- **Awns: colour (late observation)**: 1 = Brown (tawny).
- **Lemma and palea pubescence**: 1 = Glabrous.
- **Lemma and palea: colour (late observation)**: 1 = Gold and gold furrows; 2 = Gold and brown furrows; 3 = Gold and brown furrows.
- **Lemma: anthocyanin colouration of area below apiculus (late observation)**: 1 = Absent.
- **Lemma: shape of apiculus. Stage: after harvest**: 1 = Absent.
- **Sterile lemma: colour**: 1 = Absent.
- **Caryopsis: shape**: 1 = Pointed.
- **Caryopsis: pericarp colour**: 1 = Pointed.
- **Endosperm type**: 1 = Gold; 2 = Brown (tawny).
Evaluation of the genetic relationship among lines allow in Figure 6. These data collectively demonstrate a cluster analysis based on phenotypic traits separated the genotypes among 17 major groups and indicated high degree of phenotypic diversity. There is no obvious relationship between lines and grouping based on genetic similarities. Rice lines collection was genetically very variable and did not show an association between genetic. Qualitative characters along with their respective morphological characters were considered for cluster analysis. The dendrogram obtained revealed 17 major clusters within 0 to 10 rescaled distances based on similarity of coefficients. There is no obvious relationship between lines and grouping based on genetic similarities. This is assumption that selecting genotypes of different genetic to a breeding project.

The dendrogram construct based on unweighted pair-group method with an average to inter genetic relationship and phylogeny among varieties the resultant similarity matrix data. Seventeen rice lines were grouped into clusters were included in monogenotypic cluster. The composition of clustering pattern showed that genotypes collected might be due to change in selection for different objectives and adopting different methodology for evolving rice lines [17;18].

The dendrogram based on qualitative traits all the genotypes, grouped into 17 major clusters, each subdivided into smaller sub-clusters. It is indicated of the lines collections did not reflect their same genetic. Correlations among traits varied from 0.3087 to 1.0. Root-mean-square total-sample standard deviation based on morphological data is 0.68676 (Table 3).

Table 3. Eigenvalues of the covariance matrix for qualitative descriptors

| No | Characteristics                                      | Eigenvalue | Difference | Proportion | Cumulative |
|----|------------------------------------------------------|------------|------------|------------|------------|
| 1  | Coleoptile: anthocyanin colouration                  | 7.13436380 | 2.21742523 | 0.3087     | 0.3087     |
| 2  | Basal leaf sheath: colour                           | 4.91693857 | 1.64099699 | 0.2128     | 0.5215     |
| 3  | Leaf sheath: anthocyanin colouration                 | 3.27594157 | 0.75275486 | 0.1418     | 0.6632     |
| 4  | Leaf blade: presence/absence of anthocyanin colouration | 2.52318671 | 0.46452780 | 0.1092     | 0.7724     |
| 5  | Leaf blade: intensity of green colour                | 2.05865891 | 1.02784754 | 0.0891     | 0.8615     |
| 6  | Leaf blade: attitude                                 | 1.03081137 | 0.39808301 | 0.0446     | 0.9061     |
| 7  | Leaf blade: pubescence                              | 0.63272836 | 0.13353244 | 0.0274     | 0.9335     |
| 8  | Leaf blade pubescence on blade surface               | 0.49919592 | 0.04406435 | 0.0216     | 0.9551     |
| 9  | Leaf margin: pubescence                             | 0.45513157 | 0.27034271 | 0.0197     | 0.9748     |
### 4. Conclusion

The major objective of establishing rice lines is more effectively in qualitative traits variability. Dendrogram was constructed based on dissimilarity matrix to confirmed genetic variability and evaluate the different lines in breeding program. This study demonstrates that rice diversity in complex manner.
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